NSW NOW The new state of business

ENERGY SAVER

Energy efficient lighting

Technology report




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Technical details

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Table of contents

Overview

Lighting contributes significantly to business energy use and operating costs. Increasing energy prices highlight the need to reduce the cost of lighting. Energy use associated with lighting systems can be reduced by up to 82 per cent if energy efficient lighting practices are adopted.

Efficient lighting systems not only reduce energy consumption but improve the working environment, increase safety and enhance staff well-being.

This technical report is designed to help you identify appropriate and reliable energy efficient lighting technology that would be suitable for your facility. The report has been written for lighting consultants, energy auditors, suppliers, installers, project managers and businesses that are preparing and reviewing tender documents for lighting projects.

How to use this report

The *Energy Saver Energy efficient technology report – technical details* is not intended to be read cover to cover, but should be used as a reference guide for choosing the most appropriate lighting upgrade for your space.

For each existing light application, a comparison of potential energy efficient upgrade options are discussed.

How to use the lighting report – technical details

The *Energy Saver Energy efficient lighting technology report* – technical details document contains detailed information for each lighting option including a technical specification, to allow you to make the correct requests to lighting suppliers. The technical specifications are designed to be used in conjunction with the main technology report.

Finding the lighting upgrade that applies to you

This report is designed on the premise that the reader is aware of their current lighting system.

Please review the table overleaf to select which types of existing lights are relevant. This table outlines potential upgrade options for that specific type of light, including a summary of the typical costs and energy savings.

For those who are unsure as to their current systems please read general lighting information in the *Energy Saver Energy efficient lighting technology report* and Appendix 1.

SUMMARY OF LIGHTING UPGRADE OPTIONS

The options are assigned a colour according to which type of existing lighting system they are to replace. All pages with the corresponding colour tab are specific for that option.

Energy and cost savings associated with typical lighting upgrades

	Upgrade options	Quantity of luminaires	Cost reduction ($ p.a.)	Typical capital cost ($)	Energy saving (kWh p.a.)	Typical simple pay back (yr)	GHG reduction (tCO_2 p.a.)	Energy reduction (%)
Twin 36 W T8 recessed linear fluorescent luminaire (page 5)								
1	Retrofit single 36 W T8 reflector and electronic ballast kit	100	3292	12,000	14,040	3.7	14.8	60
2	New twin 28 W T5 fluorescent luminaire ✔	100	1722	8,500	7800	4.9	8.3	33
3	New single 28 W T5 luminaire ✔	100	3552	13,000	15,600	3.7	16.5	67
4	Linear LED replacement lamps, 2 x 19 W	200 lamps	2704	13,000	13,520	3.8	14.3	58
5	T8 to 28 W T5 conversion kits	200 kits	1722	8,000	7800	4.6	8.3	33
6	New 30W integrated LED luminaire ✔	100	3,824	9,000	15,600	2.4	16.5	67
Twin 36 W T8 surface mounted linear fluorescent luminaire (page 20)								
1	New 43 Watt LED luminaire, Integrated LED module and power supply, fitted with diffuser ✔	100	704	15,500	12,220	2.9	12.9	52
2	New twin 28 W T5 linear fluorescent luminaire	100	1722	11,500	7,800	6.7	8.3	33
3	New complete single 28 W T5 linear fluorescent luminaire ✔	100	3553	10,500	15,600	3.0	16.5	67
4	Linear LED lamps, 2 x 19 W	200 lamps	3408	12,000	13,520	3.5	14.3	58
5	T8 to 28 W T5 conversion kit	200 kits	1722	8,000	7,800	4.6	8.3	33
50 W MR16 low voltage dichroic halogen lamp (page 32)								
1	35 W IRC halogen lamp	100	1651	1200	5200	0.7	5.5	31
	35 W IRC halogen lamp with electronic transformer	100	2015	3200	7020	1.6	7.4	42
2	7 W LED replacement lamp	100	4,152	3400	14,040	0.8	14.8	83

Energy and cost savings associated with typical lighting upgrades

	Upgrade options	Quantity of luminaires	Cost reduction ($ p.a.)	Typical capital cost ($)	Energy saving (kWh p.a.)	Typical simple pay back (yr)	GHG reduction (tCO_2 p.a.)	Energy reduction (%)
3	New 16 W LED luminaire	100	4086	8000	12,740	2.0	13.5	75
4	15 W compact fluorescent lamp replacement	100	3517	5500	13,000	1.6	13.8	77
5	New 13 W compact fluorescent luminaire	100	3962	10,000	13,000	2.5	13.8	77
PAR lamps and other halogen downlights (not included)								
1	New 35 W ceramic metal halide luminaire	100	4723	20,000	16,120	4.2	17.0	62
2	New 27 W LED luminaire (non-dimmable)	100	6504	25,000	18,980	3.8	20.0	73
3	New 2 x 18 W compact fluorescent (DALI dimmable)	100	5388	25,000	15,600	4.6	16.5	60
4	New 27 W LED luminaire (DALI dimmable)	100	6504	32,000	18,980	4.9	20.0	73
400 W mercury vapour luminaires (page 43)								
1	New 250 W metal halide luminaire	100	9011	20,000	42,120	2.2	44.6	37
2	4 x 54 W T5 fluorescent luminaire	100	11,964	55,000	53,560	4.6	56.7	48
3	New 110 W LED luminaire	100	19,317	55,000	83,720	2.9	88.7	75
4	200 W induction lamp luminaire	100	14,117	65,000	57,720	4.6	61.1	51
400 W metal halide luminaires (page 51)								
1	New 320 W pulse-start metal halide luminaire	100	5893	30,000	27,300	5.1	28.9	51
2	New 210W LED luminaire	180	14,042	63,000	63,440	4.5	67.2	54
3	New 300 W induction lamp luminaire	100	8582	78,000	36,140	9.1	38.3	31
500 W linear lamp shovel and box floodlight (page 56)								
1	New 150 W metal halide luminaire	10	2472	3000	12,012	1.2	12.7	66
2	New 110 W LED luminaire	10	3142	5000	14,196	1.6	15.0	78

1 Interior lighting

LINEAR FLUORESCENT LUMINAIRES

OPTIONS FOR UPGRADING Twin 36 W T8 recessed linear fluorescent luminaires

OPTION 1:
Retrofit kit, single 36 W T8 lamp with high efficiency reflector and electronic ballast

This upgrade option retains the existing body of the luminaire. This is particularly useful where existing ceilings are based on non metric dimensions, as replacement of these non standard luminaires would be costly.

This option is also useful where air handling troffers are installed. Air handling troffers are luminaires with air vents along the sides that are connected to the air conditioning system.

Illuminance, uniformity and glare

This option effectively places a new lighting system within the housing of the existing luminaire. The light distribution characteristics should be similar where the upgrade is based on a luminaire that employs a diffuser. If the upgrade is based on a louvred luminaire, the light distribution characteristics would need to be verified as appropriate for the specific use.

Recommended illuminance levels, uniformity and glare control covered under AS/NZS 1680 must be met. This should not pose a problem where a quality reflector is used, but this must be proven at the design stage by using industry standard lighting design software.

Where slightly lower illuminance levels result from this upgrade, task lighting could be used. Illuminance on workstations could be increased by relocating luminaires to suit the office layout.

A lamp with a high lumen output should be selected – typically 3250 lm initial output flux at 25°C. Illuminance measurements should be made before the upgrade to establish the existing illuminance, and then after the upgrade, to demonstrate that the illuminance meets AS/NZS 1680 recommendations.

The power density should not exceed BCA Volume 2 Section J requirements (e.g. maximum 9 W/m^2 for an office with 320 lx maintenance illuminance).

Colour temperature and colour rendering

Triphosphor T8 lamps have a CRI of about 82 for a high efficiency lamp, which provides excellent colour rendering for normal office work.

T8 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K.

All calculations of total cost of ownership are carried out utilising the method shown on page 7 under the heading 'Calculations'. This calculation platform is the same one used within the lighting calculator, **Calculight**, which can be used for project specific total cost of ownership by visiting the OEH website (**www.environment.nsw.gov.au**) and searching for Calculight.

In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

Triphosphor T8 lamps have a rated life of about 16,000 hours when used with electronic ballasts. Typical practice for bulk re-lamping is replacement after 80 per cent of rated life, which corresponds to about 12,800 hours. Re-lamping involves the replacement of all lamps at once, even if some lamps are still functional. This reduces maintenance costs associated with ad hoc replacement. For a typical commercial office with 2600 hours of operation per year, replacement would be at five year intervals.

The high efficiency reflector is a key element in achieving the required light output. Therefore it is important that the manufacturer's maintenance requirements are adopted by the end user.

This upgrade is not recommended for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment. T8 lamps with a longer life span are available to extend the replacement interval.

The number of lamps will be halved with this upgrade, thus reducing the lamp replacement cost. However, when a lamp fails, the whole luminaire fails, increasing the urgency of replacement.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from improved colour rendering when replacing old halophosphor lamps. Careful design could increase the illuminance on walls and partitions, which would also enhance the ambience of the office and potentially increase staff satisfaction.

Potential drawbacks

Upgrading with this option could:

- lower illuminance
- increase risk of failure as failure of the single lamp will make the whole luminaire inoperative
- require additional compliance checks as the modified luminaire must comply with all standards as though it were a new luminaire.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
14,040	2808	223	261	3292	12,000	3.65	14.8	148

Calculations

Calculations are based on 100 luminaires, where lamp replacement cost is $5 per lamp.
Power before upgrade = 2 x (36 W + 9 W) x 100 luminaires x 1/1000 = 9.00 kW
Power after upgrade = 36 W x 100 luminaires x 1/1000 = 3.60 kW
Energy saving = (9 – 3.60) kW x 2600 hr x 1/1000= 14.04 MWh
Energy cost saving = 14.04 MWh x $0.20 x 1000 = $2808
Maintenance lamp saving = before ($5 x 2600/8000 h x 200 lamps = $325) – after ($5 x 2600/12,800 hr x 100 lamps = $102 p.a.) = $223
Maintenance labour savings = before (5 min/60 x 2600/8000 X $70/hr x 200 lamps = $379 p.a.) – after (5 min/60 x 2600/12,800 x $70/hr x 100 lamps = $118 p.a.) = $261
Total cost savings = $2808 + $223 + $261 = $3292 p.a.
Pay back period = $12,000/$3292 = 3.65 years
GHG reduction = 14 MWh x 1.06 tCO_2/MWh = 14.80 tCO_2
No. of ESC using commercial lighting energy savings formula (allows savings to be brought forward for 10 years) = 148

Technical specifications

Safety	The luminaire lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1: 2002 Lamp control/gear – General and safety requirements* ▪ *IEC 61347-2-13 Edition 1.0 Lamp control/gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	At least 15,000 hours at 50% failure.
Warranty	5 years minimum
Lamp	Luminous flux: minimum of 3250 lm. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 82 minimum.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 2:
New twin 28 W T5 linear fluorescent luminaire

Recommendation

OPTIONS 2, 3 and 6 are the preferred options for upgrading fluorescent twin 36 W troffers. These upgrades will provide brand new, fully compliant, luminaires that should deliver good energy reductions. These are low risk options and minimal design verification is required.

This upgrade is applicable to most offices with standard recessed troffers.

The luminaires can only be used where a standard metric T-bar ceiling system is in place and air handling is not required as an integral element of the luminaire. Air handling and non-standard ceiling tile versions are available, but are generally costly. Option 1 (p. 5) can be a very cost efficient method of dealing with these ceiling types.

Illuminance, uniformity and glare

The 2 x 28 W T5 luminaire will provide a similar maintenance illuminance and uniformity to the existing luminaires, by direct replacement in the existing luminaires' locations. The design of the luminaire should ensure that glare is within recommended limits.

Relocating new luminaires to suit office workstation layouts may improve lighting quality by directing light where it is needed.

The lamps should meet the requirements of the technical specification provided below. Avoid unbranded lamps, as a number of poor quality T5 lamp products have been found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Figure 1: Twin T5 in fixtures with louvres

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp, which provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

This upgrade ensures that new components are used, minimising the risk of ongoing maintenance that can be encountered with retrofit options.

Typical practice for bulk re-lamping is replacement after 80 per cent of rated life, which corresponds to about 12,800 hours. Replacement would occur every five years for a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning louvres and lamps to ensure lighting characteristics are maintained.

The electronic ballasts typically have an operating life of 50,000 hours. Therefore these luminaires will need major maintenance or replacement after 19 years of operation (based on the operating hours assumed here).

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering if old halophosphor lamps are replaced. In addition, the light levels will almost certainly match or improve upon the existing light levels. Careful design could increase the illuminance on walls and partitions, which would also enhance the office's ambience and potentially increase staff satisfaction.

Glare control in modern luminaires is also greatly improved and these will almost certainly provide a more subtle lighting effect.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

The energy savings are relatively low compared with single lamp upgrades.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
7800	1560	20	142	1722	8500	4.9	8.3	82.6

Technical specifications

Safety	The entire luminaire would be specified to meet current safety standards and so this option eliminates any risk in regard to compliance. The luminaire, lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable)
Rated lamp life	15,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: minimum of 2600 lm. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: minimum of 82.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 3:
New complete single 28 W T5 linear fluorescent luminaire

Figure 2: A T8 lamp compared with a T5 Lamp

The upgrade is applicable to most offices with standard recessed troffers.

The luminaires can only be used where a standard metric T-bar ceiling system is in place, and air handling is not needed by the luminaire. Air handling and non-standard ceiling tile versions are available, but are generally costly. Option 1 (p. 5) can be a very cost efficient method of dealing with these types of ceilings.

Illuminance, uniformity and glare

The 1 x 28 W T5 luminaire has a significantly lower lumen output than the existing luminaires. This means that it will not always provide the required illuminance in all situations. However, it can deliver good outcomes in most situations. The design of the luminaire should ensure that glare is within recommended limits.

Relocating new luminaires to suit office workstation layout may improve lighting quality by directing light where it is needed.

The lamp should meet the requirements of the technical specification provided below. Avoid unbranded lamps, as a number of poor quality T5 lamps have been found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets AS/NZS 1680 recommendations.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp. This provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

This upgrade ensures that new components are used, minimising the risk of ongoing maintenance requirements that can be encountered with retrofit options.

Typical practice for bulk re-lamping is replacement after 80 per cent of rated life, which corresponds to about 12,800 hours. Replacement would occur at five year intervals in a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's recommended cleaning methodology for louvres and lamps to maintain lighting characteristics.

The electronic ballast typically has an operating life of 50,000 hours. Therefore these luminaires will require major maintenance or replacement after 19 years of operation (based on assumed operating hours).

Maintenance budgets should include a replacement value for these new luminaires at end of their life.

This upgrade is not recommended for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment. T5 lamps with a longer life span can be used to extend the replacement interval.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering if old halophosphor lamps are replaced. Careful design could increase illuminance on walls and partitions, which would also enhance the office's ambience and potentially increase staff satisfaction.

Glare control in modern luminaires is also greatly improved and will almost certainly provide a more subtle lighting effect.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

This option can yield the shortest pay back period with the highest energy savings.

Potential drawbacks

Regular maintenance scheduling of light re-lamping is essential as light levels will be very close to the minimum acceptable.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
15,600	3120	172	260	3552	13,000	3.7	16.5	165

Technical specifications

Safety	The entire luminaire would be specified to meet current safety standards and so this upgrade eliminates any risk in regard to compliance. The luminaire lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable)
Rated lamp life	Minimum of 15,000 hours for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: 2,600 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 82 minimum.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 4:
Linear LED lamps, 2 x 19 W

The upgrade uses existing luminaires and components. If the condition of the existing luminaires is poor and they are not likely to remain serviceable for the accepted life of the upgrade, Options 6, 2 and 3 would be more appropriate.

This option is an excellent solution where access is limited or difficult.

Figure 3: LED strip 24 W lamp

Figure 4: LED strip 24 W lamp with starter replacement

Illuminance, uniformity and glare

Care must be taken when applying this option due to differences in the way that the light leaves the light source and interacts with the luminaire.

Relocating luminaires to suit the office workstation layout may improve lighting quality by directing light where it is needed.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

The power density should not exceed the BCA Volume 2 Section J requirement i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

LED lighting delivers white light in much the same way as fluorescent lights. The primary difference is that LED lamps deliver a greater light level in higher colour temperatures (e.g. cooler colours such as cool white and daylight, and lower levels at warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

As with fluorescent lamps, the LED lamps have a good CRI (typically above 80), which provides excellent colour rendering for normal office work.

LED lamps are also available in a range of colour temperatures like fluorescent lamps. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

Some reputable manufacturers offer lamps with life ratings between 30,000 and 50,000 hours as well as L70, which relates to a long operating life of between 11 and 19 years. This will significantly reduce maintenance costs.

This option re-uses lamp holders and cables so it is important that all luminaires are checked at time of upgrade to ensure that their components are in good condition.

Maintenance budgets should include a replacement value for luminaires at the end of the new lamp's life.

This upgrade could be valuable for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on walls and partitions, which would also enhance the office ambience and potentially increase staff satisfaction.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

There is significant variation between available products. This means that care must be taken to ensure that the correct solution is selected. Verify that all areas of light quality and quantity are addressed in the design.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
13,520	2704	325	379	3,408	13,000	3.81	14.3	143

Technical specifications

Safety	The lamp, and where applicable the altered luminaire, shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* (where applicable) ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* (where applicable) ▪ AS/NZS 60598. The product must be constructed in such a way that the pins at either end cannot become live.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable). This compliance must be demonstrated for the completed luminaire after the changes have been made.
Rated lamp life	30,000 hours to L70 minimum.
Warranty	5 years minimum.
Lamp	Luminous flux: 1400 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 80 minimum.
Photometric performance	LM79 IES file for entire luminaire and lamp combination prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 5:
T8 to 28 W T5 conversion kit

This upgrade uses the existing luminaires and components. If the condition of existing luminaires is poor and they are not likely to remain serviceable for the accepted life of the upgrade, then Options 2 and 3 would be more appropriate.

Illuminance, uniformity and glare

In most cases, the luminaire will respond well to the new (thinner) T5 lamp. In some cases, glare control can become an issue due to the lower surface area of the T5 tube.

Relocation of the luminaires to suit the office workstation layout may improve lighting quality by directing light where it is needed.

The lamps should meet the requirements of the technical specification. Avoid unbranded lamps, as a number of poor quality T5 lamp products have recently been found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations in AS/NZS 1680.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp, which provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually the cool white colour, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

The typical practice for bulk re-lamping is replacement after 80 per cent of rated life, which corresponds to about 12,800 hours. Replacement would occur at five year intervals in a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning louvres and lamps to ensure lighting characteristics are maintained.

The electronic ballast typically has an operating life of 50,000 hours. Therefore, these luminaires will require major maintenance or replacement after 19 years of operation (based on assumed operating hours).

This upgrade is not recommended for inaccessible locations (e.g. stairways) where the cost of replacement is high due to the need for special equipment. T5 lamps with a longer life span are available to extend the replacement interval.

This option re-uses lamp holders and cables, so it is important that all luminaires are checked at time of upgrade to ensure that the components are in good condition.

Maintenance budgets should include a replacement value for the altered luminaires at end of life.

Figure 5: A T5 lamp with an adapter kit (left) compared with a T8 lamp (right)

Figure 6: T5 with high efficiency reflector

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on walls and partitions, which would also enhance the ambience of the office and potentially increase staff satisfaction.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

A large number of products of varying quality and compliance are available on the market. To assess product quality, ensure that the supplier can demonstrate the compliance of the components. The supplier should also be prepared to provide certification stating that the complete luminaire is compliant after the upgrade has taken place.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
7800	1560	20	142	1722	8000	4.6	8.3	82

Technical specifications

Safety	The luminaire lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable). This compliance must be demonstrated for the completed luminaire after the changes have been made.
Rated lamp life	16,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: 2600 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 82 minimum.
Photometric performance	IES file for entire luminaire and lamp combination prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 6:
New 30 W integrated LED luminaire

The upgrade is applicable to most offices with standard recessed troffers.

The luminaires can only be used where a standard metric T-bar ceiling system is in place, and air handling is not needed by the luminaire. Air handling and non-standard ceiling tile versions are available, but are generally costly. Option 1 (p. 5) can be a very cost efficient method of dealing with these types of ceilings.

Figure 7: 30 W integrated LED luminaires

Illuminance, uniformity and glare

The 30 W LED luminaire has a significantly lower lumen output than the existing luminaires. This means that it will not always provide the required illuminance in all situations. However, it can deliver good outcomes in most situations. The design of the luminaire should ensure that glare is within recommended limits.

Relocating new luminaires to suit office workstation layout may improve lighting quality by directing light where it is needed.

The luminaire should meet the requirements of the technical specification provided below. Avoid luminaires that are not supplied with a photometric file prepared in the Illuminating Engineering Society of North America (IESNA) LM79 format. This is an approved product testing methodology.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets AS/NZS 1680 recommendations.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

As with fluorescent lamps, LED light sources have a good CRI (typically above 80), which provides excellent colour rendering for normal office work.

The primary difference is that LED lamps deliver a greater light level in higher colour temperatures compared to fluorescent lights (e.g. cooler colours such as cool white and daylight have higher colour temperatures compared to a warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

Some reputable manufacturers offer luminaires with life ratings between 30,000 and 50,000 hours to 70 per cent of initial output (or L70), which relates to a long operating life of between 11 and 19 years. This will significantly reduce maintenance costs.

Control gear body and lamp are integrated and therefore the entire luminaire will require replacement at end of life. Maintenance budgets should include a replacement value for luminaires at end of life.

This upgrade could be valuable for inaccessible locations (e.g. over stairways), where the cost of replacement is high.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable version is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on walls and partitions, which would also enhance the office ambience and potentially increase staff satisfaction.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

There is significant variation between available products. Many of the options offered will have difficulty meeting the unified glare rating (UGR) requirements for office lighting and screen based tasks. This means that care must be taken to ensure that the correct solution is selected. Verify that all areas of light quality and quantity are addressed in the design.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
15,600	3,120	325	379	3,824	9,000	2.35	16.5	165

Technical specifications

Safety	The luminaire shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	30,000 hours to L70 minimum.
Warranty	5 years minimum.
Lamp	Luminous flux: 2500 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required CRI: 80 minimum.
Photometric performance	LM79 IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTIONS FOR UPGRADING Twin 36 W T8 surface mounted linear fluorescent luminaires

OPTION 1:
New 43 Watt LED luminaire, Integrated LED module and power supply, fitted with diffuser

Recommendation

OPTIONS 1 and 3 are the preferred options for upgrading surface mount twin 36 W fluorescent luminaires. These upgrades will provide brand new, fully compliant luminaires that should deliver good energy reductions. These are low risk options and minimal design verification is required.

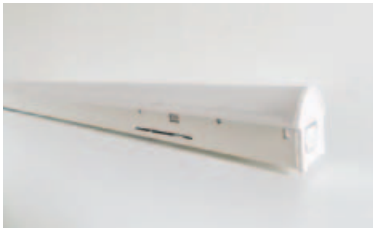

Figure 8: 43 Watt LED luminaire, Integrated LED module

This option entirely replaces the existing luminaire. It is however slightly narrower and this thinner housing may lead to painting or ceiling rectification works.

Illuminance, uniformity and glare

This option has different light distribution characteristics to the existing. The light level will probably be slightly lower than the existing. Also, and the opal diffuser has less surface area than that of the existing luminaire. Combined with the high light output of the LED array, this option may cause glare. In most applications this will not be a problem this solution is unlikely to be appropriate for office areas where screen based tasks are carried out.

Recommended illuminance levels, uniformity and glare control covered under AS/NZS 1680 must be met. This should not pose a problem, but this must be proven at the design stage by using industry standard lighting design software.

Where slightly lower illuminance levels result from this upgrade, task lighting could be used.

Illuminance measurements should be made before the upgrade to establish the existing illuminance, and then after the upgrade, to demonstrate that the illuminance meets AS/NZS 1680 recommendations.

The power density should not exceed BCA Volume 2 Section J requirements (e.g. maximum 9 W/m2 for an office with 320 lx maintenance illuminance).

Colour temperature and colour rendering

LED lighting delivers white light in much the same way as fluorescent lights. The primary difference is that LED's deliver a greater light level in higher colour temperatures (e.g. cooler colours such as cool white and daylight, and lower levels at warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

As with fluorescent lamps, LED's have a good CRI (typically above 80), which provides excellent colour rendering for most applications. We do not recommend the use of any discharge lamps where colour matching is carried out.

LED's are also available in a range of colour temperatures like fluorescent lamps. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

Luminaires should be able to deliver at least 50,000 hours of operation to L70, which relates to a long operating life of 19 years in our scenario of 50 hours operation per week. This will significantly reduce maintenance costs.

This upgrade could be valuable for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable version is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on vertical surfaces, which would enhance the ambience and potentially increase user satisfaction.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

There is significant variation between available products. This means that care must be taken to ensure that the correct solution is selected. Verify that all areas of light quality and quantity are addressed in the design.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
12,220	4680	325	379	704	15,500	2.9	12.9	129

Technical specifications

Safety	No specific safety issues are generated by this upgrade. The luminaire shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	The luminaire shall comply with ACMA requirements and be C-tick labelled for compliance with AS/NZS CISPR 15.
Rated lamp life	At least 50,000 hours at 70% of initial light output. Manufacturer to supply sufficient documentation to verify the claim.
Warranty	5 years minimum for luminaire.
Lamp	Luminous flux should be sufficient to be a viable substitution for the existing lamp.
Photometric performance	IES file prepared by NATA-registered laboratory preferably to IESNA LM79. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity to comply with AS/NZS 1680 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

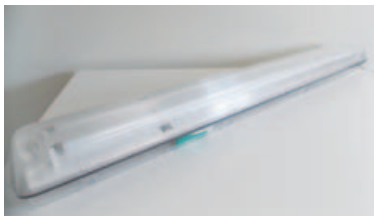

Figure 9: Twin 28 W T5 linear fluorescent luminaire

OPTION 2:
New twin 28 W T5 linear fluorescent luminaire

This option entirely replaces the existing luminaire. It is however a slightly different size and shape which may lead to painting or ceiling rectification works.

Illuminance, uniformity and glare

The 2 x 28 W T5 luminaire will provide a similar maintenance illuminance and uniformity to the existing luminaires, by direct replacement in the existing luminaires' locations. Bare tube versions are likely to deliver an increase in glare. The design of diffused versions should manage glare so that it is not significantly worse than that of the existing.

The lamps should meet the requirements of the technical specification provided below. Avoid unbranded lamps, as a number of poor quality T5 lamp products have been recently found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp, which provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

This upgrade ensures that new components are used, minimising the risk of ongoing maintenance that can be encountered with retrofit options.

Typical practice for bulk re-lamping is replacement after 80% of rated life, which corresponds to about 12,800 hours. Replacement would occur every five years for a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning to ensure lighting characteristics are maintained.

The electronic ballasts typically have an operating life of 50,000 hours. Therefore these luminaires will need major maintenance or replacement after 19 years of operation (based on the operating hours assumed here).

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.

The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering if old halophosphor lamps are replaced. In addition, the light levels will almost certainly match or improve upon the existing light levels. Careful design could increase the illuminance on vertical surfaces, which would also enhance the ambience and potentially increase user satisfaction.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

The energy savings are relatively low compared with single lamp upgrades.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
7800	1560	20	142	1722	8500	4.9	8.3	82.6

Technical specifications

Safety	The entire luminaire would be specified to meet current safety standards and so this option eliminates any risk in regard to compliance. The luminaire, lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	The ballast shall comply with ACMA C-tick requirements. The completed luminaire shall comply with AS/NZS CISPR 15.
Rated lamp life	15,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: minimum of 2600 lm. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: minimum of 82.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C
Power factor	Greater than 0.90.

OPTION 3:
New complete single 28 W T5 linear fluorescent luminaire

Figure 10: Single 28 W T5 linear fluorescent luminaire

This option entirely replaces the existing luminaire. It is however a slightly different size and shape which may lead to painting or ceiling rectification works.

Illuminance, uniformity and glare

The 1 x 28 W T5 luminaire has a significantly lower lumen output than the existing luminaires. This means that it will not always provide the required illuminance in all situations. However, it can deliver good outcomes in most situations.

Bare tube versions are likely to deliver an increase in glare. The design of diffused versions should manage glare so that it is not significantly worse than that of the existing.

The lamp should meet the requirements of the technical specification provided below. Avoid unbranded lamps, as a number of poor quality T5 lamps have been recently found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets AS/NZS 1680 recommendations.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m^2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp. This provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

This upgrade ensures that new components are used, minimising the risk of ongoing maintenance requirements that can be encountered with retrofit options.

Typical practice for bulk re-lamping is replacement after 80% of rated life, which corresponds to about 12,800 hours. Replacement would occur at five year intervals in a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's recommended cleaning methodology to maintain lighting characteristics.

The electronic ballast typically has an operating life of 50,000 hours. Therefore these luminaires will require major maintenance or replacement after 19 years of operation (based on assumed operating hours).

Maintenance budgets should include a replacement value for these new luminaires at end of their life.

This upgrade is not recommended for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment. T5 lamps with a longer life span can be used to extend the replacement interval.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.

The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering if old halophosphor lamps are replaced. Careful design could increase illuminance on vertical sutfaces, which would also enhance the ambience and potentially increase user satisfaction.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

This option can yield the shortest pay back period with the highest energy savings.

Potential drawbacks

Regular maintenance scheduling of light re-lamping is essential as light levels will be very close to the minimum acceptable.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
15,600	3120	172	260	3552	13,000	3.7	16.5	165

Technical specifications

Safety	The entire luminaire would be specified to meet current safety standards and so this upgrade eliminates any risk in regard to compliance. The luminaire lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	The ballast shall comply with ACMA C-tick requirements. The completed luminaire shall comply with AS/NZS CISPR 15.
Rated lamp life	15,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: minimum of 2600 lm. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: minimum of 82.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C
Power factor	Greater than 0.90.

OPTION 4:
Linear LED lamps, 2 x 19 W

The upgrade uses existing luminaires and components. If the condition of the existing luminaires is poor and they are not likely to remain serviceable for the accepted life of the upgrade, Options 1, 2 and 3 would be more appropriate.

This option is an excellent solution where access is limited or difficult.

Illuminance, uniformity and glare

Care must be taken when applying this option due to differences in the way that the light leaves the light source and interacts with the luminaire.

Relocating luminaires to suit the office workstation layout may improve lighting quality by directing light where it is needed.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

The power density should not exceed the BCA Volume 2 Section J requirement i.e. maximum of 9 W/m2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

LED lighting delivers white light in much the same way as fluorescent lights. The primary difference is that LED lamps deliver a greater light level in higher colour temperatures (e.g. cooler colours such as cool white and daylight, and lower levels at warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

As with fluorescent lamps, the LED lamps have a good CRI (typically above 80), which provides excellent colour rendering for normal office work.

LED lamps are also available in a range of colour temperatures like fluorescent lamps. In temperate climates, office lighting is usually cool white, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience, and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

Some reputable manufacturers offer lamps with life ratings between 30,000 and 50,000 hours as well as L70, which relates to a long operating life of between 11 and 19 years. This will significantly reduce maintenance costs.

This option re-uses lamp holders and cables so it is important that all luminaires are checked at time of upgrade to ensure that their components are in good condition.

Maintenance budgets should include a replacement value for luminaires at the end of the new lamp's life.

This upgrade could be valuable for inaccessible locations (e.g. over stairways), where the cost of replacement is high due to the need for special equipment.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Figure 11: LED strip 24 W lamp

Figure 12: 20 W LED tube. These are not recommended. Exposed LED lamps can create glare.

Figure 13: A LED strip 24 W lamp with starter replacement

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on walls and partitions, which would also enhance the office ambience and potentially increase staff satisfaction.

The longer lamp life should also minimise disruption due to longer maintenance intervals.

Potential drawbacks

There is significant variation between available products. This means that care must be taken to ensure that the correct solution is selected. Verify that all areas of light quality and quantity are addressed in the design.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
13,520	2704	325	379	3408	12,000	3.5	14.3	143

Technical specifications

Safety	The lamp, and where applicable the altered luminaire, shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements (where applicable)* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements (where applicable)* ▪ AS/NZS 60598. The product must be constructed in such a way that the pins at either end cannot become live.
Electromagnetic compatibility	The luminaire shall comply with ACMA requirements and be C-tick labelled for compliance with AS/NZS CISPR 15.
Rated lamp life	30,000 hours to L70 minimum.
Warranty	5 years minimum.
Lamp	Luminous flux: 1400 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 80 minimum.
Photometric performance	IES file for entire luminaire and lamp combination prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 5:
T8 to 28 W T5 conversion kit

This upgrade uses the existing luminaires and components. If the condition of existing luminaires is poor and they are not likely to remain serviceable for the accepted life of the upgrade, then Options 2 and 3 would be more appropriate.

Illuminance, uniformity and glare

In most cases, the luminaire will respond well to the new (thinner) T5 lamp. In some cases, glare control can become an issue due to the lower surface area of the T5 tube.

Relocation of the luminaires to suit the office workstation layout may improve lighting quality by directing light where it is needed.

The lamps should meet the requirements of the technical specification. Avoid unbranded lamps, as a number of poor quality T5 lamp products have recently been found in the market.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations in AS/NZS 1680.

The power density should not exceed BCA Volume 2 Section J requirement, i.e. maximum of 9 W/m2 for an office with 320 lx maintenance illuminance.

Colour temperature and colour rendering

Triphosphor T5 lamps have a good CRI (about 82) for a high efficiency lamp, which provides excellent colour rendering for normal office work.

T5 triphosphor lamps are available in a range of colour temperatures. In temperate climates, office lighting is usually the cool white colour, corresponding to a colour temperature of 4000 K. In the tropics, a colour temperature of 5000 K (daylight) provides a cooler ambience and in cold climates 3000 K (warm white) provides a warmer ambience.

Maintenance

The typical practice for bulk re-lamping is replacement after 80% of rated life, which corresponds to about 12,800 hours. Replacement would occur at five year intervals in a typical commercial office with 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning louvres and lamps to ensure lighting characteristics are maintained.

The electronic ballast typically has an operating life of 50,000 hours. Therefore, these luminaires will require major maintenance or replacement after 19 years of operation (based on assumed operating hours).

This upgrade is not recommended for inaccessible locations (e.g. stairways) where the cost of replacement is high due to the need for special equipment. T5 lamps with a longer life span are available to extend the replacement interval.

This option re-uses lamp holders and cables, so it is important that all luminaires are checked at time of upgrade to ensure that the components are in good condition.

Maintenance budgets should include a replacement value for the altered luminaires at end of life.

Figure 14: A T5 lamp with an adapter kit (left) compared with a T8 lamp (right)

Figure 15: A replacement T5 lamp with an integral reflector and ballast

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A more pleasant ambience should result from better colour rendering when old halophosphor lamps are replaced. Careful design could increase illumination on walls and partitions, which would also enhance the ambience of the office and potentially increase staff satisfaction.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

A large number of products of varying quality and compliance are available on the market. To assess product quality, ensure that the supplier can demonstrate the compliance of the components. The supplier should also be prepared to provide certification stating that the complete luminaire is compliant after the upgrade has taken place.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
7800	1560	20	142	1722	8000	4.6	8.3	82

Technical specifications

Safety	The luminaire lamp and electronic ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	The luminaire shall comply with ACMA requirements and be C-tick labelled for compliance with AS/NZS CISPR 15.
Rated lamp life	16,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: 2600 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: 82 minimum.
Photometric performance	IPhotometric performance IES file for entire luminaire and lamp combination prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTIONS FOR UPGRADING 50 W MR16 low voltage dichroic halogen lamps

OPTION 1:
35 W infra-red coating (IRC) halogen lamp with or without an electronic transformer

The upgrade is applicable to all applications currently utilising MR16 dichroic halogen lamps.

Illuminance, uniformity and glare

All light characteristics of the existing system will be essentially unaffected by this upgrade.

Consider the impact of these changes on areas covered under BCA Volume 2 Section J requirements to ensure that the new design is fully compliant.

Colour temperature and colour rendering

This upgrade will retain the colour temperature and colour rendering (CRI 100) that can be expected with existing halogen light sources.

Figure 16: Low voltage halogen transformer – electronic

Maintenance

The existing lamps are often generic, budget lamps, with a rated life of 2000 hours, based on the 50 per cent failure method. Many other lamps, including IRC lamps, would last much longer in this 'typical' environment, with some offering 5,000 hours.

It is recommended to choose manufacturers who document a long operating lamp life.

Most electronic transformers have a rated life of 50,000 hours, which equates to more than 19 years, based on our assumed usage. As a result, lamp replacement will be limited to occasional failures and global changes will not be required until well beyond the typical luminaire operating life.

When replacing lamps, it is prudent to inspect the existing transformer, lamp holder and fly lead, to make sure they are in good, serviceable condition.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a dimmable electronic transformer is in circuit. Appropriately matched dimmers must be used.
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

This method will not create much, if any, visual change to the lit environment. There is an opportunity with this upgrade to adjust the light direction and enhance the lighting effect.

Potential drawbacks

There are no significant drawbacks or potential pitfalls with this upgrade, although other options may increase energy savings.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
Energy savings and financial return per 100 luminaires without electronic transformers								
5200	1040	156	455	1651	1200	0.7	5.5	55
Energy savings and financial return per 100 luminaires with electronic transformers								
7020	1404	156	455	2015	3200	1.59	7.4	74

Technical specifications

Safety	The replacement of the lamp should not generate any safety issues, but all aspects of the existing system should be in good serviceable condition. The electronic transformer should be compliant with the appropriate standards and will be marked accordingly. The luminaire, lamp and electronic transformer shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	The transformer shall be supplied with ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	4000 hours minimum, for 50% failures.
Warranty	Transformer: 3 years minimum.
Lamp	Luminous flux: 750 lm minimum.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Ballast	Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347, IEC 55015, IEC 61000 and IEC 61547.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

Figure 17: LED lamps, fixtures and fittings

OPTION 2:
7 W LED retro fit replacement lamp

This upgrade will work in all luminaires except those that manage glare control for MR16 lamps. These luminaires are typically designed with a small aperture in front of the lamp or utilise a reflector and set the lamp back. Care must be taken to ensure that the lamp is designed to operate with the existing transformer and or dimmer combination. This technology cannot deliver the same light as the existing lamp in this wattage and so care must be taken to ensure appropriate light levels are achieved.

Illuminance, uniformity and glare

The lamp is packaged in a similar physical shape to the existing MR16 lamp, but they differ in how the light is delivered into the space. This leads to a variety of different light effects. Very few of the replacement lamps will produce a light beam that completely replicates the illumination or uniformity of the existing lamp. However, many of these lamps can be used to deliver a satisfactory outcome.

The existing lamp can be a source of glare. MR 16 lamps produce a beam with a 'crossover' that allows glare control luminaires to only allow the controlled beam of light to enter the space.

It is likely that the new LED lamp will cause as much glare, but not more than, the existing installation.

If the lamp is set back in the existing luminaire or it uses a small aperture over the front of the lamp, then an IRC lamp would provide a better solution.

Consider the impact of these changes on areas covered under BCA Volume 2 Section J requirements, to ensure that the new design is fully compliant.

Colour temperature and colour rendering

LED lamps are usually available in a variety of colour temperatures. As LED lamps produce 'white' light, those with cooler colour temperatures generally produce more light. Therefore many manufacturers produce lamps of very cold colour temperature to ensure that as much light is produced as possible, however in most situations, very cool coloured light will not be appropriate.

Choose the same colour temperature lamps as the existing halogen light sources (generally about 3000 K).

The existing lamp has a CRI of 100, while most LED lamps have a CRI between 75 and 85. This means that colour rendering will not be as accurate after upgrading with LED lamps. The colour rendering of LED lamps is quite similar to that of fluorescent lamps, so this lower CRI will not be a problem in most cases.

If colour rendering is important in the existing system, then IRC lamps are recommended (covered in Option 1, p. 32).

Maintenance

These lamps should be easy to maintain as they are a straight retrofit.

Select a quality product, from a supplier who can deliver evidence to substantiate lamp life claims.

Heat control is a balancing act in LED lamps. LED lamps do not generate a lot of heat, but the heat that they do generate will destroy them if it is not handled correctly. The shape and dimension of standard MR16 lamps is not appropriate for removing this heat. Therefore, LED lamps of MR16 dimensions will probably not last the 50,000 hours at 70 per cent of initial light output that is expected.

Many manufacturers offer MR16 replacement lamps that contain LED and claim that these deliver the same output as a 50 W halogen lamp. Manufacturers should

provide evidence of the testing used to establish the output and the operating life of their products.

Visually inspect the existing transformer, lamp holder and fly lead to ensure that they are in good serviceable condition when replacing lamps.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire:

- will not be dimmable unless a compatible dimmable electronic transformer is in circuit
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

A well-chosen product will create minimal visual change to the lit environment.

There is an opportunity with this upgrade to adjust light direction and enhance the lighting effect where possible.

Potential drawbacks

There is a significant risk that the product purchased will not deliver the light output, distribution or life that is promised, as there is a wide variety of products that could be used. It is also quite possible that the product will not be compatible with the existing transformer and dimming combinations on site. Setting up a trial area prior to full-scale commitment would be a valuable exercise.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
14,040	2808	624	720	4152	3,400	0.8	14.8	148

Technical specifications – 7 W LED lamp

Safety	The lamp contains power management equipment converting 12 V AC to DC, and therefore should comply with all standards applicable to devices of this kind. No specific safety issues are generated by this upgrade. The reduction in heat output over the existing luminaire will almost totally remove the fire risk typically associated with halogen lamps. The lamp shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable). This compliance must be demonstrated for the completed luminaire after the changes have been made.
Rated lamp life	At least 25,000 hours at 70% of initial light output. Manufacturer to supply sufficient documentation to verify the claim.
Lamp	Actual produced light must be sufficient to make a viable substitution for the existing lamp.
Warranty	3 years minimum for lamp.
Photometric performance	IESNA LM79 file prepared by NATA-registered laboratory. Maintenance illuminance on working plane: in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Transformer	Ensure compatibility between existing transformer and lamp.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 3:
New 16 W LED luminaire

This upgrade will be applicable in any areas that currently use MR16 lamps. These lamps have a very long life and are also appropriate for applications where access is limited or difficult.

Illuminance, uniformity and glare

Luminaires designed to support the characteristics of LED light sources will be better able to replace the existing system. Most of the products for sale more closely represent the existing MR16 system.

Luminaires of this type can produce glare. When applying this option to areas where glare may be an issue care should be taken in the selection of an appropriate product.

Consider the impact of the upgrade on areas covered under BCA Volume 2 Section J requirements, to ensure that the new design is fully compliant.

Colour temperature and colour rendering

LED lamps are usually available in a variety of colour temperatures. As LED lamps produce 'white' light, those with cooler colour temperatures generally produce more light. Therefore many manufacturers produce lamps of very cold colour temperature to ensure that as much light is produced as possible. However, in most situations, very cool coloured light will not be appropriate.

Choose the same colour temperature LED lamps as the existing halogen light sources (generally about 3000 K). The existing lamp has a CRI of 100, while most LED lamps have a CRI between 75 and 85. This means that colour rendering will not be as accurate after upgrading with LED lamps.

Use IRC lamps if colour rendering is important in the existing system (covered in Option 1, p. 32).

Maintenance

Luminaire maintenance should be restricted to total failures, which are quite rare in quality luminaires.

There is no regular maintenance required, based on the current scenario of a luminaire operating for more than 19 years. This means that the luminaires will operate maintenance-free for longer than a typical commercial fit out.

Purchase a few extra luminaires as 'spares', as these products are rapidly developing and regularly being upgraded. In the event that failures occur early in the luminaire's life, replacements should be available. However, the product might not be available in ten years and having spares on hand may mitigate risk.

Select a quality product from a supplier who can provide evidence to back up lamp life span claims.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- Can only be dimmed if a dimmable power supply is specified. Ensure that the dimming power supply and dimmer are compatible.
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Recommendation

OPTION 3 is the preferred option for this section. This will deliver excellent energy reductions whilst providing brand new, fully compliant luminaires. Minimal lighting design verification is required with this option and there is minimal risk in its selection and implementation. Using good quality products is an essential element of minimising risk.

Staff satisfaction and productivity benefits

A well-chosen product will create minimal visual change to the lit environment.

There is an opportunity with this upgrade to adjust light direction and enhance the lighting effect where possible.

Potential drawbacks

This option has a slightly longer pay back period and does not reduce GHG emissions by as much as Option 2 (p. 34). This is balanced against a greater likelihood of comparable lighting effects and a longer operating life.

There is a significant risk that the product purchased will not deliver the light output, distribution or life that is promised, as there is a wide variety of lamp options that vary in quality.

It is also quite possible that the product will not be compatible with the existing dimming system.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
12,740	2548	780	758	4086	8000	2	13.5	Refer to key issues

Technical specifications

Safety	No specific safety issues are generated by this upgrade. The reduction in heat output with this upgrade will almost totally remove the fire risk typically associated with halogen lamps. The luminaire and power supply shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	At least 50,000 hours at 70% of initial light output. Manufacturer to supply sufficient documentation to verify the claim.
Lamp	Luminous flux should be sufficient to be a viable substitution for the existing lamp.
Warranty	5 years minimum for luminaire.
Photometric performance	IES file prepared by NATA-registered laboratory to IESNA LM79. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity to comply with AS/NZS 1680 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 4:
15 W compact fluorescent lamp and lampholder

This upgrade is applicable to most luminaires but the lampholder must be replaced and the new lamp, which has slightly different dimensions, must fit the existing luminaire.

This option is only applicable where a lower light level is acceptable.

Figure 18: A compact fluorescent GU 10 base halogen replacement lamp

Figure 19: Compact fluorescent replacement lamp in recessed downlight

Illuminance, uniformity and glare

Illuminance will probably be significantly lower than the existing luminaire, but uniformity is usually good as there is little beam control. Glare can be a problem due to the low position of the lamp in the enclosure.

Where verification of compliance is required, a design should be carried out by a competent lighting designer, using industry standard lighting design software.

Consider the impact of this upgrade on areas covered under BCA Volume 2 Section J requirements, to ensure that the new design is fully compliant.

Colour temperature and colour rendering

The fluorescent lamps are available in a variety of colour temperatures. Choose the same colour temperature as the halogen light source (about 3000 K) when replacing them.

The CRI of the existing lamp is 100. Most fluorescent replacement lamps have a CRI greater than 80. This means that colour rendering will not be as accurate, but this will not be a problem in most cases.

IRC lamps are recommended if colour rendering is important in the existing system (covered in Option 1, (p. 32).

Maintenance

Once the lampholder has been replaced, the subsequent lamp changes should be reasonably simple.

Select a quality product, from a supplier who can provide evidence to back up claims of lamp life.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable version is specified. Check that dimmable lamp is compatible with existing dimming.
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

This upgrade is unlikely to deliver any specific benefits.

Potential drawbacks

The potential drawbacks of this option include:

- insufficient light levels
- professional design is essential
- testing the lighting outcomes in a trial area is essential.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
13,000	2600	260	657	3517	5500	1.6	13.8	138

Technical specifications

Safety	The converted luminaire will be a mains voltage device and must comply with all the relevant electrical requirements The lamp and lampholder shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	At least 10,000 hours to 50% failure.
Lamp	Luminous flux should be sufficient to be a viable substitution for the existing lamp.
Warranty	1 year minimum on lamp.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 5:
New 13 W lamp with compact fluorescent luminaire

This upgrade will work most effectively in areas where downlights are fixed and designed to light the horizontal surfaces below.

Illuminance, uniformity and glare

A luminaire specifically designed to support the characteristics of a fluorescent light source will be better able to replace the existing system.

Most of the products available more closely represent the existing MR16 system when used with wide beam lamps, as is typical.

A design should be produced by a lighting designer using industry standard lighting design software where verification of compliance is required.

Luminaires of this type can produce glare. The way in which a luminaire is designed and the position of the lamp within the luminaire can affect glare significantly. When applying this option to areas where glare may be an issue, care should be taken in the selection of an appropriate product.

Consider the impact of these changes on areas covered under BCA Volume 2 Section J requirements, to make sure that the new design is compliant.

Colour temperature and colour rendering

Fluorescent lamps are available in a variety of colour temperatures. Choose the same colour temperature as the halogen light source (about 3000 K) when upgrading.

The CRI of the existing lamp is 100. Most fluorescent replacement lamps have a CRI greater than 80. Colour rendering will not be as accurate, but this will not generally be a problem.

IRC lamps are recommended if colour rendering is important in the existing system (covered in Option 1, p. 32).

Maintenance

Maintenance is of limited concern due to the long lamp life. Lamp changes will be not required for at least five years, based on the existing scenario. Lamps are reasonably priced and commonly available.

Maintenance costs can be minimised by selecting a quality product.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

Quality compact fluorescent luminaires produce a more even illumination and can enhance the appearance of an area.

Potential drawbacks

This option has a slightly longer pay back period and does not reduce GHG emissions by as much as Option 2. However, this should be balanced against the comfort of using a well-established technology with limited risk.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
13,000	2600	699	663	3962	10,000	2.5	13.8	138

Technical specifications

Safety	No specific safety issues are generated by this upgrade. Heat output is reduced compared to the existing luminaire, which will almost totally remove the fire risk typically associated with halogen lamps. The luminaire and ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.13 Edition 1.0 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	At least 12,000 hours at 50% failure.
Lamp	Luminous flux should be sufficient for the lamp to be a viable substitute when LOR of luminaire is considered.
Warranty	3 years minimum on luminaire.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations to suit the application. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTIONS FOR UPGRADING 400 W mercury vapour luminaires

OPTION 1:
New 250 W metal halide luminaire

This upgrade is applicable to all existing applications. Generally, increases in lamp life will significantly reduce the cost of ownership.

Illuminance, uniformity and glare

This upgrade improves light quality by improving the quality of light colour.

Illuminance, uniformity and glare control remain the same or are improved with this upgrade.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the recommendations of AS/NZS 1680 are met.

Warehouse layouts often change over time, which can result in a lighting grid that does not relate to rack position. Consider rearranging the layout of the luminaires to suit the requirements of the space during the upgrade process. This can significantly improve lighting quality.

Colour temperature and colour rendering

Colour temperature and colour rendering will be significantly improved in this option. The use of 4000–6500 K lamps is typical and effective in this application.

Maintenance

This upgrade uses new components, which minimises the risk of ongoing maintenance that can be encountered with retrofit upgrades.

The typical practice for bulk re-lamping is to replace lamps after 80 per cent of rated life has passed. This corresponds to about 9600 hours. In this scenario, replacement occurs in just under four years, based on 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning reflectors and cover glasses to ensure lighting characteristics are maintained.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The new luminaire should not be operated by movement sensors. High intensity discharge lamps cannot be instantly switched on. They will generally take 60–90 seconds to reach full output and colour when powered and may take as much as ten minutes to restrike if switched off.

Standard metal halide technology is not suitable for daylight linking for the same reason.

Lighting control based energy savings can be achieved with metal halide technology if the luminaire is designed for multilevel switching. If this is the case, then a control system can be designed that uses occupancy sensing and daylight linking. This should be subject to a cost-benefit analysis.

Figure 20: Metal halide lamp

Figure 21: Double-ended quartz metal halide lamp

Figure 22: Single-ended ceramic metal halide lamp

Staff satisfaction and productivity benefits

This upgrade will provide a more pleasant ambience due to better colour rendering.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

There are no significant drawbacks with this upgrade.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
42,120	8424	271	316	9011	20,000	2.22	44.6	446

Technical specifications

Safety	The entire luminaire would meet current safety standards and therefore this upgrade eliminates any risk in regards to compliance. The luminaire, lamp and ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	12,000 hours minimum for 50% failures.
Lamp	Luminous flux: 19,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Warranty	3 years minimum.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance in accordance with AS/NZS 1680 recommendations, unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Ballast	Ballast losses to be no more than 8% of lamp rating. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 2:
New 4 x 54 W fluorescent luminaire

This upgrade is applicable to all existing situations. Longer lamp life generally reduces the cost of ownership significantly.

Illuminance, uniformity and glare

Light quality is improved with this upgrade through improving colour quality.

Illuminance, uniformity and glare control should remain the same or be improved with this upgrade. Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

Warehouse layouts often change over time, which can result in a lighting grid that does not relate to rack position. Consider rearranging the layout of the luminaires to suit the requirements of the space during the upgrade process. This can improve lighting quality significantly.

Colour temperature and colour rendering

Colour temperature and colour rendering will be significantly improved with this upgrade. The use of 4000–6500 K lamps is typical and effective in this application.

Maintenance

This upgrade uses new components, which minimises the risk of ongoing maintenance that can be encountered with retrofit options.

Typical practice for bulk re-lamping involves replacing lamps after 80 per cent of their rated life, which corresponds to about 12,800 hours. In this scenario, lamps would be replaced at just under five years, based on 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning reflectors and diffusers to ensure lighting characteristics are maintained.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

This upgrade will result in a more pleasant ambience due to improved colour rendering. The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

Ensure that the equipment can operate in the on site temperature conditions.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
53,560	10,712	1016	237	11,965	55,000	4.6	56.7	567

Technical specifications

Safety	The entire luminaire would be designed to meet current safety standards and therefore this upgrade eliminates any risk in regard to compliance. The luminaire, lamps and ballasts shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	16,000 hours minimum for 50% failures.
Lamp	Luminous flux: 4700 lm minimum per lamp. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Warranty	3 years minimum.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680 where applicable.
Ballast	EEI Class A2 in accordance with MEPS. EEI to be marked. Rated voltage: 230 V or 220 V/240 V. Ballast lumen factor (BLF) to be declared. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 3:
New 110 W LED luminaire

This upgrade is applicable where performance can be shown to be appropriate for the area. The extremely long lamp life, delivered by quality products, can lead to reduced maintenance costs.

Illuminance, uniformity and glare

Light quality is improved with this upgrade due to improved colour quality.

Illuminance, uniformity and glare control should remain the same or be improved with this upgrade. It is an essential part of this upgrade that professional lighting design is undertaken to ensure that the project needs are met. This upgrade will almost certainly involve specific luminaire placement and will almost certainly not involve a simple one-for-one replacement.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

Colour temperature and colour rendering

LED lighting delivers white light in much the same way as fluorescent lights. The primary difference is that LED lamps deliver a greater light level in higher colour temperatures (e.g. cooler colours such as cool white and daylight, and lower levels at warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

Colour temperature and colour rendering will be significantly improved with this upgrade. The use of 4000–6500 K lamps is typical and effective in this situation.

Maintenance

This option uses new components, which minimises the risk of ongoing maintenance that can be encountered with retrofit options.

Quality LED solutions provide 50,000 hours of operation to 70 per cent of initial output as a baseline for operating life. In this scenario, the 2600 hours of operation per annum would lead to replacement in just more than 19 years and will generally not require any maintenance for that period of time.

However, keeping the luminaire clean will be important and the cost of this should be factored into the cost-benefit analysis. This cost is highly dependent on the specific nature of the site and should be calculated for each site.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable electronic power supply is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

This upgrade will result in a more pleasant ambience due to improved colour rendering.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Recommendation

OPTION 3 is the preferred option for this section. This upgrade delivers excellent energy reduction whilst providing brand new, fully compliant luminaires. Lighting design verification is required. Project payback is very fast and when considered with energy reduction presents the best opportunity.

Figure 23: A high bay LED luminaire complete with in-built LED lamps

Potential drawbacks

- Heat sink design is critical as maintaining LED temperatures within operating limits is a key determining factor of LED longevity.
- Quality varies between the many options.
- Light distribution and beam control characteristics are rarely the same as existing fittings.
- Thermal management of power supplies must be correctly designed.
- Confidence is lacking in stated LED life span unless supported by test results.
- Very high capital expenditure.
- A different luminaire position may be needed, therefore not always a one-for-one swap.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
83,720	16,744	1625	948	19,317	55,000	2.85	88.7	887

Technical specifications

Safety	The entire luminaire would meet current safety standards therefore this upgrade eliminates any risk in regard to compliance. The luminaire, LED and power supplies shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* where applicable ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* where applicable ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	50,000 hours to 70% of initial output.
Warranty	5 years minimum.
Lamp	Luminous flux: 10,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Photometric performance	IES file prepared by NATA-registered laboratory to IESNA LM79. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	Power supply losses to be included at all times, so that the power of the luminaire is connected load. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

Option 4:
New 200 W induction luminaire

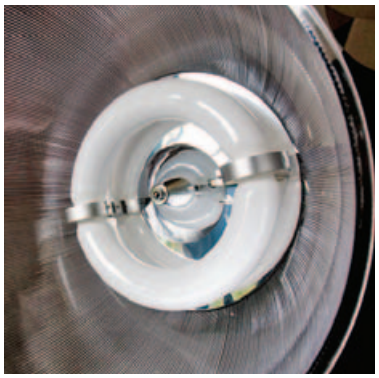

Figure 24: Induction lamp

This upgrade will be suitable for all existing applications. A longer lamp life should mean that there won't be any lamp changes during the reasonable life of the luminaire. This will significantly contribute to reducing the cost of ownership.

Illuminance, uniformity and glare

Light quality is improved with this upgrade due to improvements in colour quality.

Illuminance, uniformity and glare control should remain the same or be improved with this upgrade.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

Warehouse layouts often change over time, which can result in a lighting grid that does not relate to rack position. Consider rearranging the layout of the luminaires to suit the requirements of the space during the upgrade process. This can significantly improve lighting quality.

Colour temperature and colour rendering

Colour temperature and colour rendering will be significantly improved with this upgrade. The use of 2700–6500 K lamps is typical and effective in this situation.

Maintenance

This upgrade uses new components which minimises the risk of ongoing maintenance that can be encountered with retrofit options.

Lamps have a long indicated operating life and changes should not be required during a typical luminaire lifetime.

Follow the manufacturer's instructions for cleaning reflectors and diffusers to ensure lighting characteristics are maintained.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.
The luminaire:

- will not be dimmable unless a dimmable electronic ballast is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Smart control can save significant amounts of energy when dimmable ballasts are installed. The energy saving outcomes will depend on the specific situation and smart control systems should be subject to a cost-benefit analysis.

Staff satisfaction and productivity benefits

This upgrade will result in a more pleasant ambience through improved colour rendering.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

Induction lighting solutions are generally not offered by major suppliers and diligent scrutiny of lighting documentation is required. Seek external independent advice to validate any offer concerning induction technology.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
57,720	11,544	1625	948	14,117	65,000	4.6	61.1	611

Technical specifications

Safety	The entire luminaire would meet current safety standards and therefore this upgrade eliminates any compliance risk. The luminaire, lamps and ballasts shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	60,000 hours at 70% of initial output.
Warranty	5 years minimum.
Lamp	Luminous flux: 16,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity to also comply with AS/NZS 1680 where applicable.
Ballast	Rated voltage: 230 V or 220 V/240 V. Compliance with IEC 60929.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTIONS FOR UPGRADING 400 W metal halide luminaire

OPTION 1:
New 320 W pulse-start metal halide luminaire

This upgrade is applicable to all existing applications. Generally, increases in lamp life will significantly reduce the cost of ownership.

Illuminance, uniformity and glare

Light quality will be marginally improved with this upgrade through the improvements in colour quality of modern metal halide lamps.

Illuminance, uniformity and glare control should remain the same or be improved with this upgrade.

Measure illuminance before the upgrade to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

Warehouse layouts often change over time, which can result in a lighting grid that does not relate to the position of racks in the warehouse. Consider rearranging the layout of the luminaires to suit the requirements of the space during the upgrade process. This can significantly improve lighting quality.

Colour temperature and colour rendering

Colour temperature and colour rendering will be significantly improved with this upgrade. The use of 4000–6500 K lamps is typical and effective in this situation.

Maintenance

This upgrade uses new components, which minimises the risk of ongoing maintenance that can be encountered with retrofit options.

The typical practice for bulk re-lamping is to replace lamps after 80 per cent of their rated life, which corresponds to about 32,000 hours. In this scenario, lamps would be replaced in just over 12 years, based on 2600 hours of operation per annum.

Follow the manufacturer's recommended cleaning method for reflectors and cover glasses to maintain lighting characteristics.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The new luminaire should not be operated by movement sensors. This is because high intensity discharge lamps cannot be instantly switched on. Pulse-start technology may be able to significantly reduce warm-up and restrike times, but deliberate on/off cycling will not enhance the use of the space. Pulse-start metal halide technology is not suitable for daylight linking for the same reason.

Control-based energy savings can be achieved with pulse-start metal halide technology, if the luminaire is specified for multilevel switching. In this case, a control system can be designed and developed using occupancy sensing and daylight linking and should be subject to a cost-benefit analysis.

Staff satisfaction and productivity benefits

This upgrade will result in a more pleasant ambience due to improved colour rendering.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Potential drawbacks

There are no significant drawbacks with this upgrade.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
27,300	5460	244	190	5894	30,000	5.1	28.9	289

Technical specifications

Safety	The entire luminaire would meet current safety standards and therefore this upgrade eliminates any compliance risk. The luminaire, lamp and ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable)..
Rated lamp life	40,000 hours minimum for 50% failures.
Warranty	5 years minimum.
Lamp	Luminous flux: 31,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: > 80.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity to comply with AS/NZS 1680 where applicable.
Ballast	Ballast losses to be no more than 8% of lamp rating. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 2:
New 210 W LED luminaire

This upgrade is applicable where performance can be shown to be appropriate for the area. The extremely long lamp life, delivered by quality products, can lead to reduced maintenance costs.

Illuminance, uniformity and glare

Light quality can be improved with this upgrade due to improved light distribution from lensed LEDs.

Illuminance, uniformity and glare control should remain the same or be improved with this upgrade. It is an essential part of this upgrade that professional lighting design is undertaken to ensure that the project needs are met.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that the illuminance meets the recommendations of AS/NZS 1680.

Colour temperature and colour rendering

LED lighting delivers white light in much the same way as fluorescent lights. The primary difference is that LED lamps deliver a greater light level in higher colour temperatures (e.g. cooler colours such as cool white and daylight, and lower levels at warm white). LED manufacturers also introduced terms like neutral white, which can cause confusion when comparing LED with traditional lighting technology.

Colour temperature and colour rendering will be significantly improved with this upgrade. The use of 4000–6500 K lamps is typical and effective in this situation.

Maintenance

This option uses new components, which minimises the risk of ongoing maintenance that can be encountered with retrofit options.

Quality LED solutions provide 50,000 hours of operation to 70 per cent of initial output as a baseline for operating life. In this scenario, the 2600 hours of operation per annum would lead to replacement in approximately 19 years and will generally not require any maintenance for that period of time.

However, keeping the luminaire clean will be important and the cost of this should be factored into the cost-benefit analysis. This cost is highly dependent on the specific nature of the site and should be calculated for each site.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors.

The luminaire:

- will not be dimmable unless a dimmable electronic power supply is specified
- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

This upgrade will result in a more pleasant ambience due to improved light distribution.

The longer lamp life should also minimise disruption by increasing maintenance intervals.

Recommendation

OPTION 2 is the preferred option for this section. This upgrade provides good energy reductions whilst providing brand new, compliant luminaires. Minimal lighting design verification is required with this option. This option presents a low risk in selection and implementation.

Potential drawbacks

Ensure that the equipment can operate in the temperature conditions that will be found in the application.

Energy savings and financial return

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
63,404	12,688	975	379	14,042	63,000	4.49	67.2	672

Technical specifications

Safety	The new luminaire would meet current safety standards therefore this upgrade eliminates any risk in regard to compliance. The luminaire, LED and power supplies shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements where applicable* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements where applicable* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable)..
Rated lamp life	50,000 hours to 70% of initial output.
Warranty	5 years minimum.
Lamp	Luminous flux: 20,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Photometric performance	IES file prepared by NATA-registered laboratory to IESNA LM79. Maintenance illuminance on working plane in accordance with AS/NZS 1680 recommendations unless task lighting is to be provided. Glare management and uniformity also to comply with AS/NZS 1680.
Ballast	Power supply losses to be included at all times, so that the power of the luminaire is connected load. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 3:
New 300 W induction lamp luminaire

Energy savings and financial return per 100 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
36,140	7228	975	379	8582	78,000	9.09	38.3	383

The pay back period of this option exceeds nine years and this is not considered viable. As a result, this option has not been described in more detail but may be explored in future revisions of this report.

3 Exterior lighting

HALOGEN FLOODLIGHTING

OPTIONS FOR UPGRADING 500 W linear lamp shovel and box floodlights

OPTION 1:
New 150 W metal halide luminaire

This upgrade is suitable to all applications. The increased lamp life can significantly reduce costs in areas with limited or difficult access.

Illuminance, uniformity and glare control

Light quality is not significantly affected with this upgrade.

Illuminance should be slightly higher with this upgrade, whilst uniformity and glare control should be similar to the existing situation.

Illuminance measurements should be made before the upgrade, to establish the existing illuminance, and after the upgrade to demonstrate that illuminance has not altered significantly.

Colour temperature and colour rendering

The colour temperature of halogen lamps is about 3000 K and as metal halide lamps are available in 3000 K they should deliver a similar outcome.

The existing light source has a CRI of 100, but colour rendering is not critically important in this situation. A CRI of 80 or higher is appropriate for this application.

Maintenance

The typical practice of bulk re-lamping replaces lamps after 80 per cent of their rated life, which corresponds to about 9600 hours. Lamp replacement would occur at just under three years in this scenario, based on 2600 hours of operation per annum.

Follow the manufacturer's instructions for cleaning reflectors and cover glasses to ensure lighting characteristics are maintained.

Compatibility with dimming, dusk-to-dawn switching and other controls

Standard metal halide technology is best operated on long cycles, such as dusk-to-dawn switching.

The new luminaire should not be operated by movement sensors. High intensity discharge lamps cannot be instantly switched on but they will typically take 60–90 seconds to reach full output and colour when powered. Once they have been running for a while, they will take as long as ten minutes to restrike if they are switched off.

Staff satisfaction and productivity benefits

The longer lamp life and rare total lamp failure, should ensure that night time safety and security lighting remains operational. This can have a positive impact on staff comfort and security.

Potential drawbacks

There are no significant drawbacks with this upgrade.

Energy savings and financial return

Energy savings and financial return per 10 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
12,012	2402	-98	168	2472	3000	1.21	12.7	127

Technical specifications

Safety	The entire luminaire would meet current safety standards therefore this upgrade eliminates any risk in regard to compliance. The luminaire, lamp and ballast shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	12,000 hours minimum for 50% failures.
Warranty	3 years minimum.
Lamp	Luminous flux: 11,000 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Photometric performance	IES file prepared by NATA-registered laboratory. Maintenance illuminance on working plane in accordance with site requirements. Glare should be minimised and uniformity should be high.
Ballast	Ballast losses to be no more than 15% of lamp rating. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

OPTION 2:
New 110 W LED luminaire

Recommendation

OPTION 2 is the preferred option in this section. This upgrade delivers excellent energy reductions whilst providing a new, compliant luminaire. Minimal lighting design verification is required with this option. Choosing high quality products will minimise any risks associated with this option.

Illuminance, uniformity and glare control

This upgrade is applicable to all situations. The increased lamp life significantly reduces costs in areas with limited or difficult access.

Light quality is not significantly affected by this upgrade and illuminance, uniformity and glare should be similar to the existing system.

Illuminance measurements could be made before the upgrade to establish the existing illuminance, and after the upgrade, to demonstrate that the illuminance has not been significantly altered.

Colour temperature and colour rendering

The colour temperature of halogen lamps is about 3000 K and a similar colour temperature should be achieved as LED is available in 3000 K.

The existing light source has a CRI of 100 but colour rendering is not critical in this situation. A LED CRI of 80 or higher is appropriate for this application.

Maintenance

Quality LED solutions are providing rated life of 50,000 hour to 70 per cent of initial output. In this scenario, 3640 hours of operation per annum would lead to LED replacement in just under 14 years.

The luminaire should not require any maintenance during this period. However, keeping the light path clean will be important and the cost of this should be included. This cost will be highly dependent on the specific site and so should be calculated to the individual requirements.

Compatibility with dimming, occupancy sensors, daylight linking and other controls

The upgraded luminaire can be switched on and off by occupancy sensors. The luminaire will not be dimmable unless a dimmable electronic ballast is specified. The luminaire:

- can be switched on and off by daylight linking sensors
- can be used with any combination of the above.

Staff satisfaction and productivity benefits

The longer lamp life and rarity of total lamp failure should ensure that night-time safety and security lighting remains operational. This can have a positive impact on staff comfort and security.

Potential drawbacks

There are no significant drawbacks with this upgrade.

Energy savings and financial return

Energy savings and financial return per 10 luminaires								
Electricity savings kWh p.a.	Energy cost savings $ p.a.	Maintenance lamp savings $ p.a.	Maintenance labour savings $ p.a.	Total cost savings $ p.a.	Capital cost inc. installation $	Pay back period yr	GHG emission reduction tCO_2 p.a.	No. of ESC claimable for 10 years
14,196	2839	91	212	3142	5000	1.59	15	150

Technical specifications

Safety	The entire luminaire would meet current safety standards and therefore this upgrade eliminates any compliance risk. The luminaire, LED and power supplies shall be suitable for connection to the public electricity supply in NSW and in particular comply with: ▪ AS/NZS 3000 ▪ *AS/NZS 61347.1 2002 Lamp control gear – Part 1: General and safety requirements* where applicable ▪ *AS/NZS 61347.2.9 lamp control gear – particular requirements* where applicable ▪ AS/NZS 60598.
Electromagnetic compatibility	ACMA C-tick label for compliance with AS/NZS CISPR15 (or the new Regulatory Compliance Mark {RCM} where applicable).
Rated lamp life	50,000 hours to 70% of initial output.
Warranty	5 years minimum.
Lamp	Luminous flux: 6,600 lm minimum. Colour temperature: 4000 K (cool white) unless otherwise required. CRI: >80.
Photometric performance	IES file prepared by NATA-registered laboratory to IESNA LM-79. Maintenance illuminance on working plane: in accordance with site requirements. Glare should be minimised and uniformity should be high.
Ballast	Power supply losses to be included at all times so that the power of the luminaire is connected load. Rated voltage: 230 V or 220 V/240 V. Compliance with AS/NZS 61347 where applicable.
Environmental conditions	Maximum operating temperature: 50°C. Minimum operating temperature: –10°C.
Power factor	Greater than 0.90.

Table of figures

Index