Equipment Energy Efficiency

Decision Regulation Impact Statement: Lighting

Regulatory reform opportunities and improving energy efficiency outcomes

A joint initiative of Australian, State and Territory and New Zealand Governments.

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Background

COAG Energy Council agreed to examine the case for the next phase of lighting energy efficiency regulation in December 2015, as part of the Equipment Energy Efficiency (E3) Program's Prioritisation Plan.

This Regulation Impact Statement (RIS) considers policy proposals to improve the energy efficiency of residential and commercial lighting in Australia and New Zealand.

It considers Light Emitting Diode (LED) lamp[1] technology that is currently not subject to mandatory energy efficiency requirements — it is regulated for safety and electromagnetic compatibility only.

It also considers incandescent[2] and halogen lamps that are currently subject to Minimum Energy Performance Standards (MEPS) under the *Greenhouse and Energy Minimum Standards (GEMS) Act 2012* in Australia and *Energy Efficiency (Energy Using Products) Regulations 2002* in New Zealand. Under the GEMS Act (and equivalent New Zealand regulations) products are regulated for energy efficiency and also associated quality or performance standards.

Individual lamps do not consume large quantities of electricity. However, the average Australian home has 37 lamps[3] and the average New Zealand home has 26 lamps[4]. When aggregated, lighting accounts for around 10 per cent of a household's electricity use[5]. For the commercial sector, lighting systems account for between 20–40 per cent of electricity end-use in Australia[6] and about 40 per cent in New Zealand[7].

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[1] Lamp is the correct term to describe a light bulb and is used throughout this document.

[2] The term "incandescent lamp" is used in this report to refer to tungsten filament incandescent lamps.

[3] E3, *Residential Lighting Report*, prepared by Energy Efficient Strategies, 2016.

[4] EECA, *BRANZ survey, 2016.*

[5] E3, *Residential Baseline Study for Australia: 2000-2030,* prepared by Energy Consult, 2015*; EECA End Use Database, 2014.*

[6] Pitt and Sherry, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia – Part 1 – Report. Department of Climate Change and Energy Efficiency, 2012*.

[7] EECA, *Linear fluorescent lamps - total sales and efficiency data*. Energy Efficiency and Conservation Authority, New Zealand, 2012.

Around 80 million lamps are sold in Australia per year, with an estimated installed stock of more than 400 million. A further 20 million lamps are sold in New Zealand each year, with an estimated installed stock of more than 90 million[8].

The phase out of most incandescent lamps (Australia only) was announced in 2007 by the then Minister for the Environment, the Hon Malcolm Turnbull MP. This decision resulted in energy savings from removing cheap but inefficient incandescent lamps that were dominating the market. The phase-out of incandescent lamps commenced in Australia in 2009, alongside the introduction of MEPS for compact fluorescent lamps (CFL) and halogen lamps. Halogen lamps are now the most commonly purchased lamp in Australia, being slightly more energy efficient to incandescent lamps.

LED lamps are now widely available in Australia and New Zealand, with prices continuing to decrease. Good quality LED lamps last 5 to 15 times longer than halogen lamps and at most will consume one-quarter of the energy to produce the same light output.

However, evaluation of LED lamps available in the marketplace indicates a wide variation in quality and efficacy[9]. The availability of poor quality LED products on the market risks a rejection or slower, less complete uptake by consumers of this technology as an effective, efficient alternative to halogen lamps.

Problem

Changes to energy efficiency regulations are under consideration because:

- Consumers are being exposed to a segment of inferior LED products that are negatively impacting on consumer confidence and uptake of this more efficient technology, reducing potential savings on electricity bills and reductions in emissions.
- Imperfect information, combined with an increased diversity of lighting alternatives, makes it difficult for consumers to meaningfully compare the energy efficiency, quality and performance of lighting technologies, or be motivated to do so given the low purchase price.
- Split incentives whereby some commercial and rental property owners and builders have no incentive to purchase more efficient, higher quality, but higher upfront cost products as they don’t pay the electricity bill or incur replacement costs.
- MEPS have not kept pace with improvements in lighting technology and international best practice and therefore are no longer achieving their purpose of removing the least efficient lamps from the market.

8 Includes incandescent, halogen, compact and linear fluorescent and LED lamps.

9 Efficacy is a term used to describe the relative energy efficiency of lighting products in lumens per watt.

MEPS for some types of LED lamps are in place in China, the European Union (EU), Malaysia and Singapore. The EU is consulting on revised MEPS for LED lamps (currently planned to be finalised in late 2018 and to commence in September 2020).

There is an opportunity to increase MEPS levels for incandescent and halogen lamps to remove the least efficient lamps from the market and accelerate the transition to LED lighting. This proposal is presented for Australia only. Incandescent and halogen lamps remain for sale in New Zealand at this time to provide consumer choice across lamp categories.

Objective

The objective of the proposed government action is to remove inefficient and poor quality LED lamps from the Australian and New Zealand market. For Australia, the objective is also to accelerate the transition to efficient lighting, by removing the least efficient lamps from the market and deliver cost effective energy savings. An important part of achieving this is to minimise compliance costs for suppliers, including through close alignment with lighting regulations in major economies and markets.

Policy options

Two policy proposals (Options A and Options B) have been identified, in addition to Business As Usual (BAU).

Table 1: Policy options

Policy Proposal	Option A	Option B
1. Introduce MEPS for LED lamps: Harmonise MEPS for LED lamps with the requirements of the EU MEPS regulation currently under consultation as applied to LED lamps– both in terms of test parameters regulated and performance requirements against those parameters, and timing of introduction. Includes an innovative approach to product registration and compliance to lower implementation costs for industry.	X	X
2. Increase incandescent and halogen MEPS (Australia only) to remove the most inefficient lamps including a number of categories of halogen lamps (excluding those lamps where there is no equivalent LED lamp readily available on the market).		X

MEPS on LEDs lamps would only deliver modest energy efficiency savings for households. The major energy efficiency gains would be achieved through a phase out of halogens, which continue to comprise a significant portion of the market. MEPS on LED lamps would address the problem of consumers being exposed to a segment of inferior LED products that negatively impact on consumer satisfaction and address split incentives whereby some property owners and builders have no incentive to purchase higher quality, but higher upfront cost products. MEPS on LEDs would offer increased savings in the commercial lighting sector, by removing the least efficient linear LED lamps currently available in the market.

The policy proposal to implement MEPS on LED lamps would introduce new regulatory costs for suppliers, through testing and other compliance costs. The proposal minimises costs by aligning requirements and timing with the EU regulation currently under review, meaning suppliers who meet EU requirements would have no additional test costs from this regulation. Costs for LED lamps would be further reduced by including GEMS registration in the Electrical Equipment Safety System with electrical safety to enable a single point of registration for suppliers.

Internationally, there is a move to further transition to efficient lighting through the phase out of incandescent and halogen lamps. Several countries including Australia, China, Hong Kong, South Korea, Malaysia, Mexico, Singapore and the USA have phased out some or all incandescent lighting. The EU has commenced phasing out halogen lamps, with mains voltage halogen directional lamps phased out in 2016 and mains voltage halogen non-directional lamps are scheduled for phase out in September 2018. Korea has phased out non-directional halogen lamps. The E3 Program understands the USA plans to phase out most halogens in 2020.

The option to not intervene in the LED lamp market and rely on supplier competition to address LED lamp quality issues was considered but discounted. E3 has monitored the quality of LED lamps in the market since 2009 and while quality has significantly improved, problems remain that are unlikely to be addressed through natural market forces. The option to phase out halogen lamps in Australia without requiring MEPS on LED lamps was also considered but discounted. The absence of regulation to manage quality of LED lamps would expose consumers to inferior product. This is considered unacceptable for consumers who are likely to be required to pay a higher upfront purchase price for lamps with the removal of halogen lamps.

Cost benefit estimates

The estimated impacts of the preferred option for Australia and New Zealand to 2030 are shown in Table 2 (Australia) and Table 3 (New Zealand) below in terms of costs/benefits, energy savings and greenhouse gas emission reductions.

Table 2: Cost benefit estimates — Australia[10] (Real discount rate: 7%)

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	198	0.1	34	0			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				12.1			
	Government admin				1.3			
	GHG value @ $0/t			0				
	Total	**1,273**	**0.8**	**166**	**13**	**152**	**12.4**	**$193**
Option B - MEPS for LED Lamps + Phase Out Halogen	Residential (incl compat cost $144M)	7,702	4.8	1,503	172			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				11.7			
	Government admin				3.0			
	GHG value @ $0/t			0				
	Total	**8,777**	**5.5**	**1,634**	**187**	**1,448**	**8.8**	**$263**

Table 3: Cost benefit estimates — New Zealand[11] (Real discount rate: 6%)

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	26	0.002	1.2	0.0			
	Commercial	192	0.014	9.8	0.0			
	Regulatory burden				3.5			
	Government admin				0.5			
	GHG value @ $25/t			0.4				
	Total	**218**	**0.015**	**11.4**	**4.0**	**7.4**	**2.9**	**$480**

For Australia Option B (introduction of MEPS for LED lamps and the phase out of some incandescent and halogen lamps) would provide a large net benefit of $1.448 billion to 2030. The total benefit for Option B is $1.634 billion. Option B would provide savings on

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[10] "GHG value @ $0/t" – this refers to a greenhouse gas value of $0 per tonne. The cost benefit estimates for Australia do not include benefits associated with greenhouse gas abatement, as there is no agreed shadow carbon price. The sensitivity analysis assigns a value to greenhouse gas abatement.

[11] New Zealand estimates are presented in New Zealand dollars. National benefits are assessed using the avoided long run marginal cost of electricity (as required by New Zealand's cost benefit methodology). The benefits for New Zealand include benefits associated with greenhouse gas abatement ("GHG value @ $25/t" - as required by New Zealand's cost benefit methodology).

energy costs for consumers of $1.396 billion, and to businesses of $132 million. Option B would provide additional savings of $107 million in the cost of purchasing lamps, as while LEDs are more expensive to buy than halogen lamps initially, they don't need to be replaced as regularly.

The total cost for Option B is $187 million. Under Option B, consumers need to spend an extra $28 million on LED lamps initially. Around 9 per cent of households would incur costs to upgrade their dimmers[12] so that they are compatible with LED lamps, at a cost of $144 million. Suppliers would incur costs of $12 million complying with the regulations. Option B would save 8,777 giga-watt hours (GWh) of energy and 5.5 million tonnes (Mt) of emissions, cumulative to 2030.

For Australia, the savings from Option A (introduction of MEPS for LED lamps) are smaller, with a projected net benefit of $154 million through savings on energy costs. Option A would provide savings on energy costs for businesses of $132 million, and to consumers of $34 million. Suppliers would incur costs of $12 million complying with the regulations. Option A would save around 1,273 GWh of energy and 0.8 Mt of emissions, cumulative to 2030.

For New Zealand, the introduction of MEPS for LED lamps would provide a net benefit of an estimated $7.4 million to consumers and businesses through energy savings. MEPS for LED lamps would provide savings on energy costs for businesses of $10 million, and to consumers of over $1 million. Suppliers would incur costs of around $3.5 million complying with the regulations. It is projected to save 218 GWh and 0.015 Mt of emissions, cumulative to 2030. This consists only of the change in energy usage of LED lamps from improving the performance of these products, and is therefore much smaller than projected for Australia under Option B.

The main benefits accrue to users of lighting – consumers and businesses through savings on their electricity bills, by replacing incandescent and halogen lamps with an effective and efficient LED lamp or compact fluorescent lamp (CFL) (already subject to MEPS). The community and environment also benefit through cost effective reductions in emissions. The total costs include costs to businesses, consumers and government.

To achieve these savings on their electricity bills, consumers and businesses need to spend more upfront by purchasing a more expensive LED or CFL that costs $7, instead of a halogen lamp that costs $3 (around $4 more today, which is likely to decrease over time as LED prices continue to reduce). However this higher upfront cost is generally offset through electricity savings in the first year, with the average household better off by around $650 over 10 years by changing halogen lamps to minimum standard LED lamps

[12] A dimmer is a control that adjusts the brightness of a light.

that lasts 15,000 hours[13]. Savings are higher for higher residential users and commercial use. A hair salon would save an estimated $3,700 over 10 years in electricity savings[14].

For the proposal to phase out halogen lamps in Australia, around nine per cent of households (an estimated 720,000, including around 160,000 low income homeowners) would incur a one off upfront cost of around $250 to resolve compatibility issues with dimmers to work with LED lamps. For a household with compatibility issues, the electricity bill savings are expected to offset the $250 upfront cost within a 4 year period. If households are willing to set the dimmers to 100 per cent, most households can avoid or defer the upgrade cost and still use their lights.

For low income households, the upfront costs are likely to be difficult to absorb and they may be forced to defer the cost until they are in a position to upgrade. Rental households that are reliant on landlords who are unwilling to upgrade would also not be able to use their dimmers, unless the renter pays the upgrade cost. Households whose dimmers still won't work with LED lamps, when set to 100 per cent, would be forced to upgrade or to deal without having a functioning light (other interim solutions would include using plug-in standing or table lamps). These compatibility costs are included in the cost benefit analysis.

The benefit cost ratios are very high for Australia. To examine this, the sensitivity of the results to changes to key inputs was analysed. These sensitivity tests indicate that even with changes to key inputs to the cost benefit analysis, the policy options remain cost effective.

Consultation

The final proposals are the result of extensive stakeholder consultation. The original proposals were modified after feedback on the Consultation RIS, supplementary paper, an advisory group paper and further discussions with Lighting Council Australia (LCA) and members of the advisory group. Consultation included:

- three product profiles to review the energy efficiency of lighting in Australia and to consult on opportunities to improve, including the Incandescent, Halogen and CFL product profile (E3 2014), Commercial Lighting (E3 2015) and LEDs (E3 2015)
- a Consultation RIS (November 2016), which included six stakeholder meetings across Australia and New Zealand
- a supplementary consultation paper (September 2017) modifying the proposals following feedback

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[13] Based on the replacement of 10 lamps that are used for 1.6 hrs per day.

[14] Based on the replacement of 20 downlights that are used for 50 hours per week.

- an advisory group paper and meeting in March 2018. The Lighting Energy Efficiency Advisory Group was established to provide advice on whether MEPS on LED lamps was necessary to phase out halogen lamps
- meetings with the LED MEPS Technical Working Group, established to draft the proposed MEPS parameters and test methods
- meetings with the Compatibility Working Group, established to work through transitional issues in phasing out halogen lighting in Australia
- discussion with relevant peak bodies (Lighting Council Australia, Lighting Council New Zealand, Illuminating Engineering Society of Australia and New Zealand, International Association of Lighting Designers and electrician peak bodies; National Electrical and Communications Association, Master Electricians Australia; the consumer group CHOICE and the Energy Efficiency Council).

Further, the E3 Program commissioned the following reports to inform this RIS:

- *Residential Lighting Report 2016*, Energy Efficient Strategies
- *Household Lighting Consumer Survey 2016*, E3 and CHOICE
- *LED and Dimmer Compatibility Testing 2016*, National Electrical Communications Association (NECA)
- *LED Testing 2016*, Queensland University of Technology
- *LED Testing 2017*, by two independent test labs.
- *Light Bulb Labelling Consumer Study 2017,* Colmar Brunton

There was broad support from stakeholders for the further phase out of inefficient incandescent and halogen light bulbs in Australia, across lighting suppliers, lighting designers, retailers and consumer groups. Support for MEPS for LED lamps was mixed. Responses to the consultation RIS and supplementary consultation paper did not see any consensus emerge as to whether MEPS on LED lamps are necessary to underpin a phase out of halogen lamps.

Of the 16 public submissions to the supplementary paper, eight supported a MEPS, including four consumer groups - CHOICE, the Brotherhood of St Laurence, the Consumer Federation of Australia, and Consumers New Zealand. Four submissions conditionally supported a MEPS, but had comments and concerns with aspects of the proposal. Four submissions were opposed to MEPS, including the lighting industry associations of Australia and New Zealand, a lighting supplier and an engineering professional. Lighting Council Australia (LCA) argued there is a lack of evidence to warrant an LED lamp MEPS, and that it would result in excessive costs for industry. Lighting Council New Zealand (LCNZ) considered that there is a decreasing need for regulatory intervention in LED market activities, as the energy efficiency of LED has been advancing naturally.

To examine the issue further, a Lighting Energy Efficiency Advisory Group was set up. The Advisory Group includes lighting industry associations, suppliers, retailers, consumer and energy efficiency bodies, and Australian, New Zealand and State Government officials. An Advisory Group meeting on 9 March 2018 in Sydney recommended that if an option of

MEPS on LED lamps is proposed, industry costs should be minimised, with any new regulations to be implemented in parallel with changes to the EU lighting regulations that are due to be finalised later this year. After further consultation, LCA supported the proposed option that the MEPS on LED lamps is aligned with the updated EU regulations, and the lowering of regulatory costs through streamlined registration. No objections were raised by other members of the Advisory Group. This is the final proposal for LED lamps recommended in this RIS.

Evaluation and Conclusion

Option A is the preferred option for New Zealand and Option B is the preferred option for Australia. Option B, which includes the phase out of halogen lamps, is not being considered by New Zealand.

The recommended option for Australia provides the greatest net benefit, and would provide the largest energy and greenhouse gas savings. For New Zealand, only one option is presented, which has a positive net benefit. Over the period to 2030, net savings of $1.45 billion for Australia and $7.4 million for New Zealand are projected.

For the recommended option in Australia, consumers and businesses need to spend more upfront by purchasing a more expensive CFL or LED lamp to achieve savings on their electricity bills. The payback on the more expensive lamp is generally within one year. An estimated nine per cent of households will also face upfront costs of $250 to upgrade their dimmer systems to work with LED lamps - these upgrade costs may be difficult for low income households to manage. Households that have to upgrade dimmers will generally still save money after four years.

Implementation and Review

If the COAG Energy Council approves the recommended policy options, the *Greenhouse and Energy Minimum Standards (Incandescent Lamps for General Lighting Services) Determination 2016* would be revised and a new determination created for LED lamps for consideration by COAG Energy Council Ministers (expected in early 2019). In New Zealand, a policy option needs to be approved by Cabinet before being adopted under the *Energy Efficiency (Energy Using Products) Regulations 2002*. If approved, the updated regulations would be subject to compliance monitoring and review in both countries.

If approved the changes to the regulations would commence to align with EU timing (currently planned for September 2020). There is a risk that the EU process will be delayed beyond November 2018, potentially delaying the planned implementation date of September 2020. Should this occur, further advice will be provided to COAG Energy Council Ministers.

There is an existing issue in certain geographic areas in New South Wales and Queensland that can cause LED lamps to flicker for a short period and affect other household electrical products (including humming in electric fans, fast electric clocks and unintended operation of ovens), as ripple control signals are sent several times a day from distribution network service providers to control off-peak tariff hot water, street lamps, pool pumps and space heating. Rectification and workarounds are currently managed by networks and lighting suppliers. E3 has established a Ripple Control Working Group with stakeholders to understand conditions when this can occur and options to resolve. It is anticipated that options to manage this issue will continue to evolve, minimising any impacts on households in these areas before the planned phase out date.

Some consumers may complain about the removal of halogen lamps from the Australian market, as occurred with the removal of incandescent lamps in 2009. E3 has consulted broadly with stakeholders (consumer groups, lighting designers, suppliers, retailers) on this proposal. The introduction of MEPS on LED lamps would provide assurance to consumers that they can purchase an equivalent replacement product that provides at the least the same or better quality of light.

In particular, consumers that incur a one off upfront cost to resolve compatibility issues with dimmers used in existing lighting systems may complain about the removal of halogen lamps from the market. The E3 Program and stakeholders are jointly working to reduce the consumer cost of this option through providing information on compatible products to electricians to enable them to assist households in minimising costs.

Criticism could be managed by highlighting the savings to consumers on electricity and replacement costs and the overall benefits for society. Accelerating the transition as opposed to voluntary uptake can be justified on the basis that voluntary uptake through education can only achieve limited benefits as many consumers are not motivated to change their purchasing decision due the low upfront cost of lamps and savings not being apparent. A consumer education program, in cooperation with lighting suppliers, designers, consumer and electrical trade associations will be an important element in the implementation of the phase-out.

The Australian GEMS Regulator has developed a detailed compliance plan to be implemented if new energy efficiency regulations are agreed. This is outlined in Attachment G. Compliance with new regulations would also be a focus in New Zealand.

1. Background

Market

LED market

LED lamps are not manufactured in Australia or New Zealand. While over 90 per cent of LED lamp imports are from China, the specification of lamps is largely influenced by international standards and European (EU) and North American regulatory requirements. China introduced MEPS on omni-directional lamps in 2014 but those standards only apply to domestic consumption not exports to other countries.

Harmonisation of any regulation with international standards and other major economies is important to reduce costs for LED lamp importers.

LED lamps imported into Australia, based on these products being classified by import brokers under the LED lamp classifications for the 2017 calendar year, is 21 million units.[15]

There are a large number of non-traditional lighting suppliers importing products. Of the 436 entities importing more than 200 LED lamps in the period January to December 2017, the Department estimates that around 180 of these entities are lighting suppliers. Other players in the market include electrical contractors and builders directly importing products.

The China Association of Lighting Industry estimates that there are more than 5,000 manufacturers in China that export LED lamps world-wide.

Lamps are sold in a range of outlets including hardware stores, supermarkets, general lighting retail, specialist lighting stores, and electrical retail suppliers, (many of which have online options for purchasing). In addition, online only lighting retailers and direct manufacturer/suppliers also exist.

[15] Department of Home Affairs.

General lighting market

The Australian lighting market is estimated at around $1.5 billion in sales annually[16]. The New Zealand lighting market is estimated to be $336 million.[17] Of the installed product, approximately 13 per cent is found in non-residential (commercial/industrial) spaces and the remaining 87 per cent of lighting is used for residential purposes[18].

Whilst uptake of LED lamps is increasing, halogen, fluorescent and incandescent lamps remain as the dominant lamps purchased in Australia and New Zealand.

Australian supermarket unit sales by technology data for 2017 (January 2017 to end of April 2017) shows LED lamp sales of 18 per cent (an increase of eight per cent absolute from 2016), 66 per cent for halogen and incandescent lamps and 15 per cent for CFLs. Australian import data for 2017 shows LED lamp imports of 31 per cent, halogen and incandescent at 40 per cent and CFL at 13 per cent. This includes all lamps and market sectors. Note that due to significant differences in product lifetime between technologies, sales figures are not directly equivalent to share of installed stock.

New Zealand supermarket unit sales by technology data for 2016 shows LED lamp sales of 5 per cent, 11 per cent halogen, 69 per cent incandescent lamps and 15 per cent for CFLs. This does not reflect sales in trade stores (where it is expected proportionally higher volumes of LEDs are sold).

In addition to traditional socket based light bulbs, LED lighting is also sold as a light source integrated with the luminaire as a single unit. These products are sold as alternatives to residential lighting including downlight lamps, decorative light fittings and non-integrated commercial luminaires (holding compact or linear fluorescent lamps). Transition from a socket / lamp holder based lighting system to an integrated luminaire will usually require a qualified electrician and will most commonly occur in new builds or renovations. Integrated LED lighting products are available through lighting retailers and trade stores alongside lamps.

The new build and commercial market is moving to LED technology. Import data for 2017 for LED integrated luminaires showed more than 2 million units of integrated LED planar, batten and troffers. In comparison over the same period there were 9 million units of linear fluorescent lamps and around 6 million units of LED linear lamps. Note that some of these figures have been estimated as data indicates some level of misclassification by importers.

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[16] Lighting Council Australia estimate, 2016.

[17] EECA estimate, 2016.

[18] E3, *Commercial Product Profile*, 2015.

Stock and sales estimates

The E3 Program commissioned a comprehensive lighting audit of the residential sector in 2016 and has purchased twelve years of supermarket retail sales data up to 2017 to quantify the lighting stock and characteristics of lighting in Australian households. New Zealand commissioned a similar audit of households in 2016 and require supplier to report sales data for regulated lighting products. Import data for both countries was also used as an additional input to understand the market and validate stock estimates, noting that import data for LED lighting only became available from January 2017[19]. Lighting Council Australia also provided aggregated sales trend data from their members.

Around 80 million lamps are sold in Australia per year, with an estimated installed stock of more than 400 million. A further 20 million lamps are sold in New Zealand each year, with an estimated installed stock of more than 90 million[20].

Current residential lighting energy consumption per dwelling for Australia is estimated at around 700 kilowatt-hours (kWh) per annum.

In Australia, more than 60 per cent of residential lighting energy consumption is estimated to come from incandescent and halogen lamps[21]. In New Zealand, the estimated level is higher at 80 per cent[22].

The stock of lighting is estimated to grow to approximately 500 million in 2030 in Australia. In New Zealand stock is expected to increase to approximately 100 million by 2030.

For Australia, the forecast BAU stock of residential lamps is shown below.

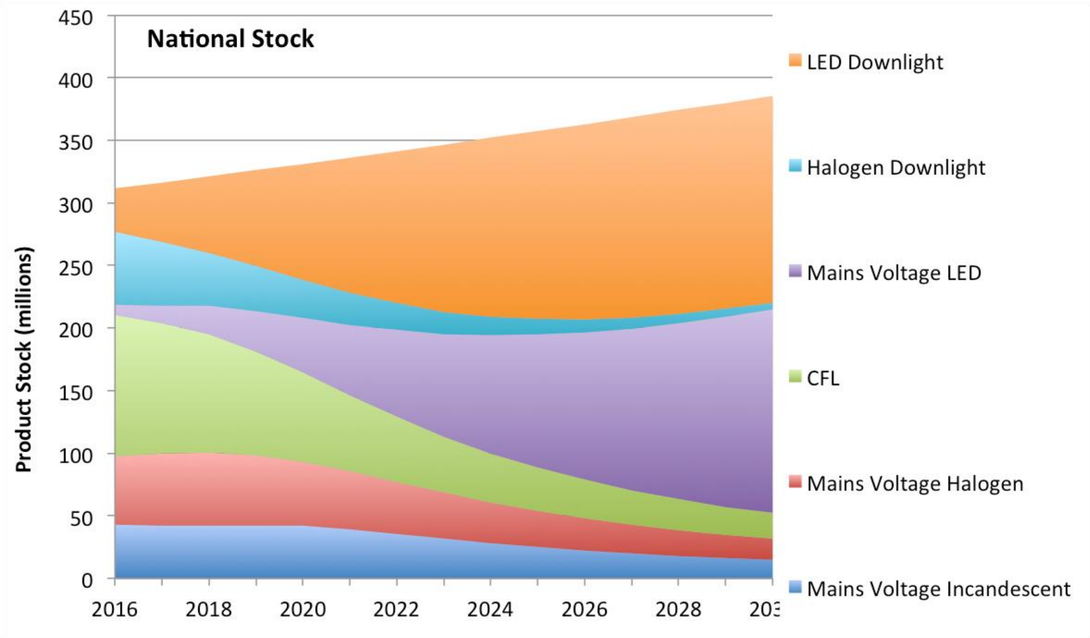
[19] LED import categories were introduced in Australia in January 2017. New Zealand is considering introducing the same codes for their imports.

[20] Of the lamp technologies referred in this RIS (LED, CFL, filament and linear fluorescent lamps).

[21] E3, 2016 Residential Lighting Report, prepared by Energy Efficient Strategies, 2016.

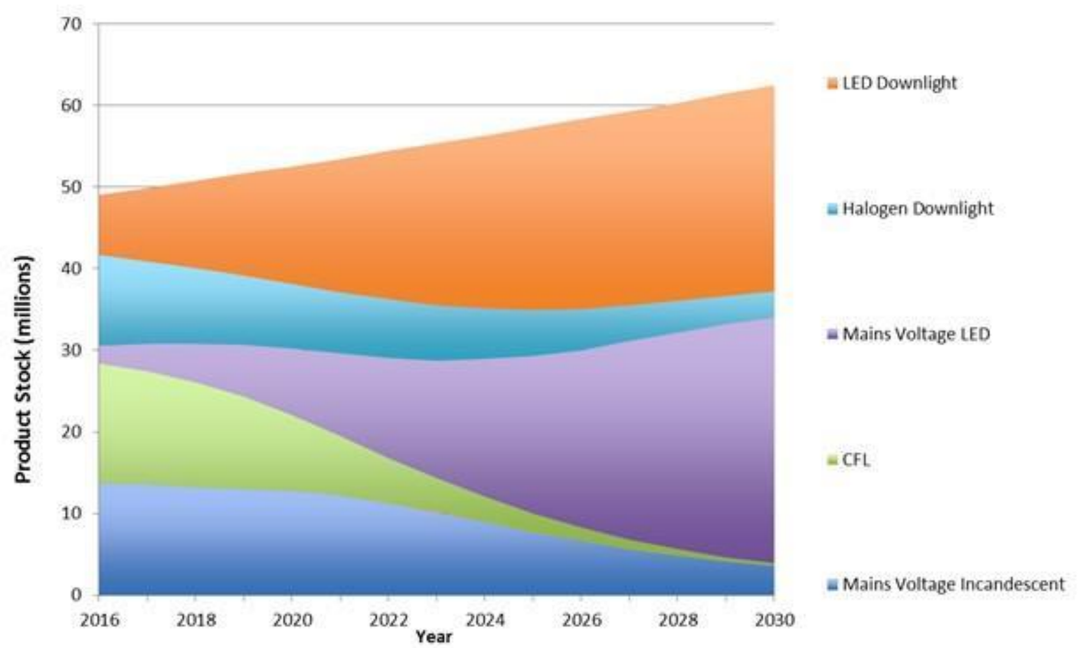
[22] EECA, BRANZ survey, 2016.

Figure 1: BAU stock of residential lamps in Australia



For New Zealand, the forecast BAU stock of residential lamps is shown below.

Figure 2: BAU stock of residential lamps in New Zealand



2016 Residential Lighting Audit - Australia[23]

Comparison of the 2016 residential lighting audit with the 2010 residential lighting audit shows that the installed stock of incandescent lamps have fallen significantly from 23 per cent to 13 per cent share, while mains voltage halogen lamps share has increased from nine

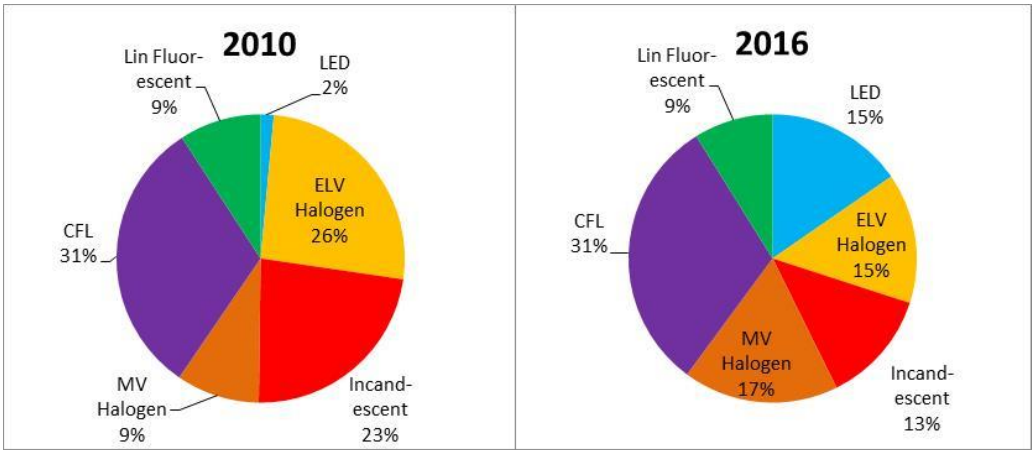
[23] E3, 2016 *Residential Lighting Report*, prepared by Energy Efficient Strategies, 2016

per cent to 17 per cent. This shows that incandescent lamps have mostly been displaced by mains voltage halogen lamps since the last survey in 2010 (following the incandescent lamp phase-out in 2009). Mains voltage halogen lamps are 30 per cent more efficient when compared to incandescent. In 2016 LED for general lighting (non-directional) still only made up three per cent of the stock (this is included in the LED total share of 15 per cent) even though there has been a significant increase in available models in the market. This data suggests that there has been limited improvement in lighting efficacy for general lighting over the past six years (noting that this is not representative of the full impact of lighting efficiency policy since 2007).

Low voltage halogen lamp share has fallen from 26 per cent to 15 per cent while LED lamp share has increased from two per cent to 15 per cent (12 per cent is LED directional). This data suggests that there has been a significant improvement in lighting efficacy for task and directional lighting due to the halogen to LED transition. LEDs are being installed in new homes/renovations but also under voluntary state downlight replacement programs. It is estimated that more than 30 per cent of Victorian households have participated in the downlight replacement program.

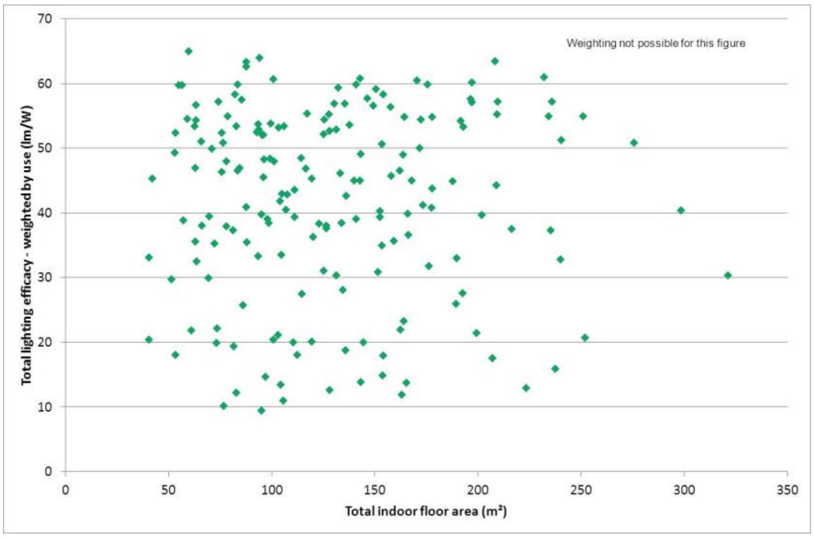
In overall terms, the share of linear fluorescents and CFLs has not changed in the past six years with a constant aggregate market share of 40 per cent for these two technologies. Whilst the physical share of efficient lighting (CFL, linear fluorescent and LED) has increased to 55 per cent, over 60 per cent residential lighting energy consumption is estimated to be from incandescent and halogen lamps.

Figure 3: Share of lighting technologies in 2010 and 2016 (Australia)



There is a large variation in the overall efficacy of lamps installed in households. Figure 4 shows the total lighting efficacy for each of the 180 homes. A value of less than 30 lumens per watt is poor while a value of over 55 lumens per watt is very good. This diagram shows the large potential in energy reduction still to be achieved through the installation of energy efficient lighting, across all sizes of dwellings.

Figure 4: House floor area versus total house lighting use weighted efficacy (Australia)



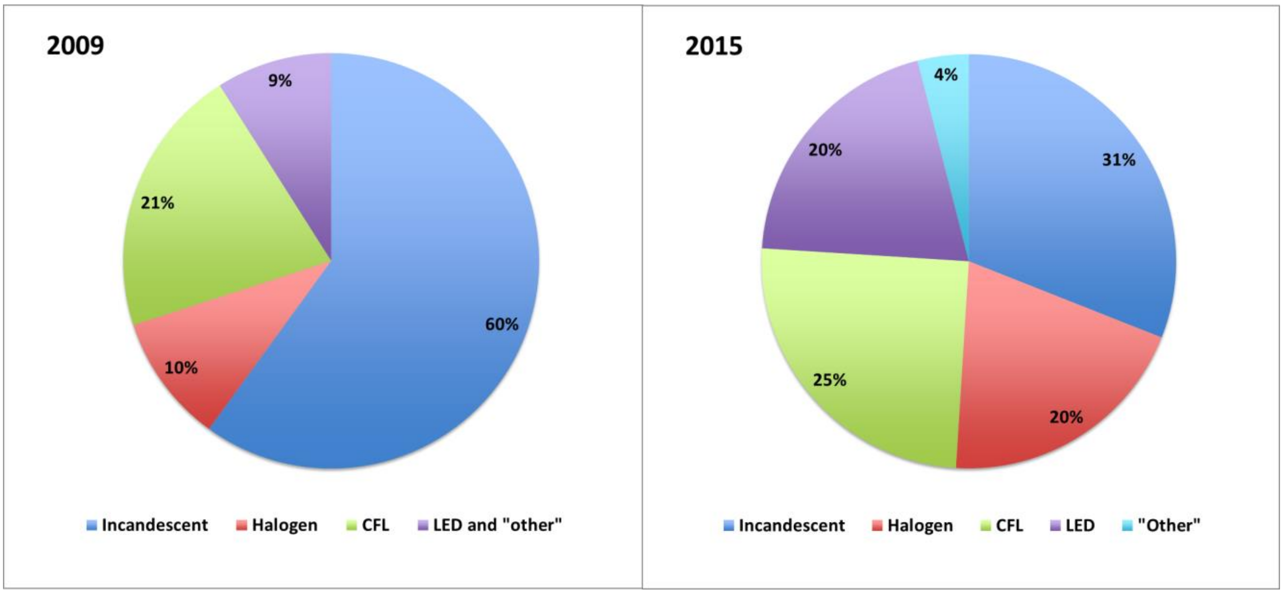
Note: Each point represents a participating household. Efficacy values are weighted by use – assumes all lamps are used as stated by householders. Demographic weightings are not applied to data in this figure.

2015 Residential Lighting Audit – New Zealand

Comparison of the 2015 residential lighting audit results with the 2009 audit results shows that incandescent lamps have fallen significantly from 60 per cent to 31 per cent share, while halogen lamp share increased from eight per cent to 17 per cent. CFLs have slightly increased to 25 per cent and LED has dramatically increased to 20 per cent. This data suggests an overall improvement from inefficient to efficient lighting stock of 20 per cent over the past seven years. Whilst the physical share of efficient lighting (CFL and LED) has increased, over 80 per cent of residential lighting energy consumption is still from incandescent and halogen lamps. [24]

[24] EECA BRANZ survey 2015, EECA BRANZ survey 2009

Figure 5: Share of lighting technologies in 2009 and 2015 (New Zealand)



See Attachment A for more detailed information about Australian and New Zealand stock and stock analysis.

Regulations

The E3 Program applies MEPS to a range of lamps sold in Australia and New Zealand.

The regulations are aimed at promoting the adoption of energy efficient lighting. They are given effect under the *Greenhouse and Energy Minimum Standards Act 2012* (GEMS Act) in Australia and the *Energy Efficiency (Energy Using Products) Regulations 2002* in New Zealand.

MEPS for incandescent lamps (Australia only) commenced in 2009 and were implemented in a staged approach through to 2012, resulting in the phase out of the majority of incandescent lamps in Australia. CFLs were subject to MEPS in Australia from 2009 and in New Zealand from 2012. This policy action was as a result of cheap but inefficient incandescent lamps dominating the market at the expense of more efficient lamps such as CFL and halogens. MEPS for CFLs were put in place largely to address consumer concerns about the quality and performance of products on the market.

Double capped fluorescent lamps (or linear fluorescent lamps) and ballasts for fluorescent lamps have been subject to MEPS since 2004.

MEPS, state government programs and technology improvements have increased the efficiency of lamps since 2009, with average Australian households now using 34 per cent less energy to light their home and average New Zealand households now using 14 per cent less energy to light their homes [25]. Table 4 summarises the lighting products registered under GEMS in Australia. There are 34 lighting suppliers in total.

Table 4: Number of lighting products registered in Australia as at March 2018

Product type	Registered suppliers	Registrations
Halogen Mains Voltage	11	199
Halogen Low Voltage	8	70
Transformers	6	23
CFL	19	391
Linear fluorescent	11	124
Ballasts	7	69

New Zealand lamp registrations include 98 CFLs (six suppliers) and 33 linear fluorescent lamps (five suppliers).

[25] E3, *Residential Baseline Study: 2000-2030*, prepared by Energy Consult, 2015; *EECA End Use Database*

2. The problem

MEPS and technology improvements have increased the efficiency of lamps since 2009 with average Australian households now using an estimated 34 per cent less electricity to light their homes. Similarly, improvements have occurred in New Zealand although to a lesser extent with the average household using 14 per cent less electricity to light their homes[26]. However, MEPS requirements have not kept pace with improvements in lighting technology and therefore are no longer achieving their purpose of removing the least efficient lamps from the market.

Inefficient incandescent and halogen lamps (representing 66 per cent of supermarket sales in Australia and 80 per cent of sales in New Zealand) dominate sales, are cheap to purchase at around $3 each for a standard lamp, but are a more expensive choice than the more energy efficient CFL and LED lamps when accounting for electricity, lifetime and replacement costs.

Good quality LED lamps currently exceed the efficacy of CFLs, with the additional advantages of being mercury free, long lasting and being available in a versatile range of colour temperatures and configurations to replace incandescent and halogen lamps. However the availability of poor quality LED lamps on the market, as identified by EU and E3 LED lamp test results, negatively impacts consumer confidence and uptake of this more efficient technology, reducing potential energy savings and reductions in emissions.

Information failures on lamp packaging are resulting in consumers being unable to easily obtain the information they need to make an informed decision. This includes information about the comparative electricity use and lifetime provided by the product, thus losing out on the opportunity to reduce electricity and replacement costs.

The low unit cost of lamps also makes it less likely that consumers will invest the time to understand the lifetime cost implications of their purchase decision. The New Zealand RightLight programme showed that while some consumer behaviours changed, many consumers continued to purchase the cheapest product on the market, despite a broad education campaign promoting the benefits of more efficient lighting. Consumer research in Australia and the United States provides further support that with such a small up-front

[26] E3, *Residential Baseline Study 2015*, based on improvements in the period 2009 to 2015

cost, a significant portion of the population are not motivated to spend time thinking about their lighting purchase decision and remain with the status quo.

Consumers and businesses can also be faced with the problem of split incentives. Cheap, potentially low-quality lamps are purchased by some builders and owners of commercial and rental properties as there is no long-term incentive to reduce the frequency of lamp replacement or electricity bills borne by tenants.

Problems with the current regulations

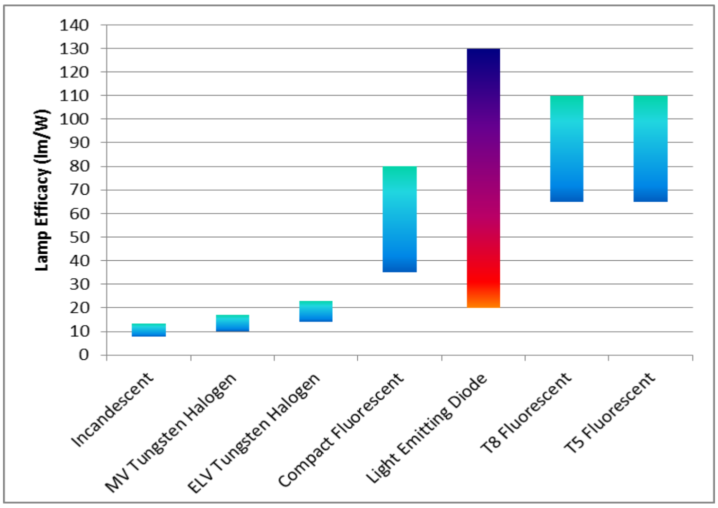
MEPS requirements have not kept pace with improvements in lighting technology and therefore are no longer achieving their purpose of removing the least efficient lamps from the market.

Figure 6 below shows the large difference in lamp efficacy between different lighting technologies based on market data. Lamp efficacy is a measure of efficiency, in lumens of light output (brightness) from a lamp per Watt of electricity. In order of increasing efficacy, lamps are typically as follows (efficacy shown for a typical 700 lm lamp):

- Incandescent: ~11 lm/W
- MV halogen: ~14 lm/W
- ELV halogen: 14–25 lm/W
- CFL: 50–75 lm/W and largely static (possibly some minor improvements being made, although this is a mature technology — research and development investment is now primarily going into LED technology)
- LED: 20–130 lm/W and increasing[27]. The average efficacy from the E3 Australian market database 2017/18 for linear LED lamps is 104 lm/W and for directional/non-directional lamps is 83 lm/Watt.
- Linear fluorescents: 65 – 110 lm/W.

[27] Includes Australian test data from 2014 to 2017, ASEAN data 2016 and US lighting facts data 2015 and 2106.

Figure 6: Typical efficacies of lamp technologies



LCA and LCNZ feedback on the Incandescent, Halogen and CFL product profile[28] is that there is not expected to be any further research and development on halogen or fluorescent lamps, rather investment is focused on LED lighting.

While there is some potential further savings that could be achieved through increasing the MEPS for CFLs, industry stakeholders have not been supportive of regulatory changes for a product they believe will rapidly be replaced by LED equivalents in the market.

The primary opportunity in achieving energy savings with LED lighting technology is through the replacement of less efficient technologies with LED lighting. Additional modest savings could also be made by removing poorer performing LED lamps from the market.

LED reputation

Evaluation of LED products currently available in the marketplace indicates a wide variation in quality and efficacy.

The Lighting Consultation RIS identified poor quality LED lamps on the market as a potential barrier to the successful phase-out of inefficient halogen lighting and transition to quality and efficient LED lighting. LED performance data over a series of years identified that while the performance of good quality LEDs had improved, there was still a range of poor quality products available that did not provide an effective alternative lighting service. The Consultation RIS referenced test results of LED testing commissioned by the E3 Program from 2009 to 2016, as well as overseas testing.

The EU, who currently have MEPS on LED lamps, published compliance results in 2017 that identify non-compliance of models with their MEPS (energy efficiency and quality

[28] E3, *Product Profile Report – Incandescent, Halogen and Compact Fluorescent Lamps*, 2014.

issues). The final report notes that the most significant problems were lamps that were not bright enough or poor lifetime performance. Flicker was also identified as a problem.

Recent testing conducted by the COAG E3 Program on LED lamps sold in Australia, identified some concerns with quality that may impact on consumer satisfaction. Problems found include:

- lamps that failed to meet the accepted level for colour rendering (to show the true colour of objects in comparison with natural light)
- lamps that failed to meet the international standards for power factor and harmonics, which when aggregated can increase costs for the energy network, which is then passed on to consumers
- inaccurate package claims, including over claiming on the amount of brightness (actual light output being significantly less than claimed on packaging)
- similar to EU testing, flicker was identified as a problem that can affect consumer satisfaction and potentially performance and more adverse health effects.

Poor quality LED lamps affect individuals, suppliers and the general community.

- Individuals purchasing relatively expensive poor quality LEDs are disappointed with the quality of the lamp – the product fails prematurely (increasing consumer cost) and/or light output and quality expectations are not met.
- Suppliers providing quality LED products are negatively impacted due to lower sales, with consumer uptake constrained or decreasing due to negative experiences, or they lose market share to inferior (lower cost) products as they are unable to compete on price.
- Overall community benefits of reducing energy use, emissions and waste is reduced as inferior LED products use more energy than necessary, fail early and do not provide a satisfactory alternative to inefficient filament lighting.

The Australian Consumer Law (ACL) does not provide the ACCC and state regulators with any role in determining which products make it to market from a quality perspective. Thus, this law will not address LED quality issues and the resulting decline in consumer confidence and take-up. The operation of the ACL and role of the ACCC is explained under 'Other policies that impact these problems' section. New Zealand's Commerce Commission and Fair Trading Act perform similar functions in New Zealand. This is not discussed in detail in this document; however further information about consumer law in New Zealand is available from the Commerce Commission website[29].

Attachment B includes a summary of LED lamp performance results for lamps purchased in 2016 and 2017 (Australian and overseas testing). For those products purchased in Australia where quality issues have been identified, an indication of sales through cross

[29] www.comcom.govt.nz/fair-trading/

matching of product supplier information with supplier import data is provided. In the absence of sales data of LED lamp models, supplier import data has been used to provide an indicative assessment of market share.

Health impacts of poor quality LED lamps

There may be a risk in forcing the market transition from halogen to LED products without requiring a standard to limit the possibility of light sources producing light output that can be harmful to some humans.

Photo-biological safety (blue light hazard and UV hazard)

Excessive blue light in LED lamps can cause retinal damage in some circumstances and UV exposure can cause harm to vulnerable groups. Suppliers, under electrical safety regulation, are already required to undertake testing for biological safety for mains voltage LED lamps to prevent humans from being exposed to harmful light (excessive blue light and UV hazard light), however, electrical safety does not cover LED extra-low voltage (< 50V) lamps in Australia.

Photo-biological safety testing is defined in an IEC test standard. Existing EU regulation requires this IEC test to be undertaken for all LED lamp types before supplying products to the EU market.

Temporal light artefacts – flicker and stroboscopic effects

Undesired changes in the perception of the environment caused by LED light that fluctuates is called “temporal light artefacts” (TLAs) and includes short term flicker and stroboscopic effects (non-visible flicker). Testing has found products on the market in the EU and Australia with TLA. The use of low cost driver circuits in manufacturing can cause this undesirable light output.

Human impacts of TLA can include a decrease in human performance, increased fatigue as well as acute health problems, such as epileptic seizures and migraine episodes (Source: International Commission on Illumination (CIE) TN 006:2016). Further information on this issue is included at Attachment C.

Imperfect information

Information failure is a problem as buyers are not able to easily compare the lifetime costs or comparative quality and performance of different lamp technologies, and therefore are missing out on electricity and replacement savings.

Market research has shown that consumers often lack knowledge about estimating the electricity use, equivalency and running costs for different lighting technologies. They may also make decisions based on incorrect or implied marketing information or limited understanding, for example that low voltage halogen lighting is efficient ('low energy') [30].

The 2016 Australian consumer survey found that only 55 per cent of i-VIEW respondents (sample considered to be representative of the general public) identified LEDs as the most energy efficient form of lighting, with 10 per cent considering that halogen lighting was the most energy efficient compared to 15 per cent who selected CFLs, and 12 per cent did not know. Similarly, only 50 per cent of i-VIEW respondents identified LED lighting as having the longest lifetime, with 14 per cent who did not know, 14 per cent selecting CFL and eight per cent selecting halogen[31].

Australian import and sales data shows that with the phase out of incandescent lamps in 2009, approximately 50 per cent of consumers shifted to halogens which, whilst slightly more efficient than incandescent, are relatively inefficient in comparison to CFLs available at that time.

Consumer research undertaken in Australia in 2010, to evaluate the education campaign that ran from 2008 to 2010[32], assists in understanding why consumers transitioned to halogen with the removal of the least efficient incandescent lamps.

- Halogens were seen as the improved incandescent; many people preferred the overall physical shape, colour and brightness of halogen and the familiarity with incandescent lamps was seen as a reason why people may increasingly purchase them in preference to CFLs.
- Many respondents expressed issues with the light characteristics or compatibility issues of CFLs.

The research also found that many consumers still lacked confidence in choosing the right lamp in terms of brightness, colour and differences between technologies. To address this issue in the future, the evaluation recommended that clear messaging on packaging would be valuable, provided it appears on all packaging.

Finally, the evaluation identified that 80 per cent of respondents said that energy efficient lighting is very or quite important to them. At that time halogen was presented as a more efficient option than incandescent and as such many of those who transitioned to halogen may have considered that this was an energy efficiency choice.

The *Consumer Household survey 2016* provides more recent insight to why consumers are still purchasing halogen. Of the 608 CHOICE respondents who had halogen installed in their homes, 41 per cent identified this was because they are replacing like for like based on

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[30] Winton Sustainable Research Strategies, 2011.

[31] E3, Consumer Household Survey, 2016.

[32] Winton Sustainable Research Strategies, 2010.

what they have in their home, 21 per cent because they prefer their light output, 19 per cent because they work best with their dimmer and seven per cent identified purchase price as the reason.

In New Zealand, (which adopted an education approach to transition away from incandescent lamps while later putting in place a MEPS for CFLs only), the majority of consumers chose to remain with incandescent lamps while some responded to education by moving to mostly halogen.

The New Zealand survey of consumers in December 2015[33] shows that around 53 per cent of respondents agreed that LED lamps would reduce household energy costs, with 40 per cent neither agreeing nor disagreeing.

Recent research in the United States has highlighted that lighting can face a higher barrier than other technologies in regards to the perception of operating cost information and potential reductions in energy bills[34]. Results suggest consumers are pessimistic about (or pay little attention to) future economic savings delivered from the energy efficient alternatives[35].

New Zealand supermarket sales and consumer research support the view that with such a small up-front cost, a significant portion of the population do not spend time thinking about their lighting purchase decision and remain with the status quo.

Lifetime cost

The lifetime cost (purchase price, replacement frequency and electricity charges) to light our homes and businesses is often not clear, and it is hard for consumers to quantify savings that can be made by replacing a less efficient lamp with one that is more efficient.

- The consumer needs to first identify the equivalent LED lamp, then calculate or otherwise identify the amount of electricity consumed by the original and alternative lamps and, using their marginal electricity tariff, calculate the electricity costs of the alternative lamps. Electricity usage and associated costs from lighting is combined with other electrical appliances on electricity bills and provided on a periodic basis, meaning that lighting electricity costs are not easily identified and the effectiveness of investing in energy saving lamps not well understood.

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33 EECA, LED Lighting consumer survey, Ipsos, 2015.

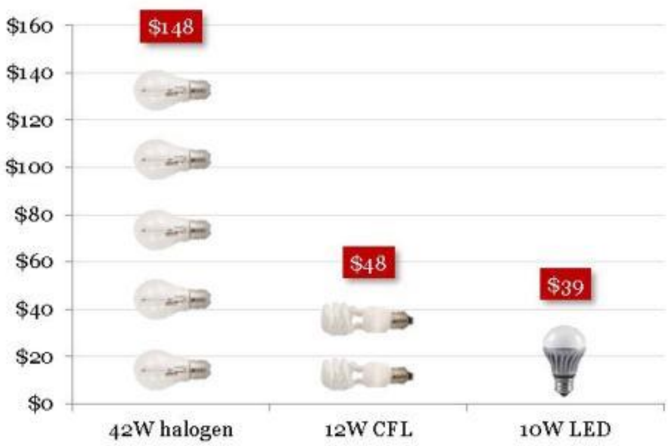
34 'Perception' was determined by conducting a field experiment with 183 participants and using the implicit discount rate (IDR) method. IDR is a method used by researches to measure the relative priority consumers place on energy efficiency verses upfront cost when making technology purchases.

35 J Min, I Azevedo, J Michalek and Wändi Bruine de Bruin, 'Labelling energy cost on light bulbs lowers implicit discount rates', *Ecological Economics, vol. 97, 2014, pp. 42-50.*

- The consumer requires a good basis for either trusting the sources of such information or verifying the promised performance, and the ability to do the calculations.
- In the *2016 Consumer Household survey* 80 per cent of respondents indicated that they would be more likely to buy LEDs when the lifetime cost was explained.[36]

Two of the main differences between lighting technologies are lifespan and efficiency. While a halogen lamp is cheaper to buy than an LED, a good quality LED lasts five to 15 times longer and consumes a quarter of the energy. For example, a lamp (running three hours per day) that produces 800 lumens has a lifetime cost over 10 years of $39 for LED, in contrast to $48 for CFL and $148 for halogen[37].

Figure 7: Lifetime costs of halogen, CFL and LED lamps over 10 years, with 800 lumen output



However, the amount of information and calculations required to compare the lifetime cost of different lamps, contrasted with the small up-front purchase cost, makes it less likely that consumers will invest the time required to make an informed decision on this cost. This is supported by the 2016 Australian consumer survey i-VIEW results which found that whilst 47 per cent were familiar with the claim that LEDs use less electricity than halogen lamps, and 43 per cent were familiar with the claim that LEDs last longer than halogen lamps, only 25 per cent were familiar with the claim that LEDs are cheaper overall than halogen lamps. Consumer research in New Zealand[38] indicates that although the majority of people agreed that LEDs would significantly reduce household energy bills (53 per cent) and are overall better value for money (52 per cent), a large proportion (40 per cent) neither agreed nor disagreed.

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[36] E3, 2016.

[37] Based on lifetimes of 6000 hours for CFL, 2000 hours for halogen and 15000 hours for LED; an LED purchase price of $10, CFL price of $6 and halogen price of $3; electricity tariff of 28.55c/kWh.

[38] EECA, Consumer Monitor survey, Ipsos, 2015.

These surveys suggest that consumers are not being provided with the information they need to make an informed decision on lifetime cost, or are not motivated to do so given the low purchase price of light bulbs and light bulbs being one of many purchases made at the supermarket or trade store.

Some retailers in Australia and New Zealand are continuing to promote LED technology with their own marketing and promotions. This includes charts displayed in-store to assist customers in finding a more energy efficient replacement lamp, highlighting information on 'lumens', differences in energy use and lifetime. The fact that in New Zealand, with a broad government campaign supplemented by retailer communication, a significant portion of consumers continue to use incandescent lamps lighting, suggests consumers may not be motivated to spend time on lamp purchase decisions and instead opt to remain with the status quo.

Quality and performance criteria

In addition to difficulty in calculating lifetime costs, buyers are unable to easily compare quality and performance criteria for different lighting technologies. Halogen lamps (in Australia only) and CFLs are required to display watts, lumens, lifetime (and mercury for CFLs) on product packaging and be accurate in any claims of incandescent equivalency. However, there are no mandatory labelling requirements for LED lamps. The absence of efficacy (lumens/watt) from all lighting technologies makes the comparison of efficiency within and between lighting technologies more difficult. The majority of consumers (55 per cent) use equivalence claims as a guide to lamp brightness, while 18 per cent use wattage and only 15 per cent use lumens (light output) as a guide[39]. Some manufacturers are also continuing to highlight watts on packaging as opposed to lumens, which makes the comparison of lamp technologies more challenging for consumers.

Compatibility concerns

The Australian *2016 Consumer Household survey* suggests that some consumers are purchasing halogen lamps due to compatibility concerns with LED lamps. Reasons provided by the 10 per cent of survey respondents who stated that they would not buy LED lamps in the future included transformer or dimmer compatibility concerns and the belief that their light fitting would need to be changed over to fit an LED. Other reasons were upfront cost, light quality and they did not believe claims of lifetime and energy efficiency. Of the sample, 43 per cent of households had a dimmer in their home and of these 62 per cent advised they had experienced issues with compatibility with certain lamps – 59 per cent CFL and 42 per cent LED.

As part of the 2016 residential lighting audit, 16 per cent of respondents with dimmers in their homes reported compatibility issues in using LED lamps with their dimmers.

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[39] E3, Consumer Household Survey, 2016

Compatibility is further explored under the options section of this RIS.

Split incentives

Principal-agent problems exist in both the commercial and residential market. While the energy performance of large commercial buildings is subject to mandatory disclosure laws in Australia, cheap inefficient lamps are still purchased for some commercial and rental properties and new properties for sale as there is no incentive to reduce replacement or electricity costs. For example, a builder or property owner (the agent) may choose cheaper, less efficient lighting to minimise their build costs. Even in cases where the agent may select LED lighting, they may choose relatively cheaper models that are comparatively less efficient or of poor quality and reliability when compared to other efficient lighting alternatives. This is not always in the best interest of the building occupant (the principal) who is exposed to the operating costs and quality of the lighting system installed. In the case of LED lighting, the exposure to higher operating costs or poor quality may occur over a long lifetime.

The *Commercial Lighting Product Profile*[40] also identified significant variations in the efficacy (judged by the light output ratio) of commercial luminaires[41] in the market, demonstrating that whilst more efficient products exist, due to split incentives there remains demand for cheap, inefficient, poor quality products.

Short term renters may consider that the higher purchase price of efficient lamps may not be worth the investment if they intend not to live at the same address for long enough to fully benefit from long life efficient lamps. A similar disincentive may affect owner-occupiers who intend to sell or rent the property. Australians and New Zealanders are highly mobile – according to the 2011 Australian Bureau of Statistics (ABS) census, 15 per cent of individuals were at a different address 12 months earlier[42] and 39 per cent were at a different address five years earlier[43]. Similarly, Statistics New Zealand found that in 2013 that 50.6 per cent of people were in a different address to five years previously.[44] In part, the reluctance of renters to invest in LED may be due to an information failure. As stock is upgraded to CFL or LED, renters will also benefit through savings in replacement costs.

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[40] E3, 2015.

[41] A luminaire includes all the parts necessary for supporting, fixing and protecting lamps, but not the lamps themselves.

[42] www.abs.gov.au/websitedbs/censushome.nsf/home/statementspersonpur1p?opendocument&navpos=450.

[43] www.abs.gov.au/websitedbs/censushome.nsf/home/statementspersonpur5p?opendocument&navpos=450

[44] www.stats.govt.nz

Recent New Zealand consumer research identified the purchase cost of LEDs as a barrier for 24 per cent of consumers[45]. Similarly, in the *2016 Residential Lighting Audit* (Australia), about 20 per cent of respondents identified LEDs are still too expensive.

While the cost of LED lamps is still higher than halogen, this cost has reduced rapidly over the last several years and is predicted to continue[46]. Based on a retail review of pricing in 2017, consumers in Australia are paying around $4 extra for a standard residential LED lamp compared to a standard halogen lamp (halogen $3 and LED replacement $7). A similar cost variance exists for extra low voltage downlights, whilst mains voltage LED downlights cost approximately $10 in comparison to the halogen equivalent at $4.

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45 EECA Consumer Monitory survey, Ipsos, 2015.

46 McKinsey & Company, *Lighting the way: Perspectives on the global lighting market*, 2012.

Other policies that impact these problems

The problems outlined above relate to problems with current regulations, information failures and principal-agent problems that are restricting the uptake of more energy efficient long life lamps. Although these issues cannot be specifically addressed by other policies, other Australian or New Zealand government programs that promote energy efficient lighting are discussed in this section.

Further, the operation of the Australian Consumer Law (ACL) and the role of the ACCC is explained. New Zealand's *Commerce Commission and Fair Trading Act* perform similar functions in New Zealand. This is not discussed in detail below, however further information about consumer law in New Zealand is available from the Commerce Commission website[47].

Interior lighting

The AS/NZS 1680 series for interior lighting contains minimum recommended illumination levels for performing a range of visual tasks efficiently and without visual discomfort. While the AS/NZS 1680 series itself is not mandatory, parts of the Standard are referred to in other legislation as a mandatory requirement (e.g. *1680.0:2009 Interior lighting - safe movement* is mandatory as required by the Building Code of Australia). There is no recommendation on efficiency of lighting products within this standard series.

Australia

State incentive schemes

State-based schemes that aim to reduce the consumption of electricity by encouraging the implementation of energy saving activities operate in New South Wales, Victoria, South Australia and the Australian Capital Territory. These schemes generally oblige electricity retailers and other large energy users to meet energy savings targets by purchasing and surrendering tradeable energy savings certificates. These certificates are created by energy savings projects, such as the bulk purchase and installation of lighting, which are more energy efficient than those that would otherwise have been installed. Projects such as these are often undertaken by third parties.

These schemes act alongside current GEMS Act lighting MEPS to reduce energy used by residential and commercial lighting.

Emissions Reduction Fund

The Emissions Reduction Fund (ERF) commenced in late 2014. The ERF is designed to provide incentives for achieving lowest cost emissions reduction activities across the Australian economy. A number of methods have been approved for use under the ERF,

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47 www.comcom.govt.nz/fair-trading/

including commercial lighting which allows for upgrades to commercial lighting to implement energy efficient technology[48].

National Construction Code and Building Code of Australia

The National Construction Code (NCC) applies to building work such as new builds and major renovations, thus restricting influence on lighting efficiency to certain stages in the building lifecycle, whereas product based regulation relates to replacement products used at all stages. Administration of the NCC is the responsibility of the states and territories under their various building and plumbing Acts and Regulations.

Volumes One and Two of the NCC detail technical provisions for building design and construction including energy efficiency. For artificial lighting there is a maximum illumination power density requirement (Watts/m^2) for new construction or significant renovation. The purpose is to avoid over-installation and excessive use of lighting, and improve the use of efficient lights and fittings.

The maximum aggregated lamp power density of hard-wired electric residential lighting is:

- 5 Watts/m^2 for internal areas
- 4 Watts/m^2 for exterior areas
- 3 Watts/m^2 for garages.

Table 5 specifies the Building Code Australia maximum illuminated power density requirements for spaces in commercial buildings and the corresponding AS 1680 lighting levels and lumens per watt. The NCC, as of 2016, is on a three year cycle, which means levels will be revised in 2019 (currently under consultation).

Table 5: Building Code Australia maximum illuminated power densities for select spaces in commercial buildings (NCC 2016)

Building Space	W/m^2	Recommended Lux Level (as per AS/NZS 1680 Interior Lighting)	lm/W
Board room and conference room	10	240	24
Corridors	8	160	20
Entry lobby from outside the building	15	160	11
Office – artificially lit to an ambient level of 200 lux or more	9	320	33
Office – artificially lit to an ambient level of less than 200 lux	7	160	23
School – general purpose learning areas and tutorial rooms	8	320	40

48 www.environment.gov.au

The NCC (Clause J6.3) contains provisions for the switching and control of lighting in commercial buildings, with the intention that 'rooms are not unnecessarily lit or using power when vacant'. Appropriate design requirements for lighting and power control devices are contained in the Specification to Part J6. This includes corridor lighting timers, time switches, motion detectors, daylight sensors and dynamic control devices[49].

Commercial Building Disclosure (CBD)

The CBD program is a national initiative designed to improve the energy efficiency of Australia's large office buildings. The program requires a current Building Energy Efficiency Certificate (BEEC) to be obtained and disclosed at the sale or lease of commercial office space of 1000 m^2 or more. The BEEC is comprised of a National Australian Built Environment Rating System (NABERS) energy star rating for the building, and an assessment of tenancy lighting in the area of the building that is being sold or leased, and general energy efficiency guidance[50].

The Australian Consumer Law (ACL)

The Australian Consumer Law is the uniform Commonwealth, state and territory consumer protection law that commenced on 1 January 2011. It forms part of the national consumer policy framework which also includes a national product safety regime and improved enforcement, cooperation and information sharing arrangements between Commonwealth, state and territory consumer protection agencies.

Relevantly to consumer protection for poor-quality LED products, the ACL contains prohibitions on misleading and deceptive conduct and false representations, a system of consumer protections and remedies in relation to defective goods and services (the 'consumer guarantees') and a harmonised national product safety and enforcement system.

Misleading and deceptive conduct

It is illegal for a business to engage in conduct that misleads or deceives or is likely to mislead or deceive consumers or other businesses. In addition to the prohibition against misleading or deceptive conduct, it is unlawful for a business to make false or misleading claims about goods or services.

While consumer protection agencies including the ACCC may take an action for breach of the ACL where suppliers are misrepresenting the nature of their goods and obtain penalties against these traders, the ACL does not provide these regulators with any role in determining which products make it to market from a quality perspective (whereas there is

[49] National Construction Code, 2016.

[50] www.cbd.gov.au

legislative recourse to intervene where unsafe products are detected in the market – see below).

Product safety

Traders cannot sell banned products and must ensure that products or product-related services comply with relevant mandatory standards before they are offered for sale.

Under the ACL's product safety provisions, Commonwealth, state and territory ministers can regulate consumer goods and product-related services by issuing safety warning notices, banning products on a temporary or permanent basis, imposing mandatory safety standards or issuing a compulsory recall notice to suppliers.

Consumer guarantees

The ACL sets out consumer rights that are called consumer guarantees. These include rights to a repair, replacement or refund as well as compensation for damages and loss and being able to cancel a faulty service.

The ACCC

The ACCC cannot pursue all the complaints it receives or issues that come to its attention about the conduct of traders or businesses, and the ACCC rarely becomes involved in resolving individual consumer or small business disputes. While all complaints are carefully considered, the ACCC's role is to focus on those circumstances that will, or have the potential to, harm the competitive process or result in widespread consumer detriment. The ACCC therefore exercises its discretion to direct resources to matters that provide the greatest overall benefit for competition and consumers. The ACCC's compliance and enforcement policy sets out how the ACCC prioritises matters.

The ACCC received 67 complaints about LED Products in the period 2012 to 2016. The ACCC has not taken any specific enforcement actions with regard to LED products. The ACCC has had previous active engagement with the Department on topics including consumer information issues in the (then) emerging LED market.

Specialist regimes

The ACCC considers that ACL regulators cannot replicate the focus and expertise that specialist regulators deliver. Parliaments have identified enhanced public risk or the need for particular expertise and established specialist regulators in several industries including electrical safety and energy efficiency. While ACL regulators can and do provide strategic interventions in important matters, and while the ACL provides an important role to assist with emerging practices, they are not substitutes for specialist regulators[51].

[51] ACCC, 2016.

New Zealand

Building energy ratings and audits

EECA Business in New Zealand have developed the NABERSNZ™ (National Australian Built Environment Rating System New Zealand) programme, administered by the New Zealand Green Building Council (NZGBC). Commercial buildings can gain a certified rating to benchmark the building or tenancy for its energy efficiency. Along with energy audits, this can encourage building owners to improve the energy efficiency of their lighting systems.

Legislative and policy framework

The *Energy Efficiency and Conservation Act 2000* provides the legislative framework for the New Zealand Energy Efficiency and Conservation Strategy (NZEECS), the operation of the Energy Efficiency and Conservation Authority (EECA) and the making of regulations pertaining to energy using products and services.

The policy context for improving the energy use of products available for sale in New Zealand is set out in the *New Zealand Energy Strategy 2017-2021*. This outlines key priorities and strategic direction across New Zealand's energy sector, including the efficient use of energy.

Its companion document, *The New Zealand Energy Efficiency and Conservation Strategy 2017-2022*, sets actions and targets which will contribute to achieving the Government's policies and objectives. One of the three priority areas identified by the Strategy is the innovative and efficient use of electricity. The target for this priority area is that 90% of electricity will be generated from renewable sources by 2025 (in an average hydrological year) providing security of supply is maintained. Significant progress has been made towards this target over the last few years, due in part to increasing uptake of energy efficient technologies. MEPS and labelling "contribute to the Government's policy priorities of innovative and efficient use of electricity by improving the energy performance of products, such as fridges, freezers and heat pumps."

Building Act 2004 and Building Code

The *Building Act 2004* sets out the rules for the construction, alteration, demolition and maintenance of new and existing buildings in New Zealand. The regulations under the Act prescribe the Building Code, which all building work must comply with. Performance standards that must be met include energy efficiency (Building Code H). Building Code Clause H1.3.5 states that artificial lighting fixtures must:

(a) be located and sized to limit energy use, consistent with the intended use of space; and
(b) be fitted with a means to enable light intensities to be reduced, consistent with reduced activity in the space.

Artificial lighting energy consumption in commercial, communal non-residential buildings with a net lettable area greater than 300 m² must comply with NZS 4243.2 section 3.3 or section 3.4 to satisfy the requirements of New Zealand Building Code H1.3.5. A lighting power allowance based on the illumination power density (watts per square metre) is set out in NZS 4243.2:2007 Table 1 Lighting Power Density Limit. A new version of this Standard, NZS 4243.2:2018 has been published, but not yet incorporated into the Code.

ENERGY STAR

New Zealand previously adopted the ENERGY STAR program as a voluntary scheme to provide endorsement labelling for high efficiency products. The US ENERGY STAR specification for lamps was adopted in New Zealand in November 2012, with modifications made to adapt it to the local market, and updated in December 2013. However, New Zealand exited this scheme in 2017.

3. Objectives

Why is government action needed?

This Consultation RIS raises a number of problems that are restricting the uptake of energy efficiency lighting in Australia and New Zealand, which is resulting in the community paying more for electricity and producing more emissions than is necessary to deliver our lighting needs.

The objective of the proposed government action is to improve the energy efficiency of lighting in Australia and New Zealand, while maintaining lighting quality, by addressing the issues that are restricting the purchase of efficient, effective long-life lighting products in Australia and New Zealand. This objective is consistent with the Australian and New Zealand government's policies to reduce greenhouse gas emissions and improve energy productivity.

To ensure options will be effective and practical, the Department has consulted extensively with the lighting industry and undertaken consumer research to inform analysis.

Without government action, the transition to efficient lighting in Australia and New Zealand will be slow and incomplete, with more energy being consumed and higher electricity costs for consumers than is necessary.

4. Policy options

Policy options under consideration

This RIS considers policy options to resolve problems identified. The original proposals have been modified after feedback on both the Consultation RIS and the supplementary consultation document. The following policy options are considered to address the problems identified in this RIS:

- No changes to the existing requirements - **Business as Usual** (BAU)
- **Option A** involves implementing MEPS for LED lamps to address quality issues and improve efficacy.
- **Option B** includes option A, as well as increasing incandescent and halogen MEPS (Australia only) to remove the most inefficient lamps, consisting of categories of halogen and incandescent lamps.

The Consultation RIS included proposals to introduce MEPS on LED integrated luminaires, introduce MEPS on non-integrated commercial luminaires and introduce mandatory labelling (see Attachment D for details, including other options explored). Based on feedback, these proposals have been removed from the Decision RIS.

Business as usual

Business as usual assumes no change to existing regulations in Australia and New Zealand.

The natural improvement of energy efficiency lighting is projected to continue as industry focusses on LED technology and consumers transition to LED. However, consumers would still be exposed to wide variation in product quality and performance, which will constrain uptake by some consumers. Information failures will remain, meaning consumers will have difficulty in making informed decisions to select more efficient, cost-effective alternative products. Consumers and businesses would continue to pay more for extra replacements and unnecessary electricity usage, losing out on savings.

The IEA 4E 2015 Lighting Benchmarking review looked at the status of lighting energy efficiency in a range of countries that had put in place efficiency measures (Australia, Austria, Canada, Denmark, Japan, Korea, UK, and USA)[52]. It found that while intervention had led to a significant reduction in market share of incandescent lamps, the anticipated increase in the average efficacy had not been as high as expected (Australia's intervention

[52] IEA 4E, 2015.

has been more effective than all but Republic of Korea). The study identified that the relatively small increases in efficacy appears simply to be that consumers are migrating from the purchase of incandescent lamps to the purchase of marginally more efficient halogen products, resulting in the risk that halogens become the new 'default' lamp of choice for consumers.

The policy options are summarised in the table below.

Table 6: Policy proposals

Policy Proposal	Option A	Option B
1. Introduce MEPS for LED lamps: Harmonise MEPS for LED lamps with the requirements of the EU MEPS regulation currently under consultation as applied to LED lamps– both in terms of test parameters regulated and performance requirements against those parameters, and timing of introduction. Includes an innovative approach to product registration and compliance to lower implementation costs for industry.	X	X
2. Increase incandescent and halogen MEPS (Australia only) to remove the most inefficient lamps including a number of categories of halogen lamps (excluding those lamps where there is no equivalent LED lamp readily available on the market).		X

Option A

Introduce MEPS on LED lamps at least cost to industry to remove inefficient and poor quality LED lamps from the Australian and New Zealand market. This would address the identified problems of consumers being exposed to a segment of LED products that negatively impact on consumer confidence and split incentives whereby some property owners and builders have no incentive to purchase higher quality, but higher upfront cost products.

This option includes alignment of test standards and levels with the EU replacement regulation for MEPS on lighting, as it relates to LED lamps, currently planned to be finalised in late 2018. The LED lamp Determination under the GEMS Act will not include EU MEPS regulation that will apply to a broader range of LED products and other lighting equipment types (e.g. LED luminaires, halogens and fluorescents), or any EU mandatory energy rating label requirement. It is expected that basic product and package marking requirements will be necessary to allow consumers to effectively replace lamps. Details to be finalised in consultation with stakeholders as part of the determination process.

Registration will be integrated in the Electrical Equipment Safety System with electrical safety to enable a single point of registration. GEMS will not require test reports to be uploaded for registration and as such registration fees will be lower. Family of models definition (rules for determining models that can be registered under the one family) will align with electrical safety.

Where compliance of a model under GEMS is identified, the supplier will be given the opportunity to demonstrate that other models in the family are compliant, similar to the approach adopted by electrical safety. E3 will consult with stakeholders to finalise the tolerance level for any check testing of LED lamps, informed by the EU approach.

Registration options for New Zealand will require further consideration, however, EECA will work to ensure that these are well aligned both with the proposed registration system for Australia, and the Energy Efficiency (Energy Using Products) Regulations 2002.

The EU revised regulations are expected to be finalised in late 2018. If a Decision RIS policy option is approved, a new Greenhouse and Energy Minimum Standards (GEMS) determination would be created for LED lamps, with equivalent regulation created in New Zealand under the *Efficiency (Energy Using Products) Regulations 2002*.

The draft determination, based on the revised EU lighting regulation, will be reviewed by the Lighting Energy Efficiency Advisory Group. As the proposed EU regulation relates to a broad range of lighting technologies, it will be necessary to translate this as applied to LED lamps only. The exposure draft determination will also be released for public comment before being provided to Energy Council Ministers for consideration (expected by early 2019).

This timing would provide stakeholders with around 18 months to comply with new regulations. Cost estimates to comply with the regulation are under section 5. Costs on suppliers are based on available information on the draft EU tests proposed.

Option B

Includes option A and the proposal to increase incandescent and halogen MEPS (Australia only) to CFL levels to remove the most inefficient lamps from the market.

As outlined above, these lamps are significantly less efficient than LED and CFL alternatives. This option would prevent consumers and businesses from being exposed to unnecessarily high electricity lighting costs and significantly reduce Australia's energy use and emissions for the benefit of society. Under this option, consumers would be required to pay more upfront but would save money due to a significant reduction in their electricity costs and less frequent lamp replacement costs.

Attachment E details the phase out of a range of halogen lamps, accounting for feedback received from stakeholders on exemptions for some product types. The phase out would occur with introduction of MEPS on LED lamps (currently planned for September 2020).

Suppliers could continue to import these products types until the start date of the new MEPS level. Previously imported stock of products could continue to be sold on the market until stock is depleted.

Understanding the costs of this option includes analysis of the extent of compatibility of LED products with existing dimmer systems. Dimmer compatibility issues and associated consumer costs are covered in section 5.

Dimmer compatibility with LED

Some LED lamps may not be compatible with existing lighting systems that include a dimmer circuit, resulting in the LED lamp not operating satisfactorily (flickers, restricted dimming).

Options where incompatibility occurs include trying another model of LED lamp (preferably with advice from a lighting retailer or supplier), engaging a qualified electrician to remove or upgrade the dimmer system or advise of a compatible lamp, or setting the dimmer to 100 per cent to avoid/defer upgrade costs.

Feedback from lamp and dimmer manufacturers indicated that older phase-cut dimmers (using leading edge technology) are likely to be the most problematic, with more recent models using trailing edge technology having a high level of compatibility with LED dimmable lamps. Whilst manufacturers provide compatibility information with dimmers on the market, information on legacy products is not maintained.

To understand the level of compatibility of dimmers installed with LED dimmable lamps on the market in 2016, the E3 Program engaged NECA to conduct compatibility testing. The purpose of the testing was to identify the extent of compatibility to inform consumer impacts for this option, and assess the benefit of a lookup resource for electricians to identify suitable LED dimmable lamps to work with existing dimmer systems. Results were mixed, showing that some households would incur upgrade costs while in some cases there was an opportunity to reduce transitional costs through communicating compatible products.

The Department in consultation with suppliers undertook further independent testing in 2017 on the most common legacy dimmers installed in Australian homes with LED standard lamps (non-directional) and LED mains voltage downlights available on the market. A number of lamps were found to be highly compatible with the majority of dimmers tested. Test results identified that 18 of 18 dimmers work satisfactorily with at least one lamp/downlight on the market, 16 work with at least two and 10 work with at least three. Three of the dimmers worked with six of the lamps tested and two dimmers worked with seven of the lamps tested.

The Department is liaising further with stakeholders on the benefit of releasing a lookup tool for electricians to assist householders in identification of compatible products. Further testing is also being undertaken to verify reliability/performance of combination products.

<u>Workarounds</u>

Households could choose to trial one lamp first before purchasing further lamps, avoiding the cost of an electrician to identify their dimmer model number.

Households unable to find a compatible lamp can avoid/defer the upgrade cost and still use their LEDs if they are willing to set the dimmer at 100 per cent. Most households will be able to avoid/defer the upgrade cost and still use their LEDs if they are willing to set the dimmer at 100 per cent. This workaround was found to work in 70 per cent of cases based on the 19 dimmers and eight LED lamp combinations tested. There is one dimmer that has not worked with any lamps tested. The supplier has advised that approximately 20,000 of this dimmer model was sold.

Electricians may also identify alternative appropriate workarounds to resolve compatibility issues (due to different equipment specifications, network distribution characteristics, voltage variations, cable lengths and types). Possible solutions include the installation of load correction devices, inductive or resistive load devices and circuit timing switches.

Other transition issues considered are detailed in Attachment F.

5. Cost benefit analysis

Business as usual

Under BAU, there is no change to the regulations for lighting products. The energy efficiency benefits arising from these requirements will continue to accrue, as well as benefits from the ongoing ‘natural’ market transition to more efficient lighting such as LED lamps.

Option A

Option A applies a MEPS to LED lamps. Under Option A, the impacts would be:

- For consumers, this option would prevent the sale of low quality, less efficient LED lamps. This would ensure that LED lamps provide an effective as well as efficient lighting solution, giving rise to consumer confidence in efficient LED lighting technology and ensuring that potential energy savings are realised.
- For suppliers, the minimum standards would provide a level playing field, removing inferior products that are unable to meet minimum efficacy and quality criterion.
- Compliance with MEPS would require testing of products and registration, including a fee to register each family of models in Australia (no fee applies in New Zealand)[53]. 16 per cent of LED lamp suppliers already register other lighting technology under existing GEMS regulations.

Option B

Option B includes LED lamp MEPS (option A), as well as increasing the scope and stringency of existing incandescent and halogen lamp MEPS to remove the most inefficient lamps from the market (this proposal applies to Australia only). Under this option:

- Consumers would be required to pay more upfront for either an LED or CFL replacement for an incandescent or halogen lamp. However, this upfront cost would be more than offset over the life of the lamp, due to reduced electricity consumption and less frequent bulb replacement (LEDs and CFLs have significantly longer lifetimes).

[53] A family of models allows a number of lamps to be treated as a grouped registration on the basis that the main characteristics of the lamps are the same.

- Some consumers would also require an electrician to upgrade existing lighting equipment (some dimmers and motion sensors) due to incompatibility with LED technology.
- This option would remove regulatory burden for some suppliers of incandescent and halogen lamps, as these products types would no longer be able to be sold in Australia.
- Renters may consider that they are disadvantaged by this option as they may move before obtaining the full benefits of long life energy efficient lamps. Whilst renters would be required to pay more for a lamps, they will also benefit from energy efficient lamps already installed at their next rental property. That is, as rental property lighting is replaced the next renter is unlikely to incur any replacement costs and would benefit from reduced electricity and lamp replacement costs.
- Property owners, as opposed to renters, would be responsible for upgrading the lighting system if compatibility issues occurred with the existing dimmer system. For tax purposes these costs can be claimed as a 'repair' or 'capital expense' depending on the circumstances. As part of communication material, the Department will work with the Australian Tax Office to develop guidance around this subject.

Consumer benefits

The household case studies below show that the higher upfront costs of upgrading to LED are returned within one year through energy savings. This is based on all lamps being used for an average of 1.6 hours per day and current LED prices (assuming no dimmers required to be changed)[54]. The number of halogen lamps for replacement is based on the predicted mix of lighting technology (halogen, fluorescent and LED) existing in townhouses and detached homes[55]. Savings will vary pending the number of lamps replaced with LED and usage.

A family living in a townhouse that replaces 7 standard halogen lamps (non-directional) with LED replacements would spend $49 extra on lamps initially (total purchase cost of LED), and would save an estimated $50 annually on their electricity bill. Over time they would also save a total of $35 on lamp purchases (as LEDs last longer, and don't have to be replaced as often as halogens). The estimated electricity bill for a townhouse in 2017–18 is $969 — this family would be **$530 better off over 10 years** through savings in energy and replacement costs.

[54] Based on lamp operating hours of 1.6 hours per day; $0.2855 per kWh; 2,000 hours halogen lifetime and 15,000 hours LED lifetime; $3 standard halogen and $7 LED replacement. All prices are assumed to remain static over 10 years. No discounting applied.

[55] Data from the *E3 2016 Residential Lighting Report and E3 Residential Baseline Study 2015* have been used to extrapolate the average number of halogen light bulbs in townhouses and detached homes.

A family living in a detached house that replaces 10 standard halogen lamps (non-directional) with LED replacements would spend $70 extra on lamps initially (total purchase cost of LED), and would save an estimated $71 annually on their electricity bill. Over time they would also save a total of $50 on lamp purchases (as LEDs last longer, and don't have to be replaced as often as halogens). The estimated electricity bill for a detached house in 2017–18 is $1529 — this family would be **$759 better off over 10 years** through savings in energy and replacement costs.

A family living in a townhouse that chose to replace 11 halogen lamps (standard or downlight) with LED lamps would spend $77 extra on lamps initially (total purchase cost of LED), and would save an estimated $66 annually on their electricity bill. Over time they would also save a total of $48 on lamp purchases (as LEDs last longer, and don't have to be replaced as often as halogens). They also have to replace 3 dimmers that aren't compatible with LED lamps, this would cost an estimated $250. The estimated electricity bill for a townhouse in 2017–18 is $969 — this family would be **$457 better off over 10 years** through savings in energy and replacement costs.

A family living in a detached house that chose to replace all of their 18 halogen lamps (standard or downlight) with LED lamps would spend $126 extra on lamps initially (total purchase cost of LED), and would save an estimated $113 annually on their electricity bill. Over time they would also save a total of $77 on lamp purchases (as LEDs last longer, and don't have to be replaced as often as halogens). The estimated electricity bill for a detached house in 2017–18 is $1529 — this family would be **$1205 better off over 10 years** through savings in energy and replacement costs.

Renters, as opposed to home owners, are more likely to replace lamps on failure, as opposed to upgrading all their lights to reduce energy costs, particularly where short term leases apply. Renters may adopt an approach of swapping out halogen or incandescent lamps in high usage areas and replacing with LED or CFL lamps to reduce upfront costs. Given the above, it is considered that renters will not be negatively impacted by this policy option.

Consumer costs

Consumer costs include the estimated costs for households to upgrade their dimmer systems, where their existing dimmer(s) currently used with standard halogen lamps (non-directional) do not work effectively with an LED replacement lamps (the lamp flickers, does not dim satisfactorily or makes a noise).

It is estimated that approximately 1.2M households have dimmers in use with standard halogen lamps[56]. Informed by recent dimmer test results of legacy dimmers with standard LED lamps, it is estimated that 60 per cent of the 1.2 million households will need to upgrade their dimmer system to retain dimming.

Estimated cost to replace 3 dimmers — dimmer purchase ($112.50) plus install ($140) = $252.50. Assumptions: dimmer cost $37.50 each, average house has 3 dimmers.[57]

Total estimated consumer cost to resolve dimmer compatibility issues = $181.8M.

Benefits achieved from more energy efficient long lasting LED lamps offset the upfront cost with the household being better off within a 4 year period through electricity and replacement savings (pending number of lamps and usage). Most households can also avoid/defer the upgrade cost and still use their LEDs if they are willing to set the dimmer to 100 per cent. Scheduling the dimmer upgrade with the next electrician job will also reduce costs.

These cost estimates are based on a number of assumptions and data from Department of Social Security and Australian Bureau of Statistics and have been extrapolated from small sample sizes.

Cost benefit analysis

The cost benefit estimates of the policy options were prepared by the consultancy Beletich Associates, who have expertise in the lighting sector and market modelling. The full method and analysis is available at Attachment A.

The cost benefit analysis in this RIS is based on the projected energy consumed by the lighting stock in a Business as Usual (BAU) case, compared to each policy option. Energy savings are the difference between the BAU case and the policy options (the same applies for greenhouse gas (GHG) emissions savings). The annual energy consumed (by each type of lighting product) is essentially the multiplication of: the stock of the lighting product type; their average annual operating hours; and their average electrical input power.

For each option, costs and benefits have been assessed to 2030. Market impacts are assessed to 2030 (changes in product sales up to 2030) and the energy impacts of these changes are assessed to 2040 (e.g. products sold in 2030 will remain in place for up to 10 years, accruing energy and financial savings).

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[56] *E3 2016 Residential Lighting Report*: 68 of 180 houses fitted with dimmers, 23 of which were connected to mains voltage halogen light bulbs (13%) (no split between directional and non-directional). Extrapolated to the entire Australian housing stock, it is estimated that 1.2 million houses have at least one dimmer connected to a standard halogen light bulb.

[57] *E3 2016 Residential Lighting Report:* for houses fitted with dimmers, the average was 3.

In order to show the impacts in each sector, the residential sector and commercial sector (which includes industrial) are modelled separately for LED MEPS. The halogen phase out largely applies only to the residential sector and is modelled as such. In addition, lamps are modelled as either residential or commercial (or both, as required). The following costs and benefits are included in the financial modelling:

Costs:

- To consumers, due to increases in the upfront price of products, reflecting costs passed on by suppliers.
- To consumers, due to transitional costs in upgrading existing lighting systems to be compatible with LED lighting.
- To government (tax payers), for implementing and administering the requirements.
- To suppliers, for complying with the new or modified regulatory requirements.

Benefits:

- To consumers, due to improved energy efficiency of available products resulting in reduced electricity costs.
- To consumers, due to the longer life of LEDs compared with halogen lights, leading to reduced replacement costs (applies to phase out proposal only).
- For New Zealand, the possible energy savings related to an increase in sales of LED lamps has not been modelled (this increase will happen in Australia as a part of the phase out, and is therefore already included in the CBA for Option B).

The following cost and benefits are not included in financial calculations:

- Benefits to the consumer, due to reduced heat load on air conditioning systems.
- Benefits to society, from reduced emissions (applies to Australia only - these are included in New Zealand modelling).

The inputs to the model are outlined in Attachment A. They include information on product categories, sales and stock data; the BAU and policy energy efficiency and cost assumptions; government and regulatory costs; electricity prices, emissions factors, product life, operating hours and sensitivity tests.

Cost and benefits of options

The following options were modelled:

- Option A - MEPS for LED lamps.
- Option B - MEPS for LED lamps and phase out of some halogen and incandescent lamps.

Following consultation, the following changes were made to the cost-benefit analysis (otherwise the modeling methodology and assumptions remain unchanged from the Consultation RIS):

- Change of product scope and timing, as described in this document.
- New tariffs available for Australia have been used to estimate benefits.

- New Zealand - amended modelling methodology to use long run marginal tariffs instead of consumer prices, which explains the significant variance in savings from the Consultation RIS.
- One MEPS level, aligning with the EU (including later timing), as opposed to multiple increases over the 10 year period.
- Newly available data for lamp pricing, imports, sales and efficacy.

The results of the cost-benefit analyses of the regulatory options for Australia and New Zealand are shown below.

Table 7: Cost benefit estimates – Australia[58] (Real discount rate: 7%)

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	198	0.1	34	0			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				12.1			
	Government admin				1.3			
	GHG value @ $0/t			0				
	Total	**1,273**	**0.8**	**166**	**13**	**152**	**12.4**	**$193**
Option B - MEPS for LED Lamps + Phase Out Halogen	Residential (incl compat cost $144M)	7,702	4.8	1,503	172			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				11.7			
	Government admin				3.0			
	GHG value @ $0/t			0				
	Total	**8,777**	**5.5**	**1,634**	**187**	**1,448**	**8.8**	**$263**

58 "GHG value @ $0/t" – this refers to a greenhouse gas value of $0 per tonne. The cost benefit estimates for Australia do not include benefits associated with greenhouse gas abatement, as there is no agreed shadow carbon price. The sensitivity analysis assigns a value to greenhouse gas abatement.

Table 8: Cost benefit estimates - New Zealand[59] (Real discount rate: 6%)

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	26	0.002	1.2	0.0			
	Commercial	192	0.014	9.8	0.0			
	Regulatory burden				3.5			
	Government admin				0.5			
	GHG value @ $25/t			0.4				
	Total	**218**	**0.015**	**11.4**	**4.0**	**7.4**	**2.9**	**$480**

For Australia, Option B (introduction of MEPS for LED lamps and the phase out of some incandescent and halogen lamps) would provide a large net benefit of an estimated $1.448 billion to 2030. The total benefit for Option B is $1.634 billion. Option B would provide savings on energy costs for consumers of $1.396 billion, and to businesses of $132 million. Option B would provide additional savings of $107 million in the cost of purchasing lamps, as while LEDs are more expensive to buy than halogen lamps initially, they don't need to be replaced as regularly.

The total cost for Option B is $187 million. Under Option B, consumers need to spend an extra $28 million on LED lamps initially. Around 9 per cent of households would incur costs to upgrade their dimmers[60] so that they are compatible with LED lamps, at a cost of $144 million. Suppliers would incur costs of $12 million complying with the regulations. Option B would save 8,777 giga-watt hours (GWh) of energy and 5.5 million tonnes (Mt) of emissions, cumulative to 2030.

For Australia, the savings from Option A (introduction of MEPS for LED lamps) are smaller, with a projected net benefit of $154 million through savings on energy costs. Option A would provide savings on energy costs for businesses of $132 million, and to consumers of $34 million. Suppliers would incur costs of $12 million complying with the regulations. Option A would save around 1,273 GWh of energy and 0.8 Mt of emissions, cumulative to 2030.

For New Zealand, the introduction of MEPS for LED lamps would provide a net benefit of an estimated $7.4 million to consumers and businesses through energy savings. MEPS for LED lamps would provide savings on energy costs for businesses of $10 million, and to consumers of over $1 million. Suppliers would incur costs of around $3.5 million complying with the regulations. It is projected to save 218 GWh and 0.015 Mt of emissions,

[59] New Zealand estimates are presented in New Zealand dollars. National benefits are assessed using the avoided long run marginal cost of electricity (as required by New Zealand's cost benefit methodology). The benefits for New Zealand include benefits associated with greenhouse gas abatement ("GHG value @ $25/t" - as required by New Zealand's cost benefit methodology).

[60] A dimmer is a control that adjusts the brightness of a light.

cumulative to 2030. This consists only of the change in energy usage of LED lamps from improving the performance of these products, and is therefore much smaller than projected for Australia under Option B.

The main benefits accrue to users of lighting – consumers and businesses through savings on their electricity bills, by replacing incandescent and halogen lamps with an effective and efficient LED lamp or compact fluorescent lamp (CFL) (already subject to MEPS). The community and environment also benefit through cost effective reductions in emissions. The total costs include costs to businesses, consumers and government.

To achieve these savings on their electricity bills, consumers and businesses need to spend more upfront by purchasing a more expensive LED or CFL that costs $7, instead of a halogen lamp that costs $3 (around $4 more today, which is likely to decrease over time as LED prices continue to reduce). However this higher upfront cost is offset through electricity savings in the first year, with the average household better off by around $650 over 10 years by changing halogen lamps to minimum standard LED lamps that lasts 15,000 hours[61]. Savings are higher for higher residential users and commercial use. A hair salon would save an estimated $3,700 over 10 years in electricity savings[62].

For the proposal to phase out halogen lamps in Australia, around nine per cent of households (an estimated 720,000, including around 160,000 low income homeowners) would incur a one off upfront cost of around $250 to resolve compatibility issues with dimmers to work with LED lamps. For a household with compatibility issues, the electricity bill savings are expected to offset the $250 upfront cost within a 4 year period. If households are willing to set the dimmers to 100 per cent, most households can avoid or defer the upgrade cost and still use their lights. For low income households, the upfront costs are likely to be difficult to absorb and they may be forced to defer the cost until they are in a position to upgrade. Rental households that are reliant on landlords who are unwilling to upgrade would also not be able to use their dimmers, unless the renter pays the upgrade cost. Households whose dimmers still won't work with LED lamps, when set to 100 per cent, would be forced to upgrade or to deal without having a functioning light (other interim solutions would include using plug-in standing or table lamps). These compatibility costs are included in the cost benefit analysis.

The benefit cost ratios are very high for Australia. To examine this, the sensitivity of the results to changes to key inputs was analysed. These sensitivity tests indicate that even with changes to key inputs to the cost benefit analysis, the policy options remain cost effective. Details of the cost benefit analysis, energy savings, emissions reductions and sensitivity scenarios are outlined in Attachment A.

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[61] Based on the replacement of 10 lamps that are used for 1.6 hours per day.

[62] Based on the replacement of 20 downlights that are used for 50 hours per week.

6. Consultation

The final proposals are the result of extensive stakeholder consultation, including:

- Three product profiles to review the energy efficiency of lighting in Australia and to consult on opportunities to improve, including the Incandescent, Halogen and CFL product profile (E3 2014), Commercial Lighting (E3 2015) and LEDs (E3 2015)
- a Consultation RIS (November 2016), which included six stakeholder meetings across Australia and New Zealand
- a supplementary consultation paper (September 2017) modifying the proposals following feedback
- meetings with the LED MEPS Technical Working Group, established to draft the proposed MEPS parameters and test methods
- meetings with the Compatibility Working Group, established to work through transitional issues in phasing out halogen lighting in Australia
- discussion with relevant peak bodies (Lighting Council Australia, Lighting Council New Zealand, Illuminating Engineering Society of Australia and New Zealand, International Association of Lighting Designers , and electrician peak bodies National Electrical and Communications Association and Masters Electricians Australia, CHOICE and the Energy Efficiency Council).
- Meeting with the Lighting Energy Efficiency Advisory Group, established to provide advice on whether MEPS on LED lamps is necessary to phase out halogen lamps.

Further, the E3 Program commissioned the following reports to inform this RIS:

- Residential Lighting Report 2016, Energy Efficient Strategies
- Household Lighting Consumer Survey 2016, E3 and CHOICE
- LED and Dimmer Compatibility Testing 2016, National Electrical Communications Association (NECA)
- LED Testing 2016, Queensland University of Technology.
- LED Testing 2017 conducted by two independent labs.

Consultation Regulation Impact Statement

Stakeholder consultation sessions on the Consultation RIS were held in Sydney, Melbourne, Brisbane, Adelaide, Perth and Auckland between 31 January and 13 February 2017, and a webinar was held on 24 February. Around 100 stakeholders attended the consultation sessions, with 22 written submissions received in response.

Notifications regarding the Consultation RIS were sent out through peak bodies, email to a compiled list of stakeholders and relevant newsletters. Further, EECA put a notice in the EECA January products news which was distributed to 300 subscribers, posted a notice on their website that consultation was open and sent several emails to all known stakeholders advising that consultation was open on the Consultation RIS and upcoming workshops and webinar.

Supplementary consultation paper

E3 published a supplementary consultation paper on the Energy Rating website in September 2017, in response to feedback on the Consultation RIS. The paper was released to provide the opportunity for further feedback where the Consultation RIS proposals had been modified or were not recommended to continue, and to seek additional information on specific issues. It was also distributed to over 500 stakeholders by email. Sixteen public submissions were received in response.

Summary of stakeholder feedback

There was broad support from stakeholders for the further phase out of inefficient incandescent and halogen light bulbs in Australia, across lighting suppliers, lighting designers, retail and consumer groups. Support for MEPS for LED lamps was mixed. Responses to supplementary consultation paper did not see any consensus emerge as to whether MEPS on LED lamps are necessary to underpin a phase out of halogen lamps. Of the 16 public submissions to the supplementary paper, eight supported a MEPS, including four consumer groups. Four submissions conditionally supported a MEPS, but had comments and concerns with aspects of the proposal. Four submissions were opposed to MEPS, including the lighting industry associations of Australia and New Zealand.

To examine the issue further, a Lighting Energy Efficiency Advisory Group was set up. The Advisory Group includes lighting industry associations, suppliers, retailers, consumer and energy efficiency bodies, and Australian, New Zealand and State Government officials. An Advisory Group meeting on 9 March 2018 in Sydney recommended that if an option of MEPS on LED lamps is proposed, industry costs should be minimised, with any new regulations to be implemented in parallel with changes to the EU lighting regulations that are due to be finalised later this year. After further consultation, LCA accepted the proposed option on the basis that the MEPS on LED lamps is aligned with the EU and lowering of regulatory costs through streamlined registration. No objections were raised by other group members. This is the final proposal for LED lamps recommended in this RIS.

Various non-government organisations and consumer groups are included on contact lists and were invited to provide formal feedback and attend consultation sessions throughout the RIS process. CHOICE and Brotherhood of St Laurence provided feedback in support of the proposed option.

Communications Committee

Pending approval of Decision RIS, a communication strategy will be drafted in consultation with stakeholders identifying key messages, communication products, communication channels and associated costs and timing. The Department will seek to form a Communications Committee with representation across the stakeholder groups to oversee the design and implementation.

7. Evaluation and conclusion

Recommended option

Option A is the recommended policy option for New Zealand. Option B is the recommended policy option for Australia. The recommended options in both countries provide the greatest net benefit, and would provide the largest energy and greenhouse gas savings.

For Australia, the introduction of MEPS for LED lamps (planned for September 2020) and the phase out of some halogen and incandescent lamps (planned for September 2020) (Option B) provides a net benefit of an estimated $1.45 billion, mainly through energy savings for consumers and businesses.

For the recommended option in Australia, consumers and businesses need to spend more upfront by purchasing a more expensive CFL or LED lamp to achieve savings on their electricity bills. The payback on the more expensive lamp is within one year. An estimated nine per cent of households will also face upfront costs of around $250 to upgrade their dimmer systems to work with LED lamps - these upgrade costs may be difficult for low income households to manage. Households that have to upgrade dimmers will generally still save money after four years.

For New Zealand, introduction of MEPS for LED lamps (planned for September 2020) provides a net benefit of an estimated $7.4 million, through energy savings for consumers and businesses. While this is considerably less than that for Australia, there are additional non-monetised benefits relating to consumer confidence and information, as well as the overall harmonization of product standards across both countries which contribute to this being a recommended option for New Zealand.

8. Implementation and review

Implementation

New and updated regulations

If the COAG Energy Council approves the policy option, the *Greenhouse and Energy Minimum Standards (Incandescent Lamps for General Lighting Services) Determination 2016* would be revised and a new determination created for LED lamps for consideration by COAG Energy Council Ministers. In New Zealand, a policy option needs to be approved by Cabinet before being adopted under the *Energy Efficiency (Energy Using Products) Regulations 2002*. If approved, the updated regulations would be subject to compliance monitoring and review in both countries.

Stakeholders would be invited to comment on at least one draft of the GEMS Determinations before it is finalised. In New Zealand, these same technical requirements will be referenced. Most likely this will be by referencing parts or all of the Australian Determination in the *Energy Efficiency (Energy Using Products) Regulations 2002*.

When the minimum performance standards were increased in 2009 for pear shaped General Lighting Service incandescent lamps (to remove the least efficient technology from the market), an import ban was applied to these products before the MEPS took effect at point of sale (at the request of the lighting industry). An import ban is not proposed in this RIS as the GEMS compliance program is considered adequate to address risks of non-compliance. There were a small number of illegal imports identified by the Department of Home Affairs with the import ban on incandescent lamps. The GEMS program now has a national compliance program in place to discourage non-compliance and take action where non-compliance occurs. There is also a facility in place that allows intelligence data to be requested from Department of Home Affairs to target non-compliant activity. Given this, an import ban is considered to be unnecessary.

The current import prohibition on GLS incandescent lamps is being considered in discussion with the Department of Home Affairs.

Timeframes

If approved the regulation is planned to commence in September 2020 (to align with the proposed commencement of future EU standards currently under consultation).

The determinations are planned to be released in early 2019, providing around 18 months for stakeholders to comply with new regulation. Subject to Cabinet approval, New Zealand will implement the MEPS within a few months of Australia by incorporation into the *Energy Efficiency (Energy Using Products) Regulations (subject to Cabinet agreement)*.

Transition arrangements

Stock of LED lamps in scope of the GEMS Act that have been manufactured in or imported into Australia prior to the relevant start date and are unable to meet the new requirements (i.e. fail to meet the new MEPS) would be grandfathered. These products may be offered for sale until existing stock is sold out. Products able to comply with the new requirements (i.e. can meet the new MEPS) would have to be registered, before they could be offered for sale.

LED lamps in scope of the New Zealand regulations that have been manufactured in or imported into New Zealand prior to the relevant start date can be sold until stock runs out. LED lamps in scope of the New Zealand regulations that have been manufactured in or imported into New Zealand after the date of implementation of the regulation must fully comply and be registered before they are made available for sale.

Implementation risks

Implementation risks associated with the proposed new regulations include:

- Suppliers and retailers have insufficient time to adjust to the new requirements. This could affect the availability of products, market competition, or compliance with the regulations. This risk is considered low.
  - The proposed start dates allows 18 months for supplier and retail stakeholders.
  - Registration is planned to be available by 12 months prior to the effective date allowing industry to register products early.
  - Non-compliant stock imported into or manufactured in Australia or New Zealand prior to the relevant start date can continue to be sold until supplies are exhausted.
- There is a risk that the EU process will be delayed beyond late 2018, potentially delaying the planned implementation date of September 2020. Should this occur further advice will be provided to COAG Energy Council Ministers.
- There is an existing issue in certain geographic areas in New South Wales and Queensland that can cause LED lamps to flicker for a short period and affect other household electrical products (including humming in electric fans, fast electric clocks and unintended operation of ovens) as ripple control signals are sent several times a day from distribution network service providers to control off-peak tariff hot water, street lamps and space heating. Rectification and workarounds are currently managed by energy networks and lighting suppliers. The Department has established a Ripple Control Working Group with stakeholders to understand conditions when this can occur and options to resolve. It is anticipated that options to manage this issue will continue to evolve, minimising any impacts on households in these areas before the planned phase out date.
- Some consumers may complain about the removal of halogen lamps from the Australian market, as occurred with the removal of incandescent lamps in 2009.

The Department has consulted broadly with stakeholders (consumer groups, lighting designers, suppliers, retailers) on this proposal. The introduction of MEPS on LED lamps would provide assurance to consumers that they can purchase an equivalent replacement product that provides at the least the same or better quality of light. In particular, consumers that incur a one off upfront cost to resolve compatibility issues with dimmers used in existing lighting systems may complain about the removal of halogen lamps from the market. The E3 Program and stakeholders are jointly working to reduce the consumer cost of this option through information on compatible products to electricians to enable them to assist households in minimising costs.

- Criticism can be managed by highlighting the savings to consumers on electricity and replacement costs and the overall benefits for society. Accelerating the transition as opposed to voluntary uptake can be justified on the basis that voluntary uptake through education can only achieve limited benefits as many consumers are not motivated to change their purchasing decision due the low upfront cost of lamps and savings not being apparent. A consumer education program, in cooperation with lighting suppliers, designers, consumer and electrical trade associations will be an important element in the implementation of the phase-out.

Review

Compliance monitoring

In Australia, the GEMS Regulator is responsible for monitoring and enforcing compliance with the GEMS Act. In doing so, the GEMS Regulator is committed to:

- assisting responsible parties to understand the requirements of the GEMS Act
- monitoring responsible parties' compliance with the requirements
- pursuing those who opportunistically or deliberately contravene the Act.

If the policy changes are adopted, the GEMS Regulator would, as part of the GEMS Compliance Monitoring program, monitor compliance with the new requirements by:

- check testing to verify MEPS, energy efficiency claims and other performance measures are met
- market surveillance to verify models are registered and display the product and package requirements
- responding to allegations of non-compliance.

In New Zealand, these education and compliance activities are undertaken by the Energy Efficiency and Conservation Authority.

Evaluation

The E3 Program uses various sources of information to evaluate the effectiveness of the program and product category requirements.

These sources include:

- retrospective reviews to compare the effect of policies, versus what was projected
- analysing sales and import data to understand consumer awareness and use of energy efficiency information and labelling
- monitoring activity on the Energy Rating website.

Attachment A – Modelling

Calculation methodology

Cost benefit analysis

The cost benefit estimates of the policy options were prepared by the consultancy Beletich Associates, who have expertise in the lighting sector and market modelling.

A financial analysis has been conducted on the societal costs and benefits for the policy proposals being considered, with the cost-benefit analysis conducted at the national level. At the state level, any differences in lighting usage, for example due to climatic differences, are significantly less pronounced than for say heating and cooling. Thus a state-level analysis was not done, and this would also add significant complexity to what is already a relatively complex model. For each option, costs and benefits have been assessed to 2030[63].

In order to show the impacts in each sector, the residential sector and commercial sector (which includes industrial) are modelled separately for LED MEPS. The halogen phase out largely applies only to the residential sector and is modelled as such. In addition, lamps are modelled as either residential or commercial (or both, as required) and this detail can be seen in the Product Attributes later in this section.

The following costs and benefits are included in the financial modelling:

Costs:

- to consumers, due to increases in the upfront price of products, reflecting costs passed on by suppliers
- to consumers, due to transitional costs in upgrading existing lighting systems to be compatible with LED lighting
- to government (tax payers), for implementing and administering the requirements
- to suppliers, for complying with the new or modified regulatory requirements.

[63] Market impacts are assessed to 2030 (changes in product sales up to 2030) and the energy impacts of these changes are assessed to 2040 (e.g. products sold in 2030 will remain in place for up to 10 years, accruing energy and financial savings). Greenhouse gas impacts are not modelled beyond 2030 due to the unknown greenhouse gas intensity of electricity this far into the future.

Benefits:

- to consumers, due to improved energy efficiency of available products resulting in reduced electricity costs
- to consumers, due to the longer life of LEDs compared with halogen lights, leading to reduced replacement costs (applies to phase out proposal only). Note that this is netted out together with upfront costs, and thus in some cases the net “costs” may appear negative, reflecting a net benefit.

The following **cost and benefits** are **not included** in financial calculations:

- benefits to the consumer, due to reduced heat load on air conditioning systems
- benefits to society, from reduced GHG emissions (applies to Australia only - these are included in New Zealand modelling).

Note that rebound is treated as zero in relation to energy use — this phenomena (increased usage due to lower energy costs or increased comfort) does not typically apply to lighting.

In terms of an approach for the cost-benefit analysis, this could be done from a consumer or societal perspective. The societal approach is the preferred method for a RIS, however the consumer approach can be used where it approximates the results that would be obtained from the societal perspective. A societal perspective would include health benefits from reducing energy costs and benefits from reduced greenhouse gas emissions. Since these benefits are difficult to quantify and will increase the overall benefit from the regulation, not considering them and using the consumer approach is a reasonable and conservative proxy for the societal analysis.

An analysis from a consumer perspective involves the use of retail product prices and marginal retail energy prices. Since the objective is to assess whether product buyers (consumers) as a group would be better off, transfer payments such as taxes are included. The analysis includes retail mark-ups and taxes that will be passed onto the consumer and including these in the costs will simplify the analysis process, while still remaining appropriate.

The consumer approach is also recommended for the development of RISs associated with the E3 Program (NAEEEP 2005). The alternative analysis approach, of assessing from a resource perspective, would require a new set of factors and assumptions to be introduced to the analysis, particularly regarding manufacturing costs, and would also mean the impact of varying discount rates would be very much more difficult to assess.

The following options were modelled:

- Option A - MEPS for LED lamps
- Option B - MEPS for LED lamps and phase out of halogen lamps.

The above MEPS are described in detail in the main body of this RIS. For each policy, a BAU and a Policy Scenario have been modelled, for both Australia and New Zealand (where required). Key assumptions and parameters for each scenario are detailed in later in this Attachment.

Greenhouse gas emissions and energy consumption

GHG emissions due to lighting are calculated by multiplying energy consumed (by lighting products at end-use) and GHG emissions intensity factors (as determined by the electricity generation mix). The GHG emissions factors used in this RIS are given in Attachment A1.

Total energy consumption was determined for a BAU and a policy scenario, for each policy proposal. Energy savings are the difference between BAU and with-policy energy consumption (the same applies to GHG savings).

The annual energy consumed (by each type of lighting product, at end-use) is essentially the multiplication of:

- the stock of the lighting product type
- their average annual operating hours and
- their average electrical input power.

Stock of lamps, for all BAU and policy scenarios, are calculated using a sophisticated stock and sales model that was developed for this RIS. This model calculates stock, using sales as the key input data. This is because there are significantly more time-series data available for sales than there are for stock (e.g. household surveys) and regulations also affect sales directly, rather than stock. An explanation for how all key model parameters were derived is provided below.

Key model parameters

The cost benefit estimates were included in a consultation RIS published in November 2016. These were subsequently updated to reflect the changes to the proposals in the September 2017 Supplementary Paper. Energy savings estimates were again updated for an advisory group paper published in February 2018, to take account of revised LED efficacy estimates (for the LED MEPS proposal). For this decision RIS, the following have also been updated:

- newly available data for lamp pricing, lamp imports, lamp efficacy and electricity pricing.
- LED MEPS synchronisation with the EU proposal. Note that aligning LED MEPS limits and timing with the EU proposal results in a net moderate reduction in available energy savings, due primarily to a delay in the introduction of MEPS compared to what was modelled previously.

Explanations for the derivation of all key model parameters are detailed below. These are all derived from available data, information obtained from industry, or where necessary realistic assumptions.

Financial Parameters

The financial modelling undertaken for the RIS is couched in real terms. All financial parameters in the model are expressed either in real 2018 Australian dollars or in real 2018 New Zealand dollars. The conversion rate from Australian to New Zealand dollars used is NZD $1 = AUD $0.85.

Where conversion to or from a nominal value is required, a nominal inflation rate of 2.6% has been used for Australia (average annual national CPI changes over the past 10 years). No such conversions were required for New Zealand as the New Zealand Government provide all required data inputs in real terms.

Discount rates for NPV calculations are expressed in real terms: 7% for Australia and 6% for New Zealand. Sensitivity tests are conducted at 0%, 3% and 11% for Australia and 0%, 3% and 8% for New Zealand (all expressed in real terms).

Projection Period

The lighting market is modelled from 2016 to the year 2030, with regulatory changes to commence in 2020. This approach has been used to capture the ongoing savings of policy-induced market changes in the period up to 2030. Energy and financial benefits (from reduced energy consumption) for products installed up to 2030, that persist beyond 2030, have been modelled (to 2040). Greenhouse gas abatement has not been modelled beyond 2030, due to uncertainties related to the greenhouse intensity of electricity this far into the future.

Sales

Historical lamp sales, for the period 2002-2017, are based primarily on lamp import data from the Australian Bureau of Statistics (ABS), Statistics New Zealand, aggregated Australian and New Zealand national supermarket data, and estimates provided by Lighting Council Australia (from their members in aggregated form showing percentage of sales by product type). Note that lamps have not been manufactured in Australia since 2002.

Figure 8: Lamp import data for Australia (source: Australian Bureau of Statistics)

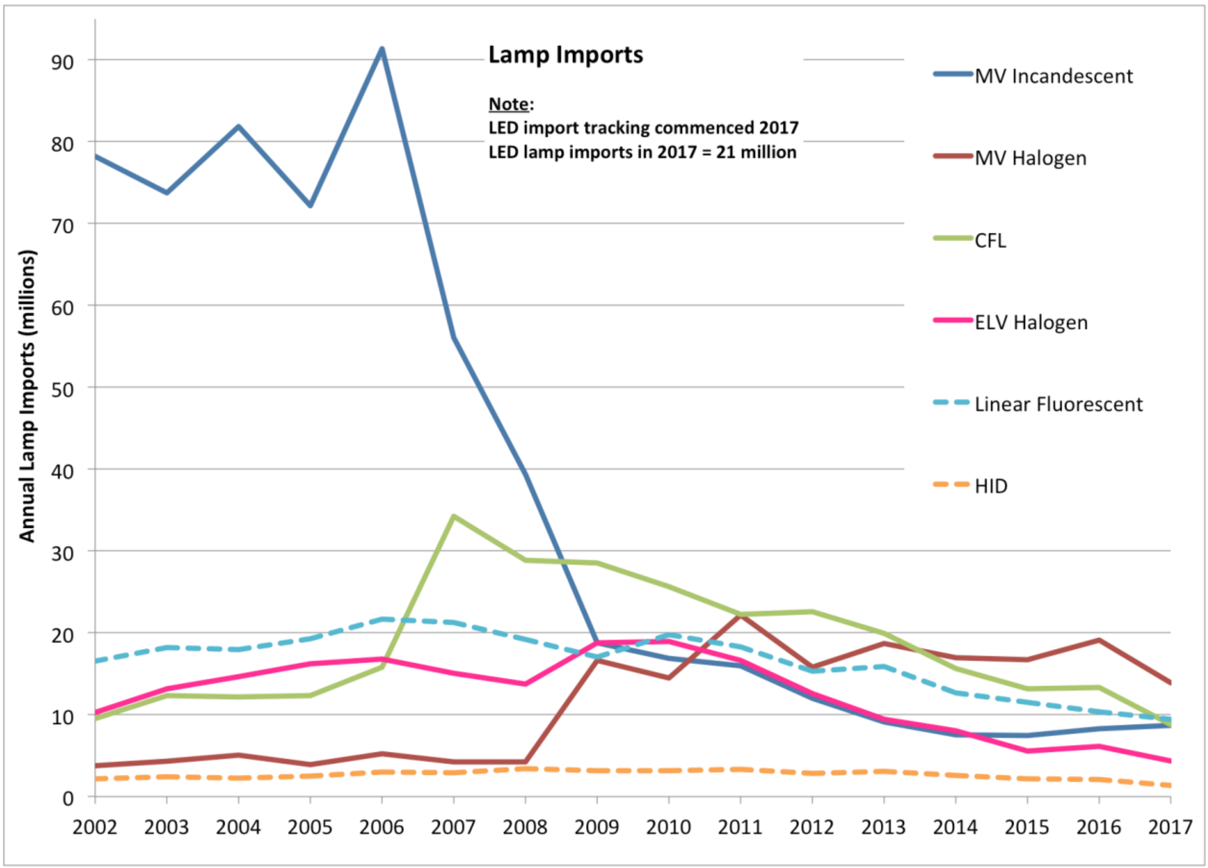
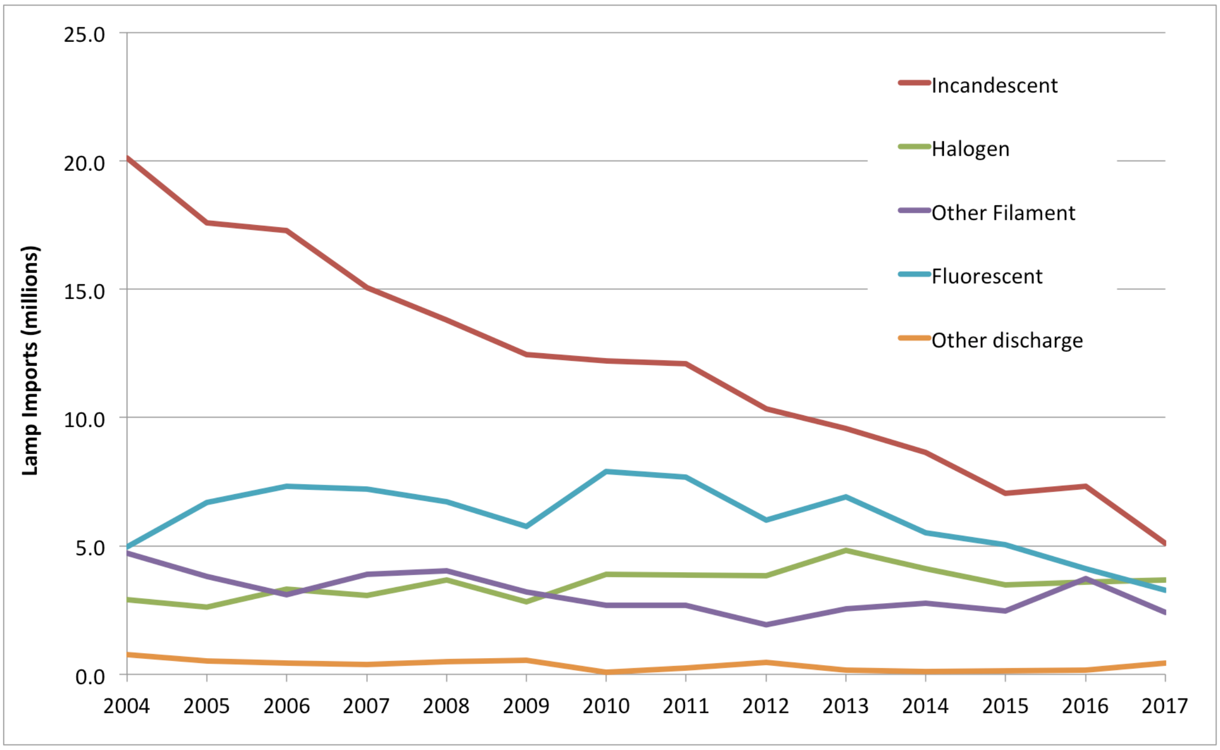


Figure 9: Lamp import data for New Zealand (source: Statistics New Zealand)



Forecast future sales are based on projected trends and reasonable assumptions and estimates where required. Forecast sales for all scenarios modelled can be seen in the series of graphs later in the Attachment.

Stock

Lamp stock is calculated as the sum of sales over X preceding years, where X corresponds to the average lifetime (in years) of the lamp type. Note that a lamp survival function has not been applied, as energy consumption depends primarily on the average life of a product (products which fail earlier and later than the average will tend to cancel each other out, in terms of energy use).

In order to validate the model's stock estimates, the resultant stock levels (for residential) were compared to household survey results[64] in the table below, for Australia. These show that the two methods derive similar values.

Table 9: Comparison of Australian residential lamp stock levels from this RIS model and 2016 household survey

Lamp Stock per Dwelling	From Model (in 2017)	From Survey (in 2016)
MV Incandescent	5	5
MV Halogen	6	6
CFL	11	12
MV LED	2	1
Downlight Halogen	6	6
Downlight LED	5	5
Total	35	35

Note this comparison is not undertaken for New Zealand as it is only required for the halogen phase out policy, where all lamp technologies in residential dwellings need to be modelled (New Zealand is not contemplating this phase out policy). The modelled stock levels (and all other attributes including lifetimes) for all products and scenarios can be seen later in this section.

Product Lifetime

The key variable that is used to calculate stock, from sales, is the average product lifetime (in years - the total number of years, on average, that the product survives before failure or removal). Note that average lifetime has been capped at 15 years, in order to reflect the fact that building renovations will also tend to limit the lifetime of products. The average lifetime of all products modelled can be seen in Table 10 below.

[64] E3 2016 Residential Lighting Report, Results of a lighting audit of 180 Australian homes, Energy Efficient Equipment Committee, June 2016.

Lifetime (in years) is a function of lamp operating life (in hours - the rated average total number of hours that a product should operate for before failure) divided by the annual operating hours (how many hours per year that it is turned on).

Annual Operating Hours

The average annual operating hours, for each product type, have been derived largely from the 2016 Australian household survey[65] (for the residential sector). An average of 3000 hours p.a. has been used for the commercial sector (60 hours per week x 50 weeks).

Electrical Input Power

The average electrical input power, for each product type, is the estimated average rated power of various types of lamps. This is in turn a function of the product's efficacy - its light output per unit of electrical input power (lumens per Watt or lm/W). More efficient lamps, for a given light output, will have lower input power for the same given light output.

Efficacy

For incandescent, halogen and fluorescent light sources, average efficacies and other attributes are assumed to remain static over time, as these are mature technologies (and essentially at the commercial or technological limits of performance). For LEDs however, efficacy is improving rapidly and this trend is predicted to continue for some years.

A time-based LED efficacy 'reference' curve was developed for this RIS, which is in turn based on the 2015 European Preparatory Study on Light Sources[66] (Figure 10 - reproduced below). This European curve is itself based on forward-looking studies by the US Department of Energy[67] and McKinsey & Co[68].

The reference curve used as the basis for the RIS modelling is based on the "low-end with label" European curve - the green curve in Figure 10 below which forecasts average efficacy reaching around 160 lm/W by 2030. This curve was chosen as it effectively represents what is predicted to occur in the absence of policy intervention. Note that on the graph below, and with some US efficacy forecasts, LED efficacies of 200 lm/W are forecast. For the sake of conservatism (for the phase out proposal) we have opted to use one of the lower

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[65] E3 2016, Residential Lighting Report, Results of a lighting audit of 180 Australian homes, Energy Efficient Equipment Committee, June 2016.

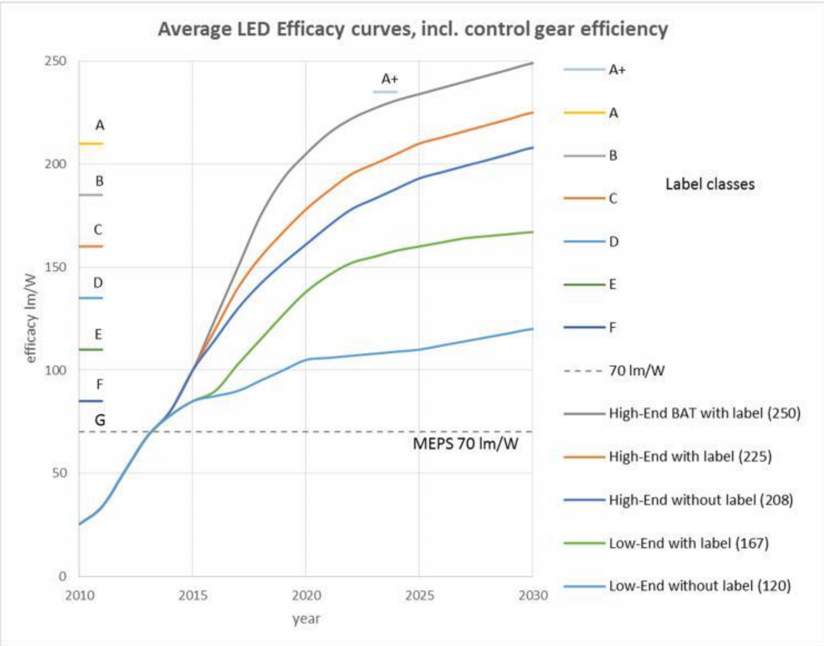
[66] EC 2015, Preparatory Study on Light Sources, for Ecodesign and/or Energy Labelling Requirements, Final report, Task 7, Scenarios - Energy, European Commission, prepared by VITO in cooperation with VHK, October 2015.

[67] US DoE 2014, Solid-State Lighting Research and Development, Multi-Year Program Plan, April 2014 (Updated May 2014), Prepared for: Solid-State Lighting Program, Building Technologies Office, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.

[68] Lighting the way: Perspectives on the global lighting market, McKinsey & Co, 2012.

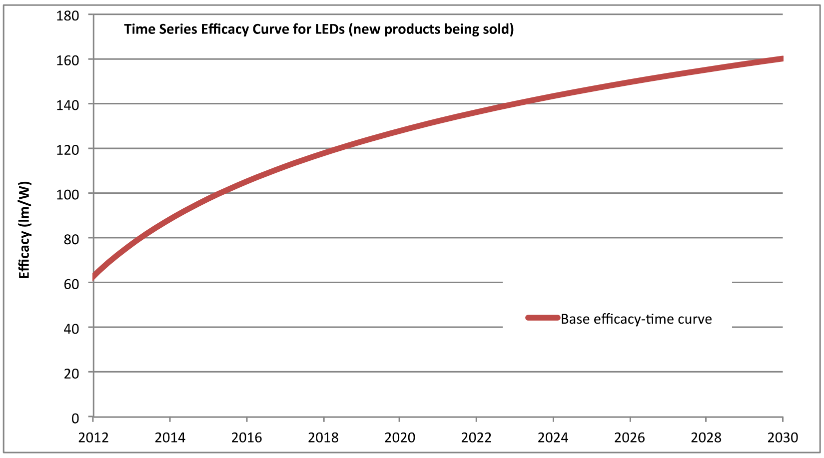
forecast curves - it is possible that LED efficacies will ultimately be higher than what we have assumed here.

Figure 10: LED Efficacy prediction (source: 2015 European Preparatory Study on Light Sources)



The reference curve used for RIS modelling is shown in Figure 11 below - as mentioned it follows the “low-end with label” European curve - the green curve - shown above. Again, it is possible that LED efficacies will ultimately be higher than what we have assumed here.

Figure 11: Reference curve for LED efficacy



In the RIS model, this reference curve is linearly scaled up or down, to suit the LED product being studied. Thus it is primarily the *shape* of this curve that is important, rather than its absolute values. The predicted efficacy curves for all products modelled can be seen in section ii of this Attachment. Several different LED lamp types are modelled, as follows:

- #9: Lamp-MV-LED-Residential

- #11: Lamp-Downlight-LED-Residential
- #13: Lamp-Downlight-LED-Commercial
- #17: Lamp-Tubular-LED-Commercial

Lamp Costs

For incandescent, halogen and fluorescent light sources, product prices are assumed to remain static (in real terms) over the period 2017-2030. This conclusion was reached after examining average supermarket halogen and CFL prices from 2006 to 2016. The chart below (Figure 12) shows the average cost of buying various lamp types from Australian supermarkets over the period 2006 to 2017 (first quarter of 2017 only). For LEDs, prices are continuing to decrease.

Figure 12: Australian supermarket lamp prices[69]

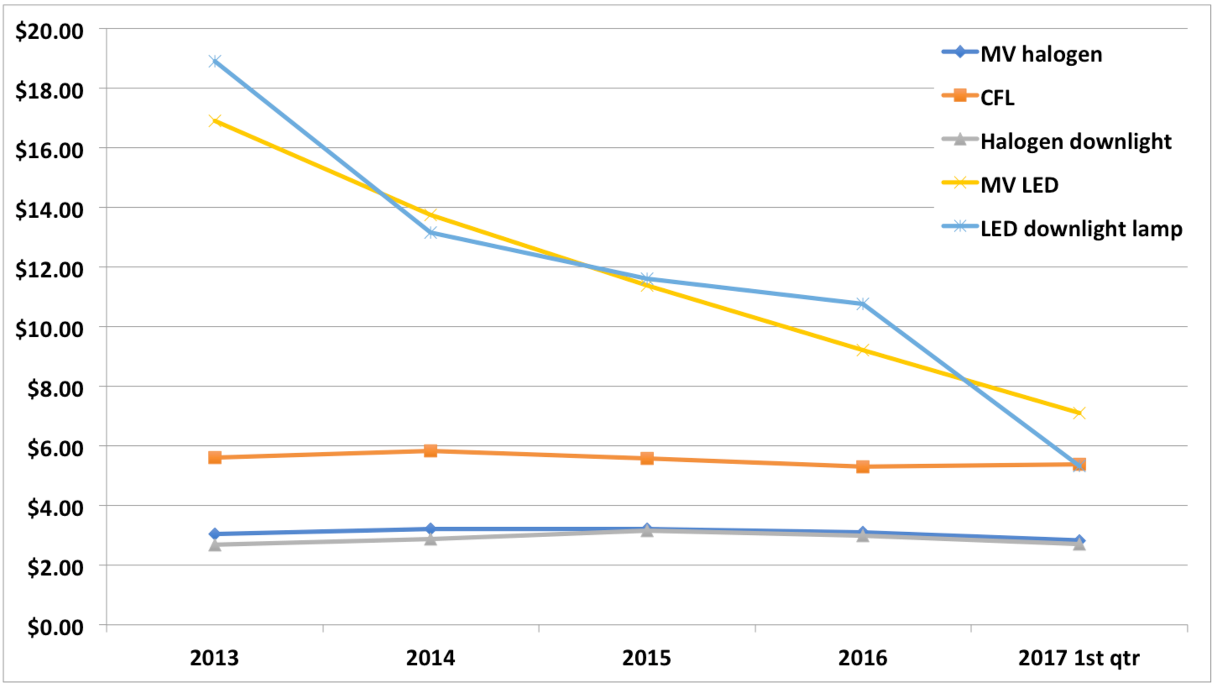


Figure 13 shows the predicted European curves.

Figure 13: Predicted LED price curves[70]

[69] Source: analysis of supermarket data.

[70] Source: European Preparatory Study on Light Sources, 2015.

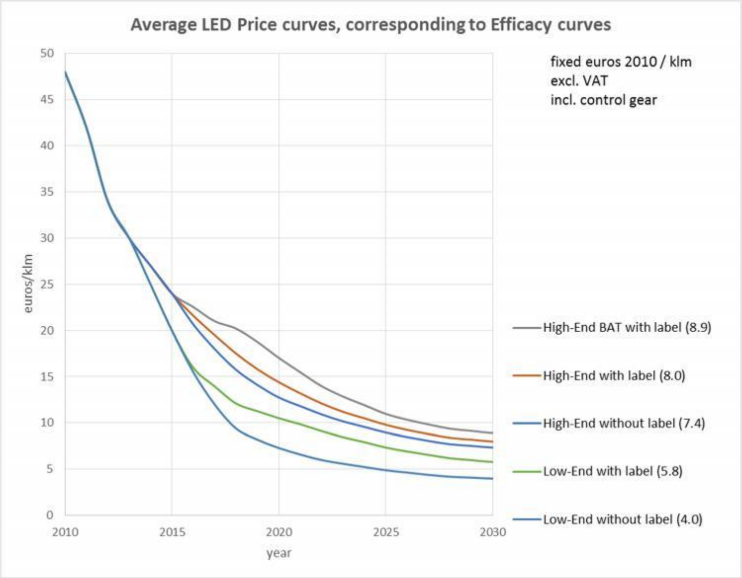
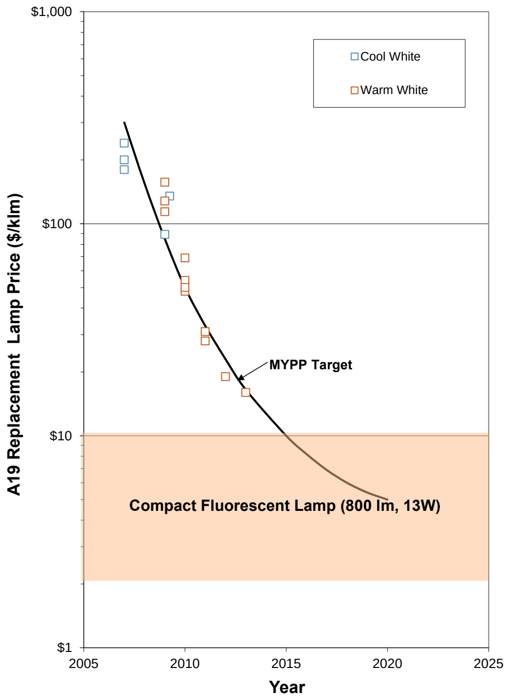


Figure 14 below shows the US Department of Energy's price projection for LED lamps.

Figure 14: Predicted LED prices[71]

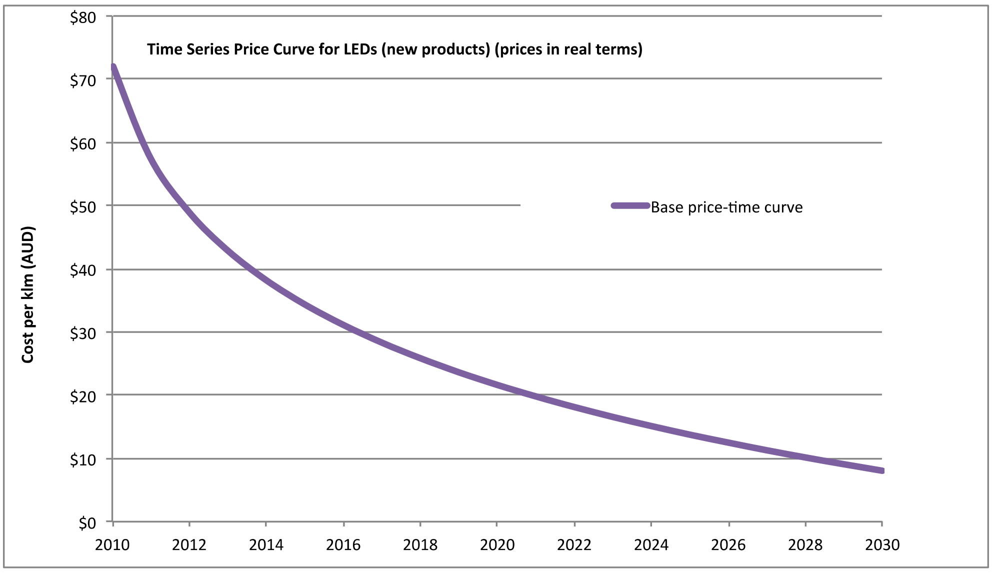


For this RIS, the "reference" price curve follows the "low-end without label" European curve - the green curve - shown in Figure 13. The US curve is lower, although the US market is thought to be significantly more competitive. For the sake of conservatism, the European curve is used as the basis "reference curve" for this RIS, shown in Figure 15

71 Source: Solid-State Lighting Research and Development, Multi-Year Program Plan, US DoE. 2014.

below (in AUD). If LED prices were projected to decrease more quickly, the energy and dollar savings would be even greater.

Figure 15: Reference curve for LED price



Again, the reference curve graphed above is linearly scaled up or down to suit the LED product being studied, and the resulting product prices can be seen later in this Attachment. Again, it is primarily the *shape* of this curve that is important, rather than the absolute values.

Efficacy Improvement Due to Policy Proposals

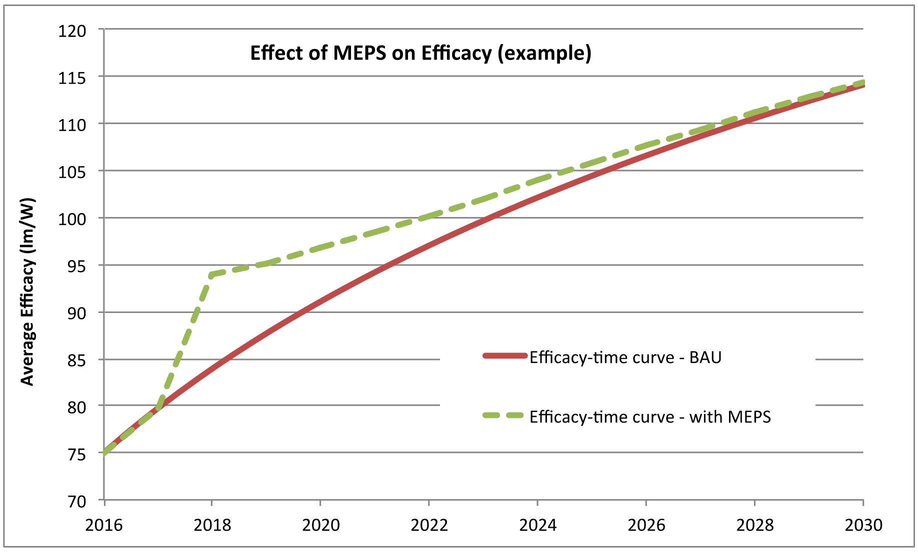
For LED MEPS, savings are based on the proposed European MEPS. Any potential subsequent increases in MEPS levels, following an initial MEPS, have not been modelled (these were modelled in the consultation RIS). Additional data - 12 months of LED lamp import data and newly acquired catalogue lamp data - has become available to inform estimates.

The E3 Lighting Supplementary paper assumed 5 to 10 lm/W efficacy increase. A subsequent "import-weighted" calculation method uses the newly-available LED import data to "sales-weight" LED efficacy values from an updated LED catalogue database. This method results in a (roughly) weighted average efficacy increase of 3.3 lm/W for omni-directional and directional LED lamps, and 10.9 lm/W for linear lamps (both are based on the proposed European MEPS level).

The impact of delaying MEPS to 2020 to harmonise with the EU (compared to 2019 as was previously proposed for an Australian MEPS) was also modelled - this tended to reduce the impacts by approximately 1.9 and 3.3 lm/W for omni-directional and directional LED lamps respectively, due to the fact that the BAU efficacy of LEDs will naturally improve over time. In other words, improvements of 1.4 and 7.6 lm/W for omni-directional and directional LED lamps resulted, respectively. These have been modelled.

A *hypothetical* example, showing MEPS improvement decaying over time, is graphed in Figure 16.

Figure 16: Hypothetical example of efficacy boost from MEPS



Actual modelled impacts, for each LED lamp type, can be seen in graphs later in this Attachment.

For the phase out option, energy savings are derived from substitution of halogen and incandescent lamps with primarily LED. Again, graphs later in this Attachment show these substitutions.

Cost Impact of MEPS

For the phase out option, cost impacts arise from the difference in lamp replacements costs between the various lamp types, as well as from the costs of installing compatible dimmers (discussed in the body of this RIS).

For LED MEPS, Australian supermarket lamp price data was analysed in order to develop an efficacy versus price relationship for LEDs lamps. Broadly speaking there was a negative relationship between price and efficiency of about -0.6 (% price increase per % efficacy increase). Thus, for the sake of conservatism, MEPS is assumed to have zero impact on price (rather than -0.6). This parameter is also subject to sensitivity testing.

Compatibility Costs

An estimated 720,000 households will be required to upgrade their dimmers to ensure they are compatible with LED lights. This cost is estimated to be $181.8 million (720,000 x $252.50). $252.50 is based on 3 x dimmers x $37.50 average dimmer cost + $140 installation cost). This is included in the CBA as $144 million in NPV terms, as this cost is assumed to be incurred over 4 years.

Government Administration Costs

Government administration costs are made up of salary, program administration, check testing, consumer information/education and miscellaneous (market research, etc.).

Total incremental cost to Government for Australia and New Zealand are estimated at $200,000 per year. Establishment costs to government in Australia and New Zealand to introduce the new regime are assumed to be $350,000. An additional $2 million over a three year period is included to deliver the supporting communication campaign in Australia (2018–19, 2019–20 and 2020–21). This adds up to total taxpayer costs of $4.35 million over 10 years.

Industry Compliance Costs

In Australia, suppliers are required to pay a registration fee and register their products with the GEMS Regulator. This fee is treated as an income to the government for modeling purposes as partial cost recovery for government of administering the regulations in Australia (registration and compliance activity). There are no registration fees in New Zealand.

Fees will be finalised as part of the determination process and informed by electrical safety registrations.

It is estimated than an additional 50 suppliers[72] are selling LED products into the New Zealand market.

Other costs of compliance (for example testing, staff education, record keeping) are accounted for using the Regulatory Burden Measurement tool (for Australia) and are included as a component of the cost benefit analysis.

Electricity Prices

For Australia, electricity prices are derived from AEMO forecasts.

For New Zealand (residential + commercial), a long-run marginal cost of NZD$0.0879 / kWh (real, all years), is used, as provide by the Ministry of Business, Innovation and Employment.

GHG Emissions Factors

Updated projected emission factors for Australia and New Zealand have been included. In Australia they are based on the Scope 3 emission factors for the consumption of electricity by the consumer. The projected Scope 1 emission factors were provided by the Department of the Environment and Energy (March 2017). The New Zealand estimates were provided by the Ministry of Business, Innovation and Employment.

[72] Based on 20 per cent of LED suppliers selling in Australia. Proportion reflective of linear fluorescent lamp registrations in Australia and New Zealand.

Sensitivity Tests

The CBA estimates were subject to the following sensitivity tests:

- Higher and lower discount rates
- Increased price efficiency ratio (increased cost impact from applying a MEPS to LEDs)
- Higher and lower (absolute) LED prices
- Higher and lower electricity prices
- Monetisation of GHG abatement
- RBM costs.

Product Attributes

A library of average lamp types was developed for use in the model. This is reproduced in Table 10 below, which also lists the parameters assigned to each product. Note that lifetime has been capped at 15 years, in order to reflect that fact that building renovations will also tend to limit the lifetime of products. Product performance and price data in the table below has been sourced from an extensive database of LED products, as well as from manufacturer catalogues and supermarket data.

Table 10: Lighting products and relevant parameters

Product Name	Description	Av Light Output (lumens)	2017 Av Power (W)	Av Efficacy in 2017 or MEPS improvement wrt BAU (lm/W)	Op Hours per Day	Annual Op Hours	Op Life (hrs)	Lifetime (yrs) (max 15)	Av Price in 2017 (AUD)
#1: Lamp-MV-Incandescent-Residential	Mains voltage incandescent lamp (directional and non-directional, not downlight)	800	75	10.7	0.6	219	1,150	5.3	$2
#2: Lamp-MV-Halogen-Residential	Mains voltage halogen lamp (directional & non-directional, not downlight)	800	52	15.4	1.0	365	1,250	3.4	$3
#3: Lamp-MV-CFL-Residential	Mains voltage CFL lamp (directional & non-directional)	850	16	53.1	2.3	840	6,000	7.1	$5
#4: Lamp-Downlight-Hal-Residential	Halogen downlight lamp (note power includes transformer losses)	625	48	13.0	1.5	548	3,500	6.4	$3
#5: Lamp-Tubular-Fluorescent-Residential	Fluorescent tubular lamp (residential)	2,000	30	66.7	1.6	584	10,000	15.0	$10
#6: Lamp-Tubular-Fluorescent-Commercial	Fluorescent tubular lamp (commercial)	3,000	36	83.3	8.2	3,000	10,000	3.3	$5
#9: Lamp-MV-LED-Residential (No MEPS)	Mains voltage LED lamp (directional & non-directional, not downlight)	834	9.5	87.8	2.3	840	15,000	15.0	$8
#10: Lamp-MV-LED-Residential (MEPS)	Mains voltage LED lamp (directional & non-directional, not downlight) (with MEPS)	834		+1.4 lm/W	2.3	840	15,000	15.0	
#11: Lamp-Downlight-LED-Residential (No MEPS)	LED downlight lamp (residential) (no MEPS)	582	8.0	72.8	1.8	657	15,000	15.0	$6
#12: Lamp-Downlight-LED-Residential (MEPS)	LED downlight lamp (residential) (with MEPS)	582		+1.4 lm/W	1.8	657	15,000	15.0	
#13: Lamp-Downlight-LED-Commercial (No MEPS)	LED downlight lamp (commercial) (no MEPS)	582	8.0	72.8	8.2	3,000	15,000	5.0	$5
#14: Lamp-Downlight-LED-Commercial (MEPS)	LED downlight lamp (commercial) (with MEPS)	582		+1.4 lm/W	8.2	3,000	15,000	5.0	
#15: Lamp-Tubular-LED-Residential (No MEPS)	LED tubular lamp (residential) (no MEPS)	1,650	15.8	104.4	1.6	584	15,000	15.0	$20
#16: Lamp-Tubular-LED-Residential (MEPS)	LED tubular lamp (residential) (with MEPS)	1,650		+7.6 lm/W	1.6	584	25,000	15.0	
#17: Lamp-Tubular-LED-Commercial (No MEPS)	LED tubular lamp (commercial) (no MEPS)	1,650	15.8	104.4	8.2	3,000	15,000	5.0	$12
#18: Lamp-Tubular-LED-Commercial (MEPS)	LED tubular lamp (commercial) (with MEPS)	1,650		+7.6 lm/W	8.2	3,000	15,000	5.0	

i. Proposal modelling

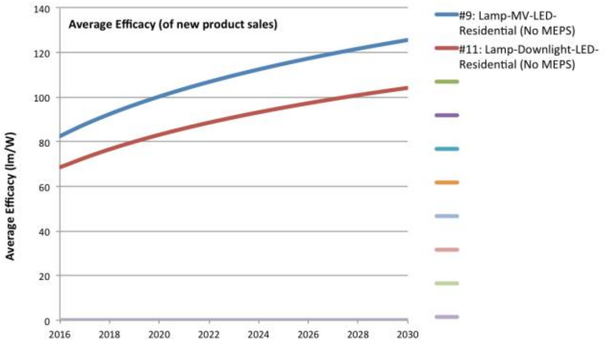
In the sections below, sales, stock, pricing and other intermediate outputs from the model can be seen, along with accompanying notes and assumptions for each policy modelled (refer notes below each graph). Note that LED MEPS and phase-out scenarios are graphed separately here.

LED MEPS (Australia) (Residential)

On this page the key metrics for the LED MEPS proposal are displayed, with the BAU scenario graphed on the left, and MEPS scenario on the right of the page. These can be compared side-by-side. Below each graph are notes which refer to the graph above. Note that for this policy option, the only differences that occur between the BAU and MEPS scenarios are for product efficacy - as can be seen in the graphs below.

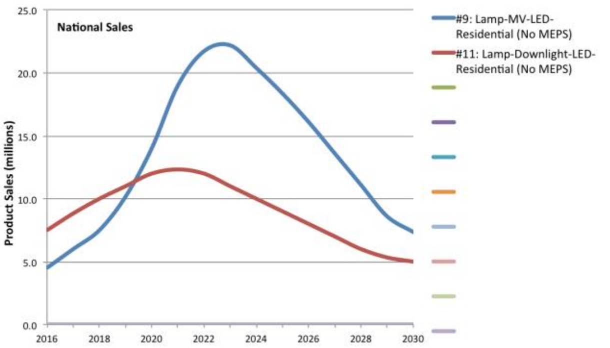
This proposal, for Australia, involves placing MEPS on LED lamps. In order to better show the impacts on each, the residential and commercial sectors are modeled separately. The residential sector is modeled on this page, and commercial sector the following page.

BAU Scenario

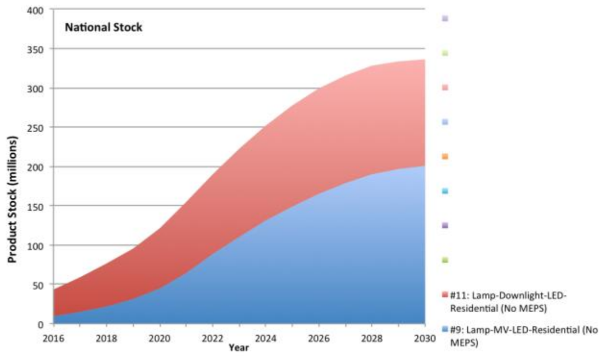


As discussed previously, the BAU average efficacy of LED lamps increases over time.

As discussed previously, LED lamp prices decrease over time.

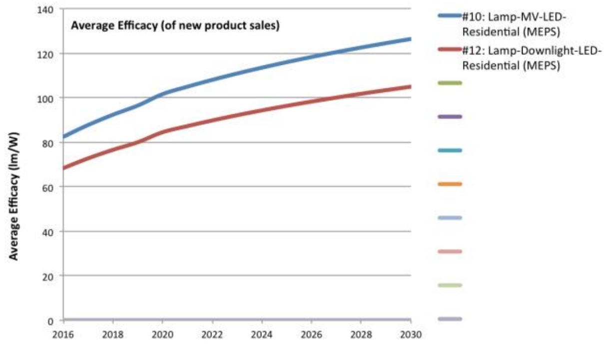


LED sales can be seen to be increasing, and will level off and may decline, due to the longer life of LEDs.

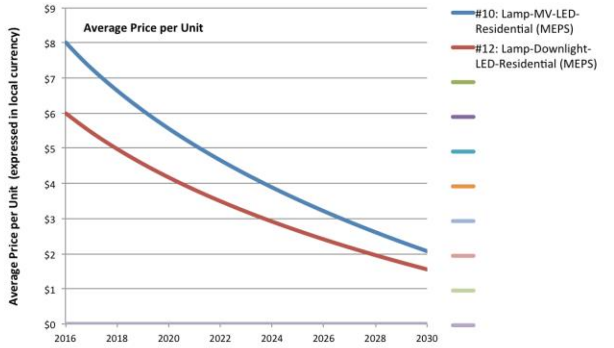


LED stocks increase rapidly from 2016 to 2030.

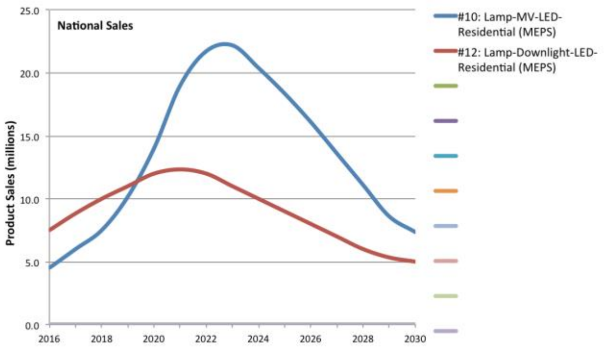
MEPS Scenario



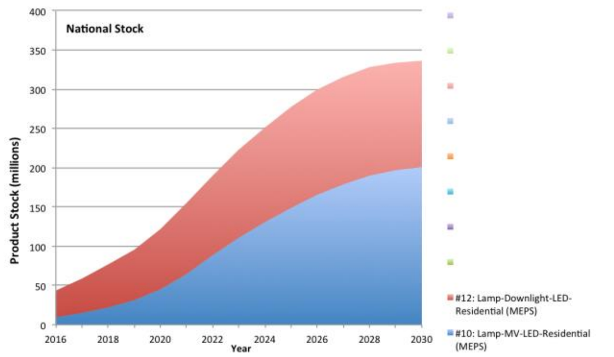
As discussed previously, MEPS results in increased efficacy of the LEDs sold. These can be seen above as the "kinks" in the efficacy curves for LEDs.



As discussed previously, increased efficacy of LEDs due to MEPS does not increase prices for LED lamps, which are same as for BAU.



Sales are modeled to be the same as the BAU scenario. Note however that sales of LEDs are likely to be higher with MEPS in place, as MEPS will increase LED quality, leading to higher consumer satisfaction with LEDs, and therefore presumably increased sales. Due to a lack of hard data to accurately quantify this (and for the sake of conservatism) this has not been modeled.

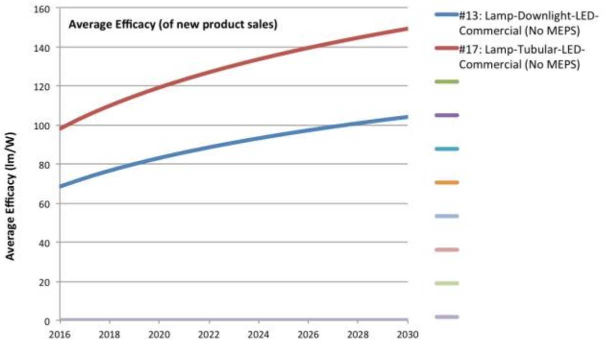


Stocks are the same as for BAU - refer also the notes for sales graph above.

LED MEPS (Australia) (Commercial)

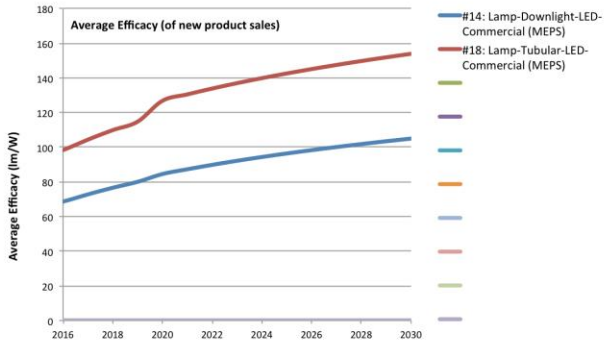
On this page the key metrics for the LED MEPS proposal are displayed, with the BAU scenario graphed on the left, and MEPS scenario on the right of the page. These can be compared side-by-side. Below each graph are notes which refer to the graph above. Note that for this policy option, the only differences that occur between the BAU and MEPS scenarios are for product price - as can be seen in the graphs below.
This proposal, for Australia, involves placing MEPS on LED lamps. In order to better show the impacts on each, the residential and commercial sectors are modeled separately. The commercial sector is modeled on this page, and the residential sector the previous page.

BAU Scenario

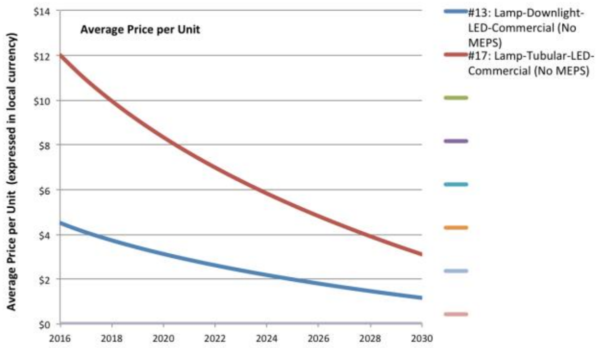


As discussed previously, the BAU average efficacy of LED lamps increases over time.

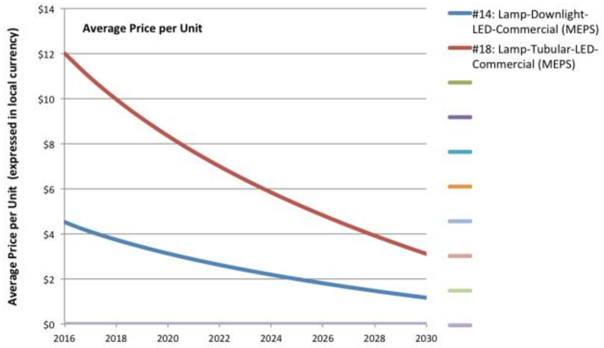
MEPS Scenario



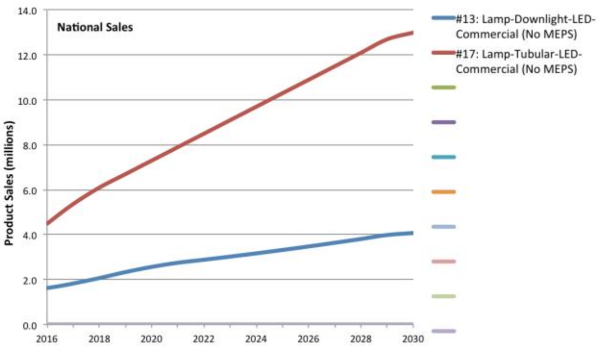
As discussed previously, MEPS results in increased efficacy of the LEDs sold. These can be seen above as the "kinks" in the efficacy curves for LEDs.



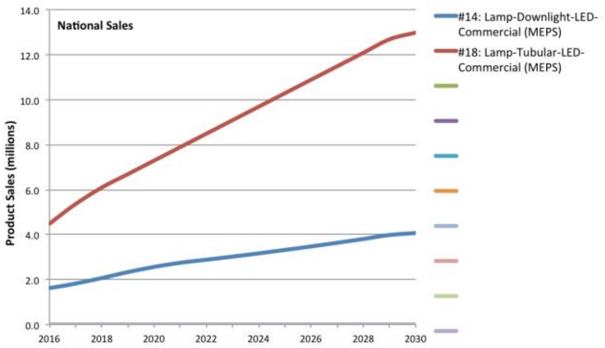
As discussed previously, LED lamp prices decrease over time.



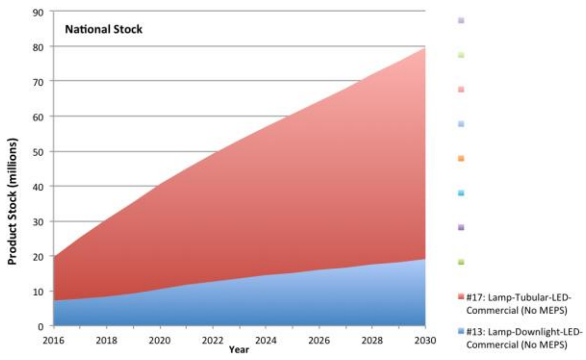
As discussed previously, increased efficacy of LEDs due to MEPS does not increase prices for LED lamps, which are same as for BAU.



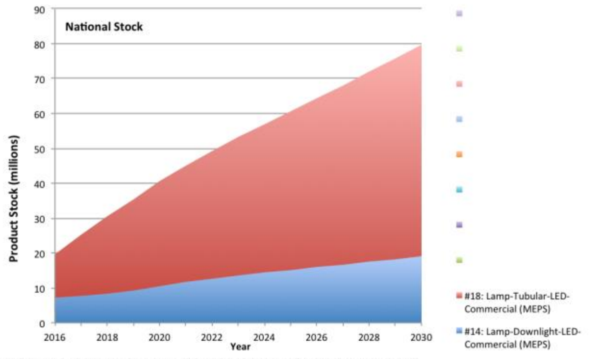
LED sales increase significantly over time. LED sales will level off and may decline, due to the longer life of LEDs.



Sales are modeled to be the same as the BAU scenario. Note however that sales of LEDs are likely to be higher with MEPS in place, as MEPS will increase LED quality, leading to higher consumer satisfaction with LEDs, and therefore presumably increased sales. Due to a lack of hard data to accurately quantify this (and for the sake of conservatism) this has not been modeled.



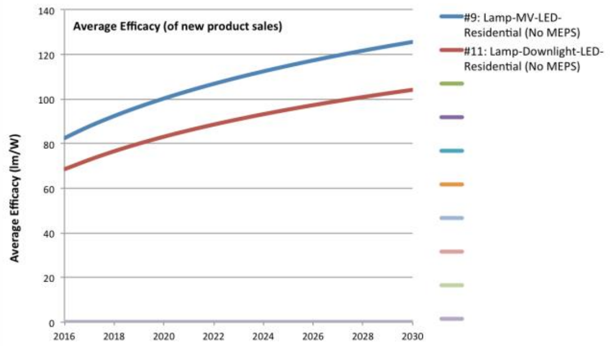
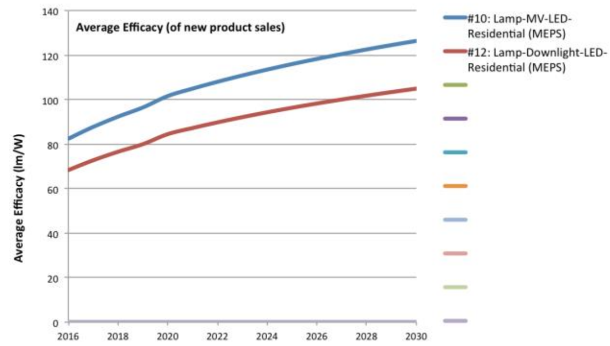
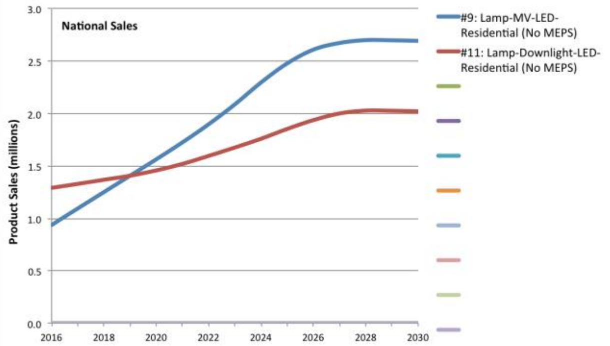
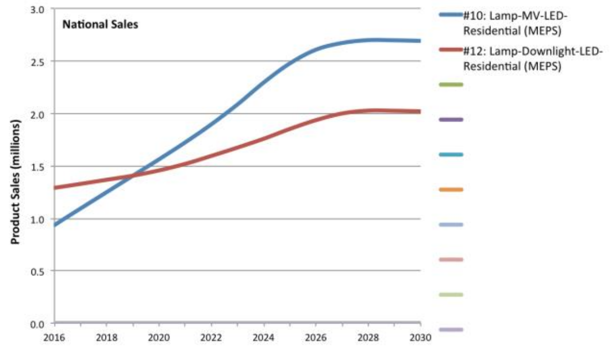
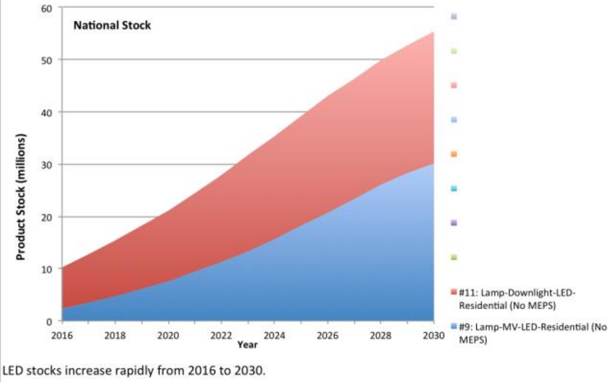
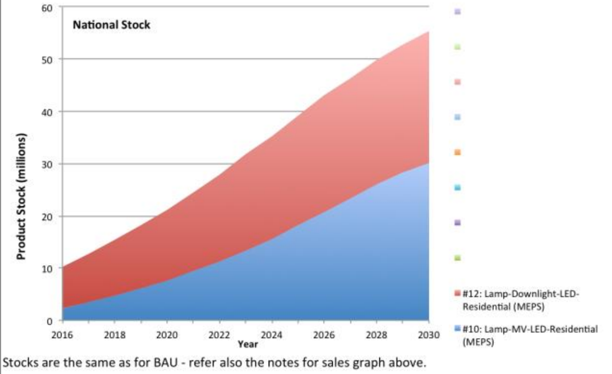
LED stocks increase rapidly from 2016 to 2030.



Stocks are the same as for BAU - refer also the notes for sales graph above.

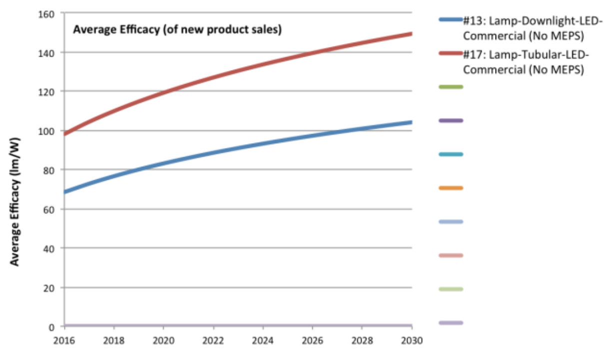
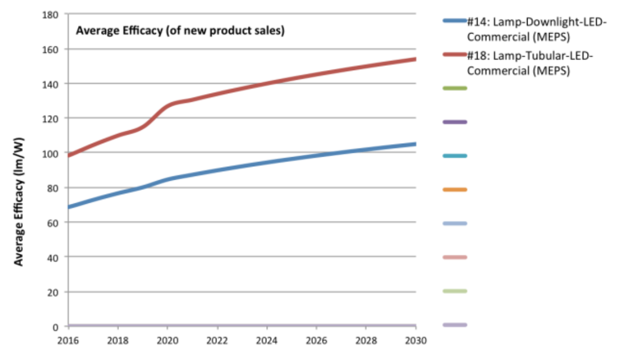
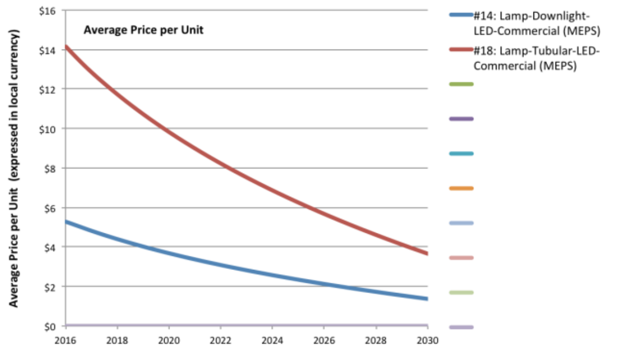
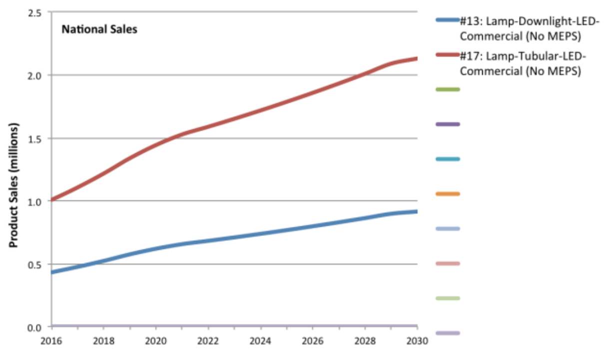
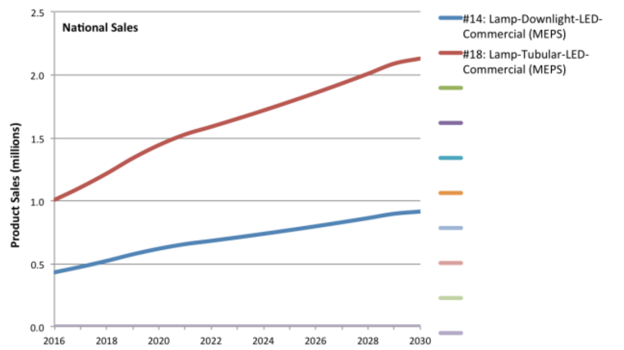
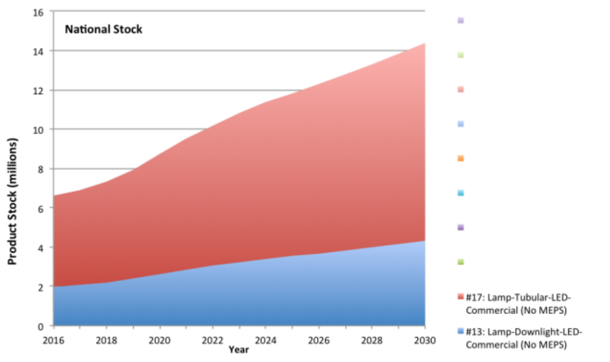
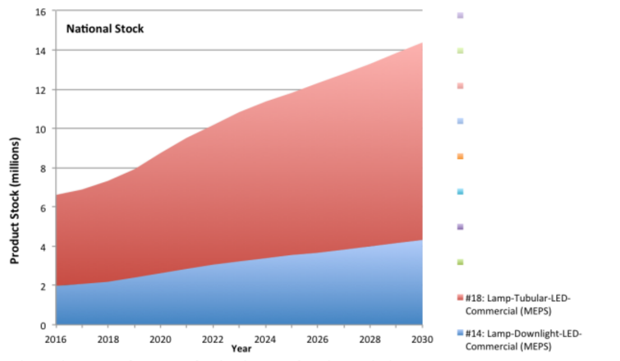
LED MEPS (New Zealand) (Residential)

On this page the key metrics for the LED MEPS proposal are displayed, with the BAU scenario graphed on the left, and MEPS scenario on the right of the page. These can be compared side-by-side. Below each graph are notes which refer to the graph above. Note that for this policy option, the only differences that occur between the BAU and MEPS scenarios are for product efficacy - as can be seen in the graphs below.
This proposal, for New Zealand, involves placing MEPS on LED lamps. In order to better show the impacts on each, the residential and commercial sectors are modeled separately. The residential sector is modeled on this page, and commercial sector the following page.

BAU Scenario	MEPS Scenario
 As discussed previously, the BAU average efficacy of LED lamps increases over time.	 As discussed previously, MEPS results in increased efficacy of the LEDs sold. These can be seen above as the "kinks" in the efficacy curves for LEDs.
 As discussed previously, LED lamp prices decrease over time.	 As discussed previously, increased efficacy of LEDs due to MEPS does not increase prices for LED lamps, which are same as for BAU.
 LED sales can be seen to be increasing, and will level off and may decline, due to the longer life of LEDs.	 Sales are modeled to be the same as the BAU scenario. Note however that sales of LEDs are likely to be higher with MEPS in place, as MEPS will increase LED quality, leading to higher consumer satisfaction with LEDs, and therefore presumably increased sales. Due to a lack of hard data to accurately quantify this (and for the sake of conservatism) this has not been modeled.
 LED stocks increase rapidly from 2016 to 2030.	 Stocks are the same as for BAU - refer also the notes for sales graph above.

LED MEPS (New Zealand) (Commercial)

On this page the key metrics for the LED MEPS proposal are displayed, with the BAU scenario graphed on the left, and MEPS scenario on the right of the page. These can be compared side-by-side. Below each graph are notes which refer to the graph above. Note that for this policy option, the only differences that occur between the BAU and MEPS scenarios are for product efficacy and for price - as can be seen in the graphs below.
This proposal, for New Zealand, involves placing MEPS on LED lamps. In order to better show the impacts on each, the residential and commercial sectors are modeled separately. The commercial sector is modeled on this page, and the residential sector the previous page.

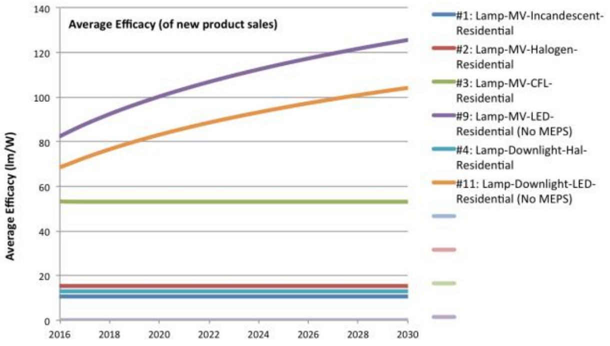
BAU Scenario	MEPS Scenario
	
As discussed previously, the BAU average efficacy of LED lamps increases over time.	As discussed previously, MEPS results in increased efficacy of the LEDs sold. These can be seen above as the "kinks" in the efficacy curves for LEDs.
	
As discussed previously, LED lamp prices decrease over time.	As discussed previously, increased efficacy of LEDs due to MEPS does not increase prices for LED lamps, which are same as for BAU.
	
LED sales increase significantly over time. LED sales will level off and may decline, due to the longer life of LEDs.	Sales are modeled to be the same as the BAU scenario. Note however that sales of LEDs are likely to be higher with MEPS in place, as MEPS will increase LED quality, leading to higher consumer satisfaction with LEDs, and therefore presumably increased sales. Due to a lack of hard data to accurately quantify this (and for the sake of conservatism) this has not been modeled.
	
LED stocks increase rapidly from 2016 to 2030.	Stocks are the same as for BAU - refer also the notes for sales graph above.

Phase Out of Halogen & Incandescent Lamps (Australia)

On this page the key metrics for the phase out proposal are displayed, with the BAU scenario graphed on the left, and phase out scenario on the right of the page. These can be compared side-by-side. Below each graph are notes which refer to the graph above.

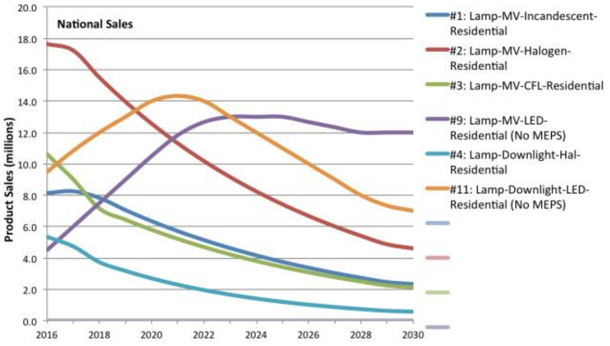
This proposal, for Australia only, involves phasing out incandescent and halogen lamps. It affects primarily the residential sector, which is modeled.

BAU Scenario

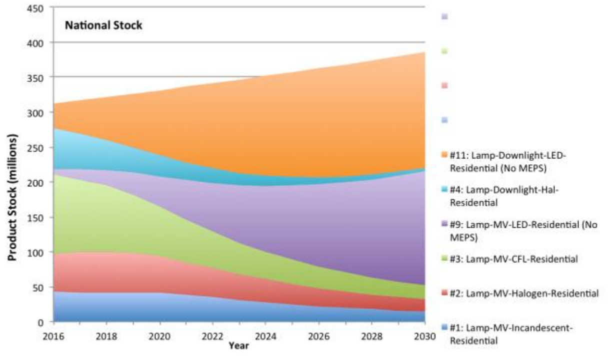


As discussed previously, the BAU average efficacy of LED lamps increases over time, with efficacy of other lamps remaining static. Note that halogen downlight efficacy includes the transformer losses.

As discussed previously, LED lamps prices decrease over time, with other lamp prices remaining static over time (in real terms).

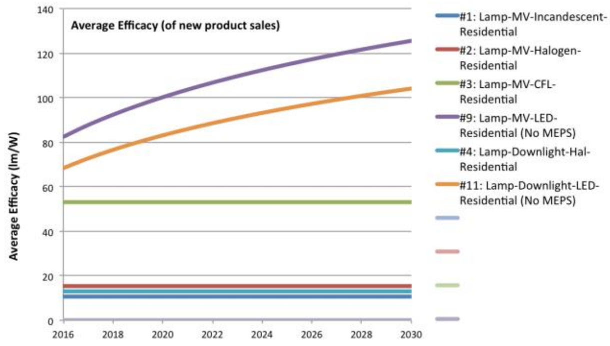


LED sales increase as other lamps decline. LED sales will level off (due to long life of LEDs). Some residual sales of incandescent and halogen lamps can be seen.

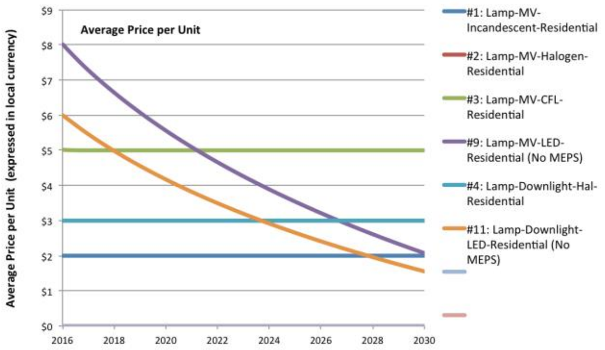


Increase in LED stocks are clearly visible, with incandescent and halogen stocks declining.
Overall lamp stock growth is due to building stock growth.

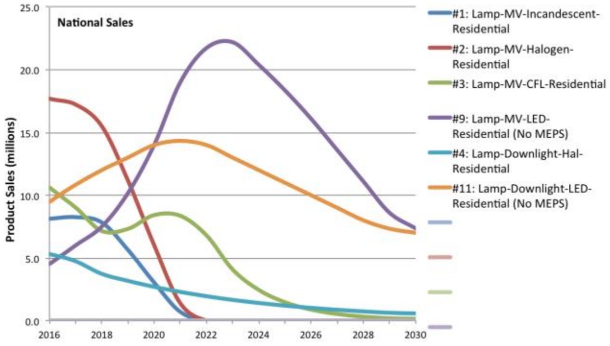
PHASEOUT Scenario



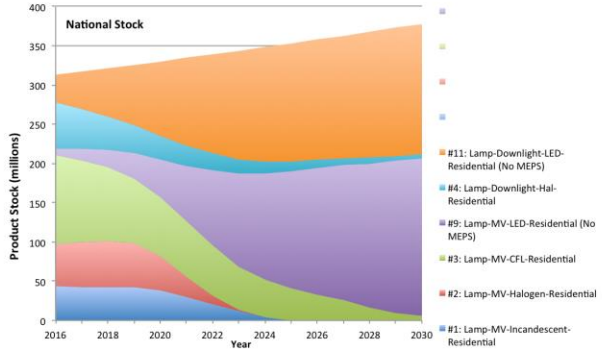
Efficacies remain the same as BaU.



Removal of halogen lamps from the market does not impact the price of LEDs - the presence of CFL and competition in the LED market continues to drive prices down.



Incandescent and MV halogen lamp sales decline over 3 years following MEPS (due to grandfathering).
LED lamp sales increase significantly following the phase out, then likely to decline (due to long life of LEDs).
CFL sales also increase after phase out, then decline and disappear from the market, in favour of LED.



Incandescent and halogen stocks decline rapidly, as these lamp types are phased out.

Summary of key energy/emission impacts and cost benefits by proposal

The tables below summarise the key financial results for Australia and New Zealand. These are also split by residential and commercial (including industrial) sectors.

Table 11: Australia Cost Benefit Analysis — Results by Option

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	198	0.1	34	0			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				12.1			
	Government admin				1.3			
	GHG value @ $0/t			0				
	Total	**1,273**	**0.8**	**166**	**13**	**152**	**12.4**	**$193**
Option B - MEPS for LED Lamps + Phase Out Halogen	Residential (incl compat cost $144M)	7,702	4.8	1,503	172			
	Commercial	1,075	0.7	132	0			
	Regulatory burden				11.7			
	Government admin				3.0			
	GHG value @ $0/t			0				
	Total	**8,777**	**5.5**	**1,634**	**187**	**1,448**	**8.8**	**$263**

Table 12: New Zealand Cost Benefit Analysis — Results by Option

Proposal	Sector	Energy Saved (GWh)	GHG Emissions Reduction (Mt)	Total (Gross) Benefit (NPV, $M)	Total (Gross) Cost (NPV, $M)	Net Benefit (NPV, $M)	(Gross) Benefit to Cost Ratio	Net Benefit Per Tonne
Option A - MEPS for LED Lamps	Residential	26	0.002	1.2	0.0			
	Commercial	192	0.014	9.8	0.0			
	Regulatory burden				3.5			
	Government admin				0.5			
	GHG value @ $25/t			0.4				
	Total	**218**	**0.015**	**11.4**	**4.0**	**7.4**	**2.9**	**$480**

Table 13 shows the net benefits for Australia of each option, by year, with no discounting applied.

Table 13: Net Benefits, by year (no discounting) — Results by Option

Net Benefit by year (millions of AUD and NZD, no discounting)			
Year	Australia - Option A - Net Benefit	Australia - Option B - Net Benefit	New Zealand - Option A - Net Benefit
2018	0	0	0.0
2019	0	1	-0.1
2020	2	-12	-0.2
2021	7	23	0.1
2022	12	85	0.5
2023	16	151	0.8
2024	21	233	1.0
2025	22	244	1.0
2026	22	245	0.9
2027	23	243	0.9
2028	23	249	0.8
2029	23	250	0.8
2030	24	248	1.3

Sensitivity tests

The results of sensitivity testing, to discount rates, are shown in the two tables below. Note that 7% is the "normal" value used for Australia and 6% for New Zealand.

Table 14: Sensitivity tests: discount rates — Australia

	Discount rate = 0%	Discount rate = 3%	Discount rate = 7%	Discount rate = 11%
Option A				
Total (Gross) Cost (NPV, $m)	20	17	13	11
Total (Gross) Benefit (NPV, $m)	324	239	166	119
Net Benefit (NPV, $m)	304	222	152	108
(Gross) Benefit Cost Ratio	16.1	14.3	12.4	10.9
Option B				
Total (Gross) Cost (NPV, $m)	239	214	187	164
Total (Gross) Benefit (NPV, $m)	3137	2335	1,634	1,186
Net Benefit (NPV, $m)	2898	2121	1448	1023
(Gross) Benefit Cost Ratio	13.1	10.9	8.8	7.2

Table 15: Sensitivity tests: discount rates — New Zealand (expressed in NZD)

	Discount rate = 0%	Discount rate = 3%	Discount rate = 6%	Discount rate = 8%
Option A				
Total (Gross) Cost (NPV, $m)	5.7	4.7	4.0	3.6
Total (Gross) Benefit (NPV, $m)	19.6	14.8	11.4	9.8
Net Benefit (NPV, $m)	13.9	10.0	7.4	6.2
(Gross) Benefit Cost Ratio	3.4	3.1	2.9	2.7

For the MEPS option, a sensitivity test was conducted on cost increases in LED efficacy. Ratios of 0.5% and 1.0% were applied (for each 1% increase in LED efficacy a price increase of 0.5% / 1.0% results). A 0.5% ratio was used in the Consultation RIS for larger commercial LED luminaires (which have been removed from the of the Decision RIS scope). The results are shown in the tables below. Note that the ratio used for the central CBA estimates was 0%, as discussed previously.

Table 16: Sensitivity tests: cost of LED efficacy increase — Australia

	Ratio 1.0%	Ratio 0.5%	Ratio 0%
Option A			
Total (Gross) Cost (NPV, $m)	40	27	13
Total (Gross) Benefit (NPV, $m)	166	166	166
Net Benefit (NPV, $m)	125	139	152
(Gross) Benefit Cost Ratio	4.1	6.1	12.4
Option B			
Total (Gross) Cost (NPV, $m)	214	200	187
Total (Gross) Benefit (NPV, $m)	1,634	1,634	1,634
Net Benefit (NPV, $m)	1421	1434	1448
(Gross) Benefit Cost Ratio	7.7	8.2	8.8

Table 17: Sensitivity tests: cost of LED efficacy increase — New Zealand (expressed in NZD)

	Ratio 1.0%	Ratio 0.5%	Ratio 0%
Option A			
Total (Gross) Cost (NPV, $m)	9.6	6.8	4.0
Total (Gross) Benefit (NPV, $m)	11.4	11.4	11.4
Net Benefit (NPV, $m)	1.8	4.6	7.4
(Gross) Benefit Cost Ratio	1.2	1.7	2.9

The results of sensitivity testing, to LED prices, are shown in the tables below. This only affects the phase out proposal (Australia only). In these scenarios, a "price multiplier" of 125% or 75% is applied to LED prices (across all time).

Table 18: Sensitivity tests: adjust LED prices – Australia

	Price Multiplier 125%	Price Multiplier 100%	Price Multiplier 75%
Option B			
Total (Gross) Cost (NPV, $m)	214	187	169
Total (Gross) Benefit (NPV, $m)	1,626	1,634	1,653
Net Benefit (NPV, $m)	1412	1448	1484
(Gross) Benefit Cost Ratio	7.6	8.8	9.8

The table below shows the results of adjusting the Australian electricity tariffs in line with weak, neutral and strong scenarios as provided by AEMO.

Table 19: Sensitivity tests: adjust electricity prices – Australia

	Tariff = Weak	Tariff = Neutral	Tariff = Strong
Option A			
Total (Gross) Cost (NPV, $m)	13	13	13
Total (Gross) Benefit (NPV, $m)	158	166	169
Net Benefit (NPV, $m)	145	152	156
(Gross) Benefit Cost Ratio	11.8	12.4	12.6
Option B			
Total (Gross) Cost (NPV, $m)	187	187	187
Total (Gross) Benefit (NPV, $m)	1583	1634	1,661
Net Benefit (NPV, $m)	1397	1448	1474
(Gross) Benefit Cost Ratio	8.5	8.8	8.9

The impact of monetising the benefit from reduced greenhouse gas emissions for Australia and New Zealand are shown in the tables below. The new scenarios tested are valuing Australian GHG reductions at $13.08/tonne (December 2017 Emissions Reduction Fund auction result) and for New Zealand at $50/tonne. The "normal" GHG valuations are $0 for Australia and $25 for New Zealand. Monetising GHG reductions at $13.08 increases the net benefit for Australia by $10 million.

Table 20: Sensitivity tests: adjust monetisation value of GHG reductions – Australia

	$0 per tonne	$13.08 per tonne
Option A		
Total (Gross) Cost (NPV, $m)	13	13
Total (Gross) Benefit (NPV, $m)	166	176
Net Benefit (NPV, $m)	152	162
(Gross) Benefit Cost Ratio	12.4	13.2
Option B		
Total (Gross) Cost (NPV, $m)	187	187
Total (Gross) Benefit (NPV, $m)	1,634	1,706
Net Benefit (NPV, $m)	1448	1520
(Gross) Benefit Cost Ratio	8.8	9.1

Table 21: Sensitivity tests: adjust monetisation value of GHG reductions - New Zealand (expressed in NZD)

	Multiplier 200%	Multiplier 100%
Option A		
Total (Gross) Cost (NPV, $m)	7.5	4.0
Total (Gross) Benefit (NPV, $m)	11.4	11.4
Net Benefit (NPV, $m)	3.9	7.4
(Gross) Benefit Cost Ratio	1.5	2.9

The tables below show the impact of doubling regulatory burden costs.

Table 22: Sensitivity tests: adjust regulatory burden costs - Australia

	Multiplier 200%	Multiplier 100%
Option A		
Total (Gross) Cost (NPV, $m)	25	13
Total (Gross) Benefit (NPV, $m)	166	166
Net Benefit (NPV, $m)	140	152
(Gross) Benefit Cost Ratio	6.5	12.4
Option B		
Total (Gross) Cost (NPV, $m)	198	187
Total (Gross) Benefit (NPV, $m)	1,634	1,634
Net Benefit (NPV, $m)	1436	1448
(Gross) Benefit Cost Ratio	8.2	8.8

Table 23: Sensitivity tests: adjust regulatory burden costs - New Zealand (expressed in NZD)

	Multiplier 200%	Multiplier 100%
Option A		
Total (Gross) Cost (NPV, $m)	7.5	4.0
Total (Gross) Benefit (NPV, $m)	11.4	11.4
Net Benefit (NPV, $m)	3.9	7.4
(Gross) Benefit Cost Ratio	1.5	2.9

iii. Regulatory burden measure

Regulatory Costs

The regulatory costs have been calculated using the Australian Government's Regulatory Burden Measurement Framework (RBM). Note that the difference from the costs presented in the cost benefit estimates is that the RBM costs are nominal (not discounted). As the E3 Program operates under the COAG, the RBM costs have been reduced to reflect the Australian Government's 43 per cent share of the program's funding agreement.

Business as Usual

Under BAU, there were estimated to be 34 suppliers (registrants) of 876 models of lighting products that directly incur costs in complying with the regulations[73]. There were estimated to be another group of 50 downstream suppliers/retailers that incur compliance costs in the supply of lighting products. This estimate includes retail groups/chains, online suppliers and other specialist stores/store chains.

The compliance costs for these businesses (both registrants and downstream suppliers) were estimated by multiplying labour costs (wage costs plus on costs) by the time spent performing a particular task. For example, for one administrative officer to complete an online registration form that takes two hours to complete, the cost is estimated as 1 x $69 x 2 = $138.

Administrative compliance costs (per year) associated with the regulations include:

- reviewing/understanding legislative requirements (once in the regulatory period, with training updated annually)
- time spent registering a product (not including the registration fee)
- purchasing test standards (twice in the regulatory period)
- internal compliance assurance
- record keeping
- testing products.

[73] Energy Rating database at 8 March 2018.

Option A – Australia

Table 24 shows the additional regulatory costs for Option A, compared with BAU.

Table 24: Option A regulatory costs

Change in costs	Business	Community organisations	Individuals	Total change in costs
Total, by sector	$791,000	$0	$0	$791,000
Cost offset	Business	Community organisations	Individuals	Total, by source
Total, by sector	$0	$0	$0	To be confirmed
Are all new costs offset? A regulatory offset has not been identified. However, the Department of the Environment and Energy is seeking to pursue net reductions in compliance costs and will work with stakeholders and across Government to identify regulatory burden reductions where appropriate.				
Total (Change in costs – Cost offset) ($million) = To be confirmed				

The average annual regulatory costs were calculated by estimating the total undiscounted (nominal) cost for each policy option over the ten year period from 2019 to 2028, and dividing this by ten. The costs shown are based on the Commonwealth's portion of the E3 Program funding agreement, which is 43 per cent.

The additional regulatory costs for Option A are estimated to be $791,000 per year. Under option A, an additional 212 suppliers and 500 registration families (per year) for LED lamps are assumed to be in scope and therefore incur compliance costs. The factors that account for the increased regulatory costs include purchasing standards, testing costs and registering products.

Option B – Australia

Table 25 shows the additional regulatory costs for Option B, compared with BAU.

Table 25: Option B regulatory costs

Change in costs	Business	Community organisations	Individuals	Total change in costs
Total, by sector	$769,000	$0	$7,817,000	$8,587,000
Cost offset	Business	Community organisations	Individuals	Total, by source
Total, by sector	$0	$0	$0	To be confirmed
Are all new costs offset? A regulatory offset has not been identified. However, the Department of the Environment and Energy is seeking to pursue net reductions in compliance costs and will work with stakeholders and across Government to identify regulatory burden reductions where appropriate.				
Total (Change in costs – Cost offset) ($million) = To be confirmed				

The additional regulatory costs for Option B are estimated to be almost $8.6 million per year. This is mostly due to the cost to individuals (an estimated 720,000 households) to fupgrade their dimmer systems so that they are compatible with LED lamps. Compared with Option A, Option B has slightly lower costs for businesses ($769,000 per year), as a result of suppliers not having to continue to register around 40 products per year that are subject to the phase out.

Option A – New Zealand

It is estimated that an additional 50[74] suppliers are selling LED products into the New Zealand market. The additional cost per LED supplier is estimated to be around $A8,700 ($NZ10,200) per year. The total regulatory cost for New Zealand is estimated to be $A434,000 per year ($NZ512,000).

Inputs to RBM costs

Number of suppliers in scope

LCA in its response to the September 2017 supplementary paper said the number of suppliers is likely to be greater than 200. E3 sourced additional data on LED imports for the calendar year 2017. Based on the updated data, the assumed number of LED lamp suppliers has been increased to 246. The 34 suppliers covered by the existing lighting regulations are included in this count.

Number of registrations

Suppliers would be required to register information with the regulator about LED lamp products they supply. The supplementary consultation paper estimated 1,200 registrations per year - but this included a narrower definition for family of models. E3 estimates the number of LED lamp registrations[75] would average 500 per year, based on aligning the family definition with electrical safety.[76]

Purchasing standards

Standards are documents often referred to in regulations that provide instructions (e.g. how to test products) in order to comply with the regulations. The estimated costs have been increased following feedback from LCA. LCA stated the supplementary paper did not recognise that in-house product engineers would need to purchase many of the additional standards, in order to understand the standard and product requirements, regardless of whether products are tested in-house or not. Based on this feedback, the standard purchase costs of $1,226 have been conservatively applied to 148 suppliers (assuming that the remaining 40 per cent of suppliers have already purchased standards for EU

[74] As per the consultation RIS estimates, this is based on 20% of LED suppliers selling in Australia. This reflects the proportion of linear fluorescent lamp registrations in Australia and New Zealand.

[75] Similar models of LED lamps could be grouped under a single registration "family".

[76] This estimate has been informed by the number of electrical safety family registrations for linear lamps (Level 3 from 1 January 2018) and catalogue data of a sample of LED lamps on the market.

regulation). Suppliers are assumed to incur this cost every five years, for an additional cost of $360,000 over the 10 year RBM period.

Testing costs

Suppliers would be required to test products (where testing hasn't already been performed) to ensure they comply with the proposed LED MEPS. E3 sought quotes for LED testing from laboratories based in Australia and overseas. The average cost was $4,612 - this price has been used in the updated costing.

CA said that based on the supplementary paper proposal, 75 per cent of LED product families supplied to the Australian market would need to undertake full testing. For the final proposal, based on aligning fully with EU requirements, it is assumed that 60 per cent of product families would undertake full testing. This estimate is likely to be conservative, as it may include testing that has already been undertaken for some products. Total test costs are estimated to be $1.1 million per year.

Registration

To minimise regulatory costs on suppliers, suppliers would be able to register products for energy efficiency regulations when registering for electrical safety in the Electrical Equipment Safety System. This streamlined single point of registration process is estimated to cost $69 per product family (one hour of an administrative officer's wages plus on costs). This is included in the updated costing as the time spent registering 500 product families per year, for a total cost of $35,000 per year.

Attachment A1: Electricity prices and GHG emissions

For Australia, electricity prices and forecasts are based on AEMO projections (2015) and these were converted from state to national values using floor area data to weight each state value. For New Zealand, long run marginal electricity costs were used, as requested and provided by the Ministry of Business, Innovation and Employment. These are constant over time (in real terms).

Table 26: Electricity prices (real 2017 $/kWh) for Australia and New Zealand (real)

Region/year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Australia - Commercial (AUD)	$0.196	$0.194	$0.192	$0.188	$0.196	$0.203	$0.212	$0.219	$0.228	$0.236	$0.242	$0.246	$0.248	$0.253
Australia - Residential (AUD)	$0.309	$0.307	$0.303	$0.296	$0.304	$0.312	$0.320	$0.328	$0.338	$0.346	$0.352	$0.356	$0.359	$0.364
New Zealand - Commercial (NZD)	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088
New Zealand - Residential (NZD)	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088	$0.088

Updated projected emission factors for Australia and New Zealand have been included. In Australia they are based on the Scope 3 emission factors for the consumption of electricity by the consumer. The projected Scope 1 emission factors (of electricity sent out by State) were provided by the Department of the Environment and Energy (March 2017). The New Zealand estimates were provided by the Ministry of Business, Innovation and Employment — these are long-run marginal costs and are constant over time (in real terms).

Table 27: GHG emission factors for electricity (kg CO2-e/kWh) for Australia and New Zealand (real)

Region/year	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Australia	0.97	0.95	0.93	0.91	0.91	0.90	0.90	0.91	0.91	0.90	0.90	0.90	0.89	0.89
New Zealand	0.1428	0.1501	0.1509	0.1343	0.1347	0.1289	0.1045	0.0997	0.1003	0.0963	0.0929	0.0918	0.0924	0.0912

ATTACHMENT B: LED Lamp Test Results

Energy Efficiency Compliant Products Program (EEPLIANT)

- EEPLIANT is a coordinated initiative by 13 Market Surveillance Authorities across the EU Single Market intended to increase the rate of monitoring, verification and enforcement activities and product compliance under the European Commission Energy Labelling and Eco-design Directives.
- EEPLIANT evaluated 141 LED lamps purchased in 2016 for compliance with current European Commission LED regulations [77]. The sample selected were based on a risk assessment of possible non-compliance so results do not represent a statistical picture of the whole market. Activity focussed on the most common types of LED lamps available on the EU market (including non-directional and directional lamps (mains voltage and low voltage lamps).
- While the exercise took a ‘risk based’ approach, with the goal to efficiently detect and remove as many non-compliant products as possible; within the project, the sample included LED lamp models with significant market relevance, including a broad mix of established and new sales brands, typically available from supermarkets, electronics stores, furniture stores or online shops.
- Initial steps, including document and packaging inspection and low cost screening tests identified 86 products for testing.
- Of the 86 lamps tested (25 directional and 61 non-directional), only 12 were fully compliant. The final report notes that the most significant problems were lamps that were not bright enough or poor lifetime performance. A summary of results are provided in Table 28.

[77] http://eepliant.eu/index.php/knowledge-base/item/2017-12-31-eepliant-1-final-report

Table 28: EEPLIANT LED Testing: Indicative levels of non-compliance for individual parameters

Regulated Parameter	Percentage Non-compliance	Number of Models Assessed
Information on packaging	45%	141
Declaration of conformity	37%	141
Documentation availability and content	54%	141
Luminous flux	55%	86
Electric power	19%	86
Energy efficiency index	39%	86
Colour temperature	12%	86
Colour rendering	2%	86
Lamp Survival Factor	22%	86
Lumen maintenance	17%	86

E3 LED lamp testing 2017

- The E3 Program purchased 35 LED lamp models (from 28 brands) from the Australian market during the period of October 2017 to December 2017 and tested these lamps through two independent laboratories for displacement power factor, luminous flux, power, efficacy, colour rendering index (CRI), correlated colour temperature (CCT), flicker (visible) and stroboscopic (non-visible flicker). Three samples of each lamp were tested for each product.
- Products were purchased online and included major brands and less well known brands.
- Tests for CCT and CRI used the latest CIE test method. For CRI, the compliance criteria applied was for existing EU and proposed EU and AUS/NZ MEPS (CRI Ra value for residential lighting of equal or above 80). Tests for CCT used the ANSI quadrangles for colour consistency (proposed AUS/NZ MEPS, less stringent than the six step MacAdam Ellipse required under existing EU regulation). Test method and minimum levels for power factor used IEC standards (also under proposed EU regulation and MEPS levels proposed for AUS/NZ). Test for efficacy (luminous flux and power) used the CIE test method and MEPS levels previously proposed for AUS/NZ. Metrics for flicker and stroboscopic used the recommended interim approach from CIE (with test methods from IEC technical papers on PstLM with pass of 1.0 and SVM with pass of 1.6).
- Of the 35 lamps tested, 15 had functional quality issues (42 per cent). Issues included:

Colour Rendering (CRI Ra is a measure of the ability of a light source to reveal the colours of objects in comparison with natural light) - Low colour rendering or inaccurate claims may reduce consumer confidence in the ability of LED lamps to provide an effective alternative to halogen lighting. Three models had values of 71, 74 and 61, significantly below the accepted minimum CRI Ra value for residential lighting of 80. One model significantly over-claimed on CRI, with a claimed Ra value of >90, with testing finding instead a value of 82.

Colour Temperature (CCT) (measure of a light source's colour appearance in Kelvin and often described as cool white, warm white, extra warm white) - One model was found to have an inaccurate colour temperature claim[78].

Displacement Power Factor (low PF imposes real costs on electricity network and therefore consumers). Seven models tested had power factors below the agreed international standard[79].

Flicker – Four models failed with a Pst > 1 (TLA – flicker effect).

Stroboscopic - Five models failed with SVM of > 1.6 (TLA – stroboscopic effect).[80]

Efficacy - Four models failed proposed draft efficacy limits -tested efficacies of 62.8 and 64.1 lm/W (non-directional) and 95.1 and 80.1 (linear LED).

A number of other models were assessed as having met requirements after laboratory uncertainty levels were taken into account.

Twelve lamps were also found to have Total Harmonic Distortion of ≥ 100%, indicating that they are unlikely to comply with IEC individual harmonics requirements. Testing of these twelve models found that six would not comply with the IEC standard.

Package claims

- Lamps were also checked for accuracy of packaging claims for lumens (brightness) and power. A 10 per cent tolerance for the marking of these values was applied (above and below), consistent with the approach under existing EU regulation.
- In addition to the above results, some lamps were found to have made inaccurate performance claims on packaging (accuracy of lumens and power). Five lamps were found to have a difference of greater than 10 per cent between claimed and tested luminous flux (with up to -26 per cent difference), while nine lamps were found to have a difference greater than 10 per cent between claimed and tested power (between +11 per cent and -41 per cent difference). Further details on test results are included on page 21.

[78] Four other lamps were found to be outside the six step MacAdam Ellipses required for colour consistency in European regulation.

[79] True power factor (required under existing EU regulation) was also tested and identified six clear failures.

[80] Note that only two models failed both Pst (visible) and SVM (non-visible).

Estimating market share

- The estimated market share of poor quality products on the market could only be accurately determined by testing a large number of LED lamp models and having sales data on all LED lamps. Sales data is not available and testing by E3 of a large number of lamps is not practical due to time and cost.
- Thus the market share of poor quality products has been estimated by cross referencing the Australian supplier import LED lamp data from 1 January 2017 to 31 December 2017 against the model brands identified with quality issues in the Australian lamp testing, to identify the extent to which a given supplier is a major importer of LED lamp products into Australia.
- Of the 12 directional and non-directional lamp models identified with functional quality issues:
    - One supplier is in the top 10 importers of LED lamps into Australia in 2017. Products failed on displacement power factor and stroboscopic.
    - One supplier is in the top 15 importers of LED lamps into Australia in 2017. Product failed on flicker.
    - Three other suppliers, were in the top 100 importers of LED lamps into Australia in 2017[81]. Products failed on displacement power factor and stroboscopic.
    - Other product failures related to lamp brands outside the top 100 importers of LED lamps. As a reference, there were 1,031 registered importers of LED lamps into Australia over 2017[82].
- An additional five suppliers that had packaging claims outside the tolerance for luminous flux and/or power, are in the top 20 importers of LED lamps into Australia in 2017.
- There is no evidence that the specific models that recorded poor test results were sold in New Zealand, however, the parent company of one of the major brands that failed does supply LED products to New Zealand. A number of the products tested are sold or their distributors are active in the New Zealand market. This, and the results of other previous testing done by EECA would indicate that the testing done by the E3 Program is overall representative of the types of products supplied in the New Zealand market and their quality.

[81] Combined these suppliers imported 50,070 lamps and 0.2 per cent of lamp imports.

[82] There was 622 entities importing over 50 lamps and 436 importing over 200 lamps.

E3 LED lamp test results

Product Data										MEPS Targets	Photometric Test Data										Flicker Test Data		Claims variance		
Lamp No	Lamp Category	Claimed Power (W)	Claimed Flux (lm)	Nominal CCT (K)	Claimed CRI (Ra)	Claimed PF	Claimed Lifetime (h)	Claimed Beam Angle (degrees)	Target MEPS Efficacy for product (lm/W)	Tested Power (W)	Tested Flux (lm)	Tested Efficacy (lm/W)	Tested CCT (K)	Variance on claimed CCT (%)	Tested CRI (Ra)	Tested True PF	Tested THD (%)	Calculated Disp PF	Meeting Displ PF requiremt?	PST	SVM	Variance on claimed power (%)	Variance on claimed flux (%)	Variance on claimed CRI (Ra)
1	Non-Directional	10	810	4000	80	>0.7	25000	300	80	10.4	834	79.9	4063	pass	82.0	0.859	42%	0.79	pass	0.235	0.651	4.5%	3%	2.0
2	Non-Directional	10	830	4203	>80	-	25000	-	80	9.7	809	83.8	4107	pass	83.0	0.840	35%	0.79	pass	0.035	0.774	-3.4%	-3%	
3	Non-Directional	9.5	806	2700	-	-	15000	-	72	7.9	800	100.8	2770	pass	82.0	0.433	51%	0.39	pass	0.040	0.344	-16.4%	-1%	
4	Directional	6	550	3000	>80	-	25000	50	68	5.8	510	87.6	3033	pass	84.0	0.448	160%	0.24	fail	0.037	0.006	-3.0%	-7%	
5	Non-Directional	3	300	6000	90	-	35000	-	64	3.1	300	97.1	6114	pass	82.3	0.383	45%	0.35	fail	0.077	2.175	3.1%	0%	-7.7
6	Non-Directional	12	-	-	-	-	-	-	80	7.1	454	64.1	3148	pass	61.7	0.255	33%	0.24	fail	0.046	0.811	-40.9%		
7	Non-Directional	9	850	2900	-	-	30000	-	80	7.6	766	101.0	3024	pass	80.7	0.532	157%	0.29	fail	0.033	0.007	-15.8%	-10%	
8	Non-Directional	10	950	3000	-	-	50000	360	80	9.5	956	100.6	3177	pass	84.0	0.483	171%	0.24	fail	0.040	0.045	-5.0%	1%	
9	Non-Directional	9	850	3000	>80	-	-	-	80	8.1	779	95.9	2977	pass	82.0	0.861	48%	0.78	pass	0.028	0.457	-9.7%	-8%	
10	Non-Directional	3	255	3000	-	-	30000	150	72	3.1	197	62.8	3346	fail	71.3	0.451	187%	0.21	fail	0.104	0.004	4.3%	-23%	
11	Non-Directional	10	810	3000	80	-	25000	300	80	9.3	817	87.9	2987	pass	81.7	0.416	120%	0.65	fail	0.363	0.002	-7%	1%	1.7
12	Non-Directional	10	806	6500	-	-	15000	150	80	8.2	810	98.4	6696	pass	86.9	0.415	150%	0.75	pass	0.455	0.000	-18.0%	0%	
13	Non-Directional - Filament	3	-	2200	>82	-	15000	-	80	2.8	250	88.8	2150	pass	96.7	0.842	63%	1.00	pass	0.832	5.600	-7%		
14	Non-Directional - Smart Lamp	9.5	800	2700	-	-	25000	-	72	9.2	785	85.6	2746	pass	82.2	0.710	58%	0.82	pass	0.318	0.451	-3%	-2%	
15	Non-Directional	8	750	4000	80	-	-	270	80	7.8	753	96.9	3946	pass	83.0	0.564	138%	0.96	pass	0.598	0.051	-2.5%	0%	3.0
16	Non-Directional - Filament	4	400	2700	>82	-	35000	360	72	4.3	462	106.6	2703	pass	81.8	0.542	140%	0.93	pass	0.928	0.152	8%	15%	-0.2
17	Non-Directional	5	400	2700	>80	-	15000	-	72	4.5	411	92.1	2743	pass	82.1	0.536	154%	0.98	pass	0.975	0.134	-10%	3%	
18	Non-Directional	6.5	600	3000	80	-	15000	-	80	6.2	593	95.6	3092	pass	84.3	0.554	79%	0.71	pass	0.701	0.133	-5%	-1%	4.3
19	Non-Directional	8	806	3000	>80	-	15000	-	80	7.4	883	119.3	3006	pass	82.4	0.528	100%	0.75	pass	0.819	0.100	-8%	10%	
20	Non-Directional	4	360	4000	-	-	-	-	72	4.1	412	99.6	4104	pass	83.0	0.529	70%	0.65	pass	1.035	0.147	2.5%	14%	
21	Non-Directional - Filament	3.5	-	2700	-	-	-	-	72	3.9	394	101.4	2729	pass	84.6	0.900	47%	0.99	pass	1.020	4.790	11%		
22	Non-Directional	5.5	470	2700	80	0.45	15000	280	72	5.4	498	92.3	2696	pass	82.5	0.567	72%	0.70	pass	0.786	0.000	-2%	6%	2.5
23	Non-Directional	5.5	450	3000	>81	-	30000	-	80	4.8	421	88.1	2969	pass	82.5	0.493	64%	0.59	pass	0.919	1.181	-13%	-6%	
24	Directional - GU10	6	400	3000	-	-	-	45	68	4.3	295	69.3	3068	pass	73.9	0.826	44%	0.90	pass	1.307	1.831	-28.3%	-26%	
25	Directional - GU10	6	470	3000	80	>0.5	20000	100	68	5.4	435	80.1	2982	pass	83.0	0.542	100%	0.77	pass	1.072	0.119	-10%	-7%	3.0
26	Directional - GU10	7	540	3000	82	>0.9	30000	60	68	5.9	565	95.2	2957	pass	82.5	0.893	25%	0.92	pass	0.822	0.916	-16%	5%	0.5
27	Directional - GU10	6	550	6000	>80	-	25000	50	68	5.7	549	97.0	6434	pass	86.7	0.480	160%	0.90	pass	0.921	0.000	-6%	0%	
28	Directional - MR16	6	500	3000	82	>0.9	30000	60	68	6.1	526	85.5	3078	pass	82.6	0.991	8%	0.99	NA	0.860	0.000	2%	5%	0.6
29	Directional - MR16	7.7	480	3000	80	-	25000	40	68	7.1	478	67.2	3129	pass	81.1	0.716	46%	0.79	NA	0.800	0.000	-8%	0%	1.1
30	Directional - MR16	4.2	310	4000	>90	-	25000	-	52	3.5	285	82.0	3995	pass	95.3	0.852	36%	0.91	NA	1.331	0.000	-16.7%	-8%	
31	Directional - MR16	7	470	3000	80	0.7	25000	35	68	7.2	481	67.1	3057	pass	85.3	0.720	45%	0.79	NA	0.927	0.000	3%	2%	5.3

FAIL: At least one functional test (ie efficacy, CCT, CRI, PFdisp, flicker)
FAIL: At least one tested value outside tolerance of claimed value (ie power, flux, CRI)
PASS: Due to applying laboratory uncertainty in measurement
PASS

Product Data									MEPS Targets	Photometric Test Data										Flicker Test Data		Claims variance		
Lamp No	Lamp Category	Claimed Power (W)	Claimed Flux (lm)	Nominal CCT (K)	Claimed CRI (Ra)	Claimed PF	Claimed Lifetime (h)	Claimed Beam Angle (degrees)	Target MEPS Efficacy for product (lm/W)	Tested Power (W)	Tested Flux (lm)	Tested Efficacy (lm/W)	Tested CCT (K)	Variance on claimed CCT (%)	Tested CRI (Ra)	Tested True PF	Tested THD (%)	Calculated Disp PF	Meeting Displ PF requiremt ?	PST	SVM	Variance on claimed power (%)	Variance on claimed flux (%)	Variance on claimed CRI (Ra)
32	Linear	11	1856	6000	-	-	-	175	100	11.5	1589	138.4	6098	pass	83.2	0.920	13%	0.93	pass	0.686	0.160	5%	-14%	
33	Linear	18	1800	4000	-	-	30000	200	100	17.5	1928	109.9	3998	pass	82.7	0.903	16%	0.91	pass	1.113	1.818	-3%	7%	
34	Linear	18	1690	4200	-	-	-	140/150	100	17.9	1740	95.1	4001	pass	84.1	0.862	44%	0.94	pass	0.983	1.185	-1%	3%	
35	Linear	20	1800	4000					100	20.9	1675	80.1	4045	pass	81.1	0.863	56%	0.99	pass	0.861	0.172	4%	-7%	

Red	FAIL: At least one functional test (ie efficacy, CCT, CRI, PFdisp, flicker)
Yellow	FAIL: At least one tested value outside tolerance of claimed value (ie power, flux, CRI)
Orange	PASS: Due to applying laboratory uncertainty in measurement
White	PASS

Below are examples of TLA test results for lamps that failed on flicker or stroboscopic effects.

Figure 17: E3 Testing: Lamp does not meet SVM (stroboscopic)

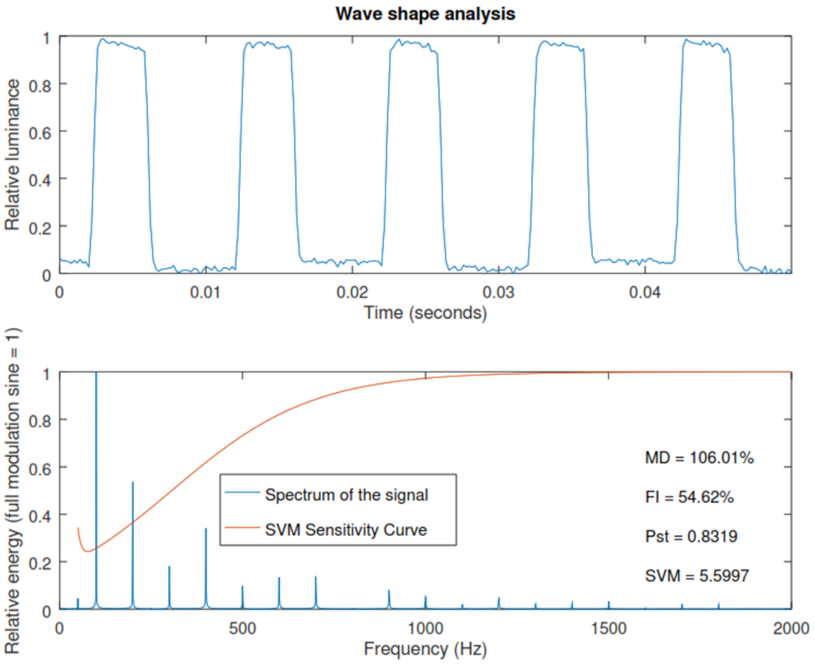


Figure 18: E3 Testing: Lamp does not meet Pst (visible flicker) or SVM (stroboscopic)

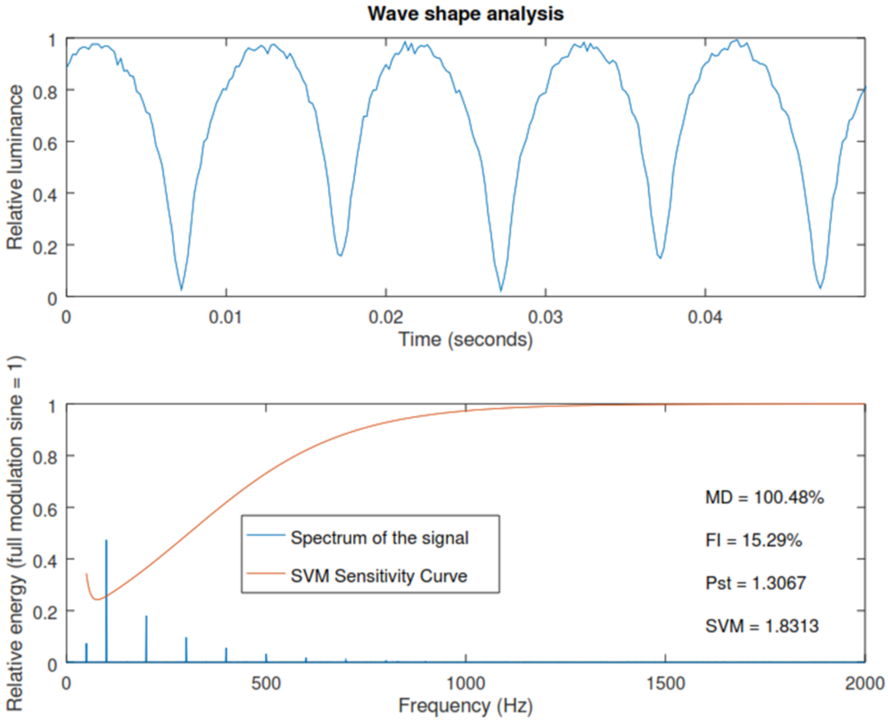
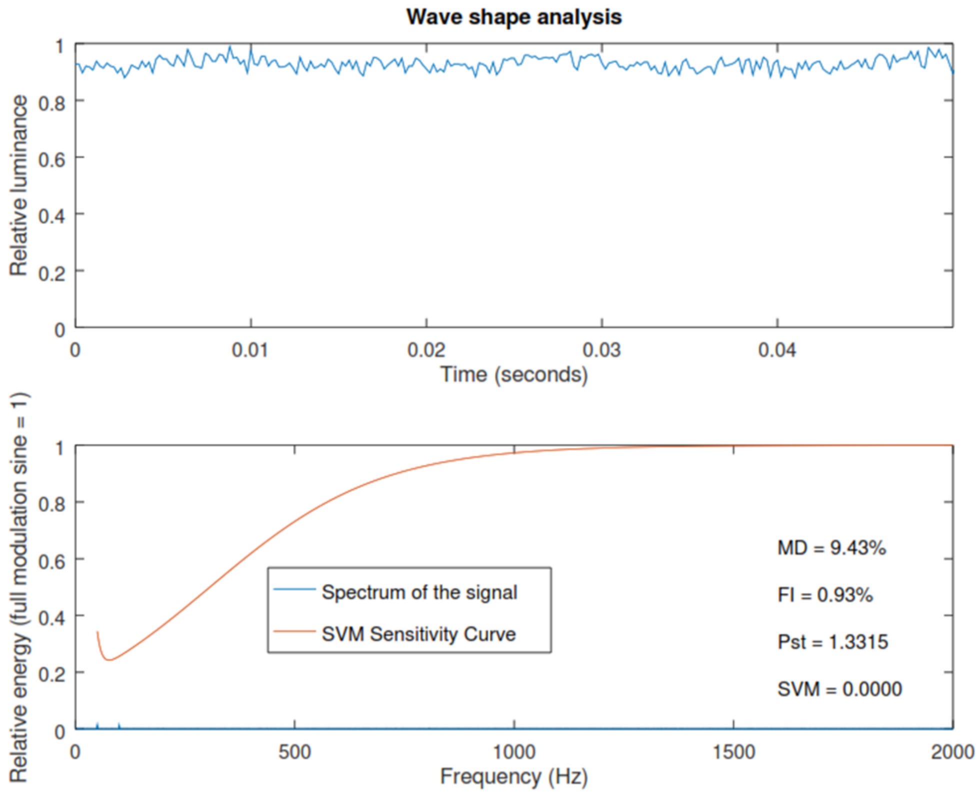
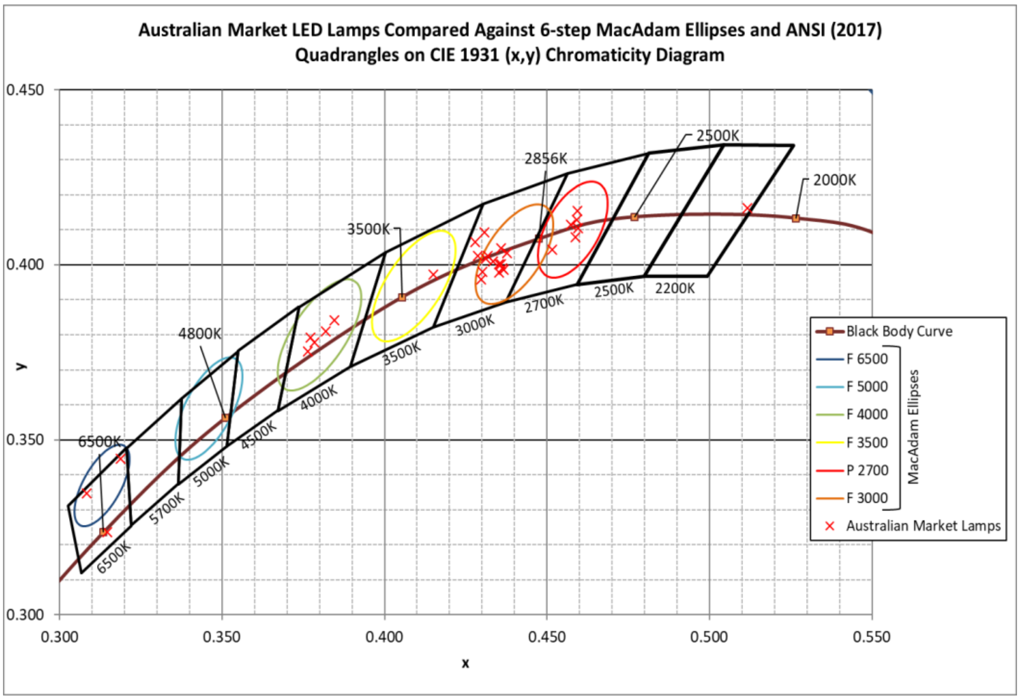


Figure 19: E3 Testing: Lamp does not meet Pst (visible flicker)



Below is the colour chart for tested lamps with EU regulation 6-step MacAdam ellipses and ANSI quadrangles, indicating one lamp claiming CCT of 3000K is outside the quadrangle. Four other lamps were found to be outside the six step MacAdam Ellipse, for their rated CCT, required for colour consistency in current European regulation.

Figure 20: E3 Testing: Colour chart for tested lamps



ATTACHMENT C: Temporal light artefacts

Temporal light modulation and temporal light artefacts

Temporal Light Artefacts (TLAs) are visual phenomena that arise when the luminous environment includes Temporal Light Modulation (TLM) and include:

- **flicker**, visual unsteadiness in which a static observer views a static light source (perceived up to frequencies of ~80 Hz);
- the **stroboscopic effect,** which is an interaction of the TLM with a moving object (e.g. a moving object appears to move discretely rather than continuous, or a rotating object is perceived as static; can occur with frequencies higher than 100 Hz (non-visible range)).
- the **phantom array**, which is an interaction between the observer's eye movements and TLM, resulting in a change in perceived shape or spatial positions of objects.

The CIE Technical Note 008:2017**,** arising from the workshop held in 2017, provides a concise summary of why this issue is important:

'Temporal light modulation, whether from the design of the driver or through dimming control, can have adverse effects on visual function and health (Wilkins et al. 2010). Therefore, it is advisable for standards to be developed that will limit the possibility that new light sources and controls will produce light output with undesirable TLM characteristics.

There is a liability risk for industry in possibly introducing products to market that may cause harm to consumers, and risks to public health for those who might experience these consequences'. The desired end state for standards documents is a set of international standards that is straightforward for manufacturers and practitioners, and in which consumers may have confidence. The Workshop Organizing Committee invites all interested stakeholders to join with us in pursuing this work so that together we will efficiently and quickly develop guidance to facilitate the development of new lighting technologies and systems that support the adoption of energy-efficient, high-quality lighting with appropriate limitations on TLM to support human needs.'

How can TLA occur in manufacturing?

Below is an extract from **CIE TN 006:2016**, which outlines that lowering TLA can be achieved but at a higher manufacturing cost.

'The need for understanding the perception of temporal light artefacts is increased by the fact that limiting the temporal modulation of light sources introduces compromises to the cost, features, or lifetime of the source, for both intended and unintended modulation. In the case of intentional modulation, lowering the visibility of temporal light artefacts can be achieved by increasing the driving frequency of the system, which can lead to higher material costs, a decrease in efficiency (Mulligan et al., 2007) and a decrease of the capabilities of the system. Examples of such decreases of capabilities are the loss of the possibility for dimming below a given level or observing visible steps between the intensity levels (Sekulovski et al., 2011). A driving frequency within a given range can also introduce other problems like audible noise (Garcia et al., 2011). To limit the influence of the unintentional sources of modulation on the light output, additional measures have to be implemented. These additional measures may result in increased material cost, increased size, lower efficiency, and lower lifetime of the light sources (Arias et al., 2012).

CIE Technical Note 006:2016 Visual Aspects of Time Modulated Lighting – Definitions and Measurement Models was published in response to the unintended effects of light modulation caused by solid state lighting (LED) products. It states 'the visible modulation of light can lead to a decrease in performance, increased fatigue as well as acute health problems like epileptic seizures and migraine episodes'. (Source: http://www.cie.co.at/publications/visual-aspects-time-modulated-lighting-systems-definitions-and-measurement-models)

Final Report CIE Stakeholder Workshop for Temporal Light Modulation Standards for Lighting Systems CIE TN 008:2017 was conducted to *'develop a roadmap of research, recommendations, and standards activities related to temporal light modulation from lighting systems that are needed in order to speed up the process of developing international standards in an efficient way while preventing overlap and duplicate effort. The roadmap leads, through collaborative effort, to evidence-based international standards intended to limit undesirable TLM from lighting products and systems. Lighting systems that meet these standards will thereby support the needs of lighting end-users, which will facilitate the market acceptance of new technologies and the achievement of energy-efficient targets.'*

The report notes possible effects of TLM on people including: *'Visual perception effects (temporal light artefacts, TLA): flicker, stroboscopic effect, and phantom array; Performance effects: eye movements changes, changes in visual performance, changes in cognitive task performance; Neurobiological effects: headache, eyestrain, migraine, epilepsy, etc*. (Source: CIE TN 008-2017 Final Report: CIE Stakeholder Workshop for Temporal Light Modulation Standards for Lighting Systems. http://www.cie.co.at/publications/final-report-cie-stakeholder-workshop-temporal-light-modulation-standards-lighting

Institute of Electrical and Electronics Engineers (IEEE) has extensively documented the health effects of flicker and has recommended practices for limits and associated flicker test methods. (Source: IEEE 1789: 2015; health aspects pp 20-24, recommended practices pp 43-56, Source: https://www.techstreet.com/standards/ieee-1789-2015?product_id=1896595) (NOTE: restriction on access to standard).

The European Commission, requested that the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) review recent evidence to assess potential risks to human health of Light Emitting Diodes (LEDs) emissions. The committee's preliminary opinion, published July 2017 among other conclusions stated:

"*LED lighting can produce a stroboscopic effect, depending on the degree of modulation. The use of modulated LED lighting in domestic and other non-industrial environments where awareness is likely to be low is of a concern. Although no published case-studies were identified, there are claims that a small number of people are very sensitive to flickering light at about 100 Hz, triggering symptoms such as headaches, migraine and general malaise.*" (Source: SCHEER (Scientific Committee on Health, Environmental and Emerging Risks), Preliminary Opinion on Potential risks to human health of Light Emitting Diodes (LEDs), 6 July 2017.

Available test standards

CIE TN 006-2016 Visual Aspects of Time Modulated Lighting – discusses the issue and recommends use of P_{st}LM and SVM. 'This Technical Note (TN) is an intermediate product of the work of the TC, available at CIE webpage. Since the CIE workshop in 2017, CIE has approved the formation of a new technical committee, TC 2-89, titled "Measurement of Temporal Light Modulation of Light Sources and Lighting Systems". The committee is tasked with the development of a measurement protocol, followed by standardized test methods for metrics developed by CIE TC 1-83 "Visual Aspects of Time- Modulated Lighting Systems.

International Electrotechnical Commission (IEC) – A recent revision of ***IEC TR 61547-1 (2017) "Equipment for general lighting purposes – EMC immunity requirements– Part 1: An objective light flickermeter and voltage fluctuation immunity test method" now describes an objective light flickermeter***, to be used for testing the intrinsic performance of all lighting equipment (without voltage fluctuations) for short term flicker light measurement (P_{st}LM). The CIE TN006-2016 recommends the use of the short-term flicker severity metric, P_{st}LM, and references this IEC Technical Report (albeit the 2015 version) to measure it.

A current draft of ***IEC DTR 63158 "Equipment for general lighting purposes – Objective test method for stroboscopic effects of lighting equipment"*** now provides an objective stroboscopic effect visibility (SVM) meter, which can be applied for performance testing of lighting equipment under different operational conditions.

The CIE TN006-2016 recommends the use of the Stroboscopic effect Visibility Measure, SVM, (now referred in this IEC draft Technical Report) to quantify the visibility of stroboscopic effects.

It is understood that the outcomes from the two CIE committees referred to above will be (a) TC 2-89: develop CIE test methods, fully specifying laboratory instructions for undertaking these tests and (b) TC1-83: review and adjust/reconfirm the threshold for passing SVM and P_{st}LM. It is anticipated that these outcomes will not be available until 2021.

In addition, the U.S. National Electrical Manufacturers' Association (NEMA) published its ***Standard for Temporal Light Artifacts*** **(NEMA 2017)** in April 2017, in which it recommends P_{st} and SVM as the metrics, includes measurement details and suggested general criteria for limits (or "acceptance criteria" in NEMA terminology) of P_{st}LM ≤ 1.0 and SVM ≤ 1.6.

IEEE - has recommended practices for limits and associated flicker test methods. IEEE has formed a Study Group to determine whether IEEE 1789 requires maintenance. (Source: IEEE 1789: 2015; health aspects pp 20-24, recommended practices pp 43-56, Source: https://www.techstreet.com/standards/ieee-1789-2015?product_id=1896595).

By recommending the IEC metrics and tests the CIE considers the threshold recommended by IEEE is too stringent based on current evidence.

ATTACHMENT D: Revised proposals and other options considered

Revised proposals

Introduce MEPS for LED lamps and integrated luminaires

The scope of MEPS for LED lamps and integrated luminaires (small directional; small non-directional; planar, battens and troffers; and large) was reduced to lamps only for this Decision Regulation Impact Statement, as a result of stakeholder feedback on the Consultation RIS that did not support MEPS on LED luminaires.

Feedback on original proposal in the Consultation RIS:

There was broad support for LED MEPS on lamps (non-directional, directional, linear) in Australia. Some stakeholders raised concerns regarding the breadth of performance parameters proposed, arguing that the performance requirements should only relate to energy efficiency.

Several submissions specifically did not support mandatory minimum marking requirements; however, it appears that there may have been some confusion between the concept of a mandatory label of specific design and a set of minimum packaging information requirements (no specified design).

Industry stakeholders have asked for a longer introduction period than the originally proposed six months.

LCNZ argued against the introduction of MEPS for LED lamps in New Zealand in the absence of the phase out of incandescent lamps and inclusion of lighting efficiency in building code requirements in New Zealand.

Many submissions from industry stakeholders expressed concern about the impact of MEPS for integrated luminaires (small directional; small non-directional; planar, battens and troffers; and large).

Concerns relate to the high numbers of integrated luminaire models currently available (estimates from stakeholders on the overall number of LED products on the market at any time range from 150,000 to one million in Australia, most being integrated luminaires) and the short product development and market periods (6–10 months), with the resulting compliance burden not being commercially viable for many suppliers. High-end lighting suppliers and lighting designers are concerned about the compliance burden upon the ‘professional’ lighting market which deals in higher value, low volume luminaires, arguing that MEPS levels restrict the supply of high-end tailored lighting products, stifling creativity, obstructing ‘efficient’ directed and designed lighting solutions, and impacting upon business models. Expensive, low-volume products may also be removed from the market due to registration and compliance costs. Stakeholders also suggested that there was insufficient evidence of poor performance with LED luminaires and raised the difficulty in enforcing MEPS in such a large market while suggesting that ACCC Law provides adequate consumer protection.

Some submissions also noted a perceived overlap with the power density requirements in section J6 of the National Construction Code and the NZS 4243: Energy Efficiency Large Buildings - Part 2: Lighting design standard (which is referenced in the New Zealand building code) and the need to update this.

Luminaires

Integrated luminaires were removed from scope in response to concerns raised by stakeholders.

New Zealand position

In response to the feedback from LCNZ, it is noted that in New Zealand, there is no plan to phase out incandescent lighting at this time, however there is agreement to ensure that within individual lighting technologies products are on the market are of reasonable quality. The New Zealand Energy Efficiency Conservation Authority (EECA) accepts the feedback related to the commercial building lighting density, and supported a project to update NZS 4243 which will address some of the concerns raised.

Abandoned proposals

Introduce MEPS for non-integrated commercial luminaires

Feedback:

Stakeholders were generally of the view that non-integrated commercial luminaires will be gradually removed from the market over the next several years.

Some stakeholders agreed that there may be a case for a simple MEPS level to be introduced to accelerate this removal and to also prevent some backwash into cheaper, lower quality non-integrated products at the lower end of the commercial building market if MEPS was introduced for LED alternatives (such as planar luminaires), locking in inefficient lighting in these buildings for years to come.

LCA did not support the introduction of MEPS for these products.

LCNZ argued against the introduction of MEPS for non-integrated commercial luminaires in New Zealand on the basis that the updating of the lighting design energy performance standard NZS4243: Part 2:2007 and building code energy limits for commercial and industrial buildings is a higher priority in this area. There is a project underway to update NZS4243.

This option was presented to serve a dual purpose of achieving energy savings in the lower end of the commercial market where there is no incentive for the agent to install efficient luminaires, as well as addressing a potential regulatory imbalance if MEPS is applied only to LED integrated luminaires.

The latter rationale is no longer applicable for the Decision RIS, with LED MEPS not being proposed on LED planars etc. until further investigation is carried out to address the regulatory issues.

Position:

In the absence of strong evidence to support the need to regulate these products out of the market, this policy proposal is not recommended in the Decision RIS.

Mandatory labelling

Feedback:

The proposal for a mandatory label for lighting products was not supported by LCA, LCNZ and most other submissions. The inclusion of the mandatory label option in the Consultation RIS was in the context of a fall back option in the absence of the halogen phase out.

Position:

This proposal is not recommended. As noted above, it is proposed that the LED MEPS include mandatory product and package marking requirements.

Other options considered

In addition to options referred above, the product profiles also raised options in relation to the MEPS levels for linear fluorescent lamps, ballasts for linear fluorescent lamps and CFLs, as well as mercury levels for linear fluorescent lamps and CFLs.

In agreement with Office of Best Practice Regulation (OBPR), a proposal to reduce allowed mercury levels in CFL and linear fluorescent lamps in order to meet the requirement of the Minamata Mercury Convention and align with levels set by major markets was managed as a separate consultation paper outside the RIS process in Australia. This was on the basis that the proposed change had a minor impact on industry and consumers[83]. Replacement determinations were in place in June 2017 and became effective from 7 December 2017.

Other options canvassed as part of stakeholder consultation included an increase in the MEPS levels for CFL (integrated) and linear fluorescent lamps. The current MEPS levels in place in Australia and New Zealand are lower than in some other markets, and in the case of the EU, it is currently proposed to phase-out CFL (integrated) and some T8 linear fluorescent lamps in 2020. While further opportunities were identified to achieve energy

[83] Regulatory amendments to reduce mercury levels were implemented for Australia only. New Zealand amendments are being managed separately.

savings in these areas, industry stakeholder feedback advised that the transition is already well underway from fluorescent to LED lighting, also indicated by recent sales figures, as discussed in the Consultation RIS. Import volumes of these products will be monitored.

An Australian tax on halogen light bulbs was explored with the Australian Treasury as an option to reduce sales of inefficient light bulbs and encourage greater uptake of energy efficient CFLs and LED. The key advantage of imposing a tax on inefficient light bulbs is that it retains consumer choice, allowing consumers with a strong preference for halogen light bulbs to continue purchasing them, should their satisfaction from purchasing the product still exceed the now higher price. However, there are a number of disadvantages to pursuing increased energy efficiency by imposing a tax on halogen light bulbs, and Treasury considers these outweigh the advantage noted above.

Key problems in moving consumers away from inefficient light bulbs include imperfect consumer information about the efficiency and lifetime costs of different lighting options, and the incentive for landlords and builders to opt for lighting with the cheapest upfront, rather than lifetime, cost. A tax would therefore have to increase the price of halogen light bulbs such that it is at least equal to the price of the more efficient light bulbs. Anything less than this and the incentive for landlords and builders to purchase the cheaper halogen product would remain, while other consumers' imperfect information would likely also lead to continued preference for the option with the lower upfront cost. Given indicative pricing of halogen light bulbs at $3 and LED lights at $7-$10, a tax that would increase the price of halogen bulbs above the price of LEDs would need to be in excess of 250 per cent, a rate well beyond what is considered reasonable for a tax.

The *2016 Consumer Household Survey* suggests some inelasticity in the demand for halogen light bulbs, indicating that 41 per cent of halogen consumers simply replace like for like based on what they have in their home. This again suggests that a tax rate would have to be very high in order to stimulate behavioural change.

Further, a tax on such a narrow base is administratively burdensome for businesses and carries high inefficiencies relative to a broad-based consumption tax. In addition, if the tax were effective in reducing consumption of halogen light bulbs it would quickly become obsolete; the revenue base would go into structural decline, and a new means of incentivising increased energy efficiency in lighting would be required. These features contravene the tax policy principles of sustainability, efficiency and simplicity.

A halogen light bulb tax has therefore not been developed as an option for consideration.

Extension of the state white certificate schemes that facilitate LED lighting upgrades in New South Wales, Australian Capital Territory, Victoria and South Australia was explored with Queensland, Tasmania, Western Australia and the Northern Territory. All jurisdictions advised that there is no plan to implement these arrangements in their jurisdiction.

Education was explored as a means to address the current information asymmetry and improve consumer knowledge of the efficiency, lifetime cost, and substitutability of different lighting technologies[84]. The New Zealand RightLight education campaign, adopted to improve sales of efficient light bulbs, demonstrates that education has an impact but can only achieve limited environment and financial benefits in comparison to regulation. New Zealand supermarket sales data shows a 15 per cent reduction in market share of incandescent light bulbs from 2009 to 2015[85].

Over this period in New Zealand, the market share of halogen increased to 12 per cent and LED to three per cent, with CFLs remaining steady at 14 per cent market share. Whilst anecdotal feedback suggests that the proportion of sales of efficient lamps is higher in trade stores, incandescent light bulbs continue to represent the bulk of sales. A 15 per cent reduction in market share of incandescent bulbs is a positive result from a public education campaign. However, it shows that even a well-designed voluntary program will not have the same level of effect as regulation. The New Zealand RightLight campaign finished in 2016. However, promotion of energy efficient light bulbs is continuing as part of the guidance to consumers under New Zealand's overall energy efficiency information program and retail partners are continuing to promote LED technology with their own marketing and promotions.

The potential benefits achieved through education (as demonstrated in New Zealand) fall short of the Council of Australian Governments' (COAG) Energy Councils expectations on savings to be achieved through the transition to more efficient lighting in Australia, as defined in the E3 Prioritisation Plan[86]. Education is therefore presented as necessary to support implementation of the agreed option, but has been discounted as a standalone proposal. The prioritisation of the E3 Program's activities is an important component of the National Energy Productivity Plan (NEPP), which was agreed by Energy Ministers on 4 December 2015. The NEPP is seeking to improve Australia's energy productivity by getting more value from the energy we consume and has set a target of increasing Australia's national energy productivity by 40 per cent by 2030. The residential sector is projected to achieve a significant proportion of the target, much of which will be delivered by the E3 Program[87].

The Prioritisation Plan has been developed to identify how the E3 work program can be aligned to accelerate policy development and focus on products that will deliver the most

[84] There are already some information programs in Australia via government websites but this is having limited impact.

[85] Incandescent sales represented 79 per cent of supermarket sales in 2006 and 83 per cent of supermarket sales in 2009. In 2015, incandescent sales represent 68 per cent of the supermarket sales.

[86] COAG Energy Council Ministers approved the E3 Prioritisation Plan in May 2016.

[87] COAG Energy Council, *National Energy Productivity Plan*, 2015.

benefits including improved energy productivity, lowering greenhouse gas emissions, and reducing energy costs. The Prioritisation Plan identifies six priority areas (including lighting) for E3's immediate focus.

As a participant in the E3 Program, New Zealand also is progressing work streams identified in the Prioritisation Plan. In New Zealand, the policy context for improving the energy use of products available for sale in New Zealand is set out in the *New Zealand Energy Strategy 2017-2021*. This outlines key priorities and strategic direction across New Zealand's energy sector, including the efficient use of energy.

Its companion document, *The New Zealand Energy Efficiency and Conservation Strategy 2017-2022*, sets actions and targets which will contribute to achieving the Government's policies and objectives. One of the three priority areas identified by the Strategy is the innovative and efficient use of electricity. The target for this priority area is that 90% of electricity will be generated from renewable sources by 2025 (in an average hydrological year) providing security of supply is maintained. Significant progress has been made towards this target over the last few years, due in part to increasing uptake of energy efficient technologies. MEPS and labelling "contribute to the Government's policy priorities of innovative and efficient use of electricity by improving the energy performance of products, such as fridges, freezers and heat pumps."

ATTACHMENT E: Phase out of inefficient lamps

Scope

Table 29 below provides information on the proposed phase out for different lamp technologies/type. E3 will finalise phase out details in consultation with stakeholders as part of drafting the determination. Energy Ministers will approve final detail in considering the replacement incandescent and halogen determination.

Note: Class refers to the product classes referenced in the GEMS Incandescent Determination.

Table 29: Proposed phase out of halogen and incandescent lamps

Technology and/or type	Proposal
Incandescent and halogen Pilot lamps	Phase out greater or equal to 10w pilot lamps
Incandescent and halogen lamps 25W and below (candle, fancy round decorative)[88] (Class 3,4,5) Caps: E14, E26, E27, B15 or B22d	Phase out greater or equal to 10w
Mains voltage Incandescent and halogen non-reflector (class 6) Caps: E14, E26, E27, B15 or B22d	Phase out all non-directional lamps
Mains voltage halogen capsules Caps: G9 bi-pin	Proposed for phase out. As part of drafting determination, review availability of LED replacements for halogen G9 in higher lumen ranges.

[88] Note – all incandescent GLS shape and candle, fancy round decorative >25W are already phased-out.

Technology and/or type	Proposal
Mains voltage reflector incandescent lamps (includes halogen) Caps: E14, E26, E27, B15, B22d, GU10	Currently unregulated. As part of drafting determination review price gap between halogen and LED (R and PAR) to confirm feasibility of phase out. Review consumer impacts of phasing out GU10 halogen downlights without MEPS on LED recessed luminaires (replacement for GU10 in addition to LED downlight).

Exemptions

The cap types listed below are proposed to be exempt from phase out for the reasons outlined below.

Extra low voltage halogen lamps

Justification:

- Due to the high upfront cost that some households would face in needing to replace their lighting system, in the absence of an equivalent LED lamp being available to work with their existing low voltage converter.

R7 Tubular halogen lamps

Justification:

- Currently available LED replacements do not emit enough light and/or are too bulky to fit inside conventional halogen floodlights.
- This type of floodlight has a shrinking penetration, in favour of integrated LED floodlights.
- This type of floodlight has perceived limited operating hours (e.g. used for backyard barbeques, etc.), thus the temporary delay in phase out will not be a large loss in energy savings.

G4 and GY6.35 ELV halogen capsules

Justification:

- LED replacements currently do not emit enough light and/or are too bulky (especially for higher power halogen lamp replacements).
- Transformer compatibility issues exist.
- Desk lamps (a popular application) have a shrinking penetration, in favour of integrated LED units.

Current Exceptions in the Incandescent Lamps for General Lighting Services Determination

The following exceptions listed in sub section 5(2) of the Determination are proposed to remain:

- Automotive lamps

- Traffic lights
- Lamps used for air and sea navigation
- Oven lamps
- Infra-red heat lamps
- Crown reflector lamps

The following exceptions listed in sub section 5(2) of the Determination are proposed to be removed:

- Rough use or vibration lamps, on the basis that LED are superior under these conditions and thus the exception is no longer necessary.

ATTACHMENT F: Phase out transitional issues

Two wire devices

Some LED lamps may not be compatible with existing light fixtures that have a sensor function (a two wire device), resulting in the LED lamp operating unsatisfactorily (lamp stays on in off state, flickers).

There is a large range of lighting products available with sensors. Motion sensors are generally installed on lights for security or ease of use reasons including outdoor lighting. The sensors are usually sold as a package with one or more lamps controlled by a single sensor. Advice from the Compatibility Working Group is that some LED lamps do not work with two wire devices. Non-compatibility can be resolved through purchase of a new unit or alternatively an electrician can modify the load so the existing unit works satisfactorily.

Informal advice from industry is that manufacturers of these sensor products moved to three wire designs from 2010, making these more recent products highly compatible with LED. Outdoor sensor lights are often exposed to the elements and therefore have a shorter life span of between 5 to 10 years. On the assumption that most two wire products will be due for replacement by 2020, the costs of upgrading sensor lights have not been accounted for. New LED outdoor sensor lights cost between $30 and $60.

Controls

For impacted households, options include:

- Deferring costs in the short term by keeping spare halogen lamps on hand
- Replacing the sensor or timer or modifying the load, seeking to incorporate this job with the next electrician visit to reduce costs.

Ripple control filtering

Some consumers in certain geographic areas in New South Wales and Queensland may notice that their LED lamps flicker for a short period (approximately 2–3 minutes), as ripple control signals are sent several times a day from distribution network service providers to control off-peak tariff hot water, street lamps and space heating. The impact may vary due to the strength of the ripple current signals experienced, which can be locally amplified due to resonance in the network resulting from reactive loads.

The problem may occur in LED lighting due to their electronic design, possibly combined with an increase in the signal strength being experienced in the network. This is an existing issue that has also been reported to affect other household electrical products (including humming in electric fans, fast electric clocks and unintended operation of ovens).

Controls

The Department has established a Ripple Control Working Group that includes membership from LCA, LCNZ, Energy Networks Australia, University of Wollongong and energy network and lighting manufacturers, to understand the geographical areas affected, conditions when this can occur and options to resolve. It is anticipated that options to further address this problem can developed with the various parties involved before the phase out. This is an existing issue that impacts other products in addition to LED lighting. Rectification and workarounds are currently and will continue to be managed by energy networks and lighting suppliers.

Suitability of LED lamps in enclosed luminaires

Informally concerns have been raised by some lighting suppliers with replacing halogen and CFL lamps with LED lamps in enclosed luminaires, such as fan lights, due to the potential impact of operating temperatures on the life of the LED. Despite requests for data to support claims no information has been provided.

Fan lights are currently being advertised and sold with CFL and LED lamps with warranties of at least two years on the product. However the default position of CFL and LED lamps sold separate is generally that the product is for use in an open fitting only. This puts consumers in a position where they are unable to replace a lamp in an enclosed luminaire without voiding the warranty of the replacement lamp.

It is understood that an LED lamp sold in a luminaire is accepted on the basis that the dimensions of the luminaire are known and tested with the LED lamp. Generally the same LED lamp included in the luminaire kit are otherwise recommended for open use only (not enclosed) and products are marketed in this way as the dimensions of the enclosed luminaire are unknown and thus may affect the life of the product. This is not a safety issue.

The E3 Program is aware that some suppliers are considering revising their marketing to note that the life of the lamp may be shortened when installed in an enclosed luminaire. The market may also resolve this problem by developing an LED suitable for higher temperatures in most enclosed luminaires.

Instore visits in October 2017 identified that suppliers are taking different approaches for packaging. Some products with packaging included claims such as “actual lifetime may vary dependent upon the type of use or product application” and “average lamp life is 25,000 hours in open air at 25 degrees C. Actual life will vary in individual circumstances”. Other suppliers have no reference to suitability for use in enclosed luminaires. One supplier was identified that retains wording “Not suitable for use in fully enclosed fixtures”.

ATTACHMENT G: COMPLIANCE

Purpose

This section outlines the Regulator's compliance approach to ensure models of LED lamps will comply with MEPS requirements. The first part of the section applies to Australia only, and discusses the GEMS Regulator and the GEMS Act. In New Zealand, EECA follows a risk led compliance approach that is informed by the *Energy Efficiency (Energy Using Products) Regulations 2002*. Many of the issues identified below around the need for engagement and education are the same, however the specific powers of the New Zealand Regulator vary. This is discussed further in the last part of Attachment D.

Background

Whilst not yet regulated, models of LED product are already supplied, offered for supply, or used for commercial purposes in Australia through a range of channels including:

- wholesalers
- retailers
- tradespersons importing and installing
    - for example; builders, electrical contractors, etc.
- commercial users importing or manufacturing for use in their own business
    - for example; mining entities undertaking fit outs of worker accommodation

Available models are often quickly replaced or updated, usually within a six to 12 month period.

The diversity of supply channels and rapid turnover of models require an agile and multi-faceted approach to compliance in order to discourage or remove non-compliant models from the market in a timely manner.

The Approach

The GEMS Regulator is committed to:

- assisting responsible parties understand the requirements of the GEMS Act
- monitoring responsible parties' compliance with the requirements
- actively pursuing those who opportunistically or deliberately contravene the Act.

Identifying Potential Suppliers

In the lead up to, and after, the implementation of LED product requirements, GEMS inspectors will conduct environmental scans to identify potential suppliers and commercial users via avenues such as:

- the collection and analysis of import data
    - LED tariff codes are now in place and analysis has commenced on the first LED product suppliers report
- collaboration with peak industry bodies
    - for example, NECA, and other trade channels
- information and data provided by the likes of the Lighting Council Australia, Electrical Regulatory Authorities Council, and others
- online and on site market surveillance.

Engaging and Educating

All identified potential suppliers will be engaged; however, using an intelligence led, risk based approach, engagement and education will be initially focused on tradesperson suppliers, specifically individuals or companies directly importing and installing models of LED product into the likes of residential, retail, or commercial buildings, where information suggests the risk of non-compliance is high.

These, and other suppliers, will be the subject of a communication strategy highlighting GEMS Act requirements, the GEMS Regulator's compliance monitoring plan, GEMS Act enforcement responses, and the consequences of non-compliance. Communication avenues include:

- LED product tariff code alert messages
- email campaign direct to LED product importers
- email campaign to LED product retailers
- email campaign to lighting suppliers already registered under the GEMS Act
- lighting, electrical, trade, and construction peak industry bodies
- energyrating.gov.au

Monitoring Compliance with the Requirements

After the implementation of LED product requirements the GEMS Regulator will monitor compliance via:

GEMS Inspector Market Surveillance

GEMS inspectors will conduct market surveillance both online and on site to determine if models of LED product are registered and meet GEMS product and package requirements.

GEMS Inspector Powers

The GEMS Act allows GEMS inspectors to:

- inspect public areas of GEMS business premises via consent
    - includes the powers to inspect products, purchase products, and inspect or collect written information
- enter any premises and exercise monitoring powers, via consent or warrant
    - includes the powers to search, examine, take measurements, photograph, inspect documents, make copies

- enter any premises and exercise investigation powers, via consent or warrant
    - in addition to the powers mentioned above, includes the powers to search (under consent and warrant) and seize evidence (under warrant only)

Most often, GEMS inspectors use the inspection/monitoring powers via consent. Where access has been refused, communication with supplier management resolves most issues. If access is refused, and cannot be obtained via communication, GEMS inspectors may apply to the courts for monitoring or investigations warrants granting access.

The GEMS Act also empowers:

- GEMS inspectors to ask questions and seek production of documents
- the GEMS Regulator to require a person to provide information
- the GEMS Regulator to require a person to appear before a GEMS inspector.

Failure to comply may result in a contravention of the GEMS Act.

Suppliers

Importing or manufacturing models of non-compliant LED product does not contravene the GEMS Act; there must be a supply, offer to supply, or commercial use of these models in Australia. Given that, most models of LED product are imported by the likes of:

- wholesalers who supply to the general public, retailers, tradespersons, or contractors
- tradespersons who first supply and then install as part of their trades services
- retailers who supply to the general public, tradespersons, or contractors.

GEMS inspectors will use GEMS inspector powers to inspect, monitor, and investigate any premises where models of LED product may be supplied; for example, importer or wholesaler warehouses, tradesperson shop fronts, or retail stores.

In relation to residential, retail, or commercial buildings under construction or recently completed, where models of non-compliant LED product may be installed, GEMS inspectors will use GEMS inspector powers to enter via consent, or if necessary, via warrant. There is no GEMS Act provision for a person to give a product of a model to the GEMS Regulator to determine GEMS registration or marking requirements. In these circumstances, GEMS inspectors may collect written information, take photographs, purchase a product or, if appropriate, seize one under an investigations warrant.

Market surveillance also includes the ongoing collection and analysis of import data to identify new suppliers and will also assist with the selection of models of LED product for check testing.

Check Testing

Check testing is undertaken to ensure models of LED product meet GEMS level (MEPS) requirements, with models selected using an intelligence led, risk based approach.

LED lamps will be 'screened' internally, prior to check testing being undertaken by external laboratories. This will seek to maximise the number of non-compliant products identified through check testing processes.

The Regulator, where possible, sources products anonymously and directly from the market. The GEMS Regulator may also require a registrant to give a product to a GEMS inspector. However, this does not apply if the model is not registered and the person is not a registrant. In these circumstances, the GEMS Regulator may purchase a product from the market or, if appropriate, seize one under an investigations warrant.

Traditionally, lighting product check testing has been a lengthy process. Given the rapid turnover of models of LED product in the market, a more streamlined process will be implemented to identify and remove non-compliant product from the market. If a model of LED product is no longer supplied when check test results are known, the GEMS Regulator still has the enforcement options available.

The Receipt of Allegations of Suspected Non-compliance

Allegations of suspected non-compliance may be sent to E3.Compliance@environment.gov.au where they will be assessed, and if appropriate, investigated.

Enforcement

The GEMS Act provides the GEMS Regulator with educative, administrative, civil, and criminal response including:

- suspending a model's registration
    - if a 'family' registration, the supplier will be required to demonstrate that other models in the family are compliant to avoid suspension of all models.
- cancelling a model's registration
    - if a 'family' registration, the supplier will be required to demonstrate that other models in the family are compliant to avoid cancelling of all models.
- enforceable undertakings
    - commitment by a supplier to do, or refrain from, some specified action, which can be enforced in court.
- infringement notices
    - simpler and faster response than formal civil or criminal proceedings
    - non-payment may result in other responses such as enforceable undertakings or applications to the courts to pay a higher amount under a civil penalty order, or be subject to criminal prosecution if the alleged contravention also constitutes an offence
- criminal strict liability offences.

The GEMS Act also allows the GEMS Regulator to publicise certain offences, contraventions, and adverse decisions including the names of registrants and the reasons for the decision.

It is important to note, the above enforcement responses are available to the GEMS Regulator even if the model previously supplied, offered for supply, or used for commercial purposes, is no longer in the market.

Enforcement Examples

The following examples are a guide only:

- a product of a model is offered for supply on site and appears to be unregistered
    - section 17 GEMS Act – Supplying GEMS products – model not registered, may apply
    - as model is unregistered, it cannot be supplied or offered for supply; therefore, suppliers must remove all products of the model from shop floors or shelves
    - GEMS Regulator will consider a supplier's history, behaviour, motivation, and intention and determine an enforcement response proportionate to the risk posed by the non-compliance.
- a product of a model is observed on site and appears to be unregistered, or does not meet GEMS level requirements and a large number have already been installed
    - assumes we are talking about residential, retail, or commercial buildings under construction or recently completed where products of the model may be installed
    - section 17 GEMS Act – Supplying GEMS products – model not registered, and/or section 16 GEMS Act – supplying GEMS products – complying with GEMS determinations, may apply
    - as model is unregistered, or does meet GEMS level requirements, it cannot be supplied or offered for supply, therefore, suppliers must remove all products of the model from shop floors or shelves if supplied this way
    - there is no GEMS Act provision for GEMS inspectors or suppliers to uninstall already supplied products
    - GEMS Regulator will consider a supplier's history, behaviour, motivation, and intention and determine an enforcement response proportionate to the risk posed by the non-compliance
        - enforceable undertaking may be used to commit a supplier to, for example, uninstall products or compensate for products already supplied and installed.

Compliance in New Zealand

Compliance with MEPS regulations is carried out by the Energy Efficiency and Conservation Authority, in accordance with the *Energy Efficiency (Energy Using Products) Regulations* 2002. These regulations, as well as the *Energy Efficiency and Conservation Act* are available to download from the New Zealand Legislation website.

The regulations detail the duties of manufacturers/importers, and persons dealing directly with consumers.

EECA employs a risk based model to compliance activities, and aims to ensure that activities are proportionate to the type of non-compliance. EECA uses a New Zealand cross agency guide (Achieving Compliance: A Guide for Regulators, DIA 2011) as a basis for their work, as well as looking to work closely with the GEMS regulations team at the Department of the Environment and Energy.

EECA compliance activities can range from informal activities and compliance advice letters, to educating suppliers of their non-compliance through to settlements and prosecutions. For newly registered products, EECA will often initially take an educative approach.

As discussed above, in areas such as LED lighting where there is rapid product change, EECA will look to take a flexible approach to market screening and check testing, and will develop a test schedule that reflects this.

ATTACHMENT H: LAMP TECHNOLOGIES

Incandescent Lamps

The incandescent lamp was the most common lamp type for domestic lighting for many years. It produces light by heating a tungsten wire filament to a high temperature by running an electric current through it until it glows brightly. The tungsten filament incandescent lamp is a low efficacy light source and has a relatively short lamp life.

Figure 21: Examples of incandescent lamps

Omni-directional (non-reflector) incandescent lamp

Directional (reflector) incandescent lamp

Halogen Lamps

Halogen lamps have a tungsten filament suspended in a mixture of an inert gas (usually argon, krypton or xenon) together with a small amount of halogen gas (usually bromine or iodine). During lamp operation, the halogen gas combines with the tungsten molecules that have evaporated from the filament. The tungsten is deposited back onto the filament and the halogen released to start the cycle again. A halogen lamp can be operated at a higher temperature than a standard incandescent lamp, resulting in a higher lamp efficacy than tungsten filament lamps.

Figure 22 Examples of halogen lamps

Halogen GLS lamp (non-reflector MV)

Halogen capsule lamp (non-reflector MV or ELV)

Halogen MR16 reflector lamp (ELV)

Halogen GU10 reflector lamp (MV)

Fluorescent Lamps (Linear, Circular, Compact)

This family of lamps make light by first creating an electric discharge or arc within a glass tube filled with a low pressure mercury vapour. The arc stimulates the mercury atoms within the vapour, exciting electrons. The energised mercury vapour atoms emit ultraviolet radiation, which in turn excites the phosphor powder coating the glass tube and generates visible light. Fluorescent lighting has a high efficacy and long lifespan.

Fluorescent lamps require a ballast to operate and are available in a variety of shapes, including linear, circular and U-shaped.

Linear fluorescent lamps are identified primarily by their designated 'T' number that defines the tube diameter in eights of an inch. The most common linear fluorescent lamps in a commercial setting are T5 (16 mm) (the most efficient of linear lamps), T8 (26 mm) and T12 (38 mm). T8 lamps are available in a range of lengths, and have a higher efficacy and better colour rendering index than T12 lamps. T8 and T12 lamps can operate with either magnetic or electronic ballasts.

T5 lamps require an adapter kit to retrofit T8 lamp fittings, as they have a different pin-base connection and are 50mm shorter. A specifically designed T5 luminaire also makes the overall use of T5 lamps more efficient, as the luminaires are designed to reflect more light out of the fixture so fewer lamps are required to light an area.

Cold cathode fluorescent lamps, which apply a higher voltage rather than heating the electrode to generate an arc, are not covered by MEPS.

Figure 23: Examples of Fluorescent Lamps

Integrated CFLs

Integrated CFLs (Figure 24) are single-capped lamps with a compact (e.g. folded or spiral) gas discharge tube, with integrated ballast circuitry for controlling the lamp.

CFLs are amongst the most efficient lamps available, employing a gas discharge technology together with a phosphor coating to produce visible light. An electronic ballast, required to operate the gas discharge at the correct current, is incorporated into the base of the lamp. Integrated CFLs in the typical lighting context are mains voltage and are a direct replacement for incandescent and halogen lamps (some 12 volt CFLs are available). They are available in both reflector and non-reflector formats. Examples are given in the photographs below.

Figure 24: Examples of CFLs

Spiral-shape omnidirectional CFL | Stick-shape omnidirectional CFL | Covered CFL | CFL reflector lamp

Non-integrated CFLs

Non-integrated CFLs predominantly have a tube diameter the same as a T5 lamp and generate light in the same manner as linear fluorescent lamps. However, they connect to the power supply with a base or socket system.

A ballast is required to operate the lamp at the correct current and can be integrated with the lamp or a separate piece of equipment. Non-integrated CFLs, sometimes referred to as a CFLn, pin-based or plug-in CFL, have the ballast installed in the luminaire, separate to the lamp. Figure 25 shows two non-integrated CFLs (right and bottom of picture), an electronic fluorescent lamp ballast (left top) and a magnetic fluorescent lamp ballast (left centre).

Figure 25: Various non-integrated CFLs and ballasts

T8-T5 adapters

T5 linear fluorescent lamps can produce the same quantity of lumens using less power than a T8. This has led to a new energy-saving technological solution in the form of the T8 to T5 adapter, which is a plug-in fixture that allows replacement of fluorescent T8 lamps with the energy-efficient T5 lamp in the existing light fitting. Evaluation of these products in the Commercial Lighting Product Profile indicated that some models may not actually result in energy savings assumed, however advice from industry is that the adapters are fast disappearing from the market as building owners actively searching for energy savings are now choosing to refit with LED linear lamps or integrated luminaires.

Figure 26: A T8-T5 adapter[89]

Light Emitting Diode (LED) Lamps

LEDs, or Solid State Lighting (SSL), use one or more semiconductor diodes (solid state chip) to emit non-coherent optical radiation (light). This radiation can either be in the visible spectrum (i.e. the LED directly produces visible light), or the visible light can be produced indirectly, e.g. with the radiation exciting phosphor which in turns emits the visible light in a similar way to CFLs. Figure 27 shows examples of LED lamps.

Figure 27: Examples of LED integral lamps[90]

Omnidirectional-replacement LED   LED MR16   Directional LED lamp

Commercial Luminaires

A luminaire includes all the parts necessary for supporting, fixing and protecting lamps, but not the lamps themselves. Commercial luminaires are those luminaires marketed and intended to be used in a commercial or business environment. The basic commercial luminaires, troffers, battens and recessed canisters, are fixed installations that have the primary purpose of enabling people to perform visual tasks, but are also used for general lighting in corridors and foyers.

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[89] Images sourced from Enduralight (www.enduralight.com.au/products/t5-adaptors).

[90] images courtesy Barryjoosen and Lee, E.G. via Wikimedia Commons.

Figure 28: Recessed troffers with louvres to direct light output (left) and a pendant batten with diffuser (right)

Auxiliary Equipment

The energy efficiency of a lighting system depends not only on the luminous efficacy of the lamp, but also on the efficiency of the auxiliary equipment. This equipment includes ballasts, starters, transformers, drivers and dimmers.

Ballasts

The ballast controls the amount of electrical current supplied to linear fluorescent, compact fluorescent and high intensity discharge (HID) lamps. Once started and the arc is established in the lamp, it progressively becomes a better conductor of electricity and increasingly more current is able to flow. The current becomes excessive within seconds (fluorescent lamps) to minutes (HID lamps) and could easily destroy the lamp. The ballast keeps this current rise under control so the lamp always receives the right current and voltage to function at its best. They consume a small amount of power in the process. Ballasts for linear fluorescent lamps are subject to MEPS in Australia and New Zealand.

Starters

The full function of the starter switch in switch start fluorescent lamp circuits is beyond the scope of this document. It is important to note they are only used to start the lamps and perform no function in the normal, light producing stage of operation. They can, however, affect how long the lamp will last.

Transformers/voltage converters

Transformers change the mains voltage (240V) to a lower voltage (typically 12V). The MR16 halogen lamps are all 12V and need to run from a transformer (also known as extra low voltage converters or ELVC). The wide range of transformers installed for halogen MR16 lighting systems in Australian homes means that it is also important to investigate whether retrofit LED lamps are compatible with installed transformers. Some suppliers will provide a list of transformers that their product has been tested with. Transformers for extra low voltage halogen lamps are subject to MEPS under the GEMS Act.

LED drivers

LEDs use direct current (DC) electrical power at low voltage. An LED driver is a power regulation unit with outputs designed to match the specific electrical characteristics of an LED or LED array.

Dimmers

Most domestic dimmers in use today will be one of two types — leading edge or trailing edge. They control the power delivered to the lamp by only switching on at a certain point in the mains voltage waveform. With iron core transformers, the best dimmer to use is the leading edge type. For electronic transformers it is best to apply the trailing edge dimmer.

ATTACHMENT I: GLOSSARY OF TERMS

Ballast

A component of conventional control gear. It controls the current through the lamp, and is used with discharge lighting, including fluorescent and high intensity discharge lamps. The term is sometimes used loosely to mean control gear. Also called a choke.

Colour rendering

An indicator of how accurately colours can be distinguished under different light sources. The colour rendering index (CRI) compares the ability of different lights to render colours accurately with the measurement of 100 considered to be excellent. A value of 80 and above is good and appropriate for most situations where people are present. Where colour identification is important, a value of 90 or above should be considered.

Colour temperature

Also known as colour appearance, the colour temperature is the colour of 'white' the light appears. It is measured in Kelvin (K), and in lamps generally ranges from 1800K (very warm, amber) to 8000K (cool). 6500K is daylight. There are many colours of 'white' available. For general use these are: warm white (2700–3300K), cool white (3300–5300K) and cool daylight (5300–6500K).

Control gear

A 'package' of electrical or electronic components including ballast, power factor correction capacitor and starter. High-frequency electronic control gear may include other components to allow dimming etc.

Diffuser

A translucent screen used to shield a light source and at the same time soften the light output and distribute it evenly.

Discharge lamp

A lamp which produces illumination via electric discharge through a gas, a metal vapour or a mixture of gases and vapours.

Efficacy (luminous efficacy)

The ratio of light emitted by a lamp to the power consumed by it, that is, lumens per Watt. When the control gear losses are included, it is expressed as lumens per circuit Watt. The higher the efficacy the more efficient the product.

Illuminance

The amount of light falling on an area, measured in lux. One lux is equal to one lumen per square metre. The higher the lux, the more visible light on a surface area.

Intensity (Candela)

Intensity is the amount of light radiated in a given direction, measured as candela (cd). The higher the candelas the more intense the light.

Kelvin

A measure of colour temperature for lamps.

Light output ratio (LOR)

The ratio of the total amount of light output of a lamp and luminaire to that of just the bare lamp.

Luminaire

A light fitting and lamp including all components for fixing and protecting the lamps, as well as connecting them to the supply.

Lumen

Unit of luminous flux, used to describe the amount of light produced by a lamp. The higher the lumens, the more visible light emitted by the lamp.

Luminance (Candela/m^2)

Luminance indicates how bright an object will appear and is measured as candela (intensity) per m^2. The higher the luminance the brighter the object will appear.

Lux

An international unit of measurement of illuminance intensity of light.

Rated average lamp life

The number of hours after which half the number of lamps in a batch fail under test conditions.

Commercial lighting

Generally refers to most lighting used for non-residential purposes including fluorescent lamps (excluding CFLs with an integrated ballast), fluorescent lamp ballasts, T8-T5 adapters, and basic commercial luminaires (troffers, battens and CFL cans).

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Decision RIS: Lighting

www.energyrating.gov.au

A joint initiative of Australian, State and Territory and New Zealand Governments