Report No 2008/08

Equipment Energy Efficiency Committee

Regulatory Impact Statement

Consultation Draft

Proposal to Phase-Out Inefficient Incandescent Light Bulbs

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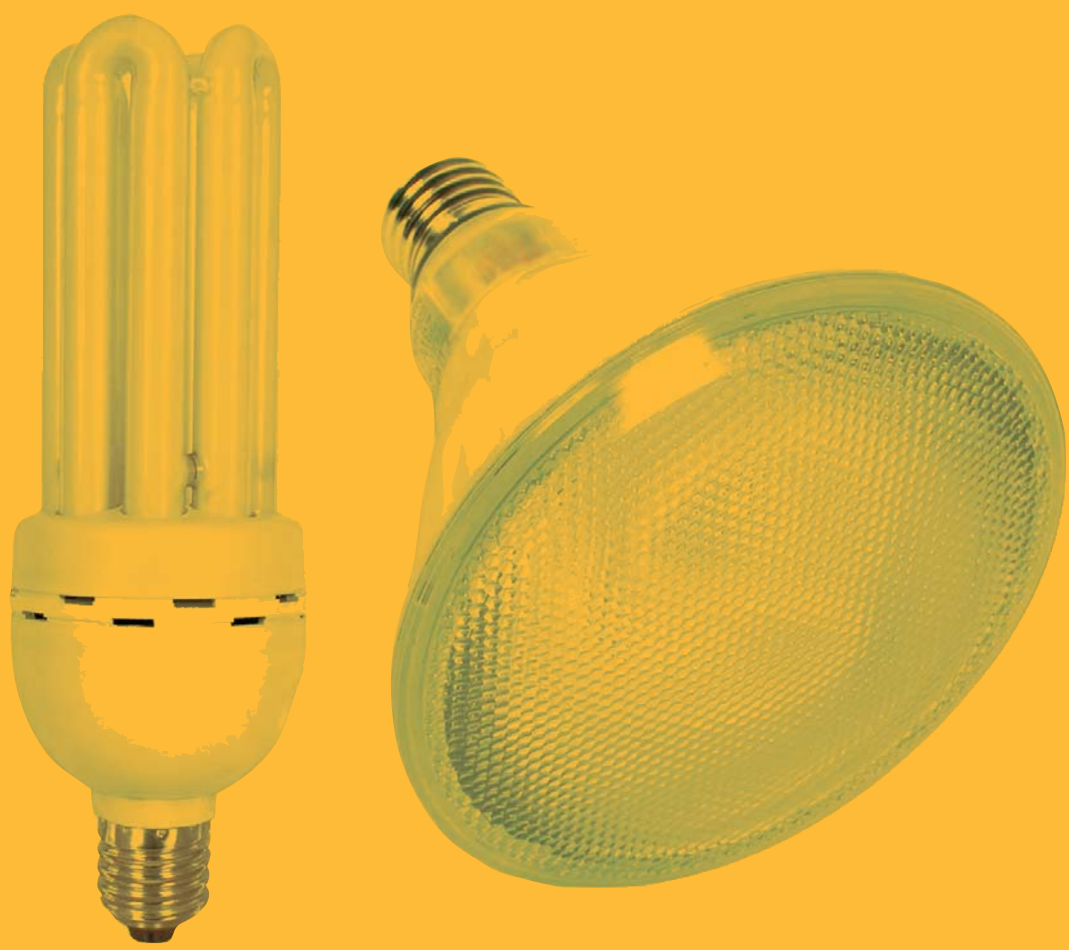
EQUIPMENT ENERGY EFFICIENCY

Discussion draft for stakeholder comment issued under the auspices of the Ministerial Council on Energy



SEPTEMBER 2008

Prepared by Syneca Consulting for DEWHA

This Regulatory Impact Statement was prepared with the assistance of Syneca Consulting and Beletich Associates. This Committee reports to the Ministerial Council on Energy, comprising the energy ministers of the Australian federal, state and territory governments, and of the New Zealand government.

The Committee invites written comments on the proposal and will accept submissions until the close of business on **10 October 2008**.

Comment is invited on any relevant matter. But please refer to the section immediately following the Executive Summary for a consolidated list of the particular issues on which E3 requests stakeholder comment. Please be specific about any concerns that you have and, where appropriate, provide supporting argument and information.

Please address written submissions to:

Mr David Boughey
Lighting and Equipment Energy Efficiency
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Heritage and the Arts
GPO Box 787, Canberra ACT 2601
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Your faithfully,

Melanie Slade
Chair, Equipment Energy Efficiency Committee
Department of the Environment, Water, Heritage and the Arts
11 September 2008

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Glossary

AGO	Australian Greenhouse Office
AS/NZS	Australian Standard/New Zealand Standard
BAU	business as usual
CaSServ	Conformance and Standards Services Pty Ltd
CfAF	Council for the Australian Federation
CFL	Compact Fluorescent Lamps
CoAG	Council of Australian Governments
CO_2-e	carbon dioxide equivalent
CCT	colour correlated temperature
CPRS	Carbon Pollution Reduction Scheme (formally known as the Emissions Trading Scheme)
CRI	colour rendering index
DPMC	Department of the Prime Minister and Cabinet
EES	Energy Efficient Strategies Pty Ltd
ECEEE	European Council for an Energy Efficient Economy
ELVC	extra low voltage converter
EPHC	Environment Protection and Heritage Council
ERAC	Electrical Regulatory Authorities Council
E2WG	Energy Efficiency Working Group
E3	Equipment Energy Efficiency Program
FTC	Federal Trade Commission (US)
GHG	greenhouse gas
GLh	gigalumen-hours (1,000,000,000 lumen-hours)
GLS	General Lighting Service lamps
GWA	George Wilkenfeld and Associates
GWh	gigawatt-hours
IEC	The International Electrotechnical Commission (global organisation that prepares and publishes international standards for electrical, electronic and related technologies)
kHz	kilohertz
kWh	kilowatt-hours
LCA	Lighting Council of Australia
LCC	Life cycle cost
LED	light emitting diode

LRC	Lighting Research Centre
MCE	Ministerial Council on Energy
MEA	Mark Ellis & Associates
MEPS	minimum energy performance standard
MLh	Mega lumen-hours (1,000,000 lumen-hours)
MMA	McLennan Magasanik Associates Pty Ltd
MoU	Memorandum of Understanding
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NETT	National Emissions Trading Taskforce
NFEE	National Framework for Energy Efficiency
NGACs	NSW Greenhouse Abatement Certificates
NHMRC	National Health and Medical Research Council
NIEIR	National Institute of Economic and Industry Research
OBPR	Office of Best Practice Regulation
PC	Productivity Commission
PNNL	Pacific Northwest National Laboratory
MJ	megajoules – 10^6 joules
Mt	megatonnes – 10^6 tonnes
NGS	National Greenhouse Strategy
REC	renewable energy certificate
SEAV	Sustainable Energy Authority Victoria (now Sustainability Victoria)
TJ	terajoules – 10^{12} joules
UNCCC	United Nations Framework Convention on Climate Change
VA	Volt-Amps
W	Watts
WSM	with specific measures
WoSM	without specific measures

Executive summary

This regulatory impact statement (RIS) details a proposal to introduce minimum energy performance standards (MEPS) for incandescent lamps, compact fluorescent lamps (CFLs) and the extra low voltage converters (ELVCs) used to provide power to low voltage halogen lighting systems.

The proposal is part of the work plan of the Equipment Energy Efficiency Program (known as E3), which is an element of Australia's response to climate change. The program is jointly managed and administrated by the Australian Commonwealth, state and territory governments and the New Zealand government.

The problem

General Lighting Service (GLS) lamps are the common pear-shaped incandescent lamps with tungsten filaments. They are the most inefficient yet widely used lamp in the residential sector. They continue to sell remarkably well because, if their energy costs are ignored, they appear cheap. More efficient lamps such as CFLs and halogen types are facing a number of problems breaking into the market. Currently a CFL sells for up to five times more than a regular GLS lamp.

There are significant information failures and split incentive problems in the market for energy efficient lamps. Energy bills are aggregated and periodic and therefore do not provide immediate feedback on the effectiveness of individual energy saving investments. Consumers must therefore gather information and perform a reasonably sophisticated calculation to compare the life-cycle costs of tungsten filament lamps and CFLs. But many lack the skills. For others, the amounts saved are too small to justify the effort or they do not remain at the same address long enough to benefit fully from a long lived energy saving lamp. According to the 2006 census, 17% of people in private dwellings were at a different address 12 months earlier.

Both CFLs and lamp labelling have also had unfortunate histories. Early disappointments with aspects of the performance of CFLs – including problems with start up times, colour and durability – have created uncertainties in the minds of users. Lamp labelling has evolved in way that identifies the lighting power of a lamp with its energy use, inhibiting awareness of energy efficiency lighting options.

The business as usual (BAU) scenario is for Australia's greenhouse emissions from lighting to increase by 150% from 1990 to 2010. Emissions will be approximately 32.4 Mt CO_2-e in 2010 or 5.4% of Australia's the projected total of 603 Mt CO_2-e in 2010. By addressing market failures the proposed measures will reduce greenhouse emissions by 28.5 Mt CO_2-e over the period 2009 to 2020.

Proposal

Initially, E3 proposed to phase out all incandescent lamps, albeit with long delays for certain types of lamp, to 2015. However, this raised serious problems regarding the availability of replacement products, particularly for lighting systems that use dimmers, sensors, timers and other forms of electronic control. The proposal was revised to avoid potentially large costs of prematurely scrapping lighting assets.

The revised MEPS proposal would:

- Remove the least efficient incandescent lamps from the market, including the familiar pear-shaped tungsten filament lamps, otherwise known as general lighting service (GLS) lamps of less than 150 watts;

- Set standards for the efficiency and quality of CFLs; and,
- Remove the least efficient ELVCs from the market.

The proposed MEPS will not ban incandescent lamps and will not mandate wholesale replacement with CFLs. Users will still be able to buy incandescent lamps of the tungsten halogen type. These are generally more efficient than the familiar tungsten filament lamps and, to comply with the proposed MEPS, will need to be the more efficient models of those currently available.

The proposed regulations will result in an increase in demand for CFLs and E3 is acutely aware that inexperienced users could be disappointed with the quality of lighting provided by CFLs of low quality. The purpose of the proposed MEPS for CFLs is to ensure that does not happen. Inferior CFLs have been the bane of past attempts in many countries to expand the market for CFLs. Australia is participating in international efforts to harmonise the various CFL standards that have emerged internationally in response to quality issues.

In regards to issues of quality, CFLs have improved steadily since the technology was commercialised 30 years ago. But CFLs of highly variable quality are still manufactured and sold internationally. The CFLs that are now marketed in Australia are already of superior quality and suppliers say their products already substantially comply with the proposed MEPS for CFLs. The MEPS for CFLs will raise the bar a little but, most importantly, will prevent a decline in product quality as large numbers of inexperience users enter the market for the first time.

The least efficient of the magnetic type of ELVC will not comply with the MEPS that are proposed, and it is expected that most will be replaced with electronic converters. However, the more efficient type of magnetic converter will comply and will be available for use in situations where electronic converters are unsuitable.

E3 proposes a firm date of November 2009 for the retail implementation of MEPS for GLS lamps, extra low voltage (ELV) halogen lamps and CFLs of the non-reflector type, and November 2010 for ELVCs. All other lamp types will have temporary exemptions that will be terminated when, with up-to-date market and product information, E3 determines that suitable replacement products are available. At this stage, it is considered feasible to terminate all exemptions by October 2012, apart from pilot lamps of 25w and below.

It is also proposed to prohibit non-complying imports in the year before the MEPS take effect at the point of sale. This means that MEPS proposed for November 2009 will apply to imports from November 2008. The two-stage arrangement does not extend to ELVCs and is subject to further development in consultation with the Australian Customs Service.

The objective

The objective of the proposed MEPS is to contribute to cost-effective greenhouse gas abatement in Australia. Abatement measures that do not increase the life-cycle cost of appliances are considered to be cost-effective. This means that the value of energy savings is not less than the incremental purchase price of a more efficient appliance.

The measures also need to be efficiently designed to:

- minimise adverse impacts on suppliers and on product quality and function; and
- be clear and comprehensive, minimising potential for confusion or ambiguity for users and suppliers.

Impact assessment

The cost to the taxpayer and business compliance costs are modest compared to the value of energy savings and the contribution to abatement. This is largely because the regulation employs administrative machinery that is well developed and familiar to industry, specifically, Australian standards and the product registration and reporting procedures have been developed by E3. The measures have been developed over a period of time and in consultation with industry.

The continued use of the more efficient types of incandescent lamps deals with a range of issues affecting the competitive supply of lamps and the availability of like-for-like replacements. E3 is committed to continue working with safety and fire authorities to address concerns that have been raised about the electrical safety of CFLs and tungsten halogen lamps in certain situations, including fire hazards. At this stage, however, E3 has no evidence that the lamp substitutions induced by the measures will increase the risk of fire. E3 encourages members of the public to come forward with relevant experience of damage or fire associated with the use of CFLs and tungsten halogen lamps.

A wide range of plausible combinations of lamp type, lamp size, duty hours of the lamp, and type of electricity tariff (residential, commercial and industrial) have been assessed and in general net savings exist. However, there are three exceptions:

- For technical reasons associated with the type of ELVC used with ELV halogen downlights, it is sometimes not possible to re-lamp with a more efficient lamp that draws less power. The new lamp would still be more efficient but, instead of using less energy, it simply generates more light. Most residential users can still save energy by dimming the lamp back to the preferred lighting level. However, a minority of residential users and a majority of commercial users do not employ this feature. They are obliged to take the improved performance as more light but still pay the incremental cost of the improved lamp.
- Lighting costs increase for combinations of small lamps (40 watts or less) or low duty (less than two hours per day) in non-residential applications. These are unlikely combinations, firstly because the smaller lamps are not generally used in commercial and industrial applications, and secondly because such lamps may be on for up to 8 hours per day.
- For technical reasons it is not always feasible to replace a conventional magnetic ELVC with the more efficient electronic type. In such situations the MEPS will require the use of an efficient magnetic ELVC that is significantly more expensive than both the conventional magnetic and electronic types. The energy savings generally don't provide adequate compensation and the cost of the lighting service increases. Suppliers say that the requirement for magnetic ELVCs is small, less than 5% of ELVC sales.

These small cost increases are outweighed by much larger cost reductions in the majority of lighting applications that are affected by the MEPS, to the point where there are weighted average cost reductions in all sectors – residential, commercial and industrial. Table 1 reports the estimated sectoral averages. Note the cost increases for ELV halogen downlights in commercial applications.

TABLE 1 CHANGE IN LIGHTING COSTS: $ PER YEAR

Lamp type	*Residential (per dwelling)*	*Commercial (per million sqm of floorspace)*	*Industrial (per million sqm of floorspace)*
Mains voltage non-reflector lamps	-$25.86	-$250,986	-$14,407
Mains voltage reflector lamps	-$3.73	-$130,160	-$37,780
Extra low voltage reflector lamps	-$0.33	+$1,312	-
Total	**-$30**	**-$379,834**	**-$52,187**

The relatively short operating life of incandescent lamps means that re-lamping and the associated cost reductions will happen relatively quickly, with most gains delivered within several years of implementation. The impact of MEPS for ELVCs will be delayed because the stock of ELVCs can only be renewed as lighting systems are refurbished and new buildings are constructed. The annual cost savings are also more modest, of the order of $1.60/dwelling and $25,000/million square metres of commercial floorspace.

Table 2 provides a summary statement of the nationwide impacts for the period to 2020. On this figuring, the proposed MEPS clearly satisfies the no regrets criterion, that is, delivering abatement at no financial cost to users. The proposals would deliver abatement of 28.5 Mt CO_2-e and simultaneously provide savings of $2,167 million. The cost of abatement is negative, -$135/tonne CO_2-e.

Sensitivity analysis indicates that this positive assessment is not altered by any plausible changes to underlying parameters. Given the wide range of circumstances that have been examined, we are confident that there will be no adverse distributional consequences.

The estimates presented in table 2 allow for a significant contribution from the energy saving incentives created by an emissions trading scheme. Specifically, we calculated the impact of the proposed measures relative to a baseline scenario that assumes no change in *per capita* demand for lighting services or the mix of technologies used to provide those services, and assumed that 25% of the gains observed in 2020 would be achieved without specific lighting measures. That fraction would be delivered by the enhanced incentives to save energy under an emissions trading scheme. The total amount of lighting-related abatement, including the contribution from an emissions trading scheme, is 36.2 Mt CO_2-e.

These abatement contributions are a fraction of the total abatement that is planned for the period to 2020. In 2006, for example, the Australian Greenhouse Office (AGO) estimated that abatement measures will deliver about 1,330 Mt CO_2-e of abatement in the period 2008 to 2020. The proposed lighting measures would contribute about 2.1% of that total.

TABLE 2 SUMMARY STATEMENT OF NATIONWIDE IMPACTS: 2008 TO 2020

Electricity consumption(GWh)	-30,305
Greenhouse emissions (Mt CO_2-e)	-28.5
Financial impacts - undiscounted dollar amounts ($M)	
cost to the taxpayer	+7.70
business compliance costs	+4.44
lamp operating costs (lamps & energy)	-3,883
Financial impacts - present values ($M), discount rate = 7.5%	
cost to the taxpayer	+6.52
business compliance costs	+2.87
lamp operating costs (lamps & energy)	-2,177
Investment analysis ($M)	
total costs	no capital costs*
total benefits	+2,167
net present value	+2,167

Note:
* Both lamps and energy are treated as operating costs of lighting services, which is consistent with normal practice in facilities management. It is analytically cumbersome to treat lamps as capital items, given their low unit cost and their short, variable lives. Hence, we have not calculated a benefit cost ratio.

Policy alternatives
Although a combination of mandatory MEPS, labelling and a communications strategy is recommended as the most effective response, alternative policy options were considered including:

- subsidies for efficient lamps;
- taxes on inefficient lamps;
- disendorsement labelling;
- comparative energy labelling; and
- information campaigns.

The RIS invites comment on the feasibility of these options.

Consultation
E3 developed the MEPS proposals in consultation with suppliers and with industry and lighting professional associations. In December 2007 a technical report was released, setting out the detailed proposal. Submissions on the technical report were received from a total of 25 organisations and individuals. Chapter 6 of this RIS provides a summary of the submissions, however E3 considers that none of the issues raised require the proposal to be altered.

This consultation RIS will provide a further opportunity for stakeholders to provide feedback. E3 has identified particular issues for comment and has consolidated these in the next section of this RIS.

Recommendations
E3 will determine its final recommendation in the light of responses to the consultation RIS.

Request for stakeholder comment

Comment is invited on any relevant matter. However, specific comment and supporting arguments are encouraged on the following matters.

Product profile – section 1.2, pages 3-8

- Does this RIS accurately describe the supply arrangements for relevant lighting technologies?
- Are there any other suppliers or groups of suppliers that should have been identified?

Impediments to energy efficiency – section 1.4, pages 9-21

This section gives an account of barriers to the take-up of energy efficient lighting technologies.

- Does this material overstate the problems?
- Can you provide any other information that would inform the assessment of impediments to energy efficiency?

Role of standards and labelling measures after the carbon reduction scheme is introduced – section 1.5, pages 21-22

The proposed regulation is a measure designed specifically for lighting technologies, and is in addition to other greenhouse abatement measures that are not specific to particular types of energy-using appliances and equipment. The proposed carbon pollution reduction scheme is the major non-specific intervention, imposing a financial penalty on a large proportion of greenhouse emissions, regardless of the specific appliances and equipment involved. This part of the document explains why E3 considers that specific measures are also required.

- Does this section help you to understand the argument for specific measures? Why or why not?
- Do you agree with the rationale? Why or why not?
- Do you have any comment on the criterion that is used, which is to implement measures that provide a real after-tax return of 7.5% per year? Implicitly, E3 asserts that energy users would not regret mandatory investments in energy efficiency that return at least 7.5% per year.

Proposed regulation – section 3.1, pages 24-31 & appendix A

- Does this part of the document adequately and accurately explain the proposed regulation?
- Two elements of the proposal need to be further developed. These are the reform of labelling arrangements and the arrangements for deciding when to terminate exemptions. Do you have any comments or suggestions on those matters?
- E3 has more work to do on the content and channels for a communications campaign. Please review E3's current thinking and offer your suggestions.
- Do you need any other information about the proposal? Please ask.

Alternatives to the proposed regulation – section 3.2, pages 31-47

- Please comment on our assessment of the alternatives to the proposed regulation.

- The proposed regulation does not completely ban incandescent lamps: it allows the continued use of the more efficient incandescent lamps. Do you agree with our assessment of the problems associated with a complete phase-out of incandescent lamps (section 3.2.6)? Please be specific.

Shortlist of policy options – section 3.2, page 31
E3 has shortlisted a number of policy options other than the proposed regulations. These include a range of regulatory and non-regulatory measures. However, E3 has not developed implementation details for these measures and this RIS does not provide a full assessment of each option.

- Is it feasible to achieve the objectives by other means, without the imposition of mandatory minimum energy performance standards?
- Should these alternative policy options be fully developed and assessed, and what further delay would be acceptable in this case?

Business compliance costs – section 4.2, pages 48-50
E3 invites suppliers to comment on the assessment of the 'red tape' costs associated with the proposal. The outstanding matter is the cost of labelling reforms and it would be particularly useful for suppliers to explain the cost factors associated with labelling initiatives.

Continued competition in supply of lighting products – section 4.3, pages 50-53
There is strong competition for the supply of lighting products and it would be a concern if the proposed regulation weakened the competitive process.

- Do you have any concerns that the regulations unfairly favour particular products or suppliers, other than on the basis of energy efficiency?
- Should we be more concerned about potentially adverse side effects that are explained in section 4.3.1 – interference with network operations, loss of free heating, and excess light?
- Users will need to adjust their lamp selection and purchasing routines and, to a degree, will learn by trial and error. Is it fair to say that this will seldom be more than a minor nuisance? What are the implications for E3's communications campaign?
- Would implementation of any of the policy options have the potential to reduce incentives for manufacturers to innovate, improve product quality and reduce prices?

Direct financial impact on residential, commercial and industrial users – section 4.4, pages 53-69
This section reports the substantive modelling of the impact of the proposal on the cost of lighting services. The assessment is overwhelmingly positive. The reader needs to understand (a) the concept of 'annualised life cycle cost' (sections 4.4.1 for Australia), (b) that beneficial impacts are reported as reductions in annualised life cycle cost, with a negative sign, (c) that exemptions will not be terminated until it becomes apparent that effective and affordable replacements will be available, and (d) in some cases it has been necessary to make a 'best guess' at the incremental cost of replacement lamps.

- Do you understand the concept of annualised life cycle cost, or does it need to be better explained?
- The intention of the regulation is to improve the energy efficiency of general purpose lighting without affecting activities that have special lighting needs, such as operating theatres, stage productions and movie-making. Do you have any concerns about activities that may be adversely affected by the measures? Please be specific.

- Do you accept that, given the level of MEPS and the implementation schedule proposed; like-for-like replacements will be available and users will therefore not be required to prematurely scrap lighting assets such as switches, dimmers, sensors, wiring and luminaires?
- How do you rate the product qualities of CFLs relative to incandescent lamps? Are CFLs superior to incandescent lamps, adequate replacements for incandescent lamps, or decidedly inferior products?
- To what extent are any concerns about CFLs moderated by the continued availability of the more efficient types of incandescent lamps, that is, tungsten halogen lamps in both mains voltage and low voltage configurations?
- Have we made unrealistic assumptions about the price of lamps or energy?
- Do you accept that the proposed measures can deliver outcomes that are overwhelming positive, and that adverse outcomes are minimal?
- Is there a need for more detailed analysis or more detailed reporting? Please be specific.

Impacts on health, safety and the environment – section 4.5, pages 69-72
This section explains the issues that have been raised in the media and otherwise put to E3, relating to the mercury content of CFLs and the electrical safety of CFLs and tungsten halogen lamps. These are issues that are primarily the concern of other agencies or other processes, and E3 decided to proceed with the consultation RIS before those matters are fully resolved.

- Is this reasonable?
- Do you have any information that would inform the assessment of impacts on heath, safety and the environment?

We have not assessed whether the emissions associated with the production and distribution of CFLs exceeds the emissions associated with the manufacture of an equivalent number of tungsten filament lamps. Implicitly, it is assumed that the operating energy dominates the environmental impacts of lighting services.

- Is this reasonable?

Nationwide impacts – section 4.6, pages 73-76
This section reports estimates of the aggregate contribution to greenhouse abatement and the associated financial savings. The measures are assessed as highly cost effective.

- Does the nationwide assessment seem plausible?
- The measures have been assessed as highly cost effective, delivering abatement at negative cost, -$135/tonne CO_2-e for Australia. Does that seem reasonable?

Sensitivity and distributional analysis –section 4.7, pages 76-78

- Is there a need for additional sensitivity analysis?
- Based on the assessment of direct financial impacts and the sensitivity analysis, we make a strong statement that there are no adverse distributional effects. Is that a reasonable interpretation of the analysis?

Closing date and address for submissions
Written submissions will be accepted until the close of business on **10 October 2008**. Please address all written submissions to:

Mr David Boughey
Lighting and Equipment Energy Efficiency
Department of the Environment, Water, Heritage and the Arts
GPO Box 787, Canberra ACT 2601
Or via email to:
energyrating@environment.gov.au

1. The Problem

This regulatory impact statement (RIS) assesses a proposal by the Equipment Energy Efficiency (E3) Committee to mandate minimum energy performance standards (MEPS) for incandescent lamps, for compact fluorescent lamps (CFLs) and for extra low voltage converters (ELVCs) used for extra low voltage halogen lighting systems, and to impose certain other standards and labelling measures in support of the main proposal.

All Australian jurisdictions have agreed to regulate products where the benefits exceed the costs.

1.1 Energy efficiency policy

Australia's greenhouse abatement and climate change policies have evolved consistently for more than 15 years, since the release of the National Greenhouse Response Strategy in 1997. The paper received overall bi-partisan support, including for national energy efficiency measures. Appendix B records some of the more important stages in that development.

In May 2007, the Prime Minister's Task Group released its report on the introduction of an Australian emissions trading system, which endorsed the support of complementary measures as a means to address market failures where an Emissions Trading Scheme was not effective:

> *Beyond information-based policies, energy efficiency policies could target areas where market barriers are likely to be more fundamental and enduring. This is likely to be in areas where consumers make infrequent decisions and where it is difficult to judge the energy and emissions implications. There is a good case for continuing the development of well-designed and consistent regulated minimum energy standards for buildings and households appliances. Purchase of energy-efficient products can have a large impact on aggregate emissions over time, and reduce the impact on household budgets of any rise in carbon prices.* (DPMC 2007 pp135)

Similarly in July 2007, the Prime Minister released *Australia's Climate Change Policy – our economy, our environment, our future*. The policy reasserted that energy efficiency regulation remains a key element of cost effective greenhouse abatement:

> *Energy efficiency is an important way to reduce greenhouse gas emissions cheaply. Demand for electricity in Australia is expected to more than double by 2050. Improvements in energy efficiency have the potential to lower that projected growth, and avoid greenhouse gas emissions. They can also deliver a net financial gain for firms and consumers. ... The MEPS programme is one of the main success stories of the National Framework for Energy Efficiency (NFEE). The NFEE was developed cooperatively across jurisdictions and covers a range of policy measures, designed to overcome market barriers to energy efficiency.* (pp 16-17)

Most recently, on 11 March 2008, Australia's ratification of the Kyoto Protocol was officially recognised by the United Nations Framework Convention on Climate Change (UNCCC). Under Kyoto, Australia is obliged to limit its greenhouse gas emissions in 2008-2012 to 108 per cent of 1990 emission levels. The Australian Government has also released a report demonstrating how Australia intends to measure the reductions in emissions required under Kyoto titled Australia's Initial Report under the Kyoto Protocol.

The MCE moves beyond "No Regrets" energy efficiency measures

In October 2006, the Ministerial Council on Energy (MCE, comprised of Australian federal, state and territory and New Zealand government energy ministers) agreed to new criteria for assessing new energy efficiency measures. The MCE replaced its previous "no regrets" test (that a measure have private benefits excluding environmental benefits which are greater than its costs) with the criteria that the MCE would consider *…new energy efficiency measures which deliver net public benefits, including low cost greenhouse abatement measures that do not exceed the cost of alternate measures being undertaken across the economy*.

This means the MCE will consider regulatory measures that may have net up-front costs but have greater private economic and greenhouse benefits over the long term, recognising that prudent investment now may avoid more costly intervention later.

International Energy Agency (IEA) sees improving energy efficiency as top priority

Australian policy is in accord with international endeavours in this field.

> *The IEA estimates that under current policies, global emissions will increase 50% by 2030 and more than double by 2050. However, if we act now, this unsustainable and dangerous pattern can be curbed. IEA findings show that emissions could be returned to current levels by 2050 and even reduced thereafter, while an ever-growing demand for energy services, notably in developing countries, can be fully satisfied. Improving energy efficiency in the major consuming sectors – buildings and appliances, transport and industry – must be the top priority. While alleviating the threat of climate change this would also improve energy security and have benefits for economic growth.* – Claude Mandil, Executive Director, IEA, Paris, February 2007.

Australia is at the forefront of international initiatives to improve the energy efficiency of globally traded products.

Equipment Energy Efficiency Program

In Australia, regulatory intervention in the market for energy-using products was first introduced with mandatory appliance energy labelling by the NSW and Victorian Governments in 1986. Between 1986 and 1999 most state and territory governments introduced legislation to make energy labelling mandatory, and agreed to co-ordinate labelling and minimum energy performance standards (MEPS) decision making through the MCE.

The proposed regulation is an element of the Equipment Energy Efficiency Program (E3). E3 embraces a wide range of measures aimed at increasing the energy efficiency of products used in the residential, commercial and manufacturing sectors. E3 is an initiative of the MCE comprising ministers responsible for energy from all jurisdictions, and is an element of Australia's National Framework for Energy Efficiency (NFEE). It is organised as follows:

- Implementation of the program is the direct responsibility of the Equipment Energy Efficiency Committee, which comprises officials from Australian federal, state and territory government agencies and representatives from New Zealand. They are responsible for implementing product energy efficiency initiatives in the various jurisdictions.
- The E3 Committee reports through the Energy Efficiency Working Group (E2WG) to the MCE and is ultimately responsible to the MCE.
- The MCE has charged E2WG to manage the overall policy and budget of the national program.

- Members of the E3 Committee work to develop mutually acceptable labelling requirements and MEPS. New requirements are incorporated in Australian standards and developed within the consultative machinery of Standards Australia.
- The program relies on State and Territory legislation for legal effect in Australia, enforcing relevant Australian Standards for the specific product type.

The appliances and equipment that are included in the E3 program must satisfy criteria of feasible and cost effective intervention. These include potential for energy and greenhouse gas emissions savings, environmental impact of the fuel type, opportunity to influence purchase, the existence of market barriers, access to testing facilities, and considerations of administrative complexity. Policy measures are subject to a cost-benefit analysis and consideration of whether the measures are generally acceptable to the community.

E3 provides stakeholders with opportunities to comment on specific measures as they are developed by issuing reports (including fact sheets, technical reports, cost-benefit analyses and regulatory impact statements) and by holding meetings.

1.2 Product profile

Product technologies - lamps
The proposal affects two broad types of lamp technology – incandescent and fluorescent. Incandescence refers to the state of a body caused by approximately white heat and is produced in incandescent lamps by passing an electric current through a tungsten filament. Fluorescence is the property of emitting light on exposure to radiation. The tubes of fluorescent lamps are coated with a fluorescent substance that is bombarded with radiation when a current passes through the argon and mercury gas that fills the tube.

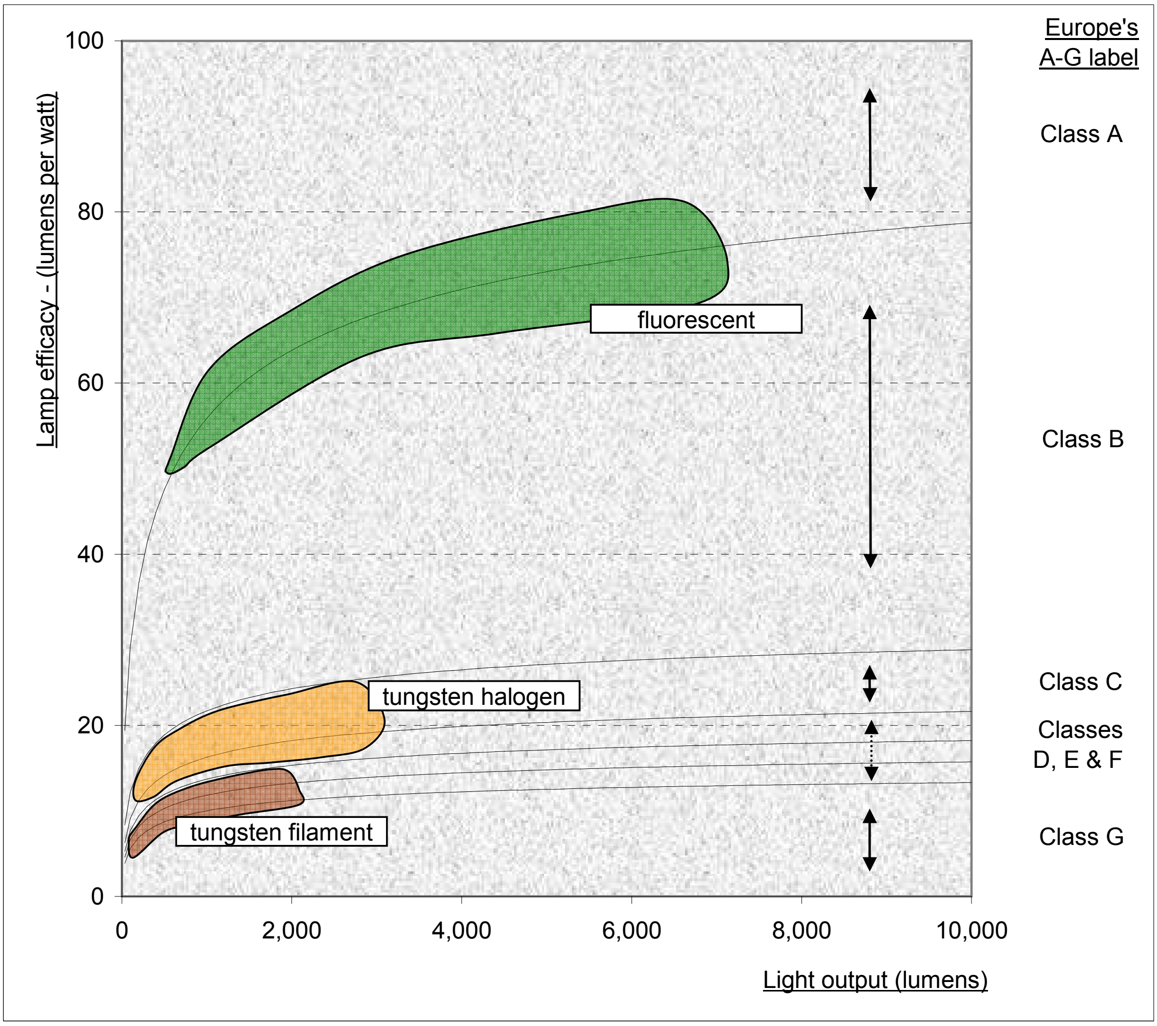
Two other technologies – high intensity discharge (HID) and solid state lighting (SSL) – are not directly affected by the measures[1].

We use figure 1.1 to briefly describe the energy efficiency characteristics of the various lamp technologies. Note the following:

- Light output is measured along the horizontal axis in lumens, which is a measure of the amount of visually useful radiation that is emitted by a lamp. For example, a common 60 watt globe emits approximately 750 lumens.
- Lighting professionals use the term ‘efficacy’ for the ratio of the rate of light production (lumens) to the rate of energy input (watts). Efficacy is measured along the vertical axis in lumens/watt.
- In 1998 the European Union introduced a lamp labelling scheme with 7 classes, labelled A to G. The thresholds increase with lamp output because it is easier to efficiently produce large amounts of light and more difficult to efficiently produce small amounts of light. The incremental class thresholds are extremely non-linear, with relatively small differences between classes D and G in the lower regions but a larger gap between classes A and C in the upper regions – see figure 1.1.
- Incandescent lamps convert less than 10% of the radiation emitted by a white hot body into light, and inhabit the lower regions of figure 1.1. Suppliers seldom place incandescent lamps higher than class C.

[1] HID lamps are used where high levels of light are required over large areas, such as for street-lighting and large public areas. SSL is a promising lighting technology lamps are not expected to be commercially viable before 2015.

FIGURE 1.1 EFFICACY OF RELEVANT LIGHTING TECHNOLOGIES



- There are several broad types of incandescent technology:
  - 'Tungsten filament' lamps are the cheapest and most widely used type of incandescent lamp and are predominately graded to class E or class F.
  - 'Tungsten halogen' lamps also have a tungsten filament. The difference is that they contain small quantities of a halogen gas as well as the inert gases (typically argon and nitrogen) that are contained in the conventional tungsten filament lamp. The halogen allows higher filament temperatures that increase efficacy and generate a whiter light, lifting tungsten halogen lamps into classes C and D. It also extends lamp life by setting up a "halogen cycle" that redeposits evaporated tungsten onto the hot surface of the filament.
  - A further refinement of tungsten halogen technology is to use coatings that reflect infra red radiation back into the bulb, further increasing temperature and efficacy.
- Both linear[2] fluorescent lamps and CFLs of reasonable quality inhabit the upper regions of figure 1.1 – either the Grade A or upper Grade B parts of figure 1.1. This report is concerned mainly with the compact type since CFLs would be directly

[2] Confusingly, the 'linear' description refers to all non-compact fluorescent lamps, including the circular type as well as those that are actually linear.

subject to MEPS. Linear fluorescent lamps will have a very minor role in replacing incandescent lamps and are already subject to MEPS.

- The data in figure 1.1 overstates efficacy in several ways.
  - It reports the initial efficacy of lamps, whereas efficacy declines over the life of most lamps.
  - It excludes the energy consumed by the external ballasts that maintain the correct voltage and current to fluorescent lamps. Some types of fluorescent lamps are self ballasted, including most CFLs.
  - It excludes the energy consumed by the ELVCs in low voltage lighting systems.
  - It excludes the reduction in efficacy when lamps on dimmer circuits are operated at less than full power.
  - It excludes the energy consumed internally by dimmers and sensors.

The energy used by dimmers and sensors is small enough to be entirely ignored. The reduction in efficacy over the life of lamps can also be ignored, since it is experienced as a reduction in light intensity, not a reduction in energy use. Our estimates of energy use and energy savings make appropriate allowances for the remaining factors.

Lighting technologies can be further disaggregated according to a number of lamp design and performance characteristics. For example, most lamps of interest are produced in reflector and non-reflector versions: the former have built-in reflector that shines the light in the desired direction. There are also differences in lamp life, light quality, lumen maintenance over the life of the lamp, and sensitivity of lamp life to switching.

Product technologies - ELVCs

Voltage converters for extra low voltage (ELV) electricity are used to reduce the voltage of mains electricity supply to a lower voltage, typically 12 volts, for operating ELV halogen lamps. (Hereafter, we refer to converters as ELV converters or ELVCs. They are also commonly called transformers. The lower voltage allows the use of a much smaller filament, creating a dot shaped point of light that can be easily focused and directed by a small light capsule.) ELVCs are supplied with screw terminals, flying leads or in some cases a mains plug. They are typically installed in a ceiling or wall cavity, close to the ELV lamp, since the transmission of power at low voltage requires thicker wires and incurs higher line losses.

ELVCs can either be magnetic or electronic type. Magnetic converters consist of a ferrous metal core wrapped with primary and secondary electrical windings. Electric current in the primary (mains) winding induces a magnetic flux in the core, which in turn induces a low voltage current in the secondary winding. The ratio of voltage reduction from the primary to secondary terminals is approximately proportional to the ratio of the number of coils in the primary and secondary windings. The output voltage of magnetic converters is typically not regulated but may incorporate varying forms of simple overload protection.

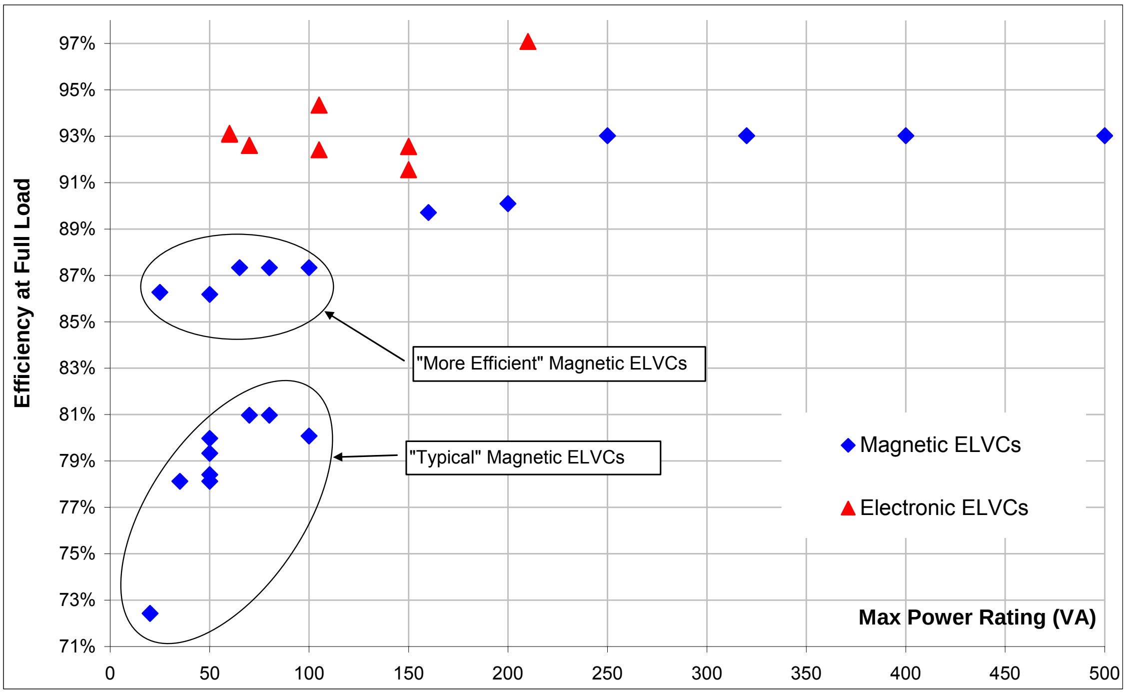
Electronic converters do the same job electronically, first converting mains frequency alternating current (50 or 60 Hz) into high frequency alternating current (typically 10-100kHz), and then passing it through a small magnetic transformer to reduce the output voltage to 12 volts of alternating current at 10-100 kHz. Units providing direct current output are also available and are used to reduce radio frequency interference and cable self-inductance over long circuits. Electronic converters are smaller and lighter than magnetic converters, and often include output voltage regulation with sophisticated protection circuitry and soft lamp starting characteristics.

Some energy is lost as current is converted to low voltage and the efficiency of ELVCs is therefore reported as the ratio of output power to input power. More efficient ELVCs lose less energy in the conversion process, which means that they use less input electricity to produce the same amount of output electricity. For example, an ELVC that consumes 10% of the input energy is said to be 90% efficient.

Electronic ELVCs are typically more efficient than magnetic units – see figure 1.2. This data indicates that the losses vary from 3% (efficiency = 97%) to about 27% (efficiency = 73%). We understand that there has been little change in the efficiency of either the magnetic or electronic types over the past 10 years, but the market share of the magnetic type has fallen.

It is apparent from figure 1.2 that most of the variation in efficiency occurs amongst magnetic converters with lower power ratings, in the range up to 100 VA. Note the group of 'more efficient' magnetic designs with rating less than 100 VA but efficiencies in excess of 85%. We understand that this group includes the 'toroidal' type of magnetic converters with windings around a donut-shaped core. This arrangement improves efficiency but winding these converters is a more involved process that adds to cost. We have conflicting advice on whether conventional magnetic designs can achieve the higher levels of efficiency.

FIGURE 1.2 FULL LOAD* EFFICIENCY OF ELV CONVERTERS



Source:
Manufacturer catalogues and laboratory testing in 2004. IEA has reported a similar range of efficiencies, saying that *…losses range from 5% to 25% at full load* (IEA 2006: page 507)
Note:
Full load mode occurs when a converter is switched on, the maximum load is connected (that is, an appropriately sized lamp), and the lamps is undimmed. In this mode the converter loses power according to its full load loss rating. The losses at part load – that is, when dimmed – are not fully understood but it is known that the percentage losses can be higher under part loads (IEA 2006: page 507).

Product supply chain - lamps
All lamps are now imported, the last Australian factory having closed in April 2002. Therefore, the import data since that closure provides good estimates of the total number and mix of lamps purchased. Basic facts include:

- Average annual imports were 130 million for the period 2003-06.

- A breakdown of imports by exporting country indicates that China and Indonesia are the major suppliers in terms of the number of lamps, with a combined share of 60%. Two other Asian countries (Thailand and Taiwan) and three European countries (Germany, Italy and Hungary) have market shares of 4-8%.
- Asian countries, particularly China, have increased market share.
- Table 1.1 provides the breakdown of imports by lamp type. Incandescent lamps account for 73% of Australian imports (tungsten filament 58%, tungsten halogen 15%). Fluorescent lamps account for most of the remainder (linear fluorescent 14%, compact fluorescent 10%).

Several types of organisation are involved in the importation and distribution of lamps.

- *Multi-national companies:* There are several international brands – GE, Megaman, Osram and Philips – that are imported or distributed through subsidiaries or agents. These are listed in table 1.2. Multinationals own some factories but also contract with generic manufacturers for the supply of 'commodity' lamps.
- *Local importer/wholesalers:* Several companies have established local brands – Crompton, Nelson, Mirabella and Sylvania. They do not own factories but enter into partnerships or contractual arrangements with generic manufacturers.
- *Local importer/retailer:* Supermarkets and other large retailers have the capacity to enter directly into supply arrangements with manufacturers, and may have a house brand.

TABLE 1.1 LAMP IMPORTS BY TYPE OF LAMP: AUSTRALIA, 2003-06 (%)

Type of lamp	*Non-reflector type*	*Reflector type*	*Total*
Incandescent	**56.5%**	**16.4%**	**73.0%**
Tungsten filament	52.5%	5.9%	58.4%
Tungsten halogen	4.0%	10.5%	14.6%
Mains voltage	*1.3%*	*2.1%*	*3.4%*
Low voltage	*2.7%*	*8.4%*	*11.2%*
Fluorescent			**23.8%**
Linear			*14.2%*
Compact			*9.6%*
High intensity discharge			**3.2%**
TOTAL			**100.0%**

TABLE 1.2 TYPES OF LAMP IMPORTER

Brand	*Company*	*Parent domicile*
	Subsidiaries of multi-national manufacturer/importer/wholesaler	
GE	GE Lighting Australia Ltd	United States
Osram	Osram Australia Pty Ltd	Germany
Philips	Philips Lighting Pty Ltd	Netherlands
	Agents for multinational manufacturer/importer/wholesaler	
Megaman	Cosmoluce Pty Ltd	Local
Sylvania	Lighting Corporation Ltd	Local
	Local importer/wholesalers	
Crompton	Lighting Corporation Ltd	Local
Nelson	HPM Group	Local
Mirabella	Mirabella International Pty Ltd	Local
	Local importer/retailers	
House brands	Coles, Woolworths, Mitre10	Local

- *Suppliers & installers:* Lamps are provided as part of lighting installations. The Australian Yellow pages list 790 wholesalers and manufacturers of lighting and lighting accessories, and 1,253 retailers of lighting and lighting accessories. A further 193 companies that appear to be lamp maintenance and replacement specialists.
- *Generalist retailers:* Households obtain most replacement lamps from supermarkets, homeware and hardware stores.

Product supply chain - ELVCs
Electronic converters are certainly imported to Australia, mainly from Asian countries, and it is expected that magnetic converters are also imported from the same sources. The more efficient types of magnetic converter are manufactured overseas and can be imported to Australia. Unfortunately, import data cannot be disaggregated to the level needed to identify quantities and sources of converter imports.

Regarding domestic production, we understand the situation as follows:

- TridonicAtco is the major Australian manufacturer of magnetic and electronic converters of the type that will be subject to the MEPS. It is a wholly owned subsidiary of its Austrian parent, TridonicAtco GmbH & Co KG. Its current range of magnetic converters does not comply with the proposed MEPS.
- Torema Australia Pty Ltd manufactures the more efficient type of magnetic converter, including for ELV halogen lamps. There other Australian manufactures but none, so far as we are aware, that manufacture the more efficient type of converter for lighting applications.

National standards and labelling measures
At present the only standards and labelling measures in Australia are MEPS for linear fluorescent lamps and the respective ballast. However, the recently published *Greenlight Australia* strategy (NAEEEC 2004b) proposes a package of measures:

- *High priority MEPS:* for ELVCs, CFLs, public amenity lighting, luminaires, tungsten halogen lamps, high pressure sodium lamps, and ballasts for high intensity discharge lamps.
- *Future MEPS:* second round of MEPS for linear fluorescent lamps and ballasts, plus MEPS for traffic signals, emergency and exit lighting, photoelectric cells and tungsten filament lamps.
- *Energy labelling:* priorities not decided but consideration given to ELVCs, luminaires, CFLs and fluorescent ballasts
- *Market transformation initiatives:* high efficiency products database plus education and training for specifiers.

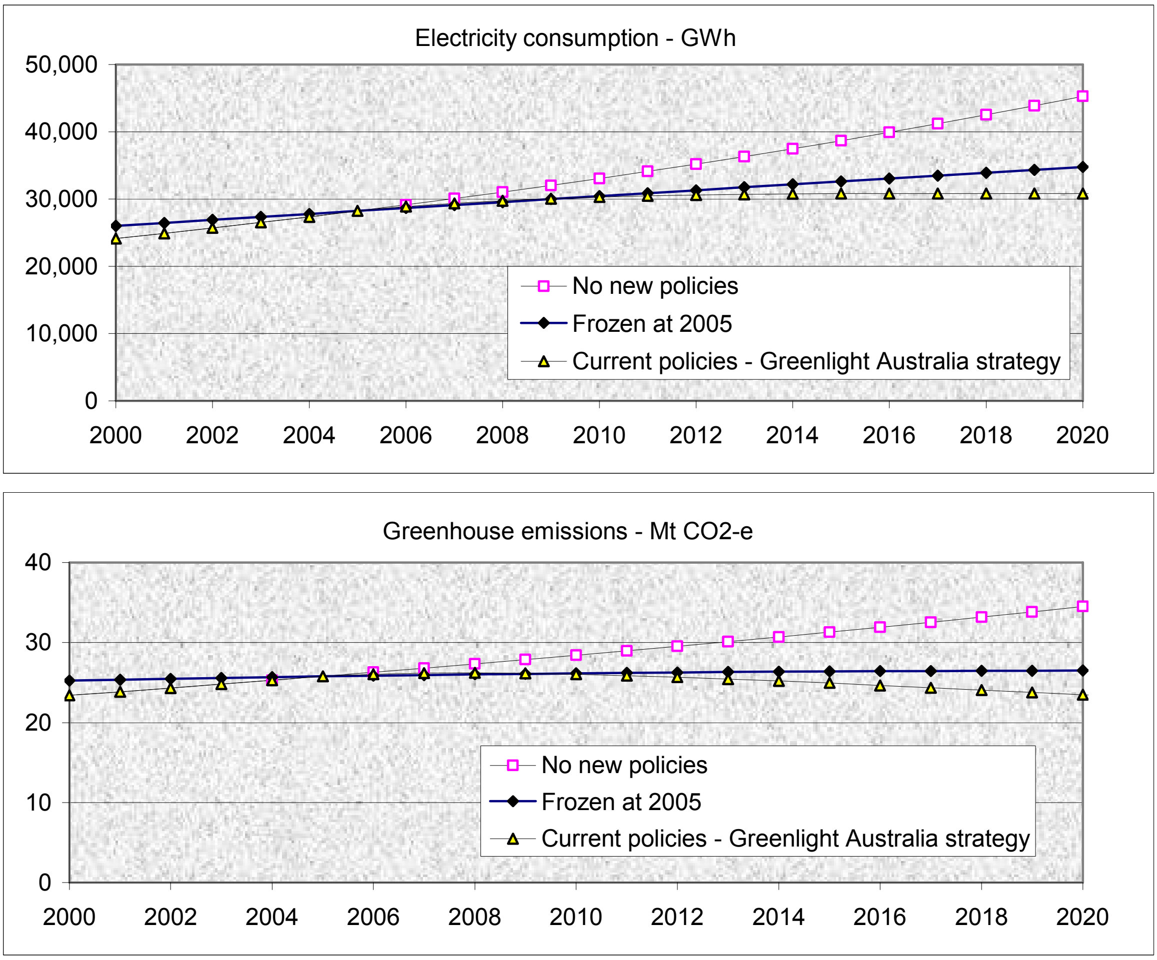
1.3 Projections of energy use and greenhouse emissions

Figure 1.3 shows the projections that were developed for the purposes of the *Greenlight Australia* strategy, but re-based to conform to the model of the lighting task that has been developed for this RIS.

- <u>No new policies</u>: *Greenlight Australia* projected growth of 3.2% per year in the absence of any new lighting policies, implying growth of about 50% in the period from 2002 to 2015.
- <u>Current policies</u>: *Greenlight Australia* set targets to restrict further growth to 20% in lighting energy consumption over the period 2002 to 2015 and reduce the rate of growth to zero by 2015.

The remaining projection is based on the assumption that the lighting configuration observed in 2005 remains ‘frozen’, which means that lighting energy consumption grows in line with the building stock. Average annual growth in the period 2005 to 2020 is 1.4%.

FIGURE 1.3 SCENARIOS FOR LIGHTING ELECTRICITY CONSUMPTION AND GREENHOUSE GAS EMISSIONS



1.4 Impediments to energy efficiency in the market for lamps

This section explains why lamp users may not minimise the lifecycle cost of lighting services, due to imperfect information and split incentives. The following section (1.5) discusses whether these market failures would still be a policy concern in the presence of a CPRS.

Imperfect information

It is assumed that users prefer to reduce the cost of lighting services where possible and therefore have an incentive to acquire the information about the cost of alternative technologies, including energy costs. However, the assessment task is not trivial.

- The user must first identify the alternative lamps that are capable of performing a particular lighting task. This is a reasonably complex matter involving, at a minimum, the amount of light produced, the colour appearance of surfaces that are illuminated and the colour appearance of the light itself. These lighting qualities are quantified, respectively, as the lumens, the colour rendering index[3] (CRI) and the colour correlated temperature[4] (CCT) of the lamps.

- Further, the user needs to compare the price of the alternative lamps and make appropriate adjustments for differences in lamp life. This is a significant factor. For example, CFLs may be four to five times more expensive than tungsten filament lamps but last six to eight times longer. In terms of purchase cost per hour of operation, a CFL is often cheaper than a tungsten filament lamp.
- The user needs to calculate or otherwise identify the amount of energy consumed by the alternative lamps and, using their marginal electricity tariff, calculate the energy costs of the alternative lamps.
- The user needs to allow for any differences in the time profile of the costs of alternative lamps, which requires information about the duty hours of the lamp and the application of an appropriate discount rate.
- Finally, the user requires a good basis for either trusting the sources of such information or verifying the promised performance, and the ability to do the arithmetic.

The question is the extent to which households are able to 'do the sums' in this way. We have considered the following matters.

Imperfect feedback from energy bills
Lack of information is not critical where users have opportunities to learn quickly and cheaply from experience and experimentation. For example, users can get rapid feedback on their choice of coffee: each purchase is relatively cheap and feedback on the product, via tasting, is immediate.

In contrast, feedback on the energy performance of energy saving lamps is impeded by the fact that (a) users are not billed separately for the energy used by each appliance, (b) the energy bill is also periodic, at intervals of 2 or 3 months, and (c) the interpretation of energy bills is complicated by seasonal variation in energy consumption and the payment of varying marginal tariffs under block tariff arrangements. Electrical appliances are therefore at the more difficult end of the spectrum of purchasing decisions. They are best regarded as 'credence goods' or 'experience goods', as opposed to 'search goods'[5].

- The attributes of a search good can be fully determined prior to use, for example, a greeting card.
- The attributes of an experience good can be determined only with use, for example, motor vehicles and other durables that users value for their whole-of-life performance, including ongoing reliability and costs of operation and maintenance.
- The attributes of credence goods may never be discovered – for example, a medical procedure – or may be determined only after a very long delay.

It seems highly significant that users do not have immediate feedback on the full costs of lighting services: electricity accounts for about 90% of the lifecycle costs of a 60 watt tungsten filament lamp[6].

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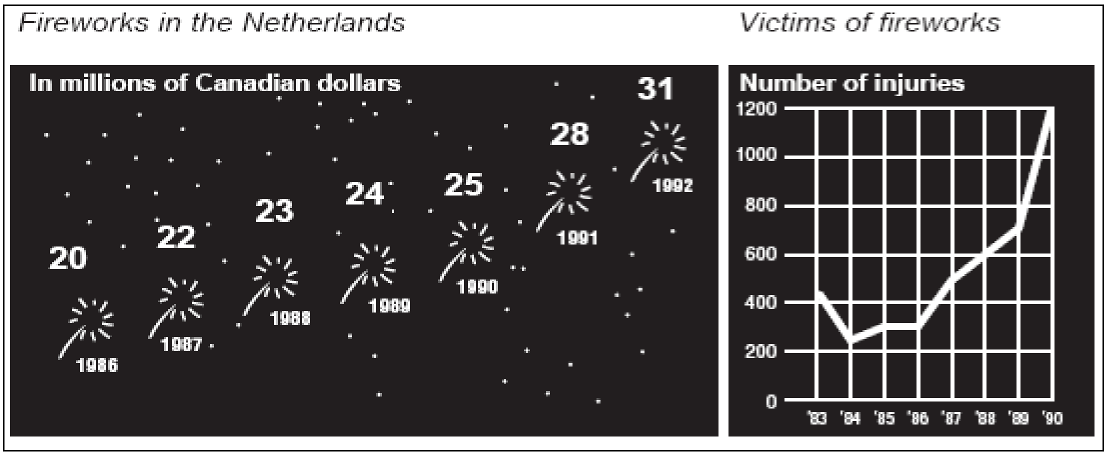
[3] Objects look 'natural' in the light of an incandescent lamp, as though illuminated by sunlight, but can look odd under fluorescent lighting, depending on the quality of the lamp. The CRI measures this quality on a scale of 1 to 100, with sunlight at 100 and most incandescent lamps close to 100. Recent generations of fluorescent technologies are in the range 70-95 and compact fluorescent lamps are in the range 82-85.
[4] The correlated colour temperature (CCT) is reported in degrees Kelvin and relates to the chromaticity of a black body heated to that temperature. (IEA 2006: page 106)
[5] This distinction originated with an article by Philip Nelson (Nelson 1970).
[6] A 60 watt tungsten filament lamp consumes 60 kWh over its life of 1,000 hours, with a value of about $9 (= 60 * 15 cents/kWh). The lamp itself typically costs less than $1.

Sizeable minority without strong pre-purchase assessment skills
A proportion of the population appear to lack the literacy, numeracy and problem-solving skills that may be required to 'do the sums'. While E3 has not directly tested the skill set of the general population with regard to the ability to 'do the sums', results of the ABS survey of adult literacy and life skills (ABS Cat 4428.0) indicate that a significant minority would have difficulty. Specifically, on tests of literacy and numeracy, the ABS estimated that the following proportions of the adult population in private dwellings are at Level 1 or Level 2, where Level 1 is the lowest level of literacy and numeracy on a scale from Level 1 to Level 5.

- document literacy – 46.8%
- prose literacy – 46.4%
- numeracy – 52.5%

To understand what these numbers mean, it is necessary to review the Level 3 tasks: these are the 'next most difficult' tasks that could not be performed by survey respondents on Levels 1 and 2. Examples of the Level 3 tasks are provided in a report jointly published by Statistics Canada and the OECD – *Learning a Living: First Results of the Adult Literacy and Life Skills Survey*[7] – and the interested reader should refer to that publication for a detailed explanation. For the purposes of this RIS, however, the following indicate the difficulty of Level 3 tasks.

- Document literacy: A document literacy task from the middle of Level 3 required the reader to look at the following charts involving fireworks from the Netherlands and to write a brief description of the relationship between sales and injuries based on the information shown.

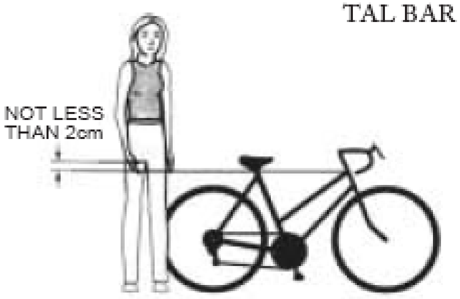


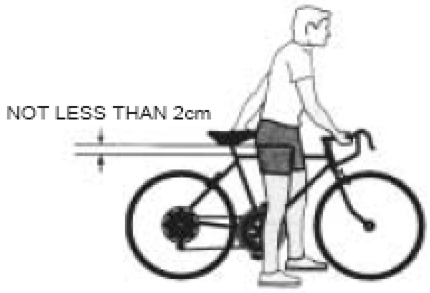
- Prose literacy: One of the prose literacy tasks at the lower end of Level 3 refers to the following page from a bicycle's owner's manual and requires the respondent to determine how to ensure the seat of a bicycle is in the proper position. The respondent needs to identify, in writing, that the seat is in the proper position when the sole of the rider's foot is on the pedal in its lowest position and the rider's knee is slightly bent.

[7] http://www.oecd.org/LongAbstract/0,3425,en_2649_37455_34867439_1_1_1_37455,00.html
The International Adult Literacy Survey (IALS) was a large-scale co-operative effort by governments, national statistical agencies, research institutions and the Organisation for Economic Co-operation and Development (OECD). The development and management of the survey were co-ordinated by Statistics Canada and the Educational Testing Service of Princeton, New Jersey.

PROPER FRAME FIT

RIDER MUST BE ABLE TO STRADDLE BICYCLE WITH AT LEAST 2 cm CLEARANCE ABOVE THE HORIZONTAL BAR WHEN STANDING.





NOTE: Measurement for a female should be determined using a men's model as a basis.

PROPER SIZE OF BICYCLE

FRAME SIZE	LEG LENGTH OF RIDER
430mm	660mm-760mm
460mm	690mm-790mm
480mm	710mm-790mm
530mm	760mm-840mm
560mm	790mm-860mm
580mm	810mm-890mm
635mm	860mm-940mm

OWNER'S RESPONSIBILITY

1. **Bicycle Selection and Purchase:** Make sure this bicycle fits the intended rider. Bicycles come in a variety of sizes. Personal adjustment of seat and handlebars is necessary to assure maximum safety and comfort. Bicycles come with a wide variety of equipment and accessories . . . make sure the rider can operate them.
2. **Assembly:** Carefully follow all assembly instructions. Make sure that all nuts, bolts and screws are securely tightened.
3. **Fitting the Bicycle:** To ride safely and comfortably, the bicycle must fit the rider. Check the seat position, adjusting it up or down so that with the sole of rider's foot on the pedal in its lowest position the rider's knee is slightly bent. **Note:** Specific charts illustrated at left detail the proper method of deter-mining the correct frame size.

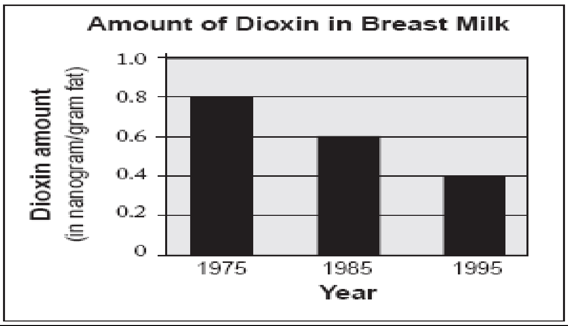
The manufacturer is not responsible for failure, injury, or damage caused by improper completion of assembly or improper maintenance after shipment.

- *Numeracy*: One of the numeracy tasks at the lower end of Level 3 referred to the following graph and accompanying text on the levels of dioxin in breast milk. Respondents were not required to calculate the amount of change over each of the periods, just describe in their own words the change in the levels of dioxin (e.g., decreased, increased, stayed the same).

Is breast milk safe?

Since the 1970s, scientists have been worried about the amount of Dioxin, a toxin in fish caught in the Baltic sea. Dioxin tends to accumulate in breast milk and can harm newborn babies.

The diagram shows the amount of Dioxin in the breast milk of North European women, as found in studies done from 1975 to 1995.



These Level 3 tasks seem commensurate with the task of absorbing general information about the qualities of energy saving and long life lamps, indicating that a significant minority of the population would not be confident about making such assessments. We also note that a numeracy task involving compound interest was assigned to Level 5.

The ABS survey also tested problem solving ability but, unfortunately, the source documentation (Statistics Canada *et al*: 2005) does not report the degree of problem solving that characterises Level 1 and Level 2. However, one of the scenarios used to assess problem solving was the planning of a family reunion, which involved the completion of a set of tasks that seems no more demanding than making an informed assessment of lamps. The specific tasks for the respondent were to:

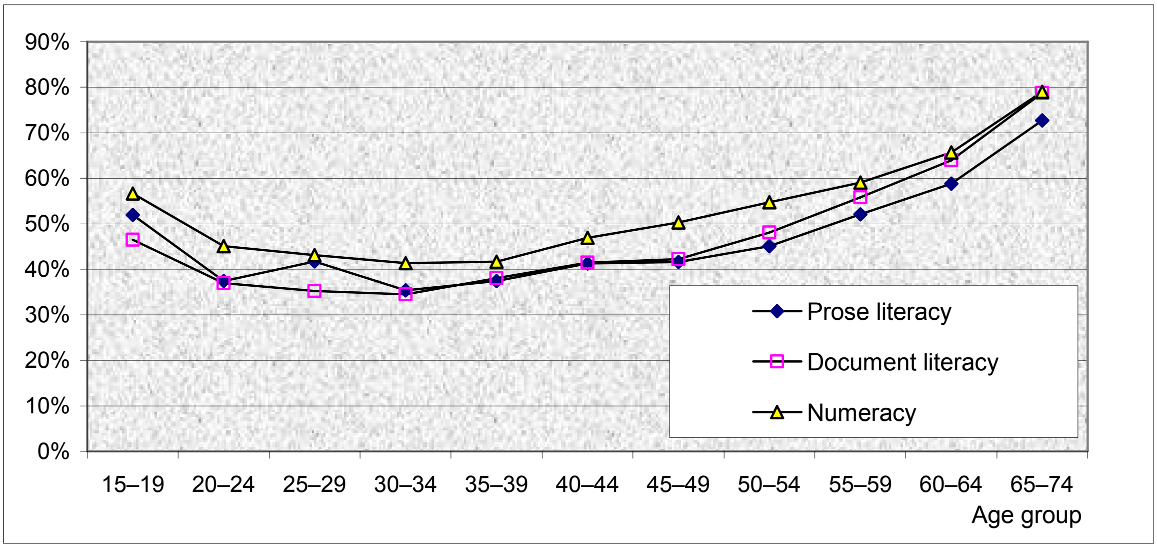
- set the date for the reunion allowing for the prior commitments of six relatives
- consider relatives' suggestions for a specific outing (a hike) and decide on a convenient location for the outing
- plan what needs to be done before booking your flight
- answer relative's questions about travelling by plane
- book your flight
- make sure your ticket is correct
- plan your own trip to the airport

The ABS found many could not complete all of these planning tasks – 34.9% of Australians were at Level 1 on problem solving and 70.1% were at Level 1 or Level 2, but now on a scale of Level 1 to Level 4.

Other general findings are that skill levels are positively related to education and labour force participation, and negatively related to age beyond 30 years. Figure 1.4 reports the latter finding.

Skill deficiencies relate to the concept of 'bounded rationality': decision makers with finite computational resources cannot make perfectly rational purchasing decisions. They use imperfect algorithms and heuristics instead, and learn by 'trial and error'. Several of the

FIGURE 1.4 PROPORTION OF AUSTRALIANS AT SKILL LEVELS 1 OR 2*, BY AGE



Source: ABS Cat 4882.0 *Adult skill and life skills survey*
Note:
* For each literacy domain, proficiency is measured on a scale ranging from 0 to 500 points. To facilitate analysis, these continuous scores have been grouped into 5 skill levels with Level 1 being the lowest measured level of literacy.

attributes of the lamp market – such as low unit cost, relatively infrequent purchases and unspectacular technology change – discourage buyers from thinking hard about their purchasing habits.

Small financial benefits
We calculate that the phasing out of tungsten incandescent lamps will save the average Australian household $30-60 per year. Some people would regard such amounts as trivial and would not bother to make the required assessments, or would give so little attention to the matter that there are few opportunities to educate and inform. This is a reasonable explanation for the apparent lack of interest in labelling information, documented in section 3.2.4, dealing with the policy option of lamp labelling. The IEA puts this issue in terms of competing demands on the decision-making resources of individuals and considers that:

> *An analysis of this factor can favour measures that remove the work from the consumer by ensuring that efficient solutions are widely available in the market place through retailer and industry incentives or mandatory regulations.* (IEA 2006: page 287)

Attitudes to small individual savings may change over time, as the price of emissions permits is factored into electricity prices and as people become more concerned to play their part in responding to the challenge of climate change.

History and evolution of lamp labelling
The practice of classifying lamps by wattage (40 watts, 60 watts, etc.), which is a measure of energy use rather than light output, is an anachronism based on familiarity with the operation and performance of tungsten filament lamps. Suppliers have responded to the need for users to understand that equivalent CFLs have lower wattage and longer life and may have different colour characteristics.

- *Same light but less energy*: Using text and images, it is common for CFL packaging to provide a direct comparison with a tungsten filament lamp that provides the same light. For example, a 14 watt CFL may be shown as equal to a 60 watt tungsten filament and saving 80% of the energy at the same time.
- *Operating life*: The CFL's operating life is often stated in hours and a graphic is used to show the CFL as equivalent to a number of tungsten filament lamps. For example, the graphic would show the CFL as equivalent to six pear shaped bulbs if the CFL has an operating life of 6,000 hours. Or long life may be indicated by stating that the lamp will last for a certain number of years, say, 3 years.
- *Colour appearance*: The issue of colour is typically reduced to a choice between 'cool white' and 'warm white', sometimes accompanied by an explanation that the cool look is a clear light that is appropriate to laundries and bathrooms and the warm look is cosy light that is appropriate to living areas and bedrooms.

Importantly, the user still has more work to fully understand the financial effects of using CFLs, in particular, to use their marginal energy tariff to calculate total energy costs and make adjustments for differences in the life of lamps.

In general, suppliers have not taken the further step of providing information about energy costs and savings on lamp packets – that is, doing the financial sums on behalf of users and providing them with dollar estimates. It is difficult to know exactly why suppliers do not employ these tactics; however the following points provide some indication.

- Information about operating expenses would need to be differentiated to a certain degree, at least for countries and regions with different currencies, energy costs and lighting requirements.

Further, packaging design and production costs associated with inventories and distribution management has been a constant issue with suppliers. In general, interchangeable products are valued highly by suppliers to global markets.

- Promised savings must then be further qualified, or discounted, to allow for inter-user variation in lamp configurations, duty hours and marginal electricity tariffs, and inter-regional variation in electricity tariffs. For example, there are non-trivial differences in commercial and residential duty hours and tariffs, and considerable potential for mixed messages and misunderstanding.
- The value of energy savings varies enormously with light output, for example, depending on whether the target is a 25 watt, 40 watt or 60 watt tungsten filament lamp. This may complicate the message to the point where users decide that the claims don't make sense and should be ignored.
- There is considerable evidence that consumers generally pay little attention to packaging information, which therefore increases packaging costs unnecessarily. This is reviewed in chapter 3, in relation to our assessment of a 'labelling only' option for government intervention in the market for lamps.

Whatever the mix of reasons, it is apparent that suppliers have broadly formed a view that information about the dollar value of energy savings does not generally earn, in marketing terms, a place on lamp packaging. Users who want to fully understand the financial implications need to do their own financial calculations.

Reputation of CFLs and adverse selection
CFLs were first commercialised in the early 1980s and, until very recently, diffusion of the technology has been constrained by a number of quality issues. IEA has described the situation as follows.

> *The first CFLs had limited CCT ranges and tended to be available in only the higher CCT cooler-light values. Current generations are available in a wider range of CCT levels than incandescent lamps, including the same warm hues provided by incandescent lamps. CFLs using magnetic ballasts were prone to delayed starts and long warm-up times and could suffer from flicker. With the introduction of higher quality lamps using electronic ballasts these problems have been overcome, and further production scaling up and cost reductions have now made CFL lamps a good alternative for standard incandescent lamps. As with other fluorescent lamps, the CRI of CFLs is not as high as for incandescent lamps. Typical values range from 82 to 86 which is good enough for most applications but may be a barrier in some situations. The highest quality CFLs now have CRIs up to 90. … Another more serious obstacle that constrained residential sales until recently was their suitability for use in existing fixtures. Early CFLs were only available in a limited range of sizes and were not small enough to fit into many standard incandescent fixtures. In the last few years, however, numerous designs have now become available, allowing them to be used in almost any standard incandescent lamp fitting. In some markets CFLs are now also available in decorative forms such as flame shapes for candelabra fittings.* (IEA 2006: pages 122-123)

Given this history of quality issues, it seems likely that take-up of CFLs has been affected by the problem of adverse selection. Adverse selection occurs where users cannot assess product quality prior to purchase and cannot systematically reward the better products with an appropriate price premium. Without that premium it is more profitable to produce products of poor quality ('lemons') and the bad products ultimately drive out better products. The market is consequently confined to the relatively few dedicated users who acquire knowledge through a repeated process of trial and error. For the remainder, however, IEA (2006: pages 285-290) characterised ongoing user concerns as uncertainty about:

- avoiding use with incompatible dimmers or luminaires;
- how to choose a fluorescent lamp with appropriate light qualities;
- whether suppliers' claims about lamp life and light quality are truthful;
- whether reports of disappointing results are representative of general experience;
- how product performance has improved over time and whether the time is right to experiment again with technologies that have disappointed in the past.

IEA considers that the product history of CFLs has created doubts and reservations about CFLs that no longer have a strong basis in terms of the actual performance of the better quality CFLs that are now available. It is certainly true that CFLs of generally unacceptable quality are still manufactured and sold internationally, but we are concerned here with documenting the improvements in the best available CFLs. This is the basis for E3's expectation that users are satisfied with the performance of the CFLs that have come onto the market over recent years. Consider that:

- IEA (2006: pages 122-123) documented a series of technological innovations, in particular, the ability of the latest CFLs to provide the warm coloured light that is associated with incandescent lamps, the use of electronic ballasts to reduce start up times and lamp flickering, and the production of smaller sized CFLs, required by some fittings.
- Many overseas governments responded to the problem of adverse selection by implementing quality standards. These were designed to build trust in CFLs and reward quality improvements. A recent review (Jeffcott *et al* 2006) identified nine existing CFL standards and another four in preparation[8]. Two certification standards have been progressively tightened as suppliers improved their products.
  - The UK Energy Trust has certified CFLs since 2001 and, after a series of amendments, implemented Version 6 from February 2008. Versions 4, 5 and 6 progressively included more types of CFL lamps and amended the requirements to impose maximum start and run-up times, longer operational life and minimum lumen maintenance over the operational life, maximum premature failure rates, improved colour appearance and maximum mercury content.
  - The US ENERGY STAR program has certified CFLs since August 1999 and has a similar history of progressively higher standards. Version 3 was introduced in January 2004 and Version 4 will be implemented from December 2008.
- E3 now proposes that Australia follow the international lead, by introducing MEPS that define minimum standards for the efficiency, lighting quality and durability of CFLs. This proposal includes recognition of certain overseas certifications and, by definition, is designed to ensure that the Australian market is supplied with superior products that will generally be accepted as like-for-like replacements for incandescent lamps.
- It is apparent from E3's consultations that suppliers are comfortable with the minimum standards that are proposed for CFLs in the Australian market. Products that are certified by the UK Energy Trust are already well-represented in the Australian market.
- The quality of the lighting service provided by CFLs has reached the point where many countries are taking measures that they characterise as 'phasing-out incandescent lamps'. A stock-take in February 2008[9] indentified the following:

[8] The multiplicity of quality standards has itself become a problem. The regulation of CFLs is currently the focus of the *International CFL Harmonisation Initiative*, focusing on international harmonisation of CFL test and performance standards and aiming to reduce compliance and manufacturing costs and ultimately reduce the price of high quality CFLs. E3 is actively participating in that initiative.
[9] Reported on the website of the Collaborative Labelling and Appliance Standards Program http://www.clasponline.org/clasp.online.whatnew.php?no=517, referenced on 4 September 2008.

- phase-out targets announced: Canada - 2012, Ireland – 2009, US – 2010 to 2012, UK – 2010
- phase-out plans proposed: Europe – 2011 to 2015, with 60+ watts phased out in 2013, Ghana, Japan, Switzerland
- accelerated CFL change-over programs in Argentina, Belgium, Egypt, France, Indonesia, Portugal, South Africa and Vietnam.

E3 recognises that there will still be concerns about replacing the familiar pear-shaped globe with CFLs and has modified the proposed measures to deal directly with such concerns. In particular, high efficiency incandescent lamps will still be available and broad classes of lamp will be exempted until product availability and performance improves to the point where lamps can be replaced on a like-for-like basis. Some exemptions may be retained until 2012 or later.

Chapter 3 provides a full account of the proposed measures and appendix A provides supplementary information, including fact sheets to address what E3 considers to be unfounded fears about the safety and convenience of lamp options.

Section 3.2.6 explains E3's reasons for not proceeding with an original proposal to completely phase-out incandescent lamps, including identification and assessment of a range of product quality issues.

Split incentives
There are circumstances where appliance selections are delegated to people who do not pay the energy bills and may avoid the consequences of a poor decision, creating a problem of split incentives. In a recent report on 'principal-agent' problems in energy efficiency decisions, the International Energy Agency (IEA 2007) explained the problem as follows.

> *Split incentives occur when participants in an economic exchange have different goals or incentives. This can lead to less investments in energy efficiency than could be achieved if the participants had the same goals. A classical example in energy efficiency literature is the 'landlord-tenant problem', where the landlord provides the tenant with appliances, but the tenant is responsible for paying the energy bills. In this case, landlords and tenants face different goals: the landlord typically wants to minimise the capital cost of the appliance (with little regard to energy efficiency), and the tenant wants to maximise the energy efficiency of the appliance to save on energy costs.*
>
> *Split incentives occur in the property ownership market, where many homeowners and businesses have limited incentive to invest in efficiency measures because they do not expect to stay in their building long enough to realise the payback from investments in energy efficiency. Split incentives also occur in the hotel industry, where the occupant seeks to maximise comfort and does not directly pay for the room's energy use. The hotel owner, on the other hand, does face the energy costs – which is why many hotels typically install compact fluorescent lamps and keys that deactivate a room's energy use when removed from their slots.* (IEA 2007: page 25)

The IEA report is an innovative attempt to quantify the split incentive problem in energy efficiency and includes a case study of residential lighting in the US (IEA 2007: chapter 9). IEA reported that split incentives have a negligible effect on residential lamping decisions, since most residential tenants pay their own energy bills and therefore bear the consequences for their re-lamping decisions.

We don't find the IEA assessment entirely convincing. The problem is that (a) CFLs have long operating lives of 6,000 to 10,000 hours and would often last for 5 years or more, and (b) Australians are highly mobile. According to the 2006 census, 17% of individuals were not at the same address as 12 months previously and a significant 43% of individuals had moved within a 5 year period. This suggests that in order to get full value from their investment in CFLs, many users would need to take their lamps with them when they move house. This may be economically rational behaviour, but somewhat tedious and time consuming, likely to result in breakages and raise suspicions in the mind of the real estate agent, and certainly inconsiderate towards subsequent residents. People without a taste for this level of rationality would leave lamps in the vacated premises.

It seems reasonable to classify this problem as one of split incentives, that is, involving the making of lamping decisions that will be inherited by subsequent residents of the dwelling. In addition to the many renters in this situation (28% of households), similar disincentives affect owner-occupiers who intend to sell or rent the property within a year or two.

It may also be more difficult to negotiate energy saving measures in group households that share energy and re-lamping bills. At the 2006 census, 3% of people lived in group households.

Trends in the Australian market
The main trends in residential lamp usage are in respect of fluorescent lamps and ELV tungsten halogen lamps.

Fluorescent lamps
Regarding fluorescent lamps, table 1.3 reports ABS estimates that 30% of Australian households did not have either linear or compact fluorescent lights in 2005. Almost 40% of households used fluorescent lights as the main form of lighting in one or two rooms, and another 25% used them in three or four rooms. Only 7% of households used fluorescent lights as the main form of lighting in the whole house. A rough calculation[10] suggests that the average dwelling has 2 rooms that are mainly lit with fluorescent lamps.

The trend is positive in Australia. Forty per cent of households reported no fluorescent lamps at the 2002 ABS survey and only 4% of households reported fluorescent lighting in the whole house. The average dwelling had about 1.5 rooms mainly lit with fluorescent lamps. Comparison with the 2002 and 1999 surveys suggests that there has been little change in the use of linear fluorescent lamps (about one room per house), which means

TABLE 1.3 PENETRATION OF FLUORESCENT LIGHTS: % OF AUSTRALIAN HOUSEHOLDS, 2005

Number of rooms mainly lit by fluorescent lamps	*Detached house*	*Semi-detached, row, terrace or town house*	*Flat/unit/ apartment*	*Other dwelling*	*Total households*
Households WITHOUT linear or compact fluorescent lights					
Sub-total	26.9%	37.0%	45.9%	26.6%	30.1%
Households WITH linear or compact fluorescent lights					
One	20.0%	23.1%	22.0%	22.7%	20.5%
Two	18.0%	15.3%	15.9%	20.2%	17.5%
Three	12.6%	8.4%	6.3%	9.9%	11.4%
Four or more	15.3%	9.6%	4.4%	8.3%	13.5%
Whole house	7.2%	6.5%	5.5%	12.2%	7.0%
Sub-total	73.1%	63.0%	54.1%	73.4%	69.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: ABS 4602.0, 2005 edition (special tabulation because of errors in the published document)

[10] It was assumed that the average number of rooms in the ‘four or more’ group was 5, and the average number of rooms in the ‘whole of house’ group was 7.

that compact fluorescent lamps have delivered the apparent increases in penetration. That said, there is a suspicion that the question asked by the ABS, which is about fluorescent and 'energy saving' lights, elicits misleading responses from those who believe that extra low voltage tungsten halogen lamps are an efficient form of lighting. They are not.

The ABS surveys suggest two other generalisations for Australia. As shown in table 1.3, fluorescent lamps are most likely in detached dwellings and least likely in flats and apartments. They are also more likely in the northern jurisdictions, with Queensland and the Northern Territory returning average room counts of 2.3 rooms and 2.9 rooms, respectively, in 2002. Tasmania had the lowest count – 1.1 rooms on average. A likely explanation is that, historically, fluorescent lamps have provided a 'cool white' look that is more acceptable closer to the equator and incandescent lamps have provided a' warm' look that is more acceptable closer to the poles (IEA 2006: page 106). Fluorescent lamps are now available in the 'warm' look.

The Australian Greenhouse Office commissioned research on user attitudes to CFLs at about the same time as the 2005 ABS survey (Artcraft 2005). Based on a combination of phone surveys and in-depth interviews[11], Artcraft found that:

- About half of respondents had never purchased a CFL and about a quarter had not heard of CFLs, even after prompting.
- Most CFLs had been purchased fairly recently from supermarkets and discount stores. Only 5.7% were from lighting stores where there was some prospect of specialist advice.
- Users are sceptical about supplier claims regarding globe life and energy savings, but also don't know how to interpret claims expressed in operating hours and don't understand that claimed lives are averages and that a proportion of globes must fail at less than the average life.

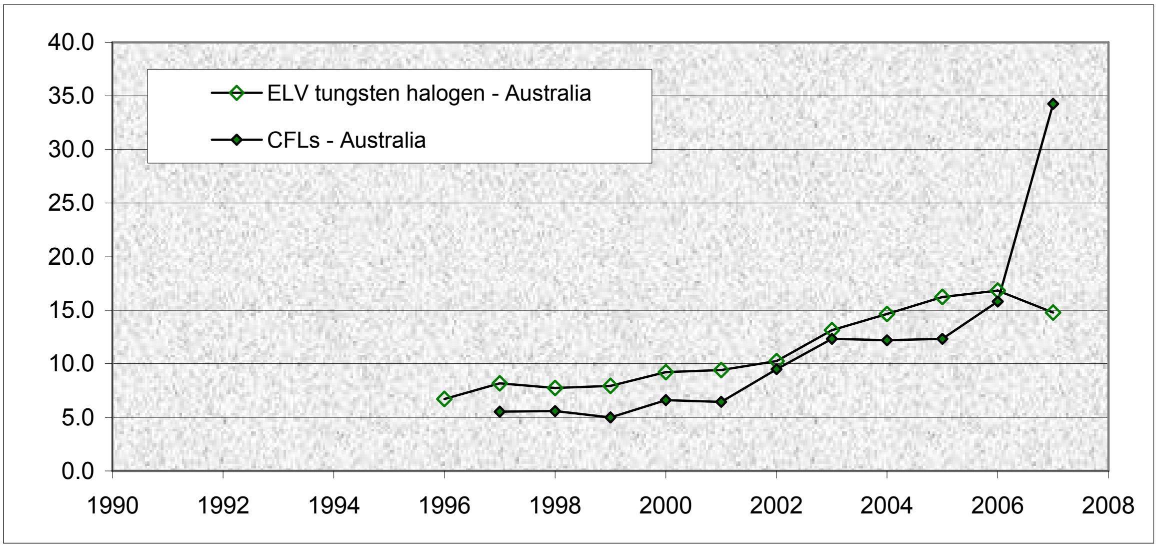
The import data seems to indicate that there have been significant developments since the 2005 surveys. Australian imports of CFLs increased by 28% in 2006 and then doubled in 2007 – see figure 1.5. However, imports returned to more normal levels in the later months of 2007 and the early months of 2008. This strongly suggests that the 2007 surge in imports was a response to the announcement, in February 2007, that Australia would phase out incandescent lamps by 2010. The surge started two months after the announcement and lasted for about 6 months. Possibly, the announcement was interpreted as a strong positive endorsement of CFLs, reassuring users that CFLs are safe and reliable. Another contributing factor may have been a belated restocking after strong sales in 2006, in that case due to generous subsidies provided by the NSW Greenhouse Abatement Scheme. The rules have since been amended and the number of CFL 'give-aways' under that scheme has fallen significantly.

Overall, the import data indicates that CFLs have been gaining market share. However, the extent of government intervention is such that it difficult to determine how much has been the result of autonomous market forces, and the degree to which it would be sustained in the absence of government intervention.

<u>ELV tungsten halogen lamps</u>
The import data tell us that there has been strong growth in the use of ELV tungsten halogen lamps – see figure 1.5. The trend rate of growth was 8.6%/year over the period 1996 to 2007). There are some indications that the rate of growth has moderated more recently.

[11] The study involved a series of three focus group discussions, fifteen in-depth interviews and telephone interviews with a representative sample of 600 people 18yrs+ in Sydney and Melbourne during mid to late April 2005.

FIGURE 1.5 IMPORTS OF ELV TUNGSTEN HALOGEN LAMPS (MILLION LAMPS)



- Imports have been flat over recent years.
- TridonicAtco told us that they manufacture 450,000 ELVCs per month at the peak of the market several years ago, using two production lines. Production has since fallen to about 80,000 per month, using one production line. Note that these figures exclude sales of electronic converters, which have increased their market share.

As noted earlier, low voltage means that the lamp can have a much smaller filament, creating a dot shaped point of light that can be easily focused and directed by a small light capsule. The resulting beam of light is narrow, making these lamps ideal for their original applications, which were to spotlight artworks and retail displays. However large numbers of these lamps are needed when used to illuminate larger areas, such as living areas and retail floorspace. On the evidence of display homes, twenty or more ELV tungsten halogen lamps may be used to illuminate living rooms.

ELV converters

The factors contributing to the continued use of magnetic converters have not been specifically researched. However, we speculate that:

- Buyers may be reassured by the familiar look and feel of magnetic converters. They are solid, chunky and weighty, and the smaller and lighter electronic types may appear inferior in comparison.
- While electronic converters can be adequately substituted for magnetic converters in at least 95% of cases (suppliers say 99%), magnetic converters should be used where durability is important and where the converter cannot be installed within two metres[12] of the lamp. The stories resulting from inappropriate use of electronic converters may create doubts in the mind of the buyer.

Conclusion on market failure

The figuring reported in chapters 4 and 5 indicates that the lighting service provided by incandescent lamps and ELVCs is unnecessarily expensive. For example:

[12] We understand that the 2 meter rule is to protect against interference created by electromagnetic radiation that is emitted from the wires on the output side of the ELVC, carrying the low voltage current provided by an electronic converter. Some sites don't have the ceiling or wall cavities that are needed to install converters close to lamps.

- In the case of a lamp that is used one hour per day, conversion from tungsten filament to CFL would save 85 cents of electricity per year, cost an additional 20 cents per year in lamps, and reduce the re-lamping task by a factor of 6.
- Electronic converters are now generally cheaper than the less efficient magnetic type, which means their use can save on both the installation and running costs of ELV tungsten halogen lamps.

E3 considers that this unnecessary expense is caused by market failure, given the evidence of information failure and split incentives. The IEA came to the same conclusion in a recent review of policies for energy efficient lighting, introducing its discussion of barriers to energy efficient lighting with the following remarks.

> *Acknowledging cost-effective potential and realising all of it are quite different matters. Undoubtedly, some part of the potential will be realised through normal market forces, but an important share will be hampered by factors that make the market function less effectively; in turn, this presents a rationale for policy intervention.* (IEA 2006: page 285)

1.5 Role of energy efficiency programs after CPRS is introduced

In 2007, the Australian Government formally announced its intention to introduce a Carbon Pollution Reduction Scheme (CPRS) (previously known as the Emissions Trading Scheme) by 2010. Economic literature suggests such a scheme can be used as an effective policy tool for internalising the costs associated with greenhouse gas emissions. However, even under a CPRS, there may still be a role for complementary policies.

Energy efficiency measures have been proven in some circumstances as a cost-effective method for households and businesses to reduce energy consumption while delivering greenhouse gas abatement. All other things being equal, the increase in costs of energy resulting from a CPRS should encourage households and businesses to improve the efficiency of their energy use. However, in some instances, market failures and/or other factors may act to mitigate some of the impacts of a CPRS, and therefore complementary energy efficiency measures may be appropriate.

For example, the presence of split incentives (such as between building owners and tenants) may lessen the effectiveness of a CPRS in delivering an ‘optimal’ investment in energy efficiency in tenanted dwellings.

In other instances, the transactions costs of investing in energy efficiency may outweigh the marginal benefits of such investments, even in a CPRS environment. For example, the potential energy savings to consumers may be small, relative to the time and effort required to calculate the associated life cycle costs when purchasing a product. In this circumstance, it is possible that a CPRS will not deliver an optimal investment in energy efficiency. A similar situation can arise if there is imperfect information, such as a lack of comparative energy consumption data on energy bills.

Taking into account the above factors, in some situations it is possible that the increase in electricity prices induced by a CPRS may result in a relatively small rise in demand for energy efficient products. Therefore it is possible that the carbon abatement costs induced by complementary energy efficiency measures may be lower than those induced solely under a CPRS. In such cases, it may be beneficial to consider energy efficiency policies, including MEPS and energy labelling, in conjunction with a CPRS.

CPRS can fix the problem of excessive emissions however, a CPRS does not:

- align the interests of a series of relatively temporary residents at an address, nor deal with the issue of split incentives;

- improve the literacy and numeracy skills of people who need to adjust their carbon budgets; or
- put information on the energy bill that tells the user whether investments in energy efficient lamps delivered the expected savings.

In short, the CPRS does not deal with the problems that people face in adjusting to the scheme.

2 Objectives of government action

2.1 Objective

The objective of government action is to contribute to cost-effective greenhouse abatement in Australia. The assessment of cost effectiveness includes consideration of both the direct financial impact and any effects on health, safety and the environment.

2.2 Assessment criteria

Abatement measures that do not increase the life-cycle cost of appliances are considered to be cost-effective. This means that the value of the energy savings to the user is not less than the incremental purchase price of a more efficient appliance and the ‘no regrets’ criterion is satisfied. The contribution to abatement is implicitly valued at zero.

MCE has determined that it will also consider greenhouse abatement measures that have a net financial cost to Australians, provided the net cost (per tonne of CO_2-e) is not higher than the cost of abatement achieved by other programs. This recognises that regulatory proposals can deliver a net benefit to the community despite an increase in financial costs, and implicitly puts a positive value on the contribution to abatement.

While MCE has not defined the maximum price that it is willing to pay for greenhouse abatement, Appendix E some supplementary figuring that assumes a value of $10-20/tonne.

Several secondary assessment criteria are also applied:

1. Does the option address market failures?
2. Does the option minimise negative impacts on product quality and function?
3. Does the option minimise negative impacts on manufacturers and suppliers? For example, the measures need to be clear and comprehensive, minimising the potential for confusion or ambiguity for users and suppliers.

3 The policy options

This chapter outlines the specific measures proposed for incandescent lamps and CFLs (section 3.1) and provides a shortlist of alternative policy options (3.2).

3.1 Proposed regulation

3.1.1 Scope of the MEPS

MEPS are proposed for certain incandescent lamps, for CFLs and for the ELVCs used with ELV lighting. The exact scope of the regulation is defined by the following standards. All have been published except for those for ELVCs, which are currently in draft form. Suppliers should refer to the technical specifications in these standards to understand the exact scope of the regulations.

- AS 4934.1: *Incandescent lamps for general lighting purposes -Test methods - energy performance*
- AS 4934.2: *Incandescent lamps for general lighting purposes - minimum energy performance standards (MEPS) requirements*
- AS 4847.1: *Self-ballasted lamps for general lighting services -Test methods - energy performance*
- AS 4847.2: *Self-ballasted lamps for general lighting services - minimum energy performance standards (MEPS) requirements*
- *AS ... :Performance of electrical lighting equipment - Transformers and electronic step-down converters for ELV lamps - Part 1: Test method-Energy performance.*
- *AS ... :Performance of electrical lighting equipment - Transformers and electronic step-down converters for ELV lamps - Part 2: Energy labelling and minimum energy performance standards requirements.*

In layman's terms, the incandescent lamps that fall within scope of the regulation are defined mainly by the physical shape of the lamp and the type of 'cap', such as the conventional pear-shaped globe with a bayonet cap. These characteristics effectively limit the regulation to the types of lamp used predominantly in dwellings and to a lesser extent in commercial and industrial buildings. See appendix A for a list of the types of incandescent lamps that are commonly used in residential applications. However, suppliers should not rely on Appendix A to define the scope of the regulation. It simply illustrates the most common types of incandescent lamp that are in scope and other types that are not in scope.

The measures will not affect the following activities with intensive or special lighting requirements:

- traffic management
- operating theatres
- stage productions
- photography and movie-making
- activities requiring enhanced spectrum lamps, such as speciality horticulture and aquaculture

3.1.2 Level of MEPS

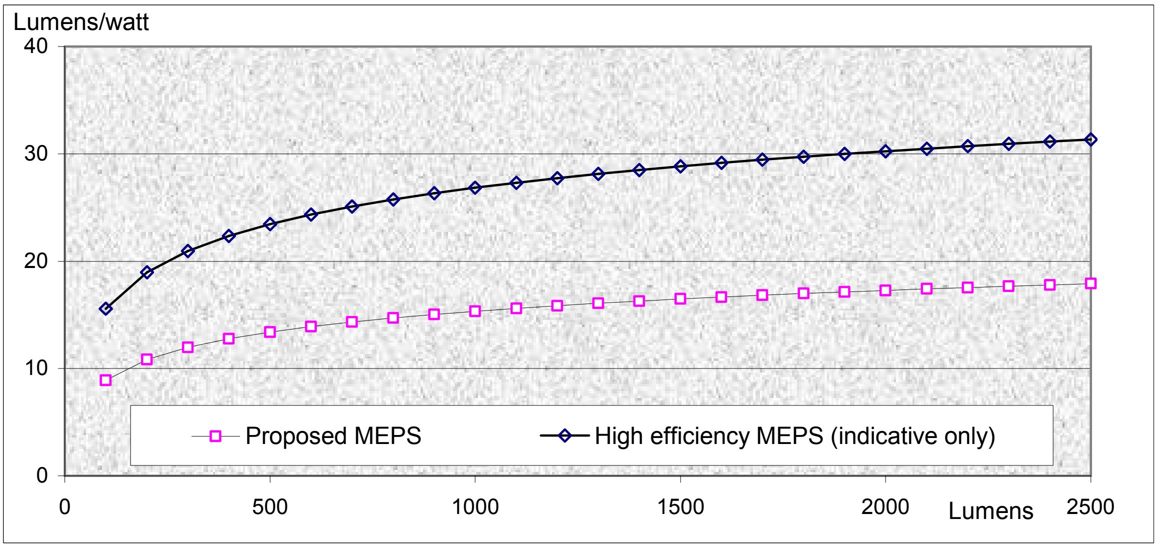
Incandescent lamps

The proposed MEPS is based around a minimum efficacy level of 15 lumens/watt for an incandescent lamp generating 900 lumens. (900 lumens is the amount of light emitted by a 60 watt lamp that would just meet MEPS.) But there is a sliding scale that is defined mathematically. Figure 3.1 shows how the MEPS requirement increases with the lumen output of the lamp.

We understand that tungsten filament lamps cannot meet this standard and will be phased out. However, MEPS will not require the phasing out of incandescent lamps of the tungsten halogen type, since this technology can comply with the standard. Some compliant lamps are already available in the market.

It is also proposed that only lamps that significantly exceed the MEPS can be designated as 'high efficiency', possibly 75% more efficient. The current generation of tungsten halogen lamps would not qualify as high efficiency lamps.

FIGURE 3.1 PROPOSED MEPS – INCANDESCENT LAMPS



The MEPS for a reference lamp generating 900 lumens is at 15 lm/w. (900 lumens is approximately the amount of light emitted by the common 60 watt globe.) There is a sliding scale for other lamp sizes, with progressively lower MEPS for lamps providing less than 900 lumens and progressively higher MEPS for lamps providing more than 900 lumens. The requirements are defined by the following formula.

$$\textit{Initial efficacy} \geq 2.8 * \ln(\textit{initial lumens}) - 4.0$$

Compact fluorescent lamps

Table 3.1 defines the proposed requirements for CFLs. These are the local or default requirements that will apply if the CFL attribute is not certified to one of two overseas schemes, which are the certification schemes of the Efficient Lighting Initiative (ELI) or the UK Energy Savings Trust (EST). See appendix A for details of these schemes.

There are three broad groups of issues in addition to the energy efficiency specifications.

- There are light quality requirements, relating to the appearance of illuminated objects and the immediacy of the response to lighting controls.
- There are durability requirements, relating to the effective life and longer term performance of the lamp.

TABLE 3.1 PROPOSED MEPS – COMPACT FLUORESCENT LAMPS

Attribute	*Local or 'default' requirements, if CFL attribute is not certified under the certification schemes of either the Efficient Lighting Initiative (ELI) or the UK Energy Savings Trust (EST)**
Energy efficiency requirements - minimum efficacy in lm/w	
Bare lamp efficiency	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens
Covered lamp efficiency	$\frac{0.85}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens
Reflector lamp efficiency	$\frac{0.6}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens
Light quality requirements	
Colour appearance	IEC 60081 Graph D-16 for CCT 2700. Other temps to be approved but following same diagram
Minimum CRI (colour rendering index)	80
Maximum starting time (seconds)	2.0
Maximum run-up time (min)	1.0
Durability requirements	
Minimum lumen maintenance	2,000 hrs = 0.88 / 5,000 hrs = 0.80 / 10,000 hrs = 0.75
Maximum premature lamp failure rate	10% at 30% of rated life
Minimum switching withstand	1,000 Cycles
Minimum lifetime (hours)	6,000
Requirements relating to external impacts	
Minimum power factor	0.55 (0.9 for lamps claiming high PF)
Maximum mercury content (mg)	5**
Harmonics	AS/NZS 61000.3.2

Note:

* See appendix A for details of the alternative certification schemes. If the lamp is certified to ELI or EST, for which starting time, run-up time and mercury content may not be specified, then the lamp shall comply with the local criteria.

** To be measured in accordance with AS/NZS 4782.3

- There are also external impact requirements to ensure that CFLs do not impact adversely on the operation of electricity networks and the environment.

The light quality requirements and, to a lesser extent the durability requirements, address issues of concern to users in previous generations of CFL products. Other countries have regulated the lighting performance of CFLs, not just their energy efficiency, aiming to protect inexperienced customers from inferior products that unfairly damage the reputation of CFLs. They have developed a range of standards in the process and E3 has identified the ELI and EST certification schemes as compatible with the standards proposed for Australia.

The option of certification against the existing ELI and EST schemes would ensure that a good range of compliant product is available when the MEPS is first implemented and reduce regulatory barriers to the competitive supply of CFLs. Appendix A provides the details of these alternative certification arrangements. More information is available from their websites www.efficientlighting.net and www.energysavingtrust.org.uk.

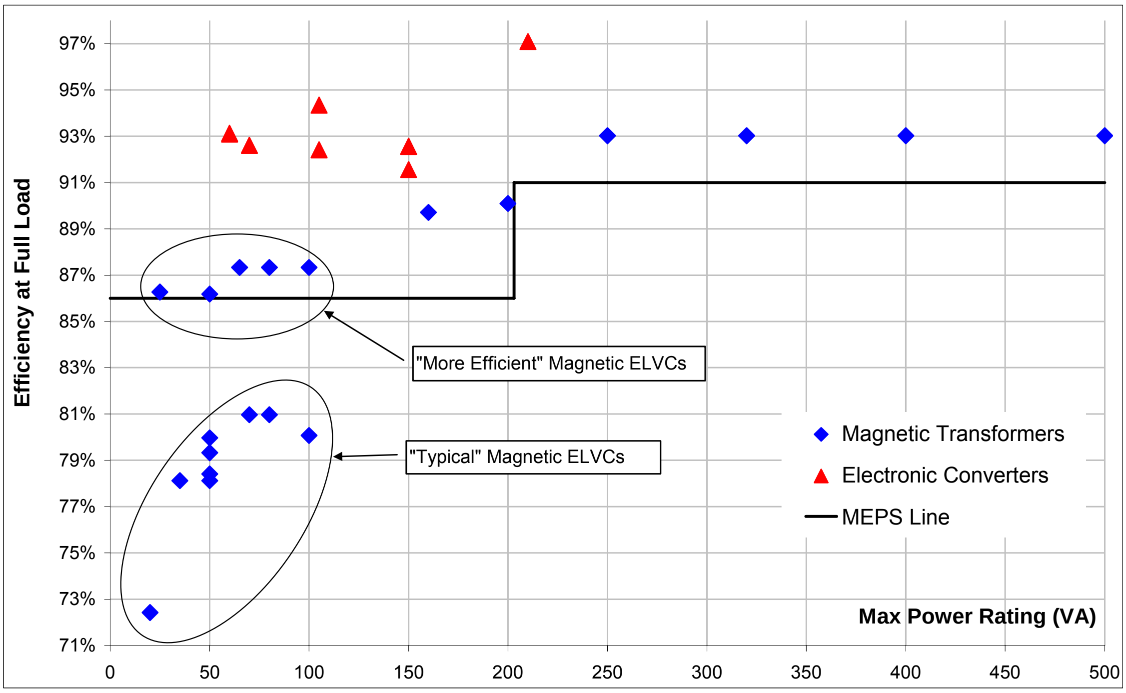
Extra low voltage converters
Table 3.2 defines the proposed MEPS for ELVCs. Figure 3.2 shows how these relate to the observed range of converter efficiencies. Formally, the MEPS vary with the rated power of the converter, measured in volt-amps (VA). For our purposes, volt-amps are equivalent to wattage (W). A stepped arrangement is proposed, with lower MEPS for ELVCs up to 200 VA. This ensures that the option of a magnetic converter is always available. Electronic converters are not suitable for applications where a more robust unit is required and where the converter cannot be located within two metres of the lamp.

TABLE 3.2 PROPOSED MEPS – EXTRA LOW VOLTAGE CONVERTERS

Rated converter power (VA)*	*MEPS level (% efficiency at full load)*
≤ 200 VA	≥ 86%
> 200 VA	≥ 91%

Note:
* VA = volt-amps, a measure of the converter capacity. For our purposes, it is equivalent to wattage.

FIGURE 3.2 EFFICIENCY OF ELVCS AND PROPOSED MEPS



3.1.3 Timing of MEPS

The MEPS apply to the sale of lamps and ELVCs. Implementation will commence in November 2009 but with exemptions that will be terminated over the period to 2012. Table 3.3 provides a schedule of terminations. The schedule for post-2009 implementation is indicative at this stage, based on the expected availability of effective and affordable replacements. Actual terminations will be implemented with the benefit of up-to-date market and product analysis, and in consultation with suppliers. The only firm post-2009 implementation dates are those for ELVCs (November 2010) and reflector CFLs (November 2011).

Table 3.3 also refers to related import restrictions that will be implemented 12 months earlier than the MEPS on sales, if that proves feasible. This arrangement would apply only to Australia and only to lamps, not ELVCs. The 2-stage process allows lamp stocks to be run down over 12 months. Hereafter, we refer to the date of application to sales (the later date) as the date of implementation.

Each year, the lamp types excluded from the scope of MEPS will be reviewed by a committee consisting of lighting industry and Government representatives. Exempt lamp types will only be included as viable, efficient and affordable alternatives become available.

E3 plans to implement a second round of MEPS from 2013, at 20 lumens/watt for a reference lamp of 900 lumens. Government representatives will work with the lighting industry to review the second round options in 2011, focusing on the feasibility of the 2013 timing and target. Again, a second round of MEPS will only be implemented as viable, efficient and affordable alternatives become available.

TABLE 3.3 SCHEDULE FOR MEPS IMPLEMENTATION

Implementation date for MEPS at point of sale	*Implementation date for import restriction* (Lamps only, Australia only)*	*Products required to comply (exemptions terminated)*
November 2009	November 2008	– GLS** (f) – extra low voltage (ELV) halogen, non-reflector (f) – CFL, non-reflector (f)
November 2010, subject to annual review	November 2009, subject to annual review	– >40w candle, fancy round & decorative lamps (i) – Mains voltage halogen non-reflector (i) – ELV halogen reflector (i) – ELVC*** (f)
November 2011	November 2010	– CFL, reflector (f)
November 2012, subject to annual review	November 2011, subject to annual review	– Mains voltage reflector lamps, inc. halogen (i) – >25w Candle fancy round & decorative lamps (i)
To be determined dependent on availability of efficient replacement product		– Pilot lamps and other lamps 25w and below (i)
Beyond 2015		– All incandescent lamps

Note:
(f) firm dates
(i) indicative dates. The schedule for terminating exemptions is indicative, based on current information about when affordable and practical replacements will become available. Actual timing will be reviewed on an annual basis with the benefit of up-to-date market and product analysis, and in consultation with suppliers.
* The feasibility of import restrictions is the subject of ongoing investigations.
** General lighting service (GLS) lamps are the familiar non-reflector incandescent globes that have been traditionally supplied to Australian markets with tungsten filaments and bayonet caps. Table A.1 in appendix A describes the main types of lamp.
*** ELVCs will not be subject to an import restriction 12 months earlier.

3.1.4 Labelling and communications measures

Users would need to come to grips with new lighting technologies in the event that conventional tungsten filament lamps are phased out. E3 proposes to assist users by reforming labelling practices and conducting a communications campaign. E3 is currently discussing labelling options with lamp suppliers and has more work to do on a proposed communications campaign. But the broad elements, described here, are already clear.

Lamp labelling
As noted in section 1.4, suppliers have anticipated the needs of CFL buyers and provide packaging information in terms of equivalence with tungsten filament lamps, for example, that a 14 watt CFL provides the same light as a 60 watt tungsten filament lamp and lasts 6 times as long. While there is presentational variation between suppliers, the common element is that tungsten filament lamps are used as 'reference lamps'. Suppliers assume familiarity with such lamps.

The transitional advantages of this approach are obvious: information is provided with reference to familiar measures and technologies. But there are several problems.

- The reference point is variable, since the light output from a tungsten filament lamp varies with the efficacy of the lamp.
- Comparative labelling with reference to tungsten filament lamps will become increasingly irrelevant as tungsten filament lamps recede into history.
- A new convention may emerge, using CFL wattage to indicate light output. Confusingly, it may coexist with the old convention.
- The diffusion and commercialisation of LEDs and other new lighting technologies will confuse the situation even further.

E3 considers that, sooner or later, users will need technologically neutral information that allows them to directly compare the light output from different lamps, rather than refer to a growing list of equivalence scales for energy input. Specifically, they will need to understand light output in terms of lumens and recognise wattage as a measure of energy input that has a highly variable relationship with light output. This learning process will be variously welcomed and resented in the short term but seems to be a necessary investment if lamp labelling is not to become confused and dysfunctional in the longer term. North American regulators have already adopted a technologically neutral approach and EU regulators propose to do the same. Common elements of the US, Canadian and (proposed) European schemes are that lamp packaging will include statements of:

- light output in lumens;
- energy used in wattage; and
- lamp life in hours.

A related issue is whether energy efficiency should also be indicated by means of a comparative label. E3 has no preferred options at this stage. It would be preferable to adapt the energy rating system that is well-established in Australia, and which is now widely understood as 'the more stars the better'. But, due to the costs associated with this label, suppliers have strongly resisted the implementation of a comparative label that is not identical to the European label, which grades lamps from G to A – see figure 3.3 below.

E3 considers that adoption of the European label would be confusing and costly, and has not pursued this option.

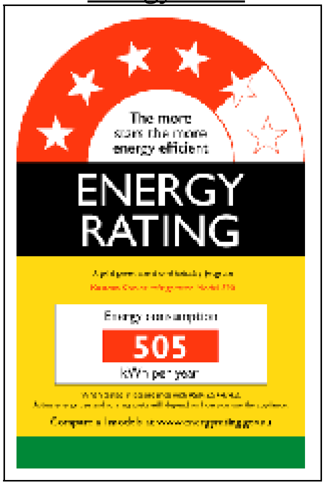
Another option is to follow the North American lead and require the following further statement.

> *To save energy costs, find the bulbs with the light output you need, then choose the one with the lowest watts.*

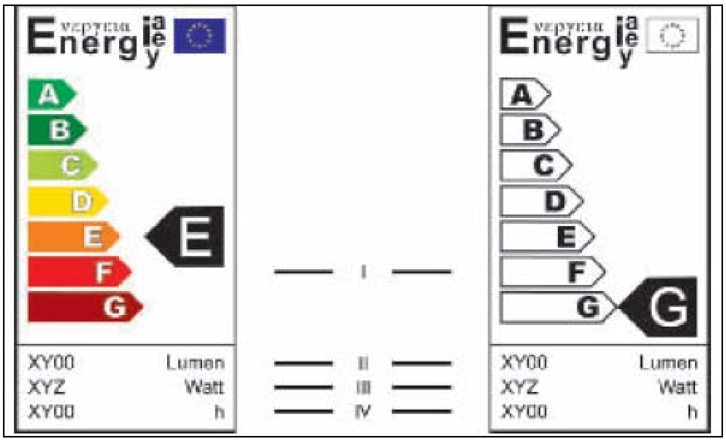
This is the next best option to providing comparative information on each package, showing how the lamp compares with the best and worst in its class.

FIGURE 3.3 ENERGY LABELS IN AUSTRALIA AND EUROPE

Australian energy label



European Union energy label



E3 invites comment on the need to distinguish between light output and energy input on lamp packaging and how best to provide standardised energy efficiency information.

E3 is also consulting with suppliers on the need to mandate the provision of other information on lamp packaging, for example:

- whether the lamp is dimmable and the extent of compatibility with existing luminaires (the light fitting)
- colour characteristics and performance characteristics like starting time, warm-up time and lumen maintenance
- power factor and disposal methods

This more extensive information has been proposed for Europe, either on or with each package. E3 invites comment on more extensive labelling requirements, but taking account of the following matters:

- There is relatively limited space on lamp packaging.
- Suppliers are motivated to provide information that reduces the incidence of customer dissatisfaction and product returns, for example, to warn that the product is not dimmable or is incompatible with certain luminaires.
- Some types of information are technically complex and may need to be presented in non-technical language, for example, colour characteristics reported as ‘soft white’ or ‘cosy white’ rather than the colour correlation temperature.
- Variations in some performance characteristics would be reduced by the proposal to regulate the performance of CFLs (table 3.1)
- E3 can also deal with these issues in its communications campaign.

Looking to the longer term, E3 also invites comment on whether the labelling scheme should address the needs of a lighting market that may become more technologically active and diverse, including LEDs with lighting qualities that are quite different to those now available.

Restricted use of comparative ‘energy savings’ claims

The option of a ‘high efficiency’ MEPS for incandescent lamps has already been noted, indicatively at 75% above the proposed MEPS. This would ensure that complying incandescent lamps that remain in the market, which will be much less efficient than CFLs, are not marketed as 'energy savers'.

Communications campaign
E3 invites comment on the key messages and channels for the communications campaign.

Key messages
E3 is preparing fact sheets on a number of health and environmental issues that may cause unwarranted concern for a minority of users. These are reproduced in draft form at appendix A, and provide the following assurances:

- CFLs are not more likely to be a risk to people with photosensitive epilepsy than other light bulbs.
- CFLs are unlikely to exacerbate a Lupus condition if general lighting has not previously done so. The use of standard acrylic light covers or diffusers effectively eliminates any risk.
- CFLs 'flicker' at a rate well above that detectable by the human brain and so should not affect sufferers of Meniere's disease or migraine headaches.
- Scientific investigation indicates that poisoning is almost impossible from exposure to the very small amounts of mercury released by CFL breakages.
- Less mercury is released into the environment from the use of CFLs than incandescent lamps.

Other tasks for the communications campaign include the provision of information about:

- how tungsten filament lamps and CFLs differ, particularly their performance with dimmers, and any issues of comparative performance that users may need to be aware of
- the continued availability of halogen incandescent lamps to users with particular needs or preferences
- circumstances where the increase in energy efficiency is delivered as more light rather than reduced electricity consumption
- the objectives and methods of the proposed regulations

Channels
A variety of communication channels are being considered, including information leaflets, a 1300 phone service, point of sale displays and the use of intermediaries like lighting designers, retailers and installers.

3.2 Alternative policy options

E3 has shortlisted the following options:

1. BAU Scenario including CPRS and other forms of non-specific greenhouse abatement policy.
2. Option 1 plus MEPS, labelling and information measures that are specific to incandescent lamps, CFLs and ELVCs.
3. Option 1 plus a subsidy for more efficient lamps and ELVCs.
4. Option 1 plus a tax on less efficient types of lamps and ELVCs.
5. Option 1 plus comparative energy labelling for lamps and ELVCs.
6. Option 1 plus an information campaign promoting more efficient lamps and ELVCs.

E3 takes option 1 as the base case and is only concerned (a) whether options 2 to 6 deliver net benefits relative to the base case, and (b) to identify which of options 2 to 6 provide the greatest net benefits.

E3 has not developed measures to implement options 3 to 6 and this document does not provide impact assessments for options 3 to 6. A basic question for stakeholders is whether measures to implement options 3 to 6 should be fully developed and assessed before a decision is made on whether to proceed with option 2. Please refer to the following discussion of each option for a list of questions for stakeholders.

Stakeholders should note that labelling and information measures are included in option 2, complementing MEPS. Options 5 and 6 are different in that they rely exclusively on information and labelling measures and would not implement MEPS.

3.2.1 Subsidies for efficient lamps

Use of subsidies to promote energy efficient lighting
Other countries have subsidised the purchase of CFLs but such measures have been used sparingly and for limited periods (IEA 2003: page 55). Similarly, subsidies in Australia have been used as a one-off financial incentive to encourage people to try CFLs and create a demonstration effect. Electricity retailers in Victoria, NSW and the ACT can earn credits towards emissions and efficiency targets by installing CFLs.

Advantages and disadvantages
The main advantage of a financial subsidy is that it allows users with a particular preference for an inefficient lamp to refuse the subsidy and retain their preferred lamp. Reasons for refusing the subsidy could include infrequent use, costs of changeover or aesthetic reasons. In contrast, MEPS reduce choice, denying particular product options regardless of individual circumstances and preferences.

A subsidy program has the following disadvantages.

- It is desirable but administratively cumbersome and intrusive to limit payments to those who would not otherwise have purchased the efficient lamps. Inevitably, significant payments go to those who would have purchased efficient lamps without the subsidy.
- Subsidies are regressive, that is, made disproportionately to those who have bigger houses and more lights.
- Subsidies reduce the cost of lighting services and encourage people to install more lamps.
- Subsidies would encourage unintended and possibly undesirable lamp substitutions, for example, the substitution of compact for linear fluorescent lamps, creating a demand to extend the subsidy to other energy-efficient technologies that are already well-established in residential, commercial and industrial applications.
- Regardless of the merits of a particular subsidy program it is easy for others to misrepresent its rationale and create demands for ‘me too’ policy measures that are less sound. It is prudent to confine subsidies to situations where recipients need to be compensated for some harm that has been done, or where the community needs to encourage activities that provide a benefit to the community. Paying people to do things that benefit themselves is not a good precedent.
- There is a risk 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.
- 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.

E3's assessment of the subsidy option

It would be possible to subsidise the purchase of efficient lamps and set the rate of subsidy at the level required to achieve any desired take-up of efficient lamps. An amount of $2.00-$4.00/lamp would be enough to eliminate the price difference between tungsten filament lamps and CFLs. The total cost of the subsidy would be of the order of $40-$80 million per year, assuming that the subsidy would be paid on about 20 million units per year. There may be significant consumer response to a smaller subsidy, for example, reducing the price differential by half. The cost would be in the range $20-40 million per year.

E3 has short listed subsidies as a policy option but has not developed measures in this RIS to implement the option, and has not consulted with suppliers about the scope and design of such a program. E3 considers that the decision is sound but invites stakeholders to argue a contrary point of view. They should address the following points in particular.

1. Although subsidies would cost taxpayers hundreds of millions of dollars over a period of years, there would be uncertainty about the effectiveness over the longer term. There is more certainty about the impact of MEPS.
2. The prudential requirements of an ongoing program that dispensed large amounts of money would be administratively demanding, for example, in respect of auditing and monitoring requirements.
3. The challenges of climate change will create significant new demands for financial compensation and incentives, including compensation for genuine hardship. The taxpayer's willingness and capacity to provide subsidies is a scarce resource and should be conserved.
4. The promotion of energy efficiency is plagued by international variation in labelling and standards. Coordination of subsidy arrangements would be even more difficult and, if adopted internationally, subsidies may create more confusion for suppliers.
5. Suppliers regard subsidies as reversible and unreliable and would factor the additional uncertainty into their product development plans.
6. The work needed to develop a subsidy program would significantly delay implementation.

3.2.2 Taxes on inefficient lamps

Use of taxes to promote energy efficient lighting

There are no overseas examples of taxes or similar arrangements being applied for radical energy efficiency objectives such as the phasing out of a particular technology. The use of revenue-raising measures has generally been limited to schemes that hypothecate the revenue to fund capital subsidies. For example, energy retailers may be obliged to subsidise energy efficient appliances and recover the cost by increasing electricity charges.

Advantages and disadvantages

The main advantage of a tax is that it allows users with a particular preference for an inefficient lamp to pay the required tax and retain their preferred lamp (i.e. purchasing the usual GLS lamp). Reasons for refusal could include infrequent use, costs of changeover or for aesthetic reasons. In contrast, MEPS reduce choice, denying particular product options regardless of individual circumstances and preferences.

The disadvantage of the tax option is that, depending on the rate of tax, some users would make ill-informed decisions to continue using inefficient lamps, not because they have a particular preference but because they do not understand the value of the energy savings.

Otherwise, the taxation option has no significant disadvantages as an instrument of economic policy.

E3's assessment of the tax option
It would be possible to tax the purchase of inefficient lamps and set the rate of tax at the level required to achieve any desired take-up of efficient lamps. A tax of $2.00-$4.00/lamp would be enough to eliminate the price difference between tungsten filament lamps and CFLs. Potentially, there would be significant consumer response to a smaller tax, for example, reducing the price differential by half.

E3 has short listed taxes as a policy option but has not developed measures that would implement the option, and has not consulted with suppliers about the scope and design of such a program. E3 considers that the decision is sound but invites stakeholders to argue a contrary point of view. They should address the following points in particular.

1. Suppliers regard tax measures as reversible and unreliable and would factor the additional uncertainty into their product development plans.
2. The work needed to develop taxation measures would significantly delay implementation.
3. There is more certainty about the impact of MEPS.
4. The use of product-specific taxes to promote energy efficiency raises the prospect of multiple new taxes being introduced over a period of time. Proponents should consider whether it is politically feasible.

3.2.3 Disendorsement label

Use of disendorsement labels to promote energy efficiency
A disendorsement label would be used to warn users that the lamp does not meet a minimum standard of energy efficiency.

E3 are aware of two labelling schemes that include disendorsement measures, both in the form of warning labels where products do not meet a minimum standard. Australia's water efficiency rating scheme requires products with less than zero stars to carry a warning that they do not meet the minimum standard. Similarly, labelling used in Korea requires selected appliances to carry a warning label if they do not satisfy the standby power criteria.

Advantages and disadvantages
The main advantage of a disendorsement label is that it allows users with a particular preference for an inefficient lamp to refuse the subsidy and retain their preferred lamp. Reasons for refusing the subsidy could include infrequent use, costs of changeover or for aesthetic reasons. In contrast, MEPS reduce choice, denying particular product options regardless of individual circumstances and preferences.

However, disendorsement labelling is not a complete solution. It does not deal with split incentives and, although it warns the user that there is a problem with a product, it also requires them to gather more information and make further calculations to fully understand the costs and benefits associated. As discussed in section 1.4, the information and assessment requirements are reasonably demanding and beyond the problem-solving capacities of many people. Some would select an inefficient product when a fully-informed assessment favours the efficient product, while others would select the efficient product when a fully-informed assessment favours the inefficient product. We cannot anticipate the scale and mix of misjudgements.

On this last point, we note the findings derived from market research commissioned by the AGO (Artcraft 2003). Artcraft found that although a majority of users would respond to a disendorsement label, they differed about the degree of inefficiency that warrants a warning label. However while most preferred stronger warning messages, some were then puzzled as to why strongly disendorsed products were not simply banned. This suggests considerable scope for variation in user interpretation of disendorsement labels.

The Productivity Commission interpreted the same research more favourably.

> *Many participants in that consumer research considered the tested warning labels to be extreme, and questioned why such appliances would be allowed to be sold (Artcraft 2003). This suggests that disendorsement labels would discourage most consumers from buying the least energy-efficient appliances, and so have a similar effect to a mandatory standard that removed those appliances from the market. However, a key difference is that disendorsement labels would not prevent a consumer from buying a less efficient appliance when that is the most cost-effective option for them, or they have a strong preference to buy such an appliance. Therefore, disendorsement labels are less likely to force individuals to forgo product features they value more highly than energy efficiency, remove products from the market that are more cost effective for some individuals, and to have regressive distributional impacts.* (PC 2005: page 203)

The other main concern for E3 is that major suppliers have strongly resisted disendorsement labelling, indicating they would not supply products associated with a warning label because it could damage their reputation and reduce the value of goodwill.

The reputation of suppliers has a significant impact on the efficient operation of markets, providing the informal equivalent of a bond or warranty for product quality. Users rely on brand names for reassurance about product quality that cannot be confidently assessed at the time of purchase, for example, that a durable product will provide reliable service over many years and maintenance costs will not be excessive. It follows from this consideration that users with a preference for energy inefficient products cannot have both the performance and reduced cost characteristics that are associated with low energy efficiency plus the quality assurances that are associated with premium branded products. It is reasonable to be concerned that the effective exclusion of major brands from the supply of less efficient products will further reduce the quality of products in this market, particularly operating life and energy efficiency.

E3's assessment of disendorsement labels

Taking into account the above, disendorsement labelling has not been short listed as a policy option that should be developed and assessed in detail. E3 invites stakeholders to argue a contrary point of view but asks that the following concerns be addressed.

1. There is not a sufficient basis to proceed with confidence, particularly if reputable brands withdraw from the market for disendorsed products. There is more certainty about the impact of MEPS.
2. The work needed to develop disendorsement options would significantly delay implementation.

3.2.4 Comparative energy labelling

Use of labels to promote energy efficient lighting

IEA (2006 page 310) reports that some form of energy labelling for lamps is mandatory in Canada, China, EU, Japan, Korea, Norway, Switzerland and USA. A number of these countries now propose to introduce MEPS.

Advantages and disadvantages

The main advantage of a comparative label is that it allows users to make informed assessments of the relative costs and benefits of different lamps and select an inefficient lamp if, on balance, it is the preferred option. In contrast, MEPS reduce choice, denying particular product options regardless of individual circumstances and preferences.

Labelling is not a complete solution. Although it alerts the user to the energy consumption of different products, it also requires the user to gather more information and make further calculations to fully understand the pros and cons. As discussed in section 1.4, the information and assessment requirements are reasonably demanding and are beyond the problem-solving capacities of many people. Importantly, the user needs to confidently make calculations that justify payment of a significant price premium.

Comparative labelling does not deal with the problem of split incentives.

Evidence on the effectiveness of labelling

United States

Energy labelling of major household appliances has been mandatory in the US since 1979 and a modified form of labelling was extended to household lamps in 1994[13]. Consumer surveys have found that 70% of Americans know about the appliance label but that only half can describe a pertinent aspect of the label (Opinion Dynamics 2000). The empirical evidence on the impact of this program has been reviewed recently (Banerjee *et al* 2003, Gillingham *et al* 2006), with the following results.

- There is little published analysis of labelling effectiveness in the US.
- There is evidence that, in the presence of labelling, energy-saving innovation is more responsive to higher energy prices. This evidence is for two appliances with significant energy costs, air-conditioners and gas water heaters (Newell *et al* 1999).
- Various aspects of the program have been criticised, including that (a) the label is unattractive and the information is poorly organised, (b) it uses technical language, (c) it does not use a star rating or similar indicator of broad product categories, and (d) there is widespread non-compliance with the labelling requirements.

On the basis of extended work with focus groups regarding the purchase of CFLs that qualified for the ENERGY STAR label, the Lighting Research Centre (LRC 2003) found that users give little attention to lamp labelling information.

> *Though many of the participants noted that energy savings and environmental concerns are important factors in their purchases, they do not consider these effects when purchasing lamps for their homes. They believe that switching off lights will have a greater effect than choice of lamp. Most shoppers don't spend time comparing lamp products and studying the packaging details other than to look for the wattage and colour … Although the package contains valuable information, consumers do not read the packaging or note the listed benefits.* (LRC 2003: page 20)

Europe

In 1992, the European Union initiated energy labelling and steadily expanded its appliance coverage over the subsequent decade, including the labelling of household lamps from 1998. The European Commission is currently reviewing these arrangements and, as part of the process, commissioned an impact study that included a review of evidence on the impact of the existing energy labelling schemes and the collation of stakeholder feedback via interviews, meetings and an on-line facility (Europe Economics *et al* 2007). The main findings are:

- There is general agreement that labelling is a positive policy tool, including agreement by manufacturers and retailers.
- There has been a noticeable and well-documented improvement in the efficiency of whitegoods since labelling was first implemented in 1992. Additional categories were added to the rating scale (A+ and A++) as more efficient appliances emerged.

[13] As discussed in section 3.1.4, lamp packages must list light output (lumens), energy input (watts) and lamp life (hours), and make the statement "To save energy costs, find the bulbs with the light output that you need and, then choose the one with the lowest watts".

- There has been much less improvement in the efficiency of household lamps. Stakeholders said that the lamp label is less effective because the label is smaller and different to the appliance label, and energy-conscious users already know that the CFL is an energy saver. Whereas they need to examine the labels on fridges and washing machines, they immediately associate CFLs with saving energy and can ignore the lamp label.

A recent UK survey tested household understanding of a range of energy efficiency measures, including CFLs (Oxera 2006). The researchers found that respondents had a reasonably good grasp of the cost of CFLs but were less certain about their durability and the money saved. Purchasing decisions were mainly influenced by price, attitude to labelling and lamp life. 'Receipt of advice' was rated as a minor influence and 'cost savings' were rated as a very minor influence. Importantly, lamps in the UK have been subject to the EU energy labelling requirements since 1998.

<u>Australia</u>
Appliance labelling was introduced progressively through the 1980s and an early review (GWA 1991) reported contemporaneous developments in the energy efficiency of refrigerators and freezers, air conditioners, dishwashers, clothes washers, gas water heaters and gas heaters. GWA documents the following response to labelling:

- a surge in measures of average energy efficiency, including disproportionate response from suppliers that were more dependant on the Australian sales, particularly domestic manufacturers
- disproportionate retirement of the least efficient models and introduction of high efficiency models
- a series of marginal product improvements to qualify for the next level of star rating

In a later review (Wilkenfeld 1997), the same author estimated that labelling had reduced the energy consumption of labelled appliances by an average of 11%, with larger gains for dishwashers (16%) and for refrigerator and freezers (12%)[14].

It is also well-documented that a large majority of Australians recognise and understand the label, and to various degrees factor energy ratings into their purchase decisions. The most recent review commissioned by E3 found that:

> *... The energy rating label is almost universally recognised with 94% of consumers Australia wide being able to recall it unaided, rising to 96% when prompted.*
>
> *...Seventy five per cent ... of consumers regard the energy rating label as important in the appliance purchasing process ...* (Artcraft 2006: page 1).

There is no evidence suggesting that energy labelling of lamps would be any more effective in Australia than overseas. Some lamps are sold in Australian with the European label but there is no reason to expect that they have had an appreciable impact. The label design is unfamiliar to Australians and, as noted, appears to have had little effect even in Europe.

Can labelling be made more effective?
Regulators periodically review and modify labelling arrangements, asking basic questions about the information that should be included on the label and how it should be presented. This may include re-consideration of the choice between categorical and continuous labelling. Figure 3.4 illustrates the difference. Categorical labelling involves the assignment of appliances to energy efficiency categories that are ranked, for example, from one star to six stars in the Australian scheme. A continuous label reports a measure of

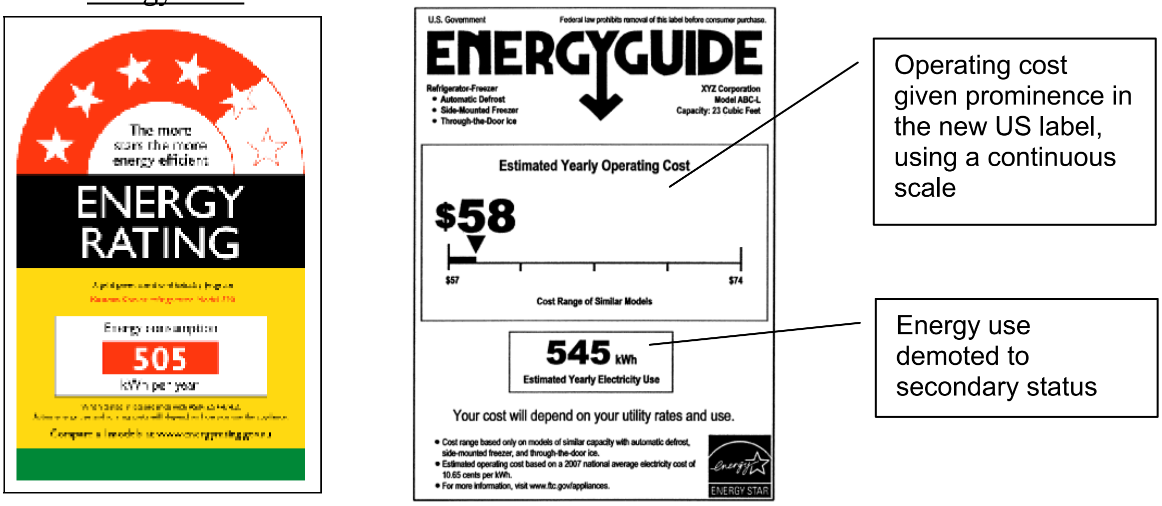
[14] Quoted by du Pont 1998: page 2-18.

energy use, such as annual energy use (kWh/year) or annual energy cost ($/year), and locates that amount on a linear scale that ranges from the most efficient appliance of that kind to the least efficient appliance of that kind.

FIGURE 3.4 EXAMPLES OF CATEGORICAL AND CONTINUOUS LABELLING

CATEGORICAL Australian energy label

CONTINUOUS New US energy label



Labelling has recently been reviewed in the United States (US), Europe and Australia.

United States

The review conducted by the US Federal Trade Commission (FTC 2007) resulted in retention of the continuous labelling approach but a redesigned label that gives more prominence to energy cost and demotes information about energy use to secondary status – see figure 3.4. However, the FTC decided that it was not always feasible to provide information about energy cost, because of space limitations or where the variation in cost conditions is such that an average figure for energy cost is misleading. Energy labelling was therefore retained for some appliances, including household lamps.

Very recently, however, FTC reopened the issue of lamp labelling and will reconsider options for providing information about energy costs. Consultations were in progress at the time of writing and a decision is expected to be announced in 2009.

Europe

The work undertaken for the European Commission's labelling review, which is also incomplete, included asking stakeholders whether the label should provide more or different information (Europe Economics *et al* 2007). The key findings were that[15]:

- The process elicited suggestions that the European label include information about operating costs, greenhouse emissions and other aspects of environmental impact.
- These seems to have been no disagreement that information on operating costs is desirable by general agreement that there was no practical options for dealing with differences in fuels costs between countries and changes in fuel costs over time. While the initial stakeholder interviews elicited support from almost 50% of stakeholders, subsequent on-line submissions and the final consultation meeting effectively rejected the suggestion.

[15] The consultation documents are published at: http://ec.europa.eu/energy/demand/legislation/domestic_en.htm

- There was also some initial support for information about emissions but, again, recognition that there are practical difficulties in dealing with variation in the emissions intensity of fuels. Again, subsequent on-line submissions and the final consultation meeting effectively rejected the suggestion.
- There was also some concern that additional information, by making the label more complex, would discourage use of the label.
- Of the broad types of reform that were considered, stakeholders assigned the lowest priority to the provision of additional information.

Australia
The option of giving prominence to energy cost was discussed and rejected in early debates about the design of the appliance label, about 20 years ago, and has not been given serious consideration since. It was considered that a prominent categorical rating (energy stars) would be effective and would avoid the complications associated with variation in marginal tariffs and appliance usage.

E3 is aware of the need for information about operating cost. Specifically, the most recent review reported that:

> *In response to a series of prompted questions, more than three in five people (62%) say that they would like to have access to a tool or calculator which would help them to compare the extent to which different types of appliances were contributing to their overall household energy bills, and around half would like to have access to a tool or calculator which would help you to compare the running costs (48%) and/or the amount of energy used (52%) and/or the greenhouse emissions (52%) of different appliance models.* (Artcraft 2006: page 51)

These tools are currently provided on the E3 website for all labelled appliances[16]. Users can obtain customised estimates of energy costs that are based on user-supplied settings for marginal tariffs and annual operating hours.

E3's assessment of labelling reform only
As in section 3.1.4, E3 proposes to reform the energy labelling arrangements for lamps, including the provision of information that would allow users to identify lamps with the same light output and compare their energy consumption. The issue here is whether 'labelling reform only' should be shortlisted as an alternative to the proposed combination of MEPS and labelling reform.

E3 considers that, based on domestic and international experience with energy labelling, it cannot confidently recommend any configuration of lamp labelling that will adequately address the impediments to energy efficiency in lighting tasks, to the point where the proposed MEPS should be delayed or abandoned. This view is based on the following considerations.

1. Mandatory labelling requirements need to have a measured, sober and informative tone, avoiding the loud or snappy 'dollar dazzler' approaches that are sometimes adopted in commercial marketing. As they see fit, suppliers can and do use normal commercial advertising practices to draw attention to favourable energy ratings.
2. There is no evidence that lamp labelling in the US and Europe has been a useful policy tool.
3. The provision of energy cost information on labels is desirable in principal but problematic in practice. It aims to provide users with ready-made cost comparisons but inevitably averages across users who face different marginal tariffs, and have different patterns of use. Users may be well advised to interpret the comparative

[16] see http://www.energyrating.gov.au/appsearch/default.asp

energy cost as an indicator of relative efficiency rather than an estimate of actual dollar savings, which is the job that the star rating already does well.

4. Much of what is 'known' about labelling is based on what people tell interviewers about their appliance purchasing behaviour and the information that they use or would like to have. This is not necessarily a reliable account of actual user behaviour and it is debatable whether we know enough about user behaviour to confidently reform labelling programs that are not obviously faulty. In particular:
    - We do not know the extent to which users can and would use energy cost information to calculate the lifecycle cost of appliances, rather than simply reinterpret the information as a categorical indicator of energy efficiency.
    - We do know that categorical rating is the most widely used form of labelling and, compared with continuous rating, is less prone to misinterpretation and elicits stronger responses from users (Egan *et al* 2005). A salutary research finding is that a large minority of users (32%) interpreted the dollar value on the first US label as the value of energy savings rather than the energy cost, reversing the intended message (du Pont 1998: page 7-6). du Pont documents a number of other idiosyncratic interpretations of labelling information, including by well-educated professionals.
    - Users make errors when interpreting label information and the error rate increases during the transition to a new label. Based on the US experience, the old and new labels can co-exist for several years.
5. All of the problems associated with cost labelling are exacerbated when applied to lamps. There is much less space on lamp packaging: they are largely distributed through grocery stores without in-store assistance to interpret labelling information; they are not major purchases of the kind that motivate inspection of labels; users don't need to look at the label to know that CFLs are energy savers.
6. For the immediate future there are competing information priorities on lamp packaging, specifically, to familiarise users with lumens as a measure of lamp output, re-establish wattage as a measure of energy input, and emphasise the very large differences in operating life.
7. The work needed to develop labelling options would significantly delay implementation. Relevant considerations are that:
    - It is confusing for users to have energy rating information presented in different formats on different appliances. Hence, giving prominence to energy costs is a decision that needs to be made at the program level, not on a product-by-product basis. E3 has reviewed labelling periodically, most recently in 2003 and 2006, and may further examine options for cost labelling at the next review.
    - Suppliers have strong views about labelling measures and, based on past experience, there is no prospect that energy labelling arrangements can be quickly reformed.
8. There is every prospect that 'labelling reform only' would be judged ineffective after a suitably lengthy trial, possibly five years, and the delayed implementation of MEPS would be strongly regretted.

E3 has shortlisted 'labelling reform only' as a policy option but has neither developed such an option nor consulted systematically with suppliers about such an option. Consequently, this consultation RIS does not provide a detailed assessment of 'labelling reform only'. E3 invites stakeholders to argue the case for fully developing this option but asks that proponents address the apparent lack of evidence for effectiveness and the delays that would result.

3.2.5 Information campaigns

Use of information campaigns to promote energy-efficient lighting

Information and awareness initiatives are the easiest and earliest policy responses to address energy related issues and have a history that dates back to the energy crises of the 1970s. Internationally, there are numerous programs, addressing a range of market barriers to the adoption of CFLs, for example:

- user awareness and knowledge of CFLs
- user fears and misperceptions about CFL performance,
- user scepticism about the amount and value of energy savings and the environmental benefits
- lack of awareness and misinformation amongst retailers, lighting department managers, builders and contractors
- lack of technical information and guidelines for designers and specifiers

IEA lists the following examples of straightforward information and awareness activities in its review of policies for energy-efficient lighting (IEA 2006: chapter 5).

- Japan – provision of *Energy Conservation Performance Catalogues* through retailers, including lists of energy-efficient lighting fixtures
- Japan – awards for the winners of design competitions, including for improved fluorescent lamps
- Canada – information on lighting efficiency through the *EnerGuide for Industry* website

The IEA list is far from exhaustive. In Australia, for example, DEWHA provides website resources that promote energy efficient lighting in the context of comprehensive guidance on how to achieve energy efficiency in homes and commercial buildings[17]. It is reasonable to expect that these promotional activities are provided in a range of other countries that have seriously responded to the challenges of climate change.

The definition of ‘information measures’ can be expanded to include (a) product certification and endorsement schemes that aim to reassure users that unfamiliar products meet minimum standards of energy efficiency or quality, (b) product initiation schemes such as CFL give-aways and rebates, designed to encourage users to experiment with unfamiliar lighting products and ‘acquire information’ about their performance first hand, and (c) voluntary programs to establish awareness of energy-efficiency and initiate new practices.

As noted in section 3.2.1, subsidy-like arrangements are used in Australia as once-off inducements to encourage people to try CFLs. The proposed MEPS for CFLs mandate certification.

Advantages and disadvantages

The main advantage of information-based measures is that they allow users with a particular preference for an inefficient lamp – because of infrequent use, cost of changeover or for aesthetic reasons – to consider the negative aspects of the lamp but still buy the lamp if, on balance, it is the preferred option. In contrast, MEPS reduce choice, denying particular product options regardless of individual circumstances and preferences.

The main disadvantages of information campaigns are the difficulty and uncertainty of achieving a lasting effect. Consider that:

[17] See http://www.environment.gov.au/settlements/energyefficiency/buildings/ & http://www.environment.gov.au/settlements/energyefficiency/index.html

- For good reasons, people ignore most of the information that is directed at them from numerous sources, leaving limited opportunities to get their attention. Exploitation of those limited opportunities requires marketing and communications expertise of a high order. It is generally necessary to co-opt organisations with marketing skills, such as energy and appliance retailers.
- Awareness and promotional activities only have a limited effect to establish new practices and norms, such as the adoption of industry guidelines or periodic auditing routines, or a habit of using endorsed products only. The awareness and promotional phase cannot be maintained indefinitely due to the large operational costs involved.

Evidence on the effectiveness of information campaigns
It is normal for information programs to claim a degree of success, but often only in terms of participation in the activity. It is difficult to find evidence of lasting effects. The following examples are from the IEA review (IEA 2006: chapter 5) and limited follow-up of those leads.

- The *Top Ten* program is popular with suppliers and attracted 15% of Switzerland's population to its website in 2005. But there is no quantitative assessment of impacts.
- The claims made on behalf of the *Change a Light, Change the World* program are trivial, possibly contributing about 15,000 tonnes CO_2-e/year to abatement in the US.
- The *Green Lights* programs in the US, Europe and China have been judged a success. For example, it is credited with the phasing out of magnetic ballasts for fluorescent lamps in commercial buildings.
- Denmark's *A-club* has recruited 150 public housing associations and local governments that represent 250,000 households.
- The combination of promotional activity with either CFL give-aways or rebates is typically assessed as cost effective. However, these assessments relate only to the initial impact and provide no information about enduring impacts on lamp purchasing behaviour. It is reasonable to suspect that there is significant backsliding after such programs are terminated.

A recent report by the Pacific Northwest National Laboratory (PNNL 2006) provides a more detailed analysis of the US experience with promotional and awareness efforts to increase the market acceptance of CFLs, which began in the late 1980s. A key finding is that little has been achieved. Nationally, CFLs accounted for only 1.6% of the installed stock in 2002. There was considerable variation between states, depending on their exposure to high electricity prices and the promotional efforts of utilities. There are lessons for the 'promotion & rebate' programs that are currently employed in Australia. In essence, PNNL says that programs must work with organisational and market structures that already exist and will endure, and avoid using artificial structures and creations that will not endure (PNNL 2006: page iv-v). For example:

- Don't rely on CFL give-aways that bypass normal distribution channels or undermine retail sales.
- Avoid give-aways that obscure the retail price, leading to 'sticker shock' when the user returns for a repeat purchase.
- Require some action on the part of the user, if only to mail in a request card.
- Involve, educate and motivate the retailers, since it is their marketing behaviour that endures beyond the promotion and awareness phase.
- Invest in attractive point-of-sale displays that will endure beyond the promotion and awareness phase.

It is apparent that the task is difficult and, unfortunately, there is no evidence that even the best-designed programs have had more than limited success. PNNL says that the market share of CFLs stabilised at 5-8% in even the most successful US region, the Pacific Northwest.

E3's assessment of information campaigns
The broad lesson that we draw from this evidence is that information-based programs have enduring effects only when they succeed in grafting new practices and norms onto pre-existing structures. Larger organisations, including large commercial organisations, are attractive targets precisely because they are highly structured. They devise rules and procedures to govern their operations and have some organisational machinery to monitor and enforce those rules. There is a sense in which they 'self-MEPS', that is, they have a capacity for formulating their own performance standards, such as specifying the use of electronic ballasts and endorsed light fittings and lamps.

We have found no evidence that activities promoting efficient lighting have lasting effects on decision-making units that don't have a significant degree of organisational structure, including households and smaller businesses. Denmark's *A-club* is not an exception to the rule. Consider that the *A-club* piggy-backs on pre-existing structures (public housing associations) that have an organisational capacity to maintain the procurement program.

Promotional and awareness activities may succeed where a small unit is contemplating a major expense and is giving more than usual attention to value for money, such as a home renovation or the design and purchase of a new house. Website resources may usefully inform such large and infrequent transactions but it seems unreasonable to assume that they would inform the day-to-day purchase of light bulbs.

These are generalisations and some proportion of households and businesses would be exceptions to the rule.

E3 considers that, based on domestic and international experience with information campaigns, it cannot confidently recommend any promotional or awareness activities that will adequately address the impediments to energy efficiency in lighting tasks, to the point where the proposed MEPS should be delayed or abandoned. The last 30 years of energy saving effort provides no evidence that a well-designed information campaign would deliver more than a fraction of the savings that can be achieved with MEPS.

E3 has shortlisted 'information only' as a policy option but has neither developed such an option nor consulted systematically with suppliers about such an option. Consequently, this consultation RIS does not provide a detailed assessment of information campaigns. E3 however, invites stakeholders to argue the case for fully developing this option but asks that proponents address the apparent lack of evidence of effectiveness and the delays that would result. E3 recognises that an information campaign will however be an important supportive element for the proposed option.

3.2.6 Complete phasing out of incandescent lamps

E3 initially proposed more stringent MEPS for incandescent lamps that, after some delay, would have the practical effect of phasing out most tungsten halogen lamps as well as all tungsten filament lamps. This would have required wholesale replacement of incandescent lamps with CFLs. E3 subsequently identified all of the product performance issues that would arise and found that there were a number of matters that could only be resolved by substantially revising the proposal.

Product performance issues that were dealt with by revising the proposal
We emphasise that the following discussion relates to the original proposal and should be read with that in mind. E3's revised proposal is to substantially neutralise these concerns

by setting the MEPS at a level that allows the continued use of the more efficient types of incandescent lamps. E3 will also use labelling and communications measures to minimise the potential for inconvenience, frustration and poor product selection.

1. Inherent issues relating to the quality of surface illumination

   (a) *Colour appearance of the illuminated surface:* Objects look 'natural' in the light of an incandescent lamp, as though illuminated by sunlight, but can look odd under fluorescent lighting, depending on the quality of the lamp. On a scale of 1 to 100, with sunlight at 100 and most incandescent lamps close to 100, recent generations of fluorescent technologies are in the range 70-95 and compact fluorescent lamps are in the range 82-85[18]. We understand that there is little evidence that people make fine distinctions based on this score and that there are no strong preferences over scores between 80 and 100 (IEA 2006: page 84). E3 proposes a minimum score of 80 for CFLs. This issue was rated as MINOR under the original proposal and will be further reduced by the continued availability of incandescent lamps under the revised proposal.

   (b) *Lumen depreciation:* Both incandescent and fluorescent lamps suffer from lumen depreciation, which is a reduction in lighting power over the life of the lamp. The rate of depreciation is higher for fluorescent lamps, with losses in the range 10-20% at average lamp life. E3 proposes a maximum of 20% lumen depreciation for CFLs at 5,000 hours. The issue was rated as MINOR under the original proposal and will be further reduced by the continued availability of incandescent lamps under the revised proposal.

   (c) *Spotlighting and downlighting of the illuminated surface:* A light source is more easily directed if it has been reduced to a point of light, and that is the particular attraction of ELV tungsten halogen lamps. It is more difficult to collect and control the light from the relatively large tubes of fluorescent lamps. They are not generally used for spotlighting retail displays, artworks and other 'features' of that kind. Putting aside legacy issues, there seem to be three future options for more energy-efficiency spotlighting and downlighting. None is entirely convincing at this stage and, under the original proposal, there would have been MODERATE losses of lighting quality in these applications.

      i. Suppliers have developed a ELV tungsten halogen lamp that uses an infra-red coating (IRC) to capture what would otherwise be waste heat and reduce the amount of electricity needed to keep the lamp at operating temperature. Some have claimed efficacy of 25lumens/watt. This is less than one third of the efficacy of CFLs but about 67% higher than ELV tungsten halogen lamps without the infra-red coating.

      ii. Suppliers have introduced CFL lamps of super compact design for downlighting, including products that directly replace ELV lamps. While likely to become a suitable replacement for most domestic downlights used for general lighting, they provide significantly less control over the 'spot'.

      iii. Light emitting diode (LED) lamps will perform the task but it is uncertain when they will be available at reasonable cost. They operate on low voltage power and require an ELVC.

   Concerns about the adequacy of these replacements are negated by the continued availability of ELV lamps under the revised proposal.

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18 The colour rendering index (CRI) is the metric used to measure this aspect of a lamp's performance. (IEA 2006: page 106)

(d) *Flicker:* Flickering is a problem associated with fluorescent lights on magnetic ballasts. These problems have been overcome by high frequency ballasts using electronics (IEA 2006: page 122). This issue is rated at NIL, even under the original proposal.

(e) *Effectiveness under extreme conditions:* Fluorescent lamps are generally less effective under extremes of heat and cold. HID lamps would fill the gap under the original proposal: they have an efficacy comparable to fluorescent lamps. This issue was rated as MINOR under the original proposal and is negated by the continued availability of incandescent lamps under the revised proposal.

(f) *Dimmers:* The legacy issues relating to dimmers are discussed at item 3(c) in this list. Putting those issues aside, and given sufficient time, suppliers are confident that dimmable CFLs will be available at reasonable cost. There is some work to be done on standards for dimmers and CFL to ensure that, in future, all dimmers are compatible with all dimmable CFLs. Dimmable CFLs have the compensating feature of maintaining their efficacy at less then full power, whereas the efficacy of incandescent lamps falls significantly as the power is reduced. This issue was rated as NIL under the original proposal, provided sufficient time for product development is allowed. The problem is eliminated by the continued availability of tungsten halogen lamps under the revised proposal.

(g) *Start-up and warm-up times:* Whereas incandescent lamps provide ‘service on demand’, fluorescent lamps can take a noticeable amount of time to start and may not reach full power for one or two minutes. E3 proposes a maximum start-up time 2 seconds for CFLs and expects most CFLs to have a start-up time of no more than 1 second. The maximum warm-up time is 1 minute. High quality CFLs with electronic ballasts will perform adequately and these issues are rated as NIL, even under the original proposal.

2. Inherent issues relating to qualities of the lamp

(a) *Colour appearance of the light:* People also have preferences for the colour appearance of the light from a lamp[19], that is, what is seen when one looks directly at the light source or experiences glare from the light source. Lighting designers aim for the natural look of sunlight, which varies with latitude, season and time of day. Historically, fluorescent lamps have provided a ‘cool white’ look that is more acceptable closer to the equator and incandescent lamps have provided a warm look that is more acceptable closer to the poles (2006: page 106). This may be a factor in the higher penetration of fluorescent lamps in Queensland and the Northern Territory. More recently, fluorescent lamps have also become available in the ‘warm’ look. This issue was therefore rated as MINOR under the original proposal and is further reduced by the continued availability of incandescent lamps under the revised proposal.

(b) *Lighting effects:* Chandeliers sparkle when illuminated by tungsten filament lamps but do not when replaced by a CFL. The same effect is exhibited when viewing diamonds. This is caused by the size of the light source which means future LED designs could give the same effect. This issue was rated as MINOR under the original proposal and is eliminated by the continued availability of incandescent lamps under the revised proposal.

(c) *Reduced life when operated outdoors:* Fluorescent lamps are susceptible to humidity but linear fluorescent lamps have been used in street-lighting applications for many years and CFLs are being introduced to the same

[19] The correlated colour temperature (CCT) is the metric used to measure this aspect of a lamp’s performance. It is reported in degrees Kelvin and is relates to the chromaticity of a black body heated to that temperature. (IEA 2006: page 106)

market. Lamps suitable for outdoor operation would be available under the original proposal but would require more careful selection. This issue was therefore rated as MINOR under the original proposal and is further reduced by the continued availability of incandescent lamps under the revised proposal.

(d) *Appearance of lamps:* CFLs can look odd or ugly in comparison to the traditional globe, particularly in situations where a decorative lamp (fancy round or candle shape) is currently used. This is moderated somewhat by products that hide the tubes in a globe with the traditional appearance. This issue was rated as MINOR under the original proposal and is eliminated by the continued availability of incandescent lamps under the revised proposal.

3. Legacy issues relating to the compatibility of new lamps with old fittings and circuits

   (a) *Compatibility with existing luminaires and fittings*: Users have sometimes been unable to acquire CFLs that will fit into existing luminaires and fittings, mostly because the base of a CFL contains a ballast that makes the lamp somewhat bulkier. Suppliers now say that the range of CFL products has improved greatly, to the point where the products required for the vast majority of applications will be readily available in supermarkets. Any residual inconvenience and frustration would have been MINOR under the original proposal and is eliminated by the continued availability of incandescent lamps under the revised proposal.

   (b) *Compatibility with existing lighting control sensors:* A range of sensors are used to control lights, turning them off and on in response to time, motion, occupancy, daylight or touch. A wiring configuration that is commonly used in Australia is such that the sensor only receives a partial power supply, which means that power is available to the lamp when, notionally, the sensor has turned the lamp off. Some CFLs are known to have flashed intermittently under these circumstances and to fail quickly. Other CFLs appear to interfere with the operation of the sensor. It appears that not all CFLs suffer from these problems but further testing would be needed to understand the full range of adverse outcomes. The possible solution is to amend the CFL standard to ensure that CFLs are designed to protect themselves from the 'off current' and to otherwise operate harmoniously with sensors. Some legacy users may need to replace sensors or to partially rewire to provide full supply to sensors. This issue is rated as a MODERATE under the original proposal, but confined to a relatively small number of users and eliminated by the continued availability of incandescent lamps under the revised proposal.

   (c) *Compatibility with existing ELVCs and low voltage circuits:* The options for replacing ELV halogen downlights have improved somewhat. The situation is that:

      i. LEDs will operate on existing ELVCs but it is uncertain when they will be available at reasonable cost.

      ii. Suppliers may to develop an IRC lamp with a slightly higher voltage – 14 volts rather than 12 volts – in order to operate effectively on existing 50 watt ELVCs.

      iii. Compact CFLs that operate with existing ELVC are now coming into the market.

   This issue presented a MODERATE difficulty under the original proposal but is eliminated by the continued availability of incandescent lamps under the revised proposal.

E3 considers that this long list is neutralised by setting the MEPS at a level that allows continued use of the more efficient types of incandescent lamp. This avoids the potentially large costs associated with the rewiring of lighting circuits and the premature replacement of lighting controls, luminaires (lamp housing) and other lamp holders and fittings, and the ELVCs used with ELV lamps.

Uncertainty about one remaining issue of product performance
There is uncertainty about one remaining issue of product performance. It is also a legacy issue concerning dimmers and wiring configurations that put the dimmer control and the lamp on the same circuit. We have been told that existing dimmers can be damaged when the tungsten filament lamps are replaced either by CFLs or MV tungsten halogen lamps, which are the only options that are certain to be available when tungsten filament lamps are phased out.

Further discussion of this issue is deferred to the impact analysis – see section 4.5.

E3's assessment of the MEPS that require complete phasing out of incandescent lamps
E3 has not shortlisted the complete phasing out of incandescent lamps as a policy option that should be developed and assessed in detail. E3 invites stakeholders to argue a contrary point of view but asks that the following concerns be addressed.

1. A complete phase-out would require the premature scrapping of existing lighting assets, especially dimmers and low voltage circuitry. This is a significant but unknown cost.
2. There would be a demand for financial compensation and the work needed to devise and assess such measures would significantly delay implementation.

4 Impact analysis

The measures are assumed to apply during the 12 year period from 2009 to 2020, but with cumulative impacts as product exemptions are terminated and non-complying lamps are replaced. This chapter reports impacts at each stage in the process by which abatement is achieved.

4.1 Cost to the taxpayer

Table 4.1 provides estimates for the incremental cost of including incandescent lamps in the E3 Program, which is taxpayer funded. The E3 Program estimates that, in the period to imposition of MEPS at the point of sale, in November 2009, it will have spent almost $3.4 million to develop and assess the proposals. Total expenses to 2020 are $9.2 million and have a present value of $7.8 million.

TABLE 4.1 COST TO TAXPAYERS OF INCLUDING INCANDESCENT LAMPS IN THE E3 PROGRAM ($A)

	Cumulative total to 2009 ($)	*Annually, 2010-2014 ($/year)*	*Annually, 2015-2020 ($/year)*
Program administration	$1,230,000	$300,000	$120,000
Government/industry steering committee	$10,000	$10,000	$10,000
Standards development	$500,000	$10,000	$0
Product testing	$500,000	$200,000	$50,000
Product and market analysis	$100,000	$50,000	$0
Publications & communications	$1,000,000	$350,000	$2,000
Impact assessment	$100,000	$10,000	$10,000
Total	**$3,440,000**	**$930,000**	**$192,000**

4.2 Business compliance costs

The Council of Australian Government (COAG) requires that impact statements provide estimates of the administrative and paperwork costs incurred by a business in meeting regulatory requirements, defined as follows:

- *Notification:* costs of reporting transactions before or after the event
- *Education:* maintaining awareness of regulations and regulatory changes
- *Permission:* applying for and obtaining permission
- *Purchases:* materials and equipment required for compliance
- *Record keeping:* keeping statutory documents up-to-date
- *Enforcement:* facilitation of audits and inspections
- *Publication and documentation:* displays and labels
- *Procedural:* required compliance activities such as fire drills and safety inspections

COAG’s concern is to monitor the administrative and paperwork burden imposed by the particular form of regulatory transaction between government and business. These compliance costs are defined to exclude the costs of developing and testing new products, except for the cost of certification tests that are required for regulatory purposes. Also excluded are the costs to suppliers of working with government to develop regulations.

The compliance costs will be modest, for these reasons.

- The regulations are readily understood and all significant suppliers are involved in the development of the regulations.
- The regulations use the technical language of all commercial transactions in the manufacture and distribution of lighting products, which means that the regulatory requirements translate directly as product specifications.
- Standard international tests will be used to measure performance. These are same tests that govern commercial transactions and the delivery of product 'to specifications'. We understand that there will be minimal need for additional product testing.
- Suppliers will need to register their products and declare their performance, using the system for on-line registrations[20] that has been developed for linear fluorescent lamps. This is a simple transcription of production information and we understand that experienced users can perform the task at the rate of 4 product groups per hour. We refer to groups of products because a single registration can be used for related products that have sufficiently similar performance characteristics.
- Compliance costs are reduced almost to zero where the practical effect of the MEPS is to ban certain lamps. The trivial remaining cost is to maintain awareness of the regulation.

The remaining compliance costs relate to possible labelling requirements, for example, a statement of light power (lumens), electrical power (watts), and efficacy (lumens/watt) or efficiency (for ELVCs). Suppliers of global brands have objected that this would disrupt their practice of marketing uniform products in uniform packaging across all countries. A special packaging design and production run would be required for the Australian market. While we accept the labelling requirements may need to be costed on this basis, suppliers would need to provide credible cost estimates. Relevant considerations are that:

- There in already fragmentation of packaging arrangements between countries, with mandatory labelling requirements in Europe, Japan and Korea, and voluntary arrangements in US, Thailand and Brazil (IEA 2006: chapter 5 & page 430-31). This may provide a basis for costing the Australian requirement.
- Given global interest in the phasing out of incandescent lamps, it seems reasonable to assume that there will be increasing global demand for comparative information.
- It may be less costly to provide the minimum required information to all users than to do a special run for Australia.
- Suppliers have an opportunity to suggest a labelling regime that delivers against the proposed requirements with minimal disruption to their global marketing arrangements.

Given this uncertainty, the estimate presented in table 4.2 is best regarded as indicative. This issue is included in the request for supplier feedback.

[20] This facility is available from E3's website - www.energyrating.gov.au

TABLE 4.2 BUSINESS COMPLIANCE COSTS

Task	*Global branded suppliers*	*Other branded suppliers*	*Other non-branded suppliers*	*Total*
Maintain awareness of regulations				
Av. annual hours per supplier	10	10	10	
Annual compliance cost	$1,200	$2,800	$4,000	
Present value	$9,282	$21,659	$30,941	$61,882
Initial registration				
Av. hours per registration	0.25	0.38	0.5	
Once-only compliance cost	$3,000	$5,250	$1,000	
Present value	$3,000	$5,250	$1,000	$9,250
Annual registrations				
Av. hours per registration	0.25	0.375	0.5	
Annual compliance cost	$750	$1,313	$250	
Present value	$5,801	$10,153	$1,934	$17,888
Record keeping				
Av. annual hours/product group	0.25	0.375	0.5	
Annual compliance cost	$3,000	$5,250	$1,000	
Present value	$23,206	$40,610	$7,735	$71,551
Labelling				
Av. annual cost per product group	$500	$500	$500	
Annual compliance cost	$150,000	$175,000	$25,000	
Present value	$1,160,292	$1,353,674	$193,382	$2,707,347
Total cost				
Present value				**$2,867,919**
Assumptions				
Number of suppliers	3	7	10	20
Staff cost ($/hour)	$40	$40	$40	
Product groups per supplier	100	50	5	
New product groups per year	25	12.5	1.25	

4.3 Impacts on competition and trade

This section examines whether the proposed regulation may affect the quality of competition in the market for lamps.

4.3.1 Are like-for-like replacements generally available?

As discussed in section 3.2.6, E3 compiled a list of concerns about the availability of like-for-like replacements for incandescent lamps and determined that there were several significant issues that could only be resolved at substantial cost. E3 now propose a MEPS that allows continued use of the more efficient incandescent lamps. The remaining issues are the following:

- *Power quality:* The installation of large numbers of CFLs can cause problems for electricity network operators. The issues are highly technical, associated with the power factor and harmonics of CFLs, but may require some networks to be upgraded to prevent interference with load control systems for off-peak hot water. We understand that these problems are not significant if CFLs are of high quality, and that the proposed MEPS for power factor and harmonics will provide adequate protection. E3 will use the consultation period to consult systematically with network operators.

- *Loss of 'free heating'*: Lamps create heat that contributes to space heating tasks and some of this free heating is lost when more efficient lamps are used. Moderating factors are that:
  - Free heating is confined to the cooler parts of the year, whereas lighting services are required in all seasons.
  - More efficient lamps also reduce space cooling loads. These savings more than compensate for the loss of free heating in most commercial and industrial buildings, where the cooling task dominates. They also reduce the loss associated with free residential heating in tropical regions and other regions where the heating task is trivial or otherwise dominated by the cooling task.
  - Tungsten halogen downlights operate at temperatures that require significant measures to reduce the fire risk. Heat is dissipated by cutting a hole in the ceiling insulation, reducing the amount of free heating that these lamps can contribute.
  - Lamps are both inefficient and emissions-intensive in their role as space heaters. This is due to a number of factors including their location on walls and ceilings, the use of recessed fittings, the energy conversion technology, and the amount of electricity used. The free heating that is lost can be replaced by heating services that are better located and are either more energy efficient (heat pumps[21]) or use fuels that are less emissions intensive (gas).
  - Tungsten filament lamps are installed disproportionately in rooms that are used less intensively, such as bathrooms and bedrooms, and benefit less from free heating.

  E3 will consult further with building energy experts[22] to assess whether these judgments are reasonable and whether, in assessing the case for MEPS, it is reasonable to ignore the issue of free heating.

- *Excess light:* Circumstances exist where users cannot take advantage of more efficient lamps by reducing lamp wattage and therefore consuming less electricity. Instead, the physical configuration of the lighting system is such that the replacement lamp uses the same amount of electricity and the increase in efficacy is delivered as more light. This problem is confined to ELV tungsten halogen lamps with certain types of ELVC and no dimmer, and is factored into the assessment of impacts on users (section 4.4).

These assessments are included in the request for feedback. We deal separately with environmental health and safety issues in section 4.5.

4.3.2 Does the regulation infringe international free trade obligations?

The proposal needs to be consistent with Australia's international obligations under the Technical Barriers to Trade (GTBT) Agreement, which is part of the General Agreement on Tariffs and Trade (GATT). Article 2 of the GTBT Agreement relates to the preparation, adoption and application of technical regulations by central governments and provides for matters such as the even-handed treatment of imports and domestically produced products, the avoidance of unnecessary obstacles to international trade, the development and use of international standards where possible, acceptance of the regulations of other countries where possible, the adoption of performance-based regulation where possible.

Based on the following considerations, the proposed regulations are consistent with the GTBT Agreement.

[21] Lamps operate as resistive heaters, converting 100% of the electrical energy into radiation. Heat pumps have a coefficient of performance of approximately 3.0, which means that the each kWh of free heating provided by a lamp can be replaced by 0.33 kWh of electricity for a heat pump.

[22] We have spoken to a leading Australian expert on building energy efficiency, Dr Paul Bannister of Energex Australia Pty Ltd. He considers that the interaction between incandescent lamps and space conditioning systems can be safely ignored for the purposes of assessing the proposed MEPS.

- All lamps are imported, which means there are no concerns about the even-handed treatment of imports and domestically-manufactured goods.
- The proposed regulation is performance-based. It sets a threshold for minimum performance and does not constrain the manner in which the minimum level of performance is achieved. It follows that the regulation does not discriminate between suppliers, other than in respect of the energy efficiency of their products.
- Standard international tests are used to determine compliance.
- E3 continues to monitor overseas lighting initiatives but Australia is the first country to start phasing out incandescent lamps and necessarily pioneers the regulatory approach. There is no comparable overseas requirement, either proposed or existing, that the Australian regulations can be aligned with.
- Where possible, the proposed performance standards for CFL are in terms of existing overseas and international standards.

4.3.3 Does the regulation otherwise reduce or distort competition?

Chapter 7 provides a statement of compliance with national competition policy.

Lamps
We are confident that the proposed measures will not reduce competition. We understand that there is a competitive supply of complying products from overseas factories, particularly in China. Australian suppliers can contract freely with manufactures to supply the Australian market. No party has suggested to E3 that an existing supplier will withdraw from the market in response to the proposed measures.

However, the market will be temporarily distorted in favour of the lamps that are exempted during the transition period. Specifically, some users will replace their GLS lamps with candle and fancy round[23] tungsten filament lamps. The most popular size, 60 watts, will be available in the candle and fancy round shapes for one year after November 2009. The smaller sizes, 40 watts and 25 watts, will be available for three and seven years respectively. They account for about 25% of tungsten filament sales. Candle and fancy round lamps may look a bit odd as replacements for GLS lamps in some situations, but otherwise there is no significant loss of lighting function.

Extra low voltage converters
To the extent that magnetic converters are replaced with electronic converters, we are confident that supply arrangement will remain competitive. The Australian manufacturer, TridonicAtco, plans to continue supplying electronic converters and there are competing imports from a range of Asian manufacturers.

We also understand that at least one company, Torema Pty. Ltd., will continue to manufacture the more efficient type of magnetic converter in Australia, and that there is also a competitive supply of imported products from Asia. There may be other Australian manufacturers that E3 has not identified.

E3 invites comment on possible threats to the competitive supply of complying ELVCs.

4.3.4 Does the regulation impose excessive costs of search and learning?

There are ‘hassle costs’ associated with the measure. Users will need to come to grips with the new lighting technologies and develop new routines for describing and identifying the lamps that meet their needs. This will involve some learning from experience, including the purchase and return of lamps that don’t quite do the job. However, much of this is an unavoidable investment in the labelling reforms that are needed to reform the practice of

[23] See table A.1 in appendix A for lamp descriptions.

sizing lamps according to the input power of the lamp. As discussed in section 3.1.4, input power no longer provides useful information about light output.

E3 considers that it is the task of the communications campaign to ensure that there is a rapid and productive learning process as the community makes the required adjustments to its routines, reducing hassle costs to a minimum. Users will need to give the issues some attention for a period of time, but at a time when family and friends are also dealing with the same issues and the communications campaign is providing materials to inform those conversations.

E3 considers that, with an appropriate communications campaign, the adjustment need not be more than a minor nuisance. Probably, many will value the opportunity to ‘do the right thing’ environmentally. E3 invites stakeholders to identify any circumstances where the adjustment would be more than a nuisance, or where communications activity would be particularly productive.

4.3.5 Does the regulation distort technology development?

It seems that suppliers have responded to regulatory signals by rapidly expanding the range of CFLs and HV tungsten halogen lamps on the market, to the point where there appear that there are no issues of product availability that cannot be accommodated by the proposed implementation schedule. A possible concern, however, is that this diverts innovative effort from more promising prospects for product development, such as LED lights and high efficiency incandescent lamps.

The alternative view is that standards and labelling measures send a strong signal that innovative effort will be rewarded. Standards and labelling measures can strongly promote the diffusion of new technologies once they become affordable and provide a range of like-for-like replacements for existing products. But the intervention needs to be technological neutral and periodic adjustments of the policy settings are necessary. MEPS can be revised upwards from time to time, and comparative product labels need to be recalibrated to reflect changes in the range of energy efficiencies on the market.

E3 invites comment on the whether the proposed measures are technological neutral, with respect to both existing and prospective technologies.

4.4 Direct financial impact on residential, commercial and industrial users

The assessment of financial impacts assumes that non-complying products will be replaced by existing lighting technologies, albeit with significant improvement, and is inherently conservative for that reason. Specifically, we ignore the prospects for light-emitting diode (LED) technology, which the IEA identified as the ‘great white hope’ for large energy savings in lighting (IEA 2006: chapter 7). IEA notes that the US Department of Energy and US manufacturers have set a target of 160 lumens/watt by 2015, which is 10 times more efficient than incandescent lamps and two and a half times more efficient than CFLs (IEA 2006: page 434). It is not known when LED lamps will be price competitive but suppliers say that costs are declining and quality is improving. We note that some Australian suppliers recently introduced LED lamps for downlight applications.

This means that the analysis for lamps is entirely in terms of three lighting technologies, tungsten filament, tungsten halogen and CFL.

4.4.1 Annualised life cycle cost

We first explain the cost concept used throughout – life cycle cost. The life cycle cost (LCC) of a lighting service is the sum of five cost elements, (1) luminaires, (2) lighting controls, wiring and ELVCs, (3) lighting system maintenance, (4) lamps, and (5) electricity. LCC is usually expressed in present value terms, which is the amount of an up-front payment that would cover all future costs of a lighting service, including energy, but discounted to allow for the fact that present dollars are more valuable than future dollars. LCC can also be expressed as the annualised equivalent of the present value amount. This is the periodic payment that, if paid annually for the period of the lighting service, would have same present value as the up-front payment. We use the annualised cost method because it is a more convenient way to report the costs of an energy service that has a number of components with different asset lives, or to compare the costs of lighting services with different asset lives.

We report the cost impacts entirely in terms of the change in the annualised LCC. This means that cost reductions (net benefits) are reported as negative numbers, being reductions in the annualised LCC. Cost increases (net costs) are reported as positive numbers, being increases in the annualised LCC.

Our calculations are entirely in terms of changes in the cost of lamps and energy, which are operating costs. It is assumed that, at the MEPS levels now proposed, there will be no need to change or prematurely scrap existing luminaires, wiring or lighting controls, and that there will be no change in other costs of operation and maintenance.

A discount rate of 7.5% is used in the discounting and annualising calculations.

Effective life of lamps with very low duty hours
We have assumed that the effective life of all lamps, both complying and non-complying, are not interrupted by breakages and premature scrapping. This is obviously unrealistic in some situations. Consider that CFLs with an operating life of 6,000 hours but used for only 10 minutes per day must last for 100 years in order to deliver all the possible savings. However, we calculate that it makes little difference if all CFLs are assumed to fail after 10 years, limiting the asset life at 10 years. This is because (a) by definition, lamps on low duty contribute little to the re-lamping task, and (b) incremental lamp costs are small relative to the energy savings. Other moderating factors are that:

- On average, lamps that are used less intensively will be replaced later and sometimes very much later than those used more intensively, and will have the advantage of more advanced and cheaper alternatives as the market for CFLs and other energy-efficient lamps develops.
- A lamp may be used less intensively for a period of time but not indefinitely. For example, an unused bedroom may be re-occupied when the house is sold or new tenants move in. Surveys that take a snapshot of lamp use are misleading in that respect.
- Failed lamps are sometimes replaced with less-used lamps from elsewhere in the dwelling, and the less-used lamp is then replaced when convenient. This cycling process reduces variation in the asset life of lamps.

4.4.2 Premature scrapping of non-lamp assets

As discussed in sections 3.1 and 3.2.6, the proposed measures are designed to ensure that like-for-like replacements will be available for all existing lamps that do not comply with the MEPS. Users will not need to prematurely scrap and replace their existing non-lamp assets such as switches, dimmers, sensors, wiring and luminaires. This will be achieved by exempting some categories of lamp from the regulation in the first instance and allowing the continued use of certain incandescent lamps. E3 will review exemptions in consultation with suppliers and terminate exemptions when suitable replacements are available.

As outlined in section 3.1.3 (table 3.3), E3 has proposed firm implementation dates for only GLS lamps (conventional pear-shaped tungsten filament lamps), LV non-reflector lamps, CFLs and ELVCs. With regard to LV reflector lamps specifically, the proposed MEPS will only eliminate the least efficient models. E3 invites comment on whether like-for-like replacements are available for all non-complying products in these categories, remembering that MV tungsten halogen lamps can be used where CFLs are unsuitable.

4.4.3 Mains voltage (MV) non-reflector lamps

There are non-complying products of both the tungsten filament and tungsten halogen type in this category. The GLS type of tungsten filament accounts for 67% of the installed stock and will not be available after November 2009. Tungsten halogen lamps and the larger candle and fancy round types of tungsten filament lamps are scheduled for November 2010, and account for another 10% of the installed stock. Most of the remainder are scheduled for November 2012, leaving only the smallest (25 watt) candle and fancy round types off the schedule at this stage.

Calculation of energy savings

Suppliers are confident that complying tungsten halogen products will be available for the scheduled termination of the exemption, in November 2010. These will be ‘enhanced technology’ products that use infra red coatings to increase the operating temperature and efficiency of the lamp. E3 has purchased two of the early products, which are claimed to be either borderline compliant or slightly above, but has yet to conduct independent tests. By comparison, non-complying ‘current technology’ products are listed in catalogues with a gap of 1-3 lumens/watt relative to the proposed MEPS. For modelling purposes we have assumed that these lamps need to improve by 2 lumens/watt, or 17% on average.

Catalogue data indicates that none of the tungsten filament lamps now on the market comply with the proposed MEPS, and suppliers say that this technology cannot bridge the gap of about 3.5 lumens/watt and will be phased out.

We assume that non-complying lamps will be replaced with a 50:50 mix of complying tungsten halogen and CFL lamps. This is a critical variable, since CFLs are three times more efficient than tungsten halogens and deliver much more abatement. But we cannot yet be confident about how users will respond. Relevant considerations are that:

1. Existing CFLs cannot replace incandescent lamps on dimmers and other types of controls. However this problem affects less than 5% of replacements and the constraint will be further relaxed as new CFL designs come on the market.
2. The tungsten halogens are somewhat cheaper than the CFLs, at $3 and $4-5 respectively, providing them with a first-cost advantage.
3. Tungsten halogen lamps resembling the conventional pear-shaped GLS are available, but so are CFLs[24].
4. Tungsten halogen lamps will be needed to replace tungsten filament lamps on dimmers and other control circuits, and may become more readily available as tungsten filaments are withdrawn from sale.
5. CFLs have an established reputation as energy and greenhouse savers. A key program design issue for E3, which remains to be solved, is how to preserve that distinction and ensure that tungsten halogen lamps are not marketed as energy efficient, or otherwise assumed by users to be the equivalent of CFLs. This issue will be prominent in E3 requests for stakeholder feedback.

Incremental cost of more efficient lamps

GLS lamps generally sell for less than $1/lamp and sometimes for less than 50 cents. We assume a price of 75 cents for all tungsten filament lamps, including all candle and fancy round types. CFLs sell for $4-5/lamp and we assume a price of $4.50/lamp.

[24] The halogen capsule, or CFL coil, is fitted inside a conventionally shaped globe, which is fitted with the bayonet or screw cap required by conventional light fittings.

Non-complying tungsten halogens are somewhat cheaper than CFLs, at $3. E3 has only a small sample of the first complying products on the market – two lamps – and paid the going price for existing lamps, which is $3/lamp. The 'enhanced technology' products seem to be priced for high volume sales and without a detectable price premium for increased efficiency. Nevertheless, we have assumed that a 10% increase in efficacy is associated with a 10% increase in the retail price, or 30 cents. This means that users will pay an extra 49 cents for complying tungsten halogens that provide a 16.5% increase in efficiency (= 1.65 * 30 cents).

We made conservative assumptions for the life of replacement lamps, putting both at the minimum that will be required by the proposed MEPS – 2,000 hours and 6,000 hours for tungsten halogens and CFLs respectively.

Financial impacts

Table 4.3 reports the resulting estimates of financial impacts in the residential sector, for various combinations of the initial lamp type, the replacement lamp type, lamp size and duty hours. Each panel relates to the replacement of non-complying tungsten filament and tungsten halogen lamps that produce the same amounts of light. Note that:

- The weighted averages across lamp types (final column) assume an initial configuration that is 98% tungsten filament and 2% tungsten halogen, and that both are replaced 50:50 by complying tungsten halogens and CFLs.
- We used conservative weightings for duty hours and wattages in the residential sector, with more than 80% of the lamps assumed to have duty hours of less than 2 hours per day and 30% of the lamps assumed to have wattages of less than 60 watts. The weighted averages for residential duty hours and wattage are 1.5 hours per day and 60 watts respectively for tungsten filaments, and 1.8 hours and 52 watts for tungsten halogens.
- The commercial and industrial sectors use more powerful lamps, more intensively. The 4-8 hour row in the 75 watt panel is indicative for the commercial and industrial sectors[25]. While the lower electricity tariffs in the commercial and industrial sectors reduce the value of savings 10-70%, we estimate that there are cost reductions for all plausible combinations. It is only unlikely configurations of low wattage lamps (40 watts or less) or low duty hours (<4 hours), or both, that return cost increases. And it is only tungsten halogen replacements that return cost increases, not CFLs.

Overall, we estimate that:

- There are cost reductions for virtually all residential combinations and the gains vary positively with the duty hours and power of the lamp. The exceptions are low wattage lamps on low duty hours that are replaced with complying tungsten halogen lamps. See the top left-hand corner of the top panel in table 4.3.
- The reduction in operating costs is far greater for CFLs than for tungsten halogen.
- The average cost saving is sensitive to the mix of tungsten halogen and CFL lamps that are used to re-lamp. The residential average approaches 70 cents/lamp if tungsten halogens dominate, and $4/lamp if CFLs dominate.
- Assuming a 50:50 mix, the average annual savings are $2.38/lamp for residential users, $9/lamp for commercial users and $6/lamp for industrial users.

[25] The commercial and industrial sectors use larger lamps than the residential sector, and more intensively. For example, a US study (Navigant 2002) puts the average wattage and duty hours at 83 watts and 9.4 hours for the commercial sector, and 126 watts and 14.2 hours for the industrial sector, compared with 65 watts and 1.9 hours for the residential sector.

TABLE 4.3 CHANGE IN ANNUALISED LCC: MV NON-REFLECTOR LAMPS, RESIDENTIAL ($/LAMP)

Duty hours per day	Type of replacement lamp: Tungsten halogen	CFL	Tungsten halogen	CFL	Weighted average
Lamp replaced:	25 watt tungsten filament		21 watt tungsten halogen		
< 1 hour	+$0.06	-$0.41	-$0.03	-$0.50	-$0.18
1-2 hours	-$0.06	-$1.64	-$0.14	-$1.72	-$0.85
2-4 hours	-$0.23	-$3.45	-$0.30	-$3.53	-$1.84
4-8 hours	-$0.56	-$7.04	-$0.63	-$7.11	-$3.80
8-12 hours	-$1.00	-$11.83	-$1.07	-$11.90	-$6.42
> 12 hours	-$1.34	-$15.42	-$1.40	-$15.48	-$8.38
Residential average	-$0.06	-$1.64	-$0.17	-$2.09	-$0.86
Lamp replaced:	40 watt tungsten filament		34 watt tungsten halogen		
< 1 hour	-$0.04	-$0.76	-$0.09	-$0.81	-$0.40
1-2 hours	-$0.35	-$2.69	-$0.32	-$2.66	-$1.52
2-4 hours	-$0.81	-$5.54	-$0.66	-$5.39	-$3.17
4-8 hours	-$1.73	-$11.23	-$1.34	-$10.84	-$6.47
8-12 hours	-$2.95	-$18.81	-$2.25	-$18.11	-$10.86
> 12 hours	-$3.86	-$24.49	-$2.93	-$23.56	-$14.16
Residential average	-$0.35	-$2.69	-$0.39	-$3.20	-$1.53
Lamp replaced:	60 watt tungsten filament		53 watt tungsten halogen		
< 1 hour	-$0.16	-$1.23	-$0.16	-$1.23	-$0.69
1-2 hours	-$0.71	-$4.09	-$0.52	-$3.90	-$2.40
2-4 hours	-$1.52	-$8.35	-$1.06	-$7.88	-$4.92
4-8 hours	-$3.14	-$16.84	-$2.13	-$15.83	-$9.97
8-12 hours	-$5.29	-$28.16	-$3.56	-$26.43	-$16.69
> 12 hours	-$6.91	-$36.64	-$4.64	-$34.37	-$21.74
Residential average	-$0.71	-$4.09	-$0.63	-$4.70	-$2.41
Lamp replaced:	75 watt tungsten filament		66 watt tungsten halogen		
< 1 hour	-$0.24	-$1.58	-$0.21	-$1.54	-$0.91
1-2 hours	-$0.96	-$5.14	-$0.66	-$4.84	-$3.04
2-4 hours	-$2.02	-$10.45	-$1.33	-$9.76	-$6.22
4-8 hours	-$4.13	-$21.04	-$2.68	-$19.59	-$12.56
8-12 hours	-$6.95	-$35.16	-$4.47	-$32.68	-$21.01
> 12 hours	-$9.07	-$45.75	-$5.82	-$42.50	-$27.35
Residential average	-$0.96	-$5.14	-$0.79	-$5.83	-$3.06
Lamp replaced	100 watt tungsten filament		89 watt tungsten halogen		
< 1 hour	-$0.38	-$2.16	-$0.28	-$2.06	-$1.27
1-2 hours	-$1.35	-$6.89	-$0.87	-$6.41	-$4.11
2-4 hours	-$2.81	-$13.94	-$1.76	-$12.89	-$8.36
4-8 hours	-$5.72	-$28.03	-$3.53	-$25.85	-$16.83
8-12 hours	-$9.59	-$46.81	-$5.90	-$43.12	-$28.13
> 12 hours	-$12.50	-$60.89	-$7.68	-$56.07	-$36.61
Residential average	-$1.35	-$6.89	-$1.05	-$7.71	-$4.13
Lamp replaced:	all tungsten filament		all tungsten halogen		
< 1 hour	-$0.15	-$1.20	-$0.15	-$1.20	-$0.67
1-2 hours	-$0.69	-$4.08	-$0.51	-$3.89	-$2.38
2-4 hours	-$1.55	-$8.58	-$1.07	-$8.10	-$5.06
4-8 hours	-$3.18	-$17.21	-$2.14	-$16.17	-$10.17
8-12 hours	-$5.55	-$29.57	-$3.68	-$27.70	-$17.52
> 12 hours	-$5.40	-$31.16	-$3.75	-$29.51	-$18.25
Residential average	-$0.69	-$4.06	-$0.62	-$4.67	-$2.38

Impact of dimming
Dimming reduces the efficacy of lamps and the energy savings from more efficient lamps. We investigated this issue by assuming that, on average, these lamps are dimmed to 80% of maximum light output and that this is associated with a 10% reduction in efficacy[26]. We find that annualised LCC is still reduced in all plausible configurations. The average residential saving is $2.07/lamp, compared with $2.38/lamp at full power, ignoring the fact that dimmable lamps tend to be installed in high use areas such as living rooms.

4.4.4 Extra low voltage (ELV) non-reflector lamps

These are tungsten halogen products that use an ELVC to step the electrical voltage down to 12 volts. Suppliers say that these products already comply with the proposed MEPS and E3 has confirmed that with a number of product tests. We are confident that this sub-market will not be affected.

4.4.5 MV reflector lamps

There are non-complying products of both the tungsten filament and tungsten halogen type in this category, contributing about 75:25 to the installed stock of non-complying lamps. There is a 3 year exemption, to November 2012.

Calculation of energy savings
Given time, suppliers consider that tungsten halogen lamps can be improved to the point where they comply with the proposed MEPS. E3 has tested a sample of six lamps and found that they would need to improve by 2 to 5 lumens/watt. We have assumed that tungsten halogen lamps will need to be improved by 3 lumens/watt, or 26% on average.

None of the tungsten filament lamps now on the market comply with the proposed MEPS. Tests commissioned by E3 indicate that the deficiency is 5 lumens/watt and that complying tungsten halogen lamps would be 54% more efficient on average. Suppliers say that this technology cannot bridge the gap.

We assume that non-complying lamps will be replaced with a 80:20 mix of complying tungsten halogen and CFL lamps. The CFL proportion has been set at only 20% because CFLs are not ‘reflector friendly’ and there is relatively small range of reflector CFLs now on the market. The problem is that the light emitting surface of a CFL is relatively large and the light cannot be easily marshalled and pointed in the desired direction. Again, the mix is a critical because CFLs are three times more efficient than tungsten halogens and deliver much more abatement.

Otherwise, the general approach is the same as that for MV non-reflector lamps.

Incremental cost of more efficient lamps
MV reflector lamps sell for $3-5/lamp with the tungsten filament lamps at the lower end and tungsten halogen at the upper end. We have assumed prices of $3.50 and $4.50 for non-complying tungsten filament and tungsten halogen lamps respectively.

The products that will eventually replace these are not generally available now. We made the following assumptions for the purposes of the RIS.

- For tungsten halogens, it is assumed that a 10% increase in efficacy is associated with a 10% increase in the retail price, or 45 cents. This means that the complying tungsten halogens will cost an extra $1.16 cents for the 26% increase in efficiency (= 2.6 * 45 cents).

[26] This relationship between dimming and efficacy is suggested by Page (2007: figure 3). It should be noted that the relationship was derived for a more powerful type of tungsten halogen lamp (300 watt ‘torchieres’) than is the subject of the proposed regulation.

- Complying reflector CFLs are assumed to sell for $6/lamp when the exemption is terminated. They cannot be much more expensive than that and still take a reasonable share of the market.

Again, we made conservative assumptions for life of the replacement lamps.

Financial impacts
Table 4.4 reports the resulting estimates of financial impacts in the residential sector. This is the same format as that used for the non reflector type (table 4.3), except that the lamps are somewhat more powerful. The weighted averages across lamp types (final column) assume an initial configuration that is 75% tungsten filament and 25% tungsten halogen, and that both are replaced 80:20 by complying tungsten halogens and CFLs.

The commercial and industrial sectors use more powerful lamps, more intensively. The 4-8 hour row in the 100 watt panel is indicative for the commercial and industrial sectors. However, electricity tariffs are lower in the commercial and industrial sectors and, allowing for that difference, the savings are reduced by 50-75%. We estimate that there are cost reductions for all plausible combinations. It is only low wattage lamps (35 watts) on industrial tariffs that return cost increases. And it is only tungsten halogen replacements that have net costs, not CFLs.

These estimates indicate that:

- There are cost reductions for all combinations and the gains vary positively with the duty hours and power of the lamp.
- The reduction in operating costs is far greater for CFLs than for tungsten halogen.
- The average cost saving is sensitive to the mix of tungsten halogen and CFL lamps that are used to re-lamp. The residential average approaches $2/lamp if tungsten halogens dominate, and $5/lamp if CFLs dominate.
- Assuming a 80:20 mix, the average annual savings are $2.57/lamp for residential users, $9/lamp for commercial users and $7/lamp for industrial users.

Impact of dimming
Dimming also reduces the efficacy of MV reflector lamps. As for the MV non-reflector lamps, however, we find that annualised LCC is still reduced in all plausible configurations. The average residential saving is $2.21/lamp, compared with $2.57/lamp at full power, ignoring the fact that dimmable lamps tend to be installed in high use areas such as living rooms.

4.4.6 ELV reflector lamps

ELV reflector lamps are all of the tungsten halogen type and are generally referred to as ‘halogen downlights’. E3 tested a sample of 15 halogen downlights and found that:

- Of twelve 50 watt lamps in the sample, seven would not comply with the proposed MEPS. Efficacy ranged from 11.4 to 17.4 lumens/watt, compared with proposed MEPS of 14.4 lumens/watt. The average non-complying lamp is 1.5 lumens below the MEPS.
- All three of the 35 watt lamps in the sample complied with the proposed MEPS. Efficacy ranged from 14.1 to 17.2 lumens/watt, compared with proposed MEPS of 13.2 lumens/watt.

Suppliers say that 50 watt halogen downlights account for at least 90% of sales. We expect that a more comprehensive testing program would show that a significant proportion of other standard products – 20, 35, 72 and 100 watts – do not comply with the proposed MEPS. This is based on a comparison of test results with other technical data provided by suppliers, and extrapolation of the 50 watt comparison to the other standard wattages.

TABLE 4.4 CHANGE IN ANNUALISED LCC: MV REFLECTOR LAMPS, RESIDENTIAL ($/LAMP)

Duty hours per day	Type of replacement lamp				Weighted average
	Tungsten halogen	CFL	Tungsten halogen	CFL	
Lamp replaced:	35 watt tungsten filament		26 watt tungsten halogen		
< 1 hour	-$0.29	-$1.02	-$0.01	-$0.74	-$0.37
1-2 hours	-$1.10	-$3.39	-$0.16	-$2.46	-$1.34
2-4 hours	-$2.30	-$6.90	-$0.39	-$4.99	-$2.77
4-8 hours	-$4.69	-$13.90	-$0.84	-$10.05	-$5.63
8-12 hours	-$7.88	-$23.23	-$1.45	-$16.79	-$9.43
> 12 hours	-$10.27	-$30.22	-$1.90	-$21.85	-$12.29
Residential average	-$0.93	-$2.89	-$0.17	-$2.53	-$1.16
Lamp replaced:	60 watt tungsten filament		50 watt tungsten halogen		
< 1 hour	-$0.57	-$1.60	-$0.19	-$1.23	-$0.69
1-2 hours	-$1.90	-$5.13	-$0.68	-$3.91	-$2.26
2-4 hours	-$3.88	-$10.37	-$1.42	-$7.91	-$4.60
4-8 hours	-$7.85	-$20.85	-$2.88	-$15.88	-$9.28
8-12 hours	-$13.14	-$34.81	-$4.83	-$26.51	-$15.52
> 12 hours	-$17.10	-$45.28	-$6.29	-$34.47	-$20.19
Residential average	-$1.62	-$4.38	-$0.71	-$4.03	-$1.98
Lamp replaced:	80 watt tungsten filament		65 watt tungsten halogen		
< 1 hour	-$0.76	-$2.07	-$0.31	-$1.61	-$0.92
1-2 hours	-$2.47	-$6.53	-$1.02	-$5.07	-$2.94
2-4 hours	-$5.02	-$13.17	-$2.08	-$10.23	-$5.96
4-8 hours	-$10.13	-$26.44	-$4.20	-$20.52	-$12.00
8-12 hours	-$16.93	-$44.14	-$7.03	-$34.24	-$20.04
> 12 hours	-$22.03	-$57.40	-$9.15	-$44.53	-$26.07
Residential average	-$2.11	-$5.58	-$1.05	-$5.23	-$2.59
Lamp replaced:	100 watt tungsten filament		85 watt tungsten halogen		
< 1 hour	-$0.95	-$2.53	-$0.41	-$2.00	-$1.14
1-2 hours	-$3.01	-$7.92	-$1.33	-$6.23	-$3.60
2-4 hours	-$6.10	-$15.96	-$2.69	-$12.55	-$7.27
4-8 hours	-$12.28	-$32.02	-$5.42	-$25.16	-$14.62
8-12 hours	-$20.52	-$53.43	-$9.06	-$41.97	-$24.41
> 12 hours	-$26.70	-$69.48	-$11.79	-$54.57	-$31.75
Residential average	-$2.57	-$6.77	-$1.37	-$6.42	-$3.17
Lamp replaced	120 watt tungsten filament		100 watt tungsten halogen		
< 1 hour	-$1.12	-$2.99	-$0.51	-$2.39	-$1.35
1-2 hours	-$3.53	-$9.31	-$1.62	-$7.39	-$4.24
2-4 hours	-$7.14	-$18.73	-$3.27	-$14.86	-$8.55
4-8 hours	-$14.36	-$37.56	-$6.58	-$29.78	-$17.17
8-12 hours	-$23.99	-$62.67	-$11.00	-$49.68	-$28.67
> 12 hours	-$31.20	-$81.50	-$14.31	-$64.60	-$37.29
Residential average	-$3.02	-$7.96	-$1.67	-$7.61	-$3.74
Lamp replaced:	all tungsten filament		all tungsten halogen		
< 1 hour	-$0.74	-$2.03	-$0.29	-$1.58	-$0.89
1-2 hours	-$2.45	-$6.52	-$1.00	-$5.07	-$2.92
2-4 hours	-$5.11	-$13.47	-$2.11	-$10.48	-$6.08
4-8 hours	-$10.22	-$26.88	-$4.23	-$20.89	-$12.14
8-12 hours	-$17.34	-$45.56	-$7.21	-$35.43	-$20.60
> 12 hours	-$18.91	-$50.49	-$7.18	-$38.76	-$22.47
Residential average	-$2.09	-$5.55	-$1.04	-$5.19	-$2.57

ELVCs and standard downlight wattages

The impact assessment for halogen downlights is complicated by the ELVCs that are used to step the electrical supply down to 12 volts. The problem is that much of the installed stock of ELVCs operates correctly only for specific standard loads – 20, 35, 50, 72 and 100 watts – and should be matched with lamps that provide that specific load[27]. This means that, until older ELVCs are replaced with newer types that operate effectively on different loads, a less efficient downlight must be replaced with a more efficient downlight that has the same wattage and provides the increased efficacy in the form of more light. Potentially, replacement lamps provide more light but use the same amount of electricity.

Given this constraint on lamp replacements, energy savings can only arise in specific ways. With reference to the dominant lamp size, 50 watts, there are three options for lamps that are not on dimmers.

1. The option of using a high efficacy 35 watt lamp is available[28] if (a) the lamp is connected to one of the newer types of ELVC that operate effectively with the lower load, or (b) there is new construction and refurbishment that provides the opportunity to install a ELVC for the 35 watt lamp. These users take advantage of the increased efficacy in the usual way, as a direct reduction in wattage and electricity consumption.
2. The option of using fewer but more efficient 50 watt lamps is also available to new construction and refurbishments, and where the user is content to partially re-lamp, leaving gaps in the existing lamp array. There are associated savings in the cost of labour and associated materials (wiring, transformers and luminaires) for new construction and refurbishments.
3. The remaining category is comprised of (a) those who cannot re-lamp at a lower wattage because they have the older type of ELVC and, (b) those who have an option of lower wattages or fewer lamps but, for reasons of ignorance or inertia, choose not to make the required changes. These users continue to purchase and install the same number of lamps of the same wattage and their new lamps simply put out more light, possibly 20-30% more. Some may use supplementary lighting that can be turned off instead.

The first two options are the same for lamps on dimmers as for lamps that are not on dimmers – 35 watt lamps or fewer 50 watt lamps. But the third option is different. It is reasonable to assume that users who cannot reduce wattage, or choose not to, would dim the new lamps back to the preferred level. There are energy savings in this case because efficacy declines as lamps are dimmed.

The limited information on the stock of halogen downlights does not allow us to confidently quantify the various types of users. Based on discussions with suppliers, however, we understand that (a) it is certain that relatively few users have the type of ELVC that will accommodate different loads, and (b) most residential users have their ELV reflector lamps on dimmers.

The constraint imposed by existing ELVCs means that it is therefore necessary to distinguish between short and long term effects. In the short to medium term, we assume that there will be:

- a relatively small number of users with the type of ELVC that allows them to re-lamp at 35 watts;

[27] A different lamp may still work but its life is shorter. Historically, the loads were standardised to facilitate the matching of ELVCs and with lamps.

[28] E3 testing indicates that 35 watt lamps of sufficiently high efficacy are now available. That is, they would provide at least the same amount of light as some of the non-complying 50 watt lamps that are now on the market.

- many residential users who must re-lamp at 50 watts but save energy by dimming the lamp;
- a significant minority of users, particularly commercial users, who must re-lamp at 50 watts but do not have dimmers and can only save energy by reducing supplementary lighting.

New construction and lighting refurbishments will relax the constraints over the longer term, allowing preferred lighting levels to be provided at lower wattages or with fewer lamps. This can happen reasonably quickly in some residential and commercial applications with high rates of refurbishment. For taxation purposes, lighting systems are generally assumed to have asset lives of 15-20 years. However, these prospects may be overtaken by technological developments, in particular, LED or CFL downlights that compete with halogen downlights on price but are much more efficient.

Calculation of energy savings

Given the uncertainties about the longer term, we focused on likely gains over the short to medium term for the purposes of this RIS. We assumed that the energy savings can be assessed as follows.

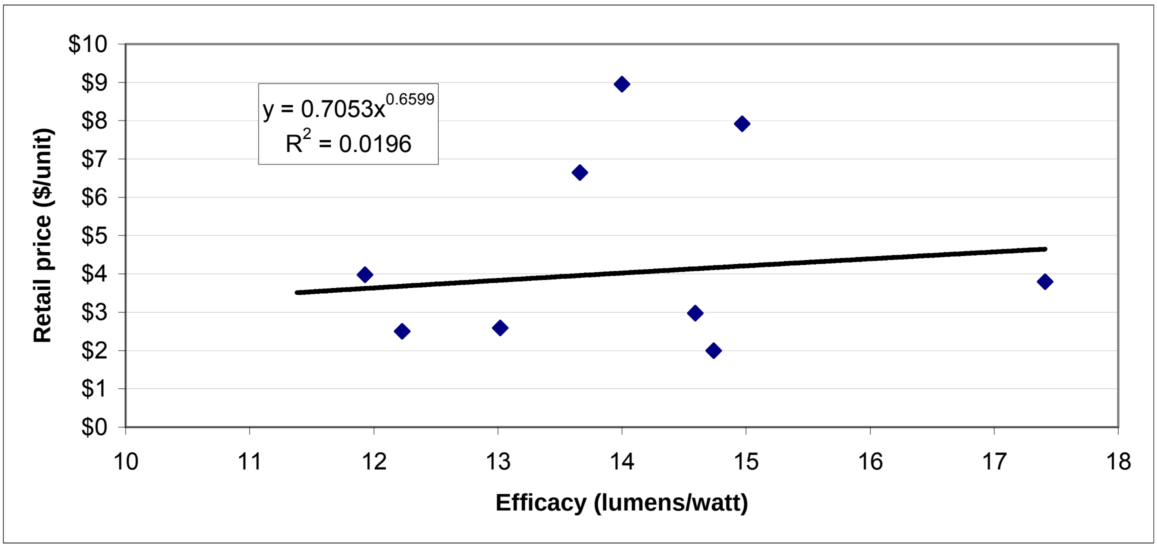
- The 50 watt lamp is representative of all halogen downlights and has average duty hours of 2.25 hours.
- Non-complying lamps account for half of all lamp sales, which is the proportion indicated by the test sample.
- Non-complying lamps are replaced with existing halogen downlights that comply with the MEPS, not with CFLs. There are CFLs on the market that are designed for the same range of applications, but they cannot deliver the dot shaped point of light associated with halogen downlights, which can be easily focused and directed by a small light capsule. Existing CFLs also have limited dimming capability and are not always compatible with existing ELVCs and dimmers. On what we know now, it seems unreasonable to expect the proposed measures to contribute significantly to a shift from halogen downlights to CFL downlights.
- 90% of users without dimmers must re-lamp at 50 watts and can only save energy by reducing supplementary lighting. We put these savings at zero. The remaining 10% re-lamp at 35 watts and none take the option of reducing the number of 50 watt lamps.
- 90% of users with dimmers must re-lamp at 50 watts and save energy by dimming back to the preferred lighting level, which is assumed to be 80% of the light provided by an average 50 watt lamp at full power. The replacement lamp is dimmed further because it is more efficient and produced more light at full power. The remaining 10% re-lamp at 35 watts and none take the option of reducing the number of 50 watt lamps.
- We note the possibility that excess light from lamps that cannot be dimmed may impose non-trivial costs on some users, for example, if they prematurely scrap their existing lamp fittings or otherwise reconfigure their lights to restore the preferred level of lighting. However we assume that the increased light is not noticed or otherwise quite acceptable, since our eyes can adapt to a broad range of light intensities[29]. We note that users can only learn by experience how much light a particular 50 watt lamp will provide, since existing labels contain only wattage information. This suggests that suppliers are unconcerned that 50 watt lamps provide varying amounts of light, ranging from 550 lumens to 850 lumens in E3's sample of twelve lamps. Arguably, suppliers would only be unconcerned if users are also unconcerned. For the purposes of this RIS, therefore, we assume that the users pay the increased cost of more efficient lamps but are otherwise unaffected.

[29] *The eye functions over a vast range of light levels; once it has adapted to the prevailing conditions, visual performance is relatively insensitive to the amount of light.* (IEA 2006: page 69)

Incremental cost of more efficient lamps
The average retail price of the 50 watt lamps in the E3 sample was $4.60, but with considerable variation and only weak evidence of a positive relationship with efficacy – see figure 4.1. We have assumed that a 10% increase in efficacy is associated with a 10% increase in the retail price, or 46 cents. (For what it's worth, the weak relationship reported in figure 4.1 indicates that a 10% increase in efficacy is associated with a 6.6 % increase in the retail price.)

This means that the users who re-lamp with 35 watt downlights incur an incremental cost of $1.98 to obtain a 43% increase in efficacy (= 4.3 * 46 cents). Users who re-lamp with complying 50 watt downlights obtain a 15% increase in efficacy and are assumed to pay an extra 70 cents (= 1.5 * 46 cents).

FIGURE 4.1 PRICE AND EFFICACY OF 50 WATT ELV TUNGSTEN HALOGEN LAMPS, REFLECTOR TYPE (E3 TEST SAMPLE)



Financial impacts
Table 4.5 reports the resulting estimates of financial impacts in the residential sector. These indicate that:

- There are cost reductions for all users except for those who must take the increased efficacy as more light rather than savings on electricity bills.
- The cost reductions are much greater where the user re-lamps at 35 watts and otherwise modest. The cost savings are modest for what we understand to be the dominant group, comprising users who save energy by dimming a more efficient 50 watt lamp back to the preferred level. The weighted average across replacement types (last column) is close to the impact of this dominant group.
- Comparison of the savings from 35 watt replacements indicates that the savings on dimmed lamps are not significantly less than the savings on undimmed lamps. However, this outcome is sensitive to our assumption that, on average, these lamps are dimmed to 80% of their output at full power.
- The average annual saving is 25 cents/lamp-year in the residential sector, assuming that 90% of these lamps are on dimmers.

TABLE 4.5 CHANGE IN ANNUALISED LCC: ELV TUNGSTEN HALOGEN LAMPS, REFLECTOR TYPE, RESIDENTIAL ($/LAMP)

Duty hours per day	*Type of replacement for non-complying lamp*		*Weighted average*
	Replaced with 35 watt lamp	*Replaced with 50 watt lamp that is borderline compliant*	
Lamps that cannot be dimmed			
< 1 hour	-$0.25	+$0.07	+$0.04
1-2 hours	-$0.92	+$0.15	+$0.04
2-4 hours	-$1.92	+$0.27	+$0.05
4-8 hours	-$3.91	+$0.51	+$0.07
8-12 hours	-$6.56	+$0.84	+$0.10
> 12 hours	-$8.55	+$1.09	+$0.12
Residential average	-$1.42	+$0.21	+$0.05
Lamps on dimmers			
< 1 hour	-$0.20	-$0.02	-$0.04
1-2 hours	-$0.78	-$0.11	-$0.18
2-4 hours	-$1.63	-$0.25	-$0.39
4-8 hours	-$3.33	-$0.53	-$0.81
8-12 hours	-$5.60	-$0.91	-$1.37
> 12 hours	-$7.30	-$1.18	-$1.80
Residential average	-$1.20	-$0.18	-$0.29
Weighted average of lamps with and without dimmers (90% with, 10% without)			
< 1 hour	-$0.21	-$0.01	-$0.03
1-2 hours	-$0.79	-$0.09	-$0.16
2-4 hours	-$1.66	-$0.20	-$0.35
4-8 hours	-$3.39	-$0.43	-$0.72
8-12 hours	-$5.69	-$0.73	-$1.23
> 12 hours	-$7.42	-$0.96	-$1.60
Residential average	-$1.22	-$0.14	-$0.25

We assessed the non-residential impacts on the assumption that there is no significant use of halogen downlights in the industrial sector and that 90% of the halogen downlights in the commercial sector are not on dimmers. The significant differences between the commercial and residential sectors are therefore that the commercial sector (a) uses lamps more intensively, 8 hours per day, (b) pays lower tariffs, and (c) is less able to obtain savings by dimming and therefore more constrained to take increased efficacy as more light. We estimate that:

- There are significant reductions in the annualised LCC where commercial users re-lamp with 35 watt lamps, $3.52/lamp for lamps at full power and $2.93/lamp where the lamp is dimmed to 80% of full power. The weighted average is close to the former, at $3.47/lamp reflecting our assumption that only 90% of halogen downlights in the commercial sector are not on dimmers.
- The annualised LCC increases by $0.70/lamp where commercial users re-lamp at 50 watt lamps and cannot dim, and declines by $0.38/lamp if the lamp is on a dimmer. The former dominates and the weighted increase in annualised LCC is $0.63 /lamp.
- Our further assumption that only 10% of commercial lamps are dimmable means that there is a small increase in the annualised LCC of halogen downlights in the commercial sector, which we estimate at +$0.25/lamp.

It is likely that these estimates will be revised with the benefit of comments on this consultation RIS and further testing of halogen downlights. Several aspects need to be better understood, including the incremental cost of more efficient lamps, the extent of constraints on re-lamping with 35 watt lamps, the dimming behaviour of users, and the efficiency characteristics of dimmed lamps.

E3 has specifically asked for comment on these issues.

4.4.7 Compact fluorescent lamps

Based on discussions with suppliers, the CFLs that are now supplied to the Australian market substantially comply with the proposed MEPS and there will not be a noticeable change in the energy efficiency, cost or performance of these products. But there is a risk that inferior CFLs will be introduced in response to the significant increase in sales that is expected when conventional tungsten filament lamps are no longer available. Inexperienced users who purchase inferior CFLs can be extremely disappointed with their performance, particularly in respect of the colour and other qualities of the light provided, and operating life. The proposed measures are to ensure that (a) disappointments are kept to a minimum, (b) there is minimal temptation to re-lamp with tungsten halogen lamps that comply with the proposed MEPS but are much less efficient than CFLs, and (c) the reputations of CFLs, and energy efficiency interventions more generally, are preserved.

Many countries regulate the lighting performance of CFLs, not just their energy efficiency, aiming to protect inexperienced customers from inferior products that unfairly damage the reputation of CFLs.

We have not attempted to quantitatively assess the effects of not implementing the proposed measures or to otherwise assess the estimate the dollar value of the costs that would be incurred if the proposed measures are not implemented. However, this issue is included in E3’s specific requests for comment.

4.4.8 ELV converters

The proposed regulation would remove the least efficient magnetic ELVCs from the market, requiring users to replace them with either the more efficient type of magnetic converter or an electronic converter. The MEPS for ELVCs are scheduled for November 2010. That is a firm date, agreed with suppliers.

Calculation of energy savings

Catalogue data on the efficiency of ELVCs indicates that converters with more than 100 watts of output power will comply with the proposed MEPS – see figure 1.2. The assessment is therefore confined to ELVCs with less than 100 watts of output power. We assume that three levels of output power are representative – 35 watts, 50 watts and 80 watts. As indicated by figure 1.2, the non-complying ELVCs are all of the magnetic type. Suppliers confidently expect most users to adopt the electronic technology in response to the regulation.

The 50 watt ELVC now dominates the market. However, we assume that the associated MEPS for ELV non-reflector lamps will strongly promote 35 watt lamps in new construction and lighting refurbishments, which provide the main market for ELVCs. Logically, the reduction in wattage from 50 watts to 35 watts should be attributed to the associated lighting MEPS and the main contribution of the MEPS for ELVCs is to raise the efficiency of 35 watt ELVCs. The relevant power savings are as follows:

- The regulation would reduce the input power of 35 watt and 50 watt ELVCs by 7.2 and 9.5 watts, respectively, if the replacement ELVC is of the electronic type.
- There are smaller reductions if the replacement ELVC is of the high efficiency magnetic type, of 4.2 watts and 5.8 watts respectively.
- The savings are further reduced if the associated lamps are on dimmers. We do not have good information about the effect of dimming on the efficiency of ELVCs and

have assumed that the dimming reduces ELVC efficiency by 5%. Building on dimming assumptions for ELV lamps, the full set of assumptions is that:

- halogen downlights are dimmed by 20%, to 80% of light output at full power;
- this is associated with a 10% reduction in the efficacy of halogen downlights, which means that dimming reduces lamp wattage by only 10%; and
- the 10% reduction is lamp wattage reduces ELVC efficiency by 5%.

The lesser market is for ELVCs with more than 50 watts of output power, and up to 100 watts. These are mainly used for 'strings' of 4 to 8 ELV lamps of the non-reflector type, with individual wattages of, mostly, 10-20 watts. A single transformer of 80 watts can provide power for, say, 4 X 20 watt lamps or 8 X 10 watt lamps. The relevant power savings are as follows:

- The regulation would reduce the input power of an 80 watt ELVCs by 12.7 and 6.8 watts, respectively, for replacement ELVCs of the electronic and high efficiency magnetic types.
- ELVC efficiency is reduced by 5% if the lamps are on dimmers, which is not usually the case in these applications.

We further assume that only 5% of the conversions are to the more efficient type of magnetic ELVC, which means that the remaining 95% deliver the larger gains associated with electronic ELVCs. This is conservative: suppliers say that only 1% of their sales are for more demanding installations for which electronic ELVCs are unsuitable.

The residential duty hours are set at 2.25 hours per day, consistent with the expectation that the associated lamps are often installed in living areas.

Incremental cost of more efficient ELVCs

Figure 4.2 reports the price data that was collected for 50 watt ELVCs when E3 first examined the potential for energy savings from ELVCs, in 2005. Conventional magnetic converters sold for the same price as electronic converters whereas the more efficient magnetic converters, with efficiencies of about 86%, sold at about double that price.

There were further discussions with a large Sydney wholesaler of electrical supplies in May 2006, who reported the trade prices of conventional magnetic and electronic converters at $12 and $7-11 respectively. We understand that, with recent rises in the price of steel and copper, the difference in trade prices has continued to move in favour of electronic converters. Suppliers consistently tell us that electronic converters are cheaper than the less efficient magnetic converters. We have assumed that conventional magnetic converters can be replaced with electronic converters at zero net cost for new installations, and regard that as a conservative assumption.

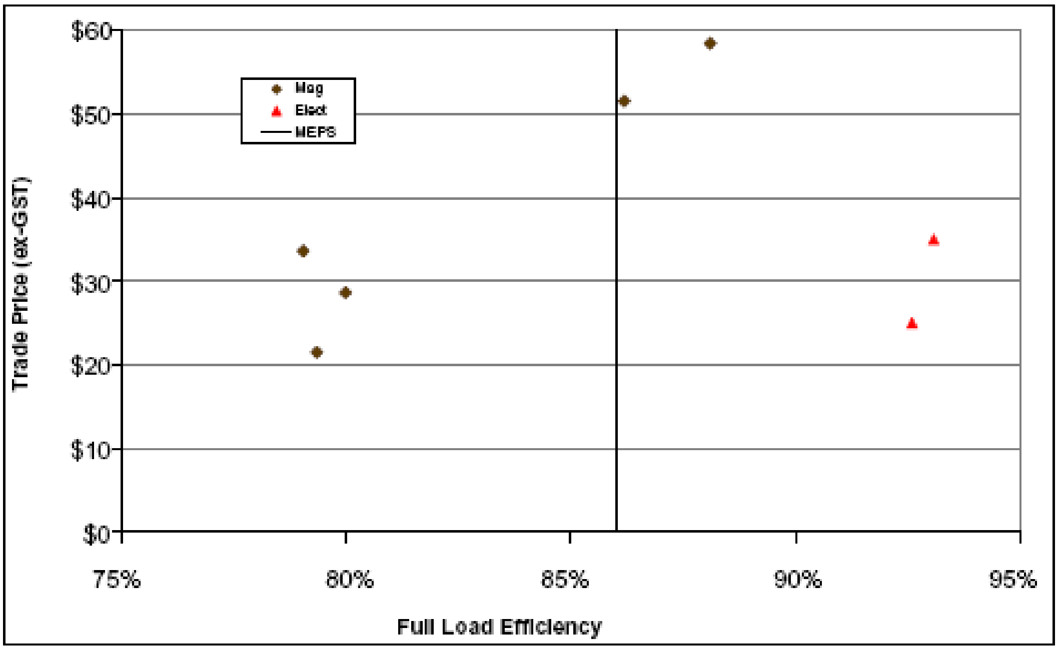
The only contrary piece of evidence has been prices observed in a large electrical retailer in Sydney, where most electronic models were priced around $28 (but down to $10) and conventional magnetic converters were about $10 dollars cheaper, at $18. Whatever the reason for the reverse relationship, we assume that electronic converters are generally priced to reflect production costs.

In contrast, suppliers agree that a significant price premium will be paid where conventional magnetic converters are replaced with the more efficient type of magnetic converter.

Using the 2005 data that is reported in figure 4.2, we have assumed that:

- The less efficient type of magnetic ELVC can be replaced with an electronic ELVC at no additional cost.

FIGURE 4.2 PRICE AND EFFICIENCY OF 50 WATT ELV CONVERTERS (E3 SAMPLE,2005)



Source: MEA 2005: page 18

- For users who are obliged to use a magnetic ELVC, less efficient type of magnetic ELVC can be replaced with a high efficiency ELVC at the additional cost of $25.

E3 has specifically asked for comment on these cost assessments.

Financial impact
Table 4.6 reports the resulting estimates of financial impacts in the residential sector. These indicate that:

- Annualised LCC declines for all users who replace with an electronic converter. Average cost reductions are in the range $1.00-$1.50/converter
- Annualised LCC increases for those who are obliged to use the more efficient magnetic converters, in the range $1.75-$2.00/converter.
- Electronic converters dominate and, on average, annualised LCC falls by $0.87/converter.

We assessed the non-residential impacts on the assumption that there is no significant use of halogen downlights in the industrial sector and that 90% of ELV lamps in the commercial are not on dimmers. Allowing for longer duty hours but lower tariffs in the commercial sector, there is a more modest increase in the annualised LCC for those obliged to use high efficiency magnetic ELVCs ($1/converter) and larger reductions for those who can use the electronic type ($3/converter). The weighted average reduction is $2.89/converter.

TABLE 4.6 CHANGE IN ANNUALISED LCC: ELV CONVERTER, RESIDENTIAL ($/CONVERTER)

Duty hours	*Lamps not on dimmers, with ELVC replaced by …*			*Lamps on dimmers, with ELVC replaced by …*		
	… high efficiency magnetic	*… electronic*	*Weighted average*	*… high efficiency magnetic*	*… electronic*	*Weighted average*
ELVC output = 35 watts						
< 1 hour	+$2.51	-$0.22	-$0.08	+$2.52	-$0.21	-$0.07
1-2 hours	+$2.26	-$0.65	-$0.50	+$2.28	-$0.62	-$0.47
2-4 hours	+$1.89	-$1.30	-$1.14	+$1.92	-$1.23	-$1.07
4-8 hours	+$1.14	-$2.59	-$2.40	+$1.21	-$2.46	-$2.28
8-12 hours	+$0.14	-$4.32	-$4.09	+$0.27	-$4.11	-$3.89
> 12 hours	-$0.60	-$5.61	-$5.36	-$0.45	-$5.34	-$5.10
Residential average	+$2.07	-$0.97	-$0.82	+$2.10	-$0.92	-$0.77
ELVC output = 50 watts						
< 1 hour	+$2.46	-$0.28	-$0.15	+$2.47	-$0.27	-$0.13
1-2 hours	+$2.11	-$0.85	-$0.70	+$2.14	-$0.81	-$0.66
2-4 hours	+$1.59	-$1.70	-$1.54	+$1.64	-$1.62	-$1.46
4-8 hours	+$0.55	-$3.41	-$3.21	+$0.65	-$3.24	-$3.05
8-12 hours	-$0.84	-$5.68	-$5.44	-$0.67	-$5.41	-$5.17
> 12 hours	-$1.88	-$7.39	-$7.11	-$1.66	-$7.03	-$6.76
Residential average	+$1.85	-$1.28	-$1.12	+$1.89	-$1.22	-$1.06
ELVC output = 80 watts						
< 1 hour	+$2.43	-$0.38	-$0.24	+$2.44	-$0.36	-$0.22
1-2 hours	+$2.03	-$1.14	-$0.98	+$2.05	-$1.08	-$0.93
2-4 hours	+$1.42	-$2.28	-$2.10	+$1.47	-$2.17	-$1.99
4-8 hours	+$0.20	-$4.56	-$4.32	+$0.32	-$4.34	-$4.11
8-12 hours	-$1.43	-$7.60	-$7.29	-$1.23	-$7.23	-$6.93
> 12 hours	-$2.65	-$9.88	-$9.52	-$2.39	-$9.40	-$9.05
Residential average	+$1.72	-$1.71	-$1.54	+$1.76	-$1.63	-$1.46

Weighted average across wattages & across lamps with and without dimmers

	ELVC replaced by high efficiency magnetic	*ELVC replaced by electronic*	*Weighted average*
< 1 hour	+$2.50	-$0.23	-$0.09
1-2 hours	+$2.24	-$0.68	-$0.54
2-4 hours	+$1.85	-$1.37	-$1.21
4-8 hours	+$1.06	-$2.74	-$2.55
8-12 hours	+$0.02	-$4.56	-$4.33
> 12 hours	-$0.77	-$5.93	-$5.67
Residential average	+$2.05	-$1.03	-$0.87

4.4.9 Summary of financial impacts

Table 4.7 summarises the figuring reported in this section. Note that the findings are not reported as averages per lamp, but as averages per dwelling or per million square metres of commercial or industrial floorspace. Appendix D describes the model of lamp stocks that has been used to aggregate savings on individual lamps to obtain the sectoral averages.

For lamps, the estimates indicate that there are net reductions in annualised LCC for all sectors, and for most types of lighting task. The exceptions are ELV reflector lamps in the commercial sector, for which the baseline assumption is that 90% of the lamps cannot be either dimmed or re-lamped at a lower wattage. The averages also hide some minor cost increases for unlikely configurations of small lamps that are replaced with tungsten halogen lamps rather than CFLs and are on low duty and non-residential tariffs.

TABLE 4.7 CHANGE IN ANNUALISED LCC: SECTORAL AVERAGES*

	Residential (per dwelling)	Commercial (per million sqm of floorspace)	Industrial (per million sqm of floorspace)
	Lamps		
MV non-reflector	-$25.86	-$250,986	-$14,407
MV reflector	-$3.73	-$130,160	-$37,780
ELV reflector	-$0.33	+$1,312	-
Total	**-$30**	**-$379,834**	**-$52,187**
	ELV converters		
	-$1.69	-$26,541	-

Note:
* Appendix D described the model of lamp stocks that has been used to aggregate the savings on individual lamp types to the sectoral averages reported here.

There are also net savings for most plausible configurations of ELVCs, the exceptions being a minority of users (less than 5% and probably about 1%) who are obliged to use the more efficient type of magnetic converter.

Note that the timeframe for savings is quite different for lamps and ELVCs. Specifically, the estimates for halogen down lights assume that, given the legacy of 50 watt ELVCs, there will be relatively limited opportunities to re-lamp at 35 watts in the short to medium term. The longer term opportunities are better, but ignored because the outlook is clouded by the uncertain prospect of LED and CFL downlights that compete directly with halogen downlights on price and quality. In contrast, more efficient ELVCs can only contribute over the medium to longer term as they are applied to new construction and lighting refurbishments. A significant contribution from ELVCs is conditional on halogen downlights not being there substantially displaced by LED and CFL downlights.

It seems likely that these estimates will be revised somewhat with the benefit of stakeholder comment on this consultation RIS. See the section immediately following the Executive Summary for a consolidated list of the particular issues on which E3 requests stakeholder comment.

4.5 Impacts on health, safety and the environment

E3 considers that there is no evidence of adverse health, safety or environmental effects that would reverse its positive assessment of the proposed measures. This section explains (a) the issues that have been raised in the media and otherwise put to E3, and (b) the ongoing processes for dealing with these issues. They relate to the mercury content of CFLs, the electrical safety of CFLs and tungsten halogen lamps, and emissions associated with the production and distribution of CFLs. Depending on how these issues are ultimately resolved, there may be some additional costs associated with regulatory or other policy responses.

4.5.1 Mercury in CFLs

CFLs contain a small amount of mercury, which is a hazardous substance. People may be exposed to mercury when fluorescent lamps are broken, usually accidentally. The mercury in fluorescent lamps also poses a waste disposal issue.

The basic facts about mercury in CFLs are as follows:

- All fluorescent lamps contain a small amount of mercury, including the linear fluorescent lamps that have been used for more than 50 years in commercial, industrial and health buildings, and in 'public assembly' buildings like schools, theatres and halls.

- Fluorescent lamps can be designed to operate effectively with varying amounts of mercury, and international best practice is to limit the mercury content to the minimum.
- The mercury content of fluorescent lamps is regulated and regulators typically require 'best practice'. The current Australian limit for the conventional linear fluorescent lamp is 15 milligrams and the proposed measures would limit the amount in CFLs to 5 milligrams. The latter is the same as in Europe. Given the relatively small size of the Australian market, Australia does not have a realistic option of imposing a lower maximum at the present time but this limit will be kept under review and revised downwards when practicable.

Exposure to mercury from broken CFLs

As discussed in 3.1.4, E3 is preparing fact sheets on a number of health and environmental issues. The fact sheets are being prepared in consultation with the Office of Health Protection within the Australian Government Department of Health and Ageing, and are reproduced in appendix A, in draft form. The fact sheet for mercury in CFLs explains how users can minimise their exposure to mercury if a CFL breaks. This includes, for example, ventilating the room, wearing rubber gloves to clean up and not using a vacuum cleaner, because this can spread the contents of the lamp and contaminate the cleaner. Similar guidelines are provided by industry bodies and other government agencies. These guidelines for household clean-up are precautionary.

Some public concerns have arisen regarding the release of mercury from broken CFLs. The concentration of mercury vapour released by a broken CFL, when measured directly above the broken lamp, can transiently exceed international guidelines for chronic exposures, either occupationally or in ambient (outdoor) air. The term 'chronic' implies that the exposure is continuous over an extended period of years. It is not appropriate to use chronic guideline values when assessing the possible risk from short term exposure.

The fact sheets provide summaries of the available scientific information. The fact sheet dealing with lamp breakage concludes that the risk to human health from exposure to the very small amounts of mercury released by CFL breakages is very low (Clear and Berman, 1993)[30]. Also, effective exposure to mercury as a result of being near a broken CFL or cleaning one up is only a fraction of the exposure associated with the average daily dietary intake of mercury as identified by the National Health and Medical Research Council (NHMRC 1999)[31].

E3 invites comment on these matters and will consider any comments in consultation with the Office of Health Protection. Further development on this issue can be addressed through the stakeholder information program if required.

Additional cost of cleaning up and disposing of broken lamps

People should exercise some care when cleaning up a broken CFL and this may involve ventilating the room and wearing gloves. They should not use the vacuum cleaner because this can spread the contents of the lamp and contaminate the cleaner. It seems impossible to know whether this is more or less work than cleaning up after breaking a tungsten filament lamp. There may be less work involved in cleaning up one tungsten filament but many more breakages. This is because tungsten filament lamps are replaced at least six times more frequently and have less value. People will probably take a bit more care in handling a CFL.

[30] Available at http://gaia.lbl.gov/btech/papers/33790.pdf
[31] Available at http://www.nhmrc.gov.au/publications/synopses/d17syn.htm

Disposal of CFLs

The issues that arise in the disposal of CFLs are that:

- Waste collectors and processors are likely to be exposed to mercury as broken CFLs enter the waste stream, and that this exposure is likely to increase as more CFLs enter the waste stream.
- Mercury from lamps in landfills can be converted to methyl mercury. Methyl mercury is more toxic than elemental mercury and, when emitted to air, may be a risk to landfill workers.
- Mercury may also escape from landfills into the environment or into ground water as leachate.

In June 2007 the Environment Protection and Heritage Council (EPHC) decided to investigate issues associated with the disposal of CFLs. DEWHA is now working with the Australian Council of Recyclers and other industry and government stakeholders, gathering information on the nature and extent of problems associated with the disposal of fluorescent lamps that contain mercury. EPHC has sought advice on whether waste CFLs should be listed as a priority waste for national action, and expects to consider this advice late in 2008. Depending on EPHC's assessment of the need, some form of product stewardship scheme may be implemented. Such a scheme would aim to safely recover mercury from CFLs or otherwise dispose of CFLs more safely.

The present situation is that (a) E3 has no evidence that disposal issues will materially affect its assessment of the proposed measures, and (b) it is not appropriate for E3 to duplicate or otherwise anticipate the work of EPHC. E3 has therefore proceeded to the consultation stage and specifically invites comment on that decision. Stakeholders may favour delay but should take into account that:

- By the end of its life, up to 60% of the mercury in a waste CFL has been chemically 'locked up' in other parts of the lamp such as the phosphor powder and the glass.
- CFLs would contribute only an estimated 1-2% of total mercury that enters landfill.
- Health and environmental protection measures should be implemented in order of cost effectiveness, which means that other protective measures may have a better claim to additional resources than the management of waste CFLs.
- All types of lamps are responsible for the emission of mercury in the combustion of fossil fuels. The contribution of a CFL to reduce emissions from that source is actually greater than the amount of mercury in a CFL.

4.5.2 Electrical safety of halogen downlights, CFLs and dimmers

Users expect products to be designed, manufactured and installed in a manner that allows them to be used safely. Concerns have been expressed that the proposed measures will increase fire risks. In particular, E3 has been told that existing dimmers can be damaged when the tungsten filament lamps are replaced either by CFLs or MV tungsten halogen lamps, and that such damage can result in fire.

These are matters of electrical safety, relating to existing products, and the relevant technical facts are as follows.

1. *Operating temperatures of downlights*: Some CFLs are not suitable for operation at the temperatures that occur in enclosed MV downlights. However, the lamp just has a shorter life. There is no fire hazard.
2. *CFL temperatures in failure mode*: Whereas a tungsten filament lamp simply stops working when the filament finally burns out and breaks, a CFL goes through a more complicated process at failure. The CFL may overheat in the process of trying to re-start itself and continues to do that until failure of its electronic components.

However, the key parts of the lamp are enclosed in an insulated case and E3 understands that CFLs fail safely.

3. *Damage to dimmers*: Dimmers are rated for electrical loads up to their design maximum, such as 450 watts. They become hot when overloaded and may be damaged. This occurs when too many lamps are put on the dimmer circuit, or some other appliance with an excessive load is connected to the circuit. Dimmers can also be damaged in two other ways.
   - The use of non-dimmable CFLs on dimmer circuits can damage the dimmer. The user has necessarily ignored the instructions on the CFL package, since non-dimmable CFLs are marked as such. Suppliers are currently assessing whether it is feasible to design dimmable CFLs that operate on most or all legacy dimmers. At this stage it is not possible to assess the chance of success.
   - E3 has been told that the use of MV tungsten halogen lamps can also damage the dimmer, but only when the lamp fails. It is claimed that arcing can occur under certain circumstances, causing the current to build to a level, and last long enough, for the dimmer to be damaged.
4. *Smarter lamps:* The electronics in CFLs and MV tungsten halogen lamps can be configured to further improve their safety. This would require an alteration to standards and would increase the cost of lamps. CFLs can also be designed for long life in recessed fittings, that is, at elevated temperatures.

The state and territory governments have primary responsibility for electrical safety but coordinate their work through the Electric Regulatory Authority Council (ERAC). ERAC is made up of representatives of the regulatory authorities of New Zealand and the Australian states, territories and commonwealth, and is recognised in the electrical industry as an authoritative voice for electrical regulators.

ERAC is aware of the proposal and E3 is now represented at meetings of the ERAC working group on product safety. Stakeholder concerns regarding safety raised during the public comment period on the technical discussion paper have been referred to ERAC for consideration. E3 will continue to consult with ERAC and will take into account any ERAC decisions regarding lighting safety as they relate to the phase-out of inefficient lighting.

E3 welcomes members of the public to submit information relating to lighting safety and in particular the use of CFLs and tungsten halogen lamps. This information will be referred to ERAC for consideration.

4.5.3 Greenhouse emissions during lamp production and distribution

We have not assessed differences in the ‘embodied emissions’ of the various types of lamps, for example, the possibility that emissions associated with the production and distribution of CFLs exceeds the emissions associated with the production and distribution of an equivalent number of tungsten filament lamps. Implicitly, it is assumed that the energy consumed during use dominates the environmental impacts of lighting services. We rely on a recent comparative study of the lifecycle environmental impacts of CFLs and incandescent lamps under Australian conditions (Parsons 2006), based on a complete inventory of the materials used in production. Parsons concluded that ... *the claimed environment benefit of compact fluorescent lamps over incandescent lamps is largely true and that it is true on almost any measure* ... (Parsons 2006: page 10). This includes a finding that CFLs reduce the use of fossil fuels by a factor or 5 even after allowing for energy used across the ‘cradle to grave’ lifecycle of these products.

E3 invites comment on whether further life cycle analysis of CFLs and incandescent lamps would materially affect the assessment.)

4.6 Nationwide impacts

4.6.1 How nationwide impacts were calculated

We estimated the nationwide impacts as the difference between a ‘without specific measures’ scenario and a ‘with specific measures’ scenario, referred to as the WoSM and WSM scenarios hereafter. Common to both scenarios are the assumptions that:

- New households form according to ABS population projections and there is commensurate growth of commercial and industrial floor-space. The increase from 2005 to 2020 is approximately 24%.
- There is no significant development of LED or other new technologies that would significantly reduce the cost of more efficient lamps.
- We ignore the growth in per-capita lighting demand that would normally be associated with increasing per-capita incomes. This is an uncertain effect and the assumption reduces our estimate of abatement.
- We ignore the rebound effect, that is, the tendency for users to respond to efficiency measures that reduce the cost of lighting services by consuming more lighting services. This is also an uncertain effect but the assumption increases our estimate of abatement.
- We ignore the apparent positive response to the announcement, on 20 February 2007, that incandescent lamps would be phased out. Import data indicate that, in response to the announcement, CFL sales increased significantly and displaced incandescent sales in the process. Plausibly, the announcement has given the community the confidence and incentive to trial CFLs, and will have the practical effect of accelerating the regulatory impact.

Baseline scenario
We developed the WoSM and WSM scenarios with reference to a baseline scenario – see figure 4.3. The baseline scenario assumes that lamp densities and types are frozen at the 2005 levels, which means that energy consumption grows in proportion to population. Appendix D describes the lamp stock model that we used to develop estimates of the lamp stock for 2005[32].

With specific measures (WSM) scenario
We expect there to be large early responses to the proposed measures but that it will take up to 10 years for the full impact to be realised. This is because the most intensively used lamps will fail first and, when replaced, will make the largest contributions to total energy savings[33]. But it will take several more years to replace lamps that are used less intensively.

This accounts for the shape of the WSM scenario shown in figure 4.3, with a large proportion of the gains achieved by 2015. Figure 4.4 provides some more detail about the time profile of transition. There are large gains in the first two or three years after implementation but a long tail before the process is substantially complete. The

[32] The International Energy Agency has noted that the lack of comprehensive lighting end-use studies is a severe constraint on policy analysis (IEA 2006: pages 168-172). Following IEA’s lead, we took a US model of the lighting task (Navigant 2002) and adjusted it in a manner calculated to make that model consistent with (a) the available Australian estimates of lighting energy consumption in both the residential and non-residential sectors, (b) ABS survey estimates of relating to the use of fluorescent lamps, and (c) lamp import data.

[33] Consider that the replacement of tungsten filament lamps will contribute most of the of the energy savings and, even with low duty hours of only one hour per day, would be replaced within 3 years. The available data indicates that 75% of the residential lighting task (lamp hours) is from lamps that operate for at least one hour per day. Almost all commercial and industrial lighting tasks are also in this category.

FIGURE 4.3 PROJECTED ENERGY CONSUMPTION FOR LIGHTING, WITH AND WITHOUT SPECIFIC MEASURES: AUSTRALIA

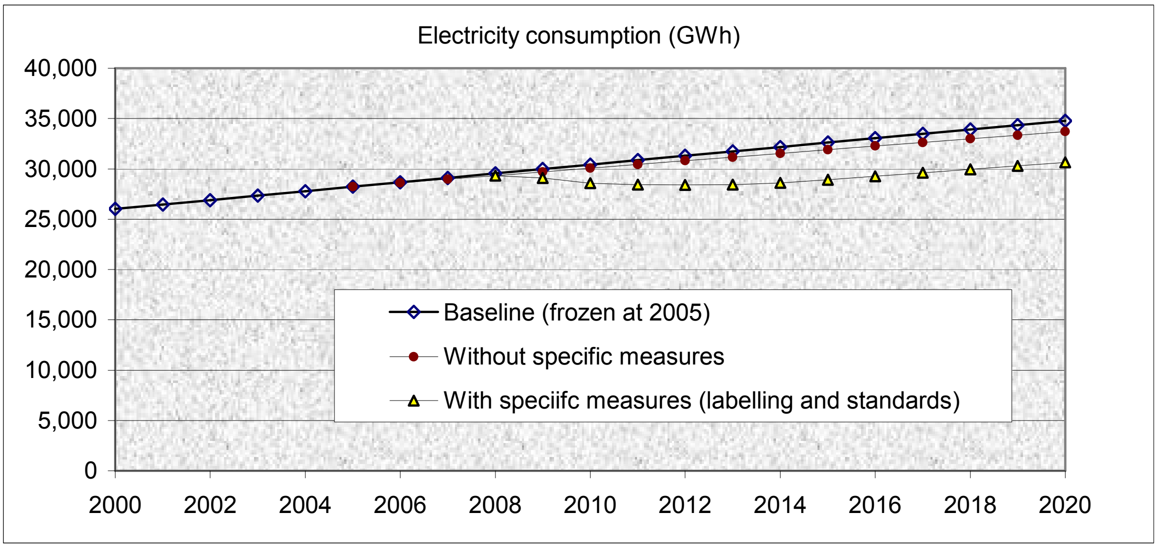
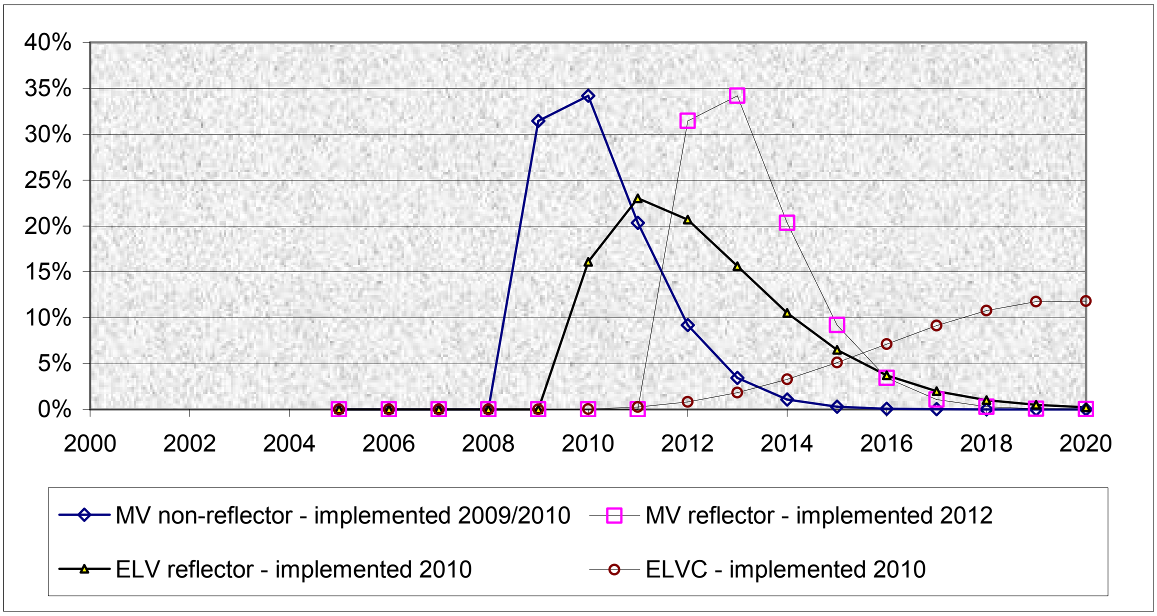


FIGURE 4.4 REPLACEMENT OF NON-COMPLYING LAMPS AND ELVCS: % OF NON-COMPLYING STOCK, BY YEAR



distribution is such that half of the gains from MV lamps, both reflectors and non-reflectors, are achieved within 18 months of implementation, and within 30 months for ELV reflector lamps.

The phasing out of non-complying ELVCs is a slower process. The distribution is such that it takes 10 years to achieve half of the gains and only 62% of the transition is complete by the end of 2020. Technological developments may have made this technology redundant by that time.

Without specific measures (WoSM) scenario
The WoSM scenario is concerned with what would happen in the absence of the specific measures, but with carbon pricing and other non-specific measures in place. This is uncertain, not least because the non-specific measures that will apply over the period to 2020 are uncertain. We make an arbitrary assumption that non-specific measures will deliver 25% of the abatement projected for 2020. Energy savings accumulate linearly to

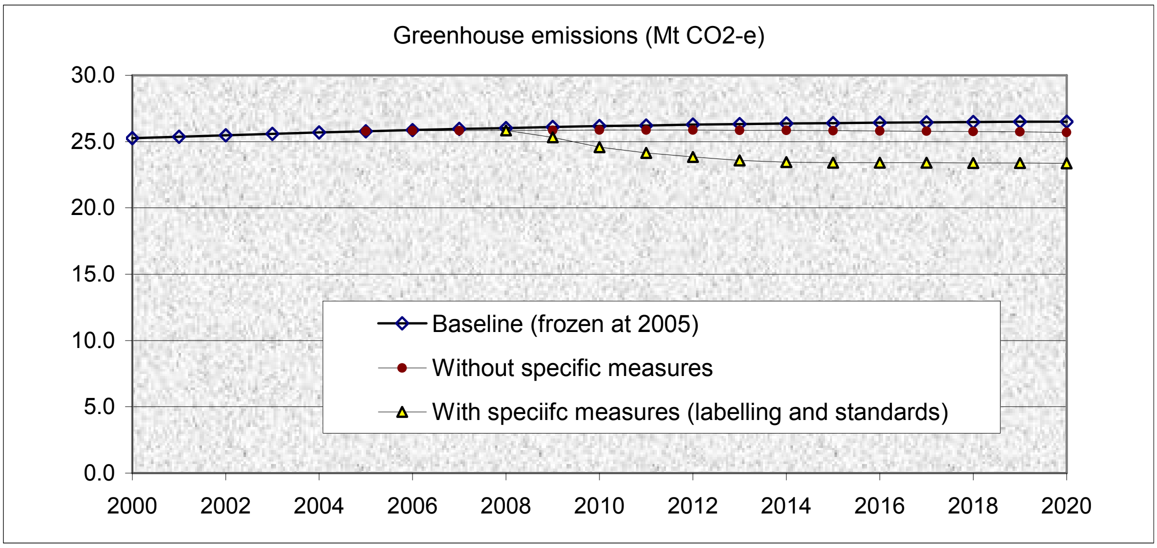
that point. This expresses the view that is put in section 1.5, which is that non-specific measures cannot address the sectoral problems that specific measures are designed to address.

4.6.2 Greenhouse abatement

The WoSM estimate for lighting greenhouse emissions is 29.7 Mt CO_2-e/year in the first commitment period of the Kyoto Protocol (2008-12). This is 4.9% of Australia's total emissions, which are projected to reach 603 Mt CO_2-e/year in 2010. Note that the estimate is for all stationary lighting tasks, not just those performed by incandescent lamps.

Figure 4.5 presents our estimates of the impact of the measures, that is, the difference between the WoSM and WSM scenarios. The proposed measures reduce lighting greenhouse emissions by 7.3% over the period 2009 to 2020, contributing 28.5 Mt CO_2-e to greenhouse abatement. This is a fraction of the total abatement that is planned for the period to 2020. In 2006, for example, AGO estimated that abatement measures will deliver about 1,330 Mt CO_2-e of abatement in the period 2008 to 2020 (AGO 2006). The proposed lighting measures would contribute about 2.1% of that total.

FIGURE 4.5 PROJECTED GREENHOUSE EMISSIONS FOR LIGHTING, WITH AND WITHOUT SPECIFIC MEASURES: AUSTRALIA



4.6.3 Cost-effectiveness of abatement

Table 4.8 reports our estimates of the nationwide impacts for the period to 2020. Note that:

- The estimate of greenhouse abatement is that reported in section 4.6.2.
- The taxpayer costs and business compliance costs are as reported in sections 4.1 and 4.2.
- The change in aggregate lamp operating costs is obtained by applying the average sectoral estimates reported in table 4.7 to estimates of the total number of residential dwellings and the floorspace of commercial and industrial buildings.

On this figuring, the proposed MEPS satisfy the 'no regrets' criterion, that is, delivering abatement at no financial cost to users. The proposals would deliver abatement of 28.5 Mt CO_2-e and simultaneously provide savings of $2,166 million. The cost of abatement is negative, -$135/tonne CO_2-e[34].

[34] This is the ratio of the net costs to abatement, but with the abatement also discounted to the present.

TABLE 4.8 SUMMARY STATEMENT OF NATIONWIDE IMPACTS: AUSTRALIA, 2008 TO 2020

Electricity consumption(GWh)	-30,305
Greenhouse emissions (Mt CO_2-e)	-28.5
Financial impacts - undiscounted dollar amounts ($M)	
cost to the taxpayer	+7.70
business compliance costs	+4.44
lamp operating costs (lamps & energy)	-3,883
Financial impacts - present values ($M), discount rate = 7.5%	
cost to the taxpayer	+6.52
business compliance costs	+2.87
lamp operating costs (lamps & energy)	-2,177
Investment analysis ($M)	
total costs	no capital costs*
total benefits	+2,167
net present value	+2,167

Note

* Both lamps and energy are treated as operating costs of lighting services, which is consistent with normal practice in facilities management. It is analytically cumbersome to treat lamps as capital items, given their low unit cost and their relatively short and variable lives. Hence, we have not calculated a benefit cost ratio.

4.7 Sensitivity and distributional analysis

4.7.1 Sensitivity analysis of financial impacts on users

The analysis of financial impacts (section 4.4) indicates that there are net financial benefits for almost all plausible combinations of lamp type, lamp size and duty hours, and for most combinations of ELVC and duty hours. The exceptions are (a) halogen downlights that cannot be dimmed or re-lamped at a lower wattage, (b) unlikely combinations of small lamps on low duty and non-residential tariffs, and (c) situations where conventional magnetic converters cannot be replaced with electronic converters. However, the losses are small relative to the gains on other lamps and ELVCs.

Inter-jurisdictional variation in the price of electricity is a further significant variable. The estimates reported in table 4.9 indicate that, while this causes significant inter-jurisdictional variation the average sectoral outcomes, there is always a significant net reduction in annualised LCC. For example, the change in annualised LCC in the residential sector varies from -$22/dwelling in Tasmania to -$38/dwelling in South Australia.

4.7.2 Distributional analysis

We have examined a wide range of plausible combinations of lamp type, lamp size, duty hours of the lamp, and type of electricity tariff (residential, commercial and industrial) and consider that there are no circumstances giving rise to adverse distributional effects. Low income households are unlikely to have the unusual configuration of lamps that is required to generate significant net costs, that is, many undimmable halogen downlights and no offsetting savings from the replacement of tungsten filament lamps.

TABLE 4.9 CHANGE IN ANNUALISED LCC: SECTORAL AVERAGES, BY JURISDICTION

	Residential (per dwelling)	*Commercial (per million sqm of floorspace)*	*Industrial (per million sqm of floorspace)*
NSW			
MV non-reflector	-$28.90	-$269,836	-$14,407
MV reflector	-$4.13	-$138,431	-$37,780
ELV reflector	-$0.39	+$1,002	-
Total	-$33	-$407,265	-$52,187
Victoria			
MV non-reflector	-$25.23	-$247,093	-$14,407
MV reflector	-$3.64	-$128,452	-$37,780
ELV reflector	-$0.32	+$1,376	-
Total	-$29	-$374,168	-$52,187
Queensland			
MV non-reflector	-$21.56	-$224,350	-$14,407
MV reflector	-$3.16	-$118,473	-$37,780
ELV reflector	-$0.24	+$1,751	-
Total	-$25	-$341,071	-$52,187
South Australia			
MV non-reflector	-$32.57	-$292,579	-$14,407
MV reflector	-$4.61	-$148,410	-$37,780
ELV reflector	-$0.47	+$627	-
Total	-$38	-$440,362	-$52,187
Western Australia			
MV non-reflector	-$22.85	-$232,310	-$14,407
MV reflector	-$3.33	-$121,965	-$37,780
ELV reflector	-$0.26	+$1,620	-
Total	-$26	-$352,655	-$52,187
Tasmania			
MV non-reflector	-$18.81	-$207,292	-$14,407
MV reflector	-$2.80	-$110,988	-$37,780
ELV reflector	-$0.18	+$2,032	-
Total	-$22	-$316,249	-$52,187
Northern Territory			
MV non-reflector	-$24.13	-$240,270	-$14,407
MV reflector	-$3.50	-$125,458	-$37,780
ELV reflector	-$0.29	+$1,489	-
Total	-$28	-$364,239	-$52,187
Australian Capital Territory			
MV non-reflector	-$20.28	-$216,390	-$14,407
MV reflector	-$2.99	-$114,980	-
ELV reflector	-$0.21	+$1,882	-$52,187
Total	-$23	-$329,488	-$14,407
ELV converters			
New South Wales	-$1.89	-$28,435	-
Victoria	-$1.65	-$26,149	-
Queensland	-$1.41	-$23,864	-
South Australia	-$2.12	-$30,720	-
Western Australia	-$1.49	-$24,664	-
Tasmania	-$1.23	-$22,150	-
Northern Territory	-$1.58	-$25,464	-
ACT	-$1.33	-$23,064	-

4.7.3 Sensitivity analysis of nationwide impacts

Table 4.10 presents a sensitivity analysis for the nationwide impacts, and represents our subjective sense of the uncertainties. The positive assessment is not altered by any plausible changes in underlying parameters.

The analysis indicates that the contribution to abatement is sensitive to the proportion of CFLs that are used to replace non-complying lamps, and also to the timing of implementation. The former may respond to policy interventions, particularly information and labelling measures, but the latter is determined by the size distribution of duty hours across the lighting stock. The latter indicates the possible significance of an 'announcement effect', that is, the effect of announcing the measures on individual incentives and confidence to start using CFLs.

The analysis is not sensitive to plausible variations in the incremental cost of more efficient lamps – see the final panel. This is because (a) the value of the energy used by lamps is large relative to the cost of lamps, and (b) more efficient lamps have longer lives than less efficient lamps, to the point where there is often little difference between the annualised cost of more and less efficient lamps, and more efficient lamps are sometimes cheaper on that basis.

TABLE 4.10 SENSITIVITY ANALYSIS OF NATIONWIDE IMPACTS: AUSTRALIA, 2008 TO 2020

	Electricity consumption (GWh)	*Greenhouse emissions (Mt CO_2-e)*	*Operating cost of lamps ($M)*	*Net present value ($M)*
Baseline				
Baseline	-30,305	-28.5	-2,177	2,167
Rate of adjustment				
Faster adjustment – 50% phase-out achieved in 25% less time	-30,777	-28.9	-2,217	2,206
Slower adjustment – 50% phase-out achieved in 25% more time	-28,569	-26.8	-2,027	2,016
Timing of implementation				
Brought forward by 1 year	-33,660	-31.8	-2,516	2,505
Delayed by 1 year	-27,003	-25.2	-1,865	1,854
Proportion of CFLs used to re-lamp				
Reduced by half (to 25% and 10% for MV non-reflectors and MV reflectors respectively)	-23,201	-21.8	-1,497	1,486
Increased by half (to 75% and 30% for MV non-reflectors and MV reflectors respectively)	-37,409	-35.1	-2,856	2,845
Discount rate				
10%	-30,305	-28.5	-1,811	1,801
5%	-30,305	-28.5	-2,640	2,628
0%	-30,305	-28.5	-4,000	3,986
Incremental cost of more efficient lamps				
Doubled	-30,305	-28.5	-2,109	2,098
Reduced by half	-30,305	-28.5	-2,211	2,201

5 Statement of compliance with national competition policy

The National Competition Policy Agreements set out specific requirements for all new legislation adopted by jurisdictions that are party to the agreements. Clause 5(1) of the Competition Principles Agreement sets out the basic principle that must be applied to both existing legislation, under the legislative review process, and to proposed legislation:

> *The guiding principle is that legislation (including Acts, enactments, Ordinances or Regulations) should not restrict competition unless it can be demonstrated that:*
>
> *(a) The benefits of the restriction to the community as a whole outweigh the costs; and*
>
> *(b) The objectives of the regulation can only be achieved by restricting competition.*

Clause 5(5) provides a specific obligation on parties to the agreement with regard to newly proposed legislation:

> *Each party will require proposals for new legislation that restricts competition to be accompanied by evidence that the restriction is consistent with the principle set out in sub-clause (1).*35

Therefore, all RIS must include a part providing evidence that the proposed regulatory instrument is consistent with these National Competition Policy obligations.

No reduction in competition
We are confident that the proposed measures will not restrict competition. We understand that there is a competitive supply of complying products from overseas factories, particularly China. Australian suppliers can contract freely with manufactures to supply the Australian market. No party has suggested to E3 that an existing supplier will withdraw from the market in response to the proposed measures.

Therefore, the proposed measures are considered to be fully compliant with the National Competition Policy.

Public benefit test satisfied
The public benefit test would be satisfied if there were a reduction in competition.

(a) Our estimates of reductions in the lifetime cost of lighting, as reported in chapter 4, show that the benefits of such a restriction would outweigh the costs.

(b) Our analysis of options, as reported in chapter 3, shows that there is no other feasible means of achieving the objectives.

[35] *Competition Principles Agreement*, Clause 5. 1995. See: www.ncc.gov.au

6 Consultation

At this stage, E3 has consulted only with lamp suppliers and retailers and with industry and professional associations. E3 will extend the consultation process to the rest of the community when the consultation RIS is published.

AGO's technical consultant, Steve Beletich, has undertaken most of the consultative work. His schedule included about 20 face-to-face meetings throughout 2007 and many more informal contacts. The work has focused on the scope, timing and level of the MEPS, the implementation schedule, and the methods for determining lamp performance.

The following organisations and groups have been involved:

- Lighting Council Australia
- Illuminating Engineers Society
- Standards Australia
- Lighting controls working group, Lighting Council Australia
- Lighting standards working group, Standards Australia

This work culminated in the public release for stakeholder consultation, in December 2007, of a technical report that sets out the proposal in detail (Beletich Associates 2007), as well as the recent publication of Australian lamp and ELVC standards. Submissions to the technical report were received from 25 organisations and individuals. Table 6.1 summarises both the issues that were raised and E3's responses, in no particular order.

In 2008, DEWHA commenced consultations with major retailers and retailer associations and is currently developing a communications strategy.

This consultation RIS will provide a further opportunity for stakeholders to provide feedback.

TABLE 6.1 E3 RESPONSES TO COMMENTS ON THE DRAFT TECHNICAL REPORT

Issue Raised	Details *of Submission*	*Response to Issue*
CFLs to be mandatory	CFLs will be made mandatory.	Many submissions were based on the perception that CFLs will be made mandatory. As discussed in the technical report and this RIS (section 3.1.2, page 25), efficient mains voltage halogen lamps will continue to be available. Such lamps are important for situations where incompatible dimmers or controllers are installed.
Safety issues	CFLs and mains voltage halogen lamps are subject to several safety risks.	CFLs and mains voltage halogen lamps have been widely available for many years, and are subject to mandatory and industry safety requirements. MEPS will not introduce or mandate the use of any new lamp technology, although it is expected to cause an increase in the market penetration of these lamps. E3 has referred this issue to the Electrical Regulatory Authorities Council (ERAC) for consideration and advice.
Education	A comprehensive education campaign is required to support MEPS.	E3 is currently scoping an education campaign.
MEPS level	MEPS level for incandescent lamps has been set too low.	It is difficult to set a higher MEPS level, as currently the only dimmable lamps are incandescent. The best available mains voltage incandescent lamps are around 15 lm/w, which has been set as the MEPS level.
MEPS level	MEPS level should be set higher in order to encourage efficient product development.	Australia represents around 1% of the global lamp market, thus it is difficult for Australia to influence global lamp development. Using MEPS as a tool to achieve this could result in the situation where no lamps become available to meet MEPS.
MEPS level	The market will deliver change faster than MEPS.	If this occurs, E3 can move to increase the MEPS level.
Marking	Mark lamps (or packaging) to better indicate efficiency	This has been flagged for further development and is currently being discussed with Lighting Council Australia and the relevant standards committee.
Embedded energy	CFLs embody more incremental energy than they save.	There are several studies which indicate that, in operation, CFLs save several thousand times more energy than their incremental embodied energy (i.e. when compared to incandescent).
CFL suitability	CFLs are unsuitable for some applications	For such applications, mains voltage halogen lamps will be available.
Holistic approach	Need to take a holistic approach and examine other measures such as financial incentives.	E3's objective has typically been to implement mandatory MEPS and labelling programs for appliances, where warranted. Financial incentives have traditionally been designed and implemented by individual states and territories. We will review the impacts of the state-based programs to see if there would be benefits from national consistency.

Issue Raised	Details *of Submission*	*Response to Issue*
Low voltage down lights	MEPS will increase the uptake of low voltage down lights.	There is a slight risk that this may occur. E3 will monitor the lamp market and react if any perverse outcomes are detected.
Low voltage down lights	Low voltage down lights should be targeted.	These lamps will be subject to MEPS, in order to eliminate the least efficient models. The large number of existing installations makes it difficult to eliminate this lamp type entirely.
Tri-phosphor CFL coatings	All CFLs should be tri-phosphor coated.	MEPS for CFLs will ensure that CFL efficacy and colour rendering attributes are adequate, which effectively means that all CFLs will be tri-phosphor coated or better.
CFL lifecycle cost	CFL are expensive and not cost effective. CFLs should be subsidised.	CFLs are very cost effective, without subsidies. CFL economics are fully evaluated in this RIS.
CFL disposal	CFLs contain mercury.	The Department of the Environment, Water, Heritage and the Arts is currently examining this issue in further detail.
MEPS not effective	MEPS is not the best way to remove barriers to uptake of inefficient lighting.	The relative cost effectiveness of MEPS for lamps is assessed in this RIS. E3 believes that MEPS is the single most cost effective tool to increase appliance efficiency.
Converters for low voltage lighting	Converter losses should be taken into account.	MEPS for these converters are outlined in this RIS (page 27) and a technical report dated April 2005.
Lamp wattage	Lamp wattage should be capped in order to guarantee energy savings.	Limiting lamp wattage is prescriptive, and E3 expects that lower wattage lamps will appear in the market (as is already occurring). If this does not occur then E3 can consider a lamp wattage cap.
Efficacy	Efficacy (lumens per watt) is an unsound criteria for MEPS.	Efficacy is the most accurate measure of lamp efficiency and is used globally for MEPS programs.
CFLs	The quality of CFLs is not being addressed.	CFLs will be subject to mandatory MEPS which will set limits for quality attributes, as discussed in the technical report and this RIS (page 25).
Energy savings	Energy savings are much smaller than contended. Cost savings to users are negligible.	The cost savings to individual households are small. Collectively, however, efficient lighting makes a significant and highly cost-effective contribution to greenhouse gas abatement.
Dimmable CFLs	Dimmable CFLs are available.	Whilst this policy has been in its design phase dimmable CFLs have become more widely available but they are 3 to 4 times more expensive than a non-dimmable product.
Decorative lamps	There is currently no CFL replacement for decorative lamps.	For decorative lamps, a number of CFL and MEPS-compliant mains voltage halogen versions of these lamps have appeared in the Australian marketplace. The staged introduction of the MEPS will be reviewed annually. Exempt lamp types will only be included a viable, efficient alternatives become available
CFL power factor and harmonics	CFL suffer from power factor and harmonics problems.	CFL MEPS includes mandatory power factor and harmonics compliance. The relative stringency of these requirements is currently being discussed by the relevant standards committee.

Issue Raised	Details of Submission	Response to Issue
Availability of MEPS-compliant lamps	The actual availability of MEPS-compliant lamps has not been assessed.	Lamp suppliers (via Lighting Council Australia) have indicated that compliant lamps are or will be available to meet MEPS. If this does not remain the case in future, the proposed MEPS program allows the flexibility to adjust MEPS levels and their timing.
Reliance on speculative future lamp technologies	MEPS relies on the emergence of technologies such as LED.	MEPS currently relies on existing (or very near term) incandescent lamp and CFL technologies. In future, if lamp technologies emerge (or do not emerge), MEPS can be adjusted accordingly. Developments in LED and lamp technology are discussed in the technical report for context only.
Mains voltage halogen lamps	There is a reliance on MV halogen lamps as a replacement for GLS, however MV halogen lamps will then be phased out.	MV halogen lamps will not be phased out. Those that meet MEPS (such as have recently been introduced to the Australian marketplace) will continue to be available.
Dimming	There is no analysis of the impact for users who choose to replace incandescent lamps with (non-dimmable) CFLs on dimmed circuits.	This would be a voluntary choice by users and will not be mandatory. Dimmable mains voltage halogen lamps will be available for these situations.
Dimmers and controllers reduce energy consumption	Such control equipment can reduce energy consumption.	The objective of MEPS is to increase the penetration of efficient lamps, not to decrease the penetration of dimmers or controllers.
Test methodologies	Efficacy data for low voltage reflector lamps is highly variable. A suitable test method for reflector lamps is not available.	MEPS for reflector lamps was delayed in order to allow for a test method to be developed. An interim Australian Standard test method has now been published and is being trialled by test laboratories.
Light fittings	Removal and replacement of light fittings would be required.	MEPS applies only to lamps, and care has been taken to ensure lamp compatibility with typical existing fittings.
CFLs	CFLs should not be the preferred lamp choice.	It is the goal of MEPS to promote efficient lamps. At this time, CFLs are the most efficient lamps available for general lighting purposes (undimmed).
GLS lamp sales	Incandescent lamp sales have more than tripled in the past decade.	This conclusion does not take into account the closure of ELMA lamp manufacturing plant in 2002, which is discussed in the technical report.
MEPS curve	The source of the equation for the MEPS efficacy curve has not been given.	The MEPS curve is based on a best fit of the efficacy of efficient lamps. It has been analysed and agreed by the manufacturers of lamps (Lighting Council Australia).
Decorative lamps	Efficacy data for decorative lamps has been omitted.	These lamps typically have the same efficacy as GLS lamps.
Mains voltage halogen lamps	MV halogen is not a suitable replacement for GLS as it is a directional light source.	Non-reflector MV halogen lamps are available that meet the MEPS requirement.
Mains voltage halogen lamps	These lamps are subject to additional surface temperature in common light fittings.	This does not appear to be the case for non-reflector lamps but will be investigated further.

Issue Raised	Details *of Submission*	*Response to Issue*
Efficacy of reflector lamps	Reflector lamps are less efficient than non-reflector lamps and this should be compensated for in MEPS.	No compensation has been allowed for in MEPS at this stage. Raw 'downward' efficacy is the best true measure of efficiency for reflector lamps.

7 Conclusion and recommended option

7.1 Assessment

The primary assessment criteria are that the measures contribute to cost-effective greenhouse abatement. Table 7.1 reports our assessment against these criteria and various secondary criteria.

TABLE 7.1 ASSESSMENT SUMMARY

Objective	*Assessment*
Do the measures reduce greenhouse emissions?	Over the period to 2020, the proposed measures would contribute 28.5Mt CO2-e to abatement.
Do the measures reduce the lifecycle cost of appliances?	Over the period to 2020, the proposed measures would reduce the cost of lighting services by $2.2 billion.
Do the measures address market and regulatory failures?	The measures address information failures and inertia in the market for lamps and ELVCs, associated with lack of user understanding of lighting as an energy cost, uncertainty about the performance of energy saving lamps, past disappointments with the performance of energy saving lamps, and weak incentives for builders and landlords to make lighting decisions in the best interests of end-users.
Does the option minimise negative impacts on product quality and function?	The proposal has been modified to negate a number of negative impacts on product quality and function. Some issues need to be investigated further, particularly the issue of adverse impacts of CFLs on the ability of electricity network operators to remotely control street lights and off-peak hot water systems.
Do the measures minimise adverse effects on suppliers?	The measures are been developed in close consultation with suppliers and, at this stage, E3 is not aware of any issues.

7.2 Conclusions

We conclude that the proposed measures will meet the assessment criteria and that the E3 Program can proceed to finalise the measures with a high degree of confidence that the objectives will be achieved.

7.3 Recommendations

It is recommended that the proposed measures be finalised, aiming for implementation in November 2009.

8 Implementation and review

General administrative arrangements

The standards and labelling measures designed by E3 rely, for legal effect, on legislation in each of the Australian states and territories. The jurisdictions have also agreed to a set of administrative guidelines. While not legally binding, they aim to promote a uniform approach, consistent outcomes and to minimise compliance costs. The E3 Program released the latest guidelines in May 2005 (NAEEEC 2005). The key administrative arrangements are:

1. The technical details of MEPS are contained in Australian/New Zealand Standards that are incorporated by reference into the legislation of the various jurisdictions. Standards are the same for all jurisdictions. The format and content of Standards are also familiar to industry, as are the operations of Standards Australia and Standards New Zealand.
2. Changes to the technical detail in Standards are subject to transition periods that are negotiated between industry and government.
3. To minimise trade barriers, E3 has a policy of adopting international standards wherever appropriate.
4. Grandfathering arrangements are adopted, allowing reasonable time for phasing out non-complying stock and changing labels.
5. All jurisdictions accept the registration of an appliance in another jurisdiction.
6. The regulatory agencies in each jurisdiction have targets for the timely processing of applications.
7. Proposed changes in administrative and operating practice are subject to consultation between the jurisdictions.

Product-specific compliance and enforcement activities

The E3 Program organises its compliance and enforcement activities as follows:

1. Compliance monitoring takes the form of a program of check testing by accredited laboratories.
2. Equipment is selected for check testing on the basis of risk factors rather than randomly. The risk factors are as follows:
    - history of success and failure in check tests;
    - age of models, with newer models given greater attention, reflecting the prospect of longer life in the market;
    - high volume sales;
    - claims of high efficiency;
    - complaints.
3. There are several sanctions. There is a ‘shaming’ option involving publication of failed brands or models in the AGO annual report. The second option is deregistration by the state authorities, subject to show cause procedures. Subsequent sale of deregistered appliances would be a criminal offence. Re-registration of models that are subject to MEPS is subject to new registration tests. The third option involves legal action.
4. Standard statistical criteria are applied to deal with normal variation in the performance of equipment selected for check testing.
5. Laboratories that produce misleading tests results may also be denied further registration business.

General monitoring and benchmarking of impacts and effectiveness

In the past the E3 Program has periodically commissioned an omnibus evaluation of overall effectiveness. The last of these was published in June 2003 (NAEEEC 2003), titled W*hen you can measure it, you know something about it: Projected impacts 2000-2020.* The general aims of such an exercise are to document expected impacts, estimate costs and benefits, and compare outcomes with earlier projections. It commits the E3 Program to examination of the appliance register and store survey data, and comparative review of trends in appliance efficiency.

The program has since advised industry that the 2003 exercise was the last of the omnibus reviews and will be replaced by piecemeal reviews. The first of these will address air-conditioners and fridges. A review of arrangements for HWS has yet to be scheduled.

Annually, the E3 Program holds a consultation forum and invites stakeholders to raise concerns about its operation and impacts.

Less frequently, the E3 Program reviews program fundamentals. The most recent exercise of this kind was a major research-based review and scoping of future directions for a wide range of appliance efficiency labels.

The program also takes occasional opportunities to benchmark its activities with programs in other countries.

Regulatory review

Each Australian State and Territory has its own arrangements for review. The ‘subordinate legislation’ acts in several states provide for the automatic revoking of regulations after 10 years. These states are Victoria, SA, Queensland and Tasmania. NSW requires that all regulations contain sunset clauses. The remaining jurisdictions have no general requirement but may include sunset clauses on a case-by-case basis.

All jurisdictions have some Parliamentary machinery for the systematic review of regulations, such as a ‘Legislation Review Committee’. Arrangements for agency or inter-agency review are more variable. Only Victoria has a specific body charged with regulatory oversight, which is the Victorian Competition and Efficiency Commission. This work is undertaken by an inter-departmental committee in NT. Otherwise, however, the review process uses a parliamentary secretariat to raise issues and solicit public comment.

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APPENDIX A: SUPPLEMENTARY INFORMATION ON THE PROPOSED REGULATION

Table A1	Types of lamp commonly used in residential applications
Table A.2	Proposed CFL performance requirements, including acceptable overseas certification schemes
Fact sheet	Photosensitive Epilepsy and Compact Fluorescent Lamps
Fact sheet	Systemic Lupus Erythematosus and Compact Fluorescent Lamps
Fact sheet	Ménière’s disease and Compact Fluorescent Lamps
Fact sheet	Mercury in Compact Fluorescent Lamps
Fact sheet	Migraines and Compact Fluorescent Lamps

Table A1 Types of lamp commonly used in residential applications, including some that are not in the scope of the regulation*

Lamp type	*Example*	*Cap types*	*Typical wattage*	*Approximate price ($A)*
GLS conventional, including frosted, clear and long-life		B22, E27	25 -100w	$0.50-$1.00
GLS coloured (NOT IN SCOPE)		B22, E27	25w	n. a.
GLS high wattage (NOT IN SCOPE)		B22, E27, E40 (500w+)	150 - 1000w	n. a.
Candle		B15, B22, E14, E27	25 - 60w	$1.00-$2.00
Fancy round		B15, B22, E14, E27	25 - 60w	$1.00-$2.00
Globe shaped		B22, E27	60 - 100w	$1.00-$2.00
Mains voltage halogen non-reflector lamps	 	E27	100 – 250w	$3.00
Mains voltage halogen non-reflector lamps, double-ended (NOT IN SCOPE)		R7s, Fa4	60 – 1500w	n. a.
Extra low voltage halogen capsule lamps		G4, GY6, GY6.35	5 - 100w	$4.00-$10.00

Lamp type	*Example*	*Cap types*	*Typical wattage*	*Approximate price ($A)*
Extra low voltage halogen reflector lamps		GZ/GU4, GX/GU5.3, G53, GZ/GU10, BA15D/19, B15D/24X17	15 - 100w	$4.00-$5.00
R & ER		B22, E14, E27	25 - 150w	$3.00-$4.00
PAR		E27	60 - 150w	$5.00-$9.00
Crown silvered		E14, E27	40 - 100w	$2.00-$3.00
Mains voltage halogen reflector lamps		E14, E26, E27, GU10, GZ10,	35 - 100w	$4.00-$7.00
PAR 38 coloured (NOT IN SCOPE)		E27	80w	n. a.
Infra-red heat lamps (NOT IN SCOPE)		B22, E27	250 - 375w	n. a.
Pilot lamp		B15, B22, E14, E27	15 – 40w	$4.00-$5.00

Lamp type	*Example*	*Cap types*	*Typical wattage*	*Approximate price ($A)*
Oven lamp, temperature resistant		E14, E27	15 – 40w	$4.00-$5.00
Refrigerator lamp		E14	15w	$4.00-$5.00
Heavy duty and surge resistant				$5.00-$10.00
Anti-insect lamp (NOT IN SCOPE)		B22, E27	60-100w	n. a.
Double-ended tubular (NOT IN SCOPE)		S15s	30 - 60w	n. a.

Note
* Suppliers should refer to the relevant standards for the exact technical specifications of the lamps that are subject to the proposed regulations. The above list may exclude some types of incandescent lamps that are subject to the regulation.

Table A.2 Proposed CFL performance requirements, including acceptable overseas certification schemes

Attribute	*Local*	*OR* *Efficient Lighting Initiative (ELI)*			*OR* *UK Energy Saving Trust (EST)* *Version 5*	*Version 6*
Efficiency requirements						
Minimum efficacy in lm/w - bare lamps	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	<4500 K	≥5 to <9 W	50	$\frac{1}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	
			≥9 to <15 W	55		
			≥15 to <25 W	60		
			≥25 to < 60 W	65		
		≥4500 K	≥5 to <9 W	46		
			≥9 to <15 W	52		
			≥15 to <25 W	57		
			≥25 to < 60 W	62		
Minimum efficacy in lm/w -covered lamps	$\frac{0.85}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	<4500 K	≥5 to <9 W	43	$\frac{0.85}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens	
			≥9 to <15 W	47		
			≥15 to <25 W	51		
			≥25 to < 60 W	55		
		≥4500 K	≥5 to <9 W	39		
			≥9 to <15 W	44		
			≥15 to <25 W	48		
			≥25 to < 60 W	53		
Minimum efficacy in lm/w - reflector lamps***	$\frac{0.6}{\frac{0.24}{\sqrt{F}}+0.0103}$ Where F = initial luminous flux in lumens				Based on minimum 'centre beam candela efficacy'	

Attribute	*Local*	*OR* *Efficient Lighting Initiative (ELI)*	*OR* *UK Energy Saving Trust (EST)*	
			Version 5	*Version 6*
Light quality requirements				
Colour appearance	IEC 60081 Graph D-16 for CCT 2700. Other temps to be approved but following same diagram	5	CCT 2650-2800 K	IEC 60081Graph D-16 for CCT 2700. Other temps to be approved but following same diagram
Minimum CRI	80	80	80	80
Maximum starting time (seconds)	2.0	1.5	*	2.0
Maximum run-up time (min)	1.0	*	*	1.0
Durability requirements				
Minimum lumen maintenance	2000 hrs = 0.88 5000 hrs = 0.80 10000 hrs = 0.75	0.8		2000 hrs = 0.88 5000 hrs = 0.80 10000 hrs = 0.75
Maximum premature lamp failure rate	10% at 30% of rated life			10% at 30% of rated life
Minimum switching withstand	1000 Cycles			
Minimum lifetime (hours)	6000	6000	6000	Not less than 10,000 hrs (not more than 15,000 hrs)
Requirements relating to external impacts				
Minimum power factor	0.55 (0.9 for lamps claiming high PF)	0.5		0.55 (0.9 for lamps claiming high PF)

Attribute	Local	OR Efficient Lighting Initiative (ELI)	OR UK Energy Saving Trust (EST)	
			Version 5	Version 6
Maximum mercury content (mg)	5**	*	*	5
Harmonics	AS/NZS 61000.3.2	AS/NZS 61000.3.2	IEC 61000.3.2	

* If the lamp manufacturer chooses to adhere to ELI or EST version 5, for which starting time, run-up time and mercury content may not be specified, then the lamp model shall comply with or exceed the local criteria for these three attributes (2.0 s, 1.0 min and 5 mg respectively).

** To be measured in accordance with AS/NZS 4782.3

*** Effective enforcement in 2010 for import and 2011 for retail.

Fact Sheet: Photosensitive Epilepsy and Compact Fluorescent Lamps

Concerns have been raised that Compact Fluorescent Lamps (CFLs) may have adverse impacts on the health of some users. One such concern is the effects of CFL 'flicker' on photosensitive epileptics.

What is photosensitive epilepsy?

Photosensitive epilepsy is the name given to epilepsy in which all, or almost all, seizures are provoked by flashing or flickering light, or some shapes or patterns. Both natural and artificial light may trigger seizures. Various types of seizure may be triggered by flickering light. Photosensitive epilepsy is rare and only 5% of epileptics are diagnosed with this form of epilepsy.

Some known triggers for people with photosensitive epilepsy are:

- Watching television or playing video games
- Having a faulty light or television that flickers
- Strobe lights
- Driving at dawn or dusk with sun shining through a line of trees
- Sun flickering on water
- Looking out of the window from a fast moving vehicle
- Geometric patterns.

The frequency of flashing light most likely to trigger seizures varies from person to person. Generally it is between 8-30Hz or flashes per second. CFLs 'flicker' at a rate well above this sensitive range (see text below) and do not pose a hazard to sufferers of photosensitive epilepsy.

Researchers have concluded that CFLs are no more likely to be a greater risk to people with photosensitive epilepsy than other light bulbs. For more information about photosensitive epilepsy see www.epilepsy.org.au/photosensitivity.asp).

CFL 'flicker'

As part of their normal operation fluorescent lamps flash on and off very rapidly - CFLs 'flicker' at a rate of more than 20,000 times per second, modern linear fluorescent tubes at more than 5,000 times per second, and older style linear fluorescents at 100 times per second. These rates of flickering are well above the level detectable by the human brain. Occasionally, fluorescent lamps develop a fault which causes them to have may have a noticeable flicker; these lamps should be replaced.

As the phase-out plan for the inefficient incandescent lamp is developed, the Government will continue to consider health issues and examine options to address any significant issues. This may include providing information about possible impacts and available alternatives (halogen lights and filters), or specific provisions such as granting import licences to representative groups for people with conditions associated with available lighting products.

Fact sheet: Systemic Lupus Erythematosus and Compact Fluorescent Lamps

Concerns have been raised that Compact Fluorescent Lamps (CFLs) can have adverse impacts on the health of some users. One such concern is the effects of ultra-violet light (UV) on sufferers of Systemic Lupus Erythematosus (SLE) or Lupus.

What is Systemic Lupus Erythematosus?

Lupus, in its many forms, is an auto-immune disorder characterised by chronic inflammation of body tissues. Patients with Lupus produce antibodies that target their own healthy tissues and organs. The causes of Lupus are not clear but, genetics, viruses, ultraviolet light, and drugs all may play some role. Lupus is up to eight times more common in women than men. Exacerbations or flare ups of Lupus can be induced by exposure to sunlight.

CFLs emit very low levels of ultra-violet light and are unlikely to pose a problem for sufferers of Lupus. All general use lamp types including the traditional incandescent bulb emit low levels of UV light. CFLs may emit slightly higher UV levels than incandescent globes of a similar level of (visible) light output but, UV output is still very low and is well below international health standard guidelines. If general lighting has not previously exacerbated the condition in an individual with Lupus it is very unlikely that CFLs would do so.

There are rare instances recorded of prolonged exposure to bare linear (tubular) fluorescent lights provoking Lupus in hypersensitive individuals. The use of standard acrylic light covers or diffusers effectively eliminates any risk. Commonly used for aesthetics and to reduce glare, light covers have been shown to reduce UV light output by about 94 %. A recent study found that UV exposure from sitting under typical office fluorescent lights for eight continuous hours is equivalent to just over one minute of sun exposure (Lytle et al 1993).

As the phase-out plan for inefficient incandescent lamps is developed, the Government will continue to consider health issues and examine options to address any significant issues. This may include providing information about possible impacts and available alternatives (halogen lights and filters), or specific provisions such as granting import licences to representative groups for people with conditions associated with available lighting products.

Fact sheet: Ménière's disease and Compact Fluorescent Lamps

Concerns have been raised that Compact Fluorescent Lamps (CFLs) may have adverse impacts on the health of some users. One such concern is the effects of CFL 'flicker' on Ménière's disease sufferers.

What is Ménière's disease?

Ménière's disease afflicts about 0.2 % of the population. It is a condition where excess fluid in the inner ear upsets the ear's balance and hearing mechanisms. This produces symptoms such as vertigo (dizziness), tinnitus (ringing in the ears) and hearing loss. The disorder usually affects only one ear and is a common cause of hearing loss.

There is no scientific evidence to suggest CFLs (or any fluorescent lights) can exacerbate or initiate symptoms of Ménière's disease. There are however, anecdotal reports that sufferers of Ménière's disease are more sensitive to flashing lights than others (because of their impaired balance systems), and so may be more susceptible to a phenomenon known as flicker vertigo.

Flicker vertigo

Flicker vertigo may arise from flicker rates in the range of 4-30Hz or 4 to 30 times per second. Symptoms range from vague and non-specific feelings of unease through to nausea, dizziness, migraines, unconsciousness, and even photosensitive epileptic seizures. Flicker vertigo can reportedly affect anyone, but some individuals may be more susceptible than others. Triggering events can be as simple as moving objects (such as helicopter blades or a tree line from a moving car) intermittently obscuring the sun, creating a flickering effect.

CFL 'flicker'

CFLs 'flicker' at a rate well above that detectable by the human brain and so should not affect Meniere's sufferers. As part of their normal operation fluorescent lamps flash on and off very rapidly - CFLs 'flicker' at a rate of more than 20,000 times per second, modern linear fluorescent tubes at more than 5,000 times per second, and older style linear fluorescents at 100 times per second. These rates of flickering are well above the 'sensitive range' for Flicker vertigo. Occasionally, fluorescent lamps develop a fault which causes them to have may have a noticeable flicker; these lamps should be replaced.

As the phase out plan for inefficient incandescent lamps is developed, the Government will continue to consider health issues and examine options to address any significant issues. This may include providing information about possible impacts and available alternatives (halogen lights and filters), or specific provisions such as granting import licences to representative groups for people with conditions associated with available lighting products.

Fact Sheet: Mercury in Compact Fluorescent Lamps and other mercury bearing lamps

Do CFLs contain mercury?

All fluorescent lamps including CFLs contain very small amounts of elemental mercury. Government and industry continue to work together to minimise the mercury content. A new standard will be introduced for CFLs that includes a maximum mercury content aligned with the European Commission standard at five milligrams (one two-hundredth of a gram) per bulb. The ordinary fluorescent tubes in current use contain approximately 15 mg per tube of mercury, consistent with the Australian Standard; these have been used safely in most commercial and public buildings in Australia and around the world for over 40 years.

To put the amount of mercury contained in CFLs in context, five milligrams g would fit on the tip of a ball point pen. The old mercury thermometers contain approximately 500 mg of mercury. With appropriate precautions regarding disposal in place, elemental mercury continues to be used safely in a variety of products including lamps, watch batteries, various medical instruments, and dental fillings.

Safe clean up and disposal guidelines

Some members of the public have expressed concerns about the release of mercury from broken CFLs. The concentration of mercury vapour released by a broken CFL, when measured directly above the broken lamp, can transiently exceed international guidelines for chronic exposure in ambient (outdoor) air. The term 'chronic' implies that the exposure is continuous over an extended period of years. It is not appropriate to use these chronic guideline values when assessing possible risk from short term exposure.

The risk to human health from exposure to the very small amounts of mercury released by CFL breakages is very low (Clear and Berman 1993, available at http://gaia.lbl.gov/btech/papers/33790.pdf). Also, effective exposure to mercury as a result of being near a broken CFL or cleaning one up is only a fraction of the exposure associated with the average daily dietary intake of mercury as identified by the National Health and Medical Research Council (NHMRC 1999, available at http://www.nhmrc.gov.au/publications/synopses/d17syn.htm).

However, following these simple and straightforward clean up and disposal instructions will further minimize risk:

- Open nearby windows and doors to allow the room to ventilate for 15 minutes before cleaning up the broken lamp
- Do not use a vacuum cleaner because this can spread the contents of the lamp and contaminate the cleaner
- Use disposable rubber gloves rather than bare hands
- Use a disposable brush to carefully sweep up the pieces
- Use a paper towel, preferably moist, to wipe up any remaining glass fragments and phosphor powder

- Wrap lamp remains in newspaper to provide protection from the broken glass and then place the parcel in a bag or sealable container along with the cleaning equipment used (i.e. gloves, brush, damp paper)
- Place in your outside rubbish bin – never in your recycling bin.

Disposal of CFLs at the end of their working life

At present, CFLs can generally be disposed of in regular garbage bins - where the garbage goes to landfill. You should check with your local authority responsible for garbage collection, as to their advice on disposal of CFLs as different local authorities may have different arrangements. For example, some garbage is sent to waste processors and this may change the arrangements for disposal. Should you choose to dispose of your CFLs this way then it's best to wrap them in newspaper to prevent them from breaking.

You should not place CFLs in your kerbside recycling bins because they can break during transport and contaminate recyclable items. Several states have household chemical collection programs or drop off points that accept CFLs for recycling. Other states are considering introducing similar schemes.

Detailed information about disposal and recycling, developed with the assistance of the states and territories is available at www.environment.gov.au/settlements/waste/lamp-mercury.html.

What the government is doing about CFL disposal

The Environment Protection Heritage Council (EPHC) - which is made up of state, territory, and Commonwealth environment ministers - is currently investigating the issues associated with the end-of-life management (disposal methods) of CFLs.

The EPHC has consulted with industry stakeholders, including the Australian Council of Recyclers, to gather information and to identify the nature and extent of any problems likely to be posed by landfill disposal of CFLs. This work is ongoing, and any recommendations resulting from this investigation will be taken into account in the formulation of a national approach on this issue.

Less Mercury is released to the Environment through the use of CFLs

Less mercury is released into the environment from the use of CFLs than incandescent lamps even though CFLs contain mercury. This is because burning coal to produce electricity releases mercury from the power station. Because CFLs use only about 20% of the electricity which incandescent bulbs use to produce the same amount of light, only about 20% of the coal needs to be burnt and so only about 20% of the amount of mercury is released.

Lamp Comparison

A 20 watt (W) CFL typically lasts for about 8000 hours (hrs) and uses 160 kilowatt hours (kWh) of electricity during its use. The equivalent 100W incandescent lamp lasts typically only 2000hrs and so four lamps are required to do the same job as the CFL. The incandescent lamps use 800kWh of electricity. So 640kWh of electricity is avoided by using a CFL. A CFL would be responsible for releasing about 2.7mg of mercury into the atmosphere, whereas the equivalent incandescent would be responsible for releasing about 13.4mg of mercury.

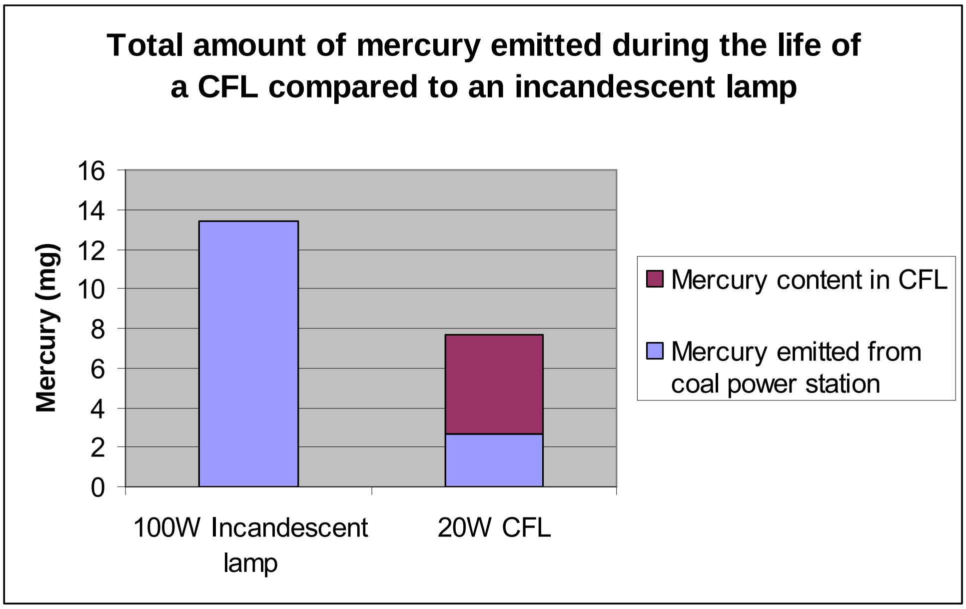

Figure 1: The above provides a comparison of the amount of mercury emitted into the environment from the production and use of a CFL compared to that of an incandescent lamp.

Fact Sheet: Migraines and Compact Fluorescent Lamps

Concerns have been raised that Compact Fluorescent Lamps (CFLs) may have adverse impacts on the health of some users. One such concern is the effects of CFL 'flicker' on migraine sufferers.

Migraine is one of the most common diseases of the nervous system. In developed countries migraine affects about 10-15% of people. Migraines can be triggered by many different things, including stress, exercise, certain foods, bright lights, flickering lights, loud noises, strong smells, lack of sleep or too much sleep. In women, attacks may be triggered by hormonal changes, for example during menstruation.

If light is suspected as the triggering event for migraines, ordinary head aches, and even eyestrain, the primary cause is likely to be glare, highly contrasting, or inappropriate light levels. These problems are a result of poor lighting design rather than a feature of fluorescent lights and can occur with any lighting technology if used inappropriately. Light fittings that enclose bulbs and distribute light evenly without compromising light output and efficiency can help avoid these problems.

The UK migraine action association (http://www.migraine.org.uk) recommends:

- Ensuring that lighting is adequate and well positioned
- Fluorescent lighting should be properly maintained to minimize flicker
- Fluorescent lights should be fitted with the correct type of diffuser to imitate natural daylight as much as possible
- Avoid reflected glare from shiny/polished surfaces, plain white walls etc, opt for matt finishes and break up surfaces with pictures, posters or plants
- Fit adjustable blinds to windows.

CFL 'flicker'

While light sources with a detectable flicker can trigger migraines in susceptible individuals, CFLs 'flicker' at a rate well above that detectable by the human brain and so should not affect migraine sufferers. As part of their normal operation fluorescent lamps flash on and off very rapidly - CFLs 'flicker' at a rate of more than 20,000 times per second, modern linear fluorescent tubes at more than 5,000 times per second, and older style linear fluorescents at 100 times per second. Occasionally, fluorescent lamps develop a fault which causes them to have may have a noticeable flicker; these lamps should be replaced.

As the phase-out plan for the inefficient incandescent lamp is developed, the Government will continue to consider health issues and examine options to address any significant issues. This may include providing information about possible impacts and available alternatives (halogen lights and filters), or specific provisions such as granting import licences to representative groups for people with conditions associated with available lighting products.

APPENDIX B: DEVELOPMENT OF AUSTRALIAN ENERGY EFFICIENCY POLICY

The Australian Government's initial response to concerns about the environmental, economic and social impacts of global warming was set out in the Prime Minister's statement of 20 November 1997, *Safeguarding the Future: Australia's Response to Climate Change.* The Prime Minister noted that the Government was seeking *"…realistic, cost-effective reductions in key sectors where emissions are high or growing strongly, while also fairly spreading the burden of action across the economy."* He also stated that the Government is "*…prepared to ask industry to do more than they would otherwise be prepared to do, that is, go beyond a 'no regrets'*[36]*, minimum cost approach where this is sensible in order to achieve effective and meaningful outcomes."* This "no regrets" test was a key part of the guidelines adopted by the Council of Australian Governments (COAG) in 1997 that any initiative proposed by the MCE, including standards and labelling measures under the Equipment Energy Efficiency Program, must meet.

In 1998 the Australian Government released *The National Greenhouse Strategy* (NGS) that was endorsed by the Australian Government and state and territory governments and committed them to an effective national greenhouse response. Progress under the NGS was reported to the Council of Australian Governments (CoAG). Many key elements of the NGS were implemented successfully, but, over time, the Australian Government identified a range of emerging climate change priorities that required attention at the federal government level. Similarly, there was acknowledgment that state and territory jurisdictional boundaries necessitated state/territory level climate change action plans and these were developed.

In 2004, the Australian Government released a new climate change strategy as articulated through its Energy White Paper, *Securing Australia's Future*, and the 2004-05 Environment Portfolio Budget. Some elements of the earlier NGS were included in the new strategy. As a critical element of the Australian Government's climate change strategy, the new energy policy represented the refinement of strategic themes pursued in relation to energy under the NGS, including energy market reform, the development of low-emissions and renewable technologies, and improvements to end-use energy efficiency.

Since that time, CoAG has remained the primary forum for progressing Australian, state and territory government collaboration on climate change issues requiring inter-jurisdictional attention. Significant progress has been made under the CoAG climate change agenda since CoAG's agreement in June 2005 to establish a new Senior Officials Group to consider ways to further improve investment certainty for business, encourage renewable energy and enhance cooperation in areas such as technology development, energy efficiency and adaptation. This work culminated in the January 2006 CoAG climate change action plan. In addition, climate change issues requiring national coordination have been managed through a number of inter-governmental ministerial councils including the Ministerial Council on Energy.

The Australian Government's climate change strategy is the mechanism through which Australia will meet its international commitments as a party to the United Nations Framework Convention on Climate Change (UNFCCC). The Government has an overall target of limiting Australia's emissions in 2008-2012 to 108% of its 1990 emissions. This is a 30% reduction on the projected "business as usual" (BAU) outcomes in the absence of interventions.

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[36] The Productivity Commission has defined "No regrets" policy options as measures that … *have net benefits (or at least no net cost) in addition to addressing the enhanced greenhouse effect. A more intuitive interpretation of 'no regrets' measures could be that they are actions which would still be considered worthwhile even in the absence of concerns about the potential adverse impact of global warming.* (PC 1997: page vii). This may involve imposing additional business costs on suppliers if the resulting more efficient products deliver a net benefit to the wider community.

Over 2006, the national policy debate over introducing a carbon price in Australia continued with the state and territory governments proposing an emission trading scheme, and the Australian Government holding a nuclear energy enquiry and announcing its own emissions trading inquiry by the *Task Group on Emissions Trading*.

In 2007, emissions trading became a major new plank in the Australian Government's response to climate change. The then Government announced in that Australia will introduce a world-class domestic emissions trading system by 2012. The new Government, elected in December, has brought the implementation date forward to 2010. Emissions trading will be the primary mechanism for achieving the long term emissions reduction goal.

Emissions trading will complement existing Government actions to reduce greenhouse gases. These include:

- improving end-use energy efficiency;
- investing in the new low emissions technologies Australia and the world will need in the future, including renewable energy technologies and clean coal;
- supporting world-class scientific research to continue to build our understanding of climate change and its potential impacts, particularly on our region; and
- assisting regions and industries to adapt to the impacts of climate change.

An emissions trading scheme will build on the success of past and ongoing measures. These measures include the *2004 Energy White Paper*, *2004-05 Climate Change Strategy*, earlier measures such as *Measures for a Better Environment* and *Safeguarding the Future*, as well as new programs announced in 2006-07.

APPENDIX C: IEA REVIEW OF POLICIES FOR ENERGY EFFICIENT LIGHTING

This appendix draws on the recent IEA report that we referenced in chapter 1 (IEA 2006: chapter 5). It provides a review of lighting policies in OECD countries and in selected non-OECD countries.

C.1 POLICIES TO IMPROVE LIGHTING COMPONENT EFFICIENCY

Governments have applied MEPS and labelling requirements to a wide range of lighting components since the 1970s and especially since the mid-1990s. The components include not only lamps but also ballasts, ELVCs, luminaires[37], and specific applications like street lights and exit signs. IEA finds that there are still many gaps in the labelling and standards program and that more work is required to provide reasonable coverage.

Australia recently introduced MEPS for ballasts and linear fluorescent lamps and, in addition to the measures addressed in this RIS, there are plans to apply MEPS to lighting technologies that are used for industrial and outdoor applications. Legislative impediments to European MEPS are currently being addressed, paving the way for a more aggressive program of MEPS.

IEA says that the main problem with MEPS, as they have been used to date, is that they promote efficiency within product categories but do little to accelerate the phasing out of incandescent lamps, which promises the largest gains. IEA makes particular reference to the aggressive use of MEPS for individual products in Canada and the US, but where overall efficacy is still held back by extensive use of incandescent lamps (IEA 2006: page 334).

IEA says labelling programs are best regarded as complementing MEPS and other programs. There has been mandatory labelling of lamps in Europe since 1998 and it may be responsible for the higher penetration of CFLs there, but that is not clear. Both mandatory and voluntary labelling schemes have been used in the US since the early 1990s, with positive but not dramatic results.

It is interesting that fluorescent lamps have actually attracted more regulatory attention – both MEPS and labelling - than the much less efficient incandescent lamps. This is partly due to their importance in commercial settings and partly to preserve the quality of CFLs as viable replacements for incandescent lamps. The danger is that poorly-informed users cannot distinguish between good and bad CFLs and that an accumulation of bad experiences with poor products will destroy the reputation of CFLs generally. Economists refer to this as the ‘lemons’ problem. The regulation of CFLs is currently the focus of the *International CFL Harmonisation Initiative*, focusing on international harmonisation of CFL test and performance standards and aiming to reduce compliance and manufacturing costs and ultimately reducing the price of high quality CFLs.

C.2 BUILDING CODES AND BUILDING ENERGY PERFORMANCE CERTIFICATION

Building codes can regulate the maximum power of lighting systems that are installed in new and refurbished buildings, with the maximum defined as watts per square metre of floor space or watts per lumen (inverse of efficacy). Some codes require daylight and lighting controls such as dimmers, occupancy and motion sensors. Many US jurisdictions have adopted the lighting provisions of building codes over the last 20 years. Australia introduced building code measures for commercial buildings in 2006 and they are about to rationalised and more widely adopted in Europe. Queensland recently introduced a requirement that 40% of the lamps in new houses are CFLs.

This form of regulation generally has the desirable property of setting a performance target and allowing suppliers to determine how best to meet that target, although the prescriptive

[37] A luminaire is the lamp housing that reflects and directs the light.

nature of the Queensland regulation is an exception. But its effectiveness is constrained by (a) the relatively slow turnover of the building stock, which can take decades, (b) reversion to inefficient products when lamps are replaced, and (c) the need for effective enforcement. Whereas enforcement of MEPS requires the monitoring of relatively few suppliers, enforcement of building codes requires the monitoring of many thousands of builders and building sites.

Many countries, particularly in Europe, are mandating the use of building energy certification (rating) schemes that are designed to provide building users (both new and existing buildings) with information about their energy efficiency. Lighting is one of the energy services included in such whole-of-building ratings and often one of the easiest to upgrade when owners seek a higher rating. Similar measures are under consideration in Australia.

C.3 MARKET TRANSFORMATION PROGRAMS

Market transformation programs usually comprise a mix of information and awareness activities, financial incentives and procurement initiatives, aiming to simultaneously ‘create demand’ and ‘build capacity’ for higher efficiency. Program organisers typically seek the cooperation of agents with significant ‘clout’, such as housing authorities and other property managers in the public sector, energy utilities and large commercial and industrial property interests. The incentive to participate is sharpest where there are there is an associated benefit in the management of loads on congested electricity networks. In residential applications there is more reliance on financial incentives, often outright gifts of CFLs. The aim is to familiarise households with good quality CFLs and increase acceptance.

IEA says that there is increasing use of financial incentive programs by the regulators of energy markets as they seek a better balance of demand reduction and supply augmentation responses to growing energy demands. The NSW Greenhouse Gas Reduction Scheme (GGAS) is an example, providing a financial incentive for electricity retailers to meet their emissions targets by installing CFLs in homes.

The problem with market transformation programs is to ensure that users do not revert to the older technologies as soon as the program is relaxed or the particular energy emergency passes.

C.4 IEA’S KEY FINDING - CURRENT POLICIES ARE INADEQUATE

IEA concludes that existing policy efforts ... *fall far short of delivering the majority of cost-effective saving potentials available through current technology and that a great deal more needs to be done* (IEA 2006: page 480). This is a major global issue: lighting accounts for 19% of electricity use and there is potential to reduce that by 40%. There is a need to define clear policy objectives. IEA identifies the phasing out of inefficient incandescent lamps as one such objective, amongst a raft of objectives covering procedures for determining lighting requirements, awareness of end-users and capacity of suppliers, upgrading of lighting technology, and objectives for emerging economies.

Regarding the replacement of incandescent lamps with CFLs, IEA considers that key factors are to reduce the price differential and preserve the quality of CFLs by eliminating inferior products. IEA noted that the time is approaching for MEPS that effectively ban tungsten filament lamps, given reductions in price, improvements in light quality, and much improved compatibility between CFLs and existing fixtures.

IEA (2006: pages 517-520) recommends adoption of mandatory energy performance requirements for lighting systems in all lighting end-uses[38]. Performance-based regulation means that components that do the same job are subject to the same requirements.

[38] This is the first of 10 recommendations. The other nine relate to the importance of building codes and their enforcement, building energy performance certification, comprehensive labelling and information activities,

APPENDIX D: MODELLING OF LAMP STOCKS, ENERGY USE AND GREENHOUSE EMISSIONS

This account of the modelling approach is organised under is organised under 3 headings:

- Statement of the accounting framework
- Explanation of the baseline estimates, describing the state of play in 2005
- Explanation of the WPM estimates, as if imposed on the 2005 lighting task

The discussion is mainly in terms of the energy used for lighting. Greenhouse emissions are calculated by applying standard measures of greenhouse intensity to the estimates of energy use.

D.1 ACCOUNTING FRAMEWORK

The production of light is measured in lumens, which is a measure of the amount of visually useful radiation that is emitted by the lamp. The common 60 watt globe emits about 750 lumens, and a 500 watt 'torchiere[39]' lamp emits about 9,500 lumens.

The amount of light that a lamp emits over a period of time is measured in lumen-hours. For example, a 60 watt globe that operates for 100 hours per year is said to provide 75,000 lumen-hours/year (= 750 * 100).

Given the amount of light produced, the amount of energy used by the lamp is determined by the energy efficiency of the lamp. This called the 'efficacy' of the lamp and is measured as the ratio of the lamp's light output (lumens) to the lamp's rate of energy input (wattage). For example, a 60 watt globe has an efficacy 12.5 lumens/watt (= 750/60) and will use 6 kWh of electricity over a year [= 75,000/(12.5 *1,000)].

These relationships can be expressed as follows.

$$E_i = \frac{G_i}{e_i}$$

where

i denotes lamp i

$G_i = \textit{annual light provided by lamp } i \ (kLh : 10^3 \textit{ lumen} - \textit{hours})$

$e_i = \textit{efficacy of lamp } i \ (\textit{lumens per watt})$

$E_i = \textit{annual energy used by lamp } i \ (kWh)$

With the exception of lamps on dimmable circuits, lamps emit light at a fixed rate and use energy at a fixed rate. Given the lighting installation for a particular space, the amount of light provided to a particular space can then be governed by switching some or all of the lights off.

The following terminology is used for the total amount of light emitted by all lights.

selective market-transformation initiatives, removal of barriers to the efficient operation of energy service providers, R&D support and work with developing countries.

[39] The torchiere lamp is a standing lamp that shines powerful light up onto the ceiling and lights the space with the reflected glow.

$$G = \frac{\sum_{i=1}^{N} G_i}{1{,}000{,}000{,}000}$$

$$E = \sum_{i=1}^{N} \frac{G_i}{e_i}$$

where

$N = total\ number\ of\ lamps$

$G = aggregate\ annual\ light\ provided\ by\ all\ lamps\ (GLh, 10^9\ lumen-hours)$

$E = aggregate\ annual\ energy\ used\ by\ all\ lamps\ (GWh)$

D.2 BASELINE ESTIMATES, 2005

The baseline estimate is that, in 2005, Australians consumed 1,366,182 GLh of light for stationary purposes, that is, excluding vehicle lights. There are four broad categories of stationary lighting task – residential, commercial, industrial and outdoor. The outdoor lighting task includes traffic lights, street lighting and other forms of public lighting, airfield lighting, billboards and parking lots).

Table D.1 shows the corresponding estimates of energy use and greenhouse emissions, and the per-capital equivalents.

These estimates have been obtained by adapting a US model of the lighting task and lighting energy use[40]. This was a 4-stage process.

Table D.1 Baseline estimates of lighting output and electricity use, 2005

	Aggregate	*Per capita*
Production of light	*GLh*	*MLh*
Residential	90,142	4.5
Commercial	744,632	37.2
Industrial	297,698	14.9
Outdoor	233,710	11.7
Total	**1,366,182**	**68.3**
Lighting electricity use	*GWh*	*kWh*
Residential	5,146	257
Commercial	15,715	786
Industrial	4,636	232
Outdoor	2,736	137
Total	**28,233**	**1,412**
Greenhouse emissions	*Mt*	*kg*
Residential	4.70	235
Commercial	14.35	718
Industrial	4.23	212
Outdoor	2.50	125
Total	**25.78**	**1,289**

[40] This was the approach adopted by the International Energy Agency (IEA) for its recent report on the global lighting task and policies for energy efficient lighting (IEA 2006).

Stage 1 - model Australian lighting task on an 'equivalent US' basis

We first calculated the Australian lighting task on an 'equivalent US' basis, as follows:

1. We obtained the US 'sectoral matrices' for each of the 4 sectors – residential, commercial, industrial and outdoor. These matrices are estimates of per-building averages of the number of lamps, average daily operating hours, average wattage and average lamp efficacy, but broken down by lamp type. There are 35 lamp types, 7 incandescent, 16 fluorescent, 6 high intensity discharge types and 2 solid state types. (There are no outdoor buildings of course and the outdoor matrix contains the total for outdoor lamps.)
2. We obtained the US estimates of total buildings in each sector - 107 million residential, 4.7 million commercial, 0.23 million industrial and 1 outdoor 'building'.
3. Total US light production and lighting energy use can be calculated from items 1 and 2. These aggregates are 38,445,000 GLh/year of light and 765,000 GWh/year of electricity. The per-capita equivalents are 1,200 MLh/year and 2,400 kWh/year.
4. We reduced the 35 lamp categories to 11 categories, largely by combining the linear fluorescent categories onto one, and recalculated the sectoral matrices to ensure the new values for average hours, wattage and efficacy were appropriately weighted. We cross-checked by reproducing the US aggregates. The resulting categories are as follows:

INCANDESCENT
Tungsten filament - non-reflector
Tungsten filament - reflector
MV tungsten halogen - non-reflector
MV tungsten halogen - reflector
ELV tungsten halogen - non-reflector
ELV tungsten halogen - reflector
FLUORESCENT
Linear
CFL - non-reflector
CFL - reflector
OTHER
HID
SSL

5. AGO's technical advisor, Steve Beletich, advised on appropriate adjustments the US estimates of lamp efficacy, allowing for the fact that residential voltage is lower in the US (120 V compared with 240 V in Australia) and some lamps are more efficient at lower voltages. His advice was informed by a review of lamp efficacies for a sample of lamps on the Australian market, using both catalogue sources and the results of an on-going testing program commissioned by the AGO. This work is reported in a technical report to the AGO (Beletich and Associates, 2007).
6. It is then a relatively simple matter to calculate the Australian lighting task on an 'equivalent US' basis.
   - The average US residential lighting task was married with ABS projection for the number of Australian households, but adjusted to take account of minor differences between the household and dwelling counts[41].
   - The sectoral matrices for the commercial and industrial sectors were re-calibrated to be expressed as amounts per million square meters of floor-space, rather than 'per building' as in the US model. This is because we have projections for Australia's stock of commercial and industrial floor-space, documented in a RIS published by the Australian Buildings Code

[41] There are somewhat more dwellings than households. Each census records about 10% more dwellings (unoccupied) than households.

Board (ABCB 2005). The average US commercial and industrial lighting tasks were then married with these projections.
- The Australian outdoor lighting task was set at one fifteenth of the corresponding US task, which is roughly in proportion to population.

However, it is apparent that the 'equivalent US' estimate is too high. Consider that:

- A series of energy end-use studies in the late 1980s and early 1990s estimated Australian residential lighting energy at 500-600 kWh/year[42]. The corresponding US figure is 1,946 kWh and, even allowing for considerable growth since the end-use studies were conducted, seems too high.
- The US study estimates that there are 43 lamps in the average US dwelling, including 34 of the tungsten filament type. Intuitively, those figures are too high for the average Australian home of 3 or 4 bedrooms. There is supporting data. On average, CFL replacement programs are finding about 20 tungsten filament lamps in the average Australian home[43] and that is likely to be an overestimate because participation in such programs is more attractive to households with large lighting tasks and because it more difficult for operators to gain access to the smaller dwellings in apartment buildings. Also, most estimates for the more developed non-US economies are in the range 15-30 lamps per dwelling and average about 24 lamps per dwelling[44].
- A 1999 study commissioned by the AGO (EMET 1999) provides estimates of the lighting energy used in the commercial building sector, with projections to 2010. Interpolation suggests a figure of about 640 kWh per capita in 2007, compared with a US figure of 1,230 kWh per capita.
- There may similar differences for the industrial and outdoor sectors. These are of less significance in the present context, since they account for small proportion of the lamps under consideration, for example, about 3% of the lamp-hours for lamps of the tungsten filament type.

While we know that that the 'equivalent US' estimate is too high, there is currently no objective data on which to base an Australian estimate. It is necessary to rely on a combination of expert judgment and scraps of evidence that can be gleaned from lamp suppliers and installers, and then to reconcile the tally across all sectors with the import data and with data from comparable countries.

<u>Stage 2 – develop Australian 2005 residential model</u>

Table D.2 presents the sectoral matrix for the Australian residential sector. For the average dwelling it gives an account of the number of the average number of lamps, hours of operation, efficacy and wattage. Light output and energy input are derived from these variables and are reported in the last two columns. The key matters of judgment were determined in stages, as follows:

1. It is assumed that there were 20 lamps in the average household. Of these, the average dwelling had 2.6 lamps on dimmer circuits and 17.4 lamps on switch circuits.
2. Of the 2.6 lamps on dimmer circuits, it is assumed that 94% were ELV halogen, 4% were tungsten filament and 2% were MV tungsten halogen.
3. Of the 17.4 lamps on switch circuits it is assumed that
   - 2.4 were linear fluorescent and one is a CFL. These settings are suggested by ABS estimates (Cat 4602.0) of the average number of rooms that had

[42] This data is reviewed in appendix G of the AGO commissioned baseline study of residential energy use (EES 1999).
[43] This estimate is based on informal advice from staff of the NSW Greenhouse Gas Reduction Scheme.
[44] This observation is based on a review of the data in Bertoldi *et al* 2006.

fluorescent and energy saving lights, but with the further assumption that there were two such lamps per room.
    - There were 1.75 tungsten halogen lamps, .5 on mains voltage and 1.25 on low voltage.
    - The remaining lamps (12.25 per dwelling) are tungsten filament.

4. The proportion of reflector lamps was determined as follows: tungsten filament – 9%; MV tungsten halogen – 60; ELV tungsten halogen – 70%; CFL 5%.
5. The average residential duty hours is 1.9 hours per day, with tungsten filament lamps on 1.5 hours and CFLs assumed to be on relatively high duty of 2.75 hours/day. Tungsten halogen lamps were put at intermediate duty, 1.85 hours/day for mains voltage lamps and 2.25 hours for ELV lamps.

It is assumed that the average household had 3 lamps that are out of scope, 2.4 linear fluorescent lamps and 0.6 tungsten filament lamps with 150 or more watts.

The key points of difference between the US and Australian models are the number of lamps and the average hours of operation. There are 53% fewer lamps in the Australian household – 20 in Australia compared with 43 in the US. The average hours of operation are 5% lower, at 1.9 hours per day in Australia compared with 2.0 hours per day in the US.

Lighting energy consumption is estimated at 684 kWh for the average Australian dwelling in 2005. This is somewhat higher than the estimates from the 15 years ago, which were in the region of 500-600 kWh per year.

Table D.2 Residential lighting matrix: average Australian dwelling, 2005

	Number of lamps/ELVCs	Average lamp hours	Efficiency (lamps, lumens/w) (ELVCs, %)	Average wattage	Average light (kLh)	Average energy (kWh)
SWITCH CIRCUITS (per dwelling)						
Tungsten filament - non-reflector	11.17	1.50	10.7	62.8	4,118.5	383.9
Tungsten filament - reflector	1.06	1.50	9.7	79.5	449.4	46.2
MV tungsten halogen - non-reflector	0.20	1.80	12.3	69.5	112.5	9.2
MV tungsten halogen - reflector	0.30	1.80	11.7	65.8	153.2	13.0
LV tungsten halogen - non-reflector	0.99	2.25	13.7	20.0	223.1	16.3
LV tungsten halogen - reflector	0.26	2.25	14.1	50.0	150.6	10.7
Linear	2.40	2.75	70.0	30.0	5,058.9	72.3
CFL - non-reflector	0.95	2.75	51.2	12.5	608.7	11.9
CFL - reflector	0.05	2.75	32.0	24.1	38.8	1.2
HID	-				-	-
SSL	-				-	-
ELVCs for reflector lamps	0.25	2.25	84.3%	93.7	-	3.0
ELVCs for non-reflector lamps	0.25	2.25	83.3%	62.5	-	2.1
All lamps	**17.38**	**1.81**	**19.2**	**49.7**	**10,914**	**570**
DIMMER CIRCUITS (per dwelling)						
Tungsten filament - non-reflector	0.06	2.25	9.4	56.7	24.7	2.6
Tungsten filament - reflector	0.06	2.25	8.7	70.6	28.2	3.2
MV tungsten halogen - non-reflector	0.02	2.25	10.5	58.8	11.3	1.1
MV tungsten halogen - reflector	0.03	2.25	10.5	58.7	17.0	1.6
LV tungsten halogen - non-reflector	0.11	2.25	12.3	17.8	19.8	1.6
LV tungsten halogen - reflector	2.34	2.25	11.8	42.4	963.9	81.4
Linear	-				-	-
CFL - non-reflector	-				-	-
CFL - reflector	-				-	-
HID	-				-	-
SSL	-				-	-
ELVCs for reflector lamps	0.03	2.25	79.8%	88.3	-	0.4
ELVCs for non-reflector lamps	2.25	2.25	78.7%	55.9	-	22.0
All lamps	2.62	2.25	9.3	53.0	1,065	114

	Number of lamps/ELVCs	Average lamp hours	Efficiency (lamps, lumens/w) (ELVCs, %)	Average wattage	Average light (kLh)	Average energy (kWh)
ALL CIRCUITS (per dwelling)						
Tungsten filament - non-reflector	11.22	1.5	10.7	62.8	4,143.2	386.5
Tungsten filament - reflector	1.12	1.54	9.7	78.9	477.5	49.5
MV tungsten halogen - non-reflector	0.22	1.85	12.1	68.2	123.8	10.3
MV tungsten halogen - reflector	0.34	1.85	11.6	64.9	170.2	14.7
LV tungsten halogen - non-reflector	1.10	2.25	13.6	19.8	242.9	17.9
LV tungsten halogen - reflector	2.60	2.25	12.1	43.1	1,114.5	92.1
Linear	2.40	2.75	70.0	30.0	5,058.9	72.3
CFL - non-reflector	0.95	2.75	51.2	12.5	608.7	11.9
CFL - reflector	0.05	2.75	32.0	24.1	38.8	1.2
HID					-	-
SSL					-	-
ELVCs for reflector lamps	0.28	2.25	83.9%	93.2	-	3.4
ELVCs for non-reflector lamps	2.50	2.25	79.2%	56.6	-	24.1
All lamps	**20.0**	**1.9**	**17.5**	**50.2**	11,978	684

<u>Stage 3 – develop Australian non-residential models</u>
Table D.3 presents the sectoral matrices for the three non-residential sectors – commercial, industrial and outdoor.

These settings have been obtained by applying adjustment factors to the US model, designed to reduce the sectoral estimates of lighting energy to plausible levels, particularly for the commercial sector. Most of the adjustment was achieved by reducing the average number of lamps per square meter of floor-space and the average hours of operation – to 80% of their US levels. These adjustments are arbitrary but we note that Australia is one of several countries with industry standards that recommend relatively low illuminance levels (IEA 2006: page 85). Recommended illuminance levels in the US tend to be ‘middle of the range’ compared with other countries.

We reduced the hours for tungsten filament lamps to 64% of the US level. One implausible feature of the US model is that the tungsten filament lamps have duty hours that are very similar to other types of lamps. Intuitively, it seems reasonable to expect that the relatively inefficient types of lamp (like tungsten filament) will tend to be restricted to tasks with lower duty hours.

We also adjusted the floor-space estimate and the average lamp wattages, reducing both to 90% of the US level.

The effect of these adjustments is to preserve the mix of non-residential lighting that has been estimated for the US but to restrict overall numbers and usage to more plausible levels. The Australian figure for the commercial sector is about 797 kWh per capita, which is comparable with the estimate of 640 kWh implied by the EMET study of 1999.

Table D.3 Non-residential lighting matrices: 2005

	Number of lamps/ELVCs	Average lamp hours	Efficiency (lamps, lumens/w) (ELVCs, %)	Average wattage	Average light (kLh)	Average energy (kWh)
COMMERCIAL (per million square meters of floor space)						
Tungsten filament - non-reflector	32,882	6.7	10.9	77.7	67,913,201	6,221,545
Tungsten filament - reflector	11,705	6.2	10.2	93.6	25,362,560	2,482,511
MV tungsten halogen - non-reflector	1,414	7.6	12.4	91.3	4,437,868	357,914
MV tungsten halogen - reflector	1,696	6.2	11.8	70.0	3,176,980	269,042
LV tungsten halogen - non-reflector	3,128	8.2	13.7	20.0	2,581,590	188,148
LV tungsten halogen - reflector	14,259	8.2	14.1	50.0	30,223,073	2,144,303
Linear	154,809	7.7	70.0	40.2	1,220,396,565	17,434,237
CFL - non-reflector	16,934	6.8	53.2	15.0	33,705,025	633,395
CFL - reflector	546	6.6	26.6	14.4	503,247	18,926
HID	3,824	8.1	58.2	363.6	238,708,088	4,100,361
SSL	219	18.4	18.9	4.5	125,066	6,604
ELVCs for reflector lamps	792	8.2	83.9%	94.2	-	36,201
ELVCs for non-reflector lamps	13,711	8.2	82.8%	62.8	-	445,367
All lamps	**241,415**	**7.5**	**47.4**	**52.3**	1,627,133,264	34,338,553
INDUSTRIAL (per million square meters of floor space)						
Tungsten filament - non-reflector	885	11.2	9.2	83.5	2,767,073	301,538
Tungsten filament - reflector	792	8.6	10.1	91.8	2,307,369	227,518
MV tungsten halogen - non-reflector	1,242	11.2	12.4	57.6	3,616,761	291,693
MV tungsten halogen - reflector	3,725	8.6	11.8	70.0	9,638,193	816,210
LV tungsten halogen - non-reflector	-				-	-
LV tungsten halogen - reflector	-				-	-
Linear	171,813	10.8	70.0	43.3	2,043,187,562	29,188,394
CFL - non-reflector	1,564	9.4	57.8	20.3	6,262,496	108,390
CFL - reflector	130	6.1	25.3	12.6	93,031	3,683
HID	8,733	11.1	58.2	382.5	789,264,704	13,557,437
SSL	39	18.7	18.9	4.5	22,770	1,202
ELVCs for reflector lamps					-	-
ELVCs for non-reflector lamps					-	-
All lamps	**188,922**	**10.7**	**64.2**	**60.2**	2,857,159,958	44,496,065

	Number of lamps/ELVCs	Average lamp hours	Efficiency (lamps, lumens/w) (ELVCs, %)	Average wattage	Average light (kLh)	Average energy (kWh)
OUTDOOR (all of Australia)						
Tungsten filament - non-reflector	758,341	5.1	11.6	102.5	1,691,254,160	145,261,791
Tungsten filament - reflector	98,917	4.6	10.5	100.0	174,196,578	16,637,002
MV tungsten halogen - non-reflector	129,374	5.1	13.6	80.0	262,510,361	19,341,876
MV tungsten halogen - reflector	194,060	4.6	13.1	100.0	427,485,198	32,639,416
LV tungsten halogen - non-reflector	-				-	-
LV tungsten halogen - reflector	-				-	-
Linear	126,267	8.6	60.8	134.9	3,265,798,036	53,732,068
CFL - non-reflector	6,313	8.6	57.8	20.3	23,304,198	403,345
CFL - reflector	-				-	-
HID	3,661,000	9.0	92.3	204.3	227,861,545,657	2,467,910,413
SSL	6,400	5.6	20.0	13.5	3,532,032	176,602
ELVCs for reflector lamps					-	-
ELVCs for non-reflector lamps					-	-
All lamps	**4,980,672**	**8.07**	**85.4**	**186.6**	233,709,626,220	2,736,105,512

Stage 4 – check for consistency with import and sales data
Given an account of the lamp stock, it is possible to estimate the annual re-lamping task and compare that with ABS estimates of annual lamp imports. The only additional data required are estimates of average lamp life. This exercise is reported in table D.4.

Inspect table D.4 to see that we have extracted estimates of total lamp hours from the stock model and, by dividing by typical lamp lives, have obtained estimates of the annual re-lamping task. These calculations suggests that there would need to be annual lamp imports of 138.9 million to maintain the estimated stock of incandescent and fluorescent lamps, including 93.5 million lamps of the tungsten filament type.

Lamp imports have averaged 135.5 million/year over the last several years, close to the re-lamping requirement of the stock model. The mix of lamps is also about right, except that there is noticeable deficit for tungsten-filament lamps of the non-reflector type, and an off-setting surplus in the imports of CFLs. This is because the mix of lamps is changing. Specifically, tungsten filament lamps are not being replaced at the rate that is needed to maintain their share of the lamp stock, and CFLs are being installed at a rate that will increase their share of the lamp stock.

Figure D.1 shows trends in lamp imports over the last decade. (Note that the series for tungsten filament and linear fluorescent lamps is for the period 2003 to 2006. There was significant domestic production of these lamps prior to 2003 which means that the earlier import data is misleading.) There has been strong growth of the three minor technologies over this period, with average annual growth of 7.4% for both MV and ELV tungsten halogen lamps and 19.4% for CFLs. This suggests that there should be surplus imports for the tungsten halogens as well. However, close examination of chart D.1 shows tungsten halogen imports have flattened over recent years and that CFL imports have accelerated at the same time.

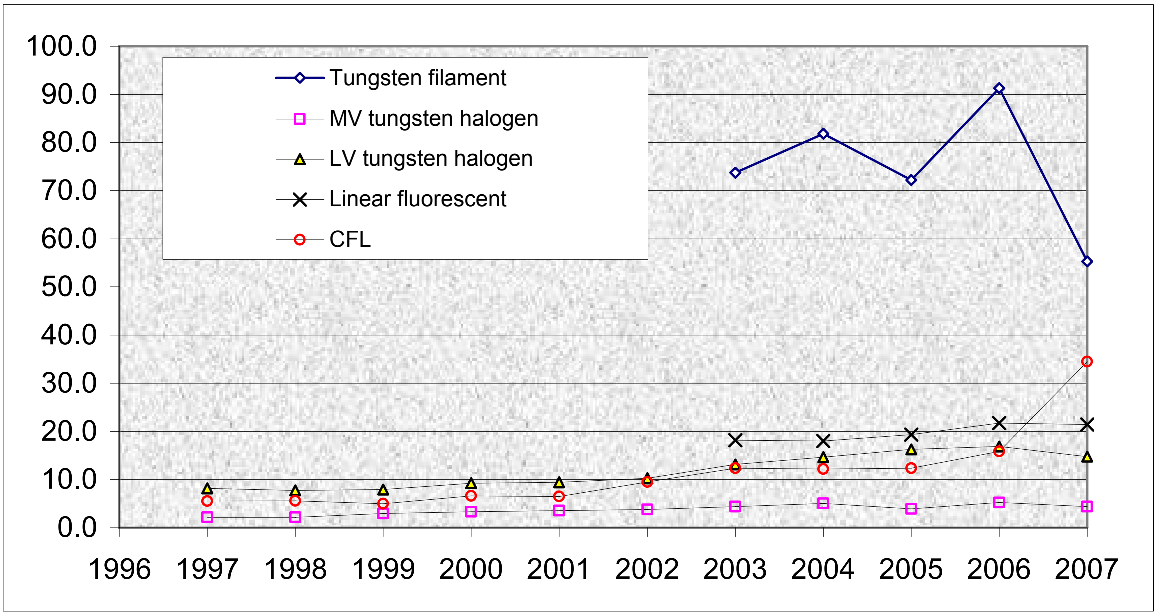
On this basis, we consider that our lighting stock model is consistent with the import data. It should be noted that we kept an eye on this reconciliation task and have modified the stock parameters in a manner calculated to eliminate obvious inconsistencies.

Table D.4 Comparison of re-lamping task with imports

	Annual lamp hours (millions)	Average lamp life (hrs)	Number of lamps (millions)		
			Annual re-lamping task	Annual lamp imports (Av. 2004 to 06)	Annual import deficit
Tungsten filament - non-reflector	84,810	1,000	84.81	74.14	-10.7
Tungsten filament - reflector	17,284	2,000	8.64	7.64	-1.0
MV tungsten halogen - non-reflector	3,478	2,000	1.74	1.89	0.1
MV tungsten halogen - reflector	5,217	2,000	2.61	2.84	0.2
ELV tungsten halogen - non-reflector	11,103	3,000	3.70	3.80	0.1
ELV tungsten halogen - reflector	35,703	3,000	11.90	12.10	0.2
Linear fluorescent	287,337	15,000	19.16	19.66	0.5
CFL	28,075	6,000	4.68	13.44	8.8
Total	**473,008**		**137.24**	**135.51**	**-1.7**

Source: AGO lamp stock model for re-lamping task. Import data from ABS

Figure D.1 Australian lamp imports (millions/year)



Source: ABS data consultancy, but with partial data for 2007 (to October 2007) converted to an annual figure on a *pro rata* basis.

D.3 'WITH SPECIFIC MEASURES' (WSM) ESTIMATES, 2005

Table D.4 reports estimates of how the 2005 lighting task would have been carried out if users had been required to comply with the proposed MEPS in 2005. The efficacy and re-lamping assumptions are those described in the sections of the RIS dealing with user impacts – see section 4.4. The figuring is hypothetical, since it ignores the fact that the implementation of MEPS will take time, but it provides a snapshot of the major impacts.

Table D.4 WSM estimates of lighting output and energy use, 2005

	Aggregate	*Per capita*	*Change relative to baseline*	
			Aggregate	*%*
Lighting energy use	*GWh*	*kWh*	*GWh*	
Residential	3,472	174	-1,674	-32.5%
Commercial	14,051	703	-1,663	-10.6%
Industrial	4,585	229	-52	-1.1%
Outdoor	2,692	135	-44	-1.6%
Total	24,800	1,240	-3,433	-12.2%
Greenhouse emissions	Mt	kg		
Residential	3.17	159	-1.53	-32.5%
Commercial	12.83	642	-1.52	-10.6%
Industrial	4.19	209	-0.05	-1.1%
Outdoor	2.46	123	-0.04	-1.6%
Total	22.65	1,132	-3.14	-12.2%

APPENDIX E: TRIAL STATEMENT OF ABATEMENT VALUATIONS THAT WILL BE INCLUDED IN FUTURE IMPACT ASSESSMENTS

The potential impact of an Australian emissions trading scheme (ETS) on the benefit-cost ratio is assessed in this appendix. Hence the RIS should take into account the increased benefits due to the avoided cost of carbon permits for electricity generators, which will result from the proposed MEPS reducing the consumption and generation of electricity at the margin. These valuations were trialled in an earlier RIS (EnergyConsult 2007) dealing with proposed MEPS for chillers. The same methodology is applied here, with the results reported in table E.1.

Table E.1 Abatement valuations for Australia

Discount rate	0%	5%	7.5%	10%
Carbon permit price = \$0/t CO_2-e				
Total Costs (\$M)	No capital costs			
Total Benefits (\$M)	3,988	2,630	2,167	1,802
Net Benefits (\$M)	3,988	2,630	2,167	1,802
Cumulative Mt CO_2-e Abatement (2008 -2020)	28.5			
Carbon permit price = \$10/t CO_2-e				
Value of greenhouse abatement (\$M)	284.6	187.8	154.9	128.8
Net Benefits (\$M) with greenhouse abatement included	4,272.1	2,817.5	2,322.1	1,931.1
Carbon permit price = \$20/t CO_2-e				
Value of greenhouse abatement (\$M)	569.1	375.6	309.7	257.7
Net Benefits (\$M) with greenhouse abatement included	4,556.7	3,005.4	2,476.9	2,060.0

APPENDIX F: BREAKDOWN OF IMPACTS BY JURISDICTION

Impacts have been allocated to jurisdictions in proportion to their population, but using each jurisdictions electricity tariffs to value the energy savings.

	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
WoSM energy use (GWh)								
2000	8,559	6,393	5,073	2,110	2,593	659.2	216.9	421.6
2001	8,700	6,499	5,156	2,144	2,636	670.0	220.5	428.5
2002	8,845	6,607	5,242	2,180	2,680	681.2	224.1	435.7
2003	8,991	6,717	5,329	2,216	2,724	692.5	227.8	442.9
2004	9,138	6,827	5,416	2,252	2,769	703.8	231.6	450.1
2005	9,285	6,936	5,503	2,289	2,813	715.1	235.3	457.4
2006	9,382	7,013	5,624	2,303	2,864	719.7	238.6	462.6
2007	9,475	7,087	5,743	2,317	2,913	723.7	241.8	467.6
2008	9,570	7,163	5,865	2,330	2,963	727.8	245.5	472.7
2009	9,665	7,238	5,988	2,344	3,014	732.2	248.7	477.3
2010	9,758	7,314	6,112	2,357	3,064	736.2	251.9	482.3
2011	9,852	7,389	6,238	2,370	3,115	740.0	255.4	486.8
2012	9,944	7,463	6,365	2,382	3,166	743.5	258.5	491.3
2013	10,036	7,537	6,492	2,395	3,216	746.6	261.7	495.8
2014	10,127	7,611	6,620	2,406	3,267	749.7	264.8	500.3
2015	10,218	7,685	6,749	2,418	3,317	752.8	268.3	504.7
2016	10,309	7,758	6,880	2,429	3,368	755.6	271.4	509.2
2017	10,398	7,831	7,010	2,440	3,419	758.0	274.5	513.3
2018	10,487	7,904	7,141	2,450	3,469	759.8	277.7	517.5
2019	10,576	7,976	7,272	2,461	3,520	761.9	280.8	521.7
2020	10,664	8,048	7,403	2,471	3,570	763.8	283.9	525.8
WSM energy use (GWh)								
2000	8,559	6,393	5,073	2,110	2,593	659.2	216.9	421.6
2001	8,700	6,499	5,156	2,144	2,636	670.0	220.5	428.5
2002	8,845	6,607	5,242	2,180	2,680	681.2	224.1	435.7
2003	8,991	6,717	5,329	2,216	2,724	692.5	227.8	442.9
2004	9,138	6,827	5,416	2,252	2,769	703.8	231.6	450.1
2005	9,285	6,936	5,503	2,289	2,813	715.1	235.3	457.4
2006	9,382	7,013	5,624	2,303	2,864	719.7	238.6	462.6
2007	9,475	7,087	5,743	2,317	2,913	723.7	241.8	467.6
2008	9,570	7,163	5,865	2,330	2,963	727.8	245.5	472.7
2009	9,463	7,088	5,867	2,294	2,952	716.7	243.5	467.3
2010	9,275	6,952	5,816	2,240	2,915	699.4	239.5	458.4
2011	9,199	6,899	5,832	2,212	2,911	690.6	238.6	454.5
2012	9,168	6,880	5,877	2,195	2,921	684.9	238.5	452.9
2013	9,149	6,872	5,929	2,182	2,935	680.1	238.7	452.0
2014	9,185	6,904	6,015	2,181	2,966	679.5	240.3	453.8
2015	9,257	6,963	6,126	2,189	3,009	681.4	243.2	457.3
2016	9,346	7,034	6,248	2,201	3,057	684.4	246.2	461.6
2017	9,433	7,105	6,370	2,212	3,105	687.1	249.2	465.7
2018	9,521	7,176	6,493	2,223	3,152	689.2	252.2	469.8
2019	9,607	7,246	6,615	2,234	3,200	691.7	255.2	473.9
2020	9,693	7,316	6,738	2,245	3,247	693.9	258.2	478.0
Energy savings (GWh)								
2000-07	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0.0	0.0	0.0
2009	202	151	121	50	62	15.6	5.1	10.0
2010	483	361	296	117	150	36.7	12.4	23.9
2011	653	489	407	158	204	49.4	16.8	32.3
2012	777	582	488	187	244	58.6	20.1	38.4
2013	886	665	563	213	281	66.5	23.0	43.8
2014	941	707	604	225	300	70.3	24.5	46.5
2015	961	722	624	229	309	71.4	25.1	47.5

2016	963	724	632	229	311	71.2	25.2	47.6
2017	965	726	640	228	314	70.9	25.3	47.6
2018	967	728	648	227	317	70.6	25.5	47.7
2019	969	730	656	227	320	70.3	25.6	47.8
2020	971	732	665	226	322	69.9	25.7	47.9
	Emissions abatement (kt CO_2-e)							
2000-07	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0.0	0.0	0.0
2009	199	165	113	55	55	12.0	5.3	9.8
2010	471	389	277	128	134	28.5	12.4	23.3
2011	629	531	378	174	170	38.5	16.7	31.1
2012	750	643	454	210	202	42.6	20.1	37.0
2013	838	721	507	230	231	48.7	23.4	41.4
2014	905	786	561	246	252	51.6	24.6	44.7
2015	883	757	569	232	261	52.8	26.1	43.6
2016	877	741	569	227	266	52.9	24.8	43.3
2017	852	720	572	225	256	53.0	24.5	42.1
2018	858	724	566	223	255	52.9	24.3	42.4
2019	853	704	567	227	258	52.8	24.7	42.1
2020	841	685	578	216	261	52.7	25.1	41.5
	Change in annualised LCC ($M)							
2000-07	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0.0	0.0	0.0
2009	-29	-19	-13	-8	-7	-1.5	-0.6	-1.0
2010	-68	-45	-33	-18	-17	-3.6	-1.5	-2.5
2011	-92	-61	-45	-25	-24	-4.8	-2.0	-3.4
2012	-109	-73	-54	-29	-28	-5.8	-2.4	-4.0
2013	-125	-84	-62	-33	-33	-6.6	-2.8	-4.6
2014	-133	-89	-67	-35	-35	-7.0	-3.0	-4.9
2015	-135	-91	-69	-36	-36	-7.1	-3.0	-5.0
2016	-136	-91	-70	-36	-36	-7.1	-3.1	-5.0
2017	-136	-91	-71	-35	-36	-7.1	-3.1	-5.0
2018	-136	-91	-72	-35	-37	-7.0	-3.1	-5.0
2019	-136	-91	-73	-35	-37	-7.0	-3.1	-5.0
2020	-135	-91	-73	-35	-37	-6.9	-3.1	-5.0