

## Improving industrial lighting

*Good lighting design and control can save up to 75% of industrial buildings lighting costs*

### The Challenge

The rewards for providing efficient and effective lighting are considerable. Good lighting can improve staff morale, improve productivity and avoid accidents.

However, energy and maintenance costs need to be considered when designing a new lighting installation or upgrading an existing one.

Failure to do so may result in years of unnecessarily high electricity and maintenance costs.

### How lighting operating costs are reduced

There are two fundamentally different approaches to reducing lighting costs.

#### Reduce hours of use

Reducing hours of use is achieved by:

- switching off lights when not in use
- dimming or partial switch off of lights when daylight conditions allow.

This can be done either manually or automatically. Switching lights off or dimming saves energy and greenhouse gasses, but cost savings are often less than expected.

Commercial and industrial electricity users are usually charged separately for maximum monthly demand and energy. Switching lights off or dimming impacts mainly on the energy component of the bill, which is often about half the total. Unless lights can be switched off over peak

demand periods **every** day of the month, the demand charges remain unchanged.

#### Minimise the lighting load

Minimising the lighting load saves both energy and demand charges, because the rate at which energy is consumed by the lighting installation is reduced. This is achieved by:

- designing to the correct light levels.
- using efficient lamps and fittings.

Examples of both approaches can be found in the list of opportunities that follows.

## No cost/low costs opportunities

### 1 Turn off lights that are not needed.

This is the simplest way of saving lighting energy. Frequent switching reduces fluorescent lamp life, but the reduced running hours means that lamps last longer. It is economical to turn off fluorescent lights if they are not required for more than 10 minutes.

A characteristic of High Intensity Discharge (HID) lamps is their long start/restart times (usually several minutes). Long restart times makes turning HID lamps off for short periods unacceptable. However, where natural daylight is available, turning them off when daylight becomes sufficient, then on again later in the day as evening falls, saves significant amounts of energy and the lamps last longer.

Labelling switches where multiple switches control lighting in large workspaces makes it easier for people to turn lights off in their local area.

Most importantly, make someone responsible for turning lights off at the end of each day.

### 2 Use daylight

Many high bay industrial and storage buildings are well placed to use daylight because they are provided with ample skylight via clear roofing panels. Allowing lighting to be manually switched off when daylight levels are sufficient.

When designing new buildings, skylight size should be carefully chosen as excessive skylight area can lead to summer overheating problems unless a traditional saw tooth roof with south facing windows is used. Every square metre of skylight oriented at right angles to the sun's rays can admit up to 1KW of solar energy. A skylight area of 10% of total roof area will give ample daylight.

### 3 Maintain the lighting system

As lighting systems age, the light levels on the working surfaces can drop by over 50%. Factors include loss of output from lamps, dirt on the reflecting and diffusing surfaces of the light fitting, and dirt on room surfaces. Cleaning the fittings can be very important in industrial situations and may be required as often as three monthly in very dirty conditions. Filtered or sealed fittings can be used in very dirty situations, but the cover glass still needs to be cleaned.

In high bay installations, bulk re-lamping is often very cost effective, as special equipment is needed to reach the fittings. If one lamp has failed the rest will be approaching the end of their life. Fittings should always be cleaned when lamps are replaced to ensure design light levels are maintained

## Higher costs opportunities

Opportunities 1 - 3 are simple no cost / low cost measures that do not involve changing the design of the system. Opportunities 4 - 7 arise in new buildings and where more costly lighting upgrades can be considered.

### 4 Design to the correct light levels

Care is required to ensure the correct lighting level is identified before proceeding with any design work. This is the most important and most often neglected step in upgrading or designing an energy efficient lighting system.

Designing to twice the recommended lighting level doubles energy consumption at a stroke. This extra energy is unlikely to be saved even by the most expensive and sophisticated energy saving equipment. Table 1 shows some typical maintenance light levels recommended by AS/NZS 1680.2.4 for industrial situations. A range of energy costs is shown for each situation. The range of costs reflects the impact of the fitting selection and lamp type used.

Table 1 Typical industrial illuminances

Situation	Recommended light level (AS1680)	Energy cost range \$/m <sup>2</sup> /year (1)
Fine work and inspection	600 lux	\$6 to \$40
Laboratories Inspection and sorting	400 lux	\$4 to \$28
Office space Entrance foyers and reception areas	320 lux	\$3 to \$20
Filing and storage rooms, walkways in open plan areas, lecture and seminar rooms	240 lux	\$2 to \$15
Live storage fine material	160 lux	\$1.60 to \$11.20
Passageways and toilet blocks Live storage bulky items	80 lux	\$0.80 to \$5.60
Dead storage bulky items	40 lux	\$0.40 to \$2.80

(1) Assuming 3,000 hours per year and 10c per kWh

## 5 Select the most suitable light source

The second most important step is to select the most efficient lamp type compatible with first cost and maintenance considerations. Table 2 shows the common lamp types and their characteristics.

Fluorescent lamps are the preferred choice in most commercial office and small manufacturing installations where ceiling heights are modest. Fluorescent lamps offer the benefits of low cost, high efficiency, good colour rendition, and rapid starting.

High intensity discharge (HID) lamps offer the benefit of high light output from a reasonably compact source. Unfortunately, with the exception of the Metal Halide lamp, high light output usually comes at the expense of colour rendition. This makes them unsuitable for areas where good colour recognition is necessary. Additionally, long start and restart times means people are reluctant to turn them off, even if they expect to be absent for several hours.

HID lamps often find application in industrial buildings and large storage facilities. The work-spaces are usually high, colour rendition is less important, and the lights are expected to be on for extended periods. Such spaces are often lit by "high bay" fittings that use high wattage, HID lamps. The high light output from these lamps enables

the use of fewer fittings. Fewer fittings means reduced capital cost and maintenance costs. This is important because the heights involved in high bay spaces make installation and maintenance difficult. Often, special equipment is needed to reach the fittings. Also the lamps small size makes it possible for the fitting to direct the light more effectively for instance where narrow beams are required to direct light between high racking.

Spaces of intermediate height are often lit with "Low bay" HID fittings. They usually accept HID lamps of intermediate size (150-250 watt). However, recent advances in the efficiency of fluorescent lamps mean they are now as efficient as the best HID lamps and considerably better than the worst. The "New Generation" (NG) triphosphor tube, introduced in 1995, has very good colour rendering and high maintenance light output. In the new T5 range, high output (HO) versions further increase the total light output available.

These advances have resulted in fluorescent technology being a strong contender for low bay applications. The maintained light output of a twin tube fluorescent fitting with two 80W HO T5 triphosphor lamps will be higher than that of a low bay fitting using a 150W SON or a 250W metal halide lamp. The fluorescent installation would cost less have better colour rendering, instant restart time, and lower maintenance costs. It is also more practical to switch off fluorescent lamps when they are not needed.

**Table 2 Lamp types**

Lamp type	Appearance	Colour rendering	Life (hours)	Run-up time (mins)	Re-strike time (mins)	Best suited for
Induction lamps	White	>80	60,000	Instant	Instant	Long hours of operation, inaccessible
High pressure Sodium (SON)	Pinkish orange	20 to 35	20,000	3-6	1-3	Long hours of operation
Triphosphor fluorescent	White	>80	16,000 - 20,000	Short	Short	Long hours of operation
Metal Halide (HPI)	White with bluish tinge	>	9,000	2	5-20	Long hours of operation
Mercury (HPL)	White with bluish tinge	40	24,000	4	4	Short hours of operation owing to low efficacy and/or short lamp life. eg suburban sports ground, intermittent operation
Halogen		100	2,000	Instant	Instant	
Self ballasted mercury (ML)			6,000	Short	Short	
Incandescent		100	1,000	Instant	Instant	

The relative efficacy of common lamps is shown in the Lamp Efficacy graph shown in Figure 1. The **efficacy** of the lamps is the end of life or maintenance light output in *lumens* divided by the *wattage* of the lamp and control gear (circuit wattage) and is an indication of the **efficiency** of the lamp.

### Metal Halide lamps

There is considerable confusion in regard to metal halide lamp technology. Metal halide lamps are a relatively new technology. When they were first developed some manufacturers adapted the ignitor technology used on high-pressure sodium lamps to operate the new metal halide lamps. Others adapted constant wattage mercury technology. The ignitor technology proved to be superior and so metal halide lamps utilising this technology were more efficient than the constant wattage equivalents.

Manufacturers previously using the constant wattage approach have now abandoned it in favour of the ignitor technology and are marketing it as “pulse start” technology.

Care must be exercised in comparing the light outputs of lamps from different manufacturers, as there is a range of outputs from different lamps of the same wattage offered by each manufacturer. For example, the initial light output of a range of 400W lamps available from one manufacturer varies from 32,000 lumens to 45,000 lumens. The light output is a trade off with cost, lamp life, colour rendering and lumen depreciation. In some cases the same lamp will give considerably different light outputs according to control gear used with it. In all cases the correct lamp should be selected for the job.

### Improving lamp efficiency in existing installations

In retrofit situations the same lamp selection principles apply, but options may be limited by the existing design. Some typical situations are discussed below.

Many high bay industrial buildings available for rent are supplied with self-ballasted mercury lamps. Because of their low efficiency, self-ballasted lamps are a low first cost but high running cost option. Replacing them with either metal halide or high-pressure sodium ballasted lamps will reduce power costs in the average industrial building by up to \$12/m<sup>2</sup>/year and, in the case of metal halide, improve colour rendering.

- Older installations are often lit by mercury lamps, which are the least efficient of the ballasted HID lamps. A retrofit metal halide or high-pressure sodium lamp is available which is a screw in replacement for the mercury lamp. The replacement lamps produce 50% - 200% more light at end of lamp life. The extra light is available to raise levels to the required standards or, providing uniformity can be maintained, to allow some fittings to be retired. However these lamps are expensive and can shorten ballast life.
- Older fluorescent installations designed for monophosphor fluorescent lamps can be re-lamped using two-thirds the number of NG triphosphor lamps and still achieve the same maintenance light levels.

A re-evaluation of the required light levels may show that light levels are unnecessarily high. Where this is the case, savings may be achievable by reducing fitting numbers. However, care must be taken to ensure that uniformity is maintained. In installations using fluorescent fittings, it may be possible to reduce the number of fluorescent tubes per fitting.

## 6 Use efficient fittings.

High bay fittings come in a variety of designs to suit different purposes. Wide beam types are most suitable for open spaces and narrow beam types are more suited to stores or warehouses with narrow aisles between high racking.

Fluorescent fittings for industrial use include batten fittings with and without reflectors and “under verandah” fittings. These are inherently efficient designs provided they are maintained adequately.

## 7 Fit control systems

As previously stated, control systems should only be considered after the lighting system has been made as efficient as practical.

There is an understandable intuitive reaction that the best way to save lighting energy is to use a device that will automatically switch off or reduce the level of lighting

when it is not needed. There are a number of devices available to achieve this but unfortunately, these measures are not normally as effective as it would appear. The reasons for this are as follows:

- As explained above, most industrial sites are on a demand tariff so that control systems will not save demand costs unless they can reduce maximum demand every day of the month. This will not be achieved by any system where full lighting power may be required at any time. Examples include daylight controls, where one dull morning will require full lighting and hence full demand, or occupancy sensors where at some time during the day spaces are fully occupied. (Some demand savings from occupancy sensors may occur in, say a store, where only a proportion of the store is occupied at any one time)
- A control device that is cost effective when controlling an inefficient lighting system may not be once the lighting system has been made efficient. For example, occupancy sensors were proposed for a classroom with a 2 kW lighting load. High efficiency reflectors and NG triphosphor lamps were fitted and the lighting load was reduced to 900W. Occupancy sensors were found to be no longer cost effective.
- Controllers, which lower light levels when natural light is available, can give smooth light level transitions. Unfortunately, even when the light level is reduced to low levels, power consumption is not reduced proportionally. Typically, in HID fittings reducing light output by 65% only reduces energy consumption by 50%. Fluorescent dimming systems are more effective. Reducing light outputs in fluorescent tubes by 65% reduces energy consumption by 68%.
- Care must be taken with lighting control systems to ensure they work reliably and don't cause annoyance. Poorly performing control systems can lower productivity or even cause the control system to be disabled.

## Key findings

### No cost/low cost

1. Switch off lights that are not needed.
2. Use daylight.
3. Maintain the lighting system.

### Higher cost

4. Select correct light levels.
5. Select the most suitable light source.
6. Use efficient fittings.
7. Fit control systems.



**emprove**

energy management  
is **smart** business

Emprove is a service provided by the Energy Efficiency and Conservation Authority (EECA). EECA is a Crown entity working to improve New Zealanders' energy choices.

**Auckland:** PO Box 37-444, Parnell, Auckland  
Telephone 09 377 5328, Fax 09 916 4643

**Wellington:** PO Box 388, Wellington  
Telephone 04 470 2200, Fax 04 499 5330

**Christchurch:** PO Box 8562, Riccarton, Christchurch  
Telephone 03 341 1126, Fax 03 341 8571

[www.emprove.org.nz](http://www.emprove.org.nz)

