National Appliance and Equipment Energy Efficiency Program

COMBINED IMPACTS

Prepared for the

Australian Greenhouse Office

by

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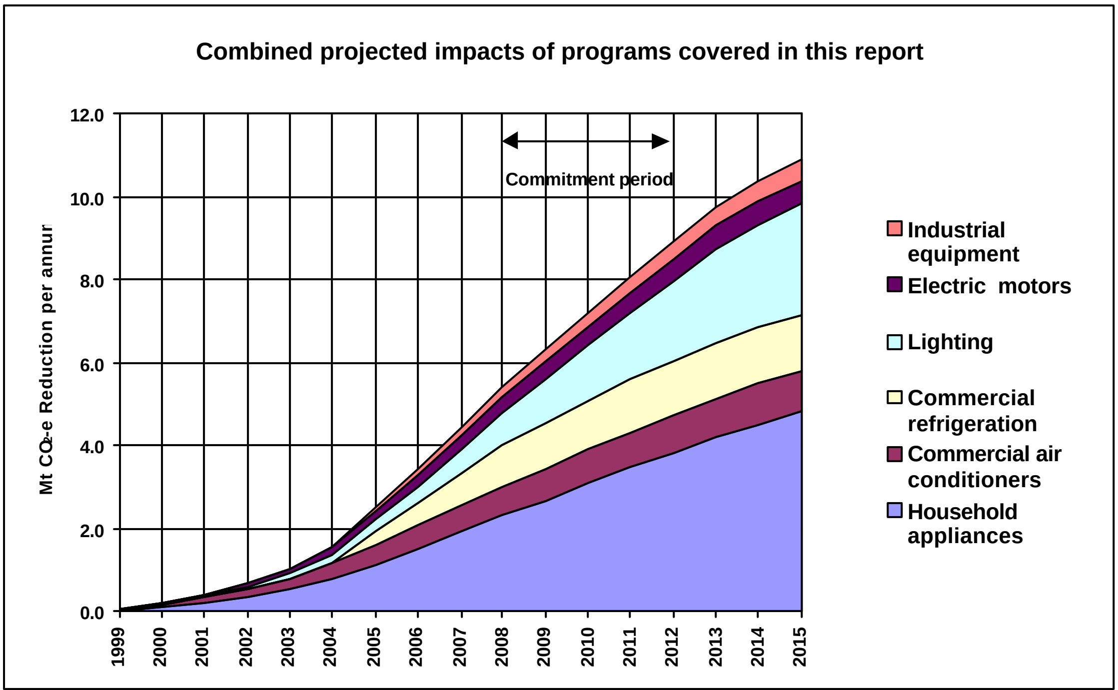
Executive Summary

This study presents an overview of the likely impacts of the National Appliance and Equipment Energy Efficiency Program (NAEEEP) on national greenhouse gas emissions in the period 2000 to 2015.

The NAEEEP comprises both mandatory and voluntary energy efficiency programs. This study covers only those programs which are generally implemented on a mandatory basis: energy labelling and minimum energy performance standards (MEPS). It reviews the likely impacts of labelling and MEPS for a wide range of household, commercial and industrial appliances and equipment. Some of these measures have been implemented, some are at advanced stages of development with target implementation dates, and some are still being developed.

The combined projected greenhouse gas impacts of all programs covered in this study is illustrated in the following diagram. It is estimated that the NAEEEP will reduce greenhouse gas emissions by a total of 81 million tonnes carbon dioxide equivalent (Mt CO_2-e) over the period 2000-2015. Household appliances are projected to contribute nearly 44% of the savings, lighting over 19%, commercial refrigeration over 14%, air conditioners 11%, and motors nearly 7%.

The average impact during the Kyoto Protocol Commitment period 2008 to 2012 is estimated to be about 7.2 Mt CO_2-e per annum reduction below business-as-usual. By 2015 the impact is projected to reach 10.9 Mt CO_2-e per annum.



The costs of these emissions reductions are calculated to be negative – ie the value to energy users of the electricity they will save is likely to significantly exceed any additional costs from purchasing more efficient products. For the programs that have been modelled in detail, the cost of emissions reductions is estimated at about - A$ 31 per tonne CO_2-e (net present value at 10% discount rate). This can be compared with the projected costs of two programs bearing on electricity supply:

- the cost of reducing emissions through imposing efficiency standards on electricity generators is estimated at about + A$ 10 per tonne (at 10% discount rate);

- the cost of reducing emissions through increasing the share of electricity generated from renewable energy by 2% is *up to* about + A$ 40/tonne.

In other words, the cost of saving emissions through appliance programs is projected to be about $ 40/tonne less than through the proposed efficiency standards for electricity generators, and up to $ 70/tonne less than through the proposed 2% additional renewables program.

The programs to be implemented after the Prime Minister's statement of November 1997, *Safeguarding the Future: Australia's Response to Climate Change,* account for about 83% of the total projected greenhouse reductions, indicating that the great majority of the NAEEEP's potential is still to be realised.

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1 Background

This study presents an overview of the likely impacts of National Appliance and Equipment Energy Efficiency Program (NAEEEP) on national greenhouse gas emissions in the period 2000 to 2015, and the estimated costs of the emission reductions for the part of the savings that have been modelled in detail (about half the total estimate). It combines the projected impacts of the major elements of the NAEEEP on electricity consumption. Impacts on other energy forms are not covered.

The NAEEEP comprises both mandatory and voluntary energy efficiency programs. This study covers only those programs which are generally implemented on a mandatory basis: comparative energy labelling - such as the “star” rating label for appliances - and minimum energy performance standards (MEPS). Experience in Australia has been that compliance with mandatory programs is high, so the energy impacts can be modelled with reasonable confidence.

Examples of voluntary programs include the “Energy Star” endorsement label for office equipment. Because not all products carry the label, buyer exposure to it is erratic, and the overall impact depends very much on the resources that industry and government bring to bear. While the energy savings can be worthwhile, they are less certain than for mandatory programs, and so have been omitted from the present study.

1.1 Methodology

The study draws on previous modelling where possible. Modelled impacts have been adjusted to revised target dates for program implementation and to common discount rates, energy prices and greenhouse gas intensity values for electricity delivered. This has been done by re-running the original models (where these are in GWA’s possession) or by extrapolating from published reports.

For some products the NAEEEP has nominated target dates for the implementation of minimum energy performance standards (MEPS), but no detailed modelling has yet been carried out so the level and energy impact can only be estimated at this stage. Where a second, more stringent round of MEPS is envisaged (eg for refrigerators and freezers in 2004) the modelling carried out for the first round gives some indication of the profile of the likely impact. However, where no detailed studies have been carried out (eg evaporative coolers), the estimates should be treated with caution.

1.2 Programs Covered

The AGO directed that the equipment types and programs listed in Table 1 be covered in this study, and grouped the programs into three categories:

1. Activities initiated before the Prime Minister's statement of November 1997, *Safeguarding the Future: Australia's Response to Climate Change*. This includes national harmonisation of household appliance energy labelling, and the implementation of MEPS for refrigerators, freezers and electric storage water heaters, which was endorsed by ANZMEC Ministers in 1995.

2. Activities indicated in the Prime Minister's statement, and for which firm target commencement dates have been announced. This includes MEPS and information programs for electric motors and packaged air conditioners, MEPS for fluorescent lamp ballasts and the introduction of a revised energy label for household appliances.

3. Activities in the current National Appliance and Equipment Energy Efficiency Committee (NAEEEC) work program.

The three categories combined cover most of the activities given a "high" or a "medium" priority in NAEEEC (1999).

Table 1 Summary of equipment types and program elements covered

Category	Programs	Start date projected in original modelling	Revised target start date	Source of data and modelling	Modelling approach for this study
Activities initiated before Prime Minister's Statement	1. Appliance energy labelling: increase effectiveness via national coordination	Late 1999	Late 1999	GWA 1999b	Original model rerun
	2. MEPS for refrigerators, freezers and water heaters	Mid 1996	Came into affect October 1999	GWA 1993	Original model rerun
Activities indicated in PM's statement, with firm start darts	3. Appliance energy labelling – introduction of new labels to enhance effectiveness	Mid 2000	Mid 2000	GWA 1999c	Original model rerun
	4. Electric motors – MEPS and information programs	Mid 2000	July 2001	Energetics (1997a)	Original model rerun
	5. Fluorescent lamp ballasts - MEPS	July 1999	July 2002	Energetics (1997b)	Original model rerun
	6. Packaged air conditioners – MEPS and information programs	Mid 1999	March 2001	Unisearch and GWA (1998)	Original model rerun
Second tranche of NAEEEC activities	7. Revision of refrigerator and freezer MEPS, equivalent to US levels	No detailed study yet	Late 2004	GWA(1993,1999b) EES (1996)	Extrapolation based on model outputs: energy impacts only
	8. Revision of electric motor MEPS, equivalent to "High Efficiency" levels	No detailed study yet	July 2005	Energetics (1997a)	Extrapolation based on model output: energy, costs, benefits
	9. Revision of packaged air conditioner standards, to COP of about 2.75 (close to US levels)	No detailed study yet	March 2005	Unisearch and GWA (1998)	Original model rerun: energy, costs and benefits
	10. Electric water heaters program	No detailed study yet	January 2006	GWA(1993,1999b)	Extrapolation based on model outputs: energy impacts only
	11. Commercial refrigeration program.	No detailed study yet	January 2006	EMET (1999), and data provided by AGO	Estimate: energy impacts only
	12. Packaged boilers program	No detailed study yet	January 2005	Energetics & GWA (1994)	Estimate: energy impacts only
	13. Packaged air compressors program	No detailed study yet	January 2005	Energetics & GWA (1994)	Estimate: energy impacts only
	14. Distribution transformers program	No detailed study yet	January 2005	Energetics & GWA (1994)	Estimate: energy impacts only
	15. Minimum efficacy standards for tubular fluorescent lamps	No detailed study yet	January 2007	Energetics & GWA (1994), EMET (1999)	Estimate: energy impacts only

2 Product Approaches and Assumptions

The input values, assumptions and outputs are detailed in an accompanying spreadsheet.[1] The main approaches and assumptions are summarised here.

2.1 Household Appliances

The projected energy impacts, costs and benefits of household appliance programs 1, 2 and 3 in Table 1 were taken directly from the modelling carried out for the Regulatory Impact Statements on uniform State labelling and MEPS regulations and Trans Tasman Mutual Recognition Act (TTMRA) exemptions (GWA 1999a, 1999b, 1999c).

The impact of national coordination was modelled as the difference between "rapid decay" in the effectiveness of labelling – as would have been expected had the States allowed their regulations to lapse under sunset provisions and allowed unlabelled products to enter from New Zealand – and "slow decay". This impact is graphed as "Coordinated Labelling 1999".

The impact of the 1999 MEPS for refrigerators, freezers and water heaters is graphed as "Ref & WH MEPS 1999".

The impact of the introduction of revised labels (and in the case of dishwashers, revised tests which correspond better to actual performance in daily use) compared with the "slow decay" scenario, is graphed as "Enhanced Labelling 2000".

NAEEEC states that: "for internationally traded products that contribute significantly to Australia's growth in greenhouse gas emissions, consideration will be given to developing MEPS for Australia that match best practice levels imposed by our major trading partners" (NAEEEC 1999).

The most stringent MEPS for refrigerators and freezers in the world are those in the USA. These are updated on a 3 to 4 year cycle, with a lead time of 3 years between announcement and effect. The latest levels were announced in 1998 and are due to take effect on 1 July 2001. These are called the US 2001 levels in the present study.

The US 2001 levels are substantially more stringent than those which took effect in Australia in 1999. In fact, the relative leniency of the Australian levels is due largely to the fact that they were developed on the assumption that they would take effect in 1996, not 1999 (GWA 1993). Since average efficiencies are rising in any case the difference between any

[1] All products MEPS summary.xls

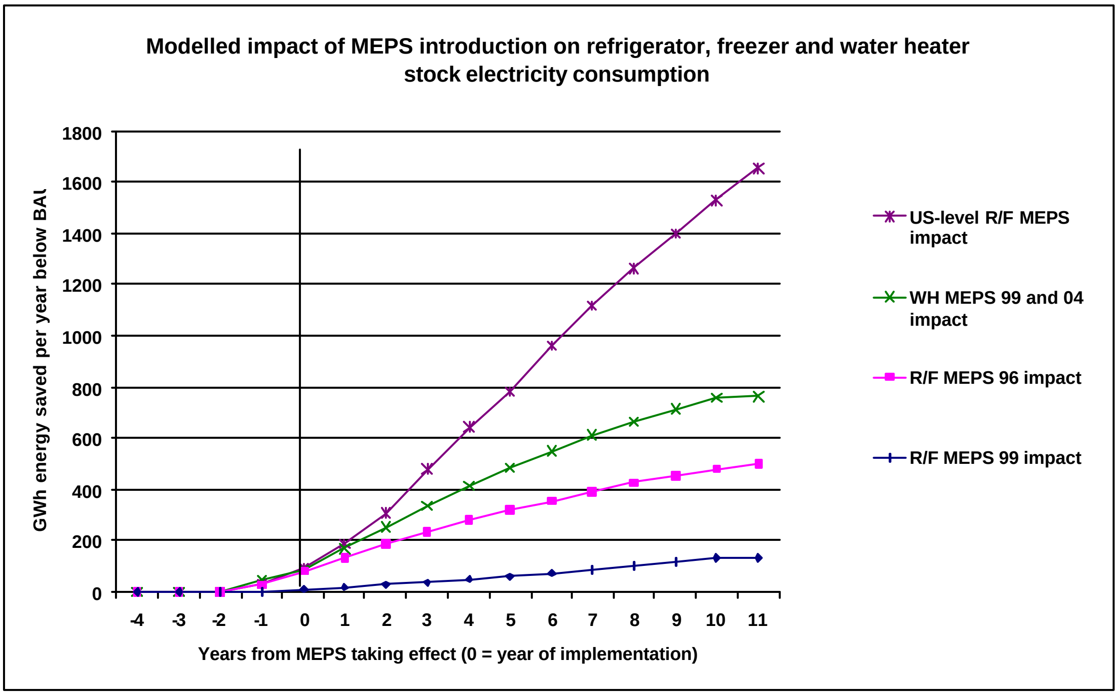
given MEPS level and the BAU average decreases over time. Hence the later the date of implementation, the less the actual impact.

A 1996 analysis by Energy Efficient Strategies (EES 1996) found that if the 2001 US MEPS levels were implemented in Australia in 2000, the sales-weighted average energy consumption of refrigerators and freezers *sold new* in that year would be 33% lower than in the base case, which already took account of the impact of the Australian 1999 MEPS levels. Of course, the impact on the entire stock of refrigerators and freezers would be more gradual, since only about 1/15 of the stock is replaced in each year.

The original modelling (GWA 1993) projected that if MEPS at the recommended levels were implemented in 1996 the electricity used by the entire refrigerator and freezer stock would be 5.4% below BAU by the 10th year (ie 2006). Given the delay in implementation, the actual impact is now estimated as 1.4% below BAU in the 10th year (ie 2009) (GWA 1999b). The EES study projects an impact of about 17.1% below BAU in the 10th year of introduction of US-level MEPS. Figure 1 illustrates these impacts. The "US-level" curve has been used to model the effect of introducing refrigerator and freezer MEPS levels in 2004 that are equivalent to the US 2001 levels.

It is possible that by 2004 the US will have announced still more stringent MEPS levels to take effect in about 2007, which would then be the earliest practical date for full convergence between Australian and US MEPS.

Figure 1 Modelled impact of MEPS introduction on refrigerators and freezers stock electricity consumption



The impact of the water heaters program proposed to commence in 2004 (program 10 on Table 1) is more difficult to estimate. Further MEPS may be an element of the program. The original MEPS study recommended heat loss levels of 70% of the values in the then Australian standard for smaller water heaters, and 55% of the standard values for larger water heaters (GWA 1993). In the event the MEPS level adopted were less stringent: 100% of the then heat loss standard for smaller water heaters and 70% for the larger. It is estimated that this will return about 40% of the energy saving potential identified. Therefore it is reasonable to assume that a new water heaters program (whether it comprises MEPS or other elements) will return the same energy reductions as the 1999 MEPS and still not exhaust the potential for cost-effective energy savings.

The USA will announce new MEPS levels for water heaters in 2000, with implementation likely in 2003.

2.2 Electric Motors

The costs and benefits of MEPS for 3-phase electric motors in the range 0.75 to 150 kW were modelled in Energetics (1997a). Two MEPS levels were analysed: one which would have excluded about 20% of the models on the market in 1995, and a more stringent one which would have excluded about 40%.

The study recommended adoption of the more stringent level to take effect in mid 2000, by which time considerably more models would meet MEPS in any case, because of the BAU trend to greater average energy efficiency. It also recommended the introduction of a "High Efficiency Motors" (HEM) endorsement program, with the HEM efficiency varying with motor capacity and type (ie number of poles). As the HEM endorsement would be a voluntary element, its impact is not estimated here.

At present it is envisaged that the recommended MEPS level will be implemented in mid 2001, one year later than recommended. It is also envisaged that HEM efficiency levels could become MEPS levels in the next MEPS iteration in mid 2005.

The impact of the one year delay on the MEPS implementation and of the MEPS 05 levels was extrapolated from the outputs of the original model used in Energetics (1997a), rather than from re-running the actual model. The projected impacts on the efficiency levels of motors sold new in 2015 compared with BAU is shown in Table 2.

Table 2 Projected energy efficiency of electric motors sold in 2015

Capacity	BAU	MEPS 01	MEPS 05
0.75 to 2.2	79.8%	81.2%	81.9%
3.0 to 7.5	87.8%	88.7%	89.1%
11 to 37	92.4%	93.1%	93.5%
45 to 90	94.7%	95.0%	95.3%
110 to 150	95.5%	95.9%	96.2%
Sales-weighted	85.1%	86.1%	86.7%
Energy-weighted	92.7%	93.3%	93.6%

Although the increments in energy efficiency may appear small, the very high lifetime energy use of motors means that even small increases in operating efficiency lead to large and cost-effective reductions in energy.

This preliminary analysis probably underestimates the energy impact of the MEPS 05 level, because the model allocates sales that would go to sub-MEPS models to the average efficiency level of the MEPS-complying models remaining on the market. The database contains the details of market as it was in 1995, and by 2005 the average efficiency of the models passing any given MEPS level will most likely be substantially higher, in which case the same calculations would return a higher projection of savings. This can only be determined by further analysis.

The costs and benefits of MEPS 05 have been estimated using the assumption that the relationships between efficiency and cost determined in Energetics (1997b) persist through the new round of MEPS, so that the average cost of motors rises in proportion to the further increment in average efficiency.

2.3 Packaged Air Conditioners

For packaged air conditioners of 7.5 to 65 kW cooling capacity, Unisearch and GWA (1998) recommended the MEPS levels in Table 3. The cost-benefit modelling was done on the assumption that MEPS would take effect in mid 1999. The present target for implementation is March 2001.

The original model was rerun to take account of the time slippage and to model the impact of a second round of MEPS, to take effect in mid 2005. The MEPS level selected for modelling was a cooling energy efficiency ratio (EER) of 2.75 W/W, similar to the levels already applying in the USA (given the number of different product classes, it is difficult to establish a direct equivalence).

Table 3 Proposed MEPS levels for Packaged Air Conditioners,

Rated cooling capacity (kW)	Minimum cooling EER (W/W)
Up to 10.0	2.25
10.0-12.5	2.30
12.6-15.5	2.35
15.6-18.0	2.40
18.1-25.0	2.45
25.1-30.0	2.50
30.1-37.5	2.55
37.6-45.0	2.60
45.6-65.0	2.65

The MEPS 01 level is projected to reduce the lifetime energy consumption of all packaged air conditioners sold in the period 2000-2015 by about 9%. The MEPS 05 level is projected to reduce the energy by a further 5%, bringing it to about 14% below BAU.

As is the case with motors, this approximation probably underestimates the energy impact of the MEPS 05 level, because the model allocates sales that would go to sub-MEPS models to the average efficiency level of the MEPS-complying models remaining on the market. The database contains the details of the market as it was in 1997, and by 2005 the average efficiency of the models passing any given MEPS level will most likely be substantially higher, in which case the same calculations would return a higher projection of savings. A more reliable estimate can only be made after analysing the changes in the market following the implementation of MEPS 01.

2.4 Fluorescent Lamp Ballasts

The impacts, costs and benefits of MEPS for fluorescent lamp ballasts were analysed in Energetics (1997b). The recommended MEPS level excludes from the market all standard efficiency, or “code” ballasts, and establishes the “low-loss” ferro-magnetic type as the least efficient on the market. The cost and benefits were calculated on the assumption that MEPS would take effect in mid 1999. It is currently envisaged that this MEPS level will take effect in mid 2002, so the modelling outputs have been adjusted for the 3 year slippage. No subsequent revision of ballast MEPS levels is currently envisaged.

2.5 Fluorescent Lamp Efficacy Standards

This assumes that minimum standards for lamp efficacy (lumens/watt) are introduced in January 2007. The minimum efficacy levels would be equivalent to those currently achieved by tri-phosphor lamps, which have about 15-18% higher efficacy than the common 26mm diameter 1200 mm tube. To translate the efficacy gain to energy savings, it would be necessary to have fewer lamps. Replacing an existing mono-phosphor lamp installation with the same number of tri-phosphor lamps will give more light for the same energy. Therefore the energy gains tend to be realised most readily in new lamp installations, which can be designed for tri-phosphor lamps. According to EMET (1999) the rate of increase in commercial lighting energy demand between 2000 and 2010 is projected to be nearly 9% per annum: such a high rate of growth would increase the opportunity to realise the efficacy gains as energy savings.

Energetics and GWA (1994) found that lamp standards would lead to worthwhile energy savings in Australia, but did not recommend their immediate development due to the need to study the impact on Australian industry, which did not manufacture tri-phosphor lamps at the time. The same authors did however recommend lamp standards for New Zealand (Energetic and GWA 1994b), where all lamps are imported and so impacts on local manufacture are not an issue.

The estimated energy impacts for Australia are taken partly from the New Zealand study. It is estimated that increase in lighting efficacy in the commercial sector would reach 12% above BAU in the 7th year after the standards take effect, but that only half of this gain is translated into energy savings – the rest is taken as increased standard of lighting. It is also estimated that about 80% of lamp energy is liberated as heat, which needs to be removed by the building air conditioning. This adds to the energy savings from lamp efficacy standards. Energy savings are projected to reach nearly 1,675 GWh per annum below BAU by 2015.

2.6 Commercial refrigeration

The impact estimate for commercial refrigeration draws on data provided by the AGO[2] and on a baseline study of greenhouse gas emisisons from the commercial sector (EMET 1999). The latter estimates that electricity consumption for processes other than building heating, cooling and lighting totalled 15.7 PJ in 1990 and is projected to rise to 28.9 PJ in 2010.

Refrigeration is estimated to account for about 80% of this value. This is supported by analysis of the energy consumed in various building types: hospitals, food stores department stores, accommodation, fast food restaurants, clubs and meeting places and other retail and wholesale. This leads to a BAU estimate of about 4,700 GWh in 2000 and 6,400 GWh in 2010.

The commercial refrigeration energy efficiency program envisaged is a combination of MEPS, to take effect in 2006, and measures to accelerate the development and takeup of technology. MEPS would impact on the "bottom end" of the market by excluding the least efficient products, and support for the development of new products or financial incentives

[2] In files GGAPCase.doc and Markssav.xls.

for the purchase of the more efficient products already on the market would accelerate availability and takeup at the top of the range.

It is estimated that the MEPS impact alone would be analogous to the impact of MEPS on the air conditioner market, and the inclusion of the other elements will double the effect and bring some of it forward. These assumptions lead to impact estimates that are generally consistent with, if slightly lower than, those estimated by the AGO. Energy reductions are projected to reach 1,540 GWh per annum below BAU by 2015.

2.7 Packaged boilers

There is limited information on packaged *electric* boilers in Energetics and GWA (1994):

> Consideration was given to including small boilers up to 300,000 BTU/hr (or 90 kW), similar to the standards in the USA and Canada, but these products are much more common in the US and Canada than here because of their use in space heating.
>
> In Australia, space heating in this capacity range is normally supplied by packaged air conditioners. There is very little boiler application in Australia for space heating, and the main uses for boilers of this type are for domestic hot water in multi-unit and institutional buildings and for steriliser steam. Even here there is a trend to hot water units and direct electric heated sterilisers rather than boilers, so this market is very small and is becoming restricted to applications such as dry cleaners.

The energy used by boilers of this type is nominally estimated as 1,000 GWh per annum, and remaining constant.. It is assumed that MEPS are introduced in 2005, with an impact profile similar to that which was projected for refrigerators (had MEPS taken effect in 1996). Energy reductions are projected to reach 54 GWh per annum below BAU by 2015.

2.8 Packaged air compressors

Energetic and GWA (1994) estimated that packaged air compressors account for about 12% of general industrial electricity load (ie excluding metal production and refining), or about 4,500 GWh per annum. It is estimated that this increases at a rate of 1.5% per annum.

There is a range of technology types and efficiencies on the market, varying from about 0.30 to 0.43 kW/litre/sec (at full load and 700 kPA). Therefore the conditions exist for a MEPS and/or labelling program. It is assumed that such a program takes effect in 2005, with an impact profile similar to that which was projected for refrigerators (had MEPS taken effect in 1996). Energy reduction are projected to reach 324 GWh per annum below BAU by 2015.

2.9 Distribution transformers

Although distribution system transformers (of about 1 MVA) are already about 98.5% efficient, nearly all the electrical energy used in Australia passes through them, so even small increments in efficiency can lead to worthwhile electricity savings. Canada is considering the introduction of MEPS for such transformers, although no technical standards have yet been announced.

Some 174,000 GWh of electricity was used in Australia in 1998/99. Assuming that that 150,000 GWh passed though transformers of the size in question, then the 1.5% lost through those transformers would have totalled 2,250 GWh.

Increasing the average efficiency from 98.5% to 98.8% would reduce the loss by one fifth, ie 450 GWh. It is assumed that this can be achieved following the implementation of MEPS in 2005, but because of the relatively low turnover of the stock, energy savings will only reach 195 GWh per annum below BAU by 2015.

2.10 Evaporative Coolers

In the hot, dry climates which favour their operation, evaporative air conditioners represent a far more energy-efficient way of cooling than refrigerative air conditioners. They have sensible cooling energy efficiency ratios on the range 23 - 44 W/W, compared with 1.5 – 3.8 W/W for refrigerative types (*Appliance Efficiency*, Vol 3 1999).

The scope for energy reductions within the evaporative cooler market is limited by their declining use (at least in the domestic sector) and relatively low electricity use per unit. According to EES et al (1999), the number of evaporative air conditioners in domestic use is declining and projected to decline further, and annual consumption is in the range 140 to 220 kWh per annum, giving a total consumption of only 87 GWh per year in 1999. The use of evaporative cooling in the commercial sector is not known, but may be significant. A nominal value of 10 times the domestic energy use has been adopted.

There appears to be a wide efficiency range, and there is an Australian Standard, so there may be scope for MEPS or labelling. Perhaps more importantly, it may be possible to promote evaporative cooling in preference to refrigerative in some regions of Australia. It is assumed that a program is introduced in 2006, and energy reductions below BAU reach about 66 GWh per annum (domestic and commercial sector combined) by 2015.

3 Outputs

3.1 Greenhouse Impacts

The combined projected greenhouse gas impacts of all programs covered in this study is illustrated in Figure 2. It is estimated that the programs will reduce greenhouse gas emissions by 81 Mt CO_2-e over the period 2000-2015. The impact of each measure builds up over time as new products replace the existing stock, so the earlier the date of implementation the greater the impact during the Kyoto Protocol Commitment Period. The average combined impact in each of the 5 years of the Commitment Period (2008 – 2012) is projected to be about 7.2 Mt CO_2-e reduction below BAU. By 2015 the impact is projected to reach 10.9 Mt CO_2-e per annum.

Figure 3 illustrates the impact of each program individually. Of the measures yet to be implemented, the largest impacts are projected to come from lamp efficacy standards, the commercial refrigeration program, refrigerator MEPS 2004, ballast MEPS 2002, water heaters program 2004 and air conditioner MEPS 2001.

Figure 2 Projected reduction in emissions, all programs covered

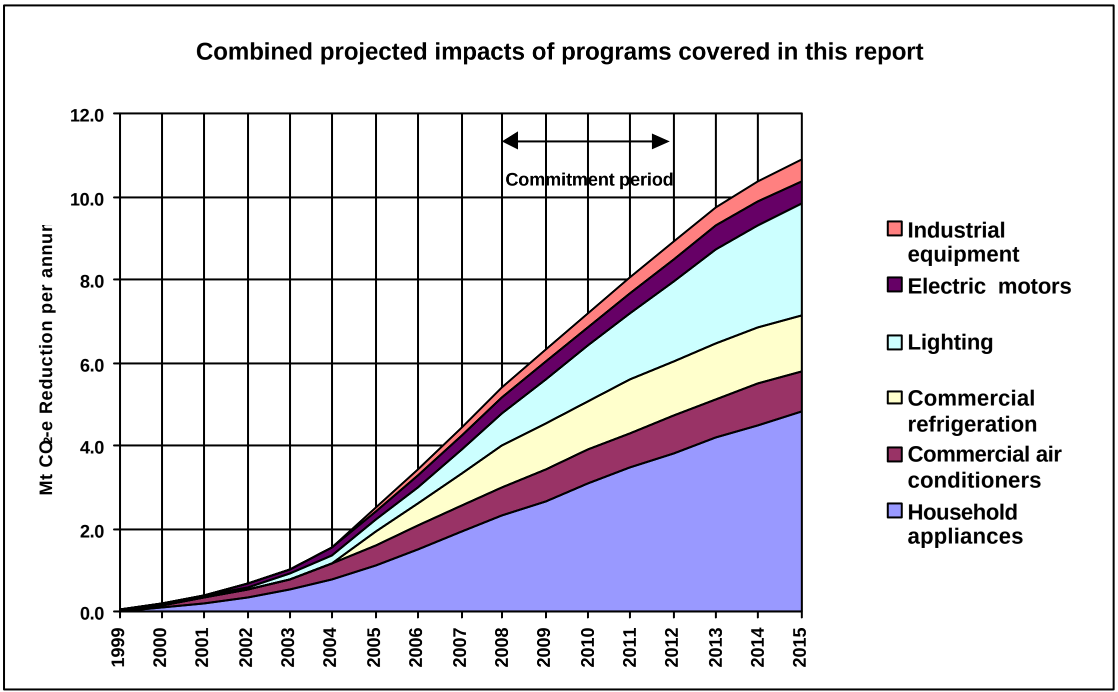


Figure 3 Projected impacts of individual programs

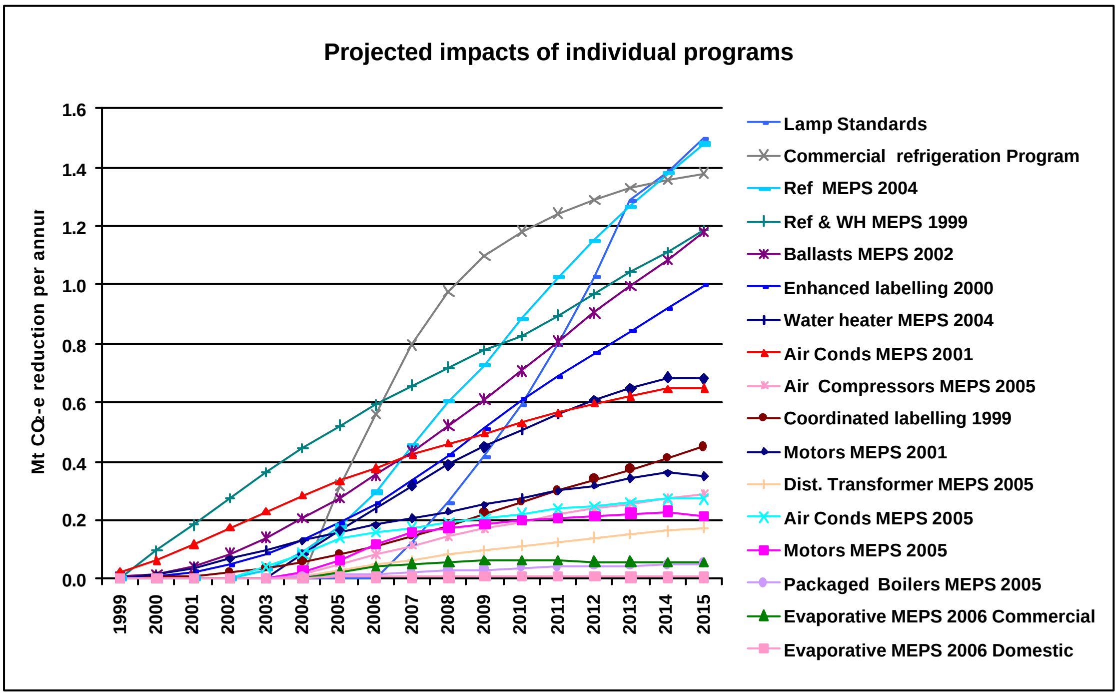


Figure 4 Share of projected emissions reductions, 2000 to 2015

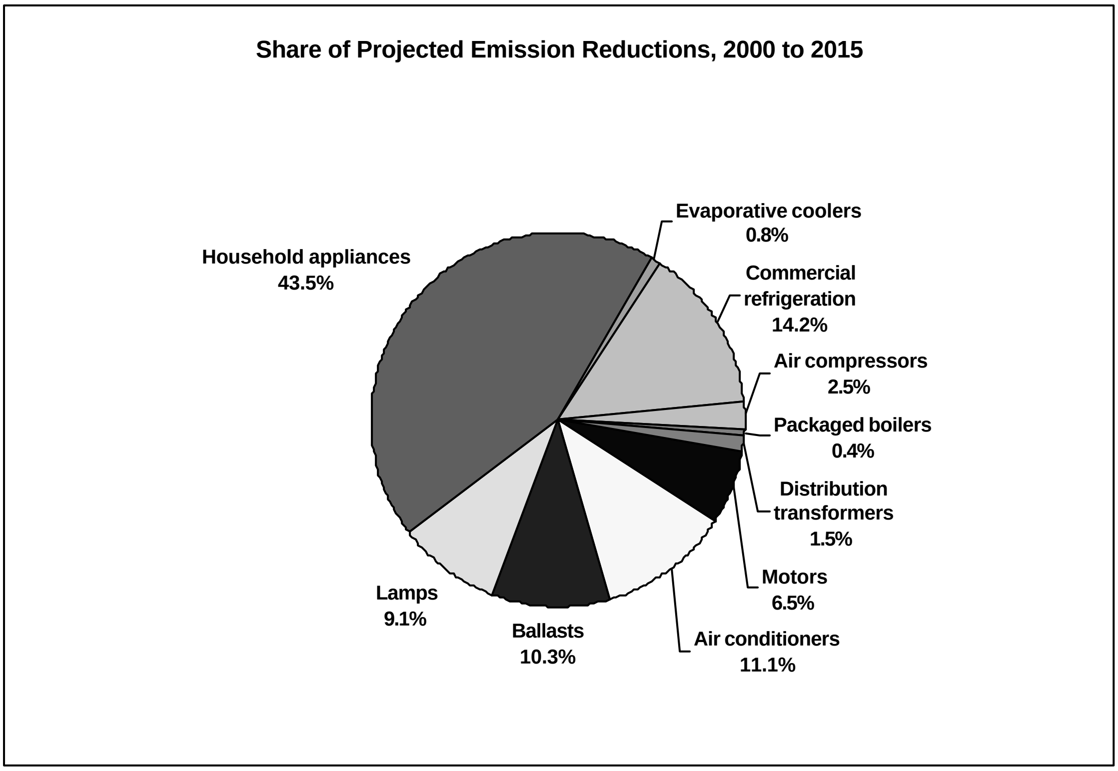
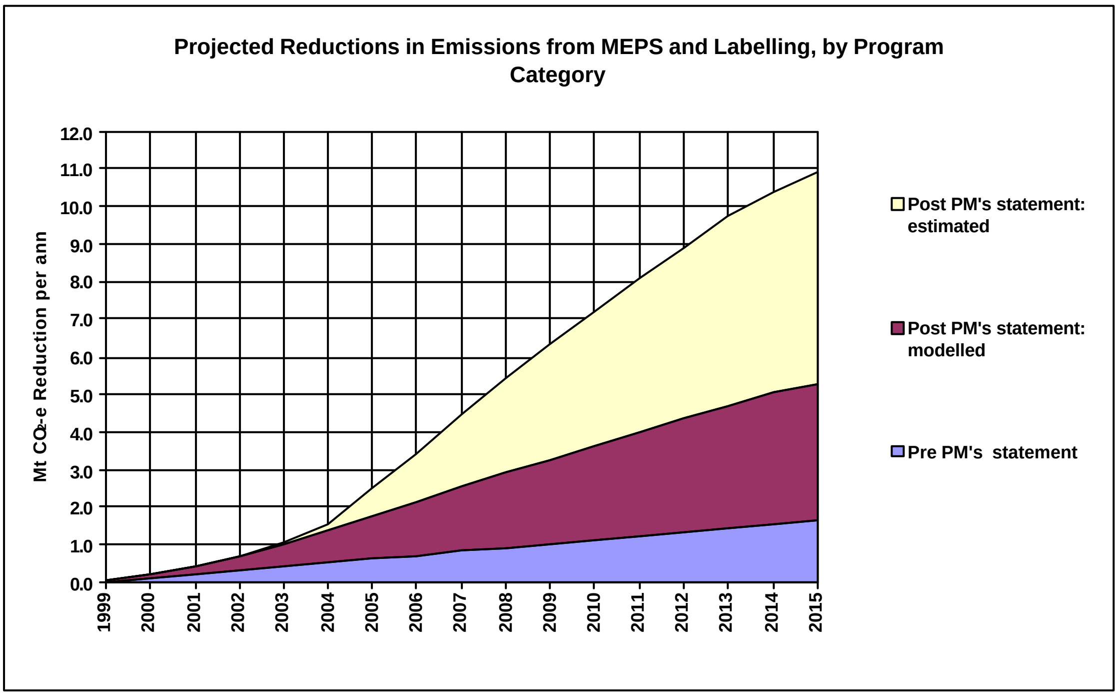


Figure 5 Projected reduction in emissions by program category



The contribution of each product type to this reduction is illustrated in Figure 4. Household appliances are projected to contribute nearly 44% of the savings, lighting over 19%, commercial refrigeration over 14%, air conditioners 11%, and motors nearly 7%.

Figure 5 presents the projected impacts according to the stage of program development. Those categorised as “Post-Prime Minister’s Statement – Estimated” are still to be modelled in detail. The “Post-PM’s statement” programs account for about 83% of the total projected greenhouse reductions, indicating that the great majority of the NAEEEP’s potential is still to be realised.

3.2 Costs and Benefits

For those programs where complete modelling has been carried out, it is possible to estimate not only greenhouse impacts but also costs and benefits. This group comprises:

- All of the activities initiated before the Prime Minister’s statement;
- All of the activities indicated in the Prime Minister’s statement with firm start dates; and
- Two of the measures in the second tranche of NAEEEC activities: electric motors MEPS 2004 and packaged air conditioner MEPS 2005

This group is projected to reduce greenhouse gas emissions by 43.1 Mt CO_2-e over the period 2000 to 2015 (out of the 81 Mt CO_2-e for all programs combined). The net present value (NPV) of the projected electricity savings is much higher than the NPV of the increases in product purchase price and the NPV of program administration costs, so the benefit/cost ratio for these programs combined is 3.5 at a discount rate of 0%, 2.9 at 5% and 2.4 and 10% (see Table 4). .

On this basis, the cost of the greenhouse gas savings is projected to be *negative*: - $ 31 per tonne at 10% discount rate. This can be compared with the projected costs of two programs bearing on electricity supply:

- the draft report of Efficiency Standards Working Group (November 1999) estimated that the cost of reducing emissions through the proposed efficiency standards for electricity generators would be about + $ 10 per tonne (at 10% discount rate);

- the Government itself has effectively capped the costs of reducing emissions through a proposed program to increase the share of electricity generated from renewable energy by 2%, at about A$ 40/tonne.[3]

In other words, the cost of saving emissions through appliance programs is projected to be about $ 40/tonne less (at 10% discount rate) than through the proposed efficiency standards for electricity generators, and up to $ 70/tonne less than through the proposed 2% additional renewables program.

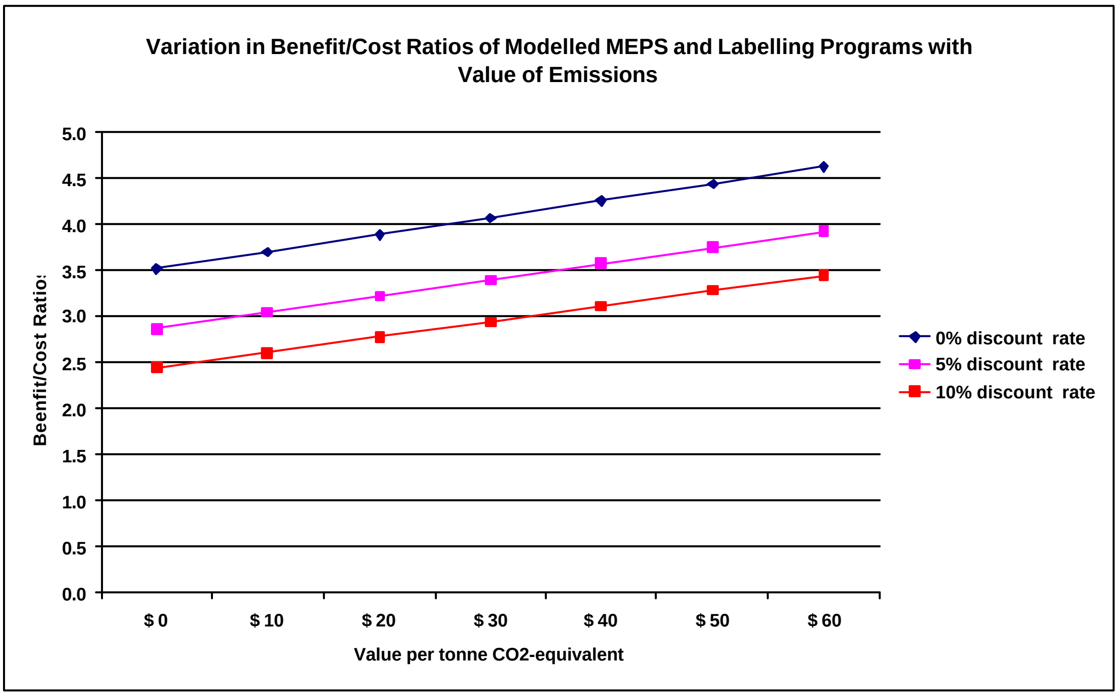
Table 4 Estimated costs and benefits, selected programs

Product	**From**	**To**	**0% discount rate**			**5% discount rate**			**10% discount rate**		
			Energy cost saved A$ M	Purchase price increase A$ M	Benefit/Cost Ratio	Energy cost saved A$ M	Purchase price increase A$ M	Benefit/Cost Ratio	Energy cost saved A$ M	Purchase price increase A$ M	Benefit/Cost Ratio
Motors	BAU	MEPS 05	981	274	3.6	441	178	2.5	228	123	1.9
Air Conds	BAU	MEPS 05	1,356	86	15.8	812	58	13.9	515	41	12.5
Ballasts	BAU	MEPS 01	1,281	483	2.7	693	291	2.4	397	186	2.1
Appliances	BAU	MEPS 99	4,527	1,481	3.1	2,141	902	2.4	1,134	584	1.9
All products modelled in detail			8,145	2,323	3.5	4,087	1,428	2.9	2,275	935	2.4
Total CO_2-e saved, 2000-2015			**$ cost/tonne saved**			**$ cost/tonne saved**			**$ cost/tonne saved**		
43.1Million tonnes			**- $ 135**			**- $ 62**			**- $ 31**		

[3] Press release on the 2% renewables target by Senator Hill, 29 November 1999, stated that "Certainty for industry to plan for the measure has been provided by fixing the target at 9,500 gigawatt hours and capping penalties for liable parties who fail to meet their purchase obligation at $ 40 per megawatt hour". Assuming a general greenhouse-intensity of 1 tonne per Mwh sent out from fossil fuel sources, this implies a maximum reduction cost to liable parties of $ 40 per tonne. The regulatory penalty sets a market limit on the cost of renewables, since a liable party facing a price of greater than A$40/MWh will be better off paying the fine.

The inclusion of a monetary value for greenhouse gas emissions would of course increase the cost-effectiveness of all greenhouse gas reduction programs, although it would not effect the differences in cost per tonne avoided between programs. This is illustrated in Figure 6. Figure 7 shows the contribution of each product class to the combined monetary benefits of this group of programs

Figure 6 Influence of CO_2-e values on benefit/cost ratios



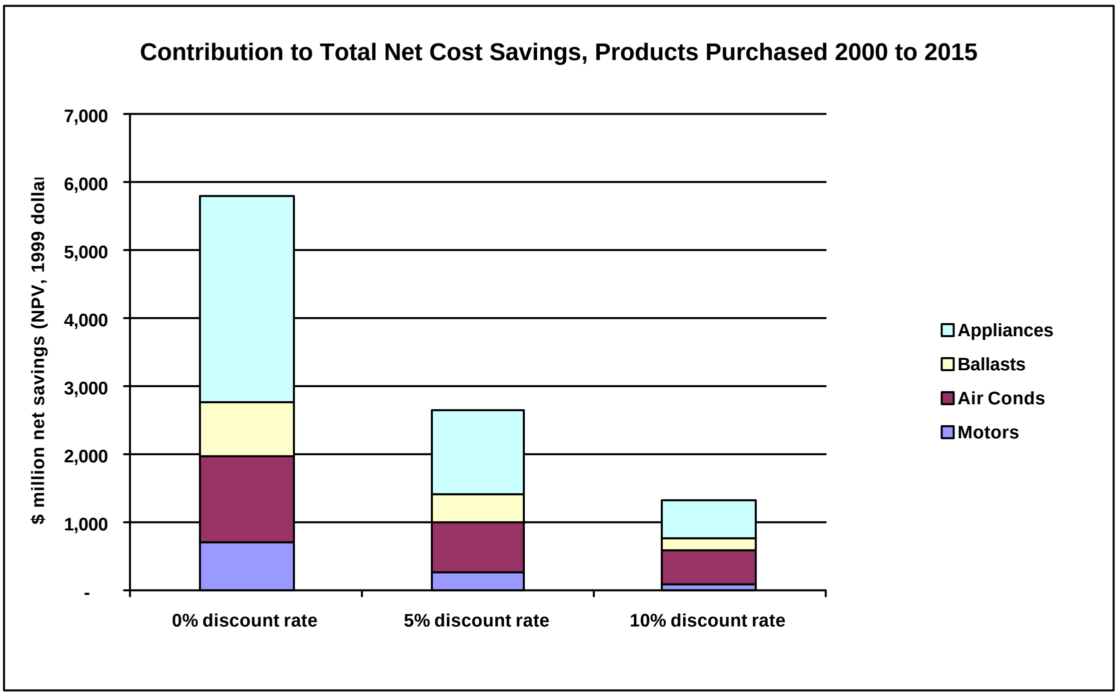


Figure 7 Contribution to net monetary savings by product type

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Figure 1

	R/F MEPS 99 impact	R/F MEPS 96 impact	WH MEPS 99 and 04 impact	US-level R/F MEPS impact
-4	0	0	0.0	0.0
-3	0	0	0.0	0.0
-2	0	0	0.0	0.0
-1	0	26	42.5	31.4
0	8	82	85.0	91.6
1	17	134	169.7	184.8
2	26	185	253.6	307.8
3	37	233	336.3	477.5
4	48	280	413.2	642.8
5	60	321	484.3	782.3
6	72	356	550.0	962.9
7	86	391	610.2	1117.0
8	101	424	665.1	1265.0
9	117	451	714.8	1401.9
10	134	477	759.3	1530.7
11	134	500	760.4	1654.2

Figure 2 (also appears in Exec Summary)

	Household appliances	Commercial air conditioners	Commercial Refrigeration	Lighting	Electric motors	Industrial equipment
1999	0.00	0.02	0.00	0.00	0.00	0.00
2000	0.10	0.06	0.00	0.01	0.01	0.00
2001	0.21	0.12	0.00	0.04	0.03	0.00
2002	0.34	0.17	0.00	0.08	0.07	0.00
2003	0.51	0.27	0.00	0.14	0.10	0.00
2004	0.80	0.37	0.00	0.20	0.15	0.03
2005	1.13	0.49	0.32	0.27	0.22	0.09
2006	1.50	0.57	0.56	0.35	0.30	0.14
2007	1.91	0.64	0.79	0.55	0.37	0.20
2008	2.31	0.71	0.98	0.78	0.40	0.25
2009	2.68	0.76	1.10	1.03	0.44	0.30
2010	3.10	0.81	1.18	1.30	0.47	0.34
2011	3.47	0.86	1.24	1.60	0.50	0.38
2012	3.83	0.90	1.29	1.93	0.53	0.42
2013	4.18	0.94	1.33	2.28	0.56	0.45
2014	4.51	0.97	1.36	2.48	0.59	0.48
2015	4.80	0.97	1.38	2.68	0.56	0.51

Figure 3

	Motors	Motors	Air Conds	Air Conds	Ballasts	Coordinated	Ref & WH	Enhanced	Ref	Water heater	Evaporative	Evaporative	Commercial		Air	Packaged	Dist.
	MEPS 2001	MEPS 2005	MEPS 2001	MEPS 2005	MEPS 2002	labelling 1999	MEPS 1999	labelling 2000	MEPS 2004	MEPS 2004	MEPS 2006	MEPS 2006	refrigeration		Compressors	Boilers	Transformer
											Domestic	Commercial	Program	Lamp Standards	MEPS 2005	MEPS 2005	MEPS 2005
1999	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.01	0.00	0.06	0.00	0.01	0.00	0.09	0.01	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
2001	0.03	0.00	0.12	0.00	0.04	0.01	0.18	0.02	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
2002	0.07	0.00	0.17	0.00	0.08	0.02	0.27	0.05	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
2003	0.10	0.00	0.23	0.04	0.14	0.04	0.36	0.08	0.03	0.00	0.000	0.00	0.00	0.00	0.00	0.00	0.00
2004	0.13	0.02	0.28	0.08	0.20	0.06	0.44	0.13	0.09	0.08	0.000	0.00	0.00	0.00	0.02	0.00	0.01
2005	0.16	0.06	0.33	0.14	0.27	0.08	0.52	0.19	0.18	0.16	0.002	0.02	0.32	0.00	0.05	0.01	0.03
2006	0.18	0.12	0.38	0.16	0.35	0.11	0.59	0.26	0.29	0.24	0.004	0.04	0.56	0.00	0.08	0.02	0.05
2007	0.21	0.16	0.42	0.17	0.43	0.14	0.66	0.33	0.45	0.32	0.005	0.05	0.79	0.12	0.11	0.02	0.06
2008	0.23	0.17	0.46	0.19	0.52	0.18	0.72	0.42	0.60	0.39	0.006	0.06	0.98	0.26	0.14	0.03	0.08
2009	0.25	0.18	0.50	0.21	0.61	0.22	0.77	0.51	0.73	0.45	0.006	0.06	1.10	0.41	0.17	0.03	0.10
2010	0.27	0.20	0.53	0.22	0.71	0.26	0.83	0.61	0.89	0.51	0.006	0.06	1.18	0.59	0.19	0.03	0.11
2011	0.30	0.21	0.56	0.23	0.81	0.30	0.90	0.69	1.02	0.56	0.006	0.06	1.24	0.80	0.21	0.04	0.12
2012	0.32	0.21	0.59	0.25	0.90	0.33	0.97	0.77	1.15	0.61	0.006	0.06	1.29	1.03	0.24	0.04	0.14
2013	0.34	0.22	0.62	0.26	1.00	0.37	1.04	0.84	1.27	0.65	0.006	0.06	1.33	1.29	0.26	0.04	0.15
2014	0.36	0.23	0.65	0.27	1.09	0.41	1.11	0.92	1.38	0.68	0.006	0.06	1.36	1.39	0.27	0.05	0.16
2015	0.35	0.21	0.65	0.27	1.18	0.45	1.19	1.00	1.48	0.68	0.005	0.05	1.38	1.50	0.29	0.05	0.17

Figure 4

Motors	Air conditioners	Ballasts	Lamps	Household appliances	Evaporative coolers	Commercial refrigeration	Air compressors	Packaged boilers	Distribution transformers
6.5%	11.1%	10.3%	9.1%	43.5%	0.8%	14.2%	2.5%	0.4%	1.5%

Figure 5

	Pre PM's statement	Post PM's statement: modelled	Post PM's Statement: Estimated
1999	0.00	0.03	0.00
2000	0.09	0.09	0.00
2001	0.19	0.21	0.00
2002	0.29	0.37	0.00
2003	0.40	0.59	0.03
2004	0.50	0.85	0.20
2005	0.60	1.15	0.77
2006	0.70	1.44	1.28
2007	0.80	1.73	1.93
2008	0.90	1.99	2.54
2009	0.99	2.26	3.05
2010	1.09	2.54	3.57
2011	1.20	2.79	4.07
2012	1.30	3.04	4.56
2013	1.41	3.28	5.05
2014	1.52	3.51	5.35
2015	1.63	3.65	5.61

Figure 6

	0% discount	5% discount	10% discount
	rate	rate	rate
$ 0	3.5	2.9	2.4
$ 10	3.7	3.0	2.6
$ 20	3.9	3.2	2.8
$ 30	4.1	3.4	2.9
$ 40	4.2	3.6	3.1
$ 50	4.4	3.7	3.3
$ 60	4.6	3.9	3.4

Figure 7

	0% discount rate	5% discount rate	10% discount rate
Motors	707	263	105
Air Conds	1,270	754	474
Ballasts	798	403	211
Appliances	3,046	1,239	550