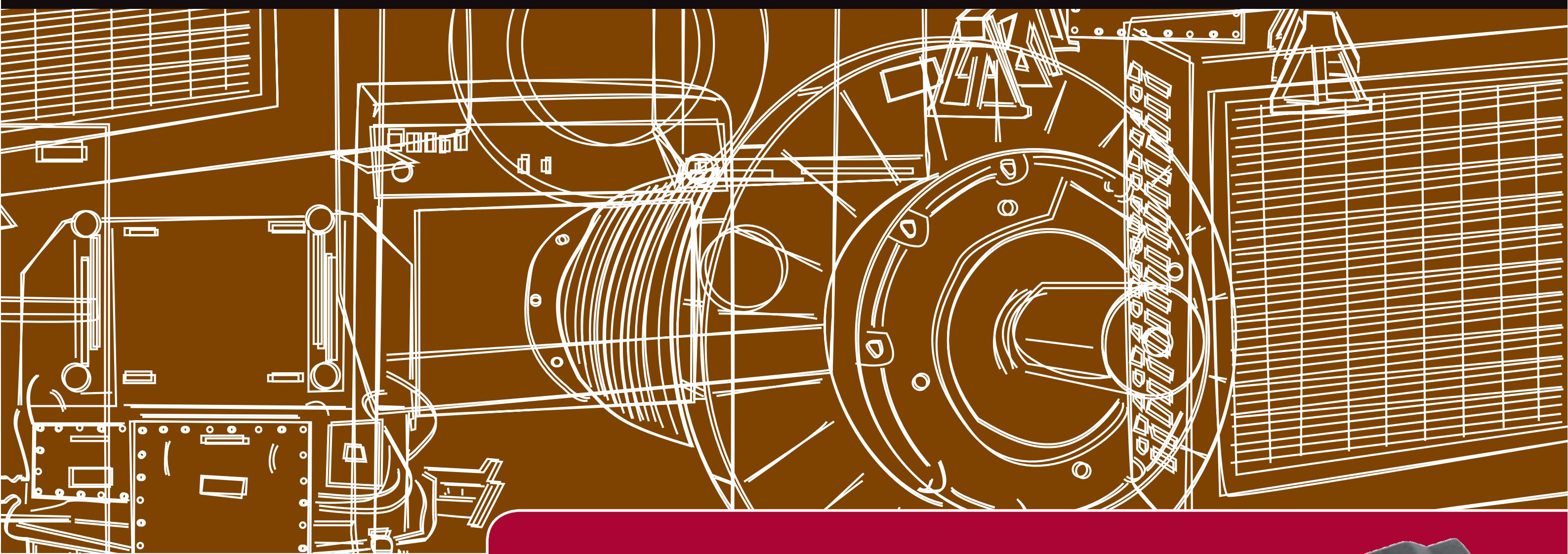
Report No: 2005/13

NATIONAL APPLIANCE AND EQUIPMENT ENERGY EFFICIENCY PROGRAM

Minimum Energy Performance Standards



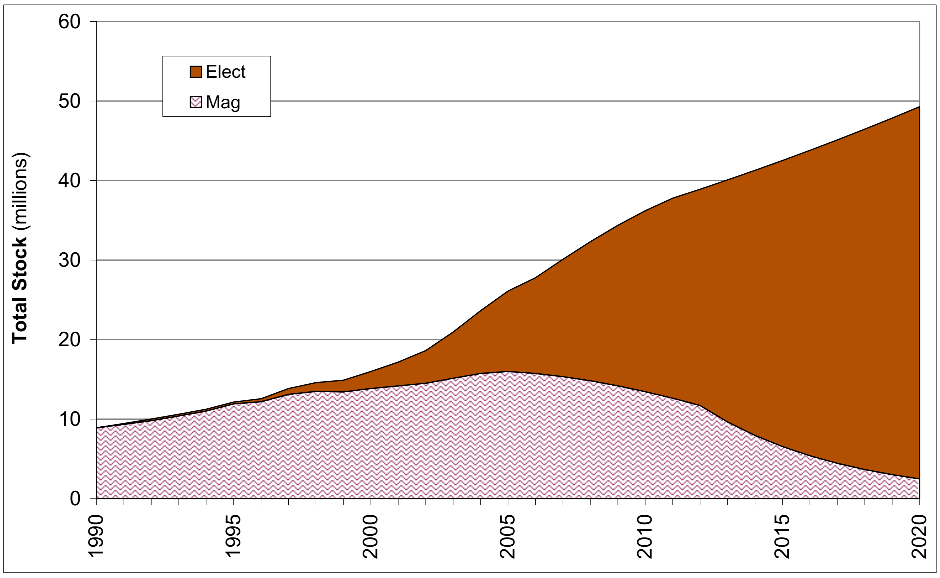
HALOGEN LIGHTING TRANSFORMERS

AN INITIATIVE OF THE MINISTERIAL COUNCIL ON ENERGY FORMING PART OF THE NATIONAL FRAMEWORK FOR ENERGY EFFICIENCY AND NEW ZEALAND ENERGY EFFICIENCY AND CONSERVATION STRATEGY

Power supply units for extra low voltage (ELV) tungsten halogen lighting (hereon referred to as 'halogen transformers') are used to reduce the voltage of mains electricity supply to a lower voltage, typically 12V AC, for operating ELV tungsten halogen lamps.

ELV tungsten halogen lamps operate at high current, with accurate beam projection from an integral reflector or luminaire. They have gained significant market share in recent years, and are now commonly used in homes, offices and shops in very large quantities.

Halogen transformers can be either magnetic or electronic. The estimated historical and forecast business-as-usual (BaU) stocks of halogen transformers are graphed in the figure below, for both magnetic and electronic units.



STAKEHOLDER COMMENT

NAEEEC invites comments from any interested person or organisation on the measures proposed in this study. Comments should be directed to energy.rating@greenhouse.gov.au by 30 June 2005. Information sessions for industry participants can be arranged during the comment period if requested.

Electronic copies of profiles and full reports released for public discussion can be obtained from www.energyrating.gov.au

The total energy losses from halogen transformers in Australia are currently estimated at 500 GWh per annum. Whilst the stock of halogen transformers is expected to continue to grow at a significant rate, the total energy consumed (as losses) is expected to decline slightly before levelling out, due to the rapidly increasing market share of efficient electronic units, which is currently estimated at more than 55% of sales.

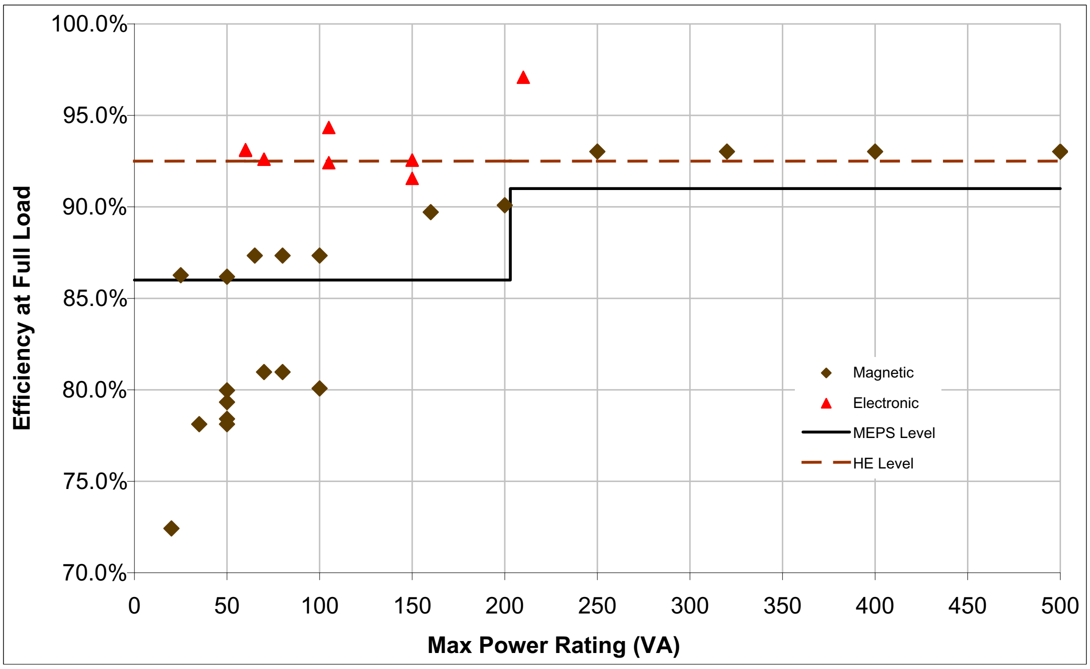
Losses occurring whilst the transformers are at full load represent the majority of losses. For the most popular 50-60VA transformer size, these losses vary between 3W and 16W per transformer. Electronic units of this size generally have losses of around 4W, whilst a typical magnetic transformer has losses of around 14W. Although the price of electronic units has fallen considerably in recent years (these can be cheaper than magnetic transformers), consumers continue to purchase inefficient magnetic units in significant quantities.

Hence there is scope to introduce a MEPS project to accelerate the transition to efficient halogen transformers. This project would not mandate the use of electronic transformers, but would set a minimum energy performance level which must be met by all transformers. It is considered that manufacturing an electronic transformer would be the most cost effective method of meeting the MEPS level, although efficient magnetic units could still be used where specific applications require.

The proposed MEPS levels and high efficiency levels are summarised in the table below.

Rated Transformer Power (VA)	MEPS Level (% efficiency)	High Efficiency Level (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200VA	≥ 91%	≥ 92.5%

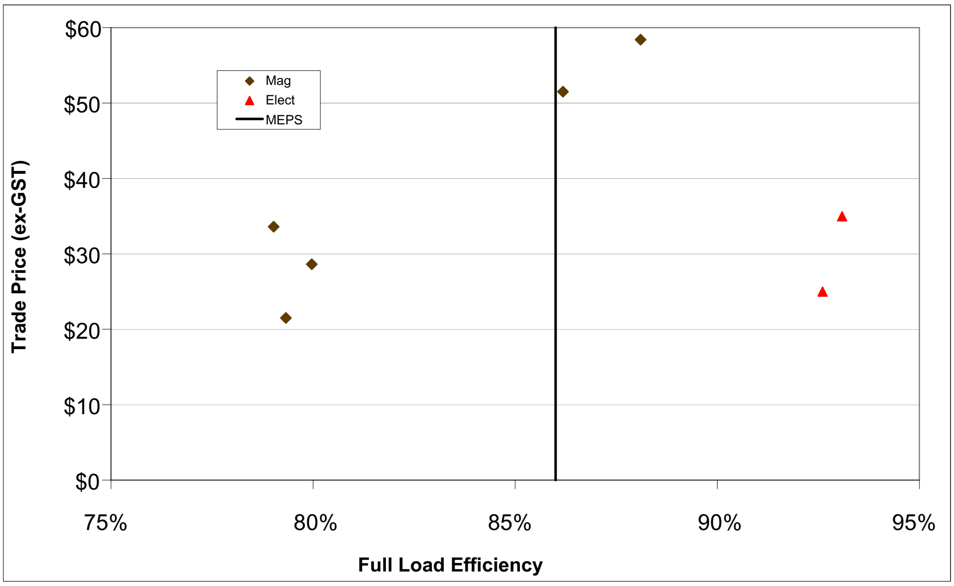
These levels are illustrated in the figure below, along with the efficiencies of a range of common magnetic and electronic transformers.



The MEPS level is lower for transformers with power rating $\leq$ 200 VA. This is in order to allow the most efficient magnetic transformers to continue to be used in applications where electronic units are inappropriate, for example where vibration, temperature or moisture are significant environmental considerations. However in the vast majority of applications, it is expected that electronic transformers would be used, due to their lower cost (which continues to decline). This is illustrated in the figure below which graphs the efficiencies and costs of common 50-65 VA transformers.

From the figure below it can be seen that, given the MEPS level, the electronic transformers are the least expensive units available, but that a reasonably efficient (yet significantly more expensive) magnetic unit could be purchased where required. The size of the niche applications market, for which electronic transformers are unsuitable, is estimated by transformer suppliers at around 1% of total sales.

Whilst there are currently no suitable international test methods for energy efficiency, the draft Australian Standard: *DR 04528 - Performance of External Power Supplies - Part 1: Test Method and Energy Performance Mark*, is suitable for modification for ELV halogen transformers. A Standards Australia working group under EL 041-08 has been established to draft a suitable test standard. China and the United States have expressed interest in using the test method developed in Australia as the basis of projects to promote energy efficiency in their countries. The Australian government will continue to develop these international partnerships, including the harmonisation of performance standards where feasible.



NAEEEC PLAN

The Australian Government will introduce regulations for halogen transformers with key components as follows:

1. Scope: magnetic and electronic transformers designed for use with extra low voltage halogen lighting:
   a. with rated load up to 500VA;
   b. with output up to 50 volts;
   c. including transformers supplied with a mains plug.

2. The draft Australian Standard: *DR 04528 - Performance of External Power Supplies - Part 1: Test Method and Energy* Performance Mark, will be modified to

suit halogen transformers. The modified method will be used as the basis for a new joint Australian & New Zealand Standard for halogen transformers, or as an addition to an appropriate existing standard.

3. The joint Standard will come into force as soon as is practical, preferably during early 2007.

4. MEPS and high efficiency levels are as follows:

Rated Transformer Power (VA)	MEPS Level (% efficiency)	High Efficiency Level (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200VA	≥ 91%	≥ 92.5%

5. The high efficiency level will be used as the preliminary phase 2 MEPS level, likely to commence not earlier than 2010.

6. The Australian Standard may also require the use of an ‘efficiency mark’ on the transformer, to declare its efficiency claim. This may not become mandatory in Australia until it is required by regulatory organisations in either the EU, United States or China.

7. The Australian Government will work with Standards Australia to have the test method developed by Australia adopted as an international standard by the IEC.

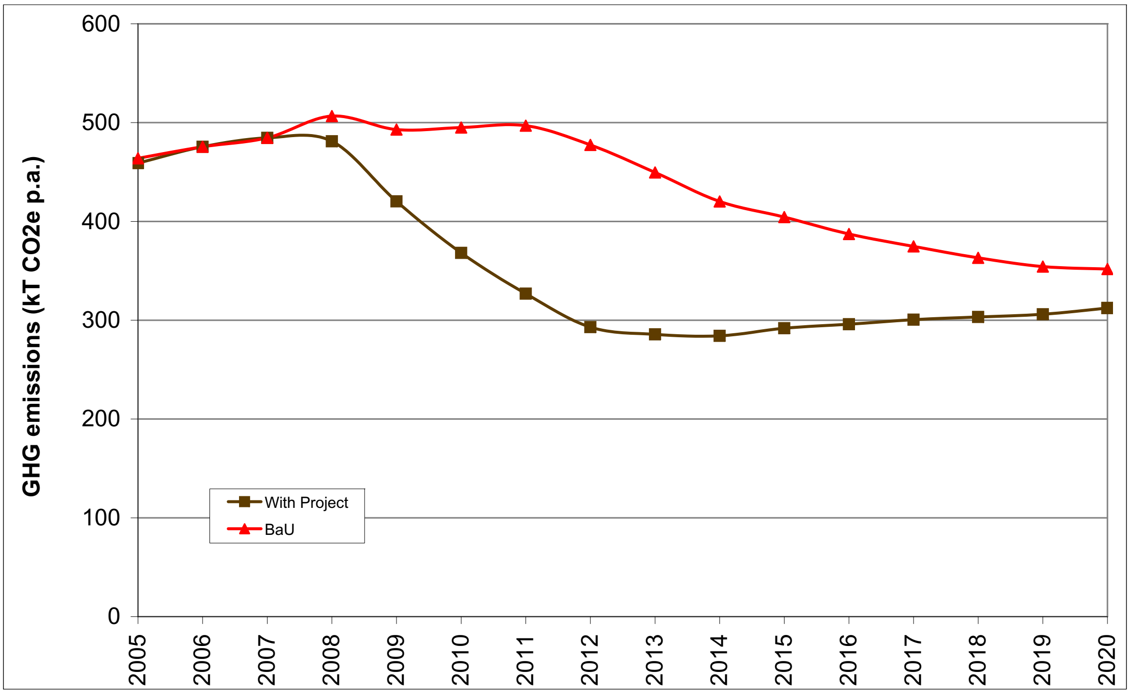
The timetable for the MEPS project is outlined in the table below.

Task	Target Completion Date	Notes
NAEEEC product profile	April 05	To be released at NAEEEC forum.
Industry Consultation	2nd qtr 05	Industry encouraged to provide written feedback.
Right Light 6 conference, Shanghai	May 05	Present Australia’s proposals to international stakeholders and encourage other countries to harmonise.
Draft standards	2nd & 3rd qtr 05	Modify external power supplies test method to suit extra low voltage halogen transformers
Consideration by relevant Standards Australia Committee (EL-041-08)	3rd & 4th qtr 05	Standards Australia committee to consider first draft of Regulatory Standard, and subsequently to consider revisions.
Release of Standard for public comment	4th qtr 05 – 1st qtr 06	
Final Standard published	1st qtr 06	
Regulatory impact statement	2nd qtr 06	A further opportunity for industry and interested parties to comment on the proposals
Ministerial approval	1st qtr 07	
States & Territories introduce legislation to enforce Standard	2nd qtr 07	Each State and Territory calls up the Australian Standard, to ensure national consistency
First review period	2010	Current regulations to be reviewed, and the next round of MEPS and high efficiency levels to be finalised.

IMPACT OF MEPS

The projected greenhouse gas emissions of the business-as-usual (BaU) and with-project scenarios are graphed below.

It is estimated that the mandatory MEPS requirement would result in total greenhouse gas reductions of 1300 kT CO_2e from 2007 to 2020.



NAEEEC MEMBERS

The Commonwealth, New Zealand, and each state and territory are represented on NAEEEC and participate in its deliberations. Representatives are officials within government departments, agencies and statutory authorities or people appointed to represent those bodies. Representatives are usually a senior officer directly responsible for energy efficiency. The membership is currently under review and may expand to include other agencies working in these fields.

The Australian Greenhouse Office (AGO) is part of the Australian Government Department of the Environment and Heritage. The AGO is responsible for monitoring the National Greenhouse Strategy in cooperation with states and territories and with the input of local government, industry and the community. An AGO officer is the chair of NAEEEC and others provide support for its activities.

The NSW Department of Energy, Utilities and Sustainability provides policy advice to the NSW Government and operates a regulatory framework aimed at facilitating environmentally responsible appliance and equipment energy use.

The Office of the Chief Electrical Inspector is the Victorian technical regulator responsible for electrical safety and equipment efficiency. Its mission is to ensure the safety of electricity supply and use throughout the state and its corporate vision is to demonstrate national leadership in electrical safety matters and to improve the superior electrical safety record in Victoria. The office's strategic focus is to ensure a high level of compliance is sustained by industry with equipment efficiency labelling and associated regulations.

The Sustainable Energy Authority was established in 2000 by the Victorian Government to provide a focus for sustainable energy in Victoria. The authority's objective is to accelerate progress towards a sustainable energy future by bringing together the best available knowledge and expertise to stimulate innovation and provide Victorians with greater choice in how they can take action to significantly improve energy sustainability.

The Electrical Safety Office, Department of Industrial Relations, is the Queensland technical regulator responsible for electrical safety and appliance and equipment energy efficiency. The office ensures compliance with electrical safety and efficiency regulations throughout Queensland.

The Environmental Protection Agency, through its Sustainable Industries Division, is Queensland's lead agency in the promotion of energy efficiency, renewable power, and other initiatives that reduce greenhouse gas emissions throughout the state. Its key aim is to achieve increased investment in sustainable energy systems, technology and practice.

Energy Safety WA seeks to promote conditions that enable the Western Australian community's energy needs to be met safely, efficiently and economically.

The Western Australian Sustainable Energy Development Office promotes more efficient energy use and increased use of renewable energy to help reduce greenhouse gas emissions and increase jobs in related industries.

The Office of the Technical Regulator seeks to coordinate development and implementation of policies and regulatory responsibilities for the safe, efficient and responsible provision and use of energy for the benefit of the South Australian community.

The Tasmanian Government's interest is managed by the Department of Infrastructure, Energy and Resources' Office of Energy Planning and Conservation (OEPC). OPEC provides policy advice on energy related matters including energy efficiency.

Electricity Standards and Safety, Department of Infrastructure, Energy and Resources, is the technical regulator responsible for electrical safety throughout Tasmania. Regulatory responsibilities include electrical licensing, appliance approval and equipment energy efficiency.

The ACT Office of Sustainability was established in January 2002 to develop, facilitate and coordinate the implementation of policies and procedures related to sustainability. From the end of 2004, the Office has expanded to take on responsibility for energy and greenhouse policy, including energy efficiency issues. The ACT Planning and Land Authority is the ACT technical regulator responsible for electrical safety and equipment efficiency.

The Department of Employment, Education and Training is responsible for administering regulations in the Northern Territory on various aspects of safety, performance and licensing for goods and services including electrical appliances.

The Energy Efficiency and Conservation Authority (EECA) is the principal body responsible for delivering New Zealand's National Energy Efficiency and Conservation Strategy. EECA's function is to encourage, promote and support energy efficiency, energy conservation and the use of renewable energy sources.

The Ministry for Environment (MfE) is the lead department in New Zealand advising the Minister of Energy on the development of government policy advice on energy efficiency, conservation and the use of renewable sources of energy. It works with EECA and also monitors its performance under the Public Finance Act.

FINAL Report

Analysis of the Potential for Minimum Energy Performance Standards

for

POWER SUPPLY UNITS FOR EXTRA LOW VOLTAGE TUNGSTEN HALOGEN LIGHTING

Prepared for
the Australian Greenhouse Office and NAEEEC
under the
National Appliance & Equipment Energy Efficiency Program
by
Mark Ellis & Associates, Steven Beletich Associates

April 2005

Table of Contents

ABBREVIATIONS

ABS	Australian Bureau of Statistics
AC	Alternating current
BaU	Business as usual
CAP	Collaborative Action Partnership (between Australia and China)
CO_2e	Carbon dioxide equivalent units
DC	Direct current
ELV	Extra low voltage
GWh	Giga watt hours
GLS	General lighting service
Hz	Hertz
HF	high frequency
kHz	Kilohertz
kt	kilotonnes
MWh	Megawatt hours
MEPS	Minimum energy performance standards
Mt	Megatonne
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NAEEEP	National Appliance and Equipment Energy Efficiency Program
NPV	Net present value
V	Volts
VA	Volt-Amps
W	Watts

1 INTRODUCTION

Power supply units for extra low voltage (ELV) tungsten halogen lighting (from hereon referred to as 'halogen transformers') are used to reduce the voltage of mains electricity supply (in Australia 230V AC) to a lower voltage, typically 12V AC, for operating ELV halogen lamps.

ELV halogen lamps have gained significant market share in recent years, due primarily to their colour rendering attributes, aesthetics, lifetime and their declining cost. They operate at extra low voltage and high current, which allows for a short tungsten filament. This in turn provides for very accurate light focusing, by either an integral reflector or separate luminaire. For this reason, ELV halogen lighting has been historically used for spot-lighting objects such as artwork and retail displays.

In recent years however, ELV halogen lamps, in particular those with an integral dichroic reflector, have become very popular for lighting large spaces such as homes, offices and shops. However their narrow beam requires that large numbers of lamps be used to illuminate such open spaces. It is not uncommon to see many dozens of lamps lighting a relatively small area. For example, a modern living room may contain 20 x 50W halogen lamps with 20 individual transformers, each with losses of 14W (and higher in some instances). This results in around 1300W of power (280W of which are transformer losses) to light a room that could alternatively be lit with perhaps 400W of GLS lamps or 100W of appropriate fluorescent lighting.

Efficient 50VA electronic transformers are available with losses of 4W or less, as compared to more than 14W. These units have reduced in price and increased their market share significantly in recent years.

The objective of this report is to examine the potential to apply minimum energy performance standards (MEPS) to halogen transformers, in order to accelerate the transition to low loss units and to eliminate inefficient models.

2 PRODUCT DESCRIPTION

2.1 Technologies

Halogen transformers can be either magnetic or electronic. Magnetic transformers 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 voltage 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 halogen transformers is typically not regulated but may incorporate varying forms of simple overload protection.

Figure 1 – Typical magnetic transformer

An electronic transformer (or more correctly 'electronic step-down converter') typically contains an electronic inverter which converts mains frequency AC (50 or 60 Hz) into high frequency AC (between 10kHz and 100 kHz), which is then passed through a small magnetic transformer to reduce the output voltage to 12V AC at 10-100 kHz. DC units are also available which rectify the high frequency output to DC, in order to reduce radio frequency interference and cable self-inductance over long circuits. Electronic transformers are smaller and lighter than magnetic transformers, and often include output voltage regulation with sophisticated transformer and lamp protection circuitry, soft starting, etc.

Figure 2 – Typical electronic transformer

Halogen transformers are generally supplied with screw terminals, flying leads or in some cases a 230V mains plug. They are typically installed in a ceiling or wall cavity, in close proximity to the lamp in order to limit the required length of high current wiring.

Magnetic transformers are typically compatible with common 'leading edge' dimmers, which remove the leading edge from the AC waveform, thereby reducing the average voltage.

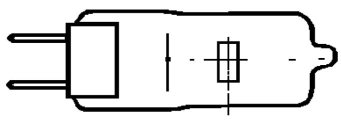
Electronic halogen transformers can be compatible with both leading edge and trailing edge dimmers, with only one dimmer type, or with none. More sophisticated electronic transformers incorporate inbuilt dimming circuits which are controlled by a dedicated dimming switch, rather than a conventional dimmer located electrically upstream from the transformer.

2.2 Applications

Halogen transformers are typically used to provide an extra low voltage power supply to one or more capsule or reflector type halogen lamps.

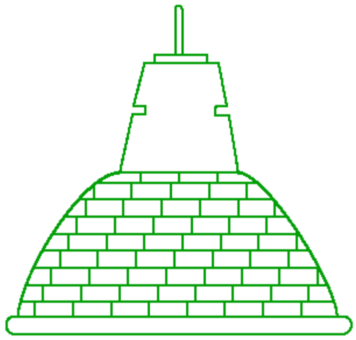
ELV capsule halogen lamps (Figure 3) are generally used in spotlight/downlight luminaires and in desk lamps. Desk lamps are typically powered by an external 'plug-pack' power supply or an internal power supply. External plug-pack power supplies are the subject of a separate MEPS project and thus are not included in the scope of this report.

Figure 3 - ELV capsule halogen lamp



ELV reflector halogen lamps (Figure 4) have an integral reflector and are generally used in spotlight/downlight luminaires. The reflector is typically of the 'dichroic' type which reduces the amount of infra red radiation (heat) projected forward. Dichroic lamps were originally developed for use with slide projectors in order to prevent overheating and subsequent melting of the slide film. Aluminium reflector models are also available which project both light and heat forward.

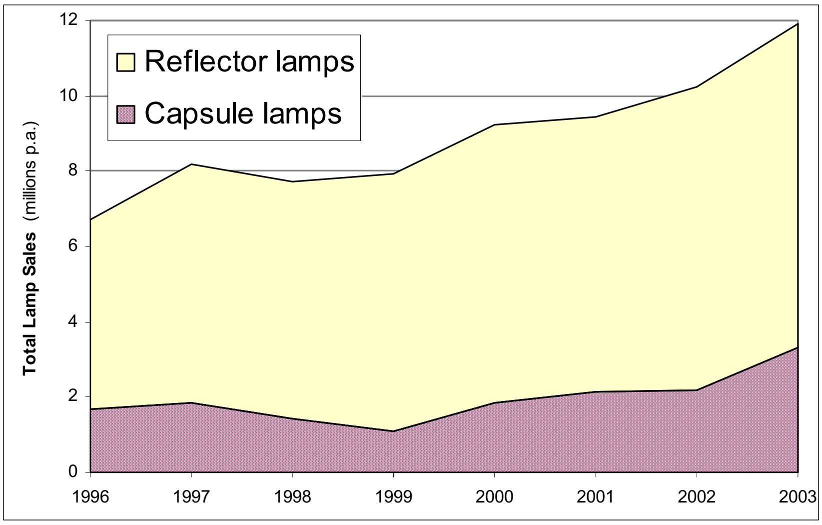
Figure 4 - ELV reflector halogen lamp



2.3 Sales and Stock

Sales of ELV tungsten halogen lamps grew at an average rate of 8.5% p.a. from 1996 to 2003, as illustrated in Figure 5.

Figure 5 – Sales of ELV tungsten halogen lamps (source: ABS import data)



Lamp manufacturers' catalogues indicate that the average operational life of an ELV tungsten halogen lamp is around 4000 hours. Assuming average operating hours of 2000 hours p.a., the average lifespan of a lamp is 2 years. This lifespan and ABS lamp import data were used to construct a stock & sales model for ELV tungsten halogen lamps. The resultant stock of lamps was estimated at 28 million in 2005.

Discussions with transformer manufacturers reveal that more than 95% of transformer sales are of units in the 35 to 105 VA range, and that the majority of halogen transformers are used with a single 50W lamp. For the purpose of this report, it was assumed that the current stock of halogen transformers is around 90% of the lamp stock. Hence the current transformer stock is estimated at 25 million units.

2.4 Market Trends

As discussed in section 2.3, sales of ELV halogen lamps are growing at a significant rate, and therefore sales of halogen transformers will also be growing at a similar rate. These rates of growth are expected to continue for several years as ELV lighting systems continue to increase in popularity in both new and existing buildings.

Manufacturers state that electronic transformers became readily available in the early 1990's and were popular by the mid 1990's. They also report that sales of electronic units currently represent more than 55% of total halogen transformer sales.

The price of these units has dropped dramatically in recent years, and they are expected to continue to take market share from magnetic transformers. Figure 6 illustrates the estimated historical and forecast business-as-usual (BaU) stocks of magnetic and electronic halogen transformers. Note that growth in electronic transformer stocks will lag sales by a number of years, due to the inherent lifespan of halogen transformers.

Figure 6 – Estimated BaU stock of halogen transformers

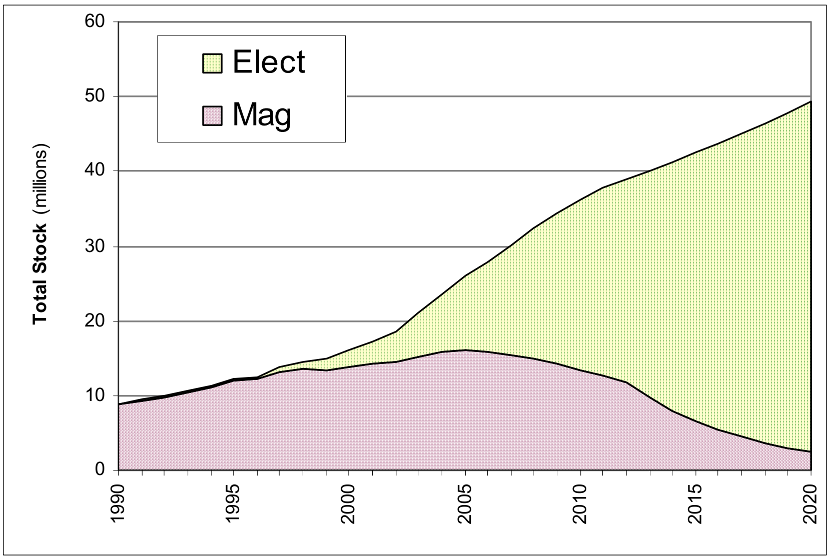


Figure 6 shows overall stocks of halogen transformers currently growing at a rapid rate, with growth expected to slow as the market begins to saturate. Growth of electronic transformer stocks can be seen to have increased since the mid 1990's to around 40% of total stock in 2005, with penetration predicted to increase to 95% by 2020.

3 ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS

3.1 Energy Consumption Issues

3.1.1 Losses

The efficiency of a transformer is a function of its electrical losses, and is defined by the following equation:

Efficiency = useful power out ÷ power in

= load power ÷ (load power + losses)

For magnetic transformers, electrical losses occur in two areas: core losses and winding losses. Core losses (also called no-load losses or iron losses) are caused by magnetic hysteresis and electrical eddy currents set up in the transformer's core, and these remain relatively constant regardless of load and temperature. Winding losses are due to the electrical resistance of the windings, and increase with the square of current. Winding losses are further influenced by temperature and, since winding losses are typically the majority loss component in small transformers, the increase in losses due to temperature caused by self heating is significant. For example an 80°C temperature rise in the winding will increase winding losses by around 30%.

Losses in electronic transformers occur in the electronic circuitry and in the high frequency transformer, and vary depending on the configuration of the circuitry and on the transformer load.

3.1.2 Operating Modes

Off Mode

Halogen transformers in typical lighting installations are switched upstream from the transformer (i.e. on the mains voltage side of the transformer), usually by a 'hard' on/off light switch. Thus when switched off, the transformer is totally de-energised and does not have any losses. Off mode is thus not relevant to this report.

No Load Mode

In a typical installation, no load mode occurs only when all lamps connected to a transformer have failed or have been physically removed. The transformer remains energised but there is effectively no load connected to its secondary terminals. No load losses of magnetic halogen transformers, from testing conducted for this study, are graphed in Figure 7. Note that the electronic transformers tested specified a minimum load for correct operation, and hence no load testing was not conducted (although complete loss of load should not present a problem for any transformer).

Figure 7 – No load losses for magnetic transformers (source: lab testing based on EPRI 2004)

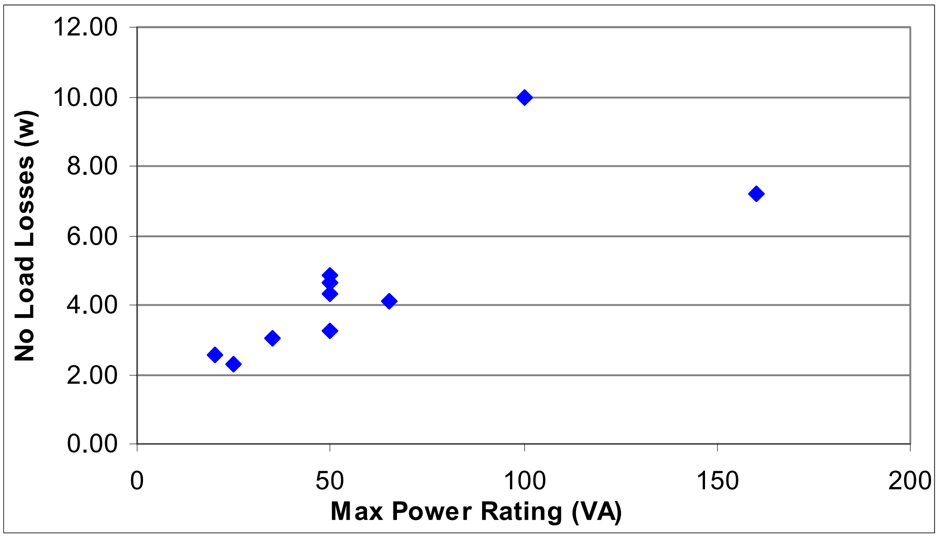


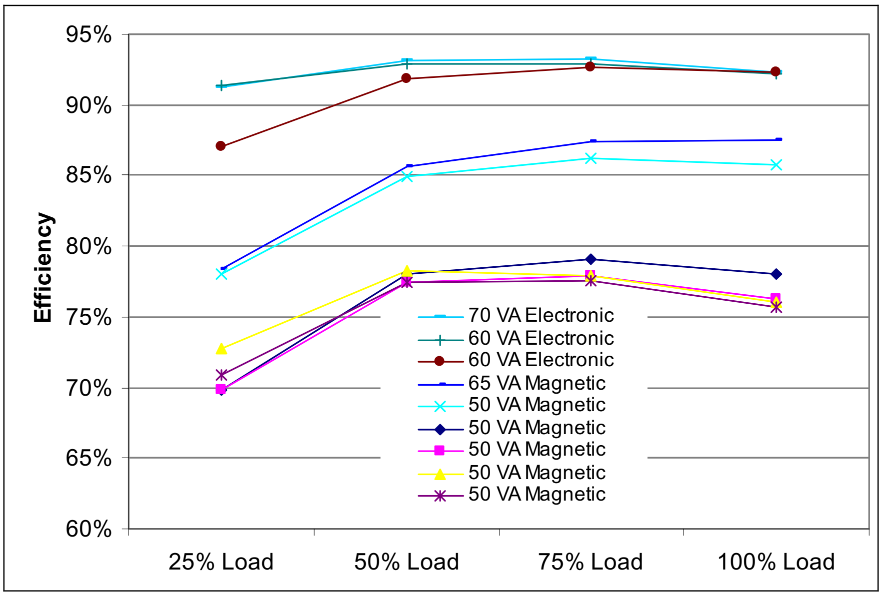
Figure 7 demonstrates that no load losses of magnetic transformers are generally proportional to their full power rating.

Part Load Mode

Part load mode can occur if a transformer is connected to lamp(s) whose load represents less than the transformer's full load rating. Unregulated magnetic transformers are not designed to operate at part load, and if this occurs the output voltage increases significantly, which can damage or reduce the life of the remaining connected lamp(s). However ferro-resonant magnetic transformers are available which can effectively regulate the output voltage.

Part load and full load efficiency test results for halogen transformers are graphed in Figure 8.

Figure 8 – Efficiencies for 50-70VA halogen transformers (source: lab testing in 2004)



From Figure 8 it is evident that the electronic transformers tested are more efficient than magnetic units at all tested load levels. There is also a reduction in efficiency at low loads (~25% of full load) for all transformers tested.

Dimmed Mode

Dimmed mode can occur when a transformer's average input voltage is reduced by an upstream dimmer (either leading edge or trailing edge type). More sophisticated electronic transformers incorporate inbuilt dimming circuits which use the transformer circuitry to regulate the output voltage, and are controlled by a separate input from a dedicated dimming switch. Dimmed mode is inherently different from part load mode.

Full Load Mode

Full load mode occurs when the transformer is switched on, undimmed and the recommended maximum load is connected. In this mode the transformer will lose power according to its full load loss rating. Figure 9 illustrates the typical full load losses of common halogen transformers.

Figure 9 – Full load losses (source: manufacturer catalogues and lab testing in 2004)

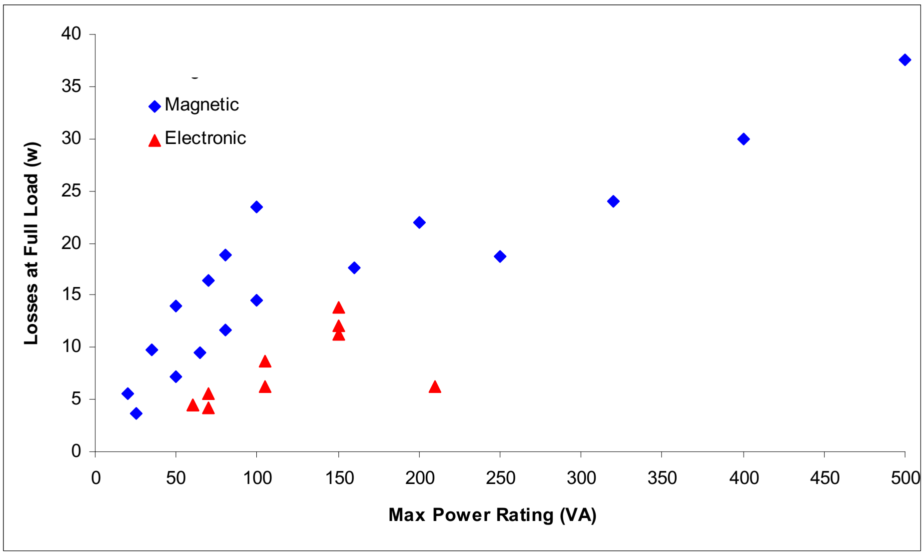


Figure 9 shows that, for common transformers below 250 VA capacity, electronic units have significantly lower full load losses.

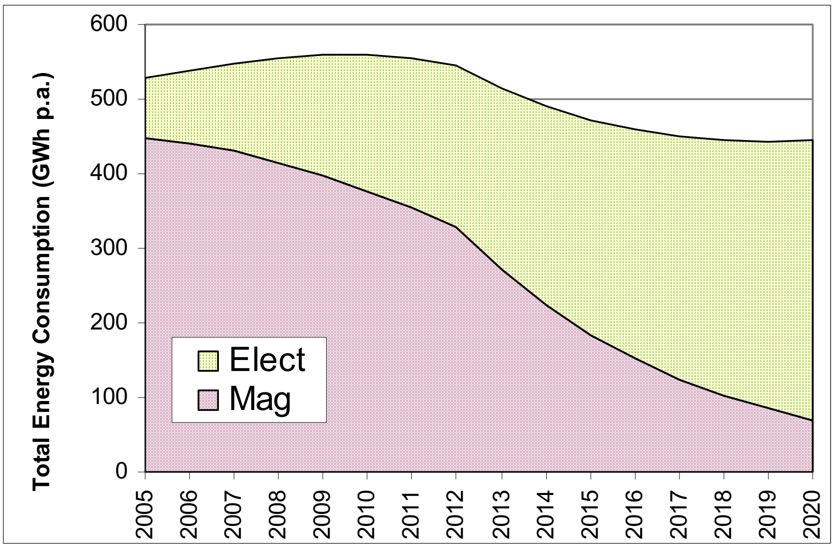
3.2 Estimated Energy Consumption and Greenhouse Gas Emissions

Full load mode is by far the most common mode for halogen transformers, and hence in this report the energy consumption (losses) of halogen transformers is estimated based on full load mode.

Discussions with manufacturers reveal that the majority of transformers sold are 50-65 VA units for use with a single 50W halogen lamp. Given this, and the fact that full load losses are essentially proportional to the transformer's power rating (see Figure 9), the 50-65 VA halogen transformer is used as the basis for modelling the total energy consumption of halogen transformers in Australia.

Transformer manufacturers state that more than 55% of halogen transformers currently sold are electronic units, with full load losses of around 4W for 50-65 VA units. The vast majority of the remainder are magnetic transformers with full load losses of around 14W for a 50VA unit. Estimates based on this information and stock projections for magnetic and electronic halogen transformers (see section 2.4), reveal BaU energy and greenhouse gas emissions from these units as illustrated in Figure 10 and Figure 11. Note that these estimates do not take into account any additional energy consumption by air conditioned buildings fitted with halogen transformers.

Figure 10 – Forecast BaU energy consumption of halogen transformers (full load losses)



In Figure 10, the total BaU energy consumption of halogen transformers can be seen to decrease and then level out, due to the transition to majority electronic transformers.

Figure 11 – Forecast BaU greenhouse gas emissions of halogen transformers (full load losses)

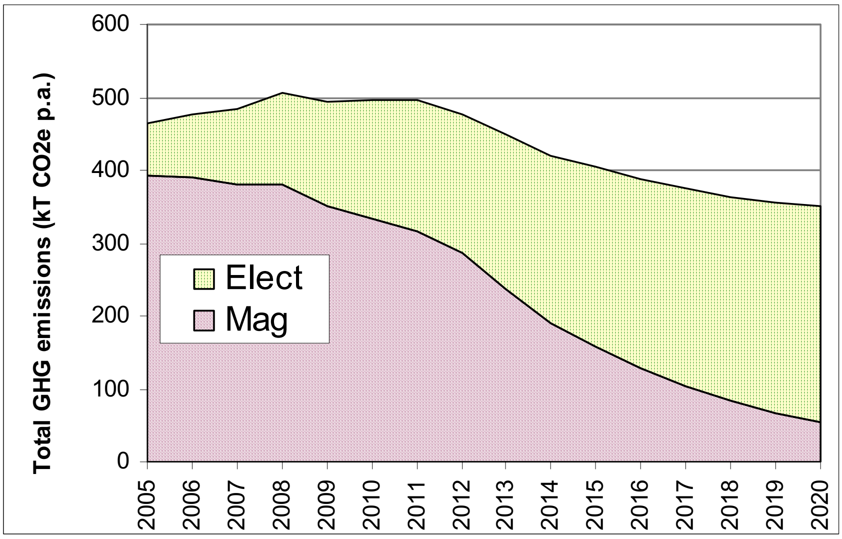


Figure 11 shows that total greenhouse gas emissions decline and then level out somewhat, due to the transition to majority electronic transformers as well as a predicted decrease in the greenhouse gas intensity of marginal electricity supplies.

3.3 Improving the Performance of Halogen Transformers

The design efficiency of magnetic halogen transformers can generally be improved by employing the following methods:

- Reducing eddy currents using high quality core materials such as high grade electrical steel, thin core laminations and high quality insulation between laminations.
- Use of low resistance windings, larger diameter wire and fewer turns.

Given the current market share of electronic transformers and their declining cost, switching to electronic transformers is considered to be the most cost effective means of improving transformer efficiency. However magnetic transformers may still continue to be used in niche applications, for example where transformer durability is paramount.

4 POLICIES FOR HALOGEN TRANSFORMERS

4.1 Related Australian and Overseas Projects

There are no known mandatory or voluntary projects relating to halogen transformers in Australia or overseas, although their increasing popularity has raised the attention of regulators in other countries. Australian officials have conducted preliminary discussions with overseas regulators regarding collaboration in a regulatory scheme for halogen transformers.

Several countries including Australia are considering or developing MEPS for external power supplies. These power supplies (as used for small electronic equipment and mobile phone chargers, etc.) have also recently been included in the voluntary US Energy Star project.

Australia and many other countries have also introduced MEPS for linear fluorescent lamp ballasts and large distribution power transformers.

4.2 Test Methods for Halogen Transformers

There are no known Australian or international standards specifically for testing the energy efficiency of halogen transformers (due perhaps to the global lack of mandatory efficiency requirements). However a list of Australian standards of relevance to halogen transformers is included in Appendix A.

The transformer testing conducted for this study was carried out according to a modified version of an EPRI test method (EPRI 2004). This method was modified primarily to suit the high frequency output of electronic transformers.

Two draft Australian standards have been developed for external power supplies, which are also based on the EPRI method:

> DR 04528 - Performance of External Power Supplies - Part 1: Test method and energy performance mark.

> DR 04529 - Performance of External Power Supply Units - Part 2: Energy performance requirements.

It is considered that DR 04528 could be modified to suit the characteristics of halogen transformers, and published either separately or as an additional part to an existing standard. In particular the test method must take into account the fact that most electronic halogen transformers have a high frequency AC output. The power of high frequency waveforms can be difficult to measure accurately, and unwanted stray inductances can be created in the test loads.

5 MINIMUM ENERGY PERFORMANCE STANDARDS

5.1 Objectives of MEPS

Given the wide range of losses evident for halogen transformers (between 3 and 16 watts for a 50-60 VA unit), and the increasing market share of efficient electronic transformers (currently estimated at more than 55%), it is considered feasible to implement a MEPS project for halogen transformers. The objectives of such a project would be to:

> Accelerate the transition to low loss halogen transformers.

> Ensure that 'dumping' of inefficient units onto the Australian market does not occur.

> Correct for market imperfections that currently prevent efficient purchase decisions by a number of residential and commercial consumers and specifiers of halogen transformers.

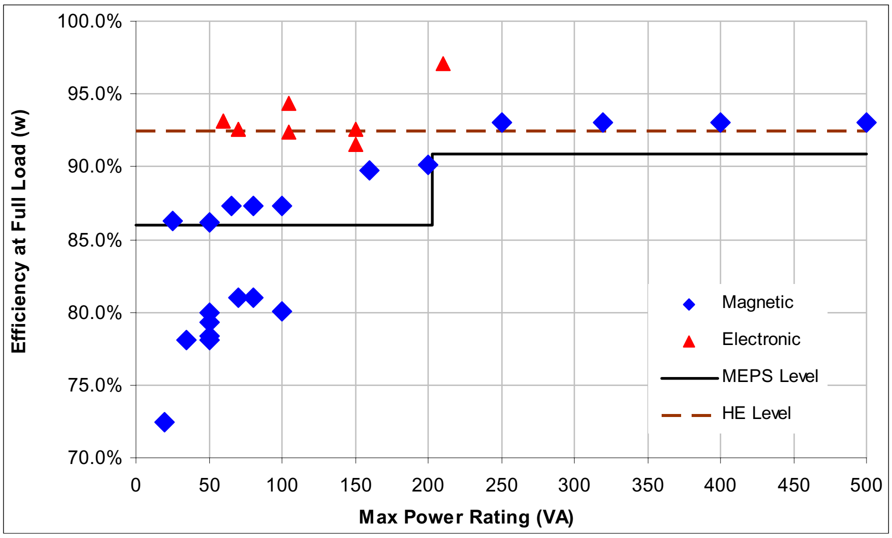
The project would not aim to simply eliminate the use of magnetic transformers. Rather it would seek to ensure that all transformers sold are efficient. Whilst electronic transformers would be the most cost effective means of meeting efficiency requirements, it is possible that magnetic transformers would still be required for niche applications, for example in adverse operating environments. The MEPS project would seek to ensure that these units are also efficient.

Additionally, the project would not seek to encourage the use of cheap, poor quality electronic transformers, with inferior longevity and durability. However, given that acceptable quality electronic transformers are already in widespread use, it is not considered likely that MEPS will skew the market towards use of inferior electronic products.

5.2 Details of MEPS

It is proposed that MEPS would be based on setting a minimum full load efficiency for halogen transformers, as full load losses represent the great majority of energy consumption and therefore greenhouse gas emissions. The proposed MEPS levels and their effect on common halogen transformers are illustrated in Figure 12.

Figure 12 – Proposed MEPS and high efficiency levels



Also graphed in Figure 12 is a proposed high efficiency (HE) level. Models which have losses at or below this level would potentially be eligible to carry a 'high efficiency' marking or be registered on a database of high efficiency products.

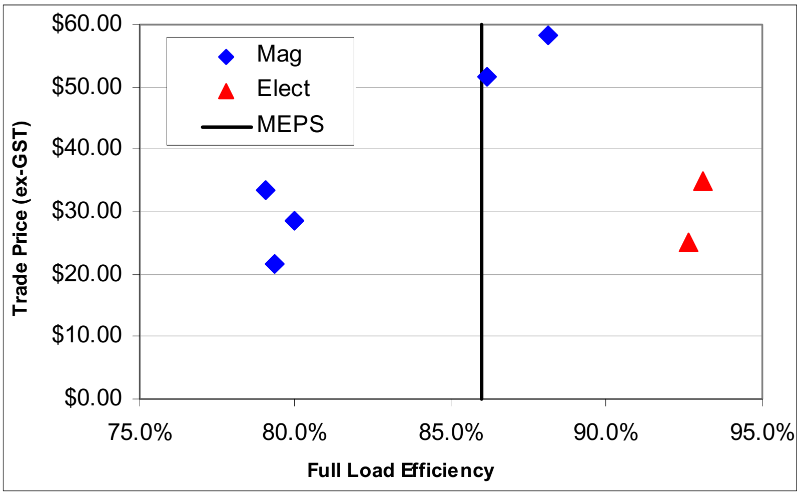
The MEPS levels and high efficiency levels are summarised in Table 1.

Table 1 - MEPS and high efficiency levels (at full load)

Rated Transformer Power (VA)	**MEPS Level** (% efficiency)	**High Efficiency Level** (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200VA	≥ 91%	≥ 92.5%

The MEPS level is lower for transformers with power rating ≤ 200 VA. This is in order to allow the most efficient magnetic transformers to continue to be used in applications where electronic units are inappropriate, for example where vibration, temperature or moisture are significant environmental considerations. However in the vast majority of applications, it is expected that electronic transformers would be used, due to their lower cost (which continues to decline). This is illustrated in Figure 13 which graphs the efficiencies and costs of common 50-65 VA transformers.

Figure 13 - Efficiency versus cost for 60-65VA transformers



From Figure 13 it can be seen that, given the MEPS level, the electronic transformers are the least expensive units available, but that a reasonably efficient (yet significantly more expensive) magnetic unit could be purchased where required.

The size of the niche applications market, for which electronic transformers are unsuitable, is estimated by transformer suppliers at around 1% of sales. Hence allowing the most efficient available magnetic units to be used for these applications will have a negligible affect on greenhouse gas abatement.

The MEPS project could ultimately take into account part load and no load efficiency, as well as efficiency in dimmed mode.

6 Greenhouse and Economic Implications

6.1 Greenhouse Gas Abatement

Commencing the MEPS project described in section 5 in 2007 would result in estimated energy consumption and greenhouse gas emissions as illustrated in Figure 14 and Figure 15 respectively. This can be compared to the forecast BaU energy and emissions graphed in section 3.2. Note that both these estimates do not take into account any additional consumption by air conditioned buildings fitted with halogen transformers.

Figure 14 – Forecast 'with project' energy consumption, by transformer type

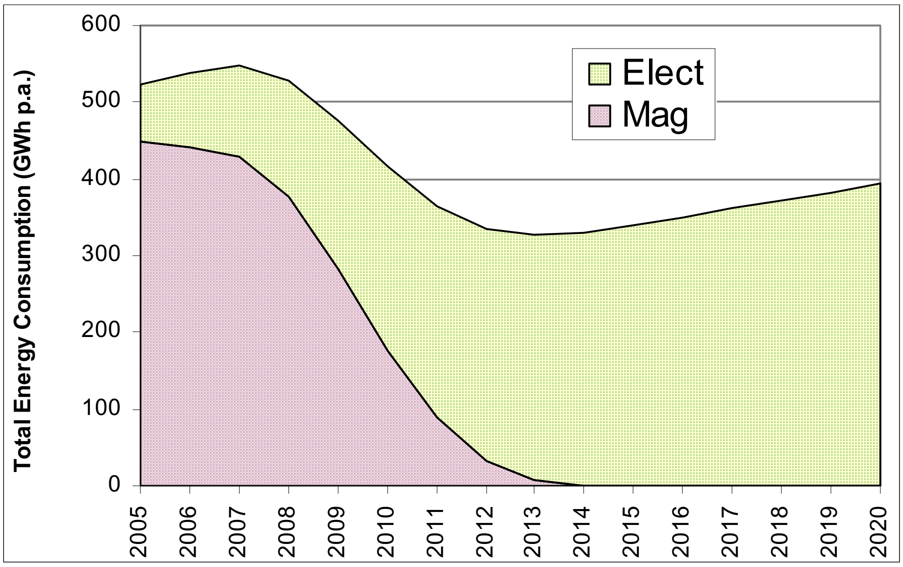
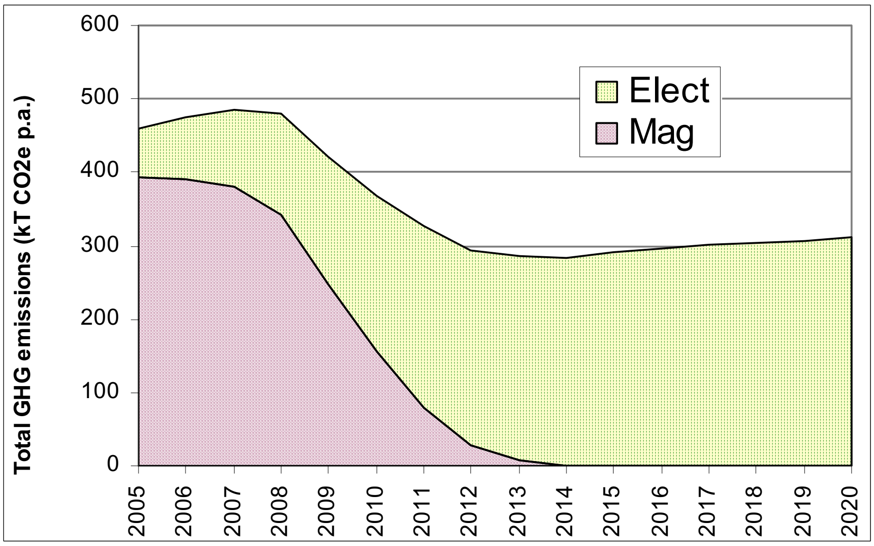


Figure 15 – Forecast 'with project' greenhouse gas emissions, by transformer type



The difference in total greenhouse gas emissions between BaU and MEPS is illustrated in Figure 16.

Figure 16 – Forecast total BaU and MEPS greenhouse gas emissions

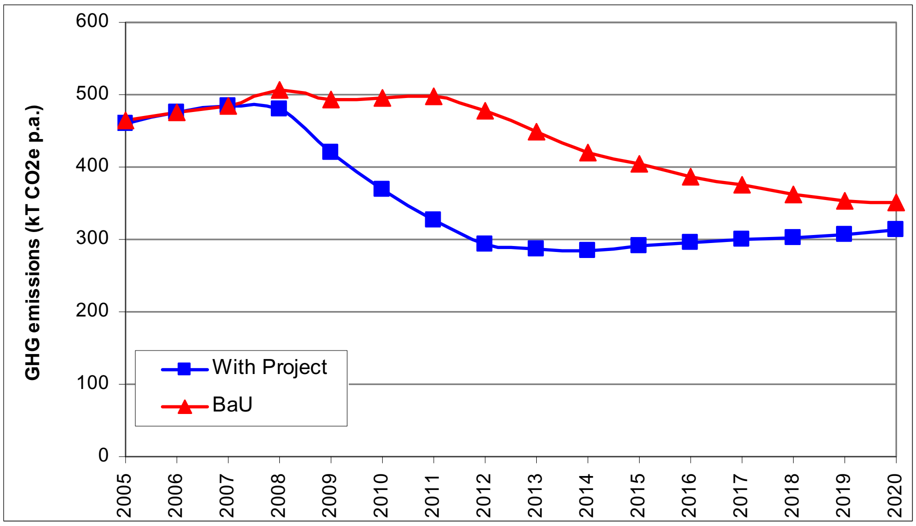


Figure 16 shows the BaU greenhouse gas emissions reducing slowly over time, as the penetration of electronic transformers increases. The 'with project' emissions can be seen to decrease rapidly as inefficient transformers are eliminated, and then to level out once efficient units have saturated the market. The proposed MEPS project is expected to result in cumulative greenhouse gas abatement of 1300 kT CO_2e from 2007 to 2020.

6.2 Cost Benefit Analysis

A 20 year cost-benefit analysis was carried out, analysing the purchase of a single electronic rather than a magnetic transformer. Note that this is not a market-wide cost benefit analysis for the entire proposed MEPS project, which will be undertaken in a separate RIS report.

Wholesale trade prices for halogen transformers were sourced from manufacturers' trade prices lists. Retail prices were sourced from visits to two large retail hardware outlets. Trade prices and retail prices for a range of common halogen transformers are graphed in Figure 17 and Figure 18 respectively.

Figure 17 – Listed trade prices of halogen transformers (ex-GST)

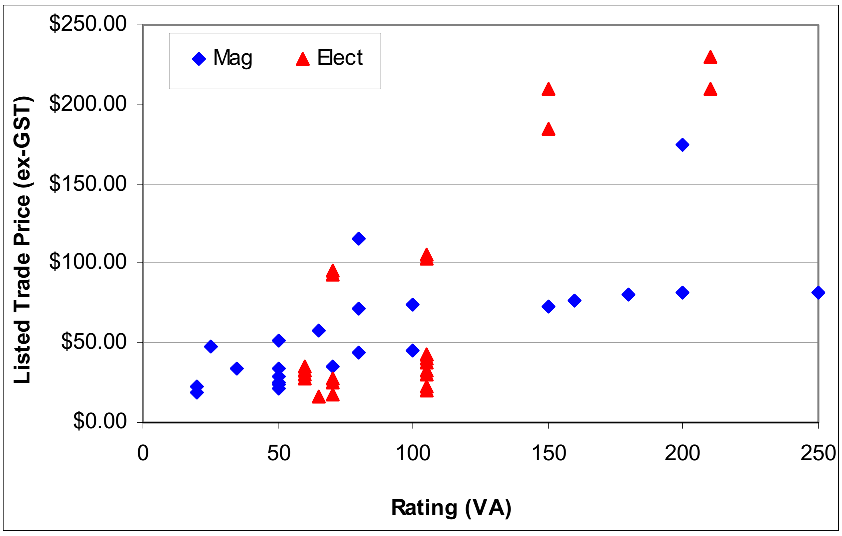
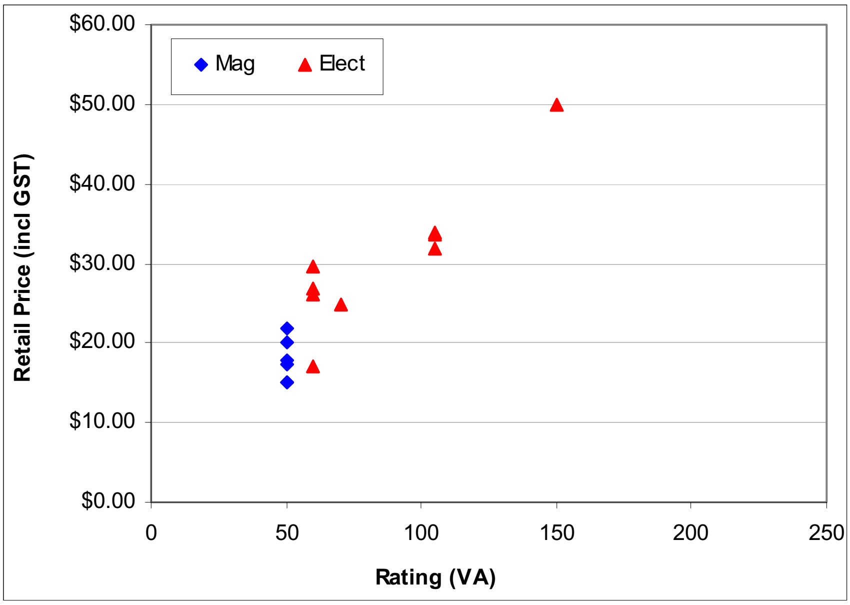


Figure 18 – Listed retail prices of halogen transformers (incl GST)



From the above figures it can be seen that both trade and retail prices are generally proportional to the transformer power rating.

Unweighted average trade and retail prices for halogen transformers are listed in Table 2, for common models in the 50-105VA range.

Table 2 – Halogen transformer pricing (unweighted averages)

Rating	Type	**Av Trade Price** (ex GST)	**Av Retail Price** (incl GST)
50-70 VA	Magnetic	$27	$18
	Electronic	$27	$25
105 VA	Magnetic	$45*	none found
	Electronic	$34	$33

Average retail prices were listed as lower than trade prices for all categories, which may reflect the buying power of the large retail outlets, as well as the discrepancy between listed trade prices and the actual prices paid by large purchasers. Transformer suppliers also state that electronic transformer trade prices continue to drop dramatically, and that retail prices for electronic units may be lagging recent reductions in trade prices due to old shelf stock. To be conservative, the retail prices are used as a basis for this simple cost-benefit analysis.

The cost-benefit analysis was based on purchase of an electronic rather than a magnetic transformer for use with a 50W halogen lamp. It was assumed that magnetic and electronic transformers have an operational life of 50,000 and 25,000 hours respectively, which results in the need to replace the units after these operating periods. The results of the cost benefit analysis are presented in Table 3 for both residential and business customers.

Table 3 – Cost benefit analysis

	Residential	Business	Notes
Run hours p.a.	1,000	3,000	
Life of magnetic transformer (yrs)	20+	16.7	
Life of electronic transformer (yrs)	20+	8.3	

	Residential	Business	Notes
Power saving per transformer (w)	10	10	
kWh saving p.a.	10	30	
Marginal cost of electricity ($/kWh)	$0.1277	$0.1356	From GWA 2001
$ saving p.a.	$1.28	$4.07	
Additional capital outlay for electronic transformer	$7.00	$7.00	For business users, the electronic transformer is replaced in year 9 and year 17, and the magnetic transformer would have been replaced in year 17.
Labour outlay to replace electronic transformer after failure	N/A	$10.00	
NPV at 5% real discount rate	**$8.92**	**$18.08**	
NPV at 10% real discount rate	**$3.87**	**$11.40**	

From this analysis, it is evident that significant financial benefits result from investing in an efficient electronic halogen transformer, with a positive net present value (NPV) for all scenarios tested. If the proposed MEPS projects were to proceed, a more detailed cost benefit analysis, together with sensitivity analyses, would be undertaken as part of the regulatory impact assessment process. The regulatory impact statement (RIS) would also examine the impact of MEPS on the existing Australian manufacture of halogen transformers.

7 CONCLUSIONS

The energy losses of halogen transformers in Australia currently represent an estimated 500 GWh per annum. Whilst the stock of halogen transformers is expected to grow at a significant rate, the energy consumed is expected to decrease slightly before levelling out, due to the rapidly increasing market share of efficient electronic units, which is currently estimated at more than 55% of sales.

Losses occurring whilst the transformers are at full load represent the majority of halogen transformer losses. For the most popular 50-60VA transformer size, these losses vary between 3W and 16W per transformer. Electronic units of this size generally have losses of around 4W, whilst the typical magnetic transformer has losses of around 14W. Consumers continue to purchase inefficient magnetic units in significant quantities, either ignoring or not understanding the life cycle cost savings available.

Hence there is scope to introduce a MEPS project to accelerate the transition to efficient units. This project would not mandate the use of electronic transformers, but would set a minimum energy performance level which must be met by all transformers. It is considered however that manufacturing an electronic transformer would be the most cost effective method of meeting the MEPS level, although efficient magnetic units could still be used where applications require it.

The MEPS levels and high efficiency levels are summarised in Table 4.

Table 4 - MEPS and high efficiency levels (at full load)

Rated Transformer Power (VA)	MEPS Level (% efficiency)	High Efficiency Level (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200VA	≥ 91%	≥ 92.5%

The mandatory MEPS requirement would result in estimated cumulative abatement of 1300 kT CO_2e from 2007 to 2020.

Whilst there are currently no suitable international test methods for energy efficiency, the draft Australian Standard: *DR 04528 - Performance of External Power Supplies - Part 1: Test Method and Energy Performance Mark*, is suitable for modification for ELV halogen transformers. A Standards Australia working group under EL 041-08 has been established to draft a suitable test standard. China and the United States have expressed interest in using the test method developed in Australia as the basis of projects to promote energy efficiency in their countries. The Australian government will continue to develop these international partnerships, including the harmonisation of performance standards where feasible.

8 RECOMMENDATIONS

The Australian Government will introduce regulations for halogen transformers with key components as follows:

1. Scope: magnetic and electronic transformers designed for use with extra low voltage halogen lighting:
    a. with rated load up to 500VA;
    b. with output up to 50 volts;
    c. including transformers supplied with a mains plug.
2. The draft Australian Standard: *DR 04528 - Performance of External Power Supplies - Part 1: Test Method and Energy Performance Mark*, will be modified to suit halogen transformers. The modified method will be used as the basis for a new joint Australian & New Zealand Standard for halogen transformers, or as an addition to an appropriate existing standard.
3. The joint Standard will come into force as soon as is practical, preferably during early 2007.
4. MEPS and high efficiency levels are as follows:

Rated Transformer Power (VA)	**MEPS Level** (% efficiency)	**High Efficiency Level** (% efficiency)
≤ 200 VA	≥ 86%	≥ 92.5%
> 200VA	≥ 91%	≥ 92.5%

5. The high efficiency level will be used as the preliminary phase 2 MEPS level, likely to commence not earlier than 2010.
6. The Australian Standard may also require the use of an 'efficiency mark' on the transformer, to declare its efficiency claim. This may not become mandatory in Australia until it is required by regulatory organisations in either the EU, United States or China.
7. The Australian Government will work with Standards Australia to have the test method developed by Australia adopted as an international standard by the IEC.

The timetable for the MEPS project is outlined in Table 5.

Table 5 – Timetable for MEPS project

Task	**Target Completion Date**	**Notes**
NAEEEC product profile	April 05	To be released at NAEEEC forum.
Industry Consultation	2nd qtr 05	Industry encouraged to provide written feedback.

Task	Target Completion Date	Notes
Right Light 6 conference, Shanghai	May 05	Present Australia's proposals to international stakeholders and encourage other countries to harmonise.
Draft standards	2nd & 3rd qtr 05	Modify external power supplies test method to suit extra low voltage halogen transformers
Consideration by relevant Standards Australia Committee (EL-041-08)	3rd & 4th qtr 05	Standards Australia committee to consider first draft of Regulatory Standard, and subsequently to consider revisions.
Release of Standard for public comment	4th qtr 05 – 1st qtr 06	
Final Standard published	1st qtr 06	
Regulatory impact statement	2nd qtr 06	A further opportunity for industry and interested parties to comment on the proposals
Ministerial approval	1st qtr 07	
States & Territories introduce legislation to enforce Standard	2nd qtr 07	Each State and Territory calls up the Australian Standard, to ensure national consistency
First review period	2010	Current regulations to be reviewed, and the next round of MEPS and high efficiency levels to be finalised.

REFERENCES

EPRI 2004 *Test Method for Calculating the Energy Efficiency of Single-Voltage External AC-DC Power Supplies*, EPRI PEAC Corporation, 13 February 2004.

GWA 2003 *Draft Revised Regulatory Impact Statement: Revised Minimum Energy Performance Standards and Alternative Strategies for Small Electric Storage Water Heaters*, prepared for the Australian Greenhouse Office, George Wilkenfeld and Associates, August 2003

APPENDIX A - AUSTRALIAN STANDARDS

> External power supply performance standards (draft):
  - DR 04528 - Performance of External Power Supplies - Part 1: Test method and energy performance mark
  - DR 04529 - Performance of External Power Supply Units - Part 2: Energy performance requirements.

> Halogen transformer safety standards:
  - AS 61558.1:2000 Safety of power transformers, power supply units and similar – General requirements and tests.
  - AS 61558.2.17:2001 Safety of power transformers, power supply units and similar – Particular requirements for transformers for switch mode power supplies (IEC 61558-2-17:1997, MOD).
  - AS 61558.2.9:2003 Safety of power transformers, power supply units and similar devices - Particular requirements for transformers for class III hand lamps for tungsten filament lamps.

> Electronic transformer standards:
  - AS 61046:2001 Auxiliaries for lamps - DC or AC Supplied Electronic Step-Down Convertors for Filament Lamps - General and Safety requirements.
  - AS 61047:2001 Auxiliaries for Lamps - DC or AC Supplied Electronic Step-Down Convertors for Filament Lamps - Performance Requirements.
  - AS 61347.2.2:2004 Lamp control gear - Particular Requirements for DC or AC Supplied Electronic Step-Down Convertors for Filament Lamps (IEC 61347-2-2:2000 MOD).