Electric Appliance Energy Labelling:

Estimated Costs and Benefits of Continuation, Abandonment or Enhancement

Prepared for the

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by

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Executive Summary

The purpose of this study is to assess the likely impacts of two scenarios:

- the discontinuation of energy labelling (the "No Labelling" (NL) Scenario); and

- the enhancement of the energy labelling program, by including water heaters, and changes such as spending more on promotion and introducing more effective scaling algorithms for the labels: this is the "Enhanced Labelling" (EL) Scenario.

The impacts of these two scenarios are compared with the option of maintaining the labelling program at its current level and scope (the "Business as Usual" (BAU) Scenario).

It is not the purpose of this report to identify possible non-regulatory mechanisms for maintaining or enhancing the labelling program, or to speculate how effective those mechanisms might be. The NL scenario simply estimates the energy and monetary costs and benefits of the abandonment of the program, and the EL scenario estimates the energy and monetary costs and benefits of the enhancement of the program as described.

Approach to the Analysis

The analysis is carried out in the following sequence:

1. Estimate the number of each currently labelled product type, and storage water heaters, which will be sold in each State and Territory in the period 1997 to 2012 (ie 16 years' sales in all).

2. For each labelled appliance type, estimate the total energy used by all units to be sold new between 1997 and 2012, over their entire service life.

3. For each labelled appliance type, estimate the total carbon dioxide emissions associated with the electricity used by all units to be sold new between 1997 and 2012, over their entire service life.

4. For each labelled appliance type, estimate the Net Present Value (NPV) of the total energy used by all units to be sold new between 1997 and 2012.

5. For each labelled appliance type, estimate the NPV of the total retail purchase price of all units to be sold new between 1997 and 2012 (exclusive of labelling costs).

6. For each labelled appliance type, estimate the NPV at the retail level of the additional costs of energy testing and labelling imposed by the labelling program on each unit to be sold new between 1997 and 2012.

7. For each State, Territory and Commonwealth, estimate the administrative and publicity costs of supporting the energy labelling program.

8. Sum the NPV of energy costs, purchase costs and labelling costs to obtain a total cost to appliance buyers of obtaining the specified energy services over the period 1997 to 2012, under the BAU, NL and EL scenarios.

9. Compare scenario results. If total NPV is lower than in the BAU scenario, then appliance buyers as a group will be better off financially, and if total NPV is higher, then they will be worse off.

10. Compare the CO_2 emissions under the three scenarios.

As with any computer-generated scenario, this approach requires a large number of assumptions (all of which are documented) and produces a large number of output values specified to many decimal places. This should not be taken to imply an unrealistic degree of confidence in the input values or on the certainty of outcomes. These are projections and estimates, not predictions. The data available on the operation of the Australian (or any other) labelling program to date are not sufficiently organised or comprehensive to allow rigorous statistical analysis.

Findings

It is projected that, in the BAU scenario, with labelling continued at its present level, total appliance purchase costs will be about $30,200 million and the lifetime energy costs will be $32,700 million (constant dollars, undiscounted). The actual industry and administration costs of labelling will be essentially negligible in comparison: $ 83 million, or 0.13% of the total cost.

As the discount rate increases, the balance between energy and appliance costs changes, since appliance costs are all incurred at the time of purchase and hence less subject to discounting than energy costs, which are incurred progressively in the years after purchase. At 10% discount rate energy accounts for less than 40% of total costs, whereas at 0% it accounts for nearly 52%. The majority of labelling costs are also incurred at the time of purchase, so like capital costs are less sensitive to the discount rate. Even so, they are still less than 0.2% of total costs at 10% discount rate.

The outcomes of the three scenarios at each of the four discount rates are summarised in the following tables. The energy and CO_2 impacts, which are identical under all discount rates, are as follows:

- it is projected that the abandonment of labelling would increase the electricity consumption of appliances now labelled by about 890 GWh (an average of 56 GWh per year), or 4.2%, compared with the continuation of labelling at the current level;

- it is projected that the abandonment of labelling would increase the CO_2 emissions from the electricity consumption of appliances now labelled by about 12.8 million tonnes (an average of 0.8 Mt per year), or 4.2%, compared with the continuation of labelling at the current level;

- it is projected that the enhancement and extension of labelling would reduce the electricity consumption of appliances now labelled, and storage water heaters, by about 1,880 GWh (an average of 118 GWh per year), or 8.9%, compared with the continuation of labelling at the current level;

- it is projected that the enhancement and extension of labelling would reduce the CO_2 emissions from the electricity consumption of appliances now labelled, and storage water heaters, by about 26.5 Mt (an average of 1.7 Mt per year), or 8.7%, compared with the continuation of labelling at the current level;

- the abandonment of labelling (the NL scenario) would forego potential energy savings of 2,780 GWh (an average of 174 GWh per year), and result in 12.5% higher energy consumption of new appliances sold between 1997 and 2012, than under the EL scenario;

- the abandonment of labelling (the NL scenario) would forego potential CO_2 emission reductions 39.3 Mt (an average of 2.5 Mt per year), and result in 12.4% higher emissions from the electricity consumption of new appliances sold between 1997 and 2012, than under the EL scenario.

Energy and CO_2 Impacts of Labelling Scenarios

	BAU	No labelling	Enhanced labelling	No labelling cf BAU	Enhanced labelling cf BAU	Enhanced cf No labelling
Lifetime energy (GWh)	21,266	22,159	19,382	+893	-1,883	-2,776
% Difference in energy				+4.2%	-8.9%	-12.5%
Lifetime CO_2 (Mt)	304.5	317.3	278.0	+12.8	-26.5	-39.3
% Difference in CO_2				+4.2%	-8.7%	-12.4%

The following tables summarise the monetary costs and benefits of abandoning labelling, at various discount rates. In the NL scenario, purchasers of new appliances between 1997 and 2012 would save $131 M in appliance costs and $83 M in labelling costs (including government administration and promotion costs). However, they would incur an additional $ 1,690 M in energy costs, so would be nearly $1,400 M worse off as a result of the abandonment of labelling. This amounts to a 2.2% cost penalty (undiscounted) on the total costs of ownership of that group of appliances.

At a 6% discount rate the penalty (in 1996 $) is $482 M (1.5%), at 8% discount rate it is $349 M (1.3%) and at 10% discount rate it is $257 M (1.1%).

Projected Cost Impacts of Abandoning Labelling

	0 % Discount		6 % Discount		8 % Discount		10 % Discount	
	$M	% of BAU	$M	% of BAU	$M	% of BAU	$M	% of BAU
Energy cost	+1,610	+4.9%	+587	+4.0%	+434	+3.8%	+325	+3.5%
Appliance cost	-131	-0.4%	-54	-0.3%	-40	-0.2%	-29	-0.2%
Labelling cost	-83	-100%	-51	-100%	-44	-100%	-39	-100%
Total costs	+1,396	+2.2%	+482	+1.5%	+349	+1.3%	+257	+1.1%

Source: Tables B9 to B16. All $ values are NPV at 1996.

In the EL scenario, purchasers of new appliances between 1997 and 2012 would spend an extra $907 M in appliance costs and $ 12 M in labelling costs (including additional government administration and promotion costs). However, they would save nearly $2,880 M in energy costs, so would be $1,960 M better off as a result of the enhancement of labelling. This amounts to a 3.1% cost saving (undiscounted) on the total costs of ownership of that group of appliances.

At a 6% discount rate the saving (in 1996 $) is $603 M (1.8%), at 8% discount rate it is $424 M (1.5%) and at 10% discount rate it is $296 M (1.3%).

Projected Cost Impacts of Enhancing Labelling

	0 % Discount		6 % Discount		8 % Discount		10 % Discount	
	$M	% of BAU	$M	% of BAU	$M	% of BAU	$M	% of BAU
Energy cost	-2,878	-8.8%	-1,097	-7.5%	-823	-7.1%	-626	-6.7%
Appliance cost	+907	+3.0%	+477	+2.6%	+392	+2.4%	+325	+2.3%
Labelling cost	+12	+14.2%	+7	+14.3%	+6	+14.3%	-6	+14.3%
Total costs	-1,960	-3.1%	-613	-1.8%	-424	-1.5%	-296	-1.3%

Source: Tables B9 to B16. All $ values are NPV at 1996.

The potential benefits of enhancing labelling appear to be somewhat greater than the potential costs of abandoning it. If labelling were abandoned both groups of benefits would be foregone. The total value of benefit foregone would be then $3,380 M (undiscounted), or a 5.3% saving on the total costs of ownership of that group of appliances. At a 6% discount rate the saving (in 1996 $) is $1,095 M (3.3%), at 8% discount rate it is $774 M (2.8%) and at 10% discount rate it is $553 M (2.3%).

There are no States or Territories where appliance buyers would be better off if labelling were abandoned, and enhanced labelling would provide significant additional benefits to consumers in all States and Territories.

The inclusion of electric storage water heaters in an enhanced labelling program is also projected to offer significant energy and CO_2 savings. However, there would be new industry/consumer labelling costs, which would not be incurred for appliance already labelled. There would also be significant additional product costs, especially for off-peak water heaters, since these would already be considerably more energy efficient because of Minimum Energy Performance Standards. Furthermore, the value to consumers of off-peak water heater energy savings is much lower than for other appliances, because of the lower off-peak electricity tariff. Consequently, off-peak water heater are the only appliance group for which enhanced labelling appears not to be cost-effective.

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Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
AGA	Australian Gas Association
EEI	Energy Efficiency Index
EL	Enhanced Labelling
GWA	George Wilkenfeld and Associates
HH	Households
MEPS	Minimum Energy Performance Standards
N/Av	Not available
NL	No Labelling
NPV	Net Present Value
OP	Off Peak
PER	Price/efficiency ratio
R/C	Reverse Cycle
SW	Sales-weighted

1 Introduction

1.1 Background

Energy Labelling Program

The energy labelling of refrigerators and freezers first became mandatory in NSW in 1986, and in Victoria in 1987. Since then the labelling program has been extended to dishwashers, air conditioners, clothes dryers and clothes washers. It is now effectively a national program, even though not all of the States and Territories have mandatory labelling requirements for all of the product types. Relatively few products of the types covered by the program are now displayed for sale without an energy label, anywhere in Australia.

Australian energy labels are also seen on many electrical appliances displayed for sale in New Zealand and in Pacific Island nations, and more formal and complete extension of the program to those markets is under consideration.

There is also an energy labelling program covering gas water heaters, room heaters and central heaters. While not mandatory in the legal sense, gas appliance labelling is now required in the product approval codes enforced by the Australian Gas Association (AGA), which makes it mandatory in effect. There is no single electricity industry body which matches the AGA in universal coverage of both energy suppliers and equipment suppliers, so to the extent that universal electrical appliance labelling is a public policy objective, it must be (and has been) pursued by regulatory means.

Labelling is now an integral element of the appliance market in Australia. In the event that the program is made non-mandatory, labelling may revert to the lower levels of visibility and impact associated with other non-mandatory labelling programs, eg electrical appliance labelling in New Zealand. If that occurs, it is possible that buyers will drift to less efficient appliances, and total appliance energy consumption will be higher than if labelling were to continue at its current level. On the other hand, some of the costs associated with testing products, fixing labels and administration of the program may also decline, and there may be some reductions in average appliance purchase costs as buyers revert to less efficient products.

Alternatively, it would be possible to make changes to the labelling program which would enhance, rather than diminish its effectiveness. Such changes, which were identified in GWA et al (1991), would include extension of the program to certain other classes of electrical appliances, the introduction of a new rating scale to increase the commercial value of further efficiency improvements, and increased support through more and/or better targeted publicity. If changes of this kind were to occur, it is possible that appliance energy consumption would be lower than if labelling continues at its current level of impact.

Related Appliance Programs

Energy labelling is not the only major program affecting the electrical appliance market. After considering the recommendations of a cost-benefit analysis (GWA et al 1993) ANZMEC Ministers agreed in 1995 that Minimum Energy Performance Standards (MEPS) would be introduced for household refrigerators, freezers and storage water heaters. Following extensive discussions between Commonwealth and State officials and the appliance industry, it has now been agreed that MEPS for these products will take effect from September 1999.

The elimination of the least efficient products in the period leading up to MEPS commencement is bound to have some effect on the average efficiency of products purchased, and on the operation of the labelling program. The apparent range of efficiencies of refrigerators and freezers on the market will narrow somewhat (although not in the way that might be expected: the form of the MEPS algorithms is such that 3 and even 2 star models in certain configurations will pass MEPS, while some 4 star models will not).

If there is no labelling for electric storage water heaters, then there will be no interactions between water heater MEPS and labelling. However, labelling for water heaters is under currently under consideration, and if it should be implemented, then its costs, operation and impacts would certainly be affected by MEPS.

At present there are no other types of household electrical appliances being seriously considered for labelling or for MEPS.

1.2 Purpose of this Study

The purpose of this study is to assess the likely impacts of two scenarios:

- the discontinuation of energy labelling (the "No Labelling" (NL) Scenario); and

- the enhancement of the energy labelling program, by including water heaters, and changes such as spending more on promotion and introducing more effective scaling algorithms for the labels (a change which should not in itself add to the administrative or testing costs): this is the "Enhanced Labelling" (EL) Scenario.

The impacts of these two scenarios are compared with the option of maintaining the labelling program at its current level and scope (the "Business as Usual" (BAU) Scenario).

It should be noted that a decision to discontinue or abandon existing State and Territory energy labelling regulations will not necessarily, or at least not immediately,

lead to the "No Labelling" scenario. However, unless alternative mechanisms for maintaining near-universal labelling are available, there is a risk that equipment suppliers will progressively pull out of the program, until there is no longer enough "critical mass" to sustain both supplier and buyer interest and the program collapses. The risk is a real one, since the commercial value to suppliers of obtaining higher energy ratings, which was a strong success factor in the early years of the program, is now much diminished (see GWA et al 1991).

It is not the purpose of this report to identify possible non-regulatory mechanisms for maintaining or enhancing the labelling program, or to speculate how effective those mechanisms might be. The NL scenario simply estimates the energy and monetary costs and benefits of the abandonment of the program, and the EL scenario estimates the energy and monetary costs and benefits of a specified enhancement of the program.

If an alternative mechanism were equally effective as the current regulatory mechanism in maintaining the labelling program, then the outcome would resemble the BAU scenario in terms of costs and benefits. If the alternative mechanism were to prove only partly as effective, the outcome would lie somewhere between the BAU and the NL scenarios.

It is most unlikely that the type of change required to bring about an EL scenario could be achieved within a non-mandatory program (whether regulated or enforced by some other means). The objective would be to give the program real commercial impact again - as it had when it was first launched - so those suppliers who found their products were disadvantaged in the market would have no reason to participate on a voluntary basis. Therefore an abandonment of mandatory labelling is likely to mean that any potential net benefits of enhanced labelling will be foregone.

1.3 Approach to the Analysis

Sequence of the Analysis

The analysis follows the following steps (explained in further detail later in this report):

1. Estimate the number of each currently labelled product type, and storage water heaters, which will be sold in each State and Territory in the period 1997 to 2012 (ie 16 years' sales in all).

It is assumed that if governments make a decision in mid 1996 to diverge from the BAU (eg to abandon or to enhance labelling), then it will take one year for any consequences such a decision to become apparent.

A 16 year time period was used for the cost-benefit evaluation of MEPS: it is close to the longest average assumed service life (ie 15 years for refrigerators and freezers) and so approximates at least one complete turnover of the stock. Extending it further would have negligible impact on the monetary value of differences between scenarios, given the discount rates used in the analysis.

It must be assumed that the general characteristics of the labelling program and the appliance market will remain relatively stable over the period 1997 to 2012. This is a reasonable assumption given that the first "cycle" of the labelling program has been just as long: from 1982, when the program was first proposed to the appliance industry by the NSW Government, to 1997, the nominal diversion point between scenarios.

The likely effects of the planned implementation of MEPS for refrigerators, freezers and storage water heaters in 1999 has been taken into account. No allowance has been made for the possible extension of MEPS to other labelled appliances, or the possible tightening of MEPS levels between 1999 and 2012. More stringent MEPS for labelled appliances would probably reduce the projected efficiency gains from labelling, but increase the efficiency gains from the two programs combined.

2. For each labelled appliance type, estimate the total energy used by all units to be sold new between 1997 and 2012, over their entire service life.

Since the energy characteristics of appliances remain more or less constant throughout their service lives, it is possible to calculate the lifetime energy consumption if the energy efficiency of the product when new is known.

3. For each labelled appliance type, estimate the total carbon dioxide emissions associated with the electricity used by all units to be sold new between 1997 and 2012, over their entire service life.

This is calculated for each State and Territory separately, since the CO_2-intensity of each electricity system different and will change over time (based on ABARE projections, national average CO_2-intensity of electricity production is expected to decline slowly.

4. For each labelled appliance type, estimate the Net Present Value (NPV) of the total energy used by all units to be sold new between 1997 and 2012.

It is necessary to do this for each State and Territory separately, since electricity tariffs vary and so do annual appliance consumptions, because of differences in climate and usage patterns. All values are discounted to mid-1996, the time at which, it is assumed, decisions are to be made about the future of the labelling program. A range of discount rates has been tested, and 8% has been adopted as the appropriate one.

5. For each labelled appliance type, estimate the Net Present Value (NPV) of the total retail purchase price of all units to be sold new between 1997 and 2012 (exclusive of labelling costs).

Appliance buyers face both retail prices and retail electricity tariffs, so it is appropriate to base the analysis on these.

6. For each labelled appliance type, estimate the Net Present Value (NPV) at the retail level of the additional costs of energy testing and labelling imposed by the labelling program on each unit to be sold new between 1997 and 2012.

Since the adoption of the MEPS program, it has become necessary for suppliers of refrigerators, freezers and water heaters to energy test their products to certify that they meet MEPS, so the marginal costs of energy testing for labelling are now effectively nil for those products (ie no testing costs would be saved by the abandonment of labelling). However, label-fixing costs could still be saved.

7. For each State, Territory and Commonwealth, estimate the administrative and publicity costs of supporting the energy labelling program.

8. Sum the NPV of energy costs, purchase costs and labelling costs to obtain a total cost to appliance buyers of obtaining the specified energy services over the period 1997 to 2012, under the BAU, NL and EL scenarios.

9. Compare scenario results. If total NPV is lower than in the BAU scenario, then appliance buyers as a group will be better off financially, and if total NPV is higher, then they will be worse off.

10. Compare the CO_2 emissions under the three scenarios.

These are not assigned a monetary value, but will indicate the greenhouse gas impacts of deviating from the BAU scenario.

Uncertainty

As with any computer-generated scenario, this approach produces a large number of output values specified to many decimal places. This should not be taken to imply a very high degree of confidence in the input values or certainty of outcomes. These are projections or estimates, not predictions. The data available on the operation of the Australian (or any other) labelling program to date are not sufficiently organised or comprehensive to allow rigorous statistical analysis.

Even so, there is enough information of various kinds available to reasonably support a range of conclusions about how the market has responded to the introduction of labelling in the past, and how it is likely to respond to its removal or enhancement (or "re-introduction"). The mathematical outcome of these conclusions and assumptions

should not be given significance beyond the second figure at best. However, there has been no attempt to do this in the following tables, since it would introduce apparent rounding and addition errors which would further mask the findings.

1.4 Sources of Information

The following sources of data have been used extensively:

- for estimates of the early energy impacts of the labelling program on refrigerator efficiency trends: *Residential Appliances in Australia: An Assessment of Market and Technology Developments, with Particular Reference to Energy-Efficiency.* (GWA 1991);

- for a qualitative view of the operation of the labelling program on supplier and buyer behaviour: *Review of Residential Appliance Energy Labelling*, George Wilkenfeld and Associates (GWA et al 1991);

- for assessments of the State administrative costs of labelling: *Regulatory Impact Statement, Electricity (Energy Labelling of Electrical Articles) Regulation 1995* (NSW 1995), as well as GWA et al (1991);

- for assessments of the Commonwealth administrative costs of labelling: *Evaluation of the National Energy Management Program* (GWA et al 1993a);

- for estimates of trends in refrigerator and freezer energy consumption and efficiency in the period 1993-95: unpublished analyses by Energy Efficient Strategies (EES) of commercial monitoring data obtained from GfK (EES 1996);

- for estimates of household numbers, stock projections, appliance prices and efficiencies: *Benefits and Costs of Implementing Minimum Energy Performance Standards for Household Electrical Appliances in Australia* (GWA et al 1993b);

- for estimates of State differences in appliance energy consumption due to climate and usage: unpublished analyses by GWA for the Australian Bureau of Agriculture and Resource Economics (ABARE), for inputs into ABARE's Mensa/Markal model (GWA 1994).

2 Assumptions

2.1 Market Characteristics

Household Numbers and Appliance Ownership

Projecting the number of each product type sold on the Australian market in any future year is a complex exercise. The principal underlying variables include:

- the number of households: this cannot be inferred directly from population projections, since household size changes with ageing and other demographic shifts. In fact, household sizes are declining, so household numbers are increasing at a faster rate than population;

- the "ownership" of particular types of appliances: ie the total number of that appliance type in the community (the "stock") divided by the total number of households. This is greater than 1 for refrigerators;

- the rate at which existing appliances are retired from the stock and replaced with a new model of the same type. Retirements may come about because of breakdown, or "forced replacement" (which is affected by the durability and intensity of use of appliances) or because of "discretionary replacement" from buyer preference for later models (which is affected by technological change and economic conditions).

Retirements do not necessarily lead to replacements: for example, the ownership of separate freezers has stabilised as more households rely on the freezer compartment of their refrigerators, and the ownership of electric water heaters is declining as gas gains market share. However, if the number of households increase at a faster rate than the decline in ownership of an appliance type, the stocks of the appliance will still increase.

It is important to model all of these variables simultaneously, or there will be logical inconsistencies between the estimates of stocks, appliance service lives and sales. This study relies on the projections modelled in GWA (1994). Table 1 gives the projected household numbers for each State and Territory.

Table 1 Projected Number of Households, 1990 to 2020

Year	NSW	VIC	QLD	WA	SA	TAS	NT	ACT	AUST
1990	1984.9	1475.2	1027.0	549.9	515.7	163.0	41.52	95.3	5852.5
1995	2105.5	1569.4	1158.9	622.2	547.4	173.9	46.85	101.1	6325.2
2000	2236.9	1672.8	1304.8	702.2	581.0	185.5	52.75	107.4	6843.3
2005	2373.1	1780.6	1472.6	794.5	616.7	198.3	59.54	113.9	7409.4
2010	2495.1	1874.6	1633.9	877.2	641.8	206.4	66.06	119.8	7914.9
2015	2587.2	1945.8	1777.6	940.3	651.5	207.4	71.87	124.2	8305.9
2020	2682.6	2019.8	1933.9	1008.0	661.3	208.5	78.19	128.8	8721.1

Source: GWA et al 1993, GWA 1994. All values thousands.

Table 2 gives the estimated national ownership rates for labelled appliances and electric water heaters in 1995, as modelled in GWA et al (1993) and GWA (1994). The main data inputs used at the time were the ABS household energy surveys carried out in 1980, 1983 and 1986, and supplementary ABS surveys for NSW in 1989. A new data source has since become available: the ownership of major appliances was surveyed by the ABS in June 1994 (ABS 1995). As Table 2 indicates, this aligns reasonably well with the estimates in GWA (1994) except that:

- the breakdown of the air conditioner stock between reverse cycle and cooling only is somewhat different;
- the ABS survey finds a higher ownership of electric water heaters - possibly because it includes older non-storage (instantaneous) types as well;
- the ABS survey finds a higher ownership of refrigerators - most likely because it fails to distinguish retained second and third refrigerators not in continual use, whereas GWA (1994) estimates only refrigerators in continual use.

In general, the agreement is good enough for the State and Territory stock estimates developed in GWA (1994) to be used in this analysis. These are given in appendix Tables A1 to A8.

Table 2 Estimated Appliance Ownership, Australia 1994/95

	Projected O/ship 1995 (GWA 1994)	Surveyed O/ship 1994 (ABS 1995)
Air Cond (R/C)	0.155	0.167
Air Cond (Cooling only)	0.112	0.094
All Air Cond (Refrig)	0.267	0.261
Storage WH (Cont)	0.184	
Storage WH (OP)	0.382	
All electric WH	0.566	0.623
Refrigerators	1.154	1.256
Freezers	0.490	0.491
Clothes Dryers	0.513	0.517
Dishwashers	0.269	0.251

Numbers Sold

Projecting the total stock of each appliance type is necessary for two purposes: to calculate the total energy consumption of the entire stock, and to build up a projection of the sales of new stock. For the purposes of the present analysis, the energy consumption of existing appliances is not an issue, since it is not affected by labelling. Only the energy consumption of *new* stock added in the period of the analysis - in this case in the year 1997 and each of the subsequent 15 years - need be taken into account.

Table 3 gives the projected sales of new appliances in 1995 and at five yearly intervals for Australia as a whole, consistent with the household numbers in Table 1 and the projected penetration rates in Tables A1 to A8 (sales in intermediate years are linearly interpolated). Tables A9 to A16 show the projected sales in each State and Territory. These follow the distribution of appliance ownership rates, not household numbers or population. For example, SA is projected to account for about 20% of national air conditioner sales in 1995, even though it has 8.7% of Australian households.

Table 3 Projected Sales of Selected Appliances, Australia 1995 to 2105

	1995	2000	2005	2010	2105
Refrigerators	530.0	584.5	644.9	701.7	749.7
Freezers	97.0	105.4	114.7	123.1	129.7
Dishwashers	115.0	131.1	149.2	167.1	183.6
Clothes dryers	210.0	233.3	259.2	284.0	305.7
Clothes washers	460.0	497.7	538.9	575.6	604.1
Air conds (R/C)	90.0	102.2	115.3	128.0	137.7
Air conds (Cool)	50.0	57.4	65.3	73.0	79.0
Water heaters (Cont)	150.0	159.2	165.2	175.6	184.0
Water heaters (OP)	180.0	191.7	207.4	220.0	228.4
Total of above	1882.0	2062.5	2260.0	2448.1	2601.9

Source: Tables A9 to A16

2.2 Product Characteristics

Having projected the number of units to be sold in each year, it is necessary to establish the product characteristics which will affect the NPV of different labelling scenarios.

Energy Efficiency Ranges Trends

The key value to be tracked in each scenario is the sales-weighted (SW) average energy consumption of products sold new in each year. This is calculated by :

1. Estimate an average energy consumption for products sold new in 1995.

These are listed in Table 4. For refrigerators and freezers the assumed starting value is the sales-weighted average for 1995 calculated by EES (1996) by combining actual model sales data supplied by GfK with information on the energy consumption of each model taken from the energy labelling register. For other appliances the averages are derived from the MEPS study (GWA et al 1993a). For storage water heaters only the standing heat loss needs to be taken into account, since the heat conversion efficiency of all models may be assumed to be 100%.

(The Enhanced Labelling scenario is assumed to cover storage heaters only. If it were to also cover heat pumps and solar-electric models the scope for reducing energy consumption through labelling might be greater, although GWA et al (1991) concluded that "the label is used only in the final stages of appliance selection, well after decisions about energy form and general product performance and configuration are made". However, the costs of testing would also rise considerably since actual draw-off tests would be required, not just heat loss tests which will in any case be needed for MEPS).

Table 4 Estimated Sales-Weighted Average Consumption of Appliances Sold New, 1995

	kWh/yr
Refrigerators	755 (a)
Freezers	585 (a)
Dishwashers	475 (b)(c)
Clothes dryers	420 (b)
Clothes washers	480 (b)(d)
Air conds (R/C: heating)	895 (b)
Air conds (R/C: cooling)	820 (b)
Air conds (cooling only)	1025 (b)
Water heaters (Cont)	720 (b)(e)
Water heaters (OP)	880 (b)(e)

Source: (a) EES (1996) (b) GWA et al 1993a (c) Assume labelled cycle; excludes externally heated water. (d) Includes allowance for externally heated water (e) Standing heat loss only.

2. Consider the relationship of the Sales-Weighted Average to the most and least energy-efficient models on the market.

This will indicate the scope for improving the SW Average through labelling or other means. The most convenient means to express the relationship is as a ratio, or "energy efficiency index" (EEI) rather than in terms of kWh.

For refrigerators and freezers, the ratios have been derived from actual sales analyses. For example, the sales weighted average energy-intensity of Class 4 (two door cyclic

defrost) refrigerators sold in Australia in 1995 was 1.99 kWh/adjusted litre (ie actual volume is weighted by the proportion of freezer volume). The most energy-efficient model on the label register had an energy-intensity of 1.99 kWh/adjusted litre, and the least efficient 3.26 kWh/adjusted litre. If the SW Avg is given a nominal EEI of 1.0, then the EEI of the most efficient model is 1.46 (1.99/1.36) and for the least efficient model it is 0.61 (1.99/3.26).

Tables 5 and 6 summarise the EEIs for refrigerators and freezer in 1996. The range of energy efficiency may appear surprisingly wide, given that labelling has been in operation for such a long time. However, this is explained by the fact that, after the initial removal of poor performers in the period leading up to the formal commencement of labelling, it has had minimal impact on the least efficient end of the market, while driving up the most efficient and the sale-weighted average (GWA et al (1991). There is clearly still considerable scope for improving the sales-weighted average.

Table 5 Energy Efficiency Indices for Refrigerator Classes, 1995

Model	Class 1	Class 2	Class 3	Class 4	Class 5	Class 52/3	Refrigerators SW Average
Most efficient	1.30	1.28	1.30	1.46	1.45	1.22	1.41
SW Average	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Least efficient	0.42	0.65	0.67	0.61	0.59	0.89	0.60

Source: EES (1996)

Table 6 Energy Efficiency Indices for Freezer Classes, 1995

Model	Class 6	Class 61	Class 7	Freezers SW Average
Most efficient	1.77	1.85	1.29	1.70
SW Average	1.00	1.00	1.00	1.00
Least efficient	0.53	0.67	0.78	0.65

Source: EES (1996)

The EEIs for other appliances have been estimated from GWA et al (1993a). They are summarised in Table 7. The EEI range for some products (eg clothes dryers and water heaters) is relatively narrow, indicating that labelling can only have limited effect on the market unless newer, significantly more efficient models are introduced. This would not be expected to occur under a BAU scenario, but would be expected in an Enhanced Labelling Scenario.

Table 7 Assumed Energy Efficiency Indices, Other Appliances, 1995

Model	Clothes Dryers	Clothes Washers (a)	R/C Air Conds	Cooling Air Conds	Water heater (Continuous)	Water heater (Off peak)
Most efficient	1.20	1.20	1.40	1.40	1.10	1.10
SW Average	1.00	1.00	1.00	1.00	1.00	1.00
Least efficient	0.90	0.90	0.80	0.80	0.90	0.90

Source: GWA et al (1993a) (a) Low effective EEI range reflects tendency to colder washes.

3. Project the Trends in Sales-Weighted Energy Efficiencies for Each Product Under Each Labelling Scenario

This is the most critical trend in projecting costs and benefits. The only product for which reliable Australia-wide data publicly available are refrigerators and freezers (the NSW Department of Energy collected some data on sales-weighted efficiency for refrigerators, freezers, dishwashers and air conditioners in the late 1980s, but they related only to those models registered for labelling in NSW, and have never been published). Table 8 summarises the information for refrigerators and freezers.

Table 8 Historical Annualised Rates of Change in Sales-Weighted Energy Consumption and Efficiency, Refrigerators

	1985-86 (a)		1987-90 (a)		1993-95 (b)		
	kWh/unit	Efficiency	kWh/unit	Efficiency	kWh/unit	Efficiency	Adj Vol
Classes 1-3	N/Av	N/Av	-2.9 %	4.0 %	-1.6 %	2.0 %	0.2 %
Class 4	-3.2 %	12.1 %	-3.3 %	3.9 %	-1.7 %	-0.6 %	-2.3 %
Class 5	-2.9 %	7.1 %	-0.8 %	2.1 %	-4.0 %	2.7 %	-1.3 %
All Refrigerators	N/Av	N/Av	-2.1	3.5 %	-1.2 %	2.0 %	0.8 %
All Freezers	N/Av	N/Av	N/Av	N/Av	-3.0 %	3.2 %	0.2 %

Sources: (a) GWA 1991 (b) EES 1996. All values % per annum change

Table 8 shows separately the rates of change in kWh per unit in energy efficiency. This is necessary in order to allow for changes in the average adjusted volume of refrigerators sold from one year to the next. In the period 1993 to 1995 for example, the average adjusted volume of all refrigerators sold increased at a rate of 0.8% per annum. If efficiency had remained constant, then average energy consumption per unit would also have increased at 0.8% per annum. However, efficiency improved at a rate of 2.0% per annum, more than offsetting the influence of increasing volume, so in fact the average consumption of models sold fell at a rate of 1.2% per annum.

For freezers, there was very little change in average size, so the increase in sales-weighted average efficiency (3.2% per annum) translated almost exactly into a reduction in average consumption (3.0% per annum).

It may be assumed that the existence of labelling contributes to this rate of efficiency improvement, then there is clearly a considerable “down-side” scope for reductions in the rate of improvement (even into negative values) in the event that labelling is abandoned.

The evidence that labelling has had, and continues to have an impact on appliance buyers and on efficiency trends is detailed in GWA et al (1991 and 1993b). Table 8

shows the influence of labelling over time. In the lead-up period when (as industry sources have confirmed) suppliers removed the least efficient models so that labelling would not expose how poorly they performed, the annualised rates of efficiency improvement were very high: over 12% for cycle defrost models, and 7% for frost frees. In the late 1980s the rates of sales-weighted efficiency improvement for these appliances settled down to 4% and 2% respectively. In the latest period, the efficiency of cyclic defrost units actually declined, although for frost frees it appears to have picked up again - possibly because this has become the most rapidly growing sector of the market, and has attracted an influx of relatively efficient overseas-made models.

Therefore the following assumptions have been made about the general trends under the different labelling scenarios:

- in the BAU scenario, the annualised rate of energy efficiency improvement will gradually decline

- in the No Labelling scenario, the annualised rate of energy efficiency improvement will decline more rapidly, but still remain above zero;

- in the Enhanced Labelling Scenario, the annualised rate of energy efficiency improvement will increase rapidly in the period 1997 to 2005, then gradually revert to the same rate as in the BAU scenario: ie a repeat of the pattern observed over the past 10 years with the initial introduction of labelling.

The actual efficiency improvement rates assumed in each period for each appliance type under each of the three scenarios are given in Tables A17 to A25. Rates of change in the efficiency of the most and least efficient models are also specified. While these do not have a direct impact on the calculations (which use only the rates of change in sales-weighted average efficiency) they give an indication of the plausibility of each scenario. Clearly, the sales-weighted average trend must lie in the region between most and least efficient.

The projected trends in efficiency are illustrated in Figures 1 to 4. Figure 1, which shows the trends for refrigerators, is also typical of the freezer market. Figure 2, which shows the trends for dishwashers, is also typical of the clothes dryer, clothes washer and air conditioner markets. Figures 3 and 4 illustrate the trends for continuous and off-peak water heaters respectively. The trends for these will be uniquely affected by MEPS, as described below.

4. Allow for the Impacts of MEPS Where Appropriate

It is intended that MEPS will be introduced in late 1999 for refrigerators, freezers and storage water heaters. Accordingly, for those products, the rate of change in the efficiency of the least efficient model in the period after 1995 has been set so that it just exceeds MEPS by 2000. As Figure 1 shows, the impact of this upward shift on

sales-weighted refrigerator (and freezer) BAU efficiency trends is projected to be relatively moderate, although still appreciable. (The impact would clearly have been far greater had the same MEPS levels been implemented in 1996, as originally envisaged in the MEPS cost-benefit evaluation. Had it been known at the time that 1999 would be the target commencement date, the cost-benefit criteria adopted in the analysis would have led to the recommendation of more stringent refrigerator and freezer MEPS levels).

There are no MEPS planned for dishwashers, clothes dryers, clothes washers or air conditioners, so there are no MEPS-related shifts projected in their efficiency trends (see Figure 2).

The MEPS-related effects for storage water heaters are very marked. For continuous water heaters, it is assumed that an energy efficiency index (EEI) of 1.0 corresponds to the allowable standing heat loss in Australian Standard AS1056. It is understood that this will become the MEPS level, and since the sales-weighted average efficiency is already close to this level, it will have only a minor impact on the BAU trend (see Figure 3). Energy labelling will have no effect unless products with considerably better efficiency than the MEPS level become available. The high cost of day rate electricity and the large unrealised potential for cost-effective increases in insulation support the assumption that, in an Enhanced Labelling scenario, models with an EEI of about 1.4 (ie 70% of the standing heat loss in AS 1056) come on the market in 2000.

For off-peak water heaters, MEPS will considerably constrain the scope for labelling, since it will immediately move the market "floor" to an EEI of about 1.4 (ie 70% of the standing heat loss in AS 1056). Energy labelling will have no effect unless products with considerably better efficiency than the MEPS level become available. given the lower cost of off-peak energy, once the 70% heat loss MEPS level is achieved it may not be cost-effective to go the further step to, say, 55% - even though, as the MEPS analysis demonstrated, it would be cost-effective to move from the present levels *direct* to 55%. It is nevertheless assumed that, in the Enhanced Labelling scenario, models with an EEI of about 1.8 (ie 55% of the standing heat loss in AS 1056) come on the market in 2005.

Price-Energy Relationships

If buyers purchase a more efficient model as a consequence of energy labelling, will it necessarily cost more? If so, then the average price of new appliance will increase if average efficiency increases. However, the relationship between price and energy-efficiency is by no means clear. Detailed studies of the Australian appliance market (GWA 1991, 1993a) have not been able to determine any statistical links between energy efficiency and product price, because:

- for some products (eg refrigerators, clothes washers), many efficiency improvements have been cost-free, provided they could be integrated into the suppliers' normal product redesign and retooling schedules;

- for some products (eg dishwashers, air conditioners), energy-efficiency has been positioned as another marketing "feature" at the high-cost end of the model range, so products which have been more energy-efficient have also been more expensive because they also incorporated more features and functions. This association of variables has frustrated statistical analysis.

However, it would be expected that after the first, relatively easy and cheap efficiency options are taken up, subsequent developments will carry some cost because more materials (eg insulation), higher quality components (eg compressors) or additional research and development will be required.

The relationship between price and energy efficiency can be conveniently described in terms of "marginal price/efficiency ratios" (PERs). For example, a PER of 0.5 would mean that, if energy efficiency increased 1% and all other attributes of the appliance remained constant, then the price would increase 0.5%.

EES (1996) found that between 1993 and 1995, the average cost per litre of adjusted volume of refrigerators sold in Australia increased from $ 2.30 to $ 2.50, an annualised rate of 4.3% per annum. The National Consumer Price Index (CPI) increased at 2.6% per annum over the same period, so the real price increase was about 1.7% per annum. The average efficiency of refrigerators increased at about 2% (see Table 8), so all else being equal the marginal price/efficiency ratio would have been about 0.85.

However, the sales mix was also changing: more costly frost free models accounted for 29% of the market in 1993, but 37% in 1995. The cost of frost frees per litre of adjusted volume increased from $ 2.44 in 1993 to $ 2.56 in 1995, an annualised rate of 2.3% per annum. After allowing for CPI, the real cost of frost frees actually declined at the rate of 0.3% per annum. Given that the efficiency of frost free units increased at 2.7% per annum (see Table 8), the marginal price/efficiency ratio would have been -0.11. In effect, the more efficient the product, the cheaper it was.

Given the above, it has been assumed that the PER for appliances in the future is likely to lie somewhere between 1 and 0 (and closer to 0), but in the absence of further analysis selecting a value is to a large extent arbitrary. Table 9 lists the PERs adopted for this study.

It is assumed that PERs will be somewhat higher for those appliances where considerable energy efficiency gains have already been made over the past decade, either because of the influence of labelling (ie refrigerators, freezers and dishwashers) or because of imports of products from high energy price countries where energy efficiency is a major design objective (ie air conditioners). The PERs adopted for

water heaters are consistent with the manufacturing cost increases due to thicker insulation calculated in the MEPS study (GWA et al 1993a).

Table 9 Assumed Marginal Price/Efficiency Ratios, 1995 to 2015

	Refrig-erators	Freezers	Dish-washers	Clothes Dryers	Clothes washers	Air cond-itioners	Water heaters
BAU	0.30	0.30	0.30	0.25	0.25	0.50	0.30
No labelling	0.50	0.50	0.50	0.25	0.25	0.50	0.30
Enhanced labelling	0.30	0.30	0.30	0.25	0.25	0.50	0.30

It is also assumed that in a market where energy efficiency carries some commercial advantage, PERs are constrained by competition. This would be much less so if labelling were discontinued, so for those products where labelling has worked best in the past (ie refrigerators, freezers and dishwashers) higher PERs are adopted for the No Labelling scenario.

2.3 State Variations

The price and efficiency characteristics of appliances sold in any given year are assumed to be constant irrespective of which State or Territory they are sold in. The following factors are treated as State and Territory variables.

Energy Usage

The average energy usage per appliance varies according to climate and to user behaviour. The ABS National Energy Survey for 1986 provides diary data on hours of use in heating and cooling mode (for air conditioners) and frequency of use (for dishwashers, clothes dryers and clothes washers) in each State and Territory. Regional variations in the heat loads on refrigerators, freezers and storage water heaters can be estimated from average local temperatures. Ratios incorporating these factors, developed in GWA (1994), are shown in Table 10.

These ratios are applied in each year of the projection. For example, the national average energy consumption for refrigerators sold new in 1995 is 755 kWh/yr (see Table 4). This is assigned an energy efficiency index of 1.0. In the BAU scenario, the sales-weighted EEI of refrigerators is projected to increase at a rate of 1.5% per annum in the 2 years 1995-97, 2.0% per annum in the 5 years 1997-2002, and 2.0% per annum in the 5 years 2002-2007 (see Table A17). Therefore the EEI will be 1.16 in 2003, and the national average energy consumption for refrigerators sold new in that year is 755/1.16, ie 651 kWh/yr. Table 10 shows that a refrigerator in Queensland consumes 1.06 times the national average, so the annual consumption of a refrigerator sold new in Queensland in 2003 will be 690 kWh/yr throughout its service life.

Table 10 Energy Consumption Ratios by State and Territory

	Refrig-erators	Freezers	Dish-washers	Clothes Dryers	Clothes washers	Air cond (heating)	Air cond (cooling)	W Heater (Cont)	W Heater (Offpeak)
NSW	0.99	1.00	0.97	0.92	1.00	0.95	1.16	0.98	0.99
VIC	0.97	0.97	1.04	1.16	1.00	1.30	0.86	1.05	1.05
QLD	1.06	1.06	1.05	0.86	1.00	0.44	1.05	0.95	0.95
WA	1.02	1.02	0.88	1.04	1.00	0.90	1.02	1.02	1.02
SA	1.02	1.02	0.96	1.01	1.00	1.05	1.03	1.04	1.04
TAS	0.80	0.75	1.00	1.15	1.00	1.50	0.30	1.10	1.10
NT	1.09	1.09	0.99	0.88	1.00	0.40	1.30	0.90	0.90
ACT	1.01	1.01	1.04	1.00	1.00	1.20	1.10	1.05	1.05

Source :GWA 1994

Energy Price

The value of the energy saved through the purchase of a more efficient appliance will vary according to the marginal domestic electricity tariff (actually it will be somewhat higher, since many labelled household appliances are installed in commercial promises, but this has not been taken into account). Table 11 indicates the domestic and off-peak tariffs applying in each State and Territory at the end of 1995 (many are still current). An average tariff for all distributors has been estimated in NSW and Victoria. In the other States and Territories, uniform tariffs were in force.

Table 11 Marginal Household Electricity Tariffs 1995

	Day rate c/kWh	Off Peak c/kWh
NSW	11.25	4.75
VIC	12.50	4.25
QLD	9.20	4.25
WA	12.29	5.00 (a)
SA	11.92	4.75
TAS	6.40	5.50 (b)
NT	12.03	N/Av
ACT	8.00	4.00

Source: Electricity distributors, annual reports. (a) No current OP tariff available, but value estimated for known (and projected) stock of OP water heaters. (b) Water heating tariff.

The likely rate of change in tariffs is a subject of great uncertainty. Although greater competition in electricity supply may constrain prices, it is likely that most of the benefit will flow to large users, at least in the early years. Furthermore, even if

average domestic prices remain steady or decline, marginal tariffs might still increase. For the purpose of this analysis projected rates of change in tariffs similar to those in the MEPS study (GWA at al 1993a) have been assumed: 1% per annum real increase to 2015, and no change thereafter. (It is necessary to project tariffs to 2027 to calculate the net present value of lifetime energy consumption for appliances with a 15 year life installed in 2012, the last year of the cost-benefit analysis).

Clearly, any cost-benefit analysis will be sensitive to energy price trends. In this case a reversal of the assumed price trend (ie projecting a *decline* of 1% per annum) will approximately halve the differences in the Net Present Value of energy between any two scenarios, at a discount rate of 8%, and an assumption of no change will reduce the NPV differences by about a quarter.

Carbon Dioxide Intensity

The CO_2-intensity of electricity supply is defined as total CO_2 emissions from thermal power stations divided by all electricity sales to end users. The analysis can be carried out at the national level or for any state or region, although care needs to be taken to account for electricity trade between regions.

The CO_2-intensity of electricity changes as generation fuel mix, power station mix, power station efficiency and line losses change. For Australia, there is no single study which explicitly projects these factors to 2020. However, GWA (1996a) reviewed the available data and projected national CO_2-intensity, for use in an OECD study. GWA (1996b) calculated State and Territory CO_2-intensities in 1994, the latest year of complete data on power station emissions and interstate electricity trading, for use by the Greenhouse Challenge Office.

It is projected that the national CO_2-intensity of electricity generation will decline as shown in Table 12, due mainly to a growing share of gas and more efficient gas-fired power stations in the mix, and will be approximately 7% lower in 2020 than in 1995. Applying the same rate of reduction to each State's current CO_2-intensity (which is a necessary simplification) produces the values in Table 12. These are used to calculate the CO_2 emitted as a result of the consumption of electricity in each State (values for intermediate years are linearly interpolated).

Table 12 Projected Carbon Dioxide Intensity of Electricity Delivered

	1995	2000	2005	2010	2015	2020
NSW	0.906	0.901	0.892	0.866	0.853	0.840
VIC	1.312	1.305	1.292	1.254	1.235	1.216
QLD	1.001	0.996	0.986	0.957	0.943	0.928
WA	1.042	1.036	1.026	0.996	0.981	0.966
SA	0.887	0.883	0.874	0.848	0.836	0.823
TAS	0.001	0.001	0.001	0.001	0.001	0.001
NT	0.650	0.647	0.640	0.622	0.612	0.603
ACT	0.906	0.901	0.892	0.866	0.853	0.840

Average	0.975	0.970	0.960	0.932	0.918	0.904

Source: GWA (1996a, 1996b)

3 Estimating Benefits and Costs

The societal benefits of the labelling program derive from the likelihood that the total consumption of energy required to operate the household appliances covered by the program will be lower than if the program did not exist. Consequently both the monetary and environmental costs of that energy will be lower in proportion.

The societal benefits of labelling can only be realised if a range of decision makers respond appropriately to the opportunities (and in some cases commercial risks) created by the existence of the program. Product suppliers need to provide and promote more energy-efficient products and remove the less efficient ones, and individuals need to seek out and purchase the more efficient ones.

In many cases, the extent to which they do this does not match the apparent monetary value of the action. For example, many purchasers pass up clearly cost-effective choices in the refrigerator market, but prefer dishwashers on the basis of label ratings which do not, in fact, lead to cost-effective energy savings. This is due to differences in customer needs, awareness and understanding of the label data, access to capital (in the event that the more energy efficient and cost-effective option costs more to buy), the discount rate used by the individual in evaluating potential future monetary benefit, and the value attached to non-monetary benefit (eg reducing environmental impact).

The interaction of these factors is complex, and there have been few attempts to properly analyse them, in Australia or elsewhere. The evidence, however, is that the resultant of these factors has produced a significant impact on sales-weighted trends in appliance energy efficiency (GWA 1991, GWA et al 1991). It is therefore appropriate to analyse the costs and benefits from a societal perspective only.

3.1 Energy Costs

Under each scenario, energy costs are calculated as the net present value (in 1996 $) of the electricity purchased over the lifetime of all labelled appliances bought new between 1997 and 2012 (inclusive). Any two scenarios can be compared on the basis of the difference between the NPV of their energy costs (provided both scenarios are generated using the same discount rate).

The value of the energy used in storage water heaters is included in all scenarios, even though the products are assumed to be labelled only in the Enhanced Labelling Scenario. However, since it is assumed that the efficiency trends for storage water heaters are identical in the BAU and the NL scenarios, the inclusion of their energy costs has no effect on the *difference* between that pair of scenarios.

3.2 Carbon Dioxide Emissions

The CO_2 emissions for each scenario are calculated by applying the coefficients in Table 12 to the electricity purchased over the lifetime of all labelled appliances bought new between 1997 and 2012 (inclusive). Any two scenarios can be compared on the basis of the difference between the calculated CO_2 emissions. These are assigned no monetary value in the calculation, and so are unaffected by the discount rate used.

3.3 Purchase Costs

Under each scenario, purchase costs are calculated as a net present value of the retail purchase price of all labelled appliances bought new between 1997 and 2012 (inclusive). Any two scenarios can be compared on the basis of the difference between the NPV of their appliance costs (provided both scenarios are generated using the same discount rate). The lower energy scenarios have higher purchase costs, because price-efficiency ratios have been set higher than zero.

The cost of storage water heaters is included in all scenarios, even though the products are assumed to be labelled only in the Enhanced Labelling Scenario. However, since it is assumed that the efficiency (and hence price) trends for storage water heaters are identical in the BAU and the NL scenarios, the inclusion of their purchase costs has no effect on the *difference* between that pair of scenarios.

3.4 Labelling and Administration Costs

Industry and Consumer Costs

All "industry" costs are in fact passed on to consumers. They are made up of the following components, as set out in Table A26.

- Cost of energy testing specifically for the Australian energy labelling program. This is calculated for each product type, from the average cost per test, and the number of new models introduced into the Australian market annually (from GWA et al 1993a, NSW 1995). Note that for products for which MEPS is to be introduced, the marginal cost of energy testing *specifically for the Australian energy labelling program* is now zero. Annual testing costs are divided by annual sales in 1995 to give a testing cost to suppliers per appliance sold, and multiplied by a retail markup factor (set at 2.0) to give a cost to consumers per labelled appliance sold.

- Actual labelling costs. This covers the administration of the program within the appliance industry, and the cost of producing and fixing labels. This is set at $ 0.50 per labelled product, and multiplied by a retail markup factor (set at 2.0) to give a cost to consumers of $ 1.00 per labelled appliance sold.

The cost to consumers per labelled appliance ranges from $ 1 for refrigerators and water heaters (for which testing costs are now absorbed into the MEPS program) to close to $ 9-10 for air conditioners, where model turnover is high and sales per model are low.

Strictly speaking, these costs are also recovered from buyers through the appliance purchase costs. However, since the uncertainty in average purchase price is far greater than the share of the price made up by labelling costs (even for air conditioners it is less than 1%), treating them separately does not significantly affect the analysis.

Labelling costs to industry and consumers are considered identical in the BAU and Enhanced Labelling scenarios, and zero in the No Labelling scenario.

Administration Costs

All administration costs for the program borne by government or electricity suppliers (who provide support for the program in some States) are passed on to consumers, either through taxes or via electricity supply costs (probably the fixed charges rather than the tariffs). They are made up of the following components, as set out in Table A26.

- Fixed administration costs, to cover policy, regulation and label registration within each jurisdiction. The costs for NSW are taken from NSW (1995), those for the Commonwealth are estimated from GWA et al (1993b) and those for other States and Territories are estimated on the basis of their population and share of the national label registration task.

- Costs of check testing, national coordination and the other functions covered by the population-weighted cost sharing arrangements between the Commonwealth, States and Territories. These are extrapolated from NSW (1995).

- Cost of promotion. This includes the cost of the retail liaison staff employed in NSW and Victoria, and the production and distribution of guides and leaflets. From NSW (1995) this is estimated at $0.20 per annum per labelled appliance sold in NSW. The same level of expenditure is assumed for Victoria, and $ 0.10 for other States and Territories.

For the BAU scenario, it is assumed that the first two of the above components remain at the 1995 level shown in Table A26 in each future year, and that promotion costs increase from the 1995 base in proportion to the sales of labelled products in each jurisdiction.

For the NL scenario, all administrative costs are set to zero. This somewhat overstates the potential cost saving, since some administrative functions and some check testing would still be necessary to support MEPS, but the extent of this cannot be estimated.

For the EL scenario, it is assumed that administrative costs follow the same trend as in the BAU scenario, except that:

- promotional expenditure in each State and Territory increases by 50%

- Commonwealth expenditure on promotion (set at zero in the other scenarios) is assumed to be equal to the sum of the (enhanced) promotional expenditure in the States and Territories.

For example, this total in 1995 was $ 246,000 (see Table A26). In the EL scenario this would rise to $ 502,000 per year and the Commonwealth would contribute a further $ 502,000. The total level of expenditure ($ 1.04 M per annum would then increase annually in proportion to the sales of labelled appliances. This is considered a reasonable representation of the national publicity and promotion effort that would be required to effectively relaunch the labelling program.

In each scenario, Consumer and Administration costs incurred in future years are discounted to a Net Present Value at the same discount rate as specified for energy cost and appliance purchase costs.

3.5 Discount Rates

The differences between the BAU, NL and EL scenarios are assessed using the following discount rates: 10%, 8%, 6% and 0%. Discount rates if 4%, 6% and 8% were used for sensitivity testing in the MEPS evaluation (GWA at al 1993a); the slightly higher range is used here to reflect that the links between actions and outcomes are less direct than for MEPS, and hence labelling is a somewhat less predictable and hence more "risky" program from a societal perspective.

The 0% discount rate has also been included for information, and to give an undiscounted picture of the relativity between different cost elements. (It may also be argued that a 0% discount rate is an appropriate basis for precautionary policy making in a time of high environmental uncertainty and risk, and until such time as a monetary value is agreed for carbon dioxide emissions).

All tariff and cost projections are in constant 1996 dollars, ie net of inflation.

3.6 Cost Structure

Table 13 analyses the costs of purchasing and operating labelled appliances in Australia in the period 1997 to 2012. It is projected that, in the BAU scenario, with labelling continued at its present level, the purchase costs will be $30,213 million and the lifetime energy costs will be $32,658 million (constant dollars, undiscounted).

The actual industry and administration costs of labelling will be essentially negligible in comparison: $ 82.5 million, or 0.13% of the total cost.

Table 13 Costs Under Various Discount Rates, BAU Scenario

	0 % Discount		6 % Discount		8 % Discount		10 % Discount	
	$M	%	$M	%	$M	%	$M	%
Energy cost	32,658	51.9%	14,574	43.9%	11,538	41.6%	9,280	39.5%
Appliance cost	30,213	48.0%	18,575	55.9%	16,132	58.2%	14,144	60.3%
Industry/consumer	67.6	0.11%	41.6	0.13%	36.2	0.13%	31.8	0.14%
Administration	14.9	0.02%	9.4	0.3%	8.2	0.03%	7.2	0.03%
Total labelling cost	82.5	0.13%	51.0	0.16%	44.4	0.16%	39.0	0.17%
Total costs	62,954	100%	33,200	100%	27,715	100%	23,463	100%

Source: Tables B9 to B16. All $ values are NPV at 1996.

As the discount rate increases, the balance between energy and appliance costs changes, since appliance costs are all incurred at the time of purchase and hence less subject to discounting than energy costs, which are incurred progressively in the years after purchase. At 10% discount rate energy accounts for less than 40% of total costs, whereas at 0% it accounts for nearly 52%. The majority of labelling costs are also incurred at the time of purchase, so like capital costs are less sensitive to the discount rate. Even so, they are still less than 0.2% of total costs.

4 Findings

4.1 National Energy and CO_2 Impacts

The outcomes of the three scenarios at each of the four discount rates are summarised in Tables 14 to 17 (condensed from Tables B9 to B16). The energy and CO_2 impacts, which are identical under all discount rates, are as follows:

- it is projected that the abandonment of labelling would increase the electricity consumption of appliances now labelled by about 890 GWh (an average of 56 GWh per year), or 4.2%, compared with the continuation of labelling at the current level;

- it is projected that the abandonment of labelling would increase the CO_2 emissions from the electricity consumption of appliances now labelled by about 12.8 million tonnes (an average of 0.8 Mt per year), or 4.2%, compared with the continuation of labelling at the current level;

- it is projected that the enhancement and extension of labelling would reduce the electricity consumption of appliances now labelled, and storage water heaters, by about 1,880 GWh (an average of 118 GWh per year), or 8.7%, compared with the continuation of labelling at the current level;

- it is projected that the enhancement and extension of labelling would reduce the CO_2 emissions from the electricity consumption of appliances now labelled, and storage water heaters, by about 26.5 Mt (an average of 1.7 Mt per year), or 8.7%, compared with the continuation of labelling at the current level;

- the abandonment of labelling (the NL scenario) would forego potential energy savings of 2,780 GWh (an average of 174 GWh per year), and result in 12.5% higher energy consumption of new appliances sold between 1997 and 2012, than under the EL scenario;

- the abandonment of labelling (the NL scenario) would forego potential CO2 emission reductions 39.3 Mt (an average of 2.5 Mt per year), and result in 12.4% higher emissions from the electricity consumption of new appliances sold between 1997 and 2012, than under the EL scenario.

These estimates are unaffected by the discount rate chosen.

Table 14 Business as Usual, No Labelling and Enhanced Labelling Scenarios, 0% Discount Rate

	BAU	No labelling	Enhanced labelling	No labelling cf BAU	Enhanced labelling cf BAU	Enhanced cf No labelling
Lifetime energy (GWh)	21,266	22,159	19,382	+893	-1,883	-2,776
Lifetime CO_2 (Mt)	30.5	317.3	278.0	+12.8	-26.5	-39.3
% Difference on CO_2				+4.2%	-8.7%	-12.4%
NPV, Energy costs (1)	32,658	34,259	29,780	+1,610	-2,878	-4,488
NPV, Appliance costs	30,213	30,082	31,120	-131	+907	+1,038
NPV, Labelling costs	83	0	94	-83	+12	+94
NPV, Total	62,954	64,350	60,994	+1,396	-1,960	-3,356
% Differences in NPV				+2.2%	-3.1%	-5.3%

(1) NPV is net present value in $ million (1996 values), 0% discount rate

Table 15 Business as Usual, No Labelling and Enhanced Labelling Scenarios, 6% Discount Rate

	BAU	No labelling	Enhanced labelling	No labelling cf BAU	Enhanced labelling cf BAU	Enhanced cf No labelling
Lifetime energy (GWh)	21,266	22,159	19,382	+893	-1,883	-2,776
Lifetime CO_2 (Mt)	304.5	317.3	278.0	+12.8	-26.5	-39.3
% Difference in CO_2				+4.2%	-8.7%	-12.4%
NPV, Energy costs (1)	14,574	15,161	13,477	+587	-1,097	-1,684
NPV, Appliance costs	18,575	18,521	19,052	-54	+477	+531
NPV, Labelling costs	51	0	58	-51	+7	+58
NPV, Total	33,200	33,682	32,587	+482	-613	-1,095
% Differences in NPV				+1.5%	-1.8%	-3.3%

(1) NPV is net present value in $ million (1996 values), 6% discount rate

Table 16 Business as Usual, No Labelling and Enhanced Labelling Scenarios, 8% Discount Rate

	BAU	No labelling	Enhanced labelling	No labelling cf BAU	Enhanced labelling cf BAU	Enhanced cf No labelling
Lifetime energy (GWh)	21,266	22,159	19,382	+893	-1,883	-2,776
Lifetime CO_2 (Mt)	304.5	317.3	278.0	+12.8	-26.5	-39.3
% Difference in CO_2				+4.2%	-8.7%	-12.4%
NPV, Energy costs (1)	11,538	11,972	11,716	+434	-823	-1,256
NPV, Appliance costs	16,132	16,092	16,524	-40	+392	+432
NPV, Labelling costs	44	0	51	-44	+6	+51
NPV, Total	27,715	28,064	27,290	+349	-424	-774
% Difference in NPV				+1.3%	-1.5%	-2.8%

(1) NPV is net present value in $ million (1996 values), 8% discount rate

Table 17 Business as Usual, No Labelling and Enhanced Labelling Scenarios, 10% Discount Rate

	BAU	No labelling	Enhanced labelling	No labelling cf BAU	Enhanced labelling cf BAU	Enhanced cf No labelling
Lifetime energy (GWh)	21,266	22,159	19,382	+893	-1,883	-2,776
Lifetime CO_2 (Mt)	304.5	317.3	278.0	+12.8	-26.5	-39.3
% Difference in CO_2				+4.2%	-8.7%	-12.4%
NPV, Energy costs (1)	9,280	9,605	8,654	+325	-626	-951
NPV, Appliance costs	14,144	14,115	14,469	-29	325	+354
NPV, Labelling costs	39	0	45	-39	6	+45
NPV, Total	23,463	23,720	23,167	257	-296	-553
% Differences in NPV				+1.1%	-1.3%	-2.3%

(1) NPV is net present value in $ million (1996 values), 10% discount rate

Tables 18 summarises the monetary costs and benefits of abandoning labelling, at various discount rates. In the NL scenario, purchasers of new appliances between 1997 and 2012 would save $ 131 M in appliance costs and $ 83 M in labelling costs (including government administration and promotion costs). However, they would incur an additional $ 1,690 M in energy costs, so would be nearly $ 1,400 M worse off as a result of the abandonment of labelling. This amounts to a 2.2% cost penalty (undiscounted) on the total costs of ownership of that group of appliances.

At a 6% discount rate the penalty (in 1996 $) is $ 482 M (1.5%), at 8% discount rate it is $ 349 M (1.3%) and at 10% discount rate it is $ 257 M (1.1%).

Table 18 Projected Cost Impacts of Abandoning Labelling

	0 % Discount		6 % Discount		8 % Discount		10 % Discount	
	$M	% of BAU	$M	% of BAU	$M	% of BAU	$M	% of BAU
Energy cost	+1,610	+4.9%	+587	+4.0%	+434	+3.8%	+325	+3.5%
Appliance cost	-131	-0.4%	-54	-0.3%	-40	-0.2%	-29	-0.2%
Labelling cost	-83	-100%	-51	-100%	-44	-100	-39	-100
Total costs	+1,396	+2.2%	+482	+1.5%	+349	+1.3%	+257	+1.1%

Source: Tables B9 to B16. All $ values are NPV at 1996.

Tables 19 summarises the monetary costs and benefits of enhancing labelling, at various discount rates. In the EL scenario, purchasers of new appliances between 1997 and 2012 would spend an extra $ 907 M in appliance costs and $ 12 M in labelling costs (including government administration and promotion costs). However, they save nearly $ 2,880 M in energy costs, so would be $ 1,960 better off as a result of the enhancement of labelling. This amounts to a 3.1% cost saving (undiscounted) on the total costs of ownership of that group of appliances.

At a 6% discount rate the saving (in 1996 $) is $ 603 M (1.8%), at 8% discount rate it is $ 424 M (1.5%) and at 10% discount rate it is $ 296 M (1.3%).

Table 19 Projected Cost Impacts of Enhancing Labelling

	0 % Discount		6 % Discount		8 % Discount		10 % Discount	
	$M	% of BAU	$M	% of BAU	$M	% of BAU	$M	% of BAU
Energy cost	-2,878	-8.8%	-1,097	-7.5%	-823	-7.1%	-626	-6.7%
Appliance cost	+907	+3.0%	+477	+2.6%	+392	+2.4%	+325	+2.3%
Labelling cost	+12	+14.2%	+7	+14.3%	+6	+14.3%	-6	+14.3%
Total costs	-1,960	-3.1%	-613	-1.8%	-424	-1.5%	-296	-1.3%

Source: Tables B9 to B16. All $ values are NPV at 1996.

The potential benefits of enhancing labelling appear to be somewhat greater than the potential costs of abandoning it. If labelling were abandoned both groups of benefits would be foregone. The total value of benefit foregone would be then be $ 3,380 M (undiscounted), or a 5.3% saving on the total costs of ownership of that group of appliances. At a 6% discount rate the saving (in 1996 $) is $ 1,095 M (3.3%), at 8% discount rate it is $ 774 M (2.8%) and at 10% discount rate it is $ 553 M (2.3%).

4.2 Impacts by State and Territory

The impacts on each State and Territory vary with local electricity tariffs, CO_2-intensities, climate and appliance usage factors. Table 20 summarises the energy, CO_2 and cost impacts (at 8% discount rate).

Table 20 Projected Impacts of Abandoning Labelling, by Jurisdiction

	Energy impact GWh	CO_2 impact Mt	NPV, energy cost $M (a)	NPV, appliance cost $M (a)	NPV, labelling cost $M (a)	NPV, total cost $M (a)
NSW	+ 286	+ 3.7	+ 140	- 12.4	- 13.6	+ 116
Victoria	+ 213	+ 4.0	+ 115	- 9.1	- 10.4	+ 97
Queensland	+ 170	+ 2.4	+ 68	- 4.8	- 6.6	+ 57
WA	+ 98	+ 1.5	+ 52	- 5.8	- 4.7	+ 42
SA	+ 87	+ 1.1	+ 45	- 6.6	- 5.1	+ 34
Tasmania	+ 18	0	+ 4.9	- 0.4	- 0.8	+ 3.9
NT	+ 7	+ 0.1	+ 3.7	- 0.2	- 0.3	+ 3.3
ACT	+ 14	+ 0.2	+ 4.9	- 0.6	- 0.7	+ 3.8
Commonwealth	-	-	-	-	- 2.1	- 2.1
	+ 893	+ 12.8	+ 434	- 40	- 44	+ 349

(a) In 1996 $, at 8% discount rate

The abandonment of labelling would lead to a rise in CO_2 emissions in all States and Territories (except Tasmania). The greatest increase would be in Victoria - close to 4 million tonnes additional emissions in the period 1997 to 2102 - followed by NSW.

If labelling were abandoned appliance purchasers in all jurisdictions would be substantially worse off. At 8% discount rate, the NPV of the increase in energy costs would be over 5 times as great as the savings from reduced appliance and labelling costs. (Note that in all States and Territories, industry and consumer costs account for more than five sixths of "labelling costs", and administration and promotional costs for the balance. Commonwealth labelling costs consist only of administration and promotion costs). The results are still

Conversely, appliance purchasers in all jurisdictions would be substantially better off through the enhancement of labelling. Table 21 indicates the costs and benefits at 8% discount rate.

Table 21 Projected Impacts of Enhancing Labelling, by Jurisdiction

	Energy impact GWh	CO_2 impact Mt	NPV, energy cost $M (a)	NPV, appliance cost $M (a)	NPV, labelling cost $M (a)	NPV, total cost $M (a)
NSW	- 605	- 7.8	- 268	+ 128	+ 1.8	-139
Victoria	- 397	- 7.4	- 196	+ 89	+ 1.0	-107
Queensland	- 413	- 5.9	- 145	+ 82	+ 1.1	- 63
WA	- 187	- 2.8	- 99	+ 39	+ 0.3	- 61
SA	- 165	- 2.1	- 78	+ 35	+ 0.3	- 42
Tasmania	- 67	0	- 17	+ 10	+ 0.2	- 6.6
NT	- 19	- 0.2	- 10	+ 3.2	+ 0.1	- 6.4
ACT	- 30	- 0.4	- 10	+ 6.1	+ 0.1	- 3.4
Commonwealth	-	-	-	-	+ 1.6	- 1.6
	- 1883	- 26.5	- 823	+ 392	+ 6.3	- 424

(a) In 1996 $, at 8% discount rate

4.3 Impacts by Appliance

It is also possible to analyse the impact on each appliance type of changes in the labelling program. Table 22 indicates the impact of the abandonment of labelling, with NPVs calculated using 8% discount rate. (Note that there is no impact on water heaters, since they are not labelled in the Business as Usual or the No Labelling scenarios). Refrigerators and freezers would account for over 52% of the energy penalty from abandoning labelling.

Table 22 Projected Impacts of Abandoning Labelling, by Appliance

	Energy impact GWh	% of total energy impact	CO_2 impact Mt	NPV (a) energy cost $M	NPV (a) appliance cost $M	NPV (a) labelling cost $M	NPV (a) total cost $M	% of total NPV Change
Refrigerators	+ 410	45.9 %	+ 5.9	+ 208	+ 27	-5.5	+229	65.0 %
Freezers	+ 57	6.4 %	+ 0.8	+ 29	+ 3	-1.0	+31	10.3%
Dishwashers	+ 57	6.4 %	+ 0.8	+ 26	+2	-3.4	+24	7.0%
Clothes dryers	+ 86	9.6 %	+ 1.2	+ 40	- 8	-3.1	+28	8.1%
Clothes washers	+ 144	16.1 %	+ 2.1	+ 66	- 28	-8.6	+29	8.2%
Air Con (R/C)	+ 114	12.8 %	+ 1.6	+ 53	-25	-9.6	+19	5.4%
Air Cond (Cool)	+ 27	3.0 %	+ 0.4	+ 13	-10	-4.9	-2	-0.5%
Water H (Cont)	0	0	0	0	0	0	0	0
Water H (OP)	0	0	0	0	0	0	0	0
	+ 893	100%	+ 12.8	+434	-40	- 44 (b)	+349	100%

(a) In 1996 $, at 8% discount rate (b) Includes $ 8.2 M saving in administration and promotion costs not assigned to any specific appliance

The table also indicates that the average price of refrigerators, freezers and dishwashers would *increase* if labelling were abandoned. This is a consequence of the assumption that the price/efficiency ratio is lower in the BAU (and EL) scenarios than in the NL scenario: ie that the existence of an effective labelling regime promotes competition with regard to product energy efficiency, and so constrains the additional costs of further efficiency improvements. The converse of this assumption is that the removal of the competitive factor of labelling allows prices to rise (at very low rates of annual change in efficiency). While the extent of the rise may be less than indicated for refrigerators etc in Table 22, it reasonable to conclude that the *removal* of labelling would probably have minimal impact on the purchase price of appliances. If so, the cost penalties of abandoning labelling would be even greater than projected here, since the offsetting saving from the expectation that appliances would become somewhat cheaper (by a total of $40 M NPV, as in Table 22) may in fact be much less.

If however labelling were enhanced, then the pressure for higher levels of efficiency is likely to lead to some increase in average prices in all appliances, for the technical reasons discussed earlier in this report. Table 23 shows the energy and cost impacts for each appliance type of enhancing the labelling program.

Refrigerators and freezers would account for nearly half the energy and CO2 benefits of program enhancement, and nearly 60% of the value of energy cost savings. The value of program enhancement appears worthwhile for clothes dryers, clothes washers and reverse cycle air conditioners, but for dishwashers and cooling-only air conditioners it is marginal (ie for those products the present level of labelling is returning a high proportion of the potential net benefit).

For water heaters, it is projected that enhanced labelling would produce considerable energy and CO_2 savings: in fact over 30% of the savings from program enhancement. (This is due partly to the concentration of off-peak sales in high CO_2 states).

However, the costs of including water heaters in the labelling program are significant. There would be new industry/consumer labelling costs, which would not be incurred for appliance already labelled. There would also be significant additional product costs, especially for OP water heaters, since these would already be at a MEPS level of 70% of current heat loss. Furthermore, the value of energy savings for OP water heaters is much lower than for continuous types. Consequently, as Table 23 shows, OP water heater are the only appliance group for which enhanced labelling appears not to be cost-effective.

Table 23 Projected Impacts of Enhancing Labelling, by Appliance

	Energy impact GWh	% of total energy impact	CO_2 impact Mt	NPV (a) energy cost $M	NPV (a) appliance cost $M	NPV (a) labelling cost $M	NPV (a) total cost $M	% of total NPV Change
Refrigerators	- 808	42.9%	-11.6	-433	+206	0	-227	53.5%
Freezers	- 111	5.9%	-1.6	-59	+23	0	-36	8.4%
Dishwashers	- 51	2.8 %	-0.7	-26	+24	0	-2	0.4%
Clothes dryers	- 78	4.1%	-1.1	-40	+9	0	-31	7.3%
Clothes washers	- 133	7.1%	-1.9	-61	+28	0	-33	7.8%
Air Con (R/C)	- 105	5.6%	-1.5	-50	+25	0	-25	5.8%
Air Cond (Cool)	- 25	1.3%	-0.4	-12	+10	0	-2	0.5%
Water H (Cont)	- 268	14.2%	-3.2	-98	+19	+1.4	-77	18.2%
Water H (OP)	- 305	16.2%	-4.4	-46	+48	+1.8	+5	-1.2%
	- 1883	100%	-26.5	-823	+392	+6.3 (b)	-424	100%

(a) In 1996 $, at 8% discount rate (b) Includes $ 3.1 M additional expenditure on administration and promotion costs not assigned to any specific appliance

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