LIGHTING EFFICIENCY – F6

Energy eco-efficiency opportunities in Queensland Foundries

Benefits of correct lighting

Lighting can account for up to seven per cent of industrial electricity use. Savings can often result from low cost changes.

Options to reduce the amount of energy consumed by lighting include:

- installing energy efficient lighting and control technology
- optimising existing control technology
- good housekeeping practices and making the most of natural lighting
- reducing lighting to the minimum required by Australian Standards.

Different types of lighting

Table 1 provides details of different lighting options.

Energy efficient lighting

Fluorescents

A fluorescent tube is a type of gas discharge lamp that uses electricity to excite mercury vapour to produce ultraviolet light that causes phosphorous in the tubes to produce visible light.

There are two main types of fluorescent bulbs, the tube and compact bulbs. Fluorescent lights are usually more suitable for general lighting rather than spot lighting that requires a narrow focus beam.

It is important to remember that machinery can often move or rotate at a frequency of 50 Hertz. Fluorescent lights also often flicker at 50 Hertz and as a result moving parts can appear to be stationary or moving more slowly. Also while most fluorescent bulbs now have reasonable colour rendering they should probably not be used in areas where true colour definition is important.

Turning on a fluorescent light uses the same amount of energy as running it for 5 seconds.[1] In addition, a fluorescent light can be switched on approximately 6600 times before it will fail to start.[2]

Comparing the cost of replacing the bulb with the cost of electricity, if the light is not going to be used for 10 minutes or more it should be switched off.[3]

1 Northwest Energy Efficiency Alliance, Lighting Design Lab, www.lightingdesignlab.com/articles/switching/switching_fluorescent.htm; USA Department of Energy, 26/01/2005, Newton Ask a Scientist, www.newton.dep.anl.gov/askasci/eng99/eng99369.htm
2 Northwest Energy Efficiency Alliance, Lighting Design Lab, www.lightingdesignlab.com/articles/switching/switching_fluorescent.htm
3 Australian Greenhouse Office, Resource and Training kit / Lighting, 2005.

Table 1 - Comparison of different types of lighting[4]

	Type of light	Wattage (W)	Capital cost	Relative operating costs	Efficacy (lumens/ watt)	Average life (hours)[5]	Deterioration of light quality over time	General information	Application
Incandescent	Incandescent Type A bulb	15-1,500	Low	High	10-17	750-2,500	Light output falls 15 per cent through life	Electricity heats a tungsten filament to produce bright light. 90% electricity lost to heat.	Bulbs to be phased out by 2010.
	Tungsten halogen (240 V) (dichroic)	20-2,000	Low	High	22	2,000	Very little	Electricity heats a tungsten filament enclosed in pockets of halogen gas. Emits bright white light using less than 10-20%[6] of the energy of an incandescent bulb and lasts around twice as long. However, generates heat and should not be used near flammable material.	Dimmable so often used for 'mood' or display lighting. Typically used for up-lighting.
	Tungsten halogen (6-21 V)	10-75	Low/ medium	Medium	30-50	2,000–4,500	Very little		Low voltage used for down-lighting. 35 Watt energy efficient halogen lighting can replace 50 Watt dichroic lighting.
Fluorescent	Fluorescent	8-36	Low/ medium	Low	Tube (T5/T8) 92-104 Compact 50-70	Tube 7,000-24,000 Compact 10,000	<20 per cent	Fluorescent lamps pass an electrical current through a tube filled with argon and mercury producing UV radiation that bombards the phosphorous coating to emit light. They are efficient (using 1/5th the power of an incandescent bulb), long lasting and produce little heat.	Good for large areas requiring no detailed work. Fluorescent light does not cast a shadow and should be avoided in areas where there are moving parts or where colour definition is important.
	Intelligent fluoro high-bay	200		Low	87	20,000+ hours	Very little	Light fitting set with sensors to adjust the light level in response to natural lighting and occupancy	High bay installations between 6-16m.
High intensity discharge	High Intensity Discharge Metal halide	35-3,500	High	Very low	60-115	5,000-20,000	<45 per cent	Metal halides provide bright white point light. They are more efficient than mercury vapour and brighter than sodium lights.	Lighting in areas where ceiling is greater than 4 m.
	High Intensity Discharge (HID) - Mercury vapour	40-1,000	Low	High	25-60	16,000-24,000	High	Producing a cool blue/green light, mercury vapour lamps have a longer lifespan to metal halides.	Exterior lighting and lighting where colour rendering is not important.
	High Intensity Discharge (HID) - Sodium high pressure	35-3,500	High	Medium	50-140	16,000 – 24,000	<15 per cent	Sodium high pressure lights provide a warm white light. The colour rendering is not as good as metal halide but the lifespan is longer.	Exterior, security lighting. Internal use in factories with ceiling height over 4m and where colour definition is not important. They are slow to start up.
LED	Light emitting diodes (LED)	3-4.2	High	Very low	10-100	50,000	Very little	Light Emitting Diodes (LEDs) are semiconductor devices that can convert electrical energy directly into light. LEDs are energy efficient and produce very little heat.	Recent developments in improving light output of white LEDs is rapidly expanding the applications of this new technology.

4 Queensland Government, 2006, Marine Fact Sheet 3 Lighting **www.ecoefficiency.com.au/Portals/56/factsheets/marine/ecomarine_fsm3.pdf**; Government of South Australia, Department of Transport, Energy and Infrastructure, Commercial and Factory Lighting, **www.energysafety.sa.gov.au/__data/assets/pdf_file/0019/15661/com_factorylighting_web.pdf**

5 Note that the "average life" of a lamp is based on laboratory testing and is determined when 50% of the lamps initially installed are still operating. Venture Lighting, Lamp Life **www.venturelighting.com/TechCenter/Lamps/lamp_life.htm**

6 Klipstein, D.L., 2006, The Greater Internet Light Bulb Book Part 1, **members.misty.com/don/bulb1.html**

Fluorescent tubes T8s

The standard tube, florescent halophosphate T8, has a standard magnetic ballast and a lifespan of around 6000 hours. The ballast controls the starting and operating voltages of a gas discharge lamp so that the right amount of light is emitted. T8s are also now available with electronic ballasts which not only have a wattage saving, but also a soft start and better current control which helps to extend the tubes lamp life. The light is prone to discolouration and will depreciate in lumen (brightness) over time.

The fluorescent triphosphor T8s have a 20 percent greater light output than standard T8s. This means it may be possible to meet the lumen (lighting levels) recommended in the Australian Standards with fewer lights. They also have reduced lumen depreciation compared to the standard T8s and a longer lifespan, lasting around 13,000 hours (magnetic ballast) and 16,000 hours (electronic ballast).[7]

Compact fluorescent bulbs use one fifth the energy of incandescent bulbs.

Fluorescent tubes T5s

T5s are thinner tubes with an electronic ballast. The standard T5 uses 28 watts, producing 104 lumens per watt compared with 36 watts used by T8s that produce 92 lumens per watt. The compact size reduces the amount of material used in their manufacture. The improved phosphorous coating also allows reduced mercury content. Fluorescent tubes are required by Australian Standards to contain less than 15 mg of mercury while compact fluorescent lamps are required to contain less than 5 mg of mercury under a new Australian Standard introduced in 2009. There is currently no mercury recycling collection in Queensland.[8]

T5s are a different length to T8s and have different lamp holders so they are ideally suited to new installations rather than retrofits. Special electronic ballasts are required to allow diming on T8; T5 fluorescent tubes utilise electronic ballasts as standard.[9]

T5HO (high output) fluorescent tubes can be used in place of metal halide lamps. Replacing metal halide lamps with an equivalent T5HO configuration can reduce energy consumption by up to 50%.

Compact fluorescents

Compact fluorescent bulbs last up to 8 times longer than incandescent bulbs and use 1/5th the energy.

Dimmable compact fluorescent bulbs are now available and can save up to 40% of energy consumption.[10]

Intelligent lighting

Intelligent lighting uses fluorescent tubes in conjunction with photosensor controls to adjust the amount of light in response to natural light from skylights or windows within specified work place health and safety parameters. They can also turn the lighting off if the room or area is not occupied. Intelligent lighting may be a good option for manufacturers with rooms or areas in their facilities that are not in continuous use or sites with skylights or access to natural daylight e.g. windows or doors.

LEDs are very energy efficient as they convert electrical energy directly into a coloured light generating very little heat.

Light emitting diodes (LEDs)

LEDs are solid semiconductor devices that convert electric energy directly into a coloured light. It is this ability to convert electricity directly into light while generating very little heat that makes LEDs so energy efficient. LEDs have been used widely in the past for back lighting, displays, signals, medical, architectural and vehicle lighting but it is only very recently that LEDs are starting to reach acceptable levels of lighting that are suitable for general purpose lighting.

The colour emitted from LEDs depends on the material used to make the diode. While red and green LEDs have been around for decades it was not until the 90's that blue and eventually white LEDs were developed. The challenge has been to create a stronger and wider beam of light and to improve the colour quality of white light emitting diodes so they can be used as a general light source.

7 NSW Department of Energy and Utilities and Sustainability, Planning for Efficiency – Assessing Your Lighting Efficiency – a technical guide.
8 Australian Department of Environment, Water, Heritage and Arts, 2009, Safe disposal of mercury-containing lamps **www.environment.gov.au/settlements/waste/lamp-mercury.html#question3**
9 US Department of Energy, 2008, Fluorescent Lighting **www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12040**
10 Origin, 2008, Lighting **www.originenergy.com.au/2678/Lighting**

The colour rendering (i.e. the ability of the light to realistically reproduce the colour of the object) of warm white LEDs is now approaching that of compact fluorescent bulbs. A wider beam has been achieved by clustering groups of diodes together and encasing them in a diffuser lenses which spreads the light.

While the costs to produce LEDs is currently high compared to fluorescents their long-lifespan, around 50,000 hours compared to about 10,000 hours for fluorescents and 1000 hours for incandescent, can dramatically reduce maintenance and replacement costs[11]. Unlike fluorescent bulbs, LEDs contain no toxic mercury and have greater resistance to shocks and vibrations due to their solid state.

Productdose.com provides an online energy saving calculator that can determine savings from replacing incandescent bulbs with compact fluorescents or LEDs. For further information visit: **www.productdose.com/LightBulb_Comparison.xls**

High intensity discharge (HID) lighting

It is common to find manufacturers utilising HIDs for factory lighting. Mercury vapour lamps are the oldest type of HIDs and are used primarily for street lighting. Most indoor mercury vapour lamps have now been replaced by metal halide lamps. Metal halide lamps produce a reliable bright, white light in a wide range of ambient temperatures and have the best colour rendition of all HIDs. Metal halide lamps do, however, have shorter life spans than both mercury vapour and high-pressure sodium lamps. Pulse start metal halide lamps require the installation of a compatible pulse start ballast but will produce higher light output while being 15% more energy efficient.

High-pressure sodium lights produce a warm white light and are commonly used for outdoor lighting. They have poorer colour rendition than metal halide lamps but a longer lifespan.

Halogen lights are typically used for task specific lighting.

Halogen lights

Halogen lights work like incandescent bulbs but have a thicker filament that allows hotter temperatures. The bright white light emitted from halogen lights is generated using less than 10-20 per cent of the energy of an incandescent bulb.[12]

Halogen lights are longer lasting than incandescent bulbs, and are typically used for task specific lighting, for example where it is important to get true colour on specific surface.

Halogen bulbs can get hotter than other bulbs and should not be used in areas where they are likely to come in contact with flammable material. Aluminium back bulbs are now available that throw the heat forward.

Phase out of inefficient light bulbs

The Australian Government is working towards a full phase out of inefficient light bulbs by 2009-2010. Bulbs targeted are those with an efficiency less than 15 lumens per watt. Currently, alternative options for equipment such as ovens are still being explored.

For more information visit: Australian Department of Environment, Water, Heritage and the Arts. **www.environment.gov.au/settlements/energyefficiency/lighting**

Light bulbs with an efficiency of less than 15 lumens per watt such as incandescent light bulbs are being phased out.

11 US Department of Energy, 2008, Light Emitting Diodes (LEDs) Fact Sheet **www1.eere.energy.gov/buildings/ssl/factsheets.html**
12 Klipstein, D.L., 2006, The Greater Internet Light Bulb Book

Savings from retrofitting efficient lighting

Table 3 demonstrates the potential savings achievable by retrofitting efficient lighting.

Table 3 - Typical savings from replacing inefficient lights with efficient lights[13]

Existing lamp	Energy Efficient lamp	No. of lights	Light wattage (kW)	Hours of use	Electricity cost (c/kWh)	Days of use per year	Cost to run per year	Annual savings
Incandescent		15	0.075	8	15.1	255	$347	
	Compact fluorescent	15	0.015	8	15.1	255	$69	$278 Bulbs last 10 times longer
Dichroic down lights		10	0.035	8	15.1	255	$108	
	Compact fluorescent	10	0.007	8	15.1	255	$22	$86 bulbs last up to twice as long
Mercury		20	0.700	8	15.1	255	$4,322	
Metal halide		20	0.400	8	15.1	255	$2,464	
	Intelligent fluoro high-bay	20	0.220	8	15.1	225	$1,355	$2,967
Halophosphate Fluorescent		16	0.040	8	15.1	255	$197	
	Triphosphate fluorescent	8	0.040	8	15.1	255	$99	$98 bulbs last 60 per cent longer

Good housekeeping

Lighting use, design and maintenance

Consideration of lighting needs, design and maintenance can provide significant savings. The following methods can help reduce energy for lighting:

- Task level lighting directs light to where it is needed rather than lighting large areas.
- Occupancy and movement sensors automatically turn off lighting in inactive areas such as freezers and storage rooms.
- Light switch segregation allows lights in areas not in use to be switched off.
- Retrofitting fluorescent light fittings with high frequency eco-controllers increases efficiency and reduces energy use.
- Natural light utilisation, e.g. skylights, reduces light requirement. The downside is they must be cleaned and can create glare and reflection. The additional heat load from sunlight must be considered for air conditioned areas. Proper design and installation of skylights can minimise these downsides.
- Regular cleaning of light fittings, reflectors and diffusers reduces energy losses.
- Photoelectric sensors measure natural light and adjust lights accordingly, including security lights.
- Auto or step dimmers reduce total energy demand by up to 20-30 per cent.
- Walls and ceilings painted in light colours reduce light requirements.

13 Queensland Government, 2006, Marine Fact Sheet 3 Lighting

RE-ROOFING TO MAXIMISE NATURAL LIGHTING[14]

Toowoomba Foundry completed a re-roofing project on its foundry buildings as part of its Greenhouse Challenge agreement. By installing ultra violet resistant alsanite material at regular intervals on the roof the site was able to reduce its artificial lighting requirements by 30% during daylight hours. The increase in natural lighting meant that the wattage of existing lighting of 1,000 watt incandescent lamps could be reduced to 400 watt from metal halide lamps. The initiative has led to a 60 percent or more reduction in the power consumption of artificial lighting, or a reduction of 200 tonnes of carbon dioxide (CO_2) emissions per annum.

Bradken Foundry at Ipswich saves $10,000 a year by installing skylights.

STAFF DEMAND NATURAL LIGHT

Bradken Foundry at Ipswich reduced energy consumption by $10,000 a year by replacing some panels of roof with skylights and turning off the halogen downlights. Initially the replacement was trialled on one section of the plant but it was soon expanded to the whole of the factory building on demand from the staff. At a total cost of $36,000 it had a payback period of around 3 and a half years.

Remove unnecessary lighting

De-lamping is another simple method to reduce lighting costs. Investigate if it is possible to remove lights in areas where lighting levels are currently higher than the Australian Standards require. A lux meter can be used to measure lighting levels. It is important to remember that some types of lighting lose lumens (or brightness) with age.

When removing fluorescent tubes consider replacing remaining tubes with efficient tri-phosphor tubes that produce 15 per cent more light and last longer than standard tubes.

To calculate annual savings from 'de-lamping' use the following equation.

$ = ((N x P x H x T)/1000)+ cost of replacing lighting

$ = annual savings
N = number of lamps removed
P = power rating of lamps (W)
H = usage per year (h/year)
T = electrical charge ($/kW h)

When designing or retrofitting a site, businesses can employ a qualified commercial lighting engineer to ensure lighting meets Australian Standards while also achieving maximum energy efficiency.

AusIndustry's Green Building Fund have grants ranging from $50,000 to $500,000 for retro-fitting and retro-commissioning of buildings to reduce base building energy consumption. This includes projects involving common area lighting.

For more information visit:

Quantifying savings: SEDA Energy Smart Toolbox Lighting Calculator
www.energysmart.com.au/wes/Displaypage.asp?flash=-1&t=200912849&PageID=52&t=20083256

Choosing a lighting system: NSW Energy Smart
www.energysmart.com.au/les/DisplayPage.asp?PageID=114

This series of fact sheets provides examples and suggestions to the modern foundry operator on how to achieve both economic and environmental benefits from eco-efficiency. Visit the project website **www.ecoefficiency.com.au** for more ideas and case studies.

14 Australian Department of Environment, Water, Heritage and the Arts, 2008, Toowoomba Foundry Re-roofing project **www.environment.gov.au/settlements/challenge/members/toowoomba.html**

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