Product Profile - Incandescent, Halogen and Compact Fluorescent Lamps

Proposals for Future Direction

25 November 2014

This document is available at the Energy Rating website (www.energyrating.gov.au).

This document was prepared with the assistance of Beletich Associates.

Contents

LIST OF FIGURES

LIST OF TABLES

1 Introduction

1.1 Purpose

This consultation document forms part of an investigation into the feasibility of revising and/or expanding the Minimum Energy Performance Standards (MEPS) for incandescent, halogen and compact fluorescent lamps and expanding the scope covered under the *Greenhouse and Energy Minimum Standards Act 2012* (GEMS) in Australia and the *Energy Efficiency (Energy Using Products) Regulations (2002)* in New Zealand. The document serves two purposes:

- To provide an update on the state of incandescent, halogen and compact fluorescent lamps, their capacity for improved energy efficiency and performance and the current and projected markets for sales of these lamps in Australia and New Zealand. This information has been collected for the benefit of policy makers, however, stakeholder feedback is sought in verifying the report's findings.
- To signal to stakeholders the opportunities and options that will likely form the basis of initial stakeholder consultation. Other types of measures to promote lighting efficiency are also discussed. Final policy options would be subject to detailed investigation through a Regulation Impact Statement (RIS). In New Zealand, approval of Ministers is required for any proposed regulatory option that might be modelled by a RIS.

1.2 Context

Energy efficiency is widely accepted as a low cost approach to reducing greenhouse gas emissions. Modelling by the International Energy Agency (IEA) shows that as much as half the savings in greenhouse gas emissions required by 2050 can be achieved by adopting energy efficiency measures. Improvements to energy efficiency can also help to reduce demand on electricity supply systems (such as during peak periods) with consequent savings in capacity requirements.

The following benefits arise from use of more energy efficient technology:

- Enhanced economic growth through increased productivity
- Improved energy security by reducing energy demand
- Improved energy affordability by reducing consumer energy costs
- Deferred need for more expensive energy supply by making better use of existing energy resources
- Reduced greenhouse gas emissions from energy consumption.

Residential lighting energy consumption, per dwelling, for Australia is estimated at around 1100 kilowatt-hours (kWh) in 2010. For New Zealand, this was estimated at around 1020 kWh in 2012 (noting that these estimates do contain some weaknesses). In both countries, more than 75% of residential lighting energy consumption is estimated to come from incandescent and halogen lamps.

Available energy efficiency measures include the use of new technologies and processes to reduce energy use in residential, business, industry and manufacturing applications. Further transition to high efficiency lamps would reduce greenhouse gas emissions by up to 2219 kilotonne CO_2-e p.a. for Australia and 966 kilotonne CO_2-e p.a. for New Zealand and therefore the cost of carbon abatement. Improvements to residential lighting have a significant negative abatement cost, at about negative $40 per tonne of CO_2-e (Lewis and Gomer 2008).

MEPS has been a key mechanism to drive performance improvements for lighting products manufactured in or imported into Australia. It is projected that a revised MEPS for incandescent, halogen and compact fluorescent lamps, by shifting the market from incandescent lamps to efficient lighting such as compact fluorescent lamps

(CFLs) and light emitting diodes (LEDs), could help reduce residential lighting energy use in Australia by approximately 65% by ensuring inefficient lighting is not available on the market.

Australia was one of the first countries in the world to announce regulations aimed at eliminating inefficient incandescent lamps from its market. This announcement occurred in February 2007 and was followed by the development of a MEPS program for incandescent, halogen and compact fluorescent lamps along with MEPS for low voltage halogen lighting transformers.

The program was implemented in a staged fashion, commencing with an Australian import restriction on tungsten filament incandescent lamps used for general lighting service (GLS; traditional A-shaped (pear shaped) "light bulbs") lamps on 1 February 2009. In November 2009 GLS tungsten filament and extra-low voltage halogen non-reflector lamps were subject to the more traditional "point of sale" MEPS in Australia. The scope of MEPS for incandescent and halogen lamps was then broadened regularly until October 2012. CFLs have been subject to MEPS in Australia since November 2009, and in New Zealand from October 2012. The New Zealand Government does not wish to limit consumer choice, and prefers to provide energy efficiency information. For this reason incandescent lamps are likely to remain for sale in New Zealand. However MEPS is supported for products where there is a range of efficiencies and room for improvement, for example, CFLs. For detailed information regarding MEPS in Australia and New Zealand refer to Chapter 6.

The Technical Report which initially proposed MEPS for incandescent, halogen and compact fluorescent lamps (Beletich 2007) recommended that the lamp types excluded from the scope of MEPS should be reviewed and that exempted lamp types should only be included in MEPS as viable, efficient alternatives became available. The report also recommended that a "stage 2" MEPS should be investigated, taking into account the availability of viable, efficient alternatives for each class of lamp. In addition, experience with the current Australia / New Zealand standards for CFLs (AS/NZS 4847) and incandescent and halogen lamps (AS/NZS 4934) has flagged a number of specific issues for review (see sections 6.4, 8.4 and 8.5).

Since 2007 a significant body of knowledge has been accumulated about the MEPS program, and many other countries have adopted regulations which emulate the Australian inefficient incandescent lamp phase out. The global lighting market has also changed considerably, particularly with the introduction of LED lighting (the subject of a separate Product Profile).

Taking into account all these factors, it is considered timely to review the MEPS program for incandescent, halogen and compact fluorescent lamps and make detailed recommendations regarding the future direction of the program. The primary purpose of this Product Profile is to undertake such a review.

1.3 Where to From Here?

1.3.1 Consultation on this Product Profile

Readers are asked for feedback on the information and proposed policy options put forward in this document, and to assist by providing robust data where possible. Stakeholder consultation meetings will also be held in Australia and New Zealand.

Feedback from industry stakeholders will be important in formulating the most appropriate policy approach, and responses to the Key Questions below will be of particular assistance.

Comments should be sent by email and be received by 13 February 2015. The subject should be clearly titled 'Incandescent, Halogen and Compact Fluorescent Lamps Product Profile' and sent to:

- **Australia:** EER-Lighting@industry.gov.au
- **New Zealand:** regs@eeca.govt.nz

1.3.2 After Consultation on this Product Profile

The material in this Product Profile, supplemented in light of any written submissions made by stakeholders and/or issues raised at stakeholder meetings, will aid governments in determining:

- whether to proceed with developing options to improve the energy efficiency and performance of incandescent, halogen and compact fluorescent lamps
- the reliability of the information currently available to consumers, and
- what other voluntary options may be suitable.

Only if the preferred options involve regulation (e.g. MEPS and/or labelling) a RIS will be prepared to analyse the costs, benefits and other impacts of the proposal. Consultation will be undertaken with stakeholders prior to any final decisions being made. Final decisions on policy will be made by the relevant Council of Australian Governments (COAG) Ministerial Council in Australia and by the New Zealand Cabinet.

Options for improving energy efficiency and performance of incandescent, halogens and CFL lighting will be considered alongside options for LED lighting which will be the subject of another Product Profile.

1.3.3 Incandescent, Halogen and Compact Fluorescent Lamps Product Profile – Key Questions

Readers are invited to comment on any aspect of this Product Profile. Responses to the key items listed in the box below would be of particular assistance in determining the future direction of the lighting program.

Can you provide data to support the anecdotal evidence that extra-low voltage halogen downlights are being replaced with LEDs?

Can you provide broader information on the market share and market trends for LED lighting in the residential sector?

Can you provide information on the market share of ENERGY STAR CFLs?

With respect to further phasing out of inefficient incandescent lighting in Australia:

- Are there effective and efficient lighting alternatives (including CFL and LED lighting) available in the market to allow further phasing out of inefficient incandescent lighting in Australia? This could include phasing out of halogen lighting. Tungsten filament and halogen lamps could be phased out in the following categories:
  - pilot lamps
  - Incandescent lamps 25W and below
  - Mains voltage omnidirectional incandescent lamps
  - Mains voltage reflector incandescent lamps
  - Extra low voltage reflector incandescent lamps.
- Are there effective and efficient lighting alternatives available in the market for mains voltage halogen directional lamps now, or will there be in the future?
- Are effective and efficient lighting alternatives available in the market for some or all of the categories of special purpose lamps currently exempted from MEPS in AS/NZS 4934.2 (see section 8.4.4)?
- Do you think the policy options discussed in Chapter 8 could feasibly address the Problem outlined in Chapter 2, in terms of market failures inhibiting improved energy efficiency of residential lighting?
- What additional costs do you think the policy options discussed in Chapter 8 would place on industry compared to the current situation?

What do you think would be the best way for governments to facilitate an increase in the average energy efficiency of residential lighting sold?

Stakeholders are asked to provide data to support in-depth cost-benefit analyses of the policy options discussed in Chapter 8.

2 The Problem

2.1 Background

Certain types of incandescent (tungsten-incandescent, non-halogen), mains voltage and extra low voltage halogen and compact fluorescent lamps manufactured in or imported into Australia are subject to MEPS. In New Zealand, compact fluorescent lamps are subject to MEPS. The objective of these MEPS is to improve the energy efficiency of lamps supplied in the Australian and New Zealand markets by addressing market failures. A range of policy options are considered within this Product Profile to address the persistent market failures outlined below.

Improved efficiency of lighting has the potential to realise savings for consumers due to decreased energy consumption, and also reduce greenhouse gas emissions in order to mitigate climate change. To date it is estimated that the phase-out of incandescent light bulbs (along with state based energy efficiency obligations schemes) is helping to save around 2.6 terawatt-hours (TWh) of electricity each year. This saving is equivalent to the total annual electricity consumption of 150,000 homes. The average household is estimated to be saving 300 kWh and $60 per annum.

The E3 Program has been in place for 21 years. In 2012 the national GEMS legislation was introduced in Australia, in order to effect better legislative implementation MEPS and labelling, replacing the separate approaches by the Australian states and territories. GEMS is supported by the states and territories through an intergovernmental agreement.

2.2 The Problem

Individual lamps do not consume large quantities of energy. However, the average Australian home has 48 lamps (E3 2013) and the average New Zealand home has 34.5 lamps (Ipsos 2012). When aggregated, lighting accounts for a significant proportion of the average household's electricity use in Australia and New Zealand - typically around 12% (EES 2008; current EECA End Use Database (enduse.eeca.govt.nz)). Note however that this proportion varies considerably depending on how significantly gas is used as a fuel.

MEPS and technology improvements have increased the efficiency of lamps in recent years with average households now using 27% (300 kWh p.a.) less energy to light their homes. However, significant numbers of consumers and businesses continue to be exposed to unnecessarily high lighting energy costs because their lamps and lighting systems are not as efficient as they could be. Market failures, including principal-agent problems and information failures, are inhibiting the uptake of more efficient lighting and government intervention may be justified.

Principal-agent problems exist when an agent does not act in the best interests of the principal due to "split incentives". For example, whilst a builder (the agent) may choose cheaper, less efficient lighting to minimise their build costs, this is not always in the best interest of the building occupant (the principal) who is exposed to the operating costs of the lighting system installed.

Information failure can also be a problem when buyers are not able to compare the lifetime costs of different lamp technologies, and therefore make sub-optimal purchase decisions. For example, market research (Winton Sustainable Research Strategies 2011) has shown that consumers often lack knowledge about estimating the energy use, equivalency and running costs for different lighting technologies. They may also make decisions based on incorrect information or limited understanding, for example that low voltage halogen lighting is efficient ("low energy"). The low unit cost of lamps also makes it less likely that consumers will invest the time required to make an informed decision.

This report identifies further initiatives that could result in potential savings of up to approximately 1 TWh (3.4 petajoules (PJ) p.a.) in New Zealand and 5.4 TWh (19.3 PJ p.a.) in Australia (this is the approximate full potential of energy savings available from fully transitioning from incandescent and halogen lamps to CFLs and LEDs).

3 Product Descriptions

This Product Profile covers the lamp types detailed below. Note that the descriptions provided are used in the context of typical general purpose illumination.

3.1 Incandescent Lamps

Incandescent lamps (Figure 1) are defined as filament lamps which utilise a tungsten or carbon filament suspended in a vacuum or inert gas. For the purpose of this Product Profile, the term 'incandescent lamp' does not include lamps with a halogen gas fill which are discussed separately below.

Incandescent lamps were invented in the late 1800s and are the least efficient type of lamp available. For residential applications they are typically mains voltage (240 V in Australia) however the current MEPS applies to all voltages. Incandescent lamps are available as omni-directional (non-reflector) and directional (reflector) lamps.

Figure 1 – Examples of incandescent lamps

Omni-directional (non-reflector) incandescent lamp

Directional (reflector) incandescent lamp

Reflector lamps will always be less efficient than equivalent non-reflector lamps, as some light is absorbed by the reflector.

3.2 Halogen Lamps

Halogen lamps (Figure 2) 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). The halogen gas suppresses degradation of the filament by a chemical regeneration process known as the halogen cycle. During lamp operation, the halogen gas combines with the tungsten molecules that have evaporated from the filament. The lamp envelope is too hot to allow the tungsten-halogen compound to be deposited on it, hence the tungsten is deposited back onto the filament and the halogen released to start the cycle again. Depositing tungsten back onto the filament in this way helps to maintain the lumen output of the lamp and helps extend the product lifetime. A halogen lamp can be operated at a higher temperature than a standard incandescent lamp of similar power, thus producing light of a higher luminous efficacy

The lamp envelope inner surface needs to be greater than 250°C for the halogen cycle to occur so bulbs must be made from heat resistant glass or quartz. Therefore these lamps are sometimes referred to as quartz halogen lamps.

Halogen lamps achieve better efficacy, have a longer operating life and produce a whiter, brighter light than incandescent lamps. In Australia and New Zealand they are designed for either 240 V operation (mains voltage or MV) or 12 V operation (extra-low voltage or ELV, sometimes referred to simply of "low voltage"). The latter requires a transformer or voltage converter (subject to MEPS in Australia). ELV lamps run at higher current, which allows for a shorter filament and thus a smaller light source which is suitable for focusing light into a tight, directional beam. As the filament is shorter, it also runs hotter and as a result ELV halogen lamps are more efficient than MV lamps (but still significantly less efficient than CFL or LED lamps).

A subset of halogen lamps are infrared coated (IRC) lamps. These lamps incorporate a coating on the filament capsule which redirects infra-red radiation (heat) back onto the filament. This allows the filament to run even hotter and therefore produce more light for the same electrical power. Note however, that IRC technology is not viable at 220-240 V and is better suited to 12 V halogen lamps.

Halogen lamps are available in both omni-directional (non-reflector) and directional (reflector) format. Examples are given in the photographs below.

Figure 2 – 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)

3.3 Compact Fluorescent Lamps

CFLs (Figure 3) for the context of this report are defined as single-capped lamps with a compact (e.g. folded or spiral) gas discharge tube, with integrated ballast circuitry for controlling the lamp (i.e. the ballast is part of the lamp). Non-integrated pin based CFLs, mainly used for commercial lighting, will be discussed in the Commercial Lighting Product Profile.

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. 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 3 – Examples of CFLs

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

3.4 Light Emitting Diode Lamps

LEDs, or Solid State Lighting (SSL) use one or more semiconductor diodes (solid state chip) to emit non-coherent optical radiation (light) in the visible spectrum. 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. LEDs are currently available to replace many types of lamps and continue to evolve rapidly to cover many different lighting applications. The performance of LED lamps is variable, although in the last 2-3 years significant improvements in performance have been observed. Figure 4 shows examples of LED integral lamps (with integral power supply electronics).

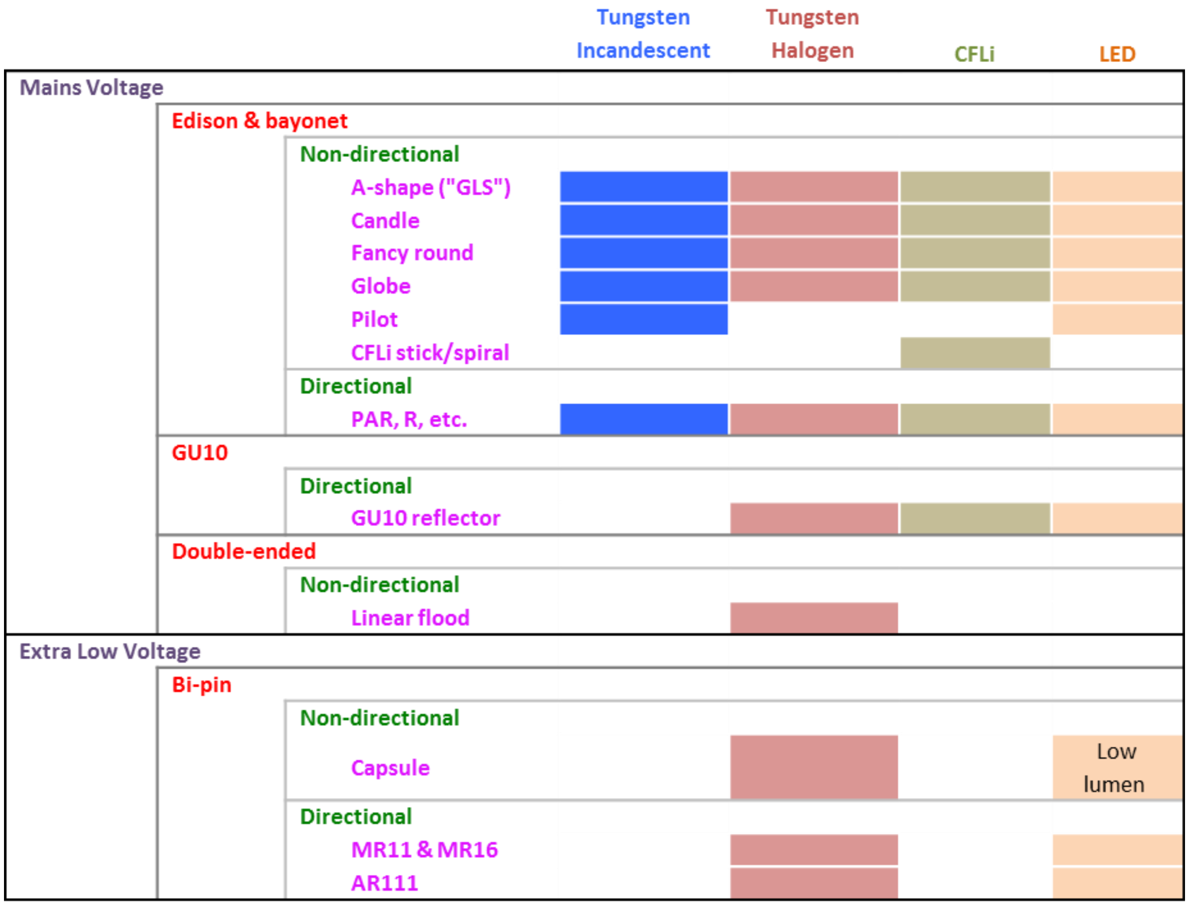
Figure 4 – Examples of LED integral lamps (images courtesy Barryjoosen and Lee, E.G. via Wikimedia Commons)

Omnidirectional-replacement LED | LED MR16 | Directional LED lamp

LEDs are only discussed in a limited context within this document as they are the subject of a separate Product Profile.

A matrix of the typical (most common, commercially-available for typical households use) permutations of voltage, cap and lamp shape for incandescent, halogen, compact fluorescent and LED lamps is given in Figure 5. Incandescent lamps and CFLs are typically mains voltage reflector and non-reflector lamps with Edison or bayonet caps. In contrast, halogen lamps and LEDs span almost the entire range of residential lamp types.

Figure 5 – Typical permutations of voltage, cap and lamp shape



4 The Lighting Market

4.1 Sources of Lamps

All incandescent lamps, halogen lamps and CFLs are manufactured outside of Australia and New Zealand. The market is dominated by companies based in Europe and the USA, with the manufacture taking place in a diverse range of countries, mainly throughout Asia, with some manufacturing also in Europe and the USA. Regulatory approaches in other markets including Europe and the USA are discussed in Chapter 7.

Importers of these lamps to Australia and New Zealand include Philips, Osram, GE, Sylvania, Nelson, Megaman and Mirabella. The main suppliers to the consumer are supermarkets, hardware stores, electrical wholesalers and smaller retailers (e.g. discount shops, corner stores, specialist lighting stores) with online purchasing an emerging source. Lamps are also supplied direct to large new building projects and via energy efficiency programs.

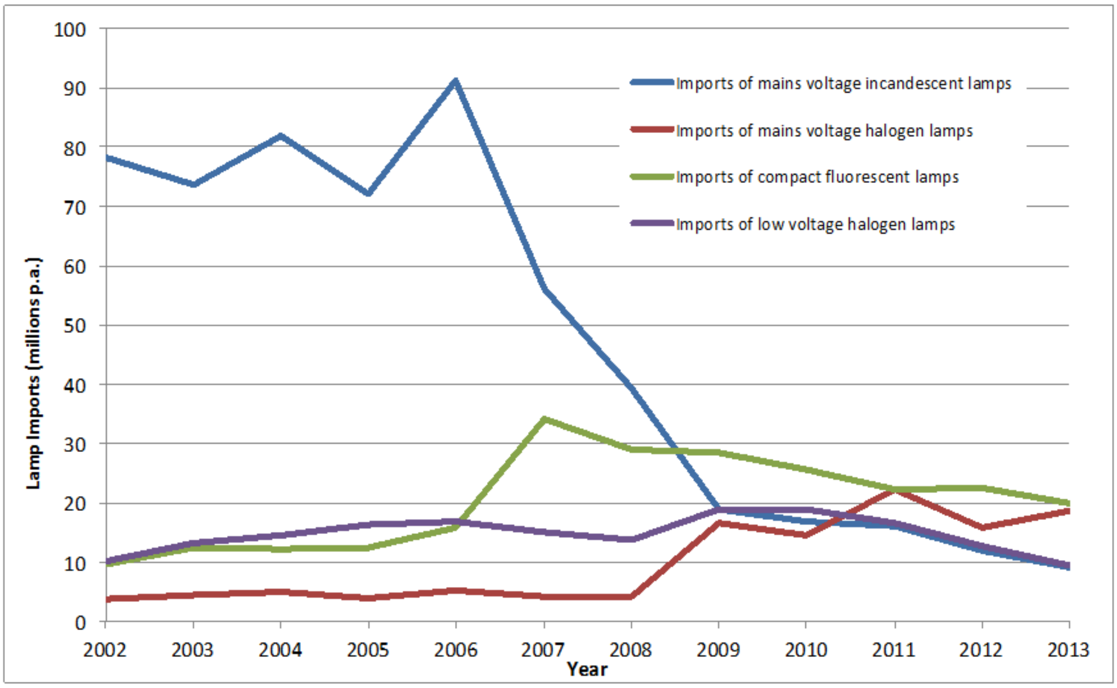
Other significant stakeholders in the residential lighting market are Lighting Council Australia, Lighting Council New Zealand, Illuminating Engineering Society of Australia and New Zealand, consumers and consumer associations.

4.2 Australian Market

The Australian lighting market has changed significantly over the past decade, as can be seen in Figure 6, which graphs the imports of incandescent lamps, halogen lamps and CFLs (self-ballasted and non-self-ballasted) into Australia. In 2002 lamp imports (for these categories) totalled about 101 million and this has decreased significantly to around 57 million in 2013. Import statistics represent a good proxy for residential lamp sales in Australia, as the sole Australian lamp manufacturing plant closed in April 2002.

Note that lamp import quantities include lamps used in both residential and commercial sectors. This is likely to be significant primarily for ELV halogen lamps, which are popular in both residential and commercial sectors. The other lamp types discussed are primarily used in the residential sector. CFL imports also include those used in giveaway programs, where some of the CFLs distributed may not have been installed. In addition, the CFL import statistics include non-self-ballasted CFLs, which are used primarily in commercial premises. These lamps represent several hundred thousand units per annum (source: personal correspondence with industry) and thus are not considered material for the purpose of evaluating Figure 6. Non self-ballasted CFLs will be considered in a separate product profile on commercial lighting.

Figure 6 – Imports per annum of relevant lamp types into Australia (including all lamp shapes - GLS, candle, fancy round, reflector, etc.) (source: ABS import data)



In Figure 6 it can be seen that imports of MV incandescent lamps reduced from a volatile 80 million per annum (2002–2006) to around 20 million in 2009 and further declined to around 9 million in 2013.

Imports of MV halogen lamps were steady at around 5 million per annum over the period 2002–2008 and jumped to 17 million in 2009. In 2011 imports had increased to 22 million and remain at just under 20 million in 2013.

Imports of CFLs climbed steadily from 10 million in 2002 to 15 million in 2006, and in 2007 jumped to around 34 million. Since then, imports have steadily declined to around 20 million in 2013. Some of this decline is likely to be due to winding back of CFL giveaway programs and the longer lifetime of CFLs which will tend to reduce their sales.

ELV halogen lamp imports rose steadily from 10 million in 2002 to 17 million in 2006, dipping to 14 million in 2008 before rising again to 19 million in 2010. Since 2010 imports of these lamps have halved. Anecdotal evidence suggests that LEDs are becoming increasingly popular as a replacement for ELV halogen lighting, which may in part explain the decrease in ELV halogen lamp imports. However no reliable data is currently available for imports or sales of LED lighting.

The percentage share of lamp imports in 2010 (Figure 7) compares favourably with the lamp share of installed stock in homes during 2010 (Figure 8). The only noticeable discrepancy is the share of MV halogen lamps. It's possible that the sales share of these lamps is higher than their installed stock share due to the stock being in flux - i.e. the stock is still increasing and it will take some time until the stock level stabilises. Note that lamp lifetime will also have an effect here - lamps with longer lifetimes will have proportionately lower sales than lamps with short lifetimes (which need to be replaced more often). The fact that longer life CFL imports were similar to stock suggests that in 2010 the stock share was still on the rise, although CFL import levels have since declined slightly.

Figure 7 – Relative share of lamps imported into Australia in 2010 (source: ABS import data)

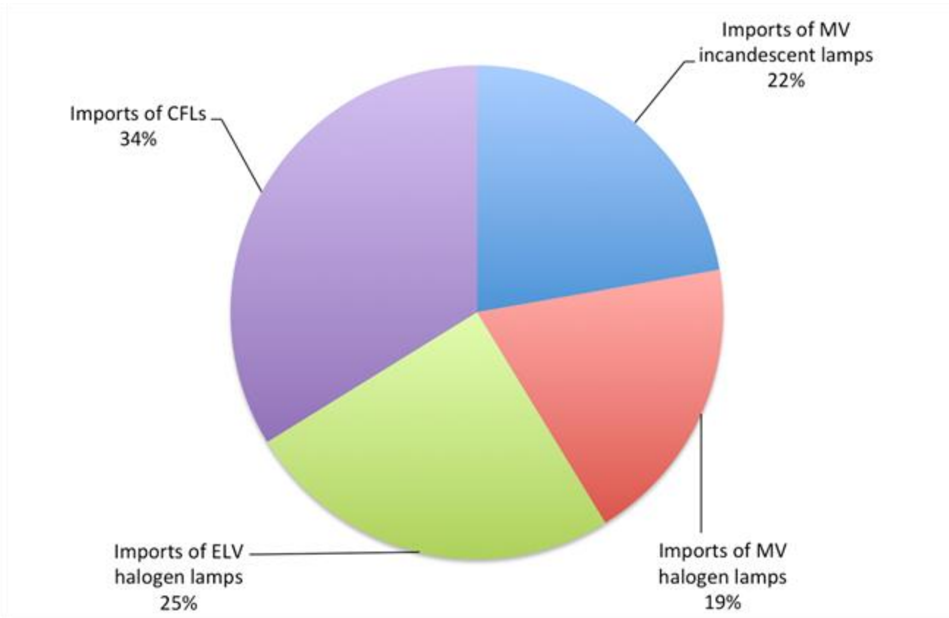
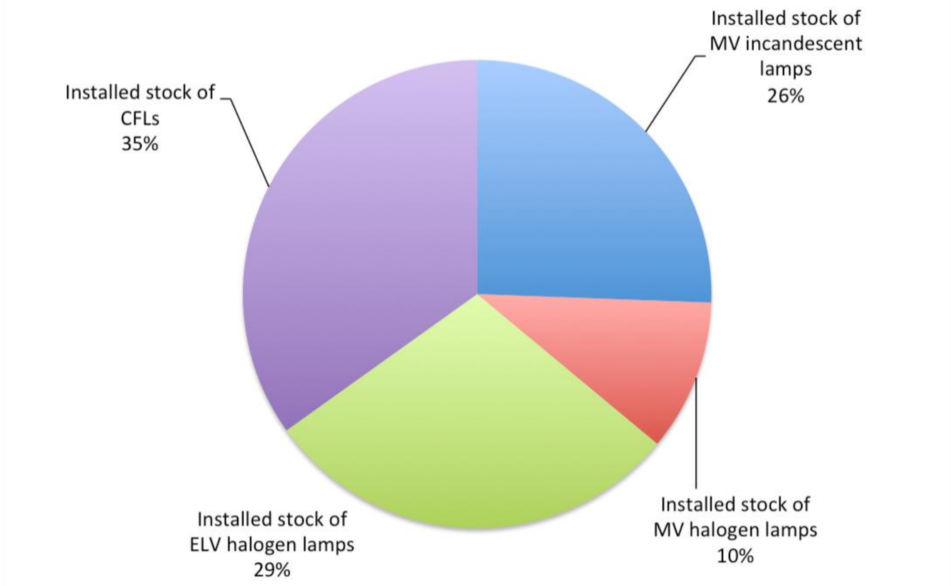


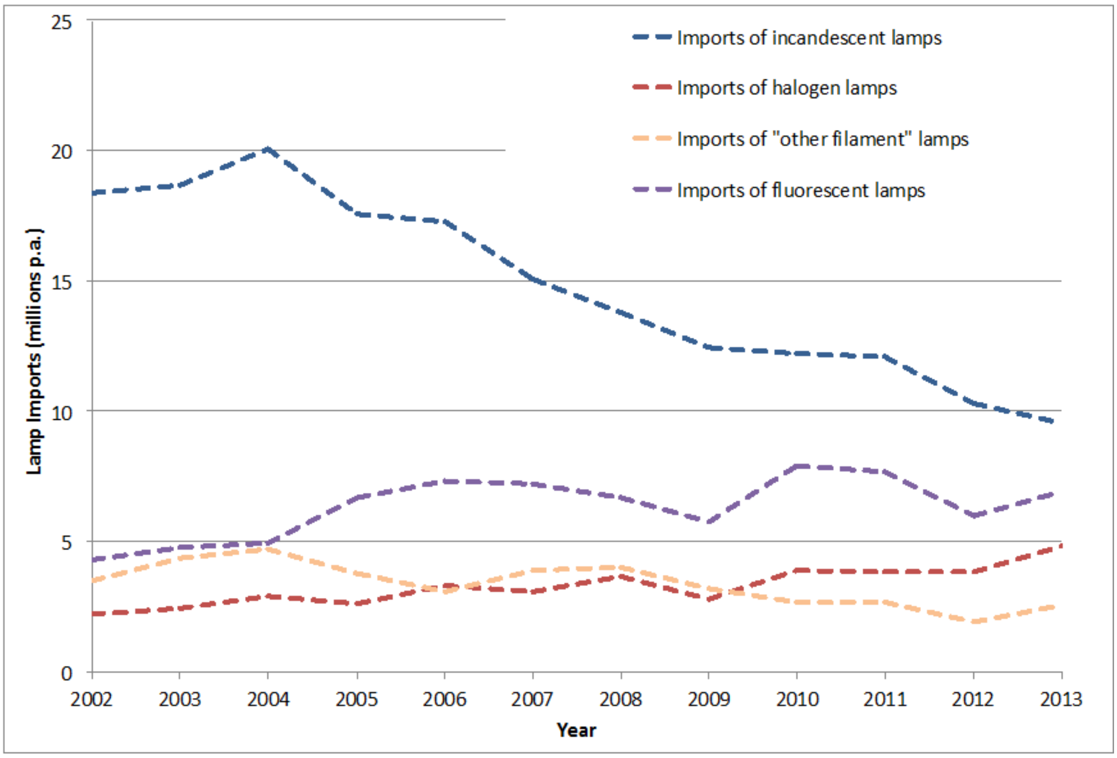
Figure 8 – Household lighting survey results – relative share of lamp stock in 2010 (E3 2013)



4.3 New Zealand Market

Import statistics for New Zealand are less granular than for Australia. Lamp types are only distinguishable as incandescent, halogen, "other filament" and fluorescent lamps (see Figure 9). The fluorescent lamps category includes all types of CFL as well as linear fluorescent lamps. The halogen lamp category includes ELV and MV lamps. Compared to Australia, the New Zealand lamp import market is considerably smaller at 24 million per annum in 2013 (note that this includes linear fluorescent lamps). The market has declined from around 28.5 million lamps per annum in 2002.

Figure 9 – Imports per annum of lamps into New Zealand



Incandescent lamp imports peaked at 20 million in 2004 and declined steadily to 10 million in 2013 (not including “other filament” lamps which may include some incandescent lamps). Halogen lamp imports (MV and ELV) increased steadily from 2 million in 2002 to 5 million in 2013 (not including “other filament” lamps which may include some halogen lamps).

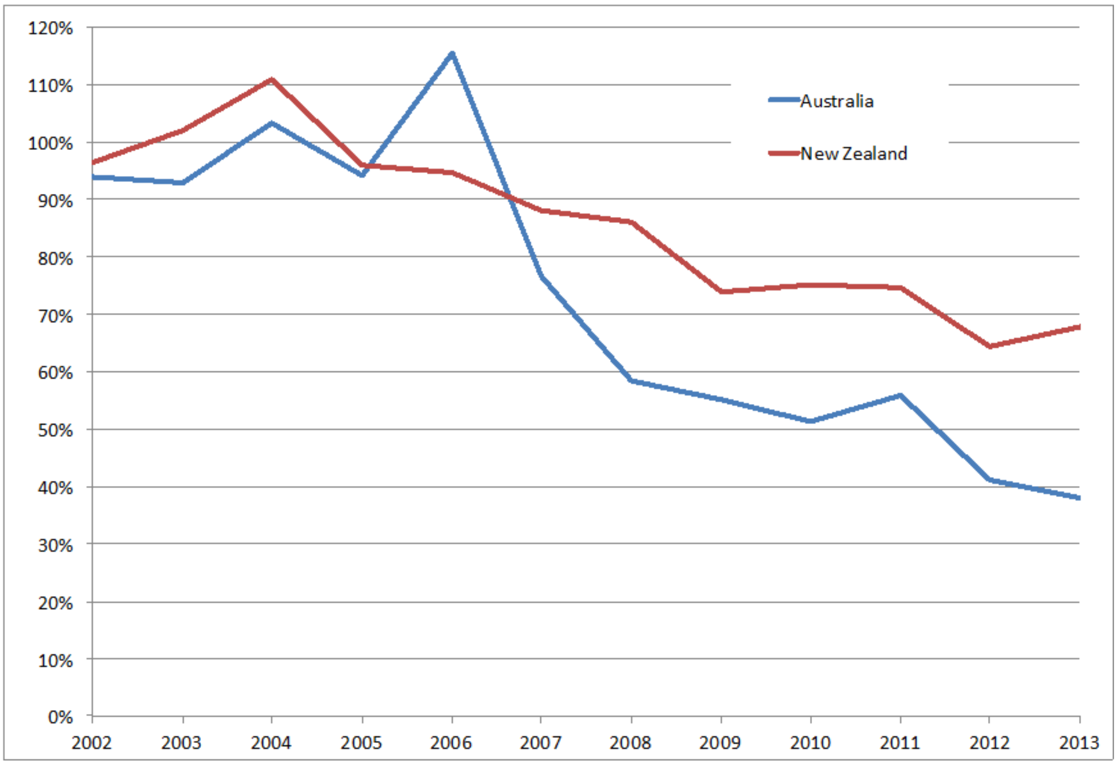
Imports of fluorescent lamps (CFL and linear) increased from around 5 million in 2002 to around 7 million in 2005. Fluorescent lamp imports have fluctuated since then, but remain at an average of around 7 million per annum. The proportion of CFLs in the fluorescent lamp category is unknown. However, recent data collected by the Energy Efficiency Conservation Authority of New Zealand (EECA) indicates that around 2.6 million CFLs were sold in New Zealand in 2013.

A survey of 140 New Zealand homes (BRANZ 2009) indicated lamp penetrations installed in homes at 64% incandescent, 25% CFL and 8–10% halogen. These are similar in proportion to the import data (2009), if the “other filament lamps” category is excluded.

4.4 Comparison of Australian and New Zealand Markets

Figure 10 graphs the imports of all types of filament lamps into Australia and New Zealand. This includes all incandescent, halogen, reflector, low voltage lamps, etc. These lamp types have been aggregated as this is the only way to compare like-with-like for Australia and New Zealand. The import data has been normalised such that the average for the period 2002-2006 are equated for Australia and New Zealand (100%).

Figure 10 – Imports of all types of filament lamps into Australia and New Zealand (normalised)



From the above figure we can see that sales of filament lamps fell around 62% in Australia and around 32% in New Zealand to 2013.

4.5 Projected Market Trends

A review of the lamp import data for Australia and New Zealand (Figure 6 and Figure 9) has led to a number of conclusions regarding current market trends for incandescent, halogen and compact fluorescent lamp sales in these countries. Table 1 estimates future qualitative market trends for the next 5 years. Current trends are due to a mixture of MEPS, the long lifetime of CFLs, increasing popularity of LEDs, as well as CFL giveaway programs, education programs and natural market forces. This includes state based energy efficiency obligation (white certificate) programs which require inefficient incandescent and halogen lamps to be physically replaced by a low energy alternative, for example in Victoria this year approximately 3 million LEDs will be installed to replace halogen down lights. Future overall lamp sales are predicted to decline, predominantly due to increased penetration of CFLs and LEDs which have longer lifetimes.

Table 1 – Current trends in lamp sales

Country	Lamp Type	Estimated Current Trend	Potential Reasoning	Expected Trend Over Next 5 Years
Australia	MV incandescent	Slight decline following a significant reduction 2006-10	Ongoing phasing out of this technology in favour of MV halogen and CFL due to MEPS and import restriction. Also natural market forces and CFL/LED giveaway programs.	Continued decline, however some lamps 25W and under currently still available
	MV halogen	Steady (but volatile) after significant increase	Has effectively reached steady state market share	Steady or decline due to LEDs
	CFL	Slight decline after significant increase	Long life of CFLs resulting in fewer replacements of failed lamps	Continued decline due to fewer lamp replacements and increasing popularity of LEDs in both the retail market and in giveaway programs
	ELV halogen	Decline	Increasing popularity of LED downlights as replacement for ELV halogen and as part of subsidy programs	Decline due to LEDs
New Zealand	MV incandescent	Decline	Natural market forces, previous CFL giveaway programs and education programs	Continued decline due to CFLs and LEDs
	MV halogen	Slight increase	Increasing popularity of MV halogen as replacement for incandescent	Steady or decline due to LEDs
	CFL	Steady	Has effectively reached steady state market share	Decline due to LEDs
	ELV halogen	Indeterminate	Not possible to separate ELV and MV halogen lamps in import data	Decline due to LEDs

Evidence from lamp testing and anecdotally also reveals that the price of LED lamps continues to fall, whilst their quality has improved dramatically over the past 2-3 years (see Figure 11 and Figure 12). This is expected to continue and drive the future trends predicted in Table 1. However it should be noted that the absence of reliable import or sales data for LED lighting means the current extent of LED uptake and future market share (without intervention) is uncertain. Although it is expected that the market will make a natural shift towards LEDs over the next few years (particularly for ELV downlights), the experience with CFLs has shown that there is a significant risk of a consumer backlash due to variation in quality, performance, lifetime, light output and inaccurate equivalency claims. These issues are currently addressed for CFLs by using MEPS that specify product quality and performance parameters in addition to efficacy and could be potentially addressed with a similar MEPS for LEDs (LED MEPS are discussed in a separate Product Profile). The capacity of LEDs to replace incandescent lighting is further discussed in section 8.3.

Figure 11 – Cost of LEDs compared to luminous flux between 2009 and 2013 (source: lamps tested by the Australian Government)

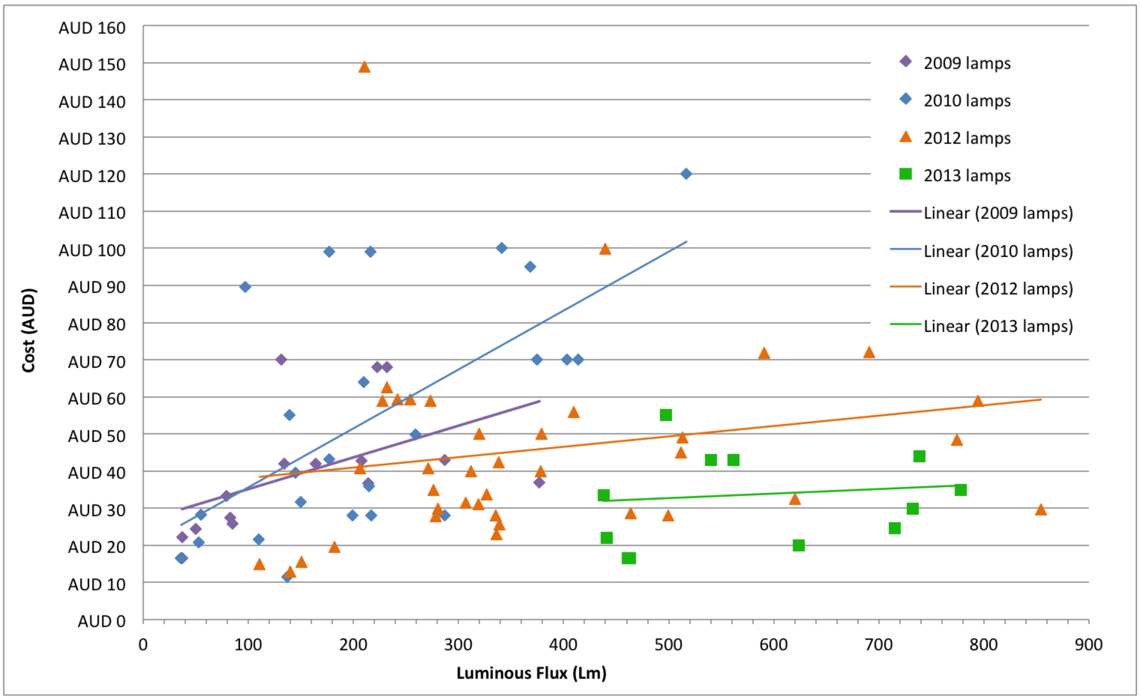
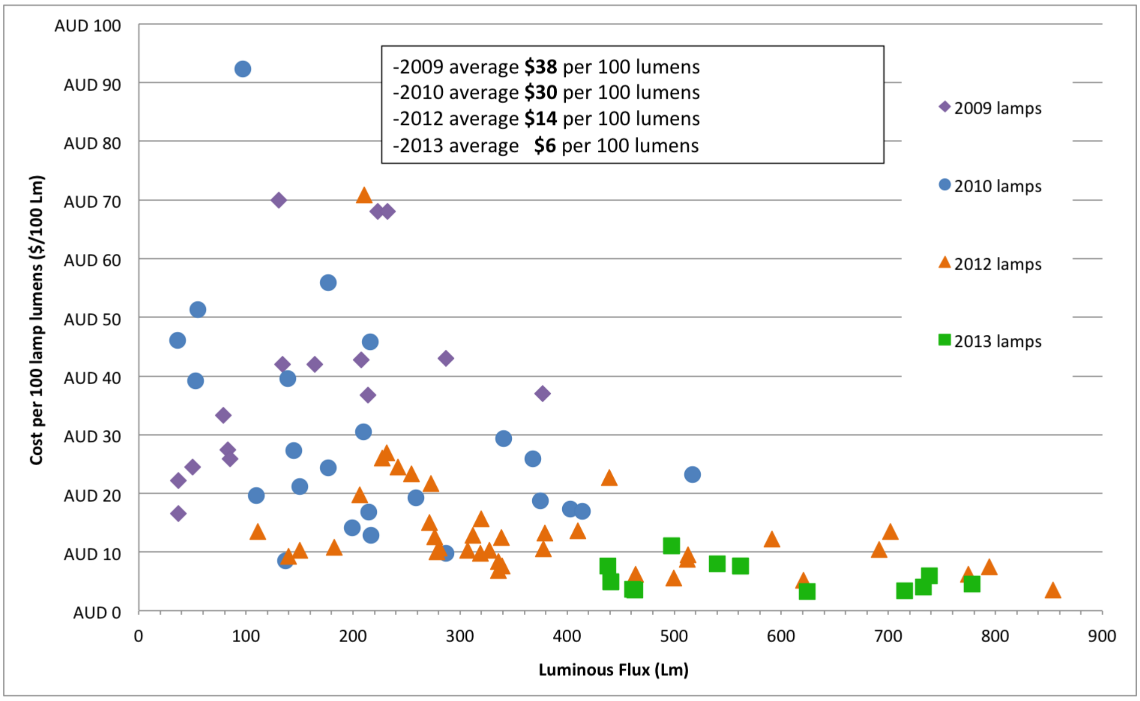


Figure 12 – LED lamp normalised cost per tested 100 lamp lumens (source: lamps tested by the Australian Government)



5 Lighting Energy Consumption and Performance

5.1 Lamp Efficacy

Lamp efficacy is a measure of efficiency, in lumens of light output from a lamp per Watt of electricity. In order of increasing efficacy, residential 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: 50-125 lm/W and increasing

Figure 13 graphs the rated and tested (2010 and 2014) efficacy of a range of typical MV incandescent and MV halogen non-reflector lamps, along with the current Australian MEPS limit (which applies to test values). Also graphed are MEPS registration values (test results for halogen lamps). MV halogen non-reflector lamps were not able to meet the original MEPS efficacy requirement, thus it was reduced to 95% of the original requirement (effective until 30 September 2016). Note that the product registration data indicates that a significant majority of registered MV halogen lamps would now comply with the full MEPS for incandescent lighting, however the sample of products recently tested more aligns with previous test data.

Figure 13 – Comparison of rated and tested efficacy of MV incandescent and MV halogen non-reflector lamps (source: lamps tested by the Australian Government in 2010, 2014, MEPS registration system)

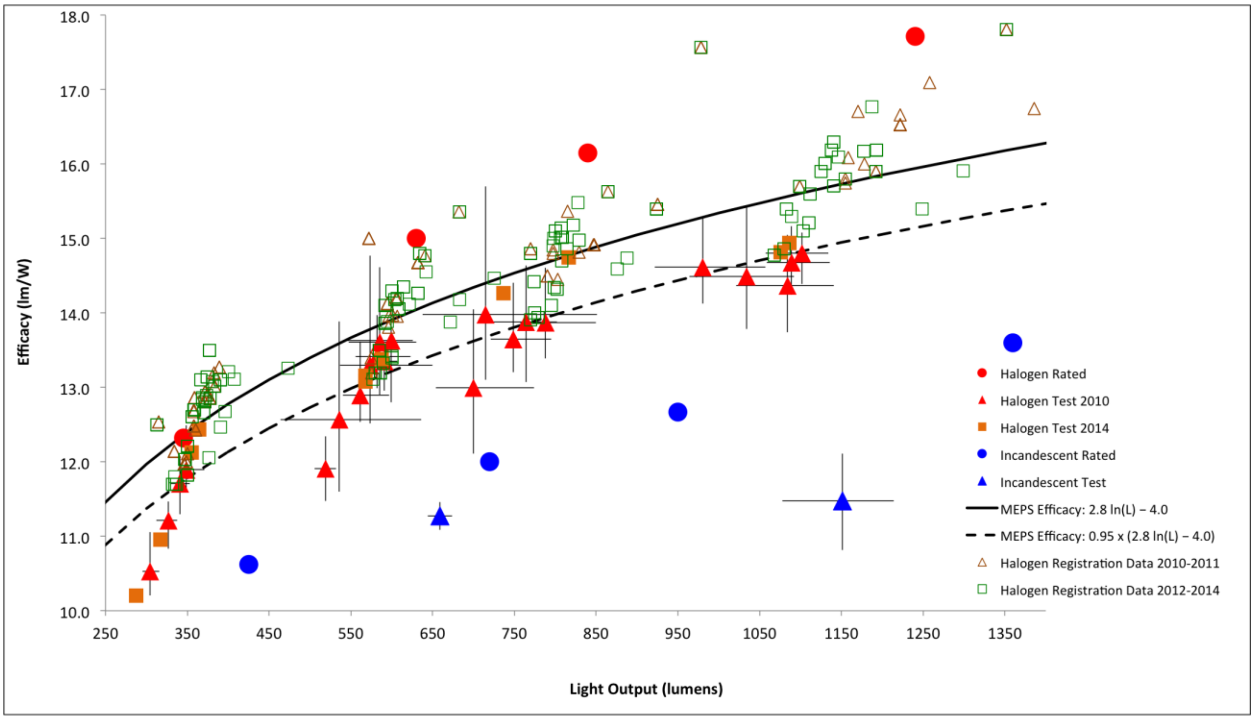


Figure 14 graphs MEPS registration values (test results) for efficacy and lumen maintenance (at 75% of rated life). The MEPS requirement for lumen maintenance is 0.8 at 75% of rated life. As can be seen in this figure, most lamp registrations claim a lumen maintenance in the range 0.85 - 0.95.

Figure 14 – MV halogen non-reflector lamps efficacy and lumen maintenance (source: MEPS registration system)

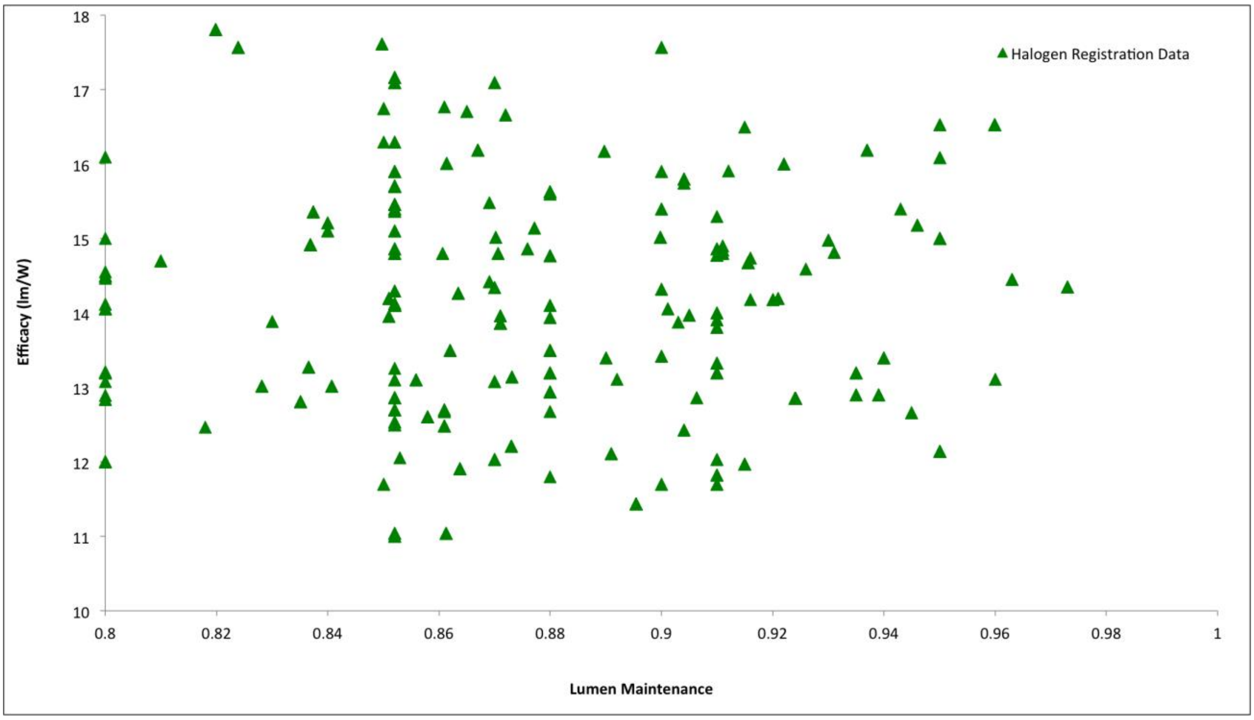


Figure 15 graphs the tested (2008) efficacy of a range of typical MV incandescent and MV halogen reflector lamps, along with the originally proposed Australian MEPS limit. MV halogen reflector lamps are currently unable to meet the MEPS limit and are therefore exempt until 30 September 2016.

Figure 16 graphs the average tested efficacy of a range of typical bare Australian CFLs sampled in 2008 and 2010, along with current CFL registration data (claimed test values) and the current Australian and New Zealand MEPS limit. Also graphed is the EU MEPS limit, including a 10% allowance for tolerance. The EU MEPS equation is effectively the same as the Australian equation, although it is phrased in terms of rated values. Allowing a difference in rated versus tested light output of 10% (as is allowed in the International Electrotechnical Commission (IEC) CFL standard 60969) would result in an effective MEPS limit 10% lower than the Australian limit - this is graphed. The allowable tolerance on power would have an additional effect (not graphed). It is not recommended to take this approach to MEPS, which should ideally be phrased in terms of tested values, without tolerances (currently testing for registration does not allow for any tolerances (from manufacturing variations or the lab test result) but check testing for compliance does take into account tolerances for lab test results).

As can be seen in Figure 16, CFLs are easily able to meet the Australian MEPS requirement - an increase in the MEPS of around 10 lm/W may be feasible (achieve on average approximately an 8% energy saving). The figure graphs a curve fit to the current CFL registration data, which could form the basis of a new MEPS limit.

Figure 15 – Comparison of tested efficacy of MV incandescent and MV halogen reflector lamps (source: lamps tested by the Australian Government 2008, 2014)

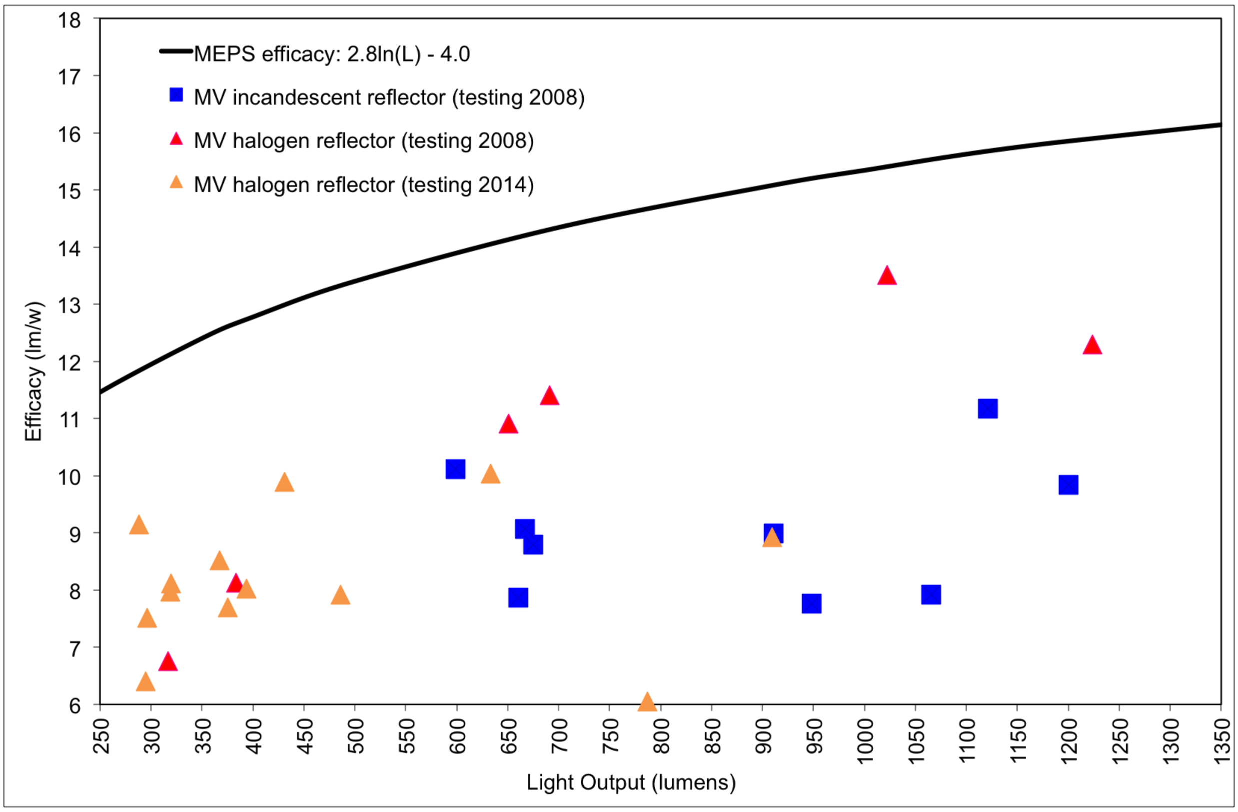


Figure 16 – Average tested efficacy of bare CFLs (source: lamps tested by the Australian Government 2008, 2010 and 2013)

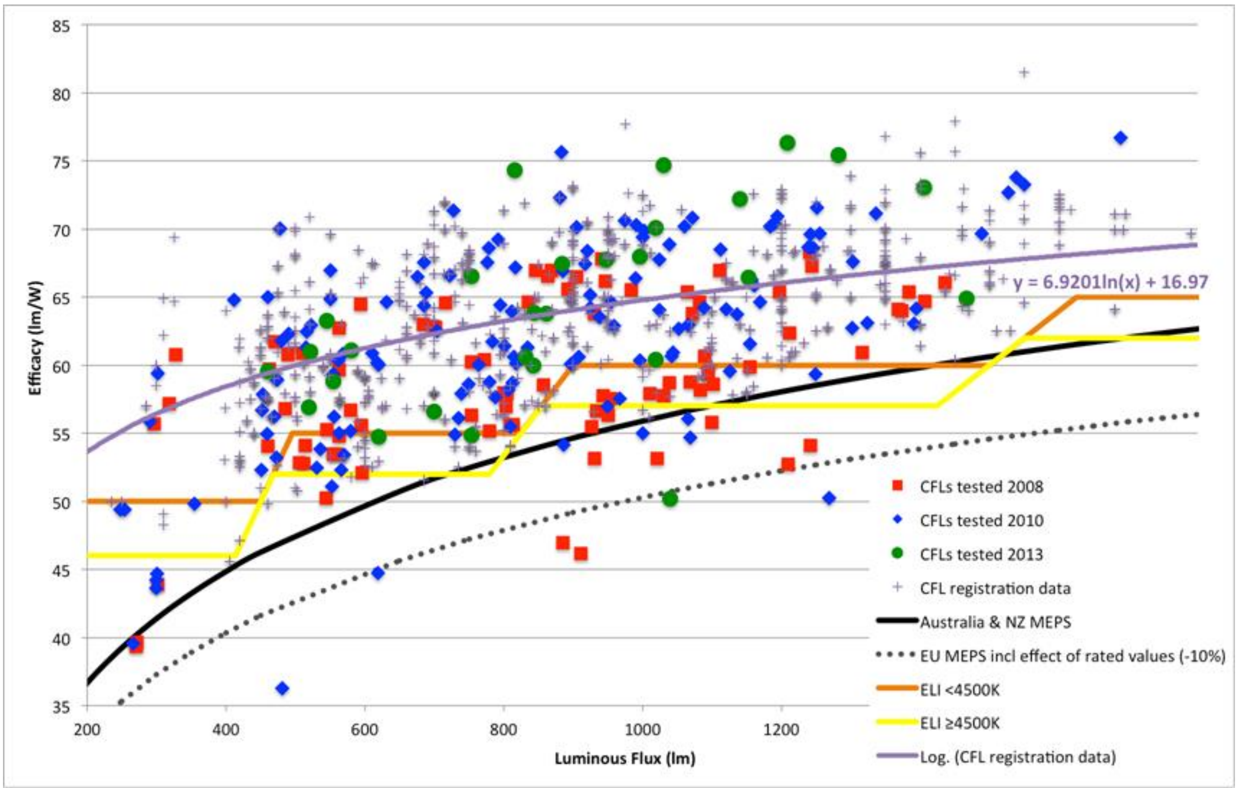
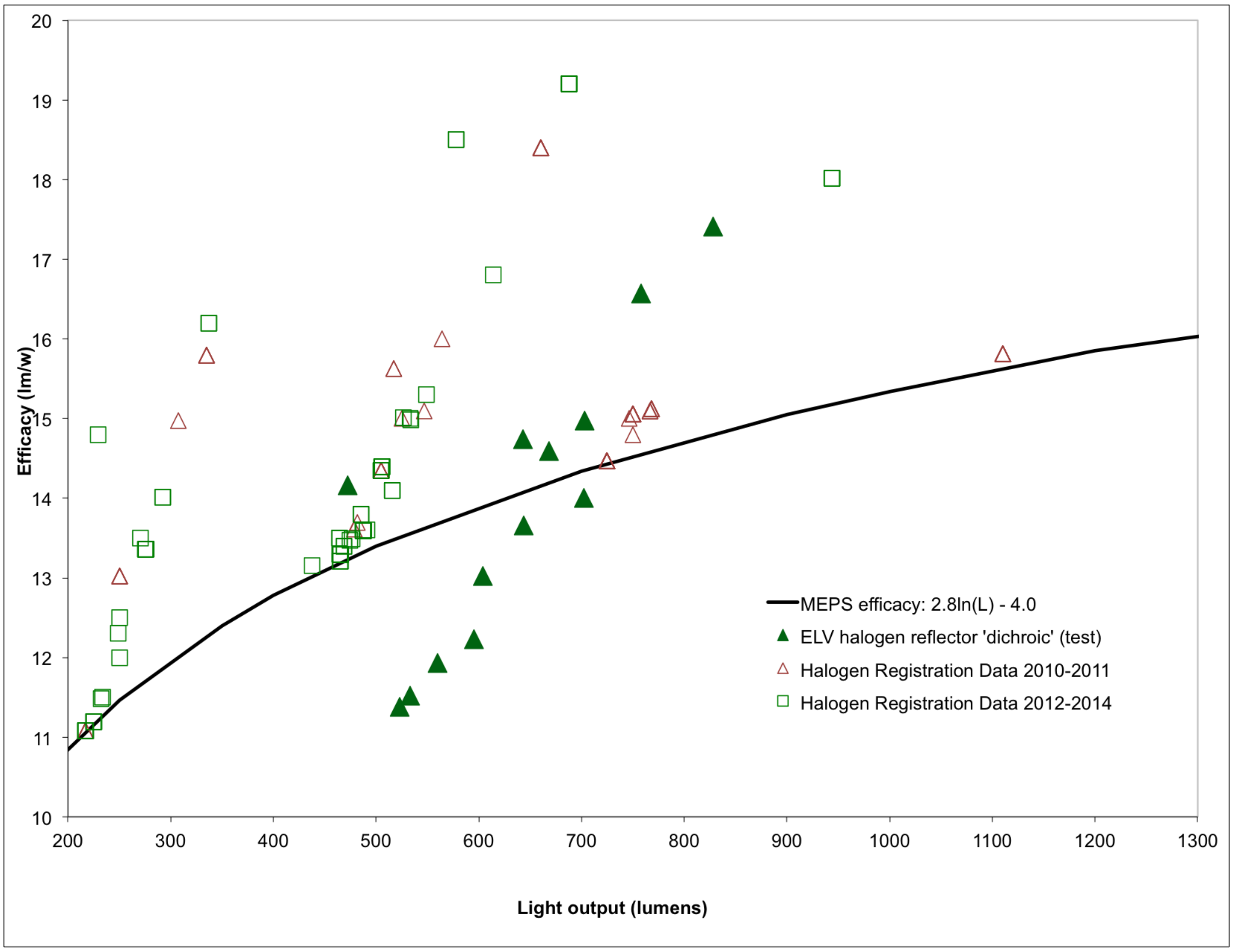


Figure 17 graphs the tested (2008) efficacy of a range of typical ELV halogen reflector lamps (primarily 50 W lamps) along with the Australian MEPS limit. The available models of ELV halogen reflector lamps in 2008 were split roughly in half by the MEPS efficacy requirement. Note that ELV halogen non-reflector lamps are easily able to meet the MEPS efficacy requirement (efficacy data not shown in Figure 17).

Figure 17 – Tested efficacy of ELV halogen reflector lamps (source: lamps tested by the Australian Government 2008)

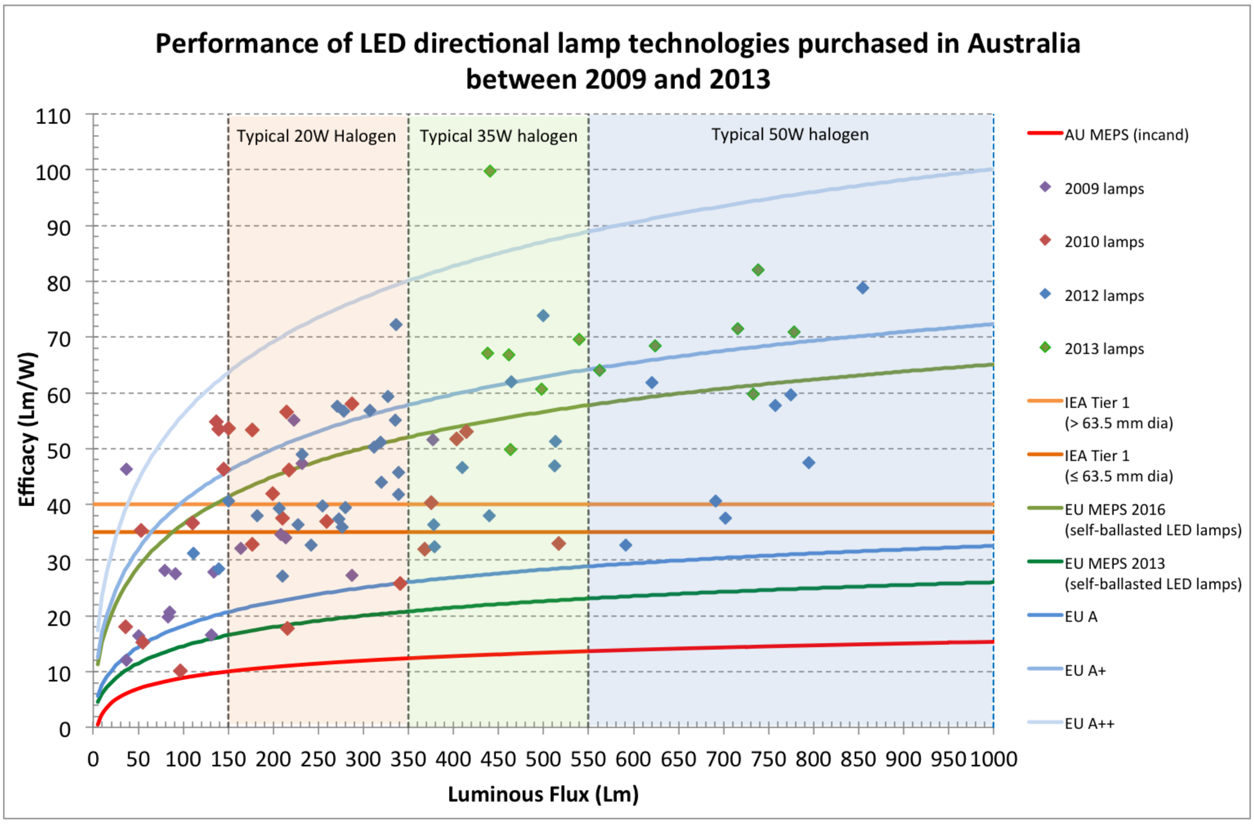


From the above figures we can conclude that:

- Check testing indicates that MV halogen non-reflector lamps still require a relaxed MEPS level but these results do not align with product registration data indicating a significant portion of the market may now be able to meet the original MEPS efficacy requirement (the requirement has been relaxed until 30 September 2016).
- MV halogen reflector lamps are significantly below the MEPS efficacy requirement (which has yet to be applied to these lamps).
- CFLs (bare) are easily able to meet the MEPS requirement.
- The available models of ELV halogen reflector lamps at the time of introduction of MEPS were split roughly in half by the MEPS efficacy requirement. ELV halogen non-reflector lamps are easily able to meet the MEPS efficacy requirement.

LEDs exhibit a range of efficacy, which continues to improve (see Figure 18). High quality LEDs have an efficacy of at least 50 lm/W however some models tested were found to have efficacy as low as 10 lm/W (testing conducted by the Australian Government) while more efficient models have been found up to more than 80 lm/W.

Figure 18 – Tested efficacy of LED directional lamp technologies purchased in Australia 2009–2013 (source: lamps tested by the Australian Government)



5.2 Modelling of Energy Consumption

The energy consumption of Residential lighting in Australia and New Zealand is the subject of a study underway at the time of writing of this Product Profile – the Residential Lighting Overview Report. This study gathers data from a wide range of sources and aggregates it into a unified energy model. It is expected that this study will be published at approximately the same time as this Product Profile, and will be available on the Energy Rating website. The Residential Lighting Overview Report utilises two recent surveys of lighting in Australian and New Zealand homes:

- Australia: The E3 2010 Residential Lighting Report represents a comprehensive in-home study of residential lighting in Australia, undertaken in 2010 and 2011. As part of the survey, 150 houses in Brisbane, Newcastle, Sydney, Melbourne and Gippsland (Victoria) were visually audited by trained personnel and complemented by a survey to understand demographics and behaviour. Note that the sample houses were skewed towards higher incomes, with under-representation of single-member and one-parent households.
- New Zealand: In 2011-2012, EECA and IPSOS surveyed 149 New Zealand homes. This was a comprehensive in-home survey of residential lighting in New Zealand, also complemented by a survey to understand demographics and behaviour. The study comprised an in-home visual survey by trained personnel, as well as paper-based survey. This was an update of an Building Research Association of New Zealand (BRANZ) survey on lighting undertaken in 2009.

Although these two data sources are 4 and 3 years old respectively, they are the most recent household lighting surveys available. Assuming an average per-lamp operating time of 1.5 hours per day, which is a reasonable assumption based on data from the E3 REMP study (E3 2012) and estimated average lamp power, Table 2 estimates average household energy consumption for lighting, for Australia in 2010 and New Zealand in 2012. Note that these estimates do contain some weaknesses (due to the age of the household survey data, assumptions such as operating time, complexity, and diversity of household lamp penetration and usage patterns, survey methodology inconsistencies, etc.), but are still considered a reasonable basis for making some conclusions for household lighting energy consumption. It is expected that LED stock will have increased since the time of these surveys.

Table 2 – Estimated household energy consumption for lighting, Australia 2010, New Zealand 2012

Lamp mix per house			Av Lamp Power (W)	Energy kWh p.a. Australia 2010	Energy Cost (@25c/kWh) Australia 2010	Energy kWh p.a. NZ 2012	Energy Cost (@25c/kWh) NZ 2012
Lamp Type	**Australia 2010**	**NZ 2012**					
MV incandescent	11.0	20.8	73	438	$109	829	$207
MV halogen	4.4	1.5	51	123	$31	42	$10
ELV halogen	12.3	2.3	49	330	$82	62	$15
CFL	15.0	8.7	14	112	$28	65	$16
Linear fluorescent	4.4	0.9	41	100	$25	21	$5
LED	0.7	0.2	10	4	$1	1	
Total	**48**	**35**		**1100**	**$277**	**1020**	**$255**

At a national level, annual residential lighting energy consumption is estimated (noting the data weaknesses stated above) at around 11 TWh (40 PJ) for Australia and 1.7 TWh (6 PJ) for New Zealand. For each country, this represents around 5% of total national electricity consumption. From this, the relative energy consumption, by lamp type, for Australian and New Zealand are shown in Figure 19 and Figure 20.

From these figures, it is clear the energy consumption of the filament lamp technologies (incandescent and halogen) still represent significant opportunities for energy saving in both Australia and New Zealand. Shifting the market from these technologies to CFL and LED has the potential to considerably reduce energy consumption. This is demonstrated in Table 3, which shows the filament lamps shifting to CFL or LED with corresponding decreases in lamp power. Energy savings in the order of 65% (compared to 2010 in Australia and 2012 in New Zealand) are possible.

Household annual energy savings, from these calculations, would be around $180 p.a. per household for both Australian and New Zealand households (assuming an electricity cost of 25c/kWh). The potential for energy savings is examined in further detail in the following section.

Figure 19 – Estimated share of household energy consumption, by lamp type, Australia 2010

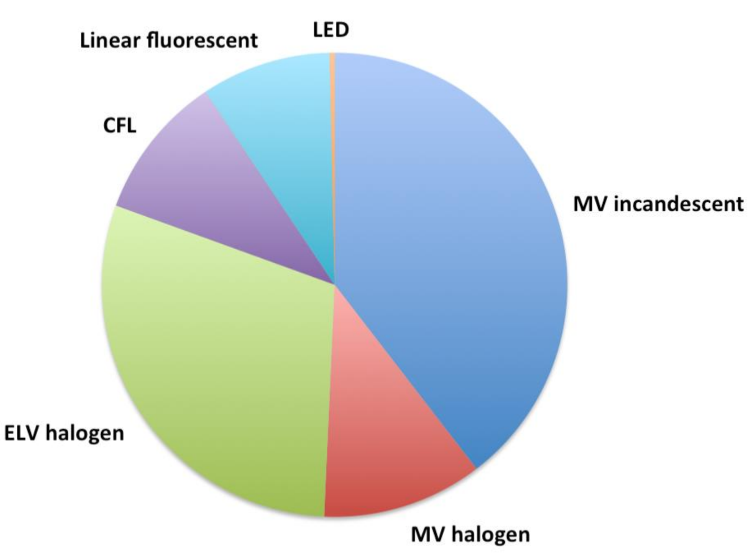


Figure 20 – Estimated share of household energy consumption, by lamp type, New Zealand 2012

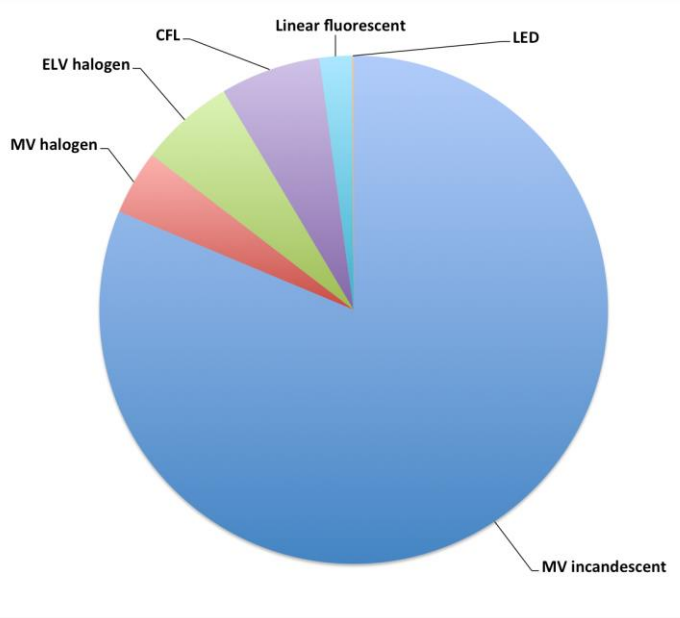


Table 3 – Potential for household lighting energy savings from converting to CFL and LED (compared to Australia 2010 and New Zealand 2012)

Lamp mix per house			Av Lamp Power (previous) (W)	Av Lamp Power (new) (W)	Energy kWh p.a. Australia	Energy Cost (@25c/kWh) Australia	Energy kWh p.a. NZ	Energy Cost (@25c/kWh) NZ
Lamp Type	**Australia**	**NZ**						
MV incandescent -> **CFL/LED**	11.0	20.8	73	15	88	$22	166	$41
MV halogen -> **CFL/LED**	4.4	1.5	51	15	35	$9	12	$3
ELV halogen -> **LED**	12.3	2.3	49	8	54	$13	10	$3
CFL	15.0	8.7	14	14	112	$28	65	$16
Linear fluorescent	4.4	0.9	41	41	100	$25	21	$5
LED	0.7	0.2	10	10	4	$1	1	
Total	**48**	**35**			**392**	**$98**	**270**	**$67**
Energy saving %					**65%**		**74%**	

Note that the data used to calculate the results in Table 3 is now several years old, and it is possible that the penetration of MV halogen lamps, CFLs and LEDs have increased further since the data was collected.

5.3 Technological Opportunities for Improved Efficiency

The potential exists for significant energy savings by changing from incandescent/halogen technologies to CFL/LED. The efficacy range of lamps currently in the market is shown in Figure 21. Note however that the LEDs graphed are directional units tested by the Australian Government in 2013 and reflect improvements in LED efficacy made in recent years. While LEDs with inferior efficacy do exist in the market, the LEDs graphed are of reasonably high quality. The difference in the best and worst lamps (both within and between technology categories) is significant and indicates the technology exists to reduce energy usage in the poorest performers.

Significant opportunities (labelled A to F) for improvement in lamp efficiency in general are outlined in Figure 22. For the purpose of this figure, lamps are categorised by their efficacy into the following groups:

- Incumbent: the least efficient type of lamp.

- Interim: the next significant step up in terms of lamp efficacy.
- High efficiency: the most efficient lamp technology currently commercially available.

A tick beside the lamp type in Figure 22 indicates that this transition has already been completed as a result of MEPS (in Australia).

These opportunities (A to F) are discussed in detail below.

Figure 21 – Typical range of efficacies for lamp types (source: testing conducted for E3)

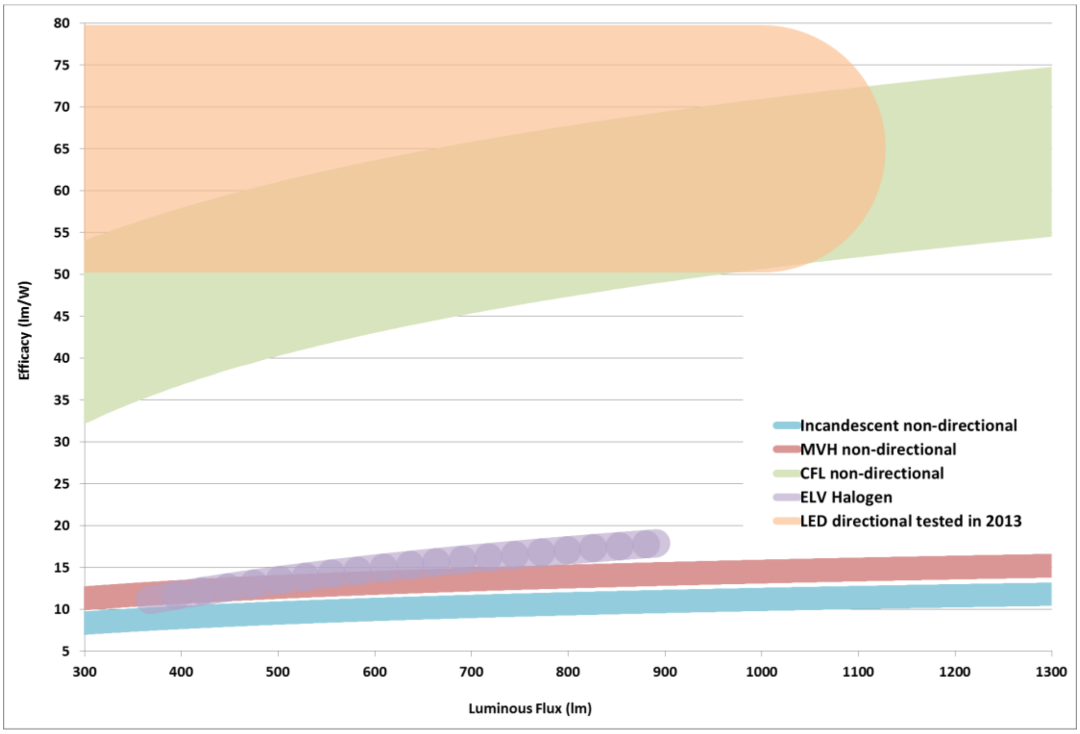
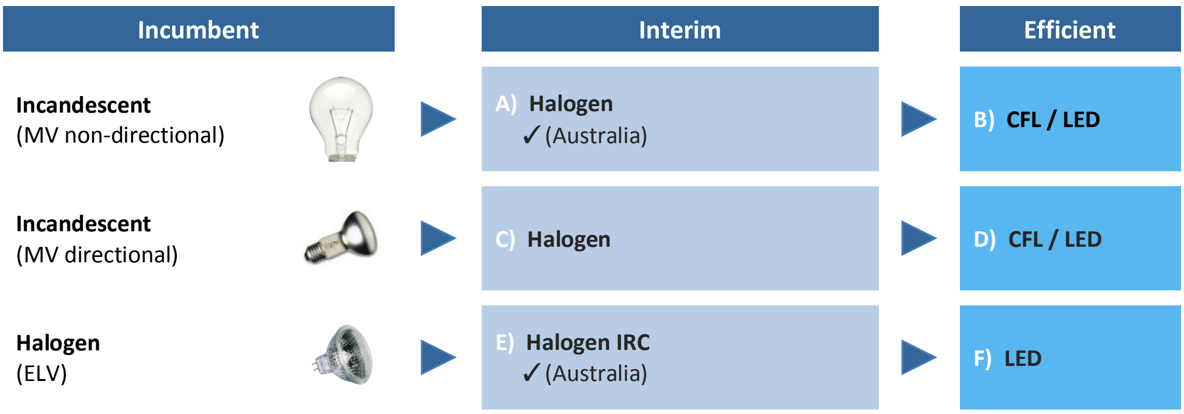


Figure 22 – Key opportunities to change to more efficient lamp technology



A) MV non-directional incandescent to halogen

- For MV non-directional lamps, the transition away from incandescent is effectively complete in Australia (for lamps above 25 W) with MEPS considered a significant driver of this transition. In Australia it may also now be possible to apply the full incandescent MEPS level to MV halogen lamps. A more gradual transition is also underway in New Zealand to a certain extent.

B) MV non-directional incandescent and halogen to CFL/LED

- In Australia a move from incandescent lamps to sales of around 50/50 CFL/MV halogens has occurred. Completing a 100% transition to CFL/LED technology would further reduce energy consumption.

C) and D) MV directional incandescent to halogen to CFL/LED

- For MV directional lamps, the phasing out of incandescent lamps in Australia has been delayed due to the inability of lamps to meet the MEPS specification (see section 6.4.3 for further discussion). Industry has informed Government that there is very little difference in efficacy between an incandescent and a halogen reflector lamp. Thus, a full transition to CFL/LED technology (D) is worthy of consideration.

E) ELV halogen to halogen IRC

- This market is dominated by 12 V reflector (MR16) lamps. Non-reflector (capsule) lamps are not a particularly significant part of the market and are most commonly used in products such as desk lamps.
- A recent change to the Australian MEPS requires that all ELV directional lamps are limited to 37 W, with efficacy meeting the MEPS requirement. The effect of this change is that Australian 50 W MR16 lamps will be replaced by nominal 35 W IRC lamps, with light output similar to pre-MEPS 50 W lamps. To meet MEPS, MR16 lamps will be required to be either IRC or very high quality halogen. There is a similar opportunity for energy savings if such a transition was made in New Zealand.

F) ELV halogen and halogen IRC to LED

- Anecdotal evidence suggests that there is a trend for ELV halogen downlights to be usurped by LEDs. For example, Australian imports of ELV halogen lamps have halved in the three years since 2010 (see Figure 6) which may be partially explained by the increasing popularity of LEDs for this application supported in some areas by white certificate replacement schemes and possibly by building code power density limits. It is not known at this stage what portion of the market will voluntarily transition to LED lighting (noting that the voluntary transition from incandescent to CFL for relevant lamp types was only partial) however completing the transition to LED would further reduce energy consumption. LEDs are well suited to this application, although in retrofit situations there remains a compatibility problem in some cases between LEDs and the installed stock of halogen electronic transformers and dimmers. CFLs are not a suitable technology to replace MR16 downlights, due to the space limitations imposed by the MR16 lamp envelope as well as the associated fitting and inability to form good directional beams. Note that there is a separate Product Profile planned for LEDs, which will discuss MEPS as an option for LEDs.

5.4 Other Performance Parameters

MEPS for CFLs extend beyond efficacy to specify minimum performance requirements for a range of parameters relating to quality of the lighting service provided (see section 6.1.2 below). This was intended to ensure that good quality efficient lamps were available to consumers as inefficient lamps were phased-out. The performance of CFLs against these parameters have been monitored through check testing alongside monitoring of product efficiency. Results of CFL performance testing of product purchased in 2013 have only recently been received, however initial analysis indicates that issues remain with the quality of CFLs available in the market. This is a preliminary comparison which does not take into account differences in the treatment of uncertainty between the 2008 and 2013 tests. Differences in the approach to sampling may also be relevant. However the results suggest that increased monitoring and enforcement on these products is required to encourage compliance.

Table 4 provides a rough comparison of the level of compliance with MEPS for a number of parameters which indicates that in some cases (such as run-up time and power factor) the performance of lamps available in the market has decreased while in others there has been an improvement.

This is a preliminary comparison which does not take into account differences in the treatment of uncertainty between the 2008 and 2013 tests. Differences in the approach to sampling may also be relevant. However the results suggest that increased monitoring and enforcement on these products is required to encourage compliance.

Table 4 – Preliminary comparison of MEPS failure rates for several CFL performance parameters

	Starting time	Run Up Time	Power Factor	Efficacy	Colour Appearance	CRI
2008	6%	1%	4%	6%		10%
2010	4%	2%	9%	3%	49%	1%
2013	0%	9%	16%	5%	33%	2%

6 Current Standards and Regulations

6.1 Testing and Minimum Energy Performance Standards/Labelling

6.1.1 Current Test Methods and Test Laboratory Capability

Standards Australia has recently published AS/NZS 4934.1:2014 that defines the methods of measurement for the energy performance of incandescent and halogen lamps used in general purpose lighting. This final version provides considerable enhancement of test methods for directional lamps compared to the interim version which was used until recently.

AS/NZS 4847.1:2010 was published by Standards Australia to specify test methods for key performance attributes of self-ballasted CFLs and other gas-discharge lamps with an integrated means for controlling, starting and stable operation, which are intended for general lighting purposes.

There are testing laboratories in Australia that are able to perform tests in accordance with these standards. In addition, international suppliers have been testing to the Australian/New Zealand standards, and ELI and UK Energy Saving Trust (EST) specifications for a number of years (these certifications are acceptable under AS/NZS 4847.2, discussed further below).

6.1.2 MEPS Regulations Impacting on Energy and Performance

In Australia, determinations under the GEMS Act set out specific product requirements. Requirements are described either directly in the determination, or the determination will refer to the applicable clause in a product standard – for lighting products the latter applies with some clarifications contained within the determination itself.

In New Zealand, certain lighting products are covered by the *Energy Efficiency (Energy Using Products) Regulations 2002* and must meet certain requirements before they can be legally sold. General requirements are set out in the regulations, and specific details for each product type, such as MEPS and labelling details, are described in product standards.

MEPS for incandescent and halogen lamps in Australia

The Australian Standard AS 4934.2:2011 specifies requirements for MEPS, maximum wattage and other requirements for incandescent and halogen lamps with a range of common shapes and caps, which operate at ELV or at MV. It covers lamps supplied individually or as part of a luminaire. Excluded from the scope are coloured lamps, automotive lamps and special purpose lamps (traffic signals, navigation lamps, oven lamps, infra-red lamps and rough use lamps). The current MEPS requirements are given in Table 5. There are currently no MEPS requirements for incandescent and halogen lamps in New Zealand.

Table 5 – Incandescent and halogen MEPS requirements for Australia

Parameter	Minimum Sample Size	Compliance Criteria
Initial efficacy	10	Average value shall be ≥ 2.8 ln (L) – 4.0 Where L = Average measured initial luminous flux of the lamp in lumens. Until 30 September 2016, MV halogen non-reflector lamps may comply with: Initial efficacy: Average test value shall be ≥ 0.95 × (2.8 ln (L) – 4.0)
Lifetime	20	Life of the median lamp (or 11th of sample size of 20) shall be at least 2000 hours.
Lumen maintenance	10	When measured at 75% of rated lamp life, the average lumen maintenance shall be at least 80%. Lamps that fail prior to 75% of rated life shall not be included in the average. All lamps shall fall within two standard deviations of the average.

The standard also requires that ELV halogen reflector lamps have an average measured power of no more than 37 W. In addition, the standard requires that all lamp packaging carry the following information:

- Light output in lumens
- Wattage in Watts
- Lamp lifetime.

MEPS for incandescent and halogen lamps was implemented in a staged fashion, commencing with an Australian import restriction on GLS incandescent lamps in February 2009. In November 2009 these lamps were subject to 'point of sale' MEPS and the scope of MEPS was widened gradually until October 2012. The staging of MEPS requirements is contained in the GEMS Act Determination for incandescent lamps summarised in Table 6.

Table 6 – Staging of MEPS for incandescent and halogen lamps (Australia)

Lamp Type	MEPS Date
GLS tungsten filament	November 2009
ELV halogen non-reflector	
> 40 W candle, fancy round and decorative tungsten filament lamps	October 2010
ELV halogen reflector	
Mains voltage halogen non-reflector	1 January 2011
Mains voltage reflector lamps including halogen (PAR, ER, R, etc.)	Not currently referred to in regulation, but scheduled for October 2016 – date to be reviewed and determined dependent on availability of efficient replacement product
> 25 W candle fancy round and decorative tungsten filament lamps	October 2012
Pilot lamps – 25 W and below	Not currently referred to in regulation – to be determined dependent on availability of efficient replacement product

MEPS for CFLs in Australia and New Zealand

MEPS for CFLs came into effect in Australia in November 2009 and in New Zealand in October 2012. These MEPS are specified in AS/NZS 4847.2:2010. The scope of the standard is CFLs with integrated means for controlling starting and stable operation that are intended for domestic and similar general lighting purposes. The Standard applies to self-ballasted lamps of all voltages and wattages irrespective of the type of lamp cap, supplied as individual lamps or part of a luminaire. Excluded from scope are:

- Coloured CFLs
- CFLs intended primarily for production of ultra-violet (UV) radiation
- CFLs intended as insect repellent lamps
- Cold-cathode CFLs
- Self-ballasted mixed mercury vapour lamps.

Lamps must comply with the performance requirements as specified in AS/NZS 4847.2 (see Table 7). In Australia and New Zealand, lamps certified by one of the following programs are also acceptable:

- ELI Technical Specification for Self Ballasted Compact Fluorescent Lamps, versions dated 1 March 2006 or 1 June 2011.
- UK EST Lamp Specification, Versions 5, 6.1 or 7.

If any of the performance attributes in the Standard are not specified in the ELI or EST test report, then the lamps shall comply with the requirements of the AS/NZS 4847.2. The onus for demonstrating compliance with the above schemes lies with the manufacturer, importer or (in Australia only) responsible vendor.

AS/NZS 4847.2 sets out additional requirements if properties including low temperature starting, light distribution, peak intensity value and beam angle are claimed.

Table 7 – CFL MEPS requirements

Parameter	Requirements	Minimum Sample size	Compliance Criteria
Maximum starting time (seconds)	2	10	≥ 80% of lamps shall start within the time specified
Maximum run-up time (seconds)	60	10	Average ≤ value specified
Minimum efficacy in lm/W (bare lamps)	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	10	Average ≥ value specified. All lamps shall fall within two standard deviations of the average.
Minimum efficacy in lm/W (covered non-reflector lamps)	$\frac{0.85}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	10	Average ≥ value specified. All lamps shall fall within two standard deviations of the average.
Minimum efficacy in lm/W (reflector lamps)	$\frac{0.6}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	10	Average ≥ value specified. All lamps shall fall within two standard deviations of the average.
Minimum lumen maintenance	2000 hrs = 0.88 5000 hrs = 0.80	10	Average ≥ value specified. All lamps shall fall within 2 standard deviations of the average.
Maximum premature lamp failure rate	10% at 30% of rated life	10	
Minimum life (hours)	6000	10	Life of the median lamp (or 6th of sample size of 10) shall be ≥ value specified
Minimum True Power factor	0.55 0.9 for high PF	10	Average ≥ value specified.
Colour appearance	IEC 60081 Graph D-16 for correlated colour temperature (CCT) 2700. Other temps to be approved but following same diagram	10	Colour co-ordinates of all lamps shall be within the tolerance area on the chromaticity chart as declared by the manufacturer, importer or responsible vendor, but shall in any case be within 5 SDCM from the target values.
Minimum colour rendering index (CRI)	80	10	Average ≥ value specified.
Maximum mercury content (mg)	5	3	Average ≤ value specified, when measured in accordance with IEC 62321 or AS/NZS 4782.3
Minimum switching withstand	3000	10	≥80% shall operate for number of cycles specified.
Harmonics	IEC 61000-3-2	1	All lamps to comply with the requirements of IEC 61000-3-2.
Immunity	The lamps shall comply with the immunity requirements of IEC 61547	1	All lamps to comply with the requirements of IEC 61547.

The Standard also specifies the following marking requirements for CFL packaging and methods for deriving corresponding values:

- Light output in lumens
- Power in watts
- Lamp lifetime
- Mercury content in milligrams.

Claims of equivalence with an incandescent lamp can also be made, as long as the minimum CFL initial (100 hour) light output is in accordance with values specified in the standard (note these are based on European Union equivalency requirements).

6.2 Import Restriction

As part of the phase-out of inefficient incandescent lighting, an Australian import restriction on GLS (traditional A-shaped (pear shaped) "light bulbs") lamps (as defined in AS 4934.2) was put in place under the *Customs (Prohibited Imports) Regulations 1956* from 1 February 2009. Australian Customs and Border Protection Service works with the Department of Industry in relation to this restriction. The regulations require a person seeking to import GLS lamps to obtain permission from the Minister for Industry prior to the importation. Permissions are only granted in a limited number of circumstances.

6.3 Other Relevant Standards, Regulations and Government Programs

Other relevant, current Australian and New Zealand standards, regulations and initiatives are as follows.

- **AS/NZS 4782.3:2014 Double-capped fluorescent lamps—Performance specifications Part 3: Procedure for quantitative analysis of mercury present in fluorescent lamps** encompasses all methods of determination of mercury by wet chemical analysis process and is suitable for all types of fluorescent lamps. This includes the measurement of mercury content of CFLs within the scope of AS/NZS 4847.2 which must be prepared and measured in accordance with AS/NZS 4782.3 or with IEC 62554 / IEC 62321-4.
- **AS/NZS 4789 Performance of transformers and electronic step-down converters for ELV lamps** came into effect in October 2010 in Australia and is not currently regulated in New Zealand. It is a mandatory standard which specifies MEPS in terms of minimum full load efficiency. Additionally, the standard requires that the output voltage of any units rated between 50-70 W (inclusive) must be more than 11 V and less than 12.8 V when measured under special load conditions with a 35 W lamp.
- **Building Code of Australia (BCA) lighting efficiency provisions** first came into effect in May 2005 and various lighting provisions have been added since, for both commercial and residential buildings. The primary mechanism for these provisions is a maximum illumination power density requirement (Watts/m^2) for new construction or significant renovation. Since May 2011, 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.
- The **Commercial Building Disclosure (CBD) Scheme** (Australia) requires premises, above a certain size, to disclose a National Australian Built Environment Rating System (NABERS) rating and the results of a tenancy lighting assessment, when being offered for sale or lease. The tenancy lighting assessment measures the power density of the installed general lighting system and can also include proposed lighting systems. The lighting provisions came into force in November 2011 (see the CBD website (www.cbd.gov.au) for more information). NABERS has been adopted on a voluntary basis in New Zealand.
- **Energy savings certificate (incentive) schemes** exist in NSW, Victoria, South Australia and the ACT, with dedicated initiatives aimed at lighting efficiency upgrades for both residential and commercial buildings.
- The **Smarter Choice program** established by the Victorian Government has information available in over 500 partnering stores to help compare the running costs and environmental performance of appliances. This program promotes the use of CFLs and LEDs through their website and also point of sale (POS) material.
- The **New Zealand Building Code** provides minimum standards for lighting efficiency in commercial and other non-residential buildings, including natural and artificial lighting levels.
- In New Zealand the **Energywise website** is a detailed web-based informational tool for efficient lighting aimed at removing informational barriers for households. The **Energy Efficiency and Conservation Authority business website** is focused on commercial and road lighting. These websites include calculators, tabulated information and extensive guidance on lighting performance and choices. EECA has also encouraged households to switch to energy efficient lighting through the RightLight information campaign, with TV advertising (the Energy spot) and retail promotions.

- **Commercial project grants** (EECA) provide grants for installation of efficient lighting and lighting controls in commercial buildings in New Zealand.
- **Commercial Building ratings** (New Zealand) – the Green Star rating tool was developed to evaluate environmental performance (including lighting energy efficiency) of commercial buildings and provides for verification of environmental impact reduction.
- The **ENERGY STAR** program in New Zealand provides endorsement labelling for high efficiency CFLs and LED lamps.

6.4 Issues Encountered During MEPS Program to Date

Several issues have been encountered during the implementation of MEPS since they were introduced in 2009 and are discussed below. An initial review of AS 4924 and AS/NZS 4847 by a technical committee has also flagged a number of other issues for review in the current versions of these standards. These other issues may be opportunities to improve the current MEPS and possible solutions are discussed in Chapter 8.

6.4.1 Rated Versus Tested Lamp Performance

One of the key issues discovered during the implementation of MEPS was that rated values for lamp power and light output can vary from actual (tested) values. This is thought to be a result of the IEC standards which allow an 8-15% variation (depending on lamp type) for rated lamp power and lamp light output versus measured values. These allowances can combine to allow for a very significant difference between rated efficacy and measured efficacy. Note that this issue does not affect MEPS directly, which is couched in terms of measured values. However, the significant differences between rated and actual efficacy, which were unexpected, were the cause of MV halogen lamps not being able to meet the initial MEPS efficacy level when tested (discussed below). Rated values that differ significantly from actual performance may impact upon consumer benefits in terms of energy consumption or in terms of the quality and suitability of the product.

6.4.2 MV Halogen Non-Reflector Lamp Performance

Revisions were required to adjust the original MEPS level to a more practical 95% of the general efficacy level for MV halogen non-reflector lamps. Lamp performance measured in 2008 was considerably less than claimed and given the Australian MEPS requirements do not generally allow for tolerances (apart from test lab tolerances applied to compliance check testing) unlike the EU, the lamps would not have been compliant. While there may be some options to further increase halogen lamp efficacy – for example, the inclusion of a step-down power supply to reduce filament voltage to a level where a more efficient filament can be employed, the global lighting industry has stated that no more investment will occur in halogen technology due to the emergence of new lighting technology such as CFLs and LEDs. Recent check testing indicates that MV halogen non-reflector lamps still require a relaxed MEPS level but these results do not align with product registration data indicating a significant portion of the market may now be able to meet the original MEPS efficacy requirement (Figure 13).

6.4.3 MV Halogen Reflector Lamp Performance

Despite industry optimism early during the development of the MEPS program, no MV halogen reflector lamps have emerged that are able to meet the MEPS requirement. MV halogen reflector lamps are less efficient than non-reflector equivalents, because the reflector absorbs some of the light, thereby reducing net lamp efficacy. Unlike MV halogen omnidirectional lamps, it is not possible to impose a minimum efficacy level that will deliver energy savings by removing less efficient tungsten filament reflector lamps, as there is little difference between the efficacy of tungsten filament and MV halogen reflector lamps (source: discussions with industry).

6.4.4 Halogen Lamps with Same Power as Incandescent Lamps

Figure 23 shows two MEPS-compliant halogen lamps that were sold on the Australian market. By marketing a halogen lamp of the same wattage as a standard tungsten filament lamp, the 60 W halogen lamp on the left is likely to have extracted increased efficacy as increased light output (rated 924 lumens), whereas the 42 W lamp on the right has extracted this as reduced lamp power (rated 592 lumens). The latter is favoured as the former will not result in energy savings, instead potentially resulting in overlit rooms if consumers mistakenly replace like with like based on lamp wattage.

Proliferation of these types of lamps has the potential to significantly undermine the energy savings of the MEPS program.

Figure 23 – Australian MEPS-compliant 42 W and 60 W lamps

6.4.5 Equivalency of Energy Efficient Lamps for Consumers

When incandescent lamps dominated the market, consumers were able to select replacement lamps based on power (Watts), and the market supplied standard omnidirectional lamps in a limited range of wattages (25, 40, 60, 75, 100). The diversification of the market has meant that lamp wattage is no longer a simple guide for selection of replacement lamps. Not only do halogen, compact fluorescent and now LED lamps each have a different range of power use, in the case of compact fluorescent and LED lamps, wattage is also not necessarily a reliable guide to light output. For example, in the case of LED lighting, luminous flux can vary up to 150 lumens between products with the same rated power consumption.

It has been suggested that a transition to selecting lamps based on luminous flux be encouraged as it refers to the actual lighting service being provided. However this has an added difficulty that luminous flux is a larger number than the Watts, and that each product will vary in the actual lumen output if it is precisely reported on the packaging. Thus it may be harder for a consumer to select with confidence a replacement lamp when the previous lamp was 712 lumens and available replacement lamps may be, for example, 695, 720 and 705 lumens. Market surveys have also indicated that some consumers confuse watts and lumens. A strategy could be developed to assist consumers' appreciation of the sensitivity of lumens to resulting lighting effect.

6.4.6 Halogen Lamp Package Savings Claims

Energy savings claims made on some halogen lamp packaging appear to be based on a comparison with tungsten filament incandescent lamps that are no longer available in the Australian market as they do not meet MEPS requirements. This matter has been raised recently with the Australian Competition and Consumer Commission who have advised that '… in some circumstances, energy efficiency comparisons made between halogen lamps and tungsten filament lamps which are no longer on the market, may be considered false, misleading or deceptive and in contravention of sections 18 and 29 of the Australian Consumer Law. Whether the representation is false, misleading or deceptive will depend on several factors, including the nature of the specific representation, the appropriateness and validity of the claim made and the overall impression the representation creates to the ordinary consumer'.

The ACCC has contacted Lighting Council Australia about this matter and Lighting Council Australia has responded that it is now the '… policy of Lighting Council Australia that comparisons on packaging and other material between the lamp being offered for sale to those which have been phased-out by regulation are no longer appropriate, unless it is clear that the lamp style being compared to is no longer offered for sale. Comparisons for safety purposes to avoid over lamping a luminaire are an exception'.

Advice from the ACCC on this matter has now also been circulated to all registrants of halogen lamps registered under the Australian Greenhouse and Energy Minimum Standards Act 2012.

6.4.7 AS 4934.2 Scope

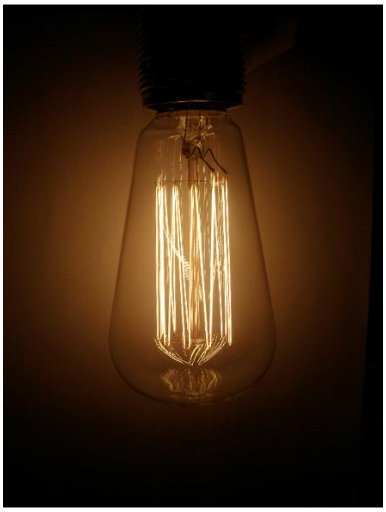
Some incandescent/halogen lamps are specifically excluded from the MEPS scope, or not included in the overall definition of incandescent/halogen lamps within AS 4934.2, as more efficient alternative lamps were not available at the time of the implementation of MEPS in 2009. Excluded lamps are coloured lamps, automotive lamps and special purpose lamps. Special purpose lamps are defined as follows:

- Lamps intended for traffic signals as outlined in AS 4113.1:1993
- Very long life lamps intended for air or sea navigation purpose
- Lamps with a temperature rating greater than 300 degrees Celsius intended for use in ovens
- Infra-red lamps
- Reinforced construction (rough use or vibration) lamps.

In reviewing the MEPS it is appropriate to consider whether these exclusions are still required. The standards technical working group considered it was now possible to include rough use and carbon filament lamps within the scope of the standard, as energy efficient alternatives have become available for these applications. For rough use lamps used in areas subject to vibration, a range of halogen and LED lamps are now available as a replacement.

Decorative carbon filament lamps (old-style tungsten; Figure 24) are currently omitted in the scope of AS 4934.2 and the GEMS determination. These inefficient lamps (and similar look-alike tungsten filament versions) have become popular in cafes and as a decorative feature light in the residential sector. Decorative LED lamps are becoming available that provide point source or filament style lines of light in clear bulbs. It should be considered if carbon filament lamps remain excluded from MEPS – note that many are 25 W and thus outside the MEPS scope of "> 25 W".

Figure 24 – Old style tungsten / carbon filament (left) alongside LED equivalent (right)



Coloured lamps are also excluded from AS 4934.2 and it is considered that a clearer definition may be required to avoid confusion. Coloured lamps are intended to mean monochromatic lamps often known as 'party lamps' that are not designed for general purpose illumination however some lamp suppliers have mistakenly interpreted this to also include tinted or painted lamps.

Other issues regarding the AS 4934.2 scope which may be reviewed are:

- The number of lamp categories, which were necessary due to the staged approach of introducing MEPS but may no longer be required.
- Inclusion of candle, fancy round and decorative tungsten filament lamps less than 25 W (the EU already apply MEPS to lamps above 7 W and may reduce this further in the future).
- Inclusion of pilot lamps.
- Removal of the current scope limit of 150 W which is currently applied to tungsten filament GLS lamps. Note that the lamp cap description in the scope will effectively limit the scope to 150 W.

6.4.8 Health Related Issues

During the implementation of MEPS, a number of health concerns were raised by members of the public, particularly those suffering from specific health conditions related to photosensitivity, UV and lamp flickering. By evaluating these concerns and consulting with various affected persons, the lighting industry and the medical community, it was agreed to provide a range of educational materials related to health issues, as well as to test various lamps for levels of UV radiation.

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) has also assisted in testing the UV radiation and visible light emissions from a range of CFLs as well as incandescent and halogen lamps retailing in Australia (see the ARPANSA website (www.arpansa.gov.au/radiationprotection/factsheets/is_CFL.cfm) for more information). Of the tested lamps, those with the highest UV levels measured at a distance of 10 centimetres over a period of 8 hours was equivalent to spending approximately 6 minutes in the midday summer sunshine in Brisbane and 7 minutes in Melbourne. The study found that UV emissions from all lamps decreased rapidly with distance.

As a result of testing for UV, it was identified that many double envelope CFL lamps emitted no more UV radiation than standard tungsten filament lamps. A range of these products submitted by industry were tested and the low UV lamps were listed by Lighting Council Australia on their website. Information regarding a range of health concerns related to lighting is provided on the Department of Industry and Energy Rating websites.

AS/NZS 4847.2:2010 currently notes the possible future inclusion of UV levels in the standards and the need for UV levels should be considered as part of this review.

6.4.9 Sales of Halogen Lamps over CFLs

Despite CFLs (and LEDs) representing a superior economic choice, sales of halogen lamps have continued to be significant and a new range of MV omnidirectional halogen lamps has emerged as an alternative to CFLs as tungsten filament lamps were phased out. While somewhat more efficient than incandescent lamps, the ongoing use of halogen lamps is a lost opportunity with respect to savings that could otherwise be made with a full transition to CFL and LED lamps.

6.4.10 Stockpiling

Although this problem has not been encountered in Australia to date, other countries have experienced significant levels of consumer stockpiling prior to implementation of MEPS (Austria for example, see Chapter 7). This may have been avoided in Australia through the implementation of an import prohibition in advance of MEPS, provision of POS education material, as well as engagement of the entire lamp supply chain in the planning of the phase-out and implementation of MEPS. Monitoring of the market in advance of and during implementation of MEPS is also seen as an important measure.

7 International Developments

7.1 Voluntary Programs

There are many "endorsement label" programs around the world, aimed at promoting the most efficient products. Examples include ENERGY STAR (US), Ecolabel (EU), as well as numerous voluntary energy efficiency endorsement labels operated by governments (e.g. India, Korea, Japan, Mexico, China, UK).

The ENERGY STAR program is now considered international and operates in New Zealand (although it is ultimately controlled by the US EPA and US Department of Energy). This program promotes industry best practice and it is strategically significant. It uses an endorsement mark to identify models certified to meet the ENERGY STAR specification, which provides an independent verification of energy performance and quality for consumers. New Zealand currently uses ENERGY STAR for CFLs and LEDs. At the time of writing, 52 CFL models, 5 LED lamps and 87 LED luminaire models were certified.

In New Zealand, ENERGY STAR CFLs must comply with AS/NZS 4847.2 and meet additional eligibility requirements for minimum efficacy, lamp life, minimum switching withstand and warranty period (see Table 8). The ENERGY STAR LED specification is undergoing further development - currently, products must comply with the US ENERGY STAR specification, with some modifications applied to suit New Zealand (allowable lamp bases and operating voltage).

Table 8 – Additional ENERGY STAR eligibility requirements for CFLs in New Zealand

Parameter	Requirements
Minimum efficacy in lm/W (bare lamps)	$\eta \geq \dfrac{1.15}{\frac{0.24}{\sqrt{F}} + 0.0103}$ Where F = initial luminous flux in lumens
Minimum efficacy in lm/W (covered lamps)	$\eta \geq \dfrac{1.04}{\frac{0.24}{\sqrt{F}} + 0.0103}$ Where F = initial luminous flux in lumens
Minimum efficacy in lm/W (reflector lamps)	$\eta \geq \dfrac{0.868}{\frac{0.24}{\sqrt{F}} + 0.0103}$ Where F = initial luminous flux in lumens
Lamp life	≥ 8000 hours
Minimum switching withstand	Lamps shall survive a rapid switching test of 3000
Warranty period	2 years

ENERGY STAR is a voluntary program and addresses energy performance only at the upper end of the market. Thus it is considered a useful addition to regulations such as MEPS, which is very effective for removing inefficient products. It is also a useful alternative to mandatory standards in a policy environment where choice based measures are favoured.

7.2 Mandatory Programs

Around the world, many countries have chosen to implement a mandatory phase-out of incandescent lamps.

The phase-out policies of a number of relevant countries are summarised in the following sections. The US has been examined, along with countries with similar mains voltage to Australia (220-240 V) noting that lamp voltage affects the theoretical efficacy of incandescent and halogen lamps. Incandescent and halogen lamps operated at 120 V allow the filament to exhibit higher efficacies (typically around 2 lumens/Watt higher; IEA 2011). This is because lower filament voltage results in higher filament current, producing more heat and (counter-intuitively) higher efficacy (although still much lower than CFLs and LEDs). Further information on international programs can be found in Appendix A.

7.2.1 European Union

The EU has adopted two key regulations with respect to residential lamps:

- Commission Regulation (EC) No 244/2009 of 18 March 2009 - requirements for non-directional household lamps.
- Commission Regulation EC No 1194/2012 of 12 December 2012 - requirements for directional lamps, LED lamps and related equipment.

These regulations are summarised in Appendix A. Note that one of the key differences between Australian/New Zealand lamp MEPS and the EU is that the EU phrases MEPS in terms of rated lamp values.

EC No 244/2009 is set out in 6 stages and applies to non-directional incandescent, halogen and compact fluorescent lamps. Requirements for the first 4 stages have eliminated low-efficacy lamps, such that all general purpose incandescent lamps should have been phased-out from the EU market by 1 September 2012. Stage 5 (from 1 September 2013) specifies minimum functionality requirements including minimum rated lamp lifetime, lumen maintenance, number of switching cycles, starting time, heat-up time, premature failure rate, UVA+UVB radiation, UVC radiation, lamp power factor and colour rendering index.

Stage 6 (to apply from 1 September 2016 although this was under review at the time of writing) sets more stringent efficacy requirements for halogen lamps – specifically, an efficacy increase of 25% (corresponding to the lower limit value of the 'B' energy class) for two types of clear lamps:

- Low voltage non-directional halogen lamps
- Mains voltage non-directional halogen lamps, excluding G9 and R7s.

Although this is not as stringent as already applies to CFL and LED lamps, this would effectively remove these halogen lamp categories from the market as they would not be able to comply with the new efficacy requirements.

Product information requirements for lamp packaging are also specified in EC 244/2009, including mercury content and the website to consult if accidental lamp breakage (for mercury-containing lamps), and constraints on the use of the term 'energy saving' or similar statements.

EC No 1194/2012 establishes an energy efficiency index (EEI) for directional and LED lamps and specifies the maximum allowable EEI for MV filament lamps, other filament lamps, high intensity discharge lamps and other lamps for each Stage (1-3). Functionality and product informational requirements are also given for lamps and control gear.

In addition to reviewing the EU stage 6 requirements, the European Commission has published a report (EC 2013) flagging the following for examination (currently underway):

- Significant energy savings are technically feasible through setting targets that are ultimately at the energy label level A+ in 2020/2021. This would phase out CFLs and halogen technology and implies that from 2020/2021 the non-directional lamp technology would be based on LEDs (and possibly organic LEDs at a later stage).
- If LED lamps meet current industry projections for 2020, the payback period of the average LED lamp with respect of cheaper alternative of a mains voltage halogen lamp will be around 1.5 years at the mentioned target level.
- A possible reduction in the number of lighting categories currently exempted from MEPS. This includes (but is not restricted to) the estimated 16 million "shockproof" lamps that are sold in the EU per year (these are exempt from MEPS) that are being sold for general lighting services which is not the intended purpose of the exemption.
- It is understood that further issues such as the current application of tolerances to MEPS compliance may also be examined.

7.2.2 United States

The US regulates non-reflector and reflector incandescent and halogen lamps, and CFLs. The regulations are summarised below and discussed in more detail in Appendix A. It should be noted that the US operates on a different voltage to Australia and therefore the specific requirements and efficacy achievable for some product differ.

Non-reflector incandescent/halogen lamps

The Department of Energy (DOE) has regulatory provisions through the Energy Independence and Security Act 2007 (EISA), stipulating that from 2012 manufacturers are required to comply with the US energy conservation standards for general service incandescent lamps (GSILs). Most of these lamps, traditionally sold as 40, 60, 75, or 100 watt lamps, are to be replaced by more efficient, lower wattage lamps, phased in over a period from 2012-14 beginning with 100 W lamps in January 2012 and ending with 40 W lamps in January 2014.

GSILs must meet the energy conservation standards specified in the Code of Federal Regulations, with a minimum colour rendering index (CRI), maximum wattage and minimum lifetime.

DOE will initiate another cycle of rulemaking in 2014 to consider a broader standard for general service lamps, which includes GSILs, CFLs, general service LED lamps, organic LED (OLED) lamps and any other lamps determined to satisfy lighting applications traditionally served by GSILs. The EISA includes a commitment to reach 45 lm/W average during this rulemaking – to come into force by 2020.

Incandescent/halogen reflector lamps

The US has regulated the energy efficiency level of incandescent reflector lamps (IRLs) since 1992. These include shapes such as R, PAR, ER, BR, BPAR, or similar with an E26 medium screw base. Energy conservation standards specified in the Code of Federal Regulations (CFR) include rated lamp wattage, lamp diameter, rated voltage and minimum average lamp efficacy. The test procedure is specified in 10 CFR 430.23 (r) (available from the US Government Printing Office (www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3).

Compact fluorescent lamps

The US has regulated the energy efficiency level of CFLs since 2005. The Energy Policy Act of 2005 (EP Act 2005) amended the Energy Policy and Conservation Act of 1975 (EPCA), setting energy conservation standards for E26 medium base CFLs.

7.2.3 China

A joint announcement by a number of Chinese government ministries and agencies in March 2012 stated that under the Energy Conservation Law of the People's Republic of China, the government would ban the import and domestic sales of incandescent GLS lamps after 1 October 2012.

The products to be phased-out were identified as tungsten incandescent GLS lamps (non-halogen) with nominal voltage of 220-250 V, used within households and similar general service lighting applications. The phasing out schedule is as follows:

- October 2012: Banning of the sale and import of tungsten incandescent lamps for general lighting applications with input power equal to, or higher than, 100W.
- October 2014: Banning of the sale and import of tungsten incandescent lamps for general lighting applications with input power equal to, or higher than, 60W.
- October 2015 to 30 September 2016: Interim review of implementation and revision of policy as necessary.
- October 2016: Banning of the sale and import of tungsten incandescent lamps for general lighting applications with input power equal to, or higher than, 15W.

The ban does not currently extend to the manufacture and export of these lamps. Excluded from the phase-out scope were reflector incandescent lamps and incandescent lamps for special lighting applications, such as scientific research, medical treatment, trains, shipping, aircraft, traffic vehicles, household appliances, etc.

7.2.4 Discussion of Lighting Efficiency Developments in Other Countries

This section discusses some interesting developments that have occurred in economies that are implementing policies to phase out incandescent lamps. The bulk of this analysis has been drawn from the IEA 4E Benchmarking Report - Impact of 'Phase-Out' Regulations on Lighting Markets (IEA 2011).

Despite the large variety of sizes, shapes, colours, caps, etc., lamps are the most globally traded energy consuming product. As a product group, lamps have the least technical difficulty in complying with local cultural and technical requirements, because of the vast range of products available on the market.

Many countries have introduced lighting efficacy requirements in an effort to save energy and reduce emissions by removing inefficient incandescent lamps from the market. As in Australia, regulations in Austria, Canada, Denmark, France, Republic of Korea, UK and the USA are not technology-specific, but rather quantitative performance standards that will effectively ban most traditional incandescent lamps. All these international regulations are being phased in over time and have exclusions for incandescent lamps of specific types for which feasible, more efficient alternatives do not exist.

Key differences in the approaches taken by countries include:

- Variation in the regulatory approach to performance levels, with indications that regulations based on a continuous and smooth efficacy curve (such as Australian MEPS) rather than discrete stepped function, are likely to yield higher energy savings and reduce a number of risks to policy implementation.
- Major differences in the stringency at which the required performance levels are set, and the associated phasing or speed at which the required actions come into force, such that not all potential savings are likely to be captured in all markets.
- Significant variation in the range of light outputs and products included in the regulations, meaning some markets may not be capturing all the potential savings.
- Significant variation in products exempted or requiring lower performance levels, increasing risks to policy success and potentially leaving consumers with lower performing products.

While there is no evidence to date that such differences are adversely affecting individual markets, they do have the potential to lead to substantial variation in policy outcomes, with some countries/regions attaining significantly higher efficiency and performance levels of installed lamps compared with those installed elsewhere.

At the international level, since 2006 Australia has been actively promoting a more harmonised approach to lighting performance requirements. In 2014, Australia put a proposal to the IEC TC34 (lighting standards committee) for tiered performance levels to be included in an optional technical specification for self-ballasted compact fluorescent lamps in order to enable a more harmonised approach to performance requirements. Despite significant support for this proposal in the Asia Pacific region, this proposal was not successful in a vote by TC34 in May 2014.

Evidence suggests that regulatory frameworks to remove less efficient lamps from the market are proving successful in Korea and the UK. According to the IEA 2011 Benchmarking Report - Impact of 'Phase-Out' Regulations on Lighting Markets, the average efficacy of lamp sales in these countries rose by up to 50% in 3 years, despite most recent policies not yet having been completely implemented. However analysis underway for the next edition of this benchmarking report indicates that in the UK at least some of these savings may have been temporary and in part more attributable to some lamp give-away schemes (Jeffcott Pers. Com.).

Korea had a remarkable average efficacy of all lamp sales of 45 lm/W in 2009. In 2011, this efficacy level was twice as high as any other country or region that had seen any policy impact at the time, and around three times better than countries such as Canada, the USA and Australia. The strong performance by Korea is likely due to the extended period in which Korea has been regulating less efficient lamps (beginning in 2003) and the regular revisions of those requirements. These revisions are currently planned to culminate in a fourth generation of regulation that comes into force in 2014. The requirement on smaller lamps imposed by these regulations will be among the most stringent in the world. The requirement for 2014 was set during the preceding 2009-2012 regulation phase-in period, suggesting that regular and well signposted regulatory revision of the lighting market is highly successful.

Significant delays between the date of announcement and the date at which regulations come into force may result in a short to medium term market effect completely at odds with the intention of the policy action. For example, Austria, which has one of the highest historical levels of incandescent lamps in the world, experienced a strong consumer backlash against the impending removal of inefficient lighting. Consumer stockpiling gave rise to a doubling of incandescent lamp sales in the year prior to regulations taking effect. This outcome is counteractive to the intent of the policy and will slow its ultimate impact, as stockpiled inefficient lamps will be put into service at a later date.

Such a situation appears to have been avoided in the UK. A voluntary agreement with major retailers to remove the most inefficient products from sale prior to implementation of the mandatory EU regulation removed the opportunity for consumers to stockpile less efficient products.

A balance needs to be struck between allowing time for the supply side of the market to respond, and the potential adverse consumer reaction delaying the ultimate policy impact well beyond the actual date of policy introduction. This balance may be very different from that for other regulated products such as appliances due to the low cost, consumable nature of lighting products. If delay is unavoidable, then policy makers should consider mitigation strategies similar to those employed in the UK and Australia (import restriction in advance of sales restrictions).

Another impact of phase-out regulations is that the total number of lighting products sold is likely to decrease dramatically, particularly in markets which currently have low penetrations of CFLs (or LEDs) and where these products are adopted rapidly. However, a fall in sales should be noticeable in all markets where regulations cause the substitution of short lifetime, inefficient lamps with more efficient, longer life alternatives.

While many countries are making the transition to efficient lighting, it would appear that incandescent lamp production is currently continuing. China is still making approximately 4 billion incandescent lamps per year – about 30% of world production. Although the Chinese domestic phase-out of inefficient lighting is already underway, this currently does not extend to similar restrictions on the export of these lamps to other markets.

8 Discussion of Policy Options

There is a range of potential policy options to improve the efficiency and/or performance of CFLs, incandescent and halogen lamps, from increasing the mandatory MEPS levels, to providing customers with more effective energy efficiency and energy use information. These options are explored below - note that multiple options could be implemented in parallel. Policy options investigated in a RIS would be subject to further consultation and approval in both Australia and New Zealand.

8.1 No Action (Business as Usual)

This scenario assumes no changes to current policy. The incandescent, halogen and compact fluorescent lamp markets would continue to operate as they do now, with those lamps in scope required to meet MEPS. It is likely that some halogen and CFL lamps would be replaced by emerging LED technology as part of business as usual, however the extent of this voluntary transition is unknown and recent history with halogen and CFL alternatives indicate it would not be complete, thereby missing significant savings opportunities.

8.2 Increase MEPS Stringency

In Chapter 5 a number of opportunities were identified with the potential for significant energy savings. These are further discussed below. Potential costs and benefits are also assessed in section 8.9.

Under New Zealand's existing policy settings, MEPS would only be considered where it does not risk eliminating a lighting technology from the New Zealand market (as is the case with the existing MEPS for CFLs).

8.2.1 MEPS for MV Incandescent / Halogen Lamps in Australia

For MV non-directional lamps above 25 W, the transition away from tungsten incandescent lamps is effectively complete in Australia, with MEPS considered a significant driver of this transition. In New Zealand there has been a government decision to promote customer choice rather than removing incandescent lamps from the market. This has resulted in a decline in sales of incandescent lamps, and an increase in sales of CFLs. In this way a more gradual transition is being achieved.

As discussed previously, there is currently limited potential to increase the efficacy of halogen lamps on the market, without significant investment in the commercial development of lamps such as those with a voltage converter in the base of the lamp (refer section 3.2 for discussion of efficacy benefits of lower voltage). This type of technology was trialled by the lighting industry in Europe and was met with limited success due to increased product cost, whilst only achieving moderate efficiency improvements (i.e. significantly lower than those of CFLs and LEDs). Registration data (Figure 13) does suggest that MV halogen lamps could now be subject to the full incandescent MEPS level, however recent check testing showed that the sample of products tested still fell below the full MEPS level. The discrepancy will require further investigation.

For MV directional lamps, the phasing out of incandescent reflector lamps in Australia has been delayed due to the inability of lamps to meet the MEPS specification (refer section 6.4 for background). The lighting industry has informed Government that there is very little difference in efficacy between an incandescent and a halogen reflector lamp.

In effect, with current incandescent/halogen technology, there is little further opportunity to increase efficacy and realise energy savings whilst retaining these types of products in the market. The following options are not all mutually exclusive:

1. *Option: adopt permanently the current 5% reduction in MEPS efficacy for MV halogen non-directional lamps in Australia.*
2. *Option: apply the full incandescent MEPS efficacy for MV halogen non-directional lamps in Australia.*
3. *Option: abandon MEPS for MV directional lamps in Australia.*
4. *Option: where effective and efficient alternative products are available at a reasonable cost, increase MEPS for incandescent/halogen lamps in Australia to a level that would result in the removal of these products from the market (assessed further in section 8.3).*

8.2.2 MEPS for ELV halogen lamps

Australian MEPS for ELV halogen reflector lamps results in MR16 lamps being required to be either IRC or very high quality halogen lamps. There is a similar opportunity for energy savings if such a transition were to be made in New Zealand. Non-reflector (capsule) lamps comply with existing MEPS and are not a particularly significant part of the market and are most commonly used in products such as desk lamps - these are not considered further.

5. *Option: introduce MEPS for ELV halogen lamps in New Zealand (including 37W limit), providing that equivalent ELV halogen lamps are available as like-for-like replacements for products that exceed the MEPS threshold.*
6. *Option: where effective and efficient alternative products are available at a reasonable cost, increase MEPS for ELV halogen lamps in Australia to a level that would result in the removal of these products from the market (assessed further in section 8.3).*

8.2.3 MEPS for CFLs

The current efficacy requirement for CFLs is based on the EU lamp label classification “A” which is approaching 20 years old. As can be seen in Figure 16, there is potential to increase the MEPS efficacy requirement for CFLs. Testing conducted for the Australian Government also shows that MEPS requirements for some other parameters could also be tightened (see also section 8.5.2).

7. *Option: increase the stringency of MEPS for CFLs in Australia and New Zealand.*

8.2.4 Consider Aligning MEPS Levels (or Parts Thereof) with the European Union

One option would be alignment of Australian and New Zealand MEPS levels with the EU. Table 9 and Table 10 below compare the key aspects of MEPS for non-directional incandescent/halogen lamps and CFLs (note that it may also be possible to align LED requirements – refer to the LED Product Profile when published).

Note in Table 9 that some of the parameters in the lower half of the table are not particularly relevant to mainstream incandescent and halogen lamps - these have likely been included in the EU MEPS for unusual lamp types such as those with a power supply in the base. Inclusion of less relevant parameters in MEPS may potentially increase testing and compliance costs. Some of these requirements may also be made more stringent in the EU by 2016 or 2020.

Table 9 – Comparison of Australian non-directional incandescent/halogen MEPS with current EU requirements

Parameter	Current Australian MEPS	Current EU MEPS	Comparison
Minimum initial efficacy (lm/W)	$0.95 \times (2.8 \ln(L) - 4.0)$	$P_{max} \leq 0.8 \times (0.88\sqrt{L} + 0.049L)$	After taking into account that EU MEPS stated in terms of rated values, the Australian and EU MEPS vary by less than 0.5 lm/W (EU slightly more stringent) meaning that lamps which pass EU MEPS automatically pass Australian MEPS)
Minimum life (hours)	2000	2000	Same
Minimum lumen maintenance	80% at 75% life	85% at 75% life	EU more stringent
Number of switching cycles before failure	-	≥ four times the rated lamp lifetime expressed in hours	EU more stringent
Starting time	-	< 0.2s	EU more stringent
Lamp warm-up time to 60%	-	< 1.0s	EU more stringent
Premature failure rate	-	≤ 5.0% at 200h	EU more stringent
UVA + UVB radiation	-	≤ 2.0 mW/klm	EU more stringent
UVC radiation	-	≤ 0.01 mW/klm	EU more stringent
Lamp power factor	-	≥ 0.95	EU more stringent

Table 10 – Comparison of Australian/NZ CFL MEPS with EU requirements

Parameter	Current Australian/NZ MEPS	Current EU MEPS	Comparison
Maximum starting time (seconds)	2.0	1.5 if P<10 W 1.0 if P≥10 W	EU more stringent
Maximum run-up time (seconds)	60	40 (100 for amalgam lamps)	EU less stringent for amalgam (most lamps now amalgam)
Minimum efficacy in lm/W (bare lamps)	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	Same
Minimum lumen maintenance	2000 hrs = 0.88 5000 hrs = 0.80	2000 hrs = 0.88 7000 hrs = 0.70	Approximately same
Maximum premature lamp failure rate	10% at 30% of rated life	2% at 400h	Cannot compare
Minimum life (hours)	0.5 survival factor at 6000h	0.7 survival factor at 6000h	EU more stringent
Minimum True Power factor	0.55	0.55 if P < 25 W 0.90 if P ≥ 25 W	Same except for ≥25W lamps
Colour appearance	≤ 5 SDCM	-	EU less stringent
Minimum colour rendering index (CRI)	80	80	Same
Maximum mercury content (mg)	5	<30 W: 2.5 mg <30 W with long lifetime (> 15 khrs): 3.5 mg ≥30 W and <150 W: 5 mg	EU more stringent
Minimum switching withstand	3000	≥ lamp lifetime expressed in hours ≥ 30,000 if lamp starting time > 0.3s	EU more stringent
UVA + UVB radiation	-	≤ 2.0 mW/klm	EU more stringent
UVC radiation	-	≤ 0.01 mW/klm	EU more stringent

For directional lamps, the EU state the efficacy requirement of MEPS in terms of a cone of “useful light” whereas the current Australian MEPS is stated in terms of light emitted in a 180° hemisphere (in recognition that the bulk of these lamps in Australia are used for general illumination). Adopting the EU “useful light” parameter would also require more expensive photometric test equipment (a goniophotometer) to measure and confirm compliance. This cost would be incurred by the manufacture/importer (for registration purposes) and by the regulatory authorities (for check testing purposes). It may be possible to align with EU requirements and “correct” for this definitional difference, although this would require detailed further investigation.

As mentioned previously, the EU is currently in the process of reviewing its MEPS, and it may be prudent to await the outcomes of this review if EU levels are to be adopted (implementation may not occur until 2016). In considering the EU reviewed approach, it should be noted that the timing and approach may be influenced by EU specific factors such as the presence of a lighting manufacturing industry in the EU, which are not relevant to Australia and New Zealand. Therefore opportunities for energy savings may be missed if the overall availability of efficient products in the Australian and New Zealand markets (usually not imported from the EU) are not also considered. It should also be noted that the current EU MEPS program for lamps states MEPS in terms of rated values, rather than tested values. This has caused some confusion (as tolerances between the two are allowable by IEC standards developed for type testing rather than regulation) and is not considered appropriate for the Australia / New Zealand system. It is understood that the application of tolerances to MEPS compliance may re-examined in the current review.

8. *Option: consider aligning Australian and New Zealand MEPS with the EU (or parts thereof) once EU MEPS reviews are complete.*

8.3 Achieve a Complete Transition to CFL/LED Technology

As discussed in Chapter 4, the Australian and New Zealand lamp market have undergone a significant shift away from tungsten incandescent lamps towards halogen and CFL technologies (although this is less significant in New Zealand due to the absence of MEPS regulation for incandescent and halogen lamps). In both countries, there are significant opportunities to further shift the market towards CFL and LED lamps.

A complete shift in the market from filament-based technologies to fluorescent and LED technologies would bring significantly higher lamp efficacies (50-100 lm/W compared to 10-20 lm/W) as well as increased lamp life and energy savings. Although it is expected that the market will make a natural shift towards LEDs over the next few years, the experience with CFLs has shown that there is a risk of a consumer backlash due to variation in quality, performance, lifetime, light output and inaccurate equivalency claims. These issues are currently addressed for CFLs by using MEPS that specify product quality and performance parameters in addition to efficacy and could be potentially addressed with a similar MEPS for LEDs. Some LED products sourced from the market have been tested indicating efficacy levels as low as filament lamps (LED MEPS are discussed in a separate Product Profile).

The question remains, however, as to whether a single MEPS should mandate efficacy levels that can only be met by LEDs and CFLs and phase out incandescent and halogen lamps from the market entirely. As discussed previously, the EU are currently investigating this type of approach.

For MV filament lamps, CFLs represent a relatively viable option, although three key problems remain – consumer acceptance (e.g. of colour properties, aesthetics and run-up time),compatibility with existing household dimmers and light fittings and concern by some consumers regarding disposal due to mercury content. LEDs are mostly superior in these regards, although LEDs have not quite matured to the point that they represent a viable, cost-effective option to replace MV filament lamps. However this is not likely to be far away – perhaps 2-3 years.

For ELV filament lamps, CFLs are not considered viable as replacement lamps, primarily due to their size and lack of beam control as directional lamps . LEDs are far superior, and anecdotally now represent a significant proportion of replacement MR16 lamp sales. Therefore, the phase-out of incandescent / halogen MR16 lamps could occur much earlier than it might for MV filament lamps. Compatibility with legacy electronic transformers and dimmers remains a problem, although this is improving. It is also the case that not all ELV LED lamps available are compatible with all light fittings. Non-directional ELV “capsule” lamps are probably too small a market segment at this stage, and LED technology is not as developed as it is for MR16 lamps.

In March 2014, CLASP submitted a Public Comment Document to the European Commission, regarding availability of alternatives to halogen lamps following Stage 6 of Regulation (EC) No 244/2009 (CLASP 2014). This document contains an assessment of the suitability of LEDS to fully replace incandescent and halogen lamps, and contains the following conclusions regarding lamp parameters:

- **Lumen output** of replacement LEDs. For most applications the lumen output of LEDs matches that of the halogens they would replace. LED lamp light output has been increasing as the efficacy of LEDs has been improving. The US market offers a 2200 lumen LED lamp that replaces a 135 W US (120 V) incandescent lamp; while the European market offers a 1520 lumen LED lamp that replaces a 115 W European (230 V) incandescent lamp. Further efficacy gains will continue to enable higher flux lamps at lower wattages, improving energy savings and reducing size and cost. It should also be noted that, in the small sections of the market where LED lumen output still does not match halogens, it may be possible to replace the halogen with a high-flux CFL (note: could also replace with fixtures using low wattage metal halide lamps).
- **Colour rendering index** of replacement LEDs. LED lamps, offer comparable lighting quality to halogen. LEDs today offer lamps with 96 CRI, and have shown a clear trend in improving colour quality. It should also be noted that CRI as a measure of the quality of light is not without its critics, and alternatives that offer better comparisons when LEDs are considered are available (e.g. Colour Quality Scale).
- **Dimmability**. Many users have grown used to being able to dim lights using a dimmer. CLASP analysis of the models collected indicates that “dimmable” LED replacement lamps can be found for the common base types (e.g., B22, E27, E14, B15). To a certain extent, the question of whether LED lamps are compatible with the existing dimmer stock, is to do with the quality of the dimmer circuit used in the LED lamp. Manufacturers of LEDs can choose to install e.g. intelligent LED drivers which can detect and adapt to an installed dimmer. Such Integrated Circuit (IC) solutions are being promoted by companies like Cirrus Logic, Marvell and iWatt since early 2012. It may be worth considering a requirement on manufacturers who market their products as

"dimmable" to incorporate intelligent adaptive LED drivers. It is not clear however that compatibility is currently available for all current lighting systems.

- **Lifetime**. The lifetime of LEDs already far out-lasts the lifetime of the halogen lamps they will replace, by a factor of 10 or more.
- **Starting time**. The starting time of LEDs can be slightly longer than halogens which are near instant on, but is much shorter than CFLs. For the lamp user, the experience of switching on an LED will be more like switching on a halogen lamp than a CFL.
- **True Power factor**. True Power factor (including harmonics) is less an issue for the lamp user, than for the electricity supplier, and the Danish Energy Agency has observed that the power factors available in the market today are reasonable for the wattages of replacements lamps of these applications. Indeed, there are no grid measurements giving evidence of a power factor problem in a grid supplying consumers with many CFLs and LEDs.
- **Size and weight**. LED products can be found that have the same length and diameter as halogen lamps in the common base types. LED retrofit lamps are heavier than halogen lamps, but they are becoming lighter as efficacy improves and heat management systems are scaled back. Manufacturers have an interest in reducing the weight of LEDs as this improves material resource efficiency and cost.

Careful consideration would need to be given to identifying any remaining uses of incandescent lamps that would require exemptions to be made.

9. *Options: with these things in mind, implement a two-pronged strategy:*
   a. *Require all new luminaires sold to be compatible with CFL or LED lamps. A regulatory or voluntary approach could be put in place to ensure or encourage that all new luminaires are fitted with MEPS-registered CFL or LED lamps when sold.*
   b. *MEPS levels be developed that will only be able to be met by more efficient lighting such as CFL and LED technology for both MV and ELV lamps, and implement these MEPS when (and if) LED technology has matured sufficiently. This would remove incandescent and halogen lamps from the market. MEPS can be staged, e.g. possibly in 2-3 years for MR16 lamps and 3-4 years for MV lamps. This may include the introduction of a performance MEPS for LED lamps (subject of another Product Profile). The most onerous task would be to determine the scope and timing for each lamp category. Note that removal of incandescent and halogen lamps from the market may not be supported by New Zealand.*

8.4 Address Issues Encountered During MEPS Program to Date

As discussed in section 6.4, a number of issues have been encountered in the MEPS program to date. A suggested approach to address each of the relevant issues is discussed below.

8.4.1 Rated Versus Tested Lamp Performance

Allowable tolerances between rated and actual values are dealt with in the marking requirements sections (of standards) for CFLs and incandescent / halogen lamps. These are currently being revised by the EL-041 standards committee, and should allow an appropriate level of tolerance between the market value and measured value. These tolerances will not however be taken into consideration when the lamp is tested for compliance with MEPS levels either for product registration or later check testing under the GEMS Act.

10. *Option: in the lamp MEPS standards, clarify an appropriate level of tolerance between the market value and measured value for use on product packaging.*

8.4.2 MV Halogen Lamps with Same Power as Incandescent Lamps

Figure 23 shows two MEPS-compliant halogen lamps that were sold on the Australian market. By marketing a halogen lamp of the same power as a standard tungsten filament lamp, the 60 W halogen lamp manifests the increased efficacy as increased light output, whereas the 42 W halogen lamp manifests the increased efficacy as reduced lamp power with similar light output.

One way to deal with this is to use MEPS to ensure that lamps are be required to be one of ~28 W, ~42 W, ~53 W, ~70 W, etc. (with appropriate tolerances). This would eliminate 60 W lamps such as appears in Figure 23. A similar approach has already been applied to MR16 lamps as a wattage limit.

11. *Option: a wattage limit for MV halogen lamps be discussed with industry, either as a voluntary agreement to eliminate any offending lamps or as MEPS and /or,*
12. *Option: require that wattage markings are made less prominent than lumens, with the adoption of simplified lumen ranges as outlined in 8.4.3 below.*
13. *Option: require a prominent statement of equivalency.*

8.4.3 Equivalency of Energy Efficient Lamps for Consumers

As noted in section 6.4.5, consumers are now faced with a variety of lighting alternatives that make selection of replacement lamps by wattage impractical, while the diverse range of lumen outputs available can be difficult for consumers to compare and understand. One option to address this issue may be the classification of lamps within a simplified range of luminous flux. A proposal by China is currently under consideration by the IEC TC34 Committee to amend IEC 62612 to state that for non-directional LED lamps, the rated luminous flux LED lamps be preferably one of the following values:

100lm, 150lm, 250lm, 350lm, 500lm, 800lm, 1000lm, 1500lm, 2000lm, 3000lm

For most consumers, only 6 of these values would be relevant (150 lumens or approximately 25 W tungsten filament, to 1500 lumens approximately 100 W tungsten filament). If this approach was to be taken on packaging in Australia and New Zealand, consideration would need to be given to requiring that the initial luminous flux of each individual LED lamp in the measured sample would be within a specified range around the particular level (for example, not less than the rated luminous flux by more than 10%, and not be more than the rated luminous flux by more than 20%). The allowance for variations in the rated luminous flux on packaging would not however extend to compliance for MEPS. Such a system could also could be applied to the full range of omnidirectional lamp types including compact fluorescent, LED and halogen lamps. It would also be beneficial to consumers for the lumens per Watt to be included on packaging. Consumer education material could be prepared to explain this approach, combined with guidance on lamp equivalency.

14. *Option: Guidance may be provided in the MEPS on a preferred range of rated luminous flux values to be used on lamp packaging, along with a requirement for lumens per Watt to be included on packaging.*

8.4.4 AS 4934.2 Scope

Rough use lamps and carbon filament lamps are currently not within the scope of AS 4934.2. Halogen, CFL and/or LED alternatives for these lamps have become available. Many of the carbon filament lamps (and tungsten filament lamps of similar style) available are 25 W and are outside the current scope of MEPS which applies to candle, fancy round and decorative lamps.

15. *Option: include rough use and carbon filament lamps in the scope of MEPS*
16. *Option: consider lowering or removing the current > 25W MEPS scope limit.*

There is confusion around the definition of “coloured lamps” which are also excluded from AS 4934.2. The exemption for coloured lamps is intended to mean monochromatic/ saturated colour lamps often known as ‘party lamps’ that are not designed for general purpose illumination. However, some lamp suppliers have mistakenly interpreted coloured lamps to also include tinted or painted lamps.

17. *Option: define coloured lamps to more clearly exclude tinted lamps and painted multi-coloured lamps, and differentiate from those that are specifically designed for non-general purpose illumination.*

There are several other changes to the scope that could be considered, including reducing categories of lamps, increasing the scope of MEPS for some products and applying watt limits.

18. *Option: reduce the number of categories of lamps in the scope, e.g. GLS tungsten filament shapes would include candle, fancy round and decorative (*Table 11*). Whilst the number of categories was necessary due to the staged approach of the introduction of lighting MEPS, these may no longer be*

required now that MEPS is in place (note that this would require the inclusion of candle, fancy round and decorative tungsten filament lamps < 25 W; see Option 19).

19. *Option: include candle, fancy round and decorative tungsten filament lamps less than 25 W within the scope of MEPS (effectively removing these products from the market). The availability of these lamps appears to have enabled a recent proliferation of decorative luminaires featuring inefficient filament lamps, often clustered to attain a similar lumen output (resulting in greater energy use) as banned incandescent lamps.*
20. *Option: include pilot lamps if effective and efficient alternatives are available.*
21. *Option: apply a limit of 150 W to the scope of all lamp categories (currently only applies to tungsten filament GLS lamps) for consistency. Note that this issue is effectively controlled by the lamp cap description in the standard, as high power lamps cannot use the lamp caps listed in the standard.*

Table 11 – Suggested re-categorisation of the AS 4934.2 incandescent and halogen lamp scope

Previous Categories	Suggested New Group	Shapes	Caps	Rated Voltage (V)	Rated Power (W)	Light Source
GLS tungsten filament Candle tungsten filament Fancy round tungsten filament Decorative lamps tungsten filament Mains voltage halogen non-reflector	Mains voltage non-directional. Note this would require removal of >25W requirement from Preface of standard	All	E14, E26, E27, B15, B22d, GU10	≥220	<150	Filament, Tungsten filament, Carbon filament, halogen
Mains voltage reflector (including halogen)	Mains voltage directional	All	E14, E26, E27, B15, B22d, GU10	>220	<150	Filament, Tungsten filament, Carbon filament, halogen
ELV halogen reflector	N/A	MR11-16	All	5-14	All	halogen
ELV halogen non-reflector	N/A	Capsule	All	5-14	All	halogen

8.5 Address Other Issues Identified in the Standards

As mentioned in Chapter 6, a number of other issues with AS 4934 and AS/NZS 4847 have been raised by the EL-41 standards and the technical committees. The range of issues and possible options to be considered that may address these issues are discussed below. In some cases where the issue is considered to be a technical requirement requiring clarification, or corrections of technical errors, these matters are being addressed through revisions to the relevant GEMS Act determination, but will still also require changes to the Standard itself.

8.5.1 AS/NZS 4847 and AS 4934

i. There is potential confusion of the use of the terms average, mean and median within the standards. Clear definitions of the terms are required. Confusion of the use of terms has been rectified in the recently published AS 4934.1 and will be clarified with the revised GEMS (Incandescent Lamps for General Lighting Services) determination. However, AS 4934.2 will need to be revised for consistency with the terms in Part 1 of the Standard. Clarification of the terms is required for AS/NZS 4847 and the relevant determination.

ii. Tolerances / uncertainties applied to test results and to MEPS requirements. As part of the change to the GEMS Act these will be removed from the relevant standard and specified in a regulatory determination.

iii. Confusion and duplication between lighting standards (e.g. definitions, labelling) and the effort required to maintain multiple standards. A single standard could be developed for incandescent, halogen and self-ballasted compact fluorescent lamps to address these issues. LEDs could also be included within the standard. Some aspects of product performance would be treated differently within the standard, i.e. it would not be “technology neutral” but all requirements would appear within one document and overlap treated efficiently.

iv. Use of IEC test methods where appropriate, such as those that have been developed since the publication of the Australian standards. For example, IEC 60969 for CFLs (publication due 2014) and IEC 60357 for incandescent and halogen lamps.

v. Review the marking requirements, including alignment of CFL and incandescent/halogen requirements, and inclusion of a requirement for packaging to specify efficacy.

vi. Alignment of lamp categories with Customs import categories known as Statistical Codes (as closely as possible – examples are listed below) or change / add to the Statistical Codes to suit the lamp categories within the standards. However, there is some overlap between customs categories (particularly for New Zealand) and these categories are changed from time to time.

- MV incandescent non-reflector: 8539220030 - Metal or carbon filament, gas filled or vacuum, non-reflector type lamps, of a power not exceeding 200 W and for a voltage exceeding 100 V (excluding tungsten halogen, ultra-violet, infra-red and sealed beam lamps).
- MV incandescent reflector: 8539220037 - Electric metal or carbon filament, gas filled or vacuum reflector type lamps, of a power not exceeding 200 W and for a voltage exceeding 100 V (excluding tungsten halogen, ultra-violet, infra-red and sealed beam lamps).
- MV halogen non-reflector: 8539210056 - Tungsten halogen filament lamps without reflector greater than 200V (excluding infra-red or ultra-violet).
- MV halogen reflector: 8539210052 - Tungsten halogen filament lamps with reflector-greater than 200 V (excluding ultra-violet or infra-red).
- CFL: 8539310043 - Fluorescent, hot cathode discharge lamps (including compact fluorescent discharge lamps and excluding straight type fluorescent discharge and ultra-violet lamps).
- ELV halogen non-reflector:
  - 8539210054 - Tungsten halogen filament lamps without reflector less than or equal to 13V other than for motor vehicles (excluding ultra-violet or infra-red).
  - 8539210055 - Tungsten halogen filament lamps without reflector greater than 13V but less than or equal to 200V (excluding ultra-violet or infra-red).
- ELV halogen reflector:
  - 8539210050 - Tungsten halogen filament lamps with reflector - less than or equal to 13 V (excluding ultra-violet or infra-red).
  - 8539210051 - Tungsten halogen filament lamps with reflector - greater than 13 V but less than or equal to 200 V.

8.5.2 AS/NZS 4847 (CFL Standard)

vii. Extend the scope of MEPS to include requirements for cold cathode CFLs. Given that cold cathode CFLs are primarily for commercial use, and are being usurped by LEDs, this is probably not required.

viii. Inclusion of a heavy switching category for CFLs. This would allow CFLs designed for "high switching" applications (e.g. bathrooms) to be verified by compliance with a voluntary section in the standard.

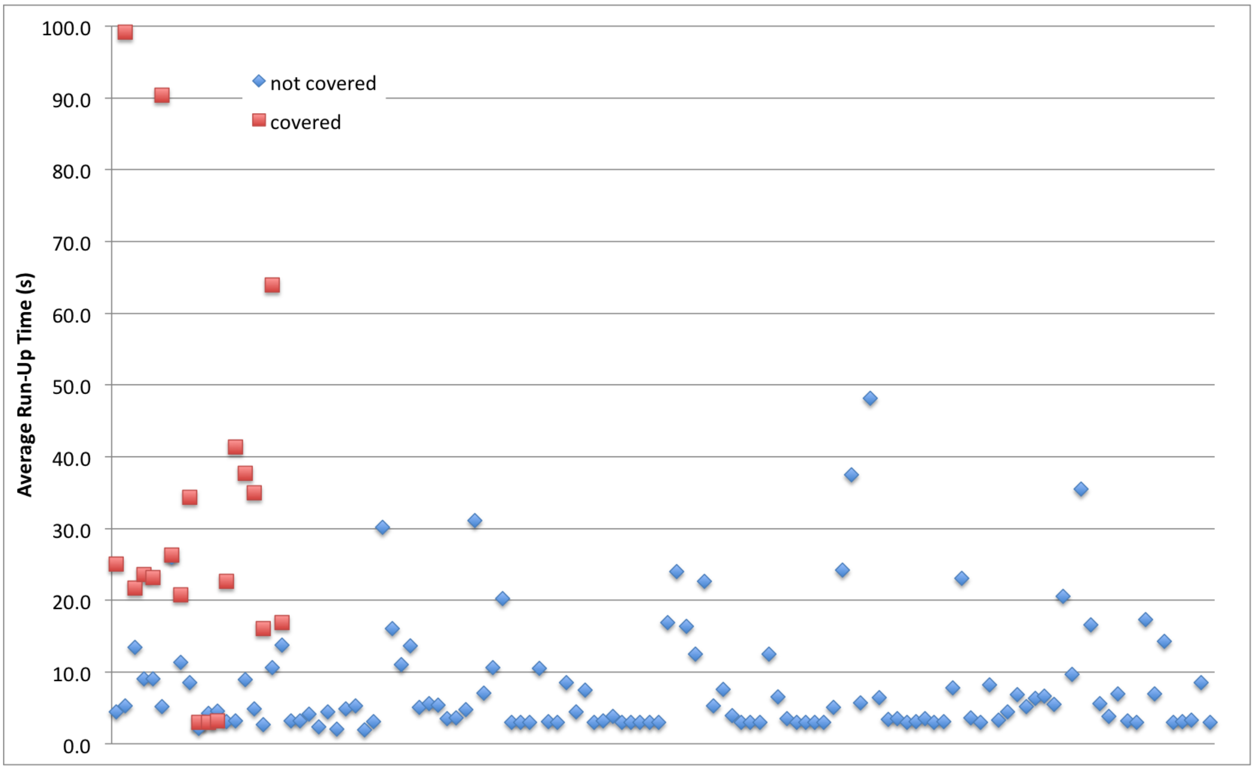
ix. Update the current switching withstand requirements (≥ 3000 cycles), for example, to match EU requirements (≥ lamp lifetime expressed in hours, or ≥ 30,000 if lamp starting time > 0.3s). The current AS/NZS 4847 requirement for switching withstand is very low and is not considered reflective of the normal use of a CFL. A 2012 Californian Study (CPUC 2012) tested a range of CFLs using different switching cycles and this revealed that 6000 cycles was achievable for the lamps tested (80% lamp survival rate).

x. Requirements for dimmable CFLs. Similar to high switching CFLs, this voluntary category would be for dimmable CFLs. Note that the inclusion of this category is likely to require significant effort as electronic compatibility is complex (for example, the large number of permutations of dimmer type /lamp type combination).

xi. Inclusion/removal of ELI/EST value parameters. The ability to use ELI and EST certification as part of CFL product registration was provided to ensure a good range of compliant products was available to consumers at the commencement of the phase-out. Consideration should be given as to whether this is still required and whether the current certification programs are still relevant and equivalent.

xii. Differing run-up time requirements for bare lamps and covered lamps. Industry has suggested that run-up time for covered lamps is unavoidably longer than for bare lamps. This is not supported by test results which show average measured run-up times for the majority of tested covered and bare CFLs (Figure 25) do meet the requirement of 60 seconds – these data seem to suggest that MEPS could be tightened. Note that the EU requires 40 seconds and 100 seconds for amalgam lamps. Consideration could be given to altering the run-up time requirement.

Figure 25 – CFL run-up time (source: testing undertaken by the Australian Government in 2010)



xiii. Constrain the allowable variation amongst test samples, in addition to requirement for the mean value to meet a requirement, using the upcoming IEC standard 60969 as a basis.

xiv. Consumers are regularly confused by terms such as "warm white", "white", "cool white", "daylight" and "natural daylight". Consider defining boundaries and marking requirements for correlated colour temperature (CCT) using the parameters defined in IEC 60081, to reduce consumer confusion of terms. Guidance on appropriate parameters for CCT can be found in IEC 60081.

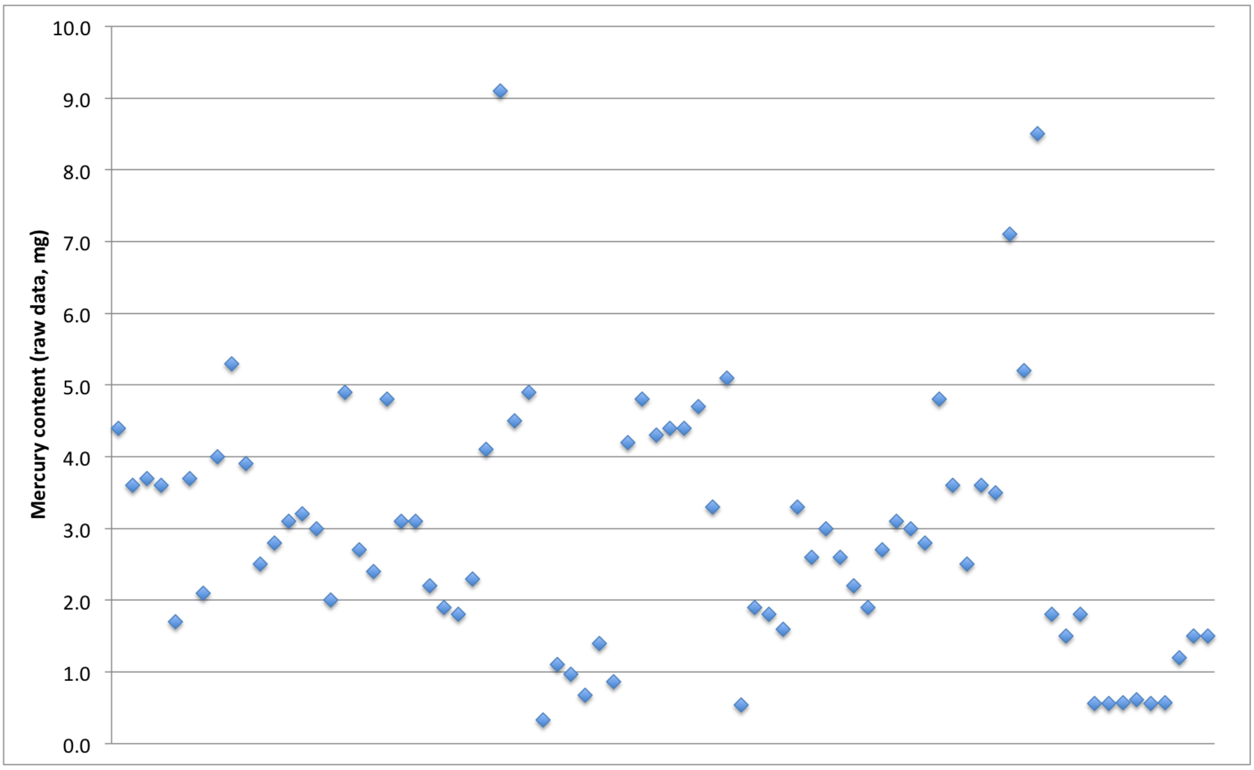
xv. Reduce mercury limits from a maximum of 5 mg to 3 mg or 2.5 mg to align with China or Europe (commenced 2013), respectively. Testing results are shown in Figure 26, from which it can be seen that a 2.5-3 mg limit would eliminate around 30% of the models on the market (or require them to reduce mercury content).

xvi. Require amalgam mercury, which is now common in CFLs (source: discussion with industry) and has safety benefits in comparison to elemental mercury if the lamp is broken in the place of use. This is primarily due to reduced mercury emissions when mercury is contained in an alloyed state however end of life environmental issues with amalgam decaying to methyl-mercury remain.

xvii. Include UV light limits, such as the EU limits UVA+UVB ≤ 2.0 mW/klm, UVC ≤ 0.01 mW/klm to provide a clear limit on UV light from CFLs. AS/NZS 4847.2 notes that UV emissions limits are under consideration and that the proposed limits are those specified in EC 244/2009. Alternatively refer to IEC 62471/CIE S09 Photobiological Safety of lamps and lamp systems.

xviii. Require mercury labelling on CFL packaging to include an indication of which website to consult to find instructions on how to clean-up broken lamps debris and/or dispose of lamps. Some feedback from consumers has indicated a need for easier access to this information. This would be similar to requirements in place in the EU and USA.

Figure 26 – CFL mercury raw test data (source: testing undertaken by the Australian Government in 2010)



8.5.3 AS 4934 (Incandescent and Halogen Standard)

xix. Consider removing lumen maintenance requirements for halogen lamps. Industry has stated that all halogen lamps are easily able to meet this requirement. This may be investigated following a review of government testing of a sample of halogen lamps for lumen maintenance currently underway.

xx. Introduce a labelling requirement such as the EU, which only allows CFLs and LED lamps to be marked as 'energy saving'. Currently some available halogen lamp products have packaging that include wording such as 'energy saving' or 'ecobulb'. Given less efficient alternatives (tungsten filament lamps) have now been removed from the market in Australia and the halogen lamps are effectively the least efficient lamps available, these claims are not considered accurate. As outlined in Section 6.4.6, the Australian Competition and Consumer Commission has recently released advice on this matter, which may address the issue without need for further specific regulation.

8.6 Import Restriction

The import restriction on GLS (traditional A-shaped (pear shaped) "light bulbs") lamps (see Section 6.2) was put in place in Australia at the suggestion of the lighting industry, in order to reduce stocks of these lamps in advance of the point of sale MEPS restrictions. As noted in Section 6.4.10, this may have helped minimise consumer stockpiling of incandescent lamps prior to implementation of MEPS, as experienced in some other countries. The limited scope of the restriction simplifies for the Australian Customs and Border Protection Service the task of identifying relevant lamps. Automated notifications regarding the import restriction and MEPS requirements are also sent to importers declaring relevant lamps categories. As all incandescent lamps are imported into Australia, the import prohibition serves as a useful means to intercepting what was previously the most commonly used of the now phased-out incandescent lamps, and applies to all imports (whereas the MEPS requirement under the GEMS Act relates to sale and commercial use). However given the phase-out has now been in place for several years, it may be possible to remove this additional layer and rely on the MEPS requirements under the GEMS Act.

8.7 Endorsement Labelling

Product energy labelling has its influence primarily at the point of consumer product purchase, thereby encouraging manufacturers to produce more efficient equipment. Energy labelling includes comparative labelling (e.g. a star rating) or the use of voluntary endorsement labelling such as ENERGY STAR. New Zealand runs an active ENERGY STAR scheme for a number of electrical appliances, including CFLs and LEDs (see Chapter 7). An option would be for Australia to adopt the New Zealand specification of ENERGY STAR for CFLs. This would provide an added means of encouraging lamp suppliers to meet high energy performance levels voluntarily.

The main disadvantage of any voluntary labelling scheme is that it is generally only the high efficiency products (typically the top 20% of the market) which are labelled and, while it would make it easier for consumers to identify these products, they would not be able to compare the performance and benefits with the lower efficiency products. Endorsement schemes also need to be supported by a robust compliance regime and considerable marketing and promotion if consumers are going to use and have confidence in endorsement labels. In the case of lighting, a performance label would not realise the savings that can be gained by use of MEPS but may add to savings if Australia follows the lead of New Zealand and has a high performance label in addition to MEPS for CFLs (and LEDs).

8.8 Other Options

8.8.1 Influencing Lighting Design

Good lighting design can further reduce overall lighting energy consumption (as well as provide better lighting quality). Influencing lighting design can be undertaken at the point of building design and also at the point of building renovation or tenancy turnover. This option could be explored further and might be achieved by training of lighting professionals, trades, retailers, etc.

During the initial stage of the inefficient lighting phase-out, the Australian government worked with the National Electrical Communications Association (NECA) in developing an Energy Efficient lighting training resource as part of their EcoSmart Electricians Program. This has also been used as a resource document in other programs run by the Illuminating Engineering Society of Australia and New Zealand and it is planned that this document be reviewed and updated. A specialist lighting retailer training package is also being developed in Australia which is intended to help retailers and customers achieve improved energy efficiency outcomes through the selection of more efficient lighting and understanding of better lighting design. The New Zealand government has also developed the Energywise website, which includes tips on lighting design and a virtual designer tool.

The maximum illumination power density requirements for new buildings and significant renovations contained in the Building Code of Australia also encourage efficient lighting design.

Ultimately, the ability of information to influence a market toward efficient lighting design relies on relevant information being made available and consumers or installers seeking out the information and/or acting on it at the time they make a purchase or recommend a product.

8.8.2 Changing Consumer Behaviour

Changing consumer behaviour can target buying behaviour and operating behaviour, and can be achieved using educational initiatives and incentives such as lamp exchange programs or POS information.

At the start of the phase-out of inefficient lighting in 2009, the initial focus of the communication strategy was to educate consumers and store assistants in-store of the most appropriate energy efficient lamp alternative to the traditional incandescent light globe.

In consultation with retailers, E3 created and distributed to retailers a range of Change the Globe (CTG) branded POS materials, including consumer and staff posters, CFL stylised hanging posters, light globe and globe conversion guides (as stand-alone cards and tear-off forms), and shelf-strips. More detail on the phase-out, including Frequently Asked Questions and fact sheets on health aspects, were included on the then Department of Environment, Water, Heritage and the Arts website (now on the Energy Rating website).

A research study assessing the POS campaign (Winton Sustainable Research Strategies 2011) in mid-2010 found that most people were aware of the phase-out before the POS campaign materials and associated publicity were released. Less than half the sample recalled seeing any POS materials to do with the phase-out and, despite being supplied to participating retailers, little POS materials were found in stores. At the time of the survey two years after the commencement of the phase-out, most people thought that the CTG POS material was no longer needed in its current format since the phase-out had largely occurred. However, many consumers felt there was still a need for some kind of POS material containing information to assists with:

- choosing the appropriate "brightness" of light to meet their needs;
- choosing the appropriate colour of light;
- clearly explaining LEDs; and
- providing advice on a range of common concerns and issues mainly related to CFLs (e.g. flickering, slow start-up, mercury, correct disposal).

More recently the E3 program has released a specialist Lighting Retailer Training Package (developed in consultation with retailers and the lighting industry) that consists of a retailer guide and suite of residential case studies intended to help retailers and their customers achieve improved energy efficiency outcomes through the selection of more efficient lighting and understanding of better lighting design.

The option of encouraging or requiring preferred rated luminous flux values outlines in section 8.4.3, accompanied by consumer education, would be one way of assisting consumers to select appropriate "brightness" of light for their needs.

One of the disadvantages of an information campaign alone is that awareness and promotional activities only have a limited effect to establish new practices and norms. The awareness and promotional phase cannot be maintained indefinitely due to the large operational costs involved. It is also dependent upon retailers being willing to have material in-store.

Encouragement of CFLs and LED lamps over halogen lamps through information and education (by industry and/or government) may be explored as an option. However, based on the difference in the level of uptake of CFL lamps between Australia (where MEPS has been in place since 2009) and New Zealand (where MEPS is not in place for incandescent lamps and only since 1 October 2012 for CFL lamps; refer Figure 10), it is clear that a combination of MEPS and education will result in significantly more uptake of efficient lighting alternatives than education programs alone.

Any further consumer awareness initiatives addressing the issues outlined above would benefit from evaluation and testing with consumers and the lighting industry prior to release.

8.8.3 Grants and Subsidies

Grants and subsidies can reduce financial barriers to energy efficient lighting. They include tax incentives, rebates and energy efficiency obligation schemes which generate subsidies for retrofit of efficient lighting.

Energy Efficiency Obligation Schemes (White Certificate)

Energy efficiency obligations schemes, that include efficient lighting among a range of other energy efficiency measures, have been implemented by several state and territory governments (e.g. NSW Energy Saving Scheme, Victorian Energy Efficiency Target and South Australian Residential Energy Efficiency Scheme). In the lighting area these schemes have sought to drive uptake of high efficiency solutions (CFL & LED) so as to complement the incandescent lighting phase-out that is more aimed at eliminating the least efficient products from the market. As the phase-out of inefficient lighting, as implemented in Australia, currently allows consumers to choose between compliant halogen and more efficient CFL or LED lighting, the state and territory-based energy savings schemes have the potential to incentivise the uptake of energy efficiency lighting beyond what MEPS achieves alone. Initially these schemes led to increasing use of the more efficient compact fluorescent lamps to replace common incandescent light globes. More recently as the availability and quality of LEDs has increased and their cost has come down, these schemes are driving uptake of LED lighting, mainly to replace halogen down light lamps. In this way, the two policy options are complementary.

Energy Efficiency Obligations schemes are generally funded by the market, with the costs of the schemes being passed on to energy consumers.

When a lighting upgrade is delivered through an energy efficiency obligation scheme, existing inefficient lighting is removed from the stock (rather than failing) and immediate energy savings are realised. There is the potential, though for the energy user to revert back to less efficient lighting technology at the end of the life of the equipment used in the upgrade, and in some cases earlier if they are dissatisfied with the efficient lighting. As mentioned above, MEPS provides a floor to limit the extent of this reversion. Strengthening of MEPS over time further improves this situation and would help to lock in the lighting energy savings being achieved by the Energy Efficiency Obligation Schemes.

A feature of Australian state and territory energy efficiency obligations schemes is that they are reviewed regularly. This includes a review of the energy savings credited from approved energy efficiency activities, including energy efficient lighting. As part of this review, the energy savings credits for an activity are determined to be the energy savings in addition to "business-as-usual" (i.e., the level of energy savings that occur in the absence of an incentive).

Strengthening of MEPS improves the energy efficiency of business-as-usual, which has the effect of lowering the credits from implementing a lighting upgrade.

This review process ensures that energy efficiency obligations schemes and MEPS continue to be complementary.

Government Subsidies and Rebates

Direct government subsidies can be used as a one-off financial incentive to encourage people to try CFLs and LEDs and create a demonstration effect. This was especially the case prior to the phase-out. To some consumers, the main advantage of a financial subsidy is that it is voluntary. However, a subsidy or rebate scheme, dependent upon design, may have the following disadvantages:

- It is desirable but administratively cumbersome and intrusive to limit incentives to those who would not otherwise have purchased the efficient lamp. Inevitably, significant payments go to those who would have purchased efficient lamps without the subsidy. Payments may also go to those who may accept, but not actually use the efficient products. (In the Australian energy efficiency obligation schemes this has been addressed by requiring installation of the energy efficient lighting directly in homes and businesses. Also, only energy savings beyond business as usual are credited. Such business as usual typically takes into account the market for energy efficient lighting.)
- Some subsidies reduce the cost of lighting services and may encourage people to install more lamps (this does not apply to direct replacement schemes).
- Subsidies rely on sufficient government funds being available (energy efficiency obligation schemes, while relying upon government for administration, are funded by a market based subsidy).
- There is a risk in a pure subsidy scheme of tacit collusion between suppliers to not pass on the full value of the subsidy. Even the perception of such collusion would create demands for price monitoring and cost reviews, which are not necessarily effective or conclusive. Energy efficiency obligation schemes overcome this potential issue by creating a competitive market for the delivery of energy efficiency measures to consumers.
- A subsidy program does not deal permanently with significant underlying issues, such as the lack of feedback from electricity bills. A subsidy can also send an unintended message that the subsidised product is not 'value for money'. This suggests that there would be significant backsliding if the subsidy is withdrawn, or that it needs to be maintained indefinitely.
- Subsidising retail sales as a means of driving further uptake of energy efficient lighting would suffer from the following limitations:
    - It may prove to be poorly targeted, with subsidies provided to customers who would have purchased energy efficient lighting anyway.
    - It is likely to be more costly, on a society-wide basis, than driving improvements through improved MEPS.
    - There may be challenges in securing scarce government funding for such a program, especially when there are many different types of appliances which might benefit from such an incentive.

The feasibility of grants and/or subsidies could be explored further.

8.9 Cost-Benefit Analysis

A preliminary cost-benefit analysis was undertaken for the regulatory options discussed in this Product Profile, with the exception of alignment with EU MEPS, which would be very difficult to quantify without significant investigation. Table 12 shows the results of the preliminary cost-benefit analysis. Note that this is existing material from the Department's preliminary investigations into regulatory options, and is provided for illustrative purposes only. All policy options for further consideration would be subject to thorough analysis of costs and benefits in a consultation RIS. The provision of lighting sales data by industry would assist more detailed analysis to be undertaken.

Table 12 – Preliminary cost benefit analysis and energy savings (from a consumer perspective)

	Complete Transition from MV incandescent & halogen lamps to CFL and LED	Complete Transition from ELV halogen lamps to CFL and LED	Transition in NZ to higher efficiency ELV halogen lamps (37W or less)	Improved CFL efficacy
Power saving per lamp (W)	40	26	15	2.0
Energy cost saving per lamp p.a. (@ 1.5hrs/day, 25c/kWh)	$5.48	$3.56	$2.05	$0.27
Additional cost per lamp (note LED lamp cost is likely to be significantly lower in the medium term)	$10.00	$10.00	$2.00	$0.50
Net present value @ 7% over 10 years (per lamp)	$28.45	$15.00	$12.42	$1.42
Internal rate of return (IRR) over 10 years	54%	34%	103%	54%
Benefit : cost ratio (nominal over 10 years)	5.5	3.6	10.3	5.5
No. lamps affected per house (Australia)	15.4	12.3		15.0
No. lamps affected per house (New Zealand)	22.3	3.8	3.8	8.7
Annual national energy savings (Australia) (TWh p.a.)	3.4	1.8		0.17
Annual national energy savings (Australia) (PJ p.a.)	12.3	6.4		0.6
Annual national energy savings (New Zealand) (TWh p.a.)	0.8	0.1	0.1	0.02
Annual national energy savings (New Zealand) (PJ p.a.)	3	0.2	0.1	0.1

As can be seen in the table above, all of the options assessed have positive NPVs and IRRs of at least 30%. Note that the national energy savings shown depend on all residential lamps being affected by MEPS, noting that there will be further savings from lamps in the commercial sector, and that natural market forces will also play a role - MEPS cannot take credit for all of these savings (although the level of anticipated business-as-usual activity is very difficult to forecast).

9 Conclusions

The conclusions of this Product Profile are:

1. Residential lighting energy consumption, per dwelling, for Australia is estimated at around 1100 kWh in 2010. For New Zealand, this was estimated at around 1020 kWh in 2012 (noting that these estimates do contain some weaknesses). In both countries, more than 75% of residential lighting energy consumption is estimated to come from incandescent and halogen lamps.
2. Further shifting these markets from inefficient incandescent lamps to efficient lighting such as CFL and LED has the potential to reduce residential lighting energy consumption by around 65%.
3. The market for LED lighting is expected to grow in Australia and New Zealand as product availability increases and prices come down, along with some decline in other types of lamp sales.
4. A number of issues have been identified within the current MEPS program, related to lamp performance, scope exclusions, UV emission levels, switching withstand requirements, and sales of halogen lamps that would benefit from adjustment in any revision of the current MEPS.
5. Since the commencement of the phase-out in Australia, at least 85 other countries have introduced lamp efficacy requirements in an effort to save energy and reduce emissions by removing inefficient incandescent lamps from the market. However, there are wide variations between countries with respect to scope, timing and technical approach. Stockpiling of incandescent lamps has been an issue in at least one country.
6. The European Union is currently reviewing its MEPS, with a view to potentially phasing out all incandescent and halogen lamps.
7. The MEPS policy options discussed in this document are:

- Maintenance of current MEPS levels including:
  - Permanent adoption in Australia of the current 5% reduction in MEPS efficacy for MV halogen non-directional lamps (Option 1).
  - Removal of MV directional lamps from the scope of MEPS in Australia (Option 3).
- Application in Australia of the full incandescent MEPS level MV halogen non-directional lamps (Option 2).
- Introduction in New Zealand of MEPS for ELV halogen lamps set at a level that allows ELV halogen lamps to remain available on the market (Option 5).
- Increase in the stringency of MEPS in Australia and (where applicable) New Zealand (Options 4 and 6) and:
  - Development of MEPS in Australia to phase out incandescent and halogen lamps and replace with CFL/LED technology, with a staged implementation in different lamp categories as and when LED technology has matured sufficiently (Option 9b).
  - An incremental increase in Australia and New Zealand in the efficacy of MEPS for CFLs, taking into account current market performance (Option 7).
  - Alignment of MEPS levels (or parts thereof) with the European Union (Option 8).
  - Regulatory or voluntary approach in Australia that all new luminaires sold are fitted with MEPS-registered CFL or LED lamps (Option 9a).

8. These options will involve differing levels of change in the lighting market and will result in different levels of additional energy savings.
   - The potential for energy savings ranges from no further energy savings (no action taken) to approximately 1 TWh (3.4 PJ p.a.) in New Zealand and 5.4 TWh (19.3 PJ p.a.) in Australia (this is the approximate full potential of energy savings available from fully transitioning from incandescent and halogen lamps to CFLs and LEDs).

9. Other policy options discussed in this Product Profile are:

- Addressing a range of issues encountered during the MEPS program to date and raised by the standards and technical committees (Options 10–21 and section 8.5).
- The possible removal of the Australian import restriction on incandescent GLS lamps (and rely on MEPS requirements under the GEMS Act) (section 8.6).
- Endorsement labelling (section 8.7).
- Influencing lighting design (section 8.8.1).
- Changing consumer behaviour (section 8.8.2).
- Grants and subsidies (section 8.8.3).

These policy options are subject to the outcomes of consultation on this Product Profile, approval from the Energy Efficiency Working Group to proceed to a RIS which will set out recommended options and assess their impacts, and subsequent Government approval. Further industry consultation will be undertaken when a RIS becomes available.

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Appendix A - International Regulations

European Union

Commission Regulation No 244/2009 Non-Directional Household Lamps

Commission Regulation (EC) No 244/2009 establishes requirements for non-directional household lamps, including when they are marketed for non-household use or when they are integrated into other products. It also establishes product information requirements for special purpose lamps. Directional and LED lamps are subject to EC 1194/2012 discussed below. The requirements set out in the Regulation do not apply to the following household and special purpose lamps:

a) lamps having the following chromaticity coordinates x and y (see blue line delineation in Figure 27 below for graphical representation - this is effectively a very broad definition of "white light"):

- $x < 0.200$ or $x > 0.600$
- $y < -2.3172x^2 + 2.3653x - 0.2800$ or $y > -2.3172x^2 + 2.3653x - 0.1000$

b) directional lamps

c) lamps having a luminous flux below 60 lumens or above 12,000 lumens

d) lamps having –

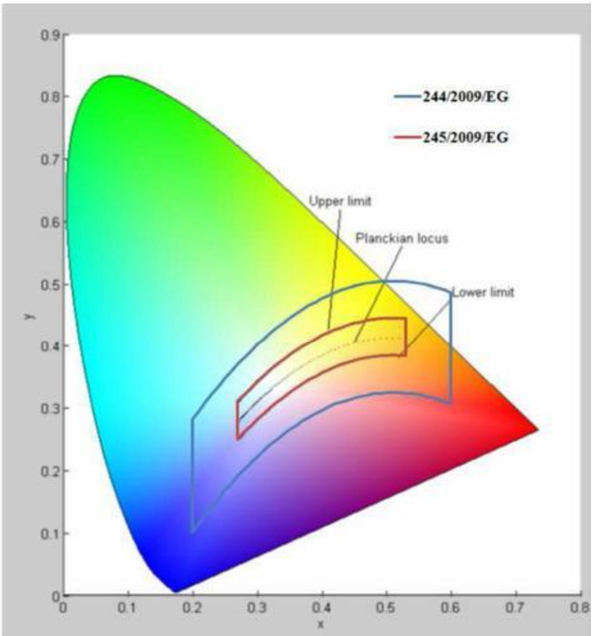
- 6% or more of total radiation of the range 250-780 nm in the range of 250-400 nm
- the peak of the radiation between 315-400 nm (UVA) or 280-315 nm (UVB) (Ultraviolet lamps)

e) fluorescent lamps without integrated ballast

f) high-intensity discharge lamps

g) incandescent lamps with E14/E27/B22/B15 caps, with a rated voltage equal to or below 60V and without integrated transformer.

Figure 27 – EU regulation 244/2009 definition of lamp colour within scope



'Special purpose lamp' means a lamp not intended for household room illumination because of its technical parameters or because the related product information indicates that it is unsuitable for household room illumination. Special purpose lamps designed essentially for other types of applications (such as traffic signals, terrarium lighting, or household appliances) and clearly indicated as such on accompanying product information are not subject to the Regulation.

EC No 244/2009 is set out in 6 stages. Requirements for the first 4 stages, applied from the 1 of September 2009, 2010, 2011 and 2012 respectively, eliminated low-efficacy ('incandescent') lamps, such that all general purpose incandescent lamps should have been phased-out from the EU market by 1 September 2012.

Stage 5 (from 1 September 2013; Table 13) was the second stage to specify minimum functionality requirements for minimum rated lamp lifetime/lamp survival factor at 6000 hours, lumen maintenance, number of switching cycles, starting time, heat-up time to reach 60% of lumen output, premature failure rate, UVA+UVB radiation, UVC radiation, lamp power factor and – for CFLs only – the colour rendering index (Ra).

Table 13 – Stage 5 functionality requirements for CFLs and lamps excluding CFLs and LEDs

Functionality Parameter	Requirement for CFLs	Requirement for lamps excluding CFLs and LEDs
Lamp survival factor at 6000h	≥ 0.70	n/a
Rated lamp lifetime	n/a	≥ 2000h
Lumen maintenance	At 2000h: ≥ 88% (≥ 83% for lamps with second lamp envelope) At 6000h: ≥ 70%	≥ 85% at 75% of rated average lifetime
Number of switching cycles before failure	≥ lamp lifetime expressed in hours ≥ 30,000 if lamp starting time > 0.3s	≥ four times the rated lamp lifetime expressed in hours
Starting time	< 1.5s if P < 10 W < 1.0s if P ≥ 10 W	< 0.2s
Lamp warm-up time to 60% Φ	< 40s or < 100s for lamps containing mercury in amalgam form	< 1.0s
Premature failure rate	≤ 2.0% at 400h	≤ 5.0% at 200h
UVA + UVB radiation	≤ 2.0 mW/klm	≤ 2.0 mW/klm
UVC radiation	≤ 0.01 mW/klm	≤ 0.01 mW/klm
Lamp power factor	≥ 0.55 if P < 25 W ≥ 0.90 if P ≥ 25 W	≥ 0.95
Colour rendering (Ra)	≥ 80	n/a

For non-CFLs/LEDs (i.e. halogen lamps) the Stage 5 requirement specifies an increase in rated lamp lifetime from at least 1000 hours to a minimum of 2000 hours (the same as Australia).

This presents a challenge to halogen lamp design, because filament lamps have a direct relationship between current through the filament versus lifetime (more current, lower life expectancy) on the one hand, and current versus luminous output (more current, more lumens) on the other.

Stage 6 (to apply from 1 September 2016) sets more stringent efficacy requirements for halogen lamps – specifically, an efficacy increase of 25% (corresponding to the lower limit value of the 'B' energy label class) for two types of clear lamps:

- low-voltage ('LV' or 'ELV') non-directional halogen lamps; and
- mains-voltage ('MV') non-directional halogen lamps, excluding G9 and R7s.

At the time of a Stage 6 review in April 2013, contrary to initial expectations, no MV halogen lamps on the market were found to meet the Stage 6 requirements. Given the high uncertainty that Stage 6-compliant lamps of this type will be available on the market by 1 September 2016, it is likely that MV halogen lamps will have to be phased out (if the Stage 6 requirement is to be retained).

Current lamp efficacy requirements are set out as the maximum rated power (P_{max}) for a given rated luminous flux (Φ), being:

Clear lamps: $P_{max} \leq 0.8 \times (0.88\sqrt{\Phi} + 0.049\Phi)$

Non-clear lamps: $P_{max} \leq 0.24\sqrt{\Phi} + 0.0103\Phi$

The correction factors in Table 14 are cumulative where appropriate.

Table 14 – EU regulation 244/2009 correction factors

Lamp Type	Max. Rated Power
Filament lamp requiring external power supply	P_{max} / 1.06
Discharge lamp with cap GX53	P_{max} / 0.75
Non-clear lamp with colour rendering index ≥ 90 and P ≤ 0.5 * (0.88√Φ +0.049 Φ)	P_{max} / 0.85
Discharge lamp with colour rendering index ≥ 90 and Tc ≥ 5000K	P_{max} / 0.76
Non-clear lamp with second envelope and P ≤ 0.5 * (0.88√Φ +0.049 Φ)	P_{max} / 0.95
LED lamp requiring external power supply	P_{max} / 1.1

EC 244/2009 also states product information requirements for lamp packaging, accompanying product information and free-access websites. For special purpose lamps, the following information must be clearly and prominently indicated on their packaging and in all forms of product information accompanying the lamp when it is placed on the market:

a) their intended purpose; and

b) that they are not suitable for household room illumination.

For non-directional lamps within the scope of EC 244/2009 the following information is to be visibly displayed prior to purchase to end-users on the packaging and on free access websites (the information does not need to be specified using the exact wording of the list below - it may be displayed using graphs, figures or symbols rather than text):

a) Nominal lamp power

b) Nominal luminous flux

c) Nominal lifetime of the lamp in hours (not higher than the rated lifetime)

d) Number of switching cycles before premature lamp failure

e) Colour temperature (also expressed as a value in degrees Kelvin)

f) Warm-up time up to 60% of the full light output (may be indicated as 'instant full light' if less than 1 second)

g) A warning if the lamp cannot be dimmed or can be dimmed only on specific dimmers

h) If designed for optimal use in non-standard conditions (such as ambient temperature Ta ≠ 25 °C) and information on those conditions

i) Lamp dimensions in millimetres (length and diameter)

j) If equivalence with an incandescent lamp is claimed on the packaging, the claimed equivalent incandescent lamp power (rounded to 1 W) must be the corresponding value (see Table 15) to the luminous flux of the lamp contained in the packaging. The intermediate values of both the luminous flux and the claimed incandescent lamp power (rounded to 1 W) must be calculated by linear interpolation between the two adjacent values;

Table 15 – Corresponding values for equivalence claim with incandescent lamps

Rated lamp luminous flux (lm) Φ			Claimed equivalent incandescent lamp power (W)
CFL	Halogen	LED and other lamps	
125	119	136	15
229	217	249	25
432	410	470	40
741	702	806	60
970	920	1055	75
1398	1326	1521	100
2253	2137	2452	150
3172	3009	3452	200

k) The term ‘energy saving lamp’ or any similar product related promotional statement about lamp efficacy may only be used if the lamp complies with the efficacy requirements applicable to non-clear lamps

l) If the lamp contains mercury –

- Lamp mercury content as X.X mg, and
- Indication of a website to consult in the case of accidental lamp breakage to find instructions on how to clean up the lamp debris.

The following information is to be made publicly available on free-access websites (as a minimum, expressed at least as values):

a) The packaging information specified above

b) Rated wattage (0.1W precision)

c) Rated luminous flux

d) Rated lamp life time

e) Lamp power factor

f) Lumen maintenance factor at the end of the nominal life

g) Starting time (as X.X seconds)

h) Colour rendering

i) If the lamp contains mercury –

- Instructions on how to clean up the lamp debris in case of accidental lamp breakage, and
- Recommendations on how to dispose of the lamp at its end of life.

Commission Regulation No 1194/2012 Directional Lamps and LED Lamps

The scope of EC 1194/2012 is directional lamps, LED lamps and associated equipment for these lamps, such as control gear and luminaires. The regulation also exempts certain special purpose lamps (see Article 2.4 of EC1194).

The regulation establishes an energy efficiency index (EEI) for lamps, which is defined as:

$EEI = P_{cor} / P_{ref}$

where

P_{cor} = the rated lamp power, corrected by a correction factor for certain lamps (see Table 1 of the Regulation).

P_{ref} = the reference power obtained from the useful light output of the lamp (Φ_{use}) by the following formulae:

If $\Phi_{use} < 1300$ lm, $P_{ref} = 0.88\sqrt{\Phi_{use}} + 0.049\Phi_{use}$

If $\Phi_{use} \geq 1300$ lm, $P_{ref} = 0.07341\Phi_{use}$

Φ_{use} = is defined as follows:

For directional lamps with beam angle ≥ 90° (other than filament lamps), Φ_{use} = the rated luminous flux in a 120° cone. Other directional lamps, Φ_{use} = the rated luminous flux in a 90° cone. Note that Australia defines flux as being in a 180° cone which better suits the general purpose illumination role that many direction lamps are used for in Australia.

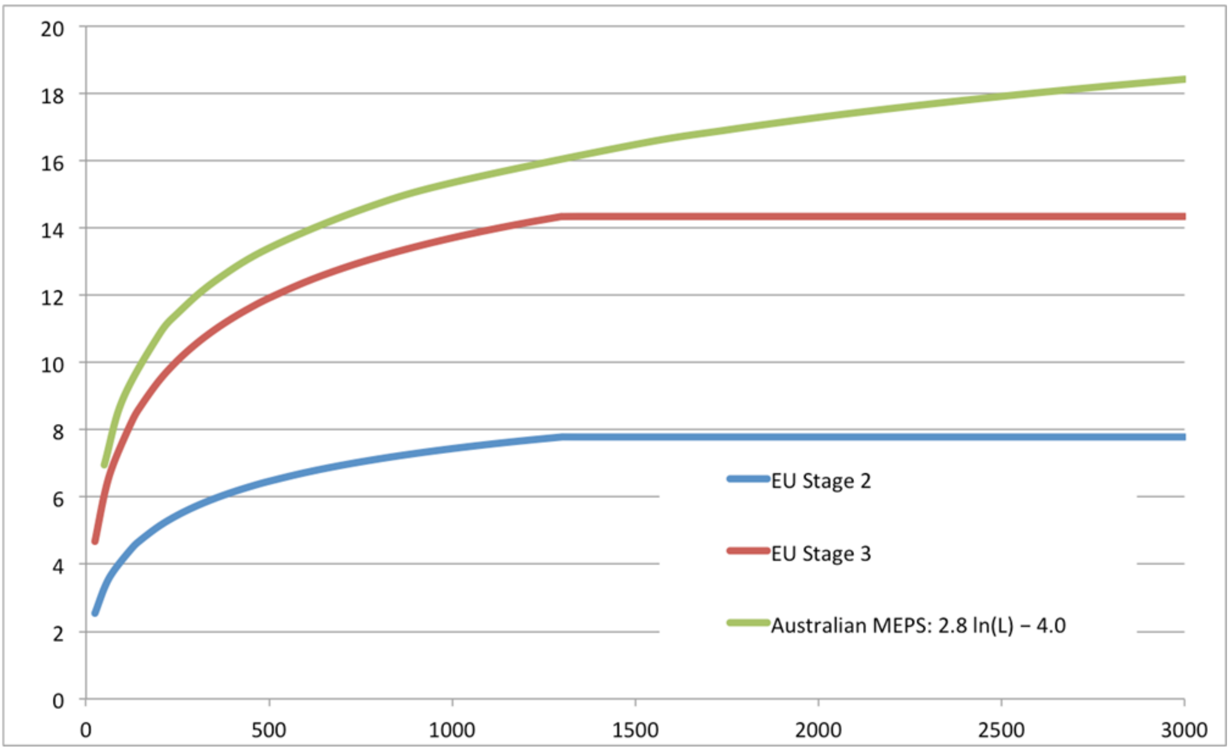
The maximum allowable EEI is given in Table 16. Note that the far right column includes LEDs.

The EU and Australian MEPs for directional lamps are graphed in Figure 28. Note there are definitional differences - the EU defines “useful light” in the cones mentioned above, and the EU phrase MEPS in terms of rated values. Thus it is difficult to make direct comparisons in this figure.

Table 16 – EC 1194/2012 maximum allowable EEI

Application date	Maximum EEI			
	Mains voltage filament lamps	Other filament lamps	HID lamps	Other lamps
Stage 1 – Sept 2013	If Φ_{use}>450lm: 1.75	If Φ_{use}≤450lm: 1.20 If Φ_{use}>450lm: 0.95	0.50	0.50
Stage 2 – Sept 2014	1.75	0.95	0.50	0.50
Stage 3 – Sept 2016	0.95	0.95	0.36	0.20

Figure 28 – EU directional lamp efficacy requirement (MV filament directional lamps)



Functionality (quality) requirements for all types of lamps and control gear are listed in section 2 of Annex III of the Regulation (see Table 17, Table 18 and Table 19 below). Product informational requirements are also listed in section 2 of Annex III of the Regulation, along with energy efficiency and functionality requirements for control gear.

Table 17 – Functionality requirements for directional CFLs (Stage 1 = September 2013, Stage 2 = September 2014, Stage 3 = September 2016)

Functionality Parameter	Stage 1 except where indicated otherwise	Stage 3
Lamp survival factor at 6000h	From 1 March 2014 ≥ 0.50	≥ 0.70
Lumen maintenance	At 2000h ≥ 80%	At 2000h ≥ 83% At 6000h ≥ 70%
Number of switching cycles before failure	≥ half the lamp lifetime expressed in hours ≥ 10,000 is lamp starting time > 0.3s	≥ lamp lifetime expressed in hours ≥30,000 if lamp starting time > 0.3s
Starting time	< 2.0s	< 1.5s if P < 10W < 1.0s if P ≥ 10W
Lamp warm-up time to 60% ϕ	< 40s or < 100s for lamps containing mercury in amalgam form	< 40s or < 100s for lamps containing mercury in amalgam form
Premature failure rate	≤ 5.0% at 500h	≤ 5.0% at 1000h
Lamp power factor for lamps with integrated control gear	≥ 0.50 if P < 25W ≥ 0.90 if P ≥ 25W	≥ 0.55 if P < 25W ≥ 0.90 if P ≥ 25W
Colour rendering (Ra)	≥ 80 ≥ 65 if the lamp is intended for outdoor or industrial applications according to point 3.13(l) of this Annex	≥ 80 ≥ 65 if the lamp is intended for outdoor or industrial applications according to point 3.13(l) of this Annex

Table 18 – Functionality requirements for other directional lamps (excluding LED lamps, CFLs and high intensity discharge lamps) (Stage 1 = September 2013, Stage 2 = September 2014, Stage 3 = September 2016)

Functionality Parameter	Stage 1 and 2	Stage 3
Rated lifetime at 50% survival	≥ 1000h (≥2000h in stage 2) ≥2000h for ELV lamps not complying with the stage 3 filament lamp efficiency requirement in point 1.1 of this Annex	≥ 2000h ≥ 4000h for ELV lamps
Lumen maintenance	≥ 80% at 75% of rated average lifetime	≥ 80% at 75% of rated average lifetime
Number of switching cycles before failure	≥ four times the rated lamp life expressed in hours	≥ four times the rated lamp life expressed in hours
Starting time	< 0.2s	< 0.2s
Lamp warm-up time to 60% ϕ	≤ 1.0s	≤ 1.0s
Premature failure rate	≤ 5.0% at 100h	≤ 5.0% at 200h
Lamp power factor for lamps with integrated control gear	Power > 25W: ≥ 0.9 Power ≤ 25W: ≥ 0.5	Power > 25W: ≥ 0.9 Power ≤ 25W: ≥ 0.5

Table 19 – Functionality requirements for non-directional and directional LED lamps

Functionality Parameter	Requirement as from Stage 1, except where indicated otherwise
Lamp survival factor at 6000h	From 1 March 2014 ≥ 0.90
Lumen maintenance at 6000h	From 1 March 2014 ≥ 0.80
Number of switching cycles before failure	≥ 15,000 if rated lamp life ≥ 30,000h otherwise: ≥ half the rated lamp life expressed in hours
Starting time	< 0.5s
Lamp warm-up time to 95% ϕ	< 2s
Premature failure rate	≤ 5.0% at 1000h
Colour rendering (Ra)	≥ 80 ≥ 65 if the lamp is intended for outdoor or industrial applications according to point 3.13(l) of this Annex
Colour consistency	Variation of chromaticity coordinates within a six-step MacAdam ellipse or less
Lamp power factor for lamps with integrated control gear	P ≤ 2W: no requirement 2W < P ≤ 5W: PF > 0.4 5W < P ≤ 25W: PF > 0.5 P > 25W: PF > 0.9

United States

Incandescent Non-Reflector Lamps

The Department of Energy (DOE) has regulatory provisions through the *Energy Independence and Security Act 2007* (EISA), stipulating that from 2012 manufacturers are required to comply with the US energy conservation standards for general service incandescent lamps (GSILs). Most of these lamps, traditionally sold as 40, 60, 75, or 100 watt lamps, are to be replaced by more efficient, lower wattage lamps. The scope of the GSIL Standard covers standard and modified spectrum incandescent or halogen incandescent lamps intended for general service applications, with a medium screw base, a lumen range of 310 to 2600 lumens and an operating voltage range of 110 - 130V. A number of lamp types (e.g. lamps that are for special purposes or that have a very low market share) are specifically excluded and not subject to the GSIL Standard.

GSILs must meet the energy conservation standards specified in the Code of Federal Regulations (CFR), with a CRI, maximum wattage, minimum lifetime, and compliance date as shown in Table 20.

Table 20 – Energy conservation standards for incandescent non-reflector lamps specified in the Code of Federal Regulations (sourced from the US Department of Energy (www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/61))

Standard Spectrum (CRI greater than or equal to 80)			
Rated lumen ranges	**Maximum rated wattage**	**Minimum rated lifetime**	**Effective date**
1490-2600	72	1000 hours	1/01/12
1050-1489	53	1000 hours	1/01/13
750-1049	43	1000 hours	1/01/14
310-749	29	1000 hours	1/01/14
Modified Spectrum (CRI greater than or equal to 75)			
Rated lumen ranges	**Maximum rated wattage**	**Minimum rated lifetime**	**Effective date**
1118-1950	72	1000 hours	1/01/12
788-1117	53	1000 hours	1/01/13
563-787	43	1000 hours	1/01/14
232-562	29	1000 hours	1/01/14

Specified GSIL test procedures (e.g. in the Electronic Code of Federal Regulations) must be used to determine compliance with DOE standards.

DOE will initiate another cycle of rulemaking in 2014 to consider a broader standard for general service lamps, which includes GSILs, CFLs, general service LED lamps, organic LED (OLED) lamps, and any other lamps determined to satisfy lighting applications traditionally served by GSIL. However, the definition of general service lamp does not apply to any lighting application or bulb shape excluded from the GSIL definition, or any general service fluorescent lamp or incandescent reflector lamp.

Incandescent Reflector Lamps

The US has regulated the energy efficiency level of incandescent reflector lamps (IRLs) since 1992 (using legislation pre-dating EISA). IRLs are directional lamps such as spotlights and floodlights used in residential and commercial applications, including recessed downlighting and track lighting. IRLs have a reflective coating on the inside of the bulb to focus and aim the light. There are five IRL configurations: basic reflector lamp (R); elliptical reflector (ER); bulge-neck reflector (BR); parabolic aluminised reflector (PAR); and bulged parabolic aluminised reflector (BPAR).

The scope of the IRL Standard covers any lamp:

1. in which light is produced by a filament heated to incandescence by an electric current, which is not coloured or designed for rough or vibration service applications, that contains an inner reflective coating on the outer bulb to direct the light;
2. that has an R, PAR, ER, BR, BPAR, or similar bulb shape with an E26 medium screw base;
3. with a rated voltage or voltage range that lies at least partially in the range of 115–130 V;
4. with a diameter that exceeds 2.25 inches (5.72 cm); and
5. that has a rated wattage of 40 W or higher.

Excluded from the scope are:

6. IRLs rated at 50 W or less that are ER30, BR30, BR40, or ER40 lamps;
7. IRLs rated at 65 W that are BR30, BR40, or ER40 lamps; and
8. R20 IRLs rated 45 W or less.

Standard and modified spectrum IRLs within the scope must meet or exceed the energy conservation standards specified in the CFR, including rated lamp wattage, lamp diameter, rated voltage and minimum average lamp efficacy, as shown in Table 21.

Table 21 – Energy conservation standards for incandescent reflector lamps specified in the Code of Federal Regulations

Rated lamp power (p)	Spectrum Modification	Lamp diameter (inches)	Rated voltage (V)	Minimum average lamp efficacy (lm/W)
40-205	Standard spectrum	>2.5	125	$6.8*P^{0.27}$
			<125	$5.9*P^{0.27}$
		≤2.5	125	$5.7*P^{0.27}$
			<125	$5.0*P^{0.27}$
40-205	Modified spectrum	>2.5	125	$5.8*P^{0.27}$
			<125	$5.0*P^{0.27}$
		≤2.5	125	$4.9*P^{0.27}$
			<125	$4.2*P^{0.27}$

To determine compliance with DOE standards, manufacturers of IRLs produced or distributed into the market on or after 25 July 2012 must follow specified test procedures in 10 CFR 430.23(r) (see the US Government Printing Office (www.gpo.gov/fdsys/pkg/CFR-2011-title10-vol3) for more information).

Compact Fluorescent Lamps

The US has regulated the energy efficiency level of integrated-ballast CFLs since 2005. The *Energy Policy Act* of 2005 (EP ACT 2005) amended the *Energy Policy and Conservation Act* of 1975 (EPCA), setting energy conservation standards for medium base CFLs. The DOE will conduct an analysis of energy, emission and cost reductions when it reviews these standards in future rulemakings.

The scope of the CFL Standard covers bare lamps and bulb covered lamps (without reflectors) manufactured and distributed into the market on or after 1 January 2006. These medium base CFLs must meet the energy conservation standards specified in the CFR.

The requirements of the CFL Standard include lamp power (Watts), minimum efficacy, 1000-hour lumen maintenance, lumen maintenance, rapid-cycle stress test and average rated lamp life (Table 22).

To determine compliance with DOE standards, manufacturers must follow specified test procedures for medium base CFLs in 10 CFR 430.23(y).

Table 22 – Energy conservation standards for medium base CFLs (sourced from the US Department of Energy (www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/28))

Factor	Requirements
Lamp Power (Watts) & Configuration[1]	**Minimum Efficacy: lumens/watt (Based upon initial lumen data).**[2]
Bare Lamp:	
Lamp Power <15	45
Lamp Power =15	60
Covered Lamp, (no reflector):	
Lamp Power <15	40
Lamp Power <19	48
Lamp Power <25	50
Lamp Power =25	55
1000-hour Lumen Maintenance	The average of at least 5 lamps must be a minimum 90% of initial (100-hour) lumen output @ 1,000 hours of rated life.
Lumen Maintenance	80% of initial (100-hour) rating at 40% of rated life (per ANSI C78.5 Clause 4.10).
Rapid-Cycle Stress Test	Per ANSI C78.5 and IESNA LM–65 (clauses 2,3,5, and 6). *Exception:* Cycle times must be 5 minutes on, 5 minutes off. Lamp will be cycled once for every two hours of rated life. At least 5 lamps must meet or exceed the minimum number of cycles.
Average Rated Lamp Life	=6,000 hours as declared by the manufacturer on packaging. At 80% of rated life, statistical methods may be used to confirm lifetime claims based on sampling performance.

The DOE has not exempted any states from the above energy conservation standards. States may, however, petition DOE to exempt a state regulation from pre-emption by the Federal energy conservation standard, and may also petition DOE to withdraw such exemptions.

Korea

Incandescent Non-Reflector Lamps

Korea has had energy efficiency regulatory standards for lighting for an extended period. MEPS and "grade" standards (1-5 efficiency grading) were first applied to incandescent and fluorescent lamps in 1992, and CFLs in 1999. These have been strengthened over the years.

The January 2012 MEPS requirements for incandescent lamps were as follows:

- 25 W ≤ P < 40 W: ≥ 8.3 lm/W
- 40 W ≤ P < 70 W: ≥ 11.4 lm/W
- 70 W ≤ P ≤ 150 W: ≥ 20 lm/W

From January 2014, all incandescent and halogen lamps were required to be 20 lm/W, which should effectively phase out MV incandescent lamps. However, it is currently unclear if this 2014 requirement has been effectively adopted and enforced. There is also a 1-5 grading requirement, however this would effectively be made redundant by the 2014 MEPS – i.e. the grading levels range from 10.9 to 21.6 lm/W (depending on lamp wattage).

Compact Fluorescent Lamps

CFLs are also subject to MEPS and "grade" standards. The current (2009) MEPS requirements are listed in Table 23 (see MEPS column).

Table 23 – Korean CFL MEPS requirements

Category		MEPS (lm/W)	Target (Lm/w) *(see efficiency grades)*
5 W ≤ P < 10 W	EX-W, EX-N, EX-L	46.1	53.0
	EX-D & etc	45.2	51.9
10 W ≤ P < 16 W	EX-W, EX-N, EX-L	51.3	58.9
	EX-D & etc	50.4	57.9
16 W ≤ P < 21 W	EX-W, EX-N, EX-L	58.2	66.9
	EX-D & etc	57.4	66.0
21 W ≤ P < 25 W	EX-W, EX-N, EX-L	60.0	69.0
	EX-D & etc	59.1	67.9
25 W ≤ P ≤ 60 W	EX-W, EX-N, EX-L	61.7	70.9
	EX-D & etc	60.9	70.0

EX (Extra, Extraordinary rays): Improved Luminous Flux and Colour Rendering performance with more phosphor (Colour rendering index >= 80).
D,N,W,WW,L : Classification according to Colour Temperature: D (Daylight : 5,700~7,100K); N (Neutral White : 4,600~5,400K); W (White : 3,900~4,500K): WW (Warm White : 3,200~3,700K); L (Light : 2,600~3,150K).
Source : KS C 7601, KS A 3325

The "Target" level in Table 23 is used in determining the 1-5 efficiency grades, as shown in Table 24.

Table 24 – Efficiency Grade

R (target efficacy / tested efficacy)	Switching	Grade
R ≤ 1.00	10,000	1
R ≤ 1.00	n/a	2
1.00 < R ≤ 1.05	n/a	3
1.05 < R ≤ 1.10	n/a	4
1.10 < R ≤ 1.15	n/a	5

Product Profile - Incandescent, Halogen and Compact Fluorescent Lamps

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