Retrospective Analysis of the Impacts of Energy Labelling and MEPS: Refrigerators and Freezers

Prepared for

The Australian Greenhouse Office: Equipment Energy Efficiency Program

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Executive Summary

Refrigerators and freezers are among the most common household appliances. Refrigerators and freezers are estimated to be responsible for nearly 17% of all greenhouse gas emissions in 2000 as a result of residential use of energy. As they are in continuous operation, they make a significant contribution to total household energy consumption wherever they are present.

In order to increase the energy efficiency of refrigerators and freezers, mandatory appliance labelling was introduced in late 1986 followed by the introduction of Minimum Energy Performance Standards (MEPS) in October 1999, which was followed by more stringent MEPS in January 2005.

The anticipated impacts of the introduction of the MEPS were projected/forecasted before the introduction of the MEPS policy options. Government decisions to implement energy efficiency programs are usually based on these estimates of the reduction in energy consumption that programs are expected to achieve, and the impact on product costs. The benefits (i.e. the value of the energy reductions) and costs of such programs are usually expressed as the difference between a 'Business as Usual' (BAU) projections and a 'with-measures' projections.

These projections are rarely reviewed after the fact. In 2005, the Productivity Commission completed an inquiry in Energy Efficiency (PC 2005) gave considerable attention to MEPS. One recommendation from this inquiry was to evaluate the impacts of the policies that have been implemented. Hence the objective of this study is to estimate the energy saving impacts from the MEPS and labelling of refrigerators and freezers, and provide a comparison with the projections made before the policy was implemented.

Objectives/ Scope of the Study

The study examines the attributes of new household refrigerators, refrigerator-freezers and freezers purchased in Australia from the early 1980s (before labelling commenced) to 2005. Following this Australian study, the UK government is intending to replicate the analysis to enable comparison of results across differing regions. It is hoped that the methodology developed will provide the basis for additional analyses in other countries.

The Australian and UK programs were implemented as follows:

Policy Option	Australia	UK (EU Program)
Mandatory energy labelling starts	1986	1994
MEPS take effect (first round)	1999	1999

In addition, due to the availability of 2005 data during 2006, the Australian study scope was expended to include an investigation of the impact of MEPS 2005. The overall aim of this study is to:

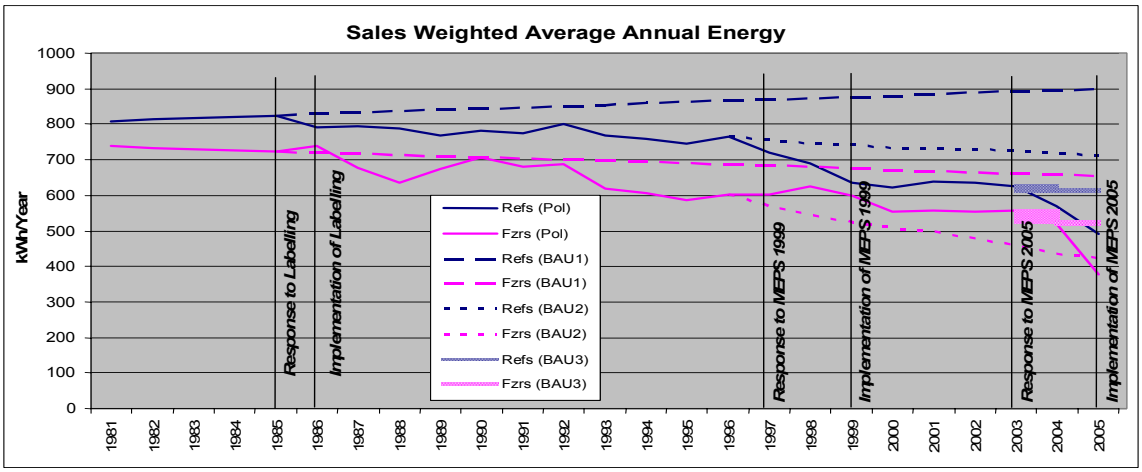
- collect and analyse the relevant product attribute data accumulated prior to and since refrigerator and freezer energy programs were implemented;
- compare the post implementation findings with the pre-program estimates of energy impacts, benefits and costs;
- identify, to the extent possible, unforseen impacts on attributes such as price, volume, whether beneficial or adverse;
- make recommendations:
    - regarding future modelling;
    - on the practicality of undertaking retrospective studies.

The methodology used to meet the aims of the study combined the reliable data sources of GfK sales data from 1993 and labelling registration data from 1986.

Results – Overview

Many results have been presented in graphical form. In order to assist reader with appreciating the impact of introduction of labelling, MEPS 1999 and/or MEPS 2005 vertical lines on the graphs have been used as markers. It has been widely accepted that, since the concept of regulations is communicated to the industry many years before the implementation date, suppliers generally respond by introducing changes to their products well before the actual date of implementation of such regulations. This is generally desirable to ensure that the products meet compliance criteria by the time of introduction of the actual regulation. Such responsiveness is noticeable nearly 1-3 years before the implementation date of a regulation, when the actual consultation process may have taken several years.

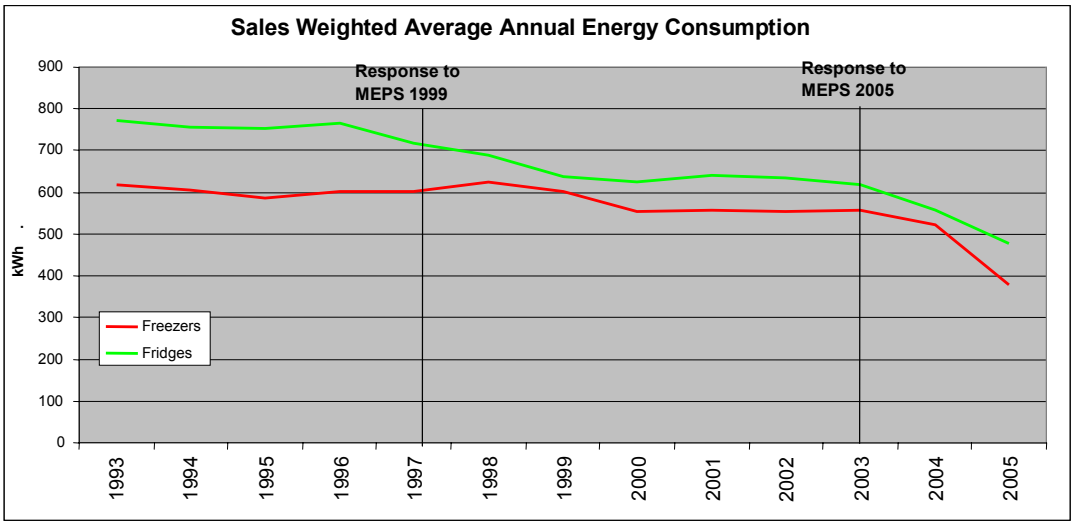
Consequently 6 markers could have been used as shown the following figure to conceptualise impacts of regulations on changing patterns;



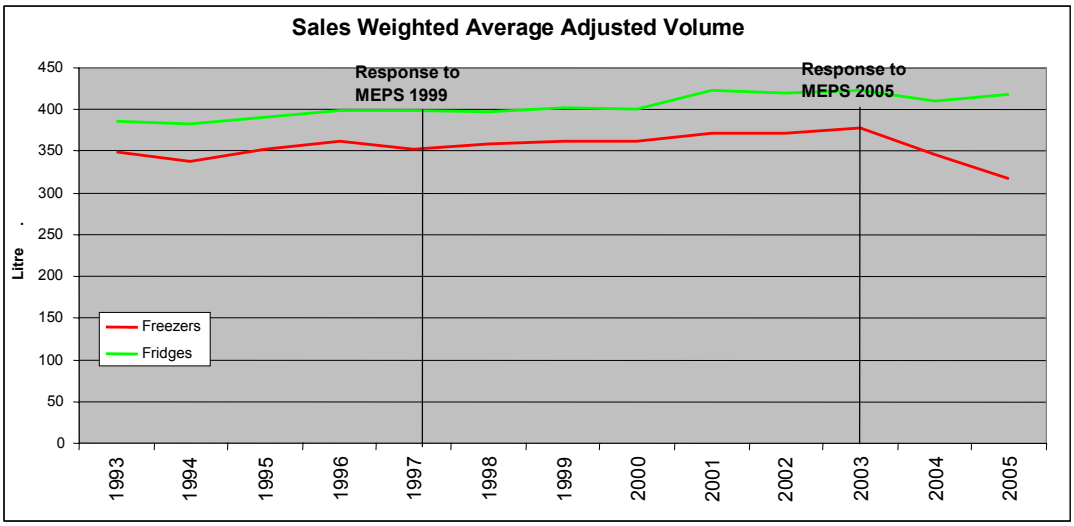
As the early response of suppliers produces changes in the market, it also produces impacts of the regulation before its implementation; hence we have used 3 markers that correspond to suppliers response to the regulations rather actual date of implementation. The graphical results presented in this report show two of these markers (***Response to MEPS 1999*** and ***Response to MEPS 2005***) as the indicator of responsiveness to the impending regulation, and on changing trends.

Results – Average Energy, Volume & Price Attributes

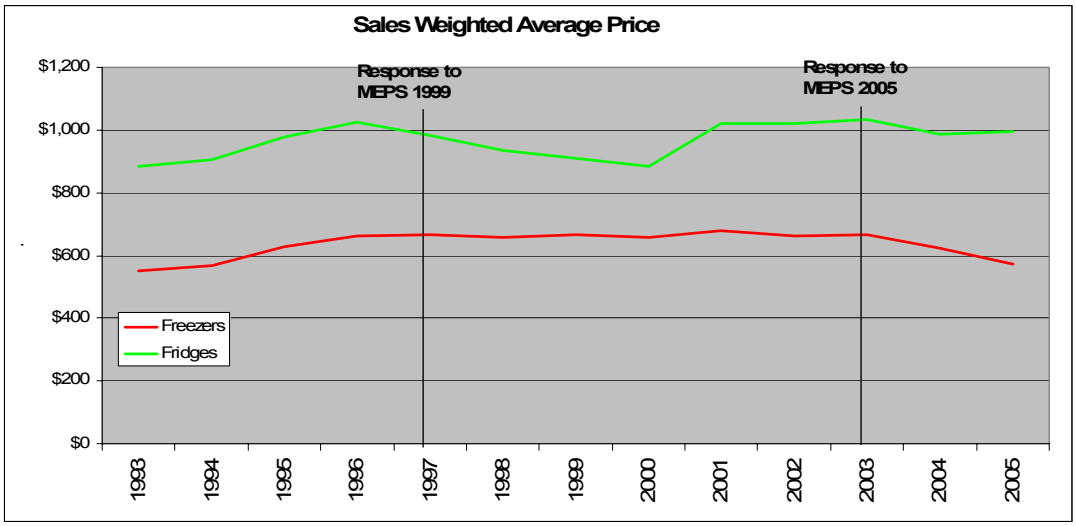
The figure following shows the trends of *sales weighted* average annual energy consumption of all refrigerators and all freezers. The trend analysis provides a strong indication of the effects on annual energy consumption of refrigerators and freezers of the implementation of two rounds of MEPS in 1999 and 2005. The response to the 2005 MEPS was substantial.



Although some individual groups have shown a decline in average size (adjusted volume), the sales weighted analysis performed on all refrigerator groups combined, as illustrated in the following figure, suggests that there has been a consistent gradual increase in the average adjusted volumes of refrigerators (including refrigerator-freezers). In contrast for freezers, there was a slightly upward trend in average adjusted freezer volumes over the period between 1997 and 2003, followed by sharp decline since 2003. This apparent volume decline is due to a surge in sales of small manual defrost freezers in 2004 and 2004 rather than a change in the sales trend of other types of freezers. The important conclusion of this analysis is that volume trends for refrigerators and freezers have been largely unaffected by regulatory programs such as energy labelling and MEPS, which is expected. Some of the increase in average volume for refrigerators is driven by the change in share of refrigerator group. The volume anomaly for freezers in 2004 and 2005 is unrelated to MEPS and appears to be driven by other factors (EES 2006).



The average price of refrigerators is illustrated in the following figure. The analysis presented in this study suggests that neither MEPS 1999 nor MEPS 2005 has affected the price of refrigerators. In the RIS for MEPS 2005 (GWA 2001), a price increase of 1.6 to 8% is assumed to occur due to the introduction of MEPS 2005. This retrospective analysis has found no evidence of such a price increase.



The variations in market price do not appear to be in direct response to the introduction of MEPS 1999 and MEPS 2005 because of the following reasons;

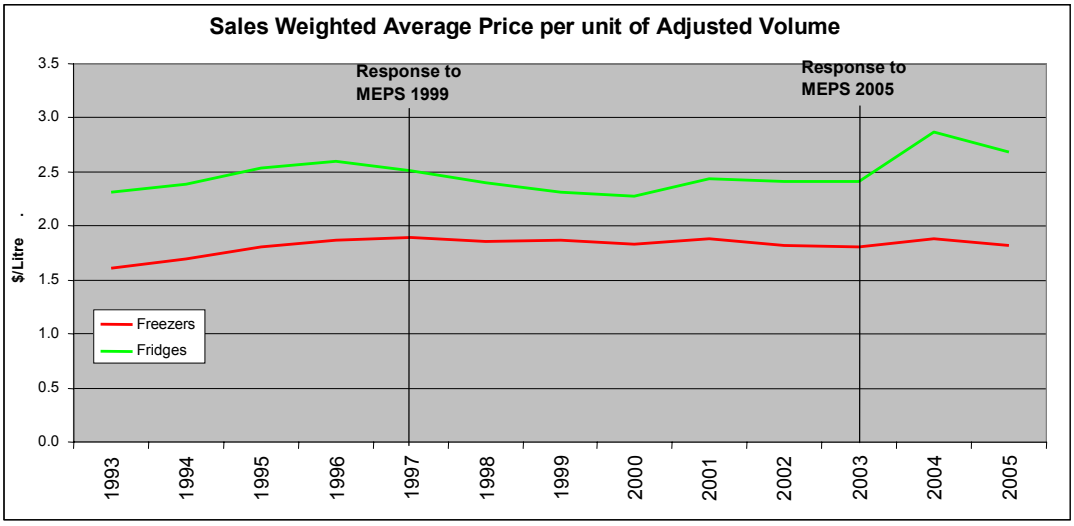
a. The changes in price trends do not appear around the years of perceived responsiveness to the introduction of the two MEPS (1997 for MEPS 1999 and 2003 for MEPS 2005)

b. The changes in price trends also do not appear in and immediately after the years of introduction of the two MEPS. The average price increase of

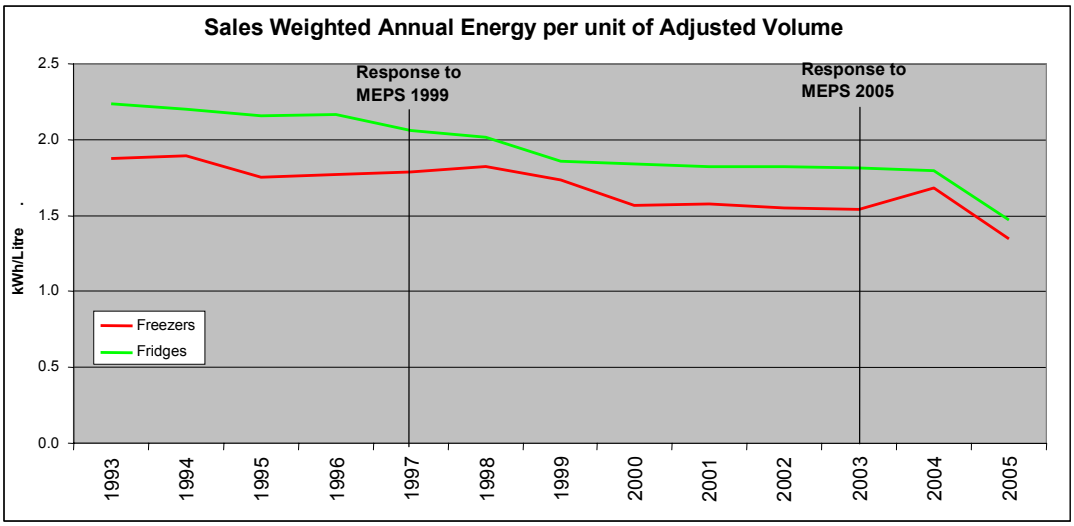
about 14% in year 2001 is likely to be due to the increase in sales of high priced Group 5S machines.

It is also important to note that these prices are actual prices paid by consumers for more than 90% of all refrigerators and freezers sold in Australia in nominal dollars (no correction for inflation). So real prices for refrigerators and freezers are continuing to decline despite increases in average volume, larger share of frost free product on the market and massive reductions in energy consumption, particularly in the lead up to MEPS 2005.

The following figure shows the changes in standardised price of refrigerators (price divided by adjusted volume) from 1993 to 2005. The changes in standardised price can not be directly attributed to the introduction of MEPS 1999 or MEPS 2005. The increase in price per unit of adjusted volume in 2004 is due to the price increases of Group 2 machines rather than the affect of MEPS 2005. It is important to note that following the perceived year of responsiveness of MEPS 1999 (1997) the standardised prices of refrigerators actually continued to decline for the next 3-4 years.

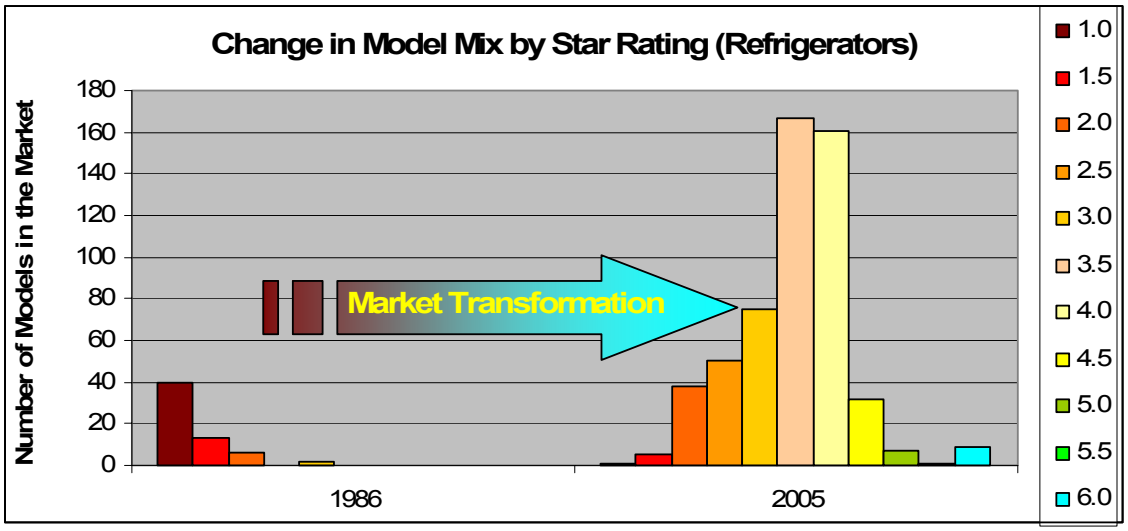


The sales weighted trends for the efficiency indicator, defined as average annual energy consumed per unit of adjusted storage volume, show consistent efficiency improvements since the introduction of labelling in 1986 and two rounds of MEPS in 1999 and 2005.



As a qualitative measure of the impact of the labelling and MEPS policies, the following figure broadly illustrates the refrigerator market transformation between the years 1986 and 2005 by comparing number of models by star rating available in these years. There are many more models available in 2005 and on average these are twice as efficient.

Illustration of Refrigerator Market Transformation between the years 1986 and 2005 (all ratings using 2000 energy label algorithm)



Results – Energy Savings and Comparison with Projected

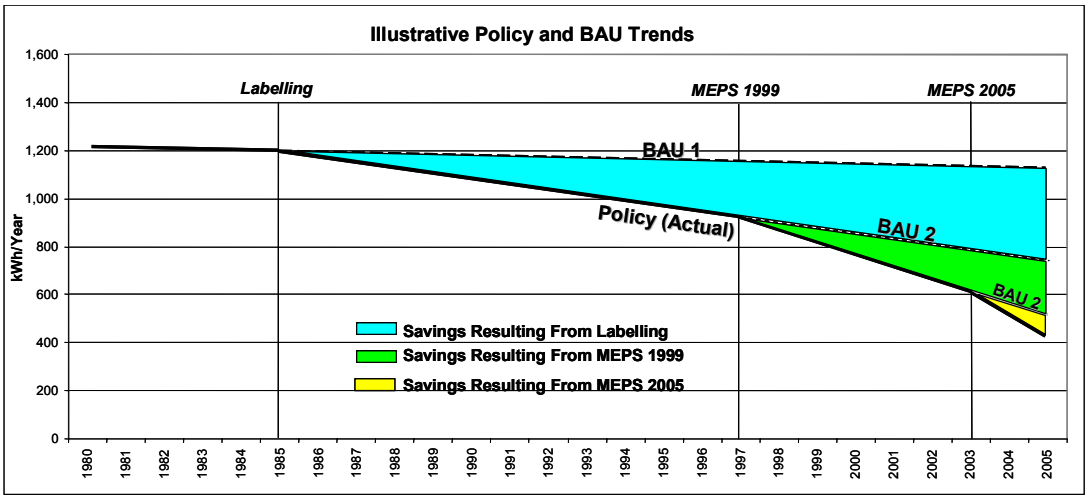
The estimated actual impacts were found to be 38% above the projected MEPS 1999 impacts over the 9 years from 1997. The estimated actual impacts of MEPS 2005 were

found to be approximately 18% below the projected impacts over the 2 years of 2004 and 2005.

Overall, the actual impacts from MEPS 1999 and MEPS 2005 were 34% above the forecasted impacts. The projected impacts from Energy Labelling were not available; hence they can not be compared to the actual estimated savings.

The energy savings resulting from three regulatory options were estimated separately based on the assumption that a policy implementation changes the previous trend and sets a new trend so that the pre-policy trend becomes BAU trend and post policy trend becomes the policy trend. However, when a new policy is implemented in addition to previous policy or as a replacement of older policy, the previous policy trend becomes BAU trend and the policy trend is determined by the new values. Hence the resulting savings for each policy implementation can be estimated separately as illustrated in following figure. As can be seen from the figure, the savings are a function of difference between the policy (actual) value and the BAU for a given year. Hence, the savings due to implementation of labelling between the period 1986 and 1997 can be estimated simply as a function of difference between the policy and BAU1 values. However, the savings due to labelling between 1997 and 2003 are the function of Policy – BAU1 – BAU2, where as the savings due to MEPS 1999 for the same period would be Policy – BAU2.

Illustrative example of separation of savings resulting from 3 policy implementations

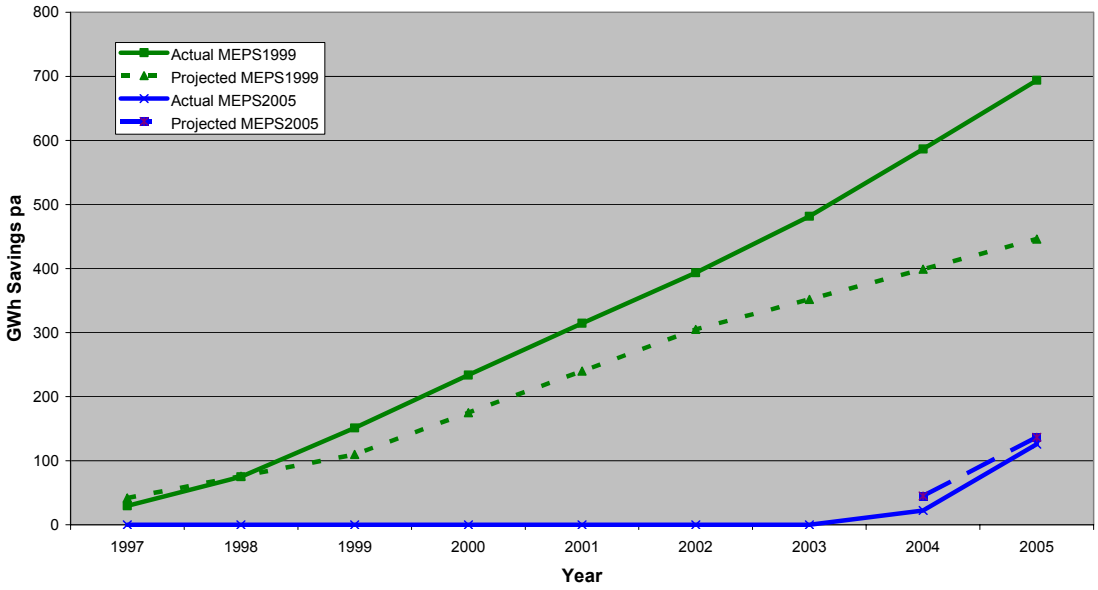


Energy Labelling is estimated to have provided over 7,000 GWh in cumulative total energy savings since the mandatory requirements were introduced in 1986.

The actual estimated impacts were found to be greater than the projected impacts for MEPS 1999, however this would be expected. The analysis and projections undertaken in the RIS are generally conservative due to the uncertainties associated with usually limited data and various assumptions that are required. These unknown attributes are typically shown as scenarios or the most conservative values are used to ensure that assessments of costs/benefits can be easily met when challenged.

The actual estimated impacts for MEPS 2005 are early in developing but appear to be tracking well with the projected impacts, even though there are only 2 years of data points. The RIS for MEPS 2005 assumed implementation Oct 2004 whereas the actual date was 1 Jan 2005. This could explain part of the difference between projected and actual results.

Comparison of Actual and Projected Energy Savings from MEPS



Conclusions

The following conclusions are based on the detailed results of this study:

1. **Projections made in Regulatory Impact Statements are relatively accurate for this product group.** The projections made in the two domestic refrigerator Regulatory Impacts Statements have largely been supported by the findings of this retrospective analysis. The original estimates were based on conservative assumptions resulting in more modest impacts being predicted but they remain robust economic analyses upon which Ministers took informed decisions at the time. They underestimated the benefits or impacts of the two regulations which, with the benefit of hindsight, should have been expected because low-end assumptions were used as a means of garnering widespread stakeholder support for the regulatory proposals.

2. **Future RIS impacts and benefit cost analysis should be conservative** - Future projections in Regulatory Impact Statements should continue to adopt assumptions in accord with the "worst case scenario" based on plausible but conservative assumptions. For example, the findings on pricing establish little evidence exists to support the plausible assumption that more efficient products should result in higher prices. Over the seven year period studied in detail, no

correlation between efficiency and price could be established from the data leading to a conclusion that the improved efficiency of domestic refrigerators and freezers was delivered by a competitive market to the consumer at no real cost increase. This conclusion, however, should not lead to future economic analysis predicting a similar outcome, far from it. The assumption of a 1.6% to 8% increase in product prices was reasonable and should, in all probability, be used in any future regulatory impact statement associated with this product

3. **Prices did not to increase after the implementation of MEPS for refrigerators**. Evidence from the implementation of MEPS 1999 for refrigerators shows no impact on price. This was true even for MEPS 2005 which had a substantial energy impact on new products. However, this does not mean that efficiency levels can be increased indefinitely with no impact on industry or prices. However, it does demonstrate that new efficiency standards which are within the realms of current technological limits can be introduced at almost no marginal cost where industry has sufficient notice of the requirements and time to plan their transition in an orderly fashion. It is important to note that while MEPS 2005 levels were very stringent (almost no products on the market in 2000 met the levels when they were first announced), the levels had been adopted for implementation in the USA and they were technically feasible using only existing technologies.

4. **Projected impacts from MEPS often occur earlier than anticipated.** Timing of projected impacts should consider the fact that industry typically responds some years before a new regulatory requirement takes effect. While registrations occur well ahead of any new regulatory requirements, the sales volume of such products can be slower to reach the market. However this effect should be considered on a product by product basis, as the lead time for response is highly dependent on the level of stringency of the MEPS, sales volume, product life and the adaptive nature of the industry.

5. **Limitations of this type of study depend on data**. This type of retrospective analysis can only be confidently undertaken where detailed information is available about the product and marketplace (e.g., model energy usage, sales data and product performance data is available) and agreement is reached on the methodology of the study. The methodology used in this study will be shared with other nations with a view to developing a robust methodology suitable for use in any developed economy for any given product.

6. **Possible new CoAG Guideline** - When a methodology is determined after comparable studies in other economies, jurisdictions should consider proposing it to the Council of Australian Governments as a candidate for a future guideline to benchmark regulatory impact analyses undertaken to support nationally-consistent rule making

7. **Alternative methodologies may provide useful insights** - Based on the comparative findings for this product, scope exists to use a model-weighted

approach as a simple retrospective analysis tool, especially given the difficulties and cost associated with attempting sales weighted analysis (where the data does not exist). This more affordable methodology could provide some timely comparisons from which to broadly compare pre and post regulation impacts. Jurisdictions should consider commissioning further work in this field. Product energy and performance characteristic data is required for retrospective analysis. The data is usually contained in registration databases associated with energy efficiency programs and includes energy performance test results, model identification, size/price and other attributes. The obvious limitation is that a full estimate of market impact for a new energy program is more difficult for a product that has not previously been regulated as good market data at a model level is usually difficult to obtain (as well as attributes of each model).

8. **Repeat this study in 3 years** - A further retrospective analysis should be undertaken in 3 years (i.e., so a decade of sales data is used) to benchmark developments in this product which would also potentially verify the early trends for MEPS 2005 and validate the on-going projected energy savings. This work might address the volatility seen in the annual sales figures for some product types.

1 Introduction

Refrigerators and freezers are among the most common household appliances. Refrigerators and freezers are estimated to be responsible for nearly 17% of all greenhouse gas emissions in 2000 as a result of residential use of energy. The installed stock of refrigerators in the residential sector is 9.8 million and for freezers 3.2 million (GWA 2001).

In order to increase the energy efficiency of refrigerators and freezers, mandatory appliance labelling was introduced in 1986 followed by the introduction of Minimum Energy Performance Standards (MEPS) in 1999, which was followed by more stringent MEPS in 2005.

The anticipated impacts of the introduction of the MEPS were projected/forecasted before the introduction of the MEPS policy options as part of the government Regulatory Impact Statement, which is required for any significant regulatory action. These forecasted impacts provided the very rationale for the introduction of the two MEPS. An examination of the trends of energy performance attributes of new refrigerators and freezers sold in Australia suggests a continued improvement in the energy performance of these machines as a result of the three policy measures.

Further evidence of the impact of the two policy options is obtained if the performance improvements in refrigerators and freezers is quantified and compared against the projections/ forecasts made prior to the introduction of the two policy options. Quantifying these performance improvements and comparing them to the original projections/forecasts is the focus of this report.

1.1 Background of Refrigerator/Freezer Energy Efficiency Trends

Government decisions to implement energy efficiency programs such as energy labelling and minimum energy performance standards (MEPS) are usually based on estimates of the reduction in energy consumption that the programs are expected to achieve, and the impact on product costs for consumers. The benefits (i.e. the value of the energy reductions) and costs of such programs are usually expressed as the difference between a 'Business as Usual' (BAU) projections and a 'with-measures' projections.

These projections are rarely reviewed after the fact. In 2005, the Productivity Commission completed an inquiry *"The Private Cost Effectiveness of Improving Energy Efficiency"* (PC 2005) which concluded that "…other mandatory measures — such as minimum performance standards — may not be privately cost effective", and it stated in relation to MEPS:

> *Notwithstanding these reservations, many ex ante assessments have alleged that MEPS can generate substantial savings in operating costs and net benefits overall for appliance users. But these assessments depend on what would have happened in the*

> *absence of MEPS, and this is largely unknowable. Clearly MEPS will have a dramatic effect when first introduced, but to the extent that they bring forward technological developments that would have occurred anyway, their effectiveness is limited.*

Hence, in this context, the aim of this study is to:

- collect and analyse the relevant product attribute data accumulated prior to and since refrigerator and freezer energy programs were implemented;
- assess the accuracy of the pre-program estimates of benefits and costs;
- make recommendations regarding future modelling;
- identify, to the extent possible, unforseen impacts on attributes such as price, volume, whether beneficial or adverse.

1.2 Scope of this Study

The study examines the attributes of new household refrigerators, refrigerator-freezers and freezers purchased in Australia from the early 1980s (before labelling commenced) to 2005. Following this Australian study, the UK government is intending to replicate the analysis to enable comparison of results across differing regions. It is hoped that the methodology developed will provide the basis for additional analyses in other countries.

The Australian and UK programs were implemented as follows:

Policy Option	Australia	UK (EU Program)
Mandatory energy labelling starts	1986	1994
MEPS take effect (first round)	1999	1999

The study was originally proposed in mid 2005. As this study and approach had never been undertaken before in Australia, the original aims were adapted to align with policy priorities and data availability. The original Terms of Reference (ToR) are shown in Appendix A. The study achieved the analysis described in the ToR including an exploration of the following trends:

- Sales-weighted BAU average energy consumption trend (kWh/yr), projected prior to program implementation
- Sales-weighted BAU energy efficiency trend (i.e. average kWh/yr moderated by changes in product volume or utility) projected prior to program implementation;
- Sales-weighted BAU average price trend, projected prior to program implementation;

- Sales-weighted average energy consumption and efficiency trends with labelling projected prior to the implementation of energy labelling;
- Sales-weighted average energy consumption and efficiency trends with labelling and MEPS, projected prior to the implementation of energy labelling;
- Actual sales-weighted energy efficiency trends monitored since program implementation (i.e. average kWh/yr moderated by changes in product volume or utility);
- Actual sales-weighted energy product price trends, moderated by changes in product volume or utility, monitored since program implementation;
- 'Revised' BAU trend (i.e. what would have happened in the absence of labelling or MEPS) taking into account factors and changes in the market not foreseen at the time the initial BAU projections were made.

In addition, due to the availability of 2005 sales data during 2006, the study scope was expended to include an investigation of the impact of MEPS 2005.

1.3 Product Categories Covered

This study covers virtually all categories of refrigerators and freezers used by residential consumers. Because sales are tracked through all major retailers in Australia, some proportion of the sales analysed will also be used in the commercial sector (primarily office kitchens and small hotels). The share of sales into this segment is unclear but is probably of the order of 5%. Some non retail sales of these types of products are also likely to be made to large corporate purchasers (eg developers and hotel chains), total sales through this channel are likely to be less than 10%.

Residential refrigerators and freezers are grouped on the basis of design of cabinet and, location and orientation of the freezer compartment. Table 1 shows the group classifications that are defined in the Australian/New Zealand performance standard for refrigerators and freezer – AS/NZS4474.1. All products sold into through retailers can be classified into one of these groups and this analysis has been the basis of this study.

Table 1: Commonly used types of Refrigerators and Freezers

Group Title	Description
Group 1	Single door, All Refrigerator, no internal frozen space
Group 2	Single door, All Refrigerator, with an internal ice making sub-compartment
Group 3	Single door, All Refrigerator, with short-term internal frozen food sub-compartment
Group 4	Two door, Cyclic Defrost Refrigerator, with separate freezer section/compartment
Group 5T	Two door, Vertical Refrigerator, Frost Free, with freezer compartment at Top
Group 5B	Two door, Vertical Refrigerator, Frost Free, with freezer compartment at Bottom
Group 5S	Two door, Vertical Refrigerator, Frost Free, with freezer compartment at Side
Group 6C	All freezer – Chest type
Group 6U	All freezer - Vertical cabinet type manual defrost
Group 7	All freezer - Vertical cabinet type frost free

1.4 Pre-Program Estimates of Impacts

Projections and estimates of the impact of a MEPS/Labelling program (typically cost/benefit and energy/greenhouse impacts) are usually undertaken before the implementation of the program as part of the Regulatory Impact Statement. These are the appropriate data sources for comparing the pre-program impact projections with the estimated actual impacts that were found by in this study. The two major reports used for pre-program projections were:

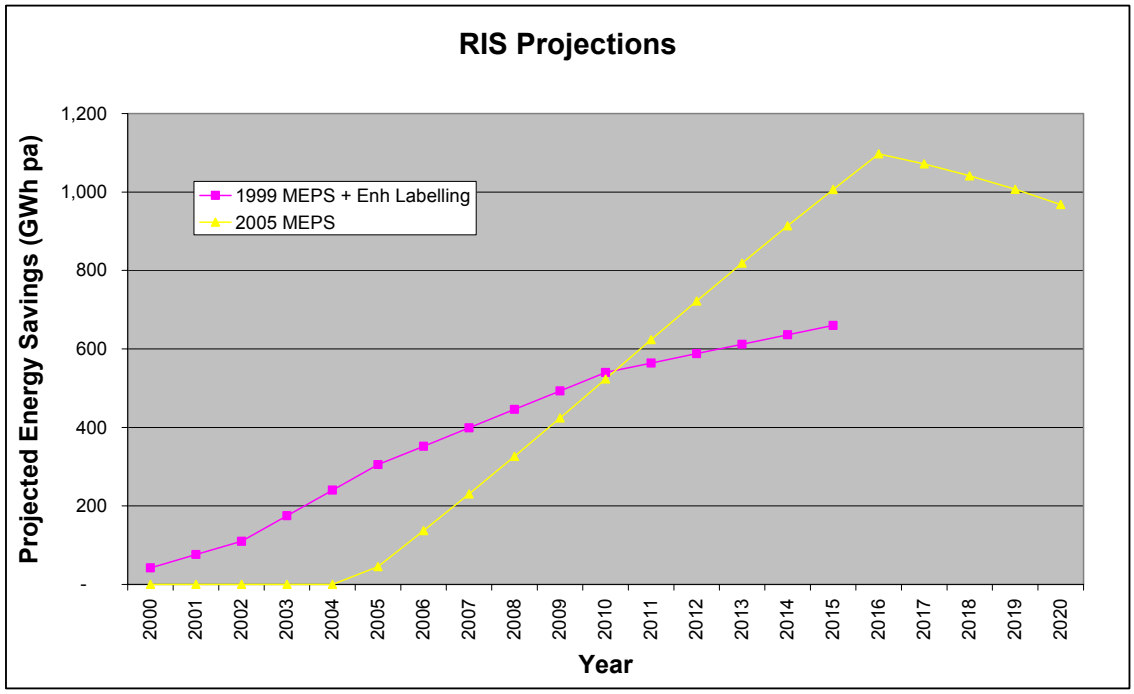
1999 MEPS: *Regulatory Impact Statement, Energy Labelling and Minimum Energy Performance Standards for Household Electrical Appliances in Australia.* George Wilkenfeld and Associates Pty Ltd with assistance from Energy Efficient Strategies Pty Ltd, Feb-1999

2005 MEPS: *Regulatory Impact Statement: Revised Minimum Energy Performance Standards for Household Refrigerators and Freezers.* George Wilkenfeld and Associates with Energy Efficient Strategies Draft For Public Comment, Aug-2001

Both of these documents are were widely circulated to stakeholders on their release and both have been available since their release through www.energyrating.gov.au in the electronic library.

Both these RIS's predicted significant energy savings from the implementation of MEPS for refrigerator and freezers, as shown in Figure 1.

Figure 1: Projections of Energy Savings from RIS



Source: Detailed spreadsheets used to calculate GHG impacts for MEPS based on RIS projections, Provided by GWA, Jul 2006

The savings from MEPS 1999 were predicted to start in 2000 and grow to over 600 GWh pa by 2015 and MEPS 2005 impacts were predicted to begin in 2005 with savings of over 1000 GWh pa by 2015, almost double the earlier MEPS. It is important to note that the original proposal was for the second round of MEPS to commence in October 2004. This was the date that was assessed in the RIS. However, due to a number of administrative reasons, mainly regarding compliance and date of manufacture, the date of implementation was moved back on a consensus basis with industry by 3 months to 1 January 2005.

Energy savings projections for Energy Labelling were not formally undertaken, either prior to or shortly after the launch of refrigerator/freezer labelling in 1986. Estimated or projected impacts were not required in the 1980s to implement this policy. Consequently no historical forecasts exist for comparison against the actual impacts of Energy Labelling as estimated in this study.

The source data for the economic study associated with the introduction of MEPS 1999, provided the combined forecasted impacts of MEPS 1999 and enhanced labelling. In 2000, the algorithms that are used to calculate the star ratings for refrigerators and freezers were modified – this was termed enhanced labelling. These modifications re-scaled the star ratings of all products and essentially raised the efficiency levels required to obtain stars in order to drive the market to higher efficiency levels.

Therefore, a comparison between the actual estimated impacts of MEPS 1999 and the forecast combined impacts of MEPS 1999 and enhanced labelling was possible.

Analysis of the impact of MEPS 2005 can be done with the data analysed to date (to the end of 2005 calendar year). The full impacts will not be evident until 2006 or beyond, so this should be reassessed again when more data is available. Sales data shows that some older stock (up to 10% of sales in 2005) are non complying models, which is permitted for products that were manufactured and registered prior to the MEPS implementation date.

2 Methodology

2.1 Review of similar studies

In order to establish a robust methodology a literature review was conducted of similar studies. This review informed the methodology and analysis techniques. The studies reviewed are shown in Appendix B, and included:

- "The Induced Innovation Hypothesis and Energy-Saving Technological Change" by Richard G. Newell, Adam B. Jaffe and Robert N. Stavins, 1998
- "Projecting the Impacts of Energy Programs: How Good Were the Estimates?" George Wilkenfeld, CLASP Asia Regional Symposium on Energy Efficiency Standards and Labelling, Bangkok May 2001.
- "Regulatory Impact Statement: Revised Minimum Energy Performance Standards for Household Refrigerators and Freezers", George Wilkenfeld and Associates with Energy Efficient Strategies August 2001
- "Review of Residential Appliance Energy Labelling for The State Electricity Commission of Victoria", George Wilkenfeld and Associates with Test Research and Artcraft Research, Final Report, September 1991.
- "Energy efficiency: The European manufacturers' achievements in year 2004". Luigi Meli - CECED director general, Tallin, July 6th 2005.
- "UK Market for A+ and A++ Refrigeration Products", Market Transformation Program, UK

These studies and papers show a wide range of approaches have been used for estimating program impacts. Most commonly the approaches provide analysis resulting in indications of efficiency gains rather than direct quantification of the energy impacts of the MEPS or Labelling programs. Overall, none of the studies could match the level of data and potential analysis that was available for the current study, which has data on 3000 models and 12 year of actual sales data with actual average retail price paid by consumers at a model level.

2.2 Methodology and Data Summary

2.2.1 Data

The final methodology used to conduct this study was determined after a review of the literature and several exploratory analyses with available data. The primary data available for the study included:

2. **Comprehensive GfK technical and supply data from 1993 to 2005.** The data comprised of make, model, group allocation, registration number, fresh food and freezer volumes, average annual energy consumption when tested under AS2572.2 (now AS/NZS 4474.2), number of units sold each year by each state, average unit price by each state. A report that analyses the results for all major household appliances is given in EES (2006).

3. **Appliance Labelling Registration Data:** This database was developed by and for energy regulators to provide a register of the details of all models of refrigerators and freezers sold in Australia, originally for the purpose of mandatory labelling but now also MEPS. The key data available in the database included; labelling registration number, brand, model, group allocation, fresh food volume, freezer volume, total volume, average annual energy consumption when tested under AS/NZS4474 (or previous test methods prior to 1997 as applicable), country of origin, date of registration, and star rating. In short, all data that is required to calculate the energy consumption and star rating for each product is recorded. The database also holds details of the registration holder, although this is not relevant to this study. The data covered the period from 1986 to 2005.

4. **Data Supplied by Australian Consumer's Association (ACA):** ACA provided printed copies of their test reports for various models of refrigerators and freezers for the period between 1975 and 2000. It is worth noting that ACA generally test only those machines that were of particular interest to its members and focus groups. This tends to focus on the most popular models and product types, although data on new technological developments (e.g. when frost free refrigerators were introduced) is also sometimes collected. The ACA data is useful as it provides a targeted snapshot of products prior to and after energy labelling was introduced. As they tend to focus of refrigerators suitable for families, some product categories are not covered very well by their reports.

The lack of complete historic data was a major constraint on the study. For example the appliance labelling registration data (1986 to 1992) did not include national sales with state level breakdown, and average price. Only the GfK data, that were available for the period between the years 1993 and 2005, provided all components of the required data for a full impact analysis. This period covered by the GfK data was not sufficient to produce trends and estimate the impacts of energy labelling, which was introduced in 1986. However, the GfK data was allowed the impacts of MEPS 1999 and MEPS 2005 to be accurately estimated. The ACA data on the other hand, together with other data sources and the energy labelling registration database, provided energy performance attributes of selected models of refrigerators and freezers for earlier years. However there were several gaps in the data in the earlier years.

2.2.2 Methodology

A number of methodology pathways were explored to enable the study to meet the required objectives. These included the use of previously estimated historical data, the adjustment of historical estimates with published reports and undertaking a model

weighted assessment only. These methodology options were explored extensively and are reported in Appendix B. The final methodology chosen for the study is summarised below and described in detail in Appendix B.

Ideally to quantify the impact of the appliance labelling and MEPS program, the sales weighted annual energy consumption of refrigerators and freezers would be obtained and compared to the weighted annual energy consumption under the business as usual (BAU)[1] scenario. The sales weighted annual energy savings can be calculated if the average annual model energy consumption and annual model sales figures for all groups of refrigerators and freezers are known under the actual market conditions (after the implementation of a policy option) and also under the BAU scenario. However, only the GfK data offered the ability to conduct sales weighted assessments from 1993. The labelling registration data only provided the ability to conduct model/market weighted analysis, although this data set was available from 1986.

As sales data was not available prior to 1993, the option of using model weighted analysis was explored so that trends could be determined over the period 1986 to 2004. An approach was developed to assess the reliability of using model weighted analysis and to identify the most accurate model weighted analysis approach. The approach involved the GfK data being used to create a sales weighted result and this was compared to alternative model/market weighted assessments at group, brand and model levels. In this way, it was possible to conduct an analysis of data using different techniques and compare the results with the more accurate sales weighted analysis. The following example illustrates the approach.

Using GfK data calculate the following;

$$SWE_a = \frac{\sum_{i=1}^{n} \mathrm{AAE}_{\mathrm{Mi\,a}}\ \mathrm{AS}_{\mathrm{Mi\,a}}}{\mathrm{TAS}_a}$$

Where for a given year;

SWE_a = Sales Weighted Average Annual Energy of Group a
$AAE_{Mi\,a}$ = Average Annual Energy Consumption of Model *i* in Group *a*
$AS_{Mi\,a}$ = Annual Sales of Model *i* in Group *a*
TAS_a = Total Annual Sales of Group *a*
n = Total Number of Models in Group *a*

and,

$$MWE_a = \frac{\sum_{i=1}^{n} \mathrm{AAE}_{\mathrm{Mi\,a}}}{\mathrm{n}}$$

Where for the same year;

MWEa = Model Weighted Average Annual Energy of Group a

[1] The business as usual scenario refers to the likely market conditions in the absence of policy option.

AAEMi a = Average Annual Energy Consumption of Model i in Group a
n = Total Number of Models in Group a

Thus if the difference between SWE_a and MWE_a is not significant, MWE_a can be substituted for SWE_a without compromising much on reliability of results, and provide trend data from 1986. In other words, if analysis conducted on GfK data showed little difference between the SWE_a and MWE_a from 1993, the group level consolidated model weighted average annual energy consumptions from labeling registration data could be used instead of sales weighted values from 1986. However, the comparison between sales weighted and model weighted average annual energy consumptions yielded differences of up to 600% between the two, suggesting that such interchange would produce results that were significantly unreliable. Further variables were used to group models using the model weighted approach, including producing a model weighted and sales weighted average annual energy grouped by star rating.

The use of star rating as the group variable provided a maximum of 30% difference between the sales weighted and model weighted values for particular categories. In almost 85% cases the difference was found to be less than 10%. Hence this approach was used to estimate sales weighted average annual energy consumptions for various groups of refrigerators and freezers in the labeling registration data. The sales weighted by star rating approach provided the ability to conduct sales weighted analysis of average annual energy consumption for the period between 1986 and 2005. The detailed methodology is described in Appendix B.

In addition, pre-labelling (pre 1986) data was still required to establish trends before labelling was introduced in 1986. For this purpose a combination of data sources were used. This included ACA tests and market survey results, and studies that reported pre labelling market conditions. Based on these data, the analysis concluded that generally there was a trend of decline in average annual energy for almost all groups of refrigerators and freezers. Due to differences in technology evolution, the rate of decline was calculated to be different for different group. The declining trends were estimated for each group separately and backcast from 1980 and 1985 by using 1986 as base year. Table 2 summarises the estimated average annual rates of declines in average annual energy consumption for various groups.

Table 2: Estimated average annual rates of decline in average annual energy consumptions of refrigerators and freezers between 1980 and 1985

Group 1	Group 2	Group 3	Group 4	Group 5B	Group 5S	Group 5T	Group 6C	Group 6U	Group 7
1.14%	0.48%	0.58%	0.61%	0.45%	1.13%	1.69%	1.02%	1.24%	0.59%

2.3 Estimated Annual Sales by Groups

Following the methodology described in Section 2.2.2, the annual sales for all groups of refrigerators and freezers were estimated for the periods 1980 and 1992. Note that GfK data provides actual sales values compiled through market research surveys of selected retail outlets since 1993. The sample of selected retail outlets is estimated to have

accounted for 75% of total national sales for the period between 1993 and 2003 and for 95% of national sales for 2004 and 2005. The values in the database were therefore scaled up to account for the total national sales. It is estimated that the GfK sample provides a reliable estimate of sales by group types and technical attributes. Consequently no adjustments were made to adjust sales value for each group separately. It is important to note that only about 85% of GfK models were identified up to 2000. From 2001 the whole sales database was provided each year. A few models each year are classified as exclusive. In some cases attributes cannot be identified for these models and in all cases no price data for these models is provided. However, total sales and sales value for all models is accurately know, so an average price for exclusive models can be determined.

Figure 2 illustrates the sales trends for all refrigerators and freezers for the period between 1980 and 2005. The figure shows that the sales of refrigerators have increased consistently since 1980. On the other hand the sales of freezers appear to have declined during the period between 1980 and 1997, when it bounced back albeit at much slower rate than that of refrigerators.

Figure 2: Annual sales of Refrigerators and Freezers (1986 – 2005)

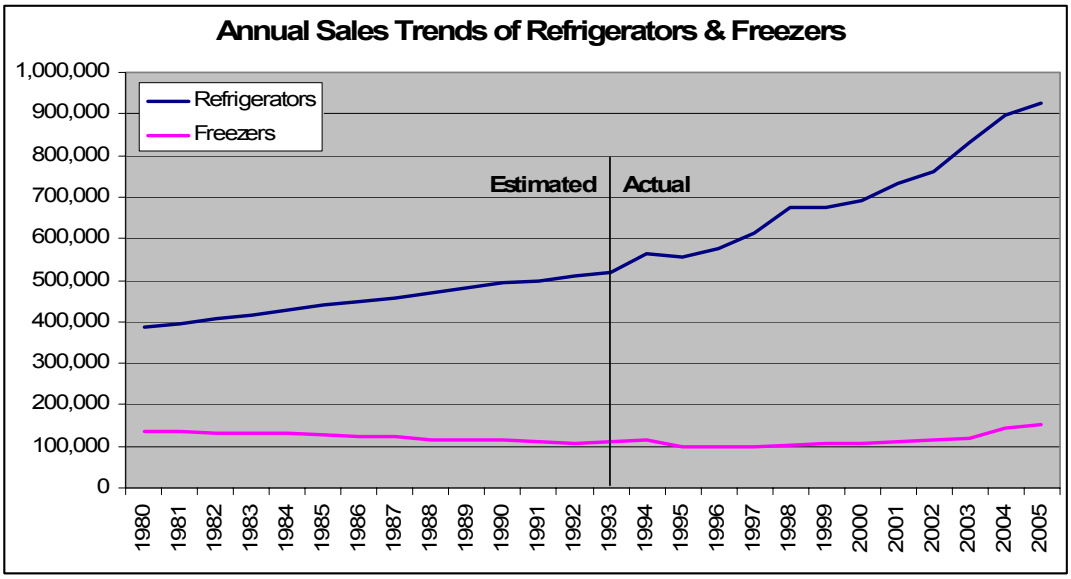
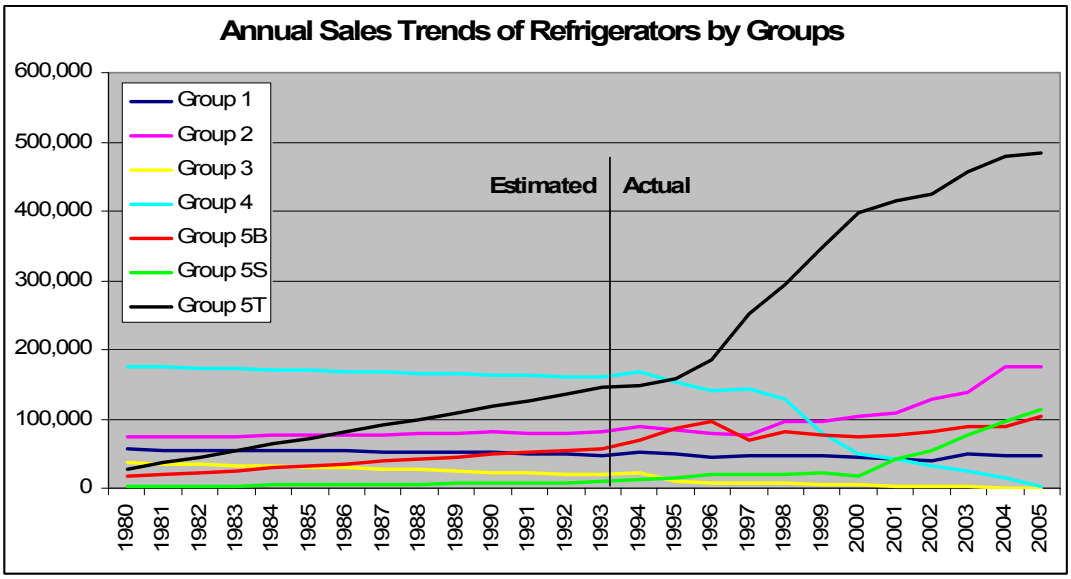


Figure 3 illustrates the sales trends for various groups of refrigerators during the period between 1980 and 2005. It can be seen from the figure that, except for Group 2, sales of single door refrigerators have declined consistently with Group 3 and Group 4 becoming almost non-existent. On the other hand sales of 2 door frost free refrigerator-freezers have increased consistently, especially the sales of Group 5T. Group 5T refrigerators grew at very high rate from 1995 and 1996, mostly at the expense of declining sales of Group 4 and Group 3 machines. More recently sales of Group 5S refrigerators are increasing at rates higher than any other group although the sales share is still modest.

Figure 3: Annual sales of Refrigerators by Groups (1986 – 2005)



Significant growth rates in sales of Group 2 refrigerators are also noticeable. Only a modest proportion are likely to end up in households – maybe even a majority of these products end up in offices and hotels. Table 3 provides the estimated and actual sales values for different groups of refrigerators.

Table 3: Annual sales of refrigerators since 1980

Year	Group 1	Group 2	Group 3	Group 4	Group 5B	Group 5S	Group 5T
1980	55,665	72,843	36,174	176,169	16,355	1,652	27,171
1981	55,247	73,517	34,898	174,892	19,540	2,202	36,228
1982	54,521	73,933	33,623	173,614	22,725	2,753	45,285
1983	53,993	74,408	32,347	172,337	25,910	3,304	54,341
1984	53,652	75,774	31,072	171,060	29,095	3,854	63,398
1985	53,285	76,918	29,796	169,783	32,280	4,405	72,455
1986	53,264	77,264	28,521	168,506	35,465	4,955	81,512
1987	51,635	76,645	27,246	167,229	38,650	5,506	90,569
1988	51,143	78,078	25,970	165,952	41,835	6,057	99,626
1989	51,983	80,223	24,695	164,675	45,021	6,607	108,683
1990	51,347	81,974	23,419	163,397	48,206	7,158	117,740
1991	50,217	79,219	22,144	162,120	51,391	7,708	126,797
1992	49,511	78,860	20,868	160,843	54,576	8,259	135,854
1993	46,460	81,762	19,593	159,566	57,761	8,810	144,911
1994	52,765	88,937	22,403	168,313	69,981	13,440	147,333
1995	50,574	84,315	11,000	151,934	86,761	14,051	157,512
1996	43,532	79,580	8,000	141,380	96,341	20,658	185,011
1997	46,063	76,261	7,124	144,433	68,492	19,256	253,006
1998	47,975	96,061	6,249	127,712	81,386	19,684	294,693
1999	47,130	96,993	5,373	79,651	76,706	21,481	347,075
2000	44,050	103,286	4,498	50,264	73,093	17,838	396,460
2001	43,205	108,694	3,622	42,362	76,438	43,124	414,174
2002	40,098	127,573	2,747	32,987	80,566	54,305	424,628
2003	48,179	137,069	1,871	23,480	88,377	75,784	457,811
2004	46,022	174,793	996	13,892	88,357	95,293	478,977
2005	46,823	175,635	120	2,049	104,474	113,039	483,146

* YELLOW cells contain estimated values. GREEN cells contain adjusted values from GfK data

Figure 4 illustrates the sales trends for various groups of freezers. It can be noticed that the sales of most popular chest type freezer (Group 6C) declined consistently until around 1995, since then it has grown rapidly. The sales of Group 6U remained stable until 1994 and than started to decline until 2003, when it started to increase at a rapid growth rate. In contrast the sales of Group 7 have increased consistently until 1999 where it has stabilised until 2003 and than started declining.

Figure 4: Annual sales of Freezers (1986 – 2005)

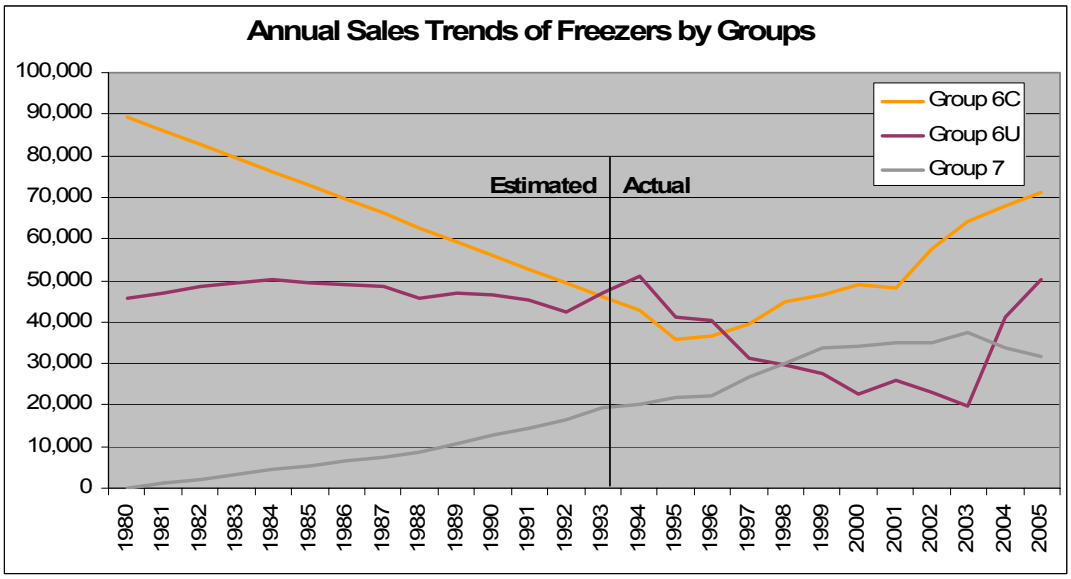


Table 4 provide actual and estimated sales values for different groups of freezers.

Table 4: Annual sales of freezers since 1980

Year	Group 6C	Group 6U	Group 7
1980	104,780	30,387	800
1981	100,259	32,757	1,159
1982	95,737	35,604	2,219
1983	91,216	37,666	3,278
1984	86,694	39,390	4,337
1985	82,172	39,906	5,396
1986	77,651	40,772	6,456
1987	73,129	41,412	7,515
1988	68,608	39,703	8,574
1989	64,086	42,292	10,581
1990	59,565	42,877	12,587
1991	55,043	42,872	14,594
1992	50,521	41,352	16,600
1993	46,000	46,989	19,247
1994	42,729	51,103	20,045
1995	35,986	41,351	21,647
1996	36,684	40,293	22,256
1997	39,659	31,479	26,938
1998	44,875	29,717	29,862
1999	46,585	27,394	33,608
2000	48,800	22,710	34,200
2001	48,341	26,022	34,823

Year	Group 6C	Group 6U	Group 7
2002	57,617	23,208	35,010
2003	64,370	19,619	37,402
2004	68,046	41,245	33,757
2005	71,262	50,148	31,853

* YELLOW cells contain estimated values. GREEN cells contain adjusted values from GfK data

2.4 Limitation of Results

Generally the results of this study are based on reliable, quantitative data. Significant amounts of data were obtained from reliable sources, such as sales data from 1993 (GfK) and labelling registration data from 1986. GfK is an international organization that collects, processes and disseminates comprehensive market information on households appliances, not only in Australia but in many countries around the world. The majority of European studies conducted to assess the impacts of energy efficiency regulations (labelling and standards) have used GfK data. On the other hand, the labelling registration database is a comprehensive record of all models of refrigerators and freezers sold in Australia since labelling became mandatory in 1986. While Victoria and NSW were the first implementers of the scheme, because of their critical market share, the earlier labelling database essentially represents the entire national market. Ever since the 1990's the labelling registration database has been coordinated nationally and the data is highly reliable back to 1986. The data at a model level from the registration data is generally much more comprehensive and accurate that the associated data collected by GfK.

It is worth noting that the available data sets are among the most comprehensive and reliable data sources of this type in most of the countries where energy efficiency regulations have been implemented.

Hence the majority of the results are based on empirical evidence rather than broad ranging assumptions. However it was necessary to derive some data from alternative data sources in order to fill a number of critical gaps in the historic data. As explained in Section 2.2.2, various robust techniques have been used to derive this data. Nonetheless, there are no authentic means to verify the level of accuracy and reliability of the final data used in the analysis.

Consequently, while the authors of this report are confident of the reliability of the results, the results should always be used in consideration to the techniques used to overcome data gaps.

3 Results

The results were developed to meet as much of the original scope of the study as possible, including analysis of the following;

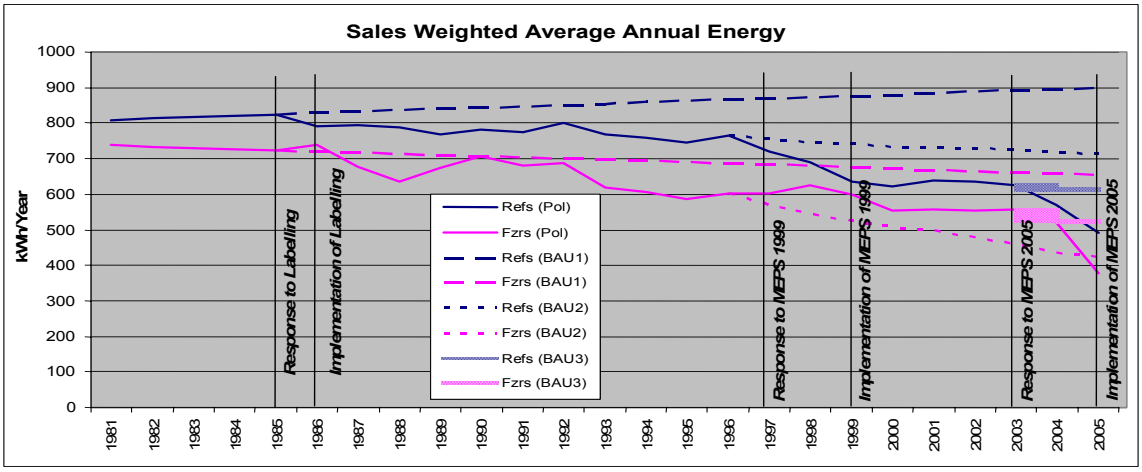
- Sales-weighted average energy consumption trends (kWh/yr) for BAU and each policy option;
- Sales-weighted energy efficiency trends (i.e. average kWh/yr per unit of adjusted volume) for BAU and each policy option;
- Sales-weighted average price trends for BAU and each policy option;
- Sales-weighted average storage volume trends for BAU and each policy option; and,
- Energy saved as a result of implementation of the policy options.

Many results have been presented in graphical form. In order to assist reader with appreciating the impact of introduction of labelling, MEPS 1999 and/or MEPS 2005 vertical lines on the graphs have been used as markers. It has been widely accepted that, since the concept of regulations is shared much earlier, suppliers generally respond by introducing changes to their products before the actual date of implementation of such regulations. This is generally desirable to ensure that the products meet compliance criteria by the time of introduction of the actual regulation. Notably the studies by Richard G. Newell et al 1998, and George Wilkenfeld 2001 have establish that such responsiveness is noticeable nearly 1-3 years before the implementation date of a regulation, when the actual consultation process may have taken several years.

Consequently 6 markers could have been used as shown in Figure 5;

1. Response to the introduction of labelling
2. Implementation of labelling
3. Response to introduction of MEPS 1999
4. Implementation of MEPS 1999
5. Response to introduction of MEPS 2005
6. Implementation of MEPS 2005

Figure 5: Markers to conceptualize impacts of regulations on changing patterns



As the early response of suppliers produces changes in the market, it also produces impacts of the regulation before its implementation; hence we have used 3 markers that correspond to suppliers response to the regulations rather actual date of implementation. The graphical results presented in the following section show two of these markers (***Response to MEPS 1999*** and ***Response to MEPS 2005***) as the indicator of responsiveness to the impending regulation, and on changing trends.

The impact of MEPS 2005 is also shown in this results section, although the ToR only specified the impact of MEPS 1999 be analysed. It was possible to derive results for MEPS 2005 as 2005 data was made available during the study.

3.1 Average Annual Energy Consumption Trends

Currently, as a requirement of MEPS, all refrigerators and freezers must be tested according to AS/NZS 4474.2 to determine their average annual energy consumption under controlled conditions, as described in the standard. AS/NZS 4474.1 was first published in 1997 and requires the testing of annual energy consumption at an ambient temperature of 32^{o}C; this requirement was first introduced in a standard in 1989 (as AS2572.2) and also at the time of the introduction of energy labelling in the state regulations. Prior to the implementation of energy labelling, the average annual energy consumption of refrigerators and freezers was tested at ambient temperature of 20^{o}C as specified in AS1430, although measurement of energy was not a key performance parameter. It was therefore important in the analysis of the consumption trends to align the results conducted under two tests when analysing a trends from data that spans the two measurement standards. This adjustment mainly affected the early ACA data set (1985 and earlier).

3.1.1 Average Annual Energy Consumption Trends After the Introduction of Labelling

As explained in Section 2, only a limited amount of reliable data could be found covering the period before labelling was introduced in 1986. This included results of occasional tests conducted by Australian Consumers Association (ACA) which were conducted on a very limited number of models. The trends of average annual energy consumption for different groups of refrigerators and freezers could be assessed by using a combination of results from GfK, labelling registration and ACA data.

3.1.1.1 Model Weighted Results

The labelling registration data was used to produce trends of *model weighted* average annual energy consumption of various groups of refrigerators and freezers. Note that the model weighted values for a year refer to simple averages of annual energy consumptions of all models for a group in that year. The model weighted values do not provide as accurate trend compared to sales weighted values, but rather an indicative situation analysis. Therefore, it is important that analysis based on model weighted values is treated with caution. Figure 6 and Figure 7 illustrate trends of changes in *model weighted* average annual energy consumption of various groups of refrigerators and freezers after introduction of labelling in 1986.

Figure 6: Model weighted average annual energy consumption of refrigerators by groups (post labelling)

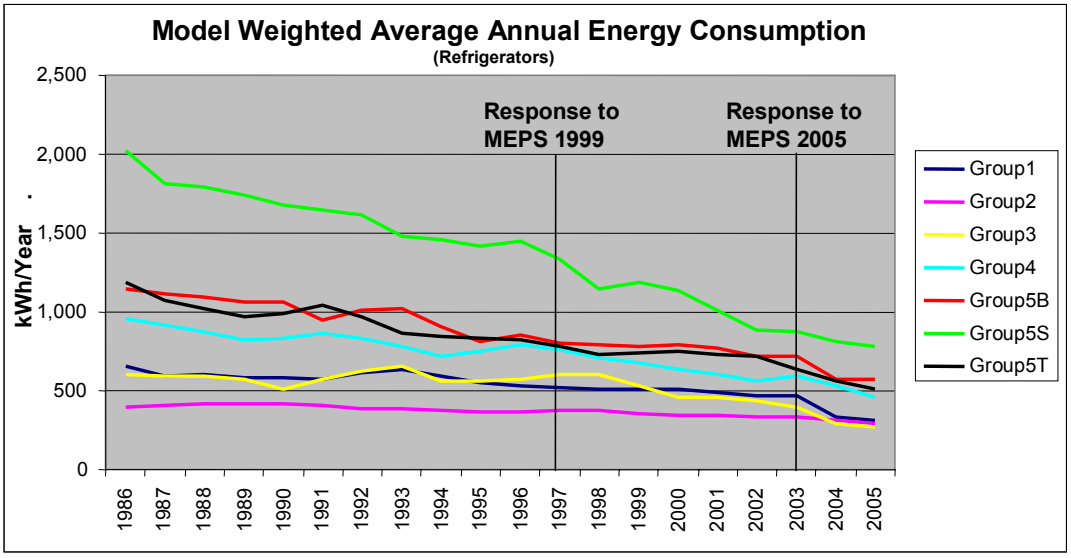
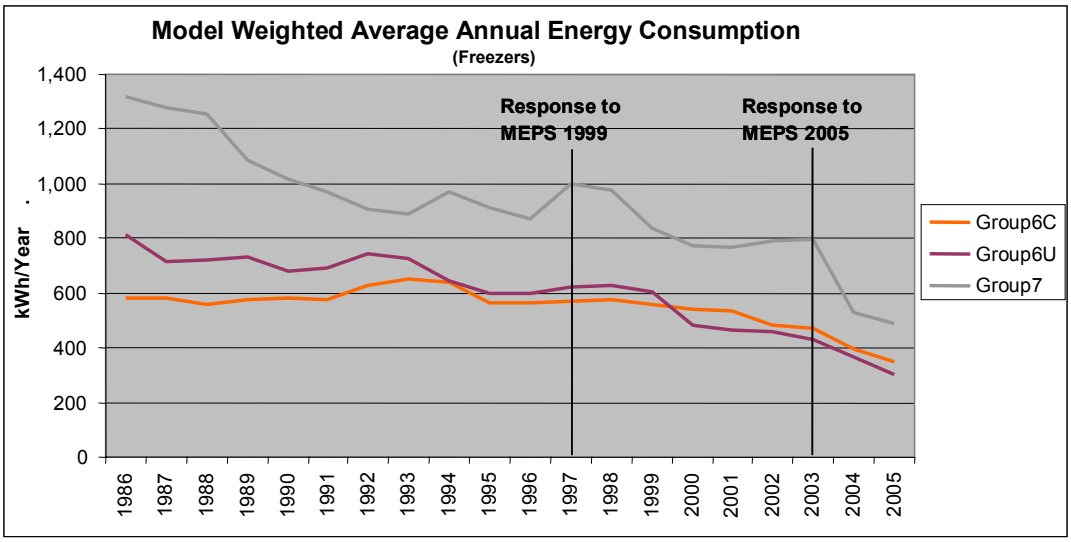


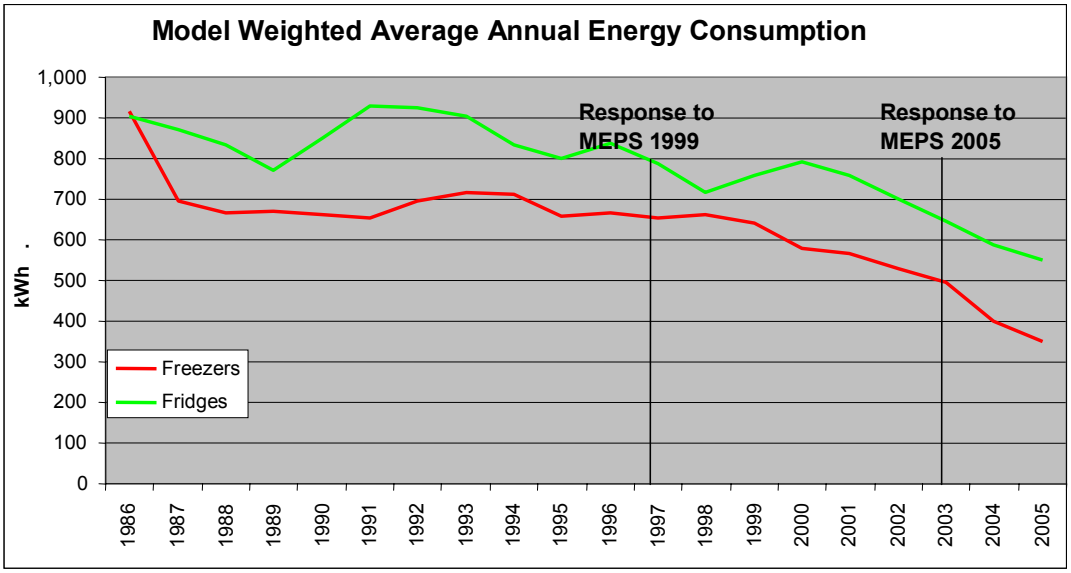
Figure 7: Model weighted average annual energy consumption of freezers by groups (post labelling)



It can be seen from the two figures above that there has been a consistently declining trend for average annual energy consumption for all groups of refrigerators and freezers. The discussion in 3.1.2 shows that some decline in average annual energy consumption was likely to occur prior to 1986. Nonetheless the two figures strongly suggest that the introduction of MEPS 1999 and MEPS 2005 produce significant impacts. This is evident from reasonably sharp decline in the trend lines after the years when suppliers are believed to have acted in anticipation of meeting the MEPS requirements i.e. 1997 to meet requirements of MEPS 1999 and again in 2003 to meet requirements of MEPS 2005.

Similar trends can be noticed when the group data is combined and analysis is performed for *all refrigerators* and *all freezers*. Figure 8 shows the trends of *model weighted* average annual energy consumption of all refrigerators and all freezers. The aggregated refrigerator and freezer data shows a significant rise in energy consumption during the period 1989 to 1993. Such a rise in average annual energy could be likely due to the effects of phase out of CFCs.

Figure 8: Model weighted average annual energy consumption of all refrigerators and freezers (post labelling)

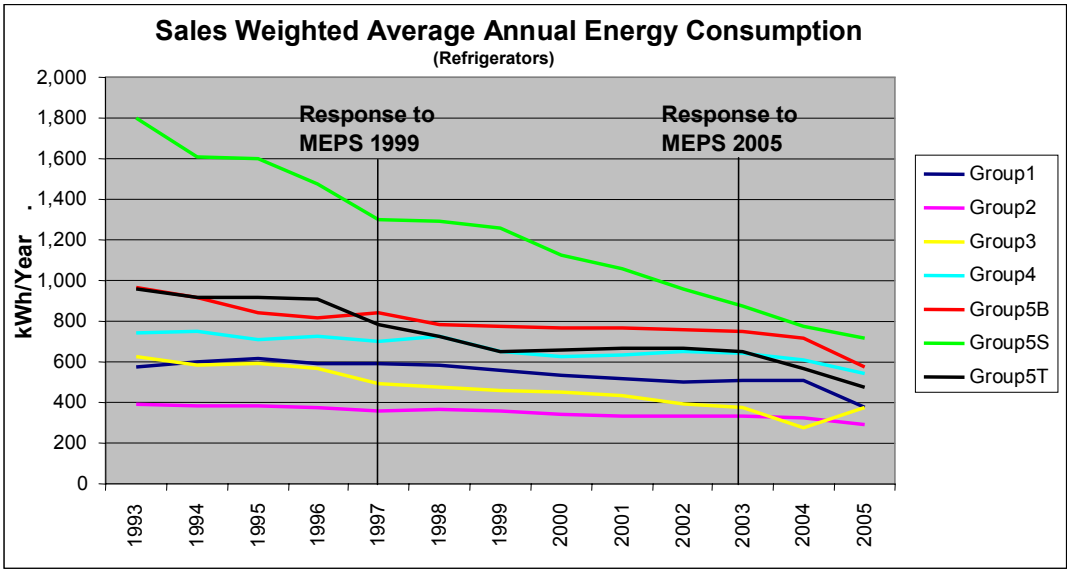


3.1.1.2 Sales Weighted Results

The GfK data was used to produce *sales weighted* trends of average annual energy consumption of different groups of refrigerators and freezers. Sales weighted average energy consumption figures provide a better indication of the average energy consumption of new appliances in any given year. Figure 9 and Figure 10 illustrate trends of changes in *sales weighted* average annual energy consumption of various groups of refrigerators and freezers. Because of the limitations of GfK data the trends start only after 1993.

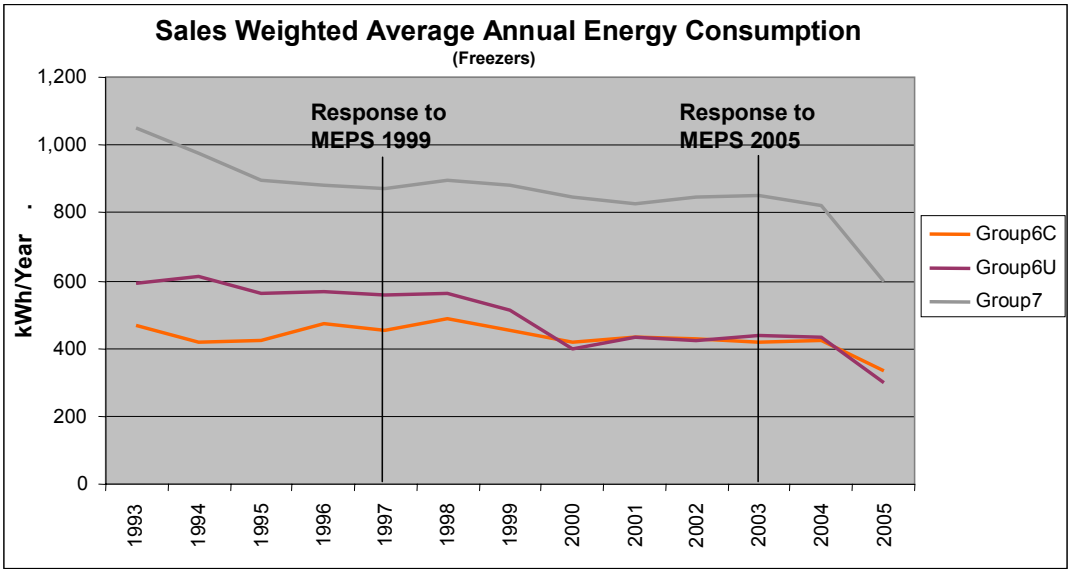
While the analysis of sales weighted average annual energy consumption also shows continuously declining trends, there appears to be differences in model weighted and sales weighted trends. The sales weighted trends do not show significant decline immediately after the perceived years of supplier responsiveness (1997 for MEPS 1999 and 2003 for MEPS 2005).

Figure 9: Sales weighted average annual energy consumption of refrigerators by groups (post 1993)



In some cases (especially in case of Group 5S) the rate of decline appears to be much higher before the actual implementation (and perceived years of supplier responsiveness). Also, there appears to be a lag between supplier responsiveness to introduce products that are compliant with the regulations and market uptake of the new products. In other words the products that are compliant to new regulations tend to be registered around 2 years before the implementation of the new regulation, whereas the impact of new products is not noticeable in the sales data until a year after registration. Note that model weighted trends, as shown in Figure 6 and Figure 7, show change almost immediately after the two vertical lines. In contrast, the sales weighted trends (Figure 9 and Figure 10) show similar change but delayed by around a year.

Figure 10: Sales weighted average annual energy consumption of freezers by groups (post 1993)



3.1.1.3 Discussion

A number of factors could be responsible for such differences between the model and sales weighted results. The higher rate of decline in average annual energy consumption could be the result of customer responsiveness to labelling scheme in case of some increasingly popular products (e.g. 5S). On the other hand, because of significant time lag between the introduction and implementation of a new regulation, it is understood that suppliers engage in the development of new products that would be compliant with anticipated new regulation. Consequently they tend to register new products that would be compliant with upcoming new regulation, around 2 years in advance. However, the new product only starts to impact on the *sales weighted* results as it's sales increase in volume and the previous model is cleared from the market.

The analysis of trends for average annual energy consumption of all refrigerators and all freezers provide a more generalised assessment. Figure 11 shows the trends of *sales weighted* average annual energy consumption of all refrigerators and all freezers. Consistent with group level trends, a generally declining trend of average annual energy consumption of all refrigerators and freezers can be noticed. Also consistent with analysis provided earlier, it can be noticed that generally the declining trend increases between the perceived year of responsiveness and the actual year of implementation of MEPS 1999 and MEPS 2005.

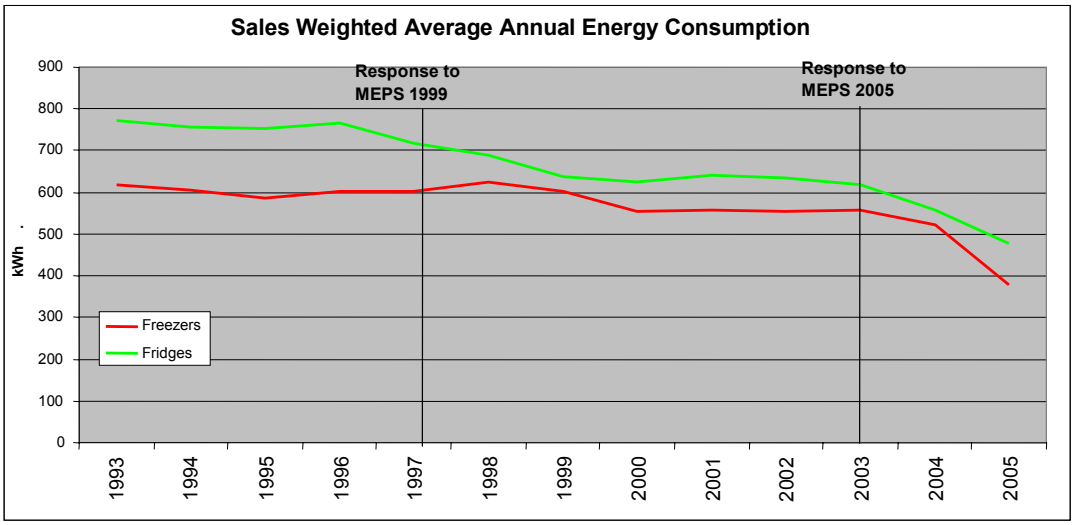
The exception to this trend is freezers before the MEPS 1999 implementation date. It was noted in *Greening Whitegoods* (EES 2006) that freezer efficiency decreased after the phase out of CFC in the period from 1994. This was due to HFC134a being less efficient at lower evaporator temperatures when compared with CFC12. Freezers operate at lower

evaporator temperatures compared to refrigerators and hence design changes took longer to compensate for the decreased efficiency.

3.1.1.4 Summary

Figure 11 shows the trends of *sales weighted* average annual energy consumption of all refrigerators and all freezers. The trend analysis provides a strong indication of the effects on annual energy consumption of refrigerators and freezers of the implementation of two rounds of MEPS in 1999 and 2005.

Figure 11: Sales weighted average annual energy consumption of all refrigerators and freezers (post 1993)



3.1.2 Average Annual Energy Consumption Trends Before the Introduction of Labelling

The only reliable data that could be found covering the period before labelling was the results of sporadic tests conducted by Australian Consumers Association (ACA) on a very limited number of models. Since the test were conducted with a limited scope and on very small proportion of models available in the market at time of the tests, the results offer very patchy data with large variations along the years of tests.

We used the ACA test results, in association with other sources, primarily to establish condition before implementation of mandatory labelling.

On the basis of such data and corresponding assessment we have established that there was generally a declining trend for average annual energy consumption for all groups of refrigerators and freezers. In case of refrigerators the average annual rate of decline in annual energy consumption, before the implementation of mandatory labelling, was

estimated to vary between 0.5% (Group 5B) and 1.7% (Group 5T), whereas the combined annual rate of decline for all types of refrigerators was estimated at around 1%.

In case of the freezers the similar rate of decline was estimated to be 1.02% (Group 6C), 1.25% (Group 6U), and 0.6% (Group 7). The overall rate of decline for all freezers was estimated at 0.9% per year.

3.2 Average Adjusted Storage Volumes Trends

The trends in refrigerator and freezer volumes are examined in this section. Volumes are typically normalised to a single value to account for the differences in size and operating temperatures between different groups of refrigerators and freezers. Because of the different utilities and normal operating temperatures, the freezer compartment consumes more energy than the fresh food compartment. Therefore, in order to provide a similar basis for assessment and energy efficiency comparison, and depending on the group of machine, the freezer volume is scaled up to a value that is equivalent to fresh food compartment volume. The total volume of any refrigerator or freezer, used in an analysis/assessment is calculated as sum of fresh food volume and the scaled up freezer volume, or otherwise called Adjusted Volume[2].

3.2.1 Average Adjusted Storage Volumes Trends After the Introduction of Labelling

The trends of average adjusted storage volumes for different groups of refrigerators and freezers could only be assessed using a combination of results based on GfK, labelling registration and ACA data.

3.2.1.1 Model Weighted Results

The labelling registration data was used to produce trends of *model weighted* average adjusted storage volumes of various groups of refrigerators and freezers. Figure 12 and Figure 13 illustrate trends of changes in *model weighted* average adjusted storage volumes of various groups of refrigerators and freezers after introduction of labelling in 1986.

It can be seen from Figure 12 that, except for Groups 2, 3 and 4, there has been little or no change in the average adjusted storage volume of refrigerators. This is contrary to the general perception that storage volumes have generally increased as demand for larger machines has increased more recently. However, changes in average adjusted volume of all refrigerators are shows an increase in average adjusted volume of refrigerators, as shown in Figure 14. It therefore becomes important to cross check this aspect with results of *sales weighted* analysis.

[2] See AS/NZS 4474 for details. The volume use to define energy labelling and MEPS requirements is gross compartment volume.

The analysis of group and all freezer data provides that average adjusted volumes have declined consistently, especially around the period of implementation of the two rounds of MEPS. Figure 13 and Figure 14 illustrate such trends. Once again this aspect is cross checked with *sales weighted* analysis.

Figure 12: Model weighted average adjusted volumes of refrigerators by groups (post labelling)

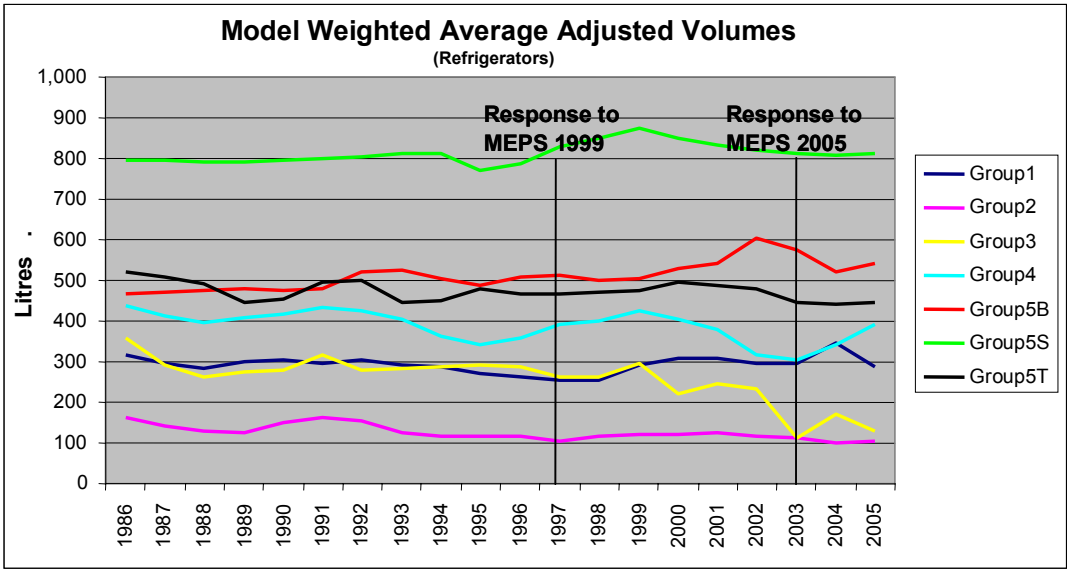


Figure 13: Model weighted average adjusted volumes of freezers by groups (post labelling)

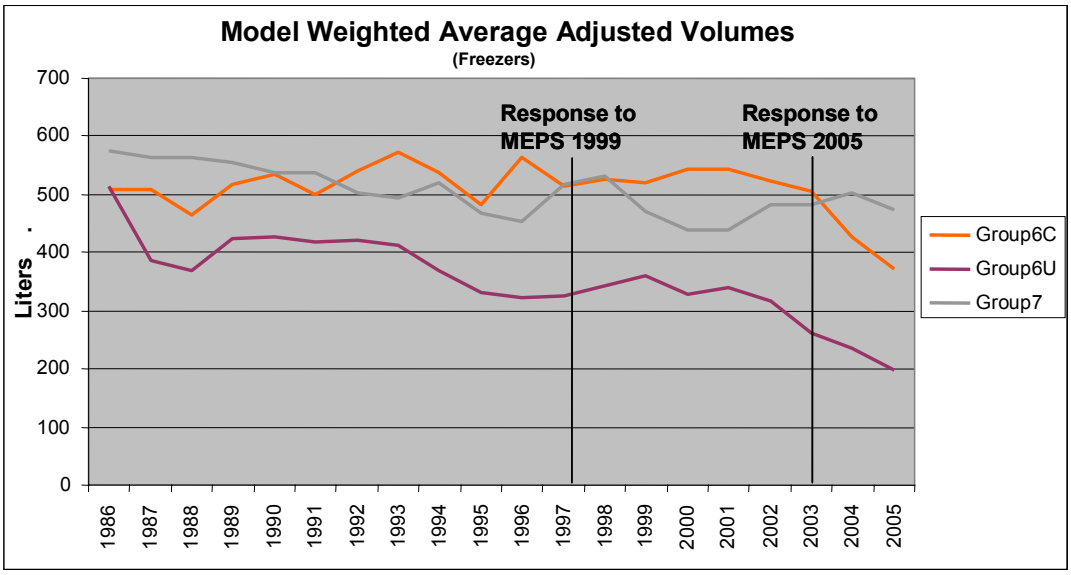
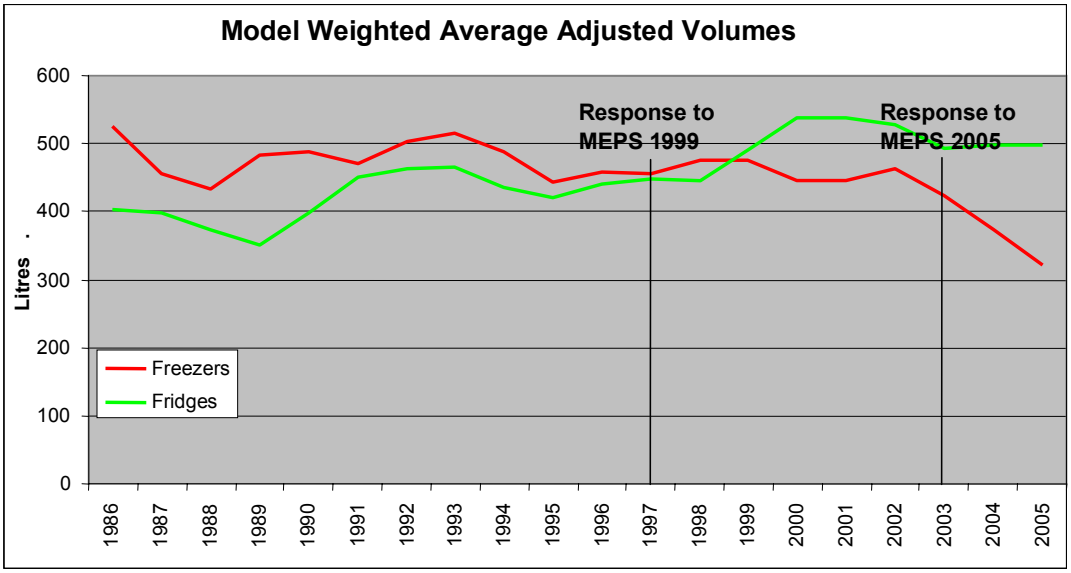


Figure 14: Model weighted average adjusted volumes of all refrigerators and freezers (post labelling)



3.2.1.2 Sales Weighted Results

The GfK data was used to produce *sales weighted* trends of average adjusted volumes of different groups of refrigerators and freezers. Figure 15 and Figure 16 illustrate trends in *sales weighted* average adjusted volumes of various groups of refrigerators and freezers. Because of the limitations of GfK data, the trends start only after 1993. In summary, Figure 17 shows trends of *sales weighted* average adjusted volumes for all refrigerators and all freezers.

Figure 15: Sales weighted average adjusted volumes of refrigerators by groups (post labelling)

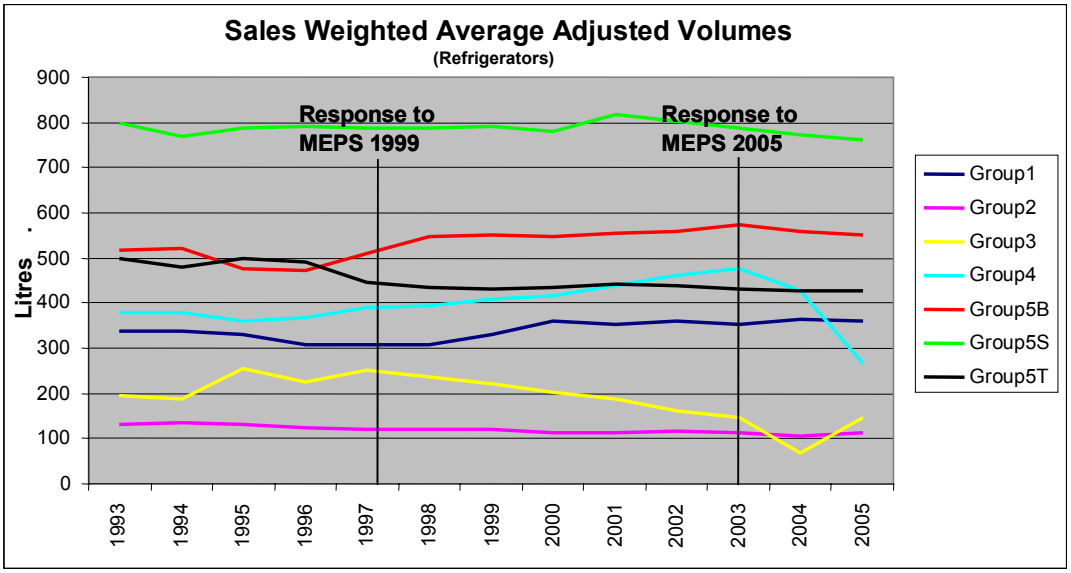
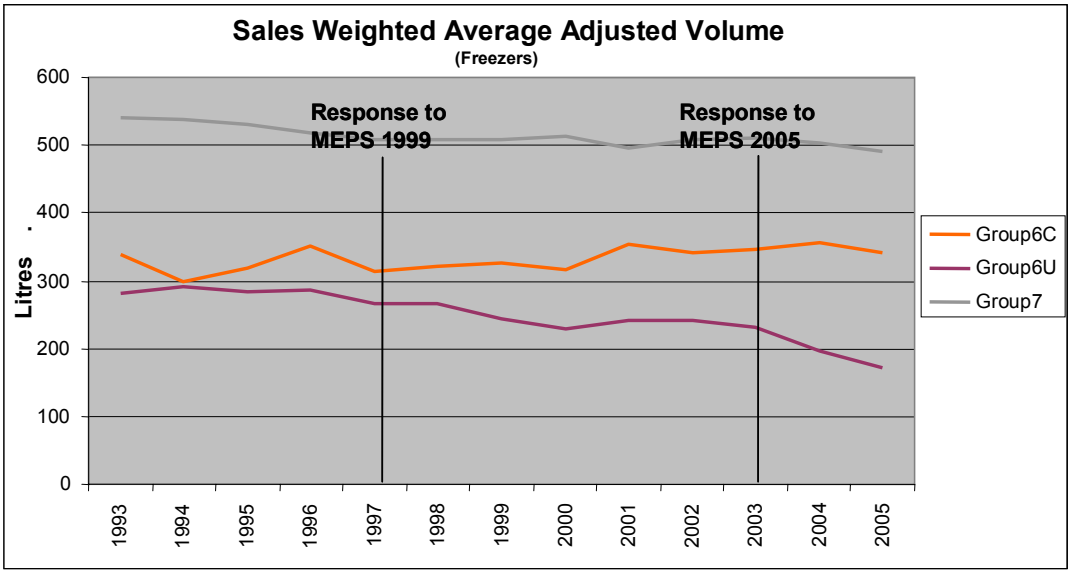


Figure 16: Sales weighted average adjusted volumes of freezers by groups (post labelling)



3.2.1.3 Discussion

The analysis of *sales weighted* average adjusted volumes show reasonably similar results for both refrigerators and freezers, compared to the *model weighted* analysis. Once again the group level analysis appears to be masking the actual trend exhibited by combined

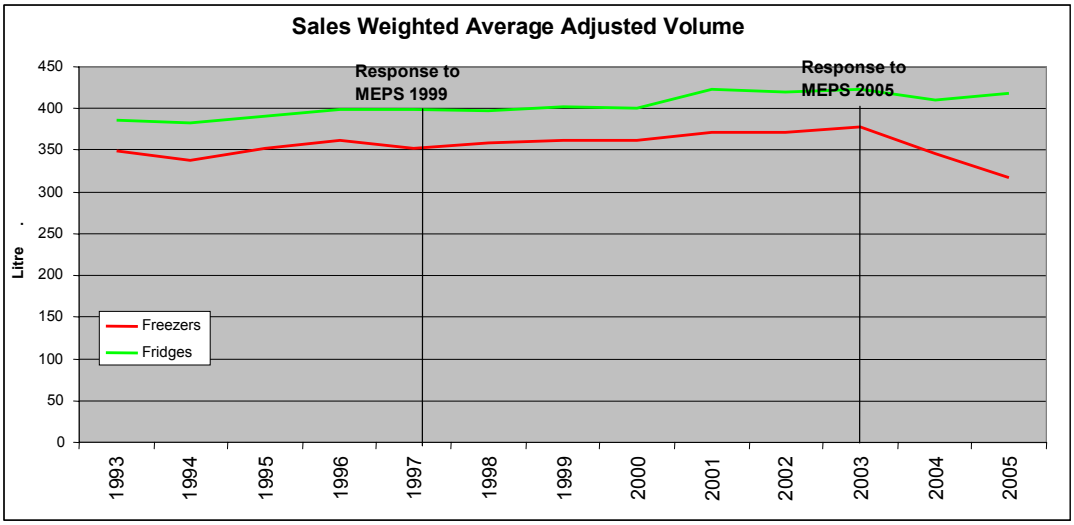
population of refrigerators. Consistent with *model weighted* analysis, the *sales weighted* analysis at group level provides that in most cases, the average adjusted storage volume of refrigerators has either remained unchanged or declined recently. However, the sales weighted analysis performed on combined data of all refrigerator groups, as shown in Figure 17, suggests that there has been a consistent increase in the average adjusted volumes of refrigerators.

The results of *sales weighted* analysis are reasonably consistent with those of *model weighted* analysis, both at group and combined freezer level. These results suggest that generally the average adjusted storage volumes of freezers have declined since the introduction of labelling in 1986. However, the sales weighted analysis performed on consolidated freezer data identified a slightly upward trend in average adjusted volumes of freezers for the period between 1997 and 2003 (the perceived years of responsiveness for MEPS 1999 and MEPS 2005) until a quickly declining trend emerged in 2003.

3.2.1.4 Summary

Although some groups have shown a decline in average adjusted volume, the sales weighted analysis performed on all refrigerator groups, as shown in Figure 17, suggests that there has been a consistent increase in the average adjusted volumes of refrigerators. While for freezers, there is a slightly upward trend in average adjusted freezer volumes over the period between 1997 and 2003, followed by sharp decline since 2003.

Figure 17: Sales weighted average adjusted volumes of all refrigerators and freezers (post labelling)



3.2.2 Average Adjusted Storage Volume Trends Before the Introduction of Labelling

The pre-labelling ACA market research data suggests that prior to the introduction of mandatory labelling the average adjusted storage volume of refrigerators increased at an average annual rate of 6%. In contrast the average adjusted storage volume of freezers increased at an average annual rate of over 10%, before the introduction of labelling in 1986. However, these results are based on ACA tests and market research surveys and should be treated with caution due to their limited scope. For example the above results are based on ACA reports published in the years 1975, 1977, 1979, 1980, 1982, and 1983 which covered refrigerator groups 4, 5B, 5S and 5T, and reports published in 1975, 1981, 1984 and 1985 covering freezer groups 6C and 6U.

3.3 Average Market Price Trends

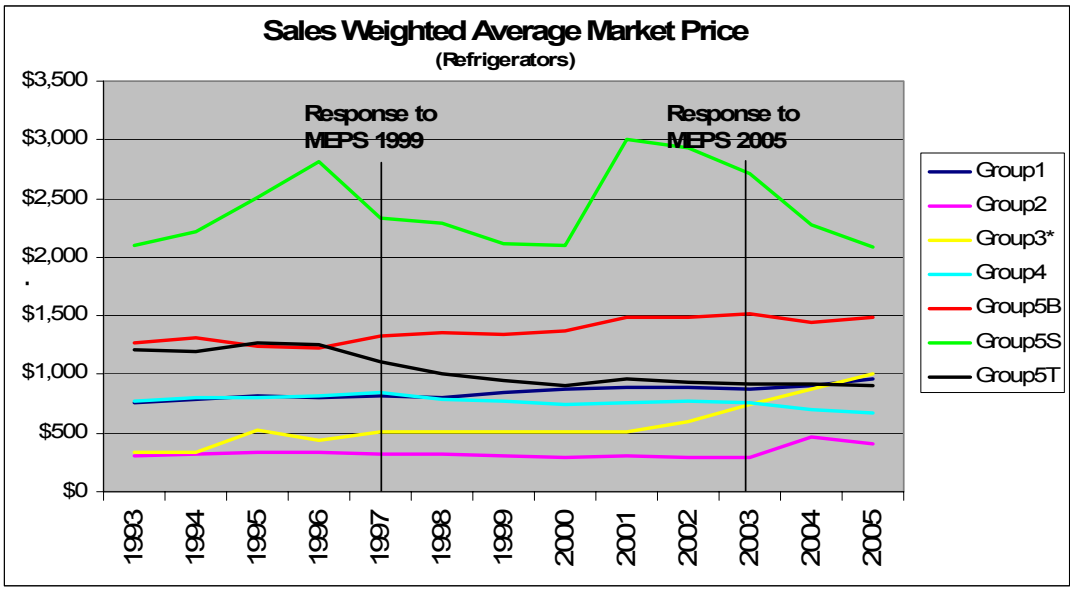
One assumption that is usually made when planning the implementation of an efficiency regulatory requirement is that price of products and services would increase as a consequence of the regulatory requirements. A Regulatory Impact Statement (RIS) generally includes estimated impacts of price rise in the overall cost benefits assessment of the implementation of a regulatory requirement. An analysis of changes in product price was conducted in order to assess the actual impacts of the appliance labelling and MEPS regulations.

3.3.1 Average Market Price Trends After the Introduction of Labelling

GfK data was used to produce *sales weighted* trends of average market prices of different groups of refrigerators and freezers. Figure 18 and Figure 19 illustrate trends of changes in *sales weighted* average market prices of various groups of refrigerators and freezers. As the GfK data was only available from 1993, the trends start from this year. No sales and market price information is available in the labelling registration data. Therefore, it was not possible to conduct *model weighted* analysis on models included in the labelling registration database.

The analysis of sales weighted average market prices of refrigerators show different trends depending on the product model group being examined. The figures show that the average market price of some popular refrigerators (Group 5T, Group 2 and Group 4) has declined consistently since 1993. Also the average prices of Group 5S refrigerators, whose sales have grown dramatically over past 5 years, more recently have been declining consistently and such decline has been sustained irrespective of introduction of MEPS 2005. It is also important to note that these prices are actual prices paid by consumers for more than 90% of all refrigerators and freezers sold in Australia in nominal dollars (no correction for inflation). So real prices for refrigerators and freezers are continuing to decline despite increases in average volume, larger share of frost free product on the market and massive reductions in energy consumption, particularly in the lead up to MEPS 2005

Figure 18: Sales weighted average price of refrigerators by groups (post labelling)



* The average price for Group 3 showed a significant spike in 2004. Because of very small sales recorded in that year, the price spike t was treated as outlier and smoothed out accordingly

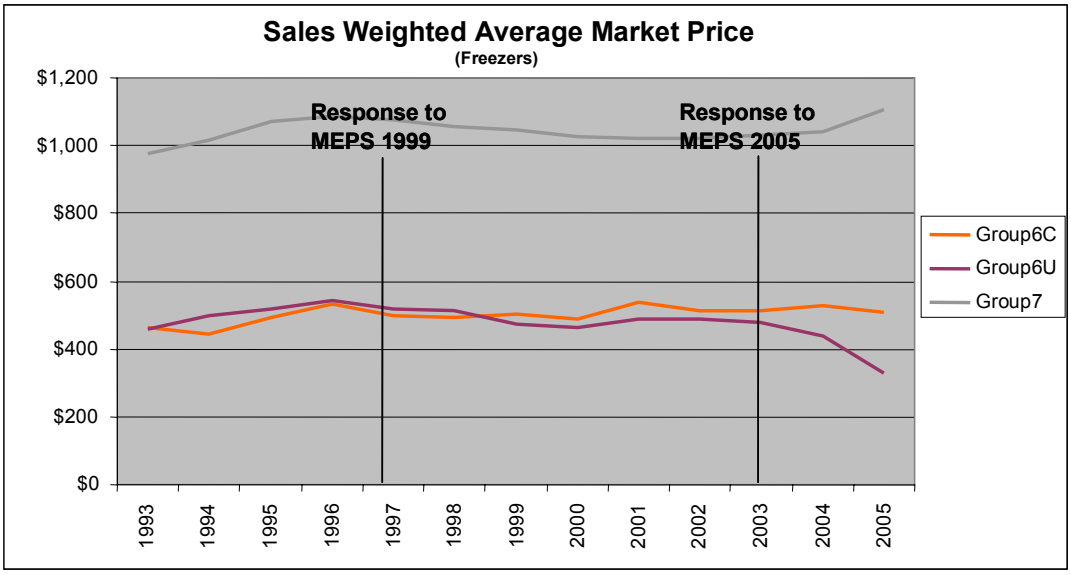
The dynamic changes in average price of Group 5S (2 door side by side) are of particular interest. The prices of the Group 5S appliances have changed erratically with periods of sharp increases and decreases. These changes are due to the low sales volume and small number of models obtained by GfK in the period to 2000. These refrigerators only started to achieve greater than 5% market share after 2000. Group 5S machines are in direct competition with the popular Group 5T machines, and up till 2000 the GfK data was not reliable. What is conclusive, and also focus of this report, is that there is no evidence to suggest that such price variations were the result of the introduction of any regulations (MEPS 1999 or MEPS 2005). Also, since 1993 the market price of some lower market share groups (Group 5B, Group 3 and Group 1) has increased. Group 3 sales have declined to less than 1000 units. Once again these price increases do not show any relevance to the introduction of either MEPS 1999 or MEPS 2005. There are several plausible explanations for this increase, which is the subject of another study (*Greening Whitegoods*[3]).

The analysis of sales weighted average market prices of freezers show much more consistent trends. The analysis shows that the average prices of historically popular Group 6C and newer Group 7 have remained rather stable, albeit with some variation, during past 12 years, with the exception that the prices of Group 7 machines show an upward change after 2004 (possibly due to the introduction of MEPS 2005). In contrast

[3] *GREENING WHITEGOODS: A report into the energy efficiency trends of Major Household Appliances in Australia From 1993 to 2005,* EES 2006, for E_3 Committee (Report 2006/06). This report was released subsequent to the majority of analysis conducted for this study. Elements of *Greening Whitegoods* have been used in this study, however for a full assessment of the market characteristics/changes of refrigerators and freezers, readers are advised to obtain this report.

the average prices of Group 6U have been declining since 1993. The rate of such decline appears to have increased after 2003, the assumed year of responsiveness by suppliers to the introduction of MEPS 2005.

Figure 19: Sales weighted average price of freezers by groups (post labelling)



In summary, there is no substantial evidence of MEPS having any significant impact on market price. Although Group 2, 3 and 7 appliance types show an increase in market price at around the time of responsiveness to MEPS 2005, the average market prices of the vast majority of refrigerators or freezers do not appear to have been affected by the introduction of MEPS 1999 nor MEPS 2005. In the RIS for MEPS 2005 (GWA 2001), a price increase of 1.6 to 8% is assumed to occur due to the introduction of MEPS 2005. This retrospective analysis has found no evidence of such a price increase.

The analysis of all refrigerator groups combined and all freezer groups combined provided more generalised assessment of changes in average price. Figure 20 illustrates the changes in average market price of refrigerators and freezers. It can be noticed from the figure that there has been an increase in average price of a refrigerator since 1993, while the average price of a freezer was only marginally higher in 2005 compared with average price of a freezer in 1993, meaning that the real price of freezers has declined substantially over the period. It can also be noted from the figure that the average price of an average refrigerator started declining after year 1996 (1 year before the perceived year of responsiveness to MEPS 1999) until 2000, then it increased to the previous 1996 levels in 2001. The refrigerator prices appear to have remained almost unchanged since 2001. In case of freezers the prices increased between 1994 and 1996, remained almost unchanged between 1996 and 2003 when they started to decrease to 1993 levels in year 2005.

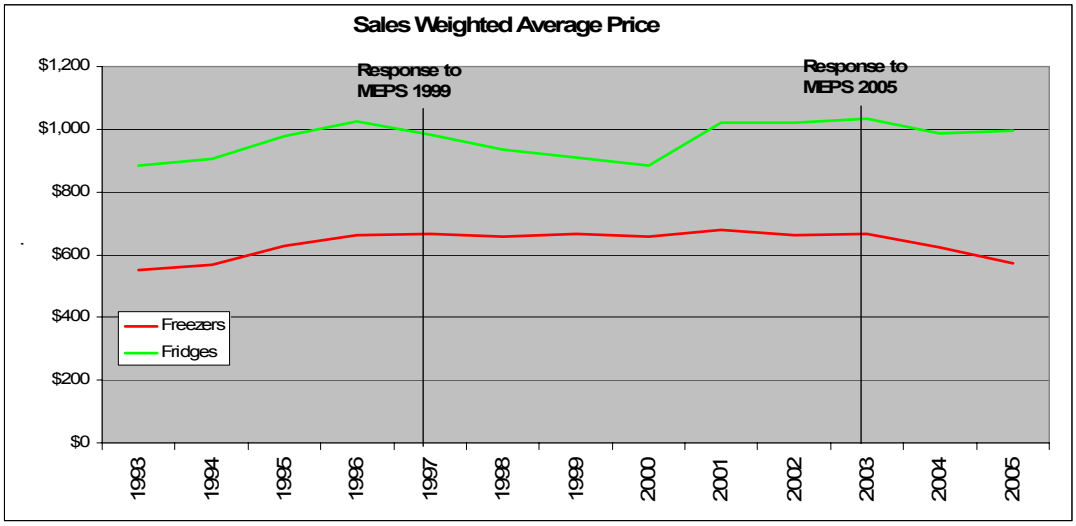
In case of aggregated data, the price trends are heavily affected by some specific groups that are many times more expensive than their counterpart standard machines. This is

likely to be the case when the sales mix changed dramatically between 1995 and 2001. For example the annual sales of high priced Group 5S machine increased at a very high rate after 2001 (see Section 2.3). Comparison between the green line in Figure 20 (representing average market price of all refrigerators) and green line in Figure 18 (representing average market price of Group 5S machines) helps establish such link. A better parameter of analysis of change in price, price per unit of adjusted volume, is presented in the next section.

3.3.1.1 Summary

The average price of refrigerators is illustrated in Figure 20. The analysis presented in this study suggests that neither MEPS 1999 nor MEPS 2005 has affected the price of refrigerators.

Figure 20: Sales weighted average price of all refrigerators and freezers (post labelling)



The variations in market price do not appear to be in direct response to the introduction of MEPS 1999 and MEPS 2005 because of the following reasons;

a. The changes in price trends do not appear around the years of perceived responsiveness to the introduction of the two MEPS (1997 for MEPS 1999 and 2003 for MEPS 2005)

b. The changes in price trends also do not appear in and immediately after the years of introduction of the two MEPS. The average price increase of about 14% in year 2001 is likely to be due to the increase in sales of high priced Group 5S machines.

3.3.2 Average Market Price Trends Before the Introduction of Labelling

The results of ACA studies, as described in Sections 2.2.1 and 3.2.2, suggest that prior to the introduction of mandatory labelling the average market price of refrigerators increased strongly before 1986. The ACA data also suggest that the average market price of freezers also increased before the introduction of labelling in 1986. As explained earlier in Sections 2.2.1, due to the limited scope and sporadic nature of ACA data it is highly unlikely that the above price variations were representative of the entire national market.

3.4 Average Market Price per Unit of Adjusted Volume Trends

Assessment of changes in the market price of products on the basis of the average market price can sometimes be misleading if the size of products has changed and hence the price. Consequently the analysis of price trends, if size changes have occurred, may not reflect other market impacts; such as the introduction of MEPS. Average price standardised over the adjusted storage volume of the product provides a better level of analysis of price trends. The following paragraphs provide analysis of change in average market price per unit of adjusted volume of different types of refrigerators and freezers.

3.4.1 Average Market Price per Unit of Adjusted Volume Trends After the Introduction of Labelling

The GfK data was used to produce *sales weighted* trends of average market prices per unit adjusted volume of different groups of refrigerators and freezers from 1993, the first year where complete price and sales data was available. Figure 21 and Figure 22 illustrate trends of changes in *sales weighted* average market prices per unit of adjusted storage volumes of various groups of refrigerators and freezers.

The *sales weighted* trends for average market price per unit of adjusted storage volume are remarkably identical in most groups to trends for *sales weighted* average market price. In other words, changes in product size have not noticeably affected the price trends for these products. This is true for the vast majority of products sold, though there are exceptions in the trends for Group 4, Group 3 and Group 6U.

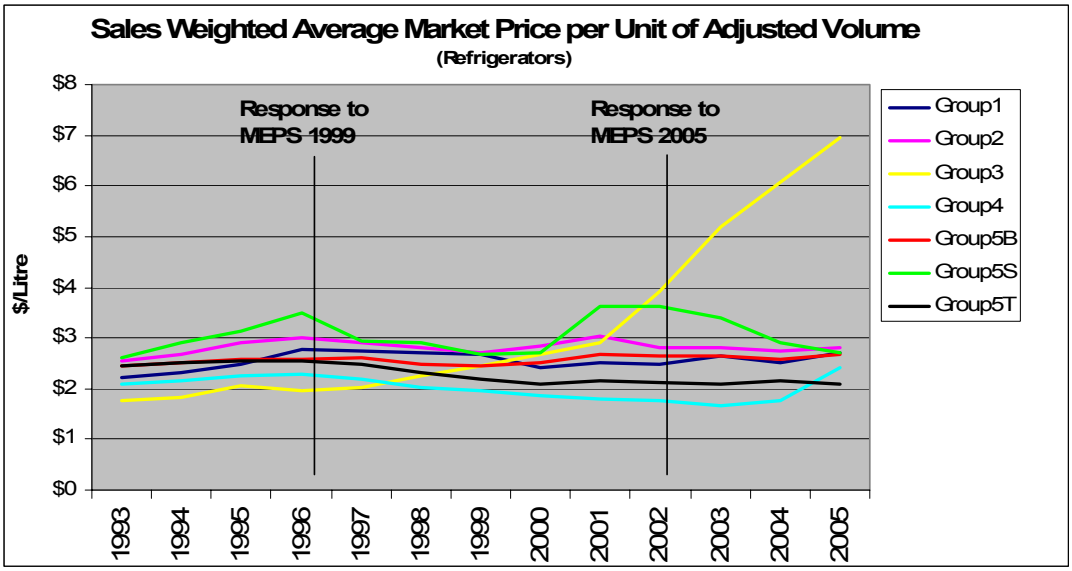
In case of Group 4 the average price trend and the trend for average price per unit of adjusted volume both showed a consistent decline since 1993, until 2004 when the price per unit of adjusted volume shows a significant rise while the average price continued to decline. Group 4 sales were also less than 3% of the market after 2004.

In case of Group 3 average market price has continued to rise since 1993. However this is most likely due to the volatility in the data due to low sales volumes, as less than 10,000 units were sold per annum post 1996. More recently the average price and average price per unit of adjusted volume have taken an unprecedented upward trend since 2001. The number of sales of Group 3 has declined very rapidly, just 49 sales in 2005 were registered by GfK, so it is possible that such high prices are the result of some specialised models that are left on the market.

In case of Group 6U the rising trend of price per unit of adjusted volume is contrary to declining trend for average market price. Yet both trends show significant decline after 2004.

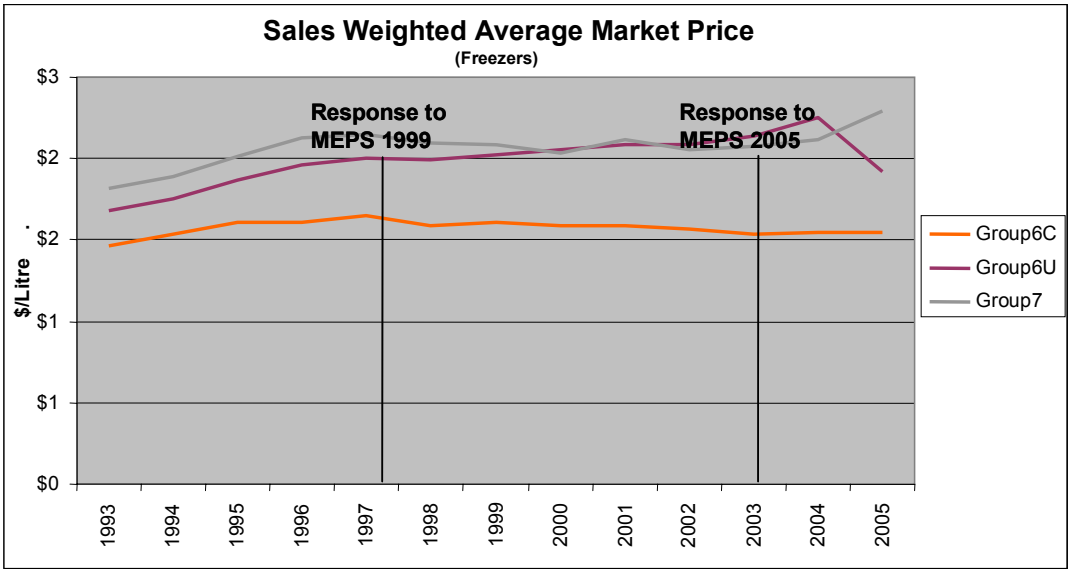
Despite these exceptions, the overall trends for sales weighted average market prices standardised with adjusted storage volume were found to be consistent with sales weighted average market prices.

Figure 21: Sales weighted average price per unit adjusted volume of refrigerators by groups (post labelling)



* The average price for Group 3 showed a significant spike in 2004. It was treated as outlier and smoothed out accordingly

Figure 22: Sales weighted average price per unit adjusted volume of freezers by groups (post labelling)



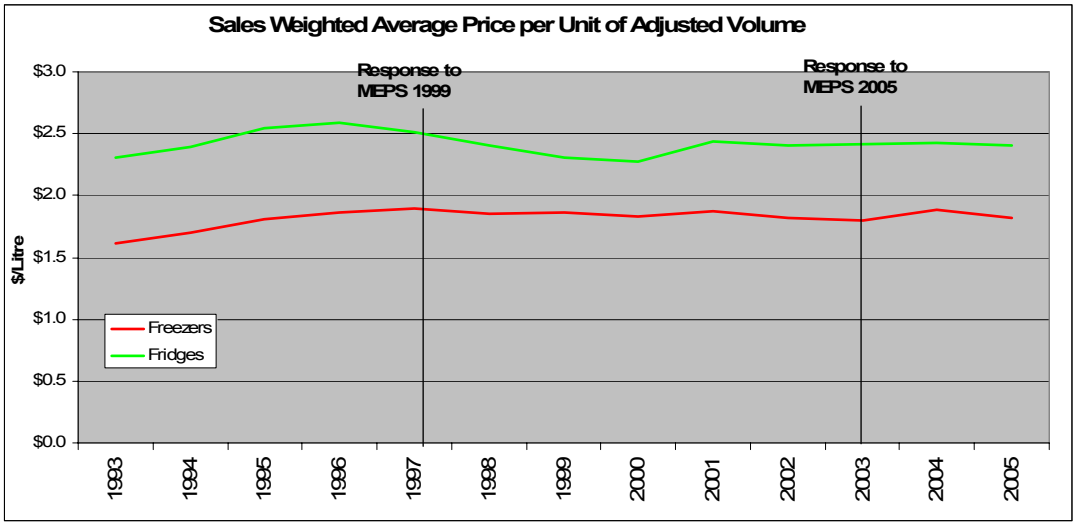
Analysis of all groups of refrigerators and freezers provides a more generalised level of assessment. Figure 23 illustrates such trends of changes in average market price standardised over adjusted volume for refrigerators and freezers. The figure shows that while the standardised average market price of freezers has remained almost unchanged after 1996, the standardised market price of refrigerators has gone through many variations between 1993 and 2005.

The standardised market price of refrigerators increased steadily between 1993 and 1996. It then declined almost in an identical manner and by 2000 it returned back to its 1993 value. The standardised price grew by about 7% between 2000 and 2001 and remained almost unchanged until 2003, when it grew further by about 19% leading to year 2004. This increase in price per unit of adjust volume is due to the rapid increase in standardised price of Group 2 machines in 2004, with group 2 machines having a market share of approximately 20% to total sales. Recently, the standardised price of refrigerators has shown a decline of about 7% between the years 2004 and 2005.

3.4.1.1 Summary

Figure 23 shows the changes in standardised price of refrigerators (price divided by adjusted volume) from 1993 to 2005. The changes in standardised price can not be directly attributed to the introduction of MEPS. For example if the first price rise (2000 – 2001) occurred immediately after the introduction of MEPS 1999, which is well after the perceived year of responsiveness (1997) to the introduction of MEPS 1999. The increase in price per unit of adjusted volume in 2004 is due to the price changes of Group 2 machines rather than the affect of MEPS 2005. It is important to note that following the perceived year of responsiveness of MEPS 1999 (1997) the standardised prices of refrigerators actually continued to decline for the next 3-4 years.

Figure 23: Sales weighted average price per unit adjusted volume of all refrigerators and freezers (post labelling)



3.4.2 Average Market Price per unit of adjusted volume Trends Before the Introduction of Labelling

The results of ACA studies, as described in Section 3.2.2, suggest that prior to the introduction of mandatory labelling the average market price per unit of adjusted storage volume of refrigerators was increasing. However, the average market price per unit of adjusted storage volume of freezers was decreasing before the introduction of labelling in 1986.

3.5 Average Efficiency (annual energy per unit of adjusted storage volume) Trends

The efficiency of a refrigerator and/or freezer is often determined as its average energy consumption standardised over adjusted volume, where adjusted volume is sum of fresh food volume and freezer volume appropriately scaled up to an equivalent fresh food volume. The trends in these attributes provide the measure of the efficiency of refrigerators and freezers.

3.5.1 Average Efficiency Trends After the Introduction of Labelling

The trends of average efficiency for different groups of refrigerators and freezers were assessed using a combination of results from GfK, labelling registration and ACA data.

3.5.1.1 Model Weighted Results

The labelling registration data was used to produce trends of *model weighted* average efficiency of various groups of refrigerators and freezers. Note that the model weighted values for a year refer to simple averages of annual energy consumptions of all models for

a group in that year. The model weighted values do not provide as accurate trend compared to sales weighted values, but rather an indicative situation analysis. Therefore, it is important that analysis based on model weighted values is treated with caution. Figure 24 and Figure 25 illustrate trends of changes in *model weighted* average efficiencies of various groups of refrigerators and freezers after introduction of labelling in 1986.

From Figure 24 it can be noticed that changes in the energy efficiency of Group 1, Group 2, Group 3 and Group 4 refrigerators have been responsive to two rounds of MEPS as there are significant decline in energy per unit volume immediately after the two vertical lines. Whereas in case of Group 5B, Group 5S and Group 5T the decline appears to have occurred irrespective of MEPS.

In contrast for freezers Figure 25 shows significant variations in either direction (increase or decrease of efficiency), with the exception of responsiveness to MEPS 2005 in case of Group 6U and Group 6C machines.

Figure 24: Model weighted average efficiency of refrigerators by groups (post labelling)

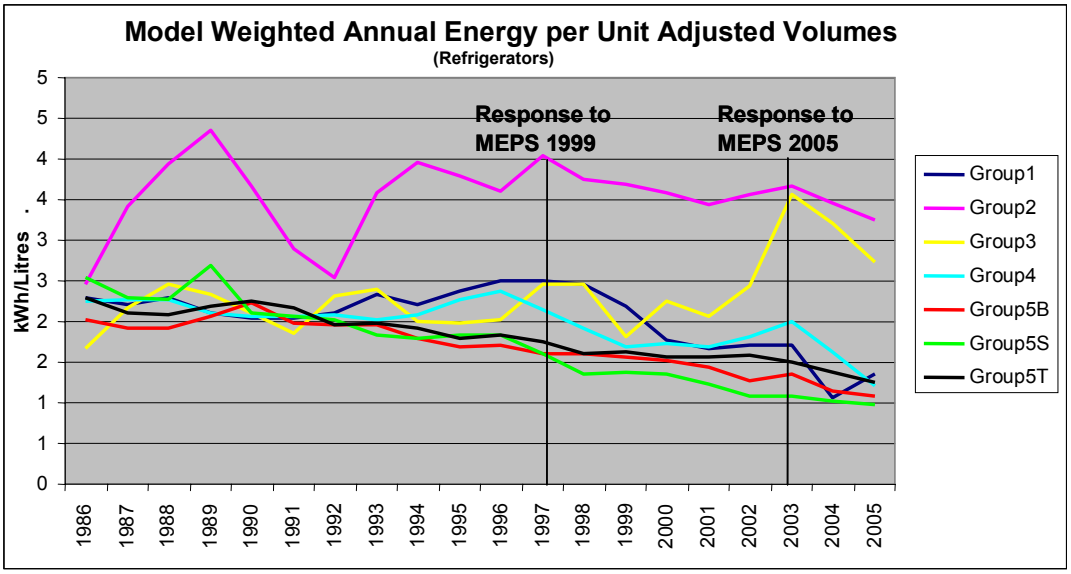
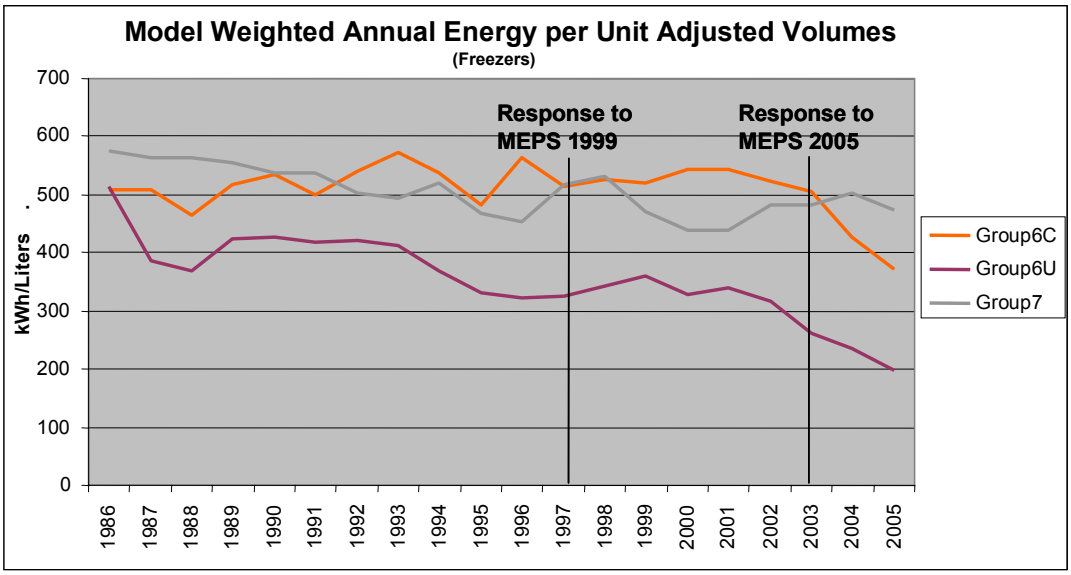
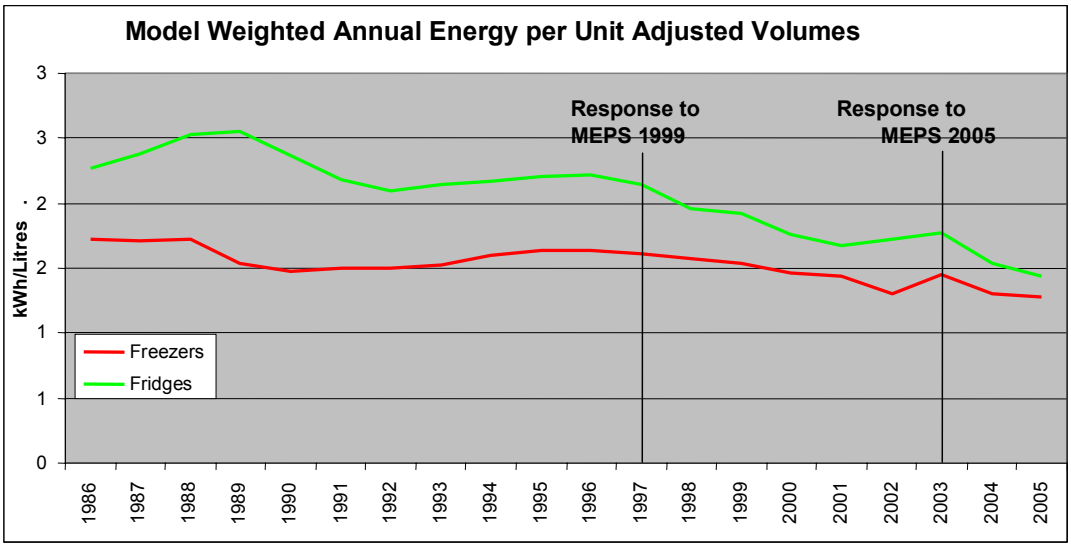


Figure 25: Model weighted average efficiency of freezers by groups (post labelling)



Analysis of all groups of refrigerators and freezers provides a generalised level of assessment. Figure 26 illustrates such trends of changes in average efficiency of refrigerators and freezers. The figure shows trends that are consistent with group level assessment discussed above. Energy consumption per unit of adjusted volume shows steady decline following the perceived years of responsiveness of introduction of two MEPS.

Figure 26: Model weighted average efficiency of all refrigerators and freezers by (post 1993)



The *model weighted* data shows there is a general downward trend for average annual energy per unit of adjusted storage volume, reflecting an improvement in efficiency for both

refrigerators and freezers which does not coincide with the introduction of MEPS. These *model weighted* results therefore illustrate that – for all groups of refrigerators and freezers – there is no clear association of changes in efficiency with the implementation of two rounds of MEPS. In contrast the sales weighted data, discussed below, suggest a different conclusion.

3.5.1.2 Sales Weighted Results

The *sales weighted* trends of average annual energy per unit of adjusted storage volume for different groups of refrigerators and freezers were produced using GfK data. Figure 27 and Figure 28 illustrate trends of changes in *sales weighted* average annual energy per unit of adjusted storage volume of refrigerators and freezers. Because of the limitations of GfK data the trends start only after 1993.

Figure 27: Sales weighted average efficiency of refrigerators by groups (post 1993)

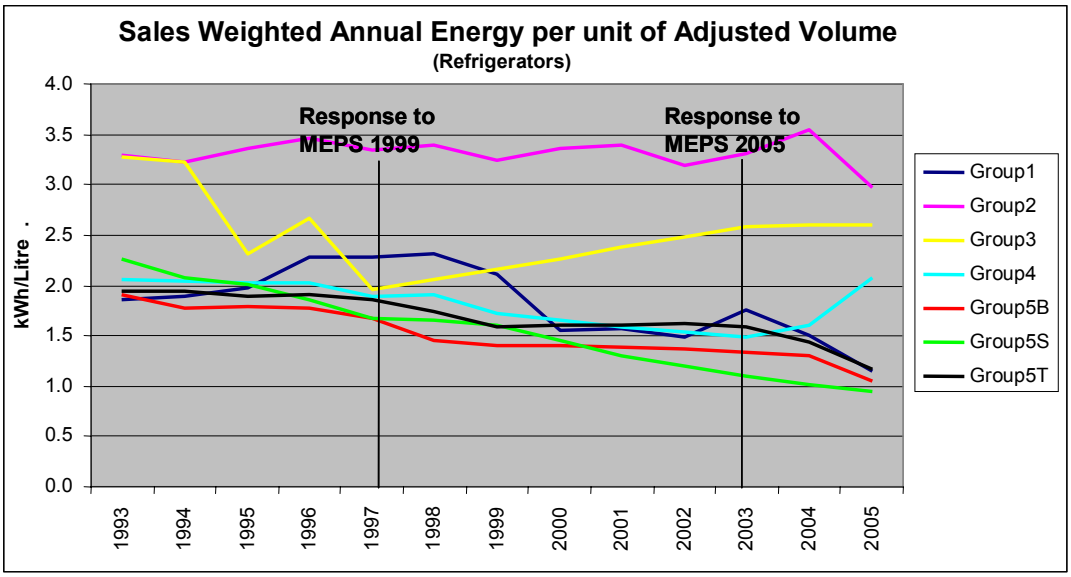
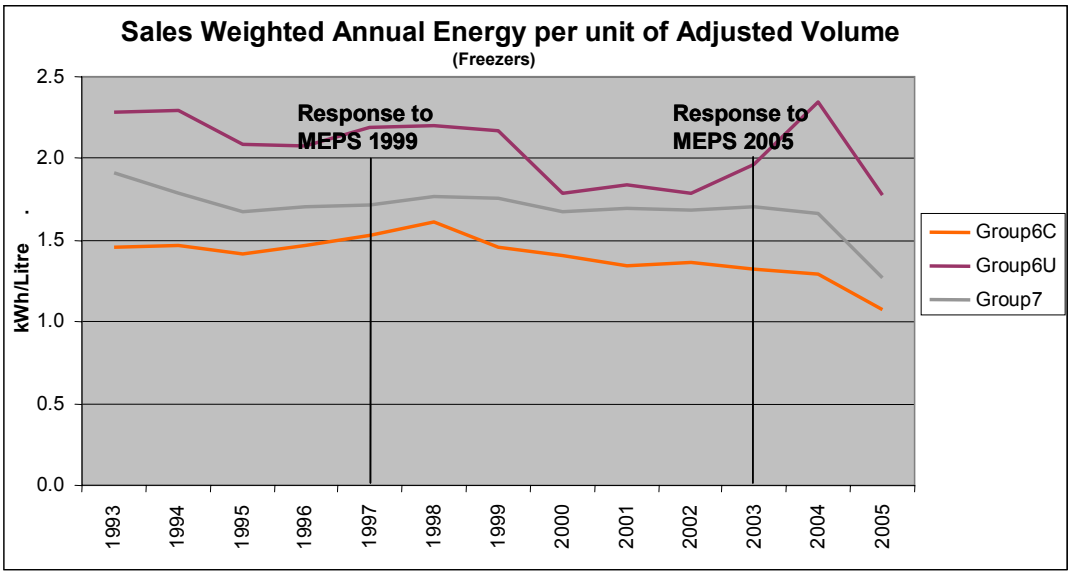


Figure 28: Sales weighted average efficiency of freezers by groups (post 1993)



The analysis of sales weighted efficiency trends show rather different results. In the majority of cases there was an upward or stalled trend before the implementation of MEPS. The trends then appear to move to downwards trends at the time (the assumed years of responsiveness) of the implementation of MEPS. The exceptional cases are Group 5S, Group 4, and Group 3.

In case of Group 5S a downward trend can be noticed that is irrespective of MEPS. In case of Group 4, an unexpected upward trend occurred after 2004, however the market share of this group is less than 0.2% in 2005. In case of Group 3, a persistent upward trend after 1997 (the presumed year of responsiveness to MEPS 1999) is rather extraordinary but, as mentioned earlier, is probably the result of the small number of sales of specialised models in this Group.

It is also noticeable that in case of MEPS 1999 the downwards trend, following the perceived year of responsiveness i.e. 1997, continues only until the year of implementation, i.e., 1999 or 2000. After this point the efficiency stalls or rate of decline decreases significantly until the perceived year of responsiveness of MEPS 2005, when another sharp decline is noticeable.

Generalised assessment using consolidated GfK data for all groups of refrigerators and freezers was also performed. Figure 29 illustrates such trends of changes in sales weighted average efficiency of refrigerators and freezers. The figure shows trends that are consistent with group level assessment discussed above. Sales weighted energy consumption per unit of adjusted volume shows steady decline following the perceived years of responsiveness of introduction of two MEPS.

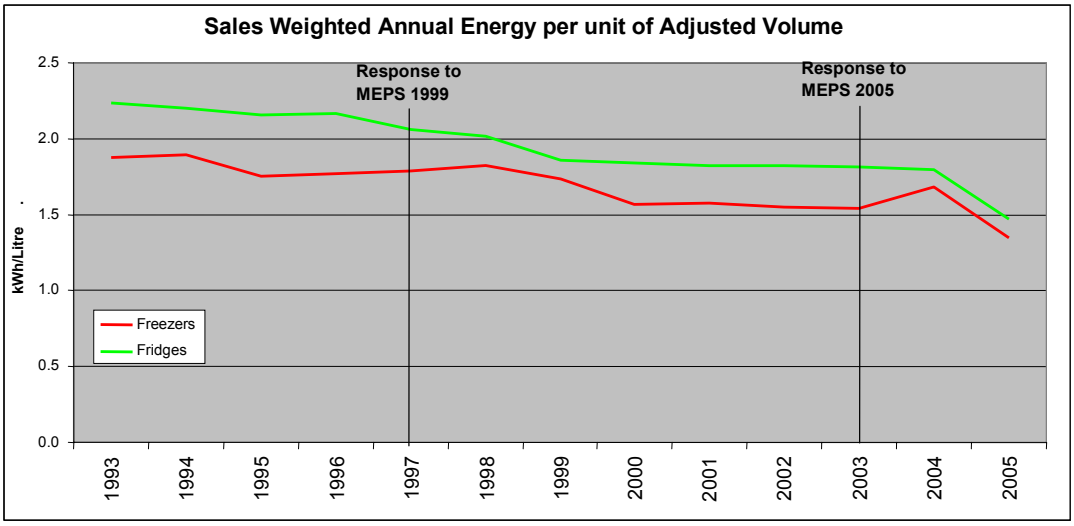
It is worth noting that consistent with previous assessments of differences between model weighted and sales weighted trends, a lag of 1 to 2 year in responsiveness is noticeable.

Also consistent with assessment made above, the decline in energy per unit of adjusted volume, corresponding to introduction of MEPS 1999, occurs only between the year of responsiveness and the actual year of implementation where it stalls until new set of regulation (MEPS 2005) is introduced.

3.5.1.3 Summary

As can be seen in Figure 29, the sales weighted trends for the efficiency indicator, defined as average annual energy per unit of adjusted storage volume, show consistent efficiency improvements since the introduction of labelling in 1986 and two rounds of MEPS in 1999 and 2005.

Figure 29: Sales weighted average efficiency of all refrigerators and freezers (post 1993)



3.5.2 Average Efficiency Trends Before the Introduction of Labelling

The results of ACA studies, as described in Section 3.2.2, suggest that prior to the introduction of mandatory labelling the average annual energy consumption per unit of adjusted storage volume of refrigerators was increasing. However, the average annual energy consumption per unit of adjusted storage volume of freezers was decreasing before the introduction of labelling in 1986.

3.5.3 Changes in Product Offering

3.5.3.1 Qualitative Results

While analytically less rigorous and unable to provide numerical conclusions, another way to assess the impacts of policy options is to determine changes in product mix, offered by suppliers, as a function of product efficiency. In case of refrigerators and freezers, star

rating categorises various models according to their efficiency bands. Data from the labelling registration database was used to produce distribution of all models of refrigerators and freezers given by their star ratings[4]. Figure 30 and Figure 31 illustrate such distributions for refrigerators and freezers. It can be noticed that the total number and proportional share of high star rated models has consistently grown since the introduction of labelling in 1986.

Important observations can be made in Figure 30;

- After 1986 (the implementation of mandatory labelling) the number of higher star rated models consistently increased. However, the number of models with lowest star rating (1.0) also grew, proportionally.

- After 1993 (the year when it the MEPS 1999 was first announced) the number of lowest rated models (1.0) started to decline steadily, while number of higher rated models continued to grow.

- By 2005, number of models with star rating 1.0 was almost negligible.

This clearly demonstrate that the two policy options, appliance labelling and MEPS, both have had complementary, if differing, impacts. Appliance labelling appears to have induced the suppliers to introduce efficient models among their historic mix of product offering, while the introduction of MEPS effectively forced low efficiency models out of the market.

[4] All start ratings are adjusted to match the new Star Rating Index introduced in 2000

Figure 30: Number of refrigerator models by their star rating

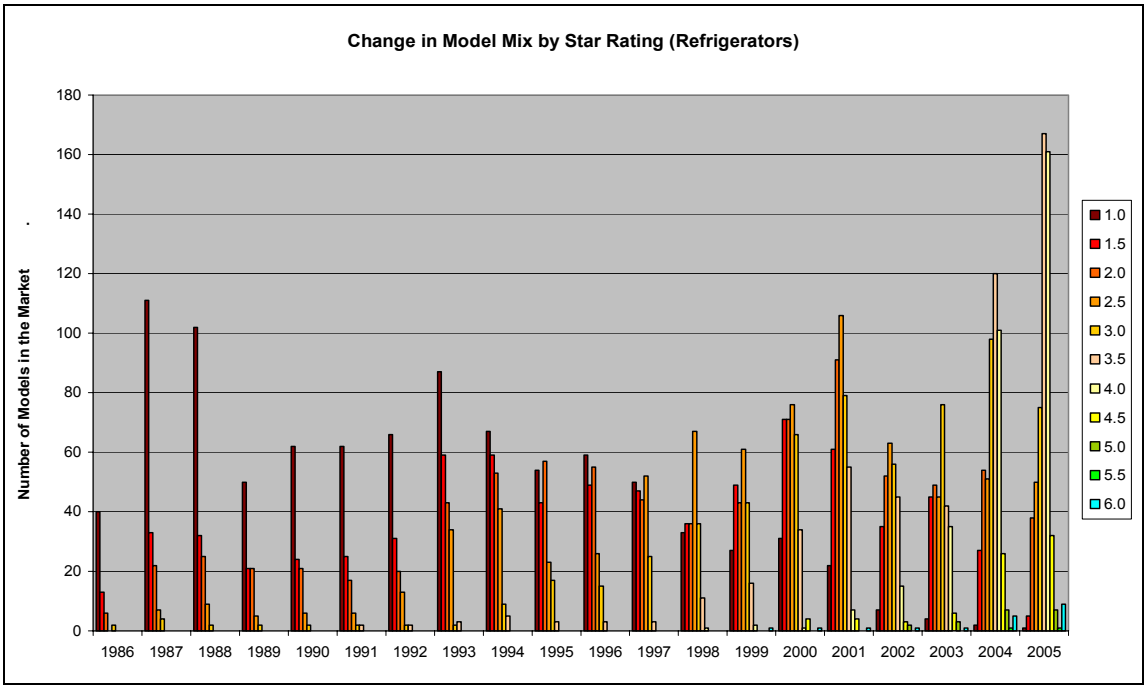
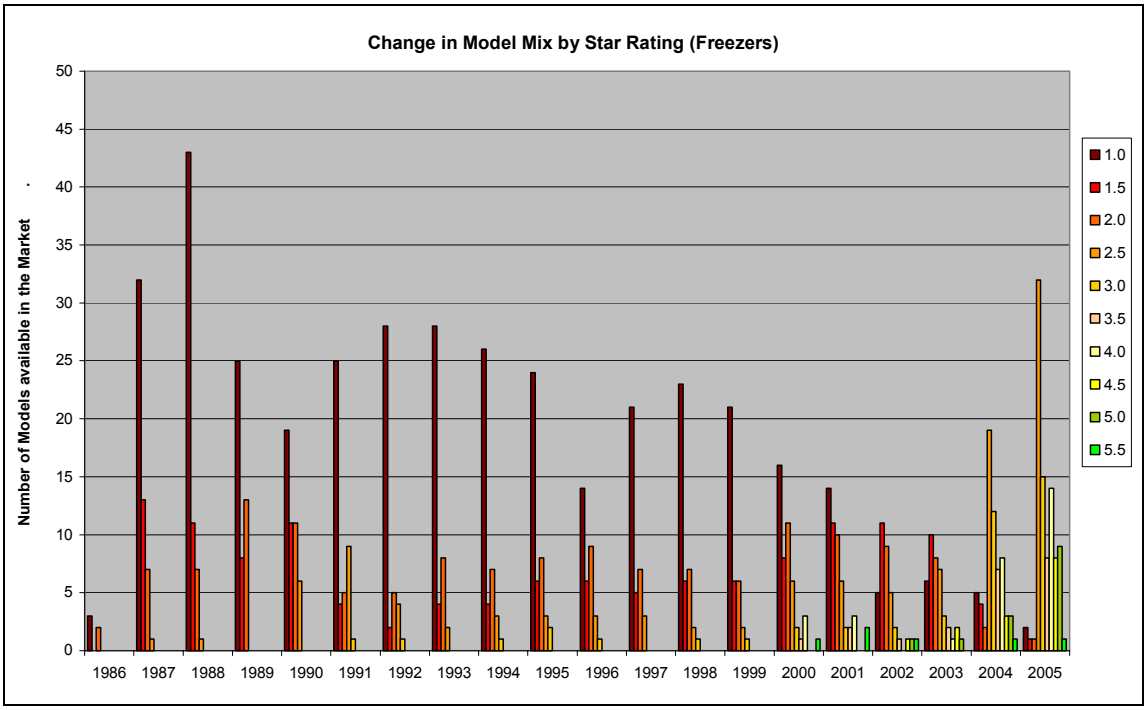


Figure 31 shows reasonably similar trends for freezers, albeit changes at much slower rates. This could be attributed to market dynamics that may have resulted due to steady/declining sales of stand-alone freezers between 1986 and 1997. However, by 2005 there appear to be proportionally more 5.0 and 5.5 star rated freezer models in the market that the counterpart refrigerator models.

Figure 31: Number of freezer models by their star rating



3.5.3.2 Summary

Figure 32 broadly illustrates the refrigerator market transformation between the years 1986 and 2005 by comparing number of models by star rating available in these years.

Figure 32: Illustration of Refrigerator Market Transformation between the years 1986 and 2005

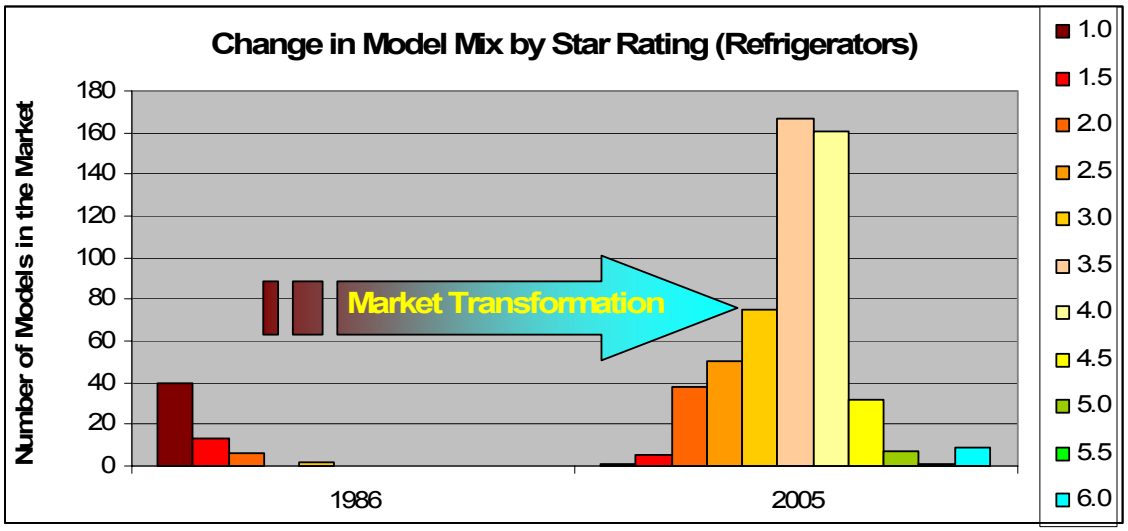
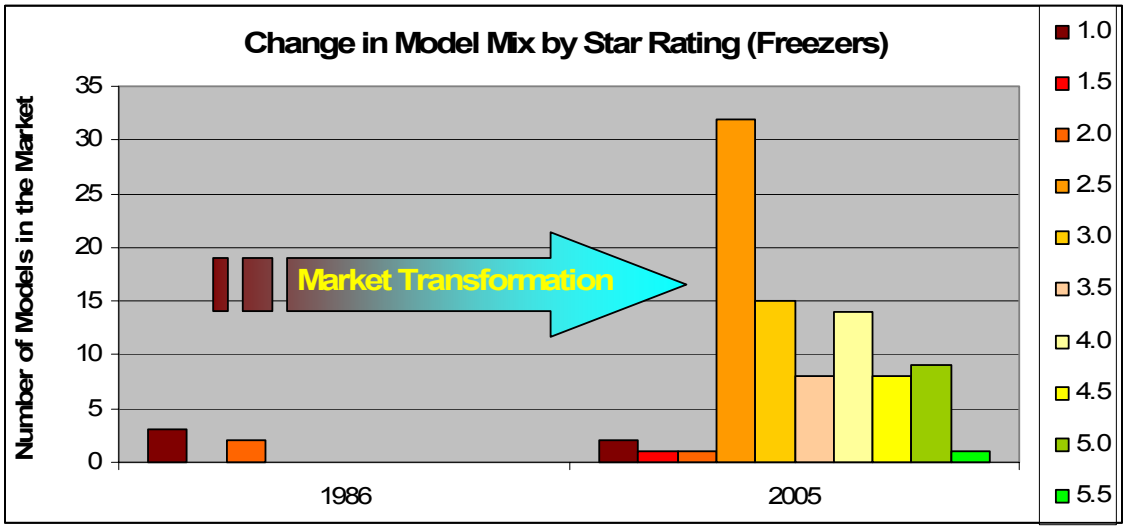


Figure 33 broadly illustrates the freezer market transformation between the years 1986 and 2005 by comparing number of models by star rating available in these years.

Figure 33: Illustration of Freezer Market Transformation between the years 1986 and 2005



3.6 Estimating the Energy Savings

The methodology used to estimate energy savings resulting from implementation of mandatory labelling in 1986, 1st round of MEPS in 1999 and 2nd round of MEPS in 2005 has been explained in the Section 2.2.2. This section provides the results from the execution of the methodology.

3.6.1 Estimated Sales Weighted Average Annual Energy Consumption Trends

The methodology used to estimate sales weighted average annual energy consumption of various groups of refrigerators and freezers, has been explained in Section 2. The sales weighted average annual energy consumptions were used to produce trend lines using 5 year moving averages. The following trends were produced;

1. **Policy:** Actual sales weighted average annual energy consumption for each group of refrigerators and freezers as estimated using methodology explained in Section 2.

2. **Business as Usual Situation 1 (BAU 1):** Trend as determined by conditions before the introduction of labelling in 1986.

3. **Business as Usual Situation 2 (BAU 2):** Trend as determined by conditions before the introduction of MEPS 1999.

4. **Business as Usual Situation 3 (BAU 3):** Trend as determined by conditions before the introduction of MEPS 2005.

As mentioned above the values for the above trends were calculated as 5 year moving averages, except for the Policy option where actual values were used. The results are shown in Figure 34, Figure 35 and Figure 36.

Figure 34 shows 4 trends of changes in combined sales weighted average annual energy consumptions of all refrigerators and all freezers. It can be seen that, as combined the average annual energy consumption of refrigerators offered a slightly inclining trend prior to the introduction of labelling in 1986. Continuation of this trend (BAU 1) is depicted using a broken line with wide segments (_ . _ . _ . _ .). The actual average annual energy shows a declining trend at the point of responsiveness (1985) of the introduction of labelling. Such trend persists until the point of responsiveness to the introduction of MEPS 1999 in 1997. Continuation of this trend (BAU 2) is depicted using a broken line with narrow segments (- - - - - - - - -). The actual average annual energy past MEPS1999, shows a further decline trend until the point of responsiveness of the introduction of MEPS 2005 in 2003. Continuation of this trend (BAU 3) is depicted using a fuzzy line (═══).

The four trends are similarly depicted for all types of refrigerators and freezers in Figure 34, Figure 35 and Figure 36

It can be seen in Figure 34 that in case of refrigerators, all BAU trends remain above the policy trend line (actual values). Which suggests that implementation of 3 policy options forced the trends of consumption levels downwards thereby ensuring energy savings. However, in case of freezers, it can be noticed that BAU 2 line assumes a lower value than actual energy consumption until 2005 when the actual energy consumption trend was forced downwards as a result of the introduction of MEPS 2005. Such disparity may be interpreted that introduction of MEPS 1999 may have forced the existing downwards trends to assume a higher value. Nonetheless overall savings are still obvious.

Figure 34: Sales Weighted Average Annual Energy Trends for All Refrigerators and Freezers under different scenarios

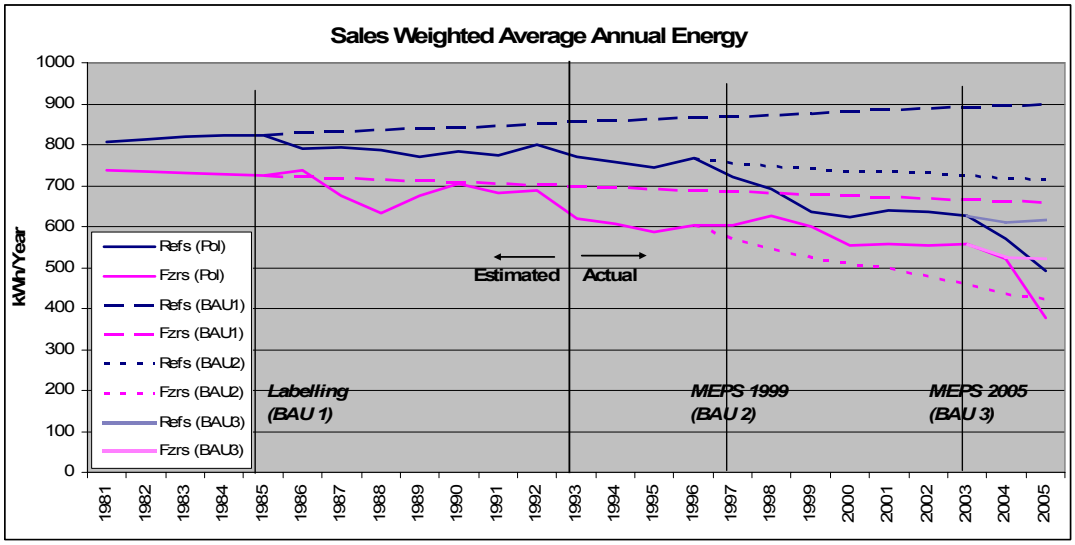


Figure 35 and Figure 36 illustrate separate trend lines for various groups of refrigerators and freezers respectively. The two figures show similar trends for various groups as illustrated by the consolidated trends in Figure 34. In case of refrigerators (Figure 35), it can be seen that in majority cases the policy line (actual values) stays mostly above the BAU lines. In case of freezers, while the policy lines of Group 6C and Group 7 are generally well below the BAU 1 and BAU 3 trend lines, they tend to have significantly higher values against BAU 2 trends. The situation is rather different in case of Group 6U where except for the period 1985 to 1994, and 2003 to 2004, the policy line remains generally above the BAU lines.

It is interesting to notice that while all refrigerator groups exhibit slightly declining BAU trends of average annual energy consumptions, prior to the introduction of labelling, the consolidated trend of average annual energy consumption for all refrigerators assumes a slightly upward trend for the same period.

Figure 35: Sales Weighted Average Annual Energy Trends for Groups of Refrigerators under different scenarios

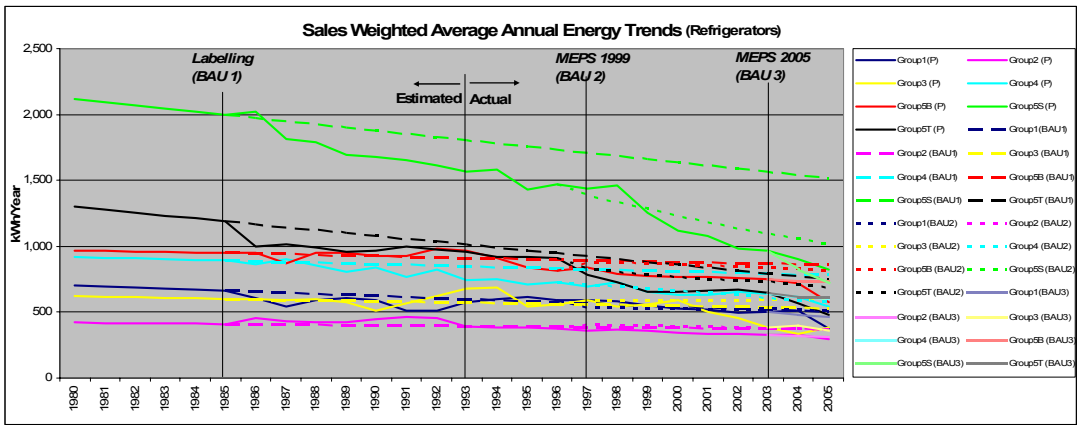
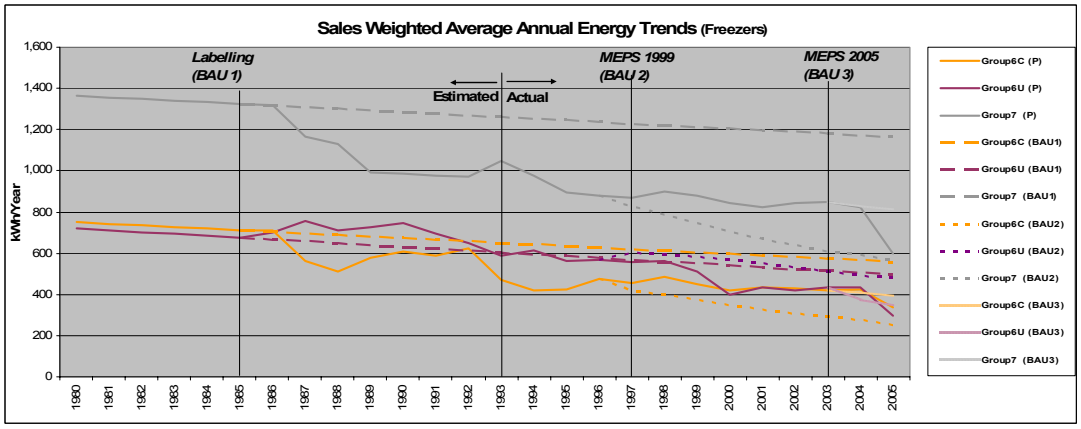


Figure 36: Sales Weighted Average Annual Energy Trends for Groups of Freezers under different scenarios



These figures above are enlarged in Appendix C to increase their clarity.

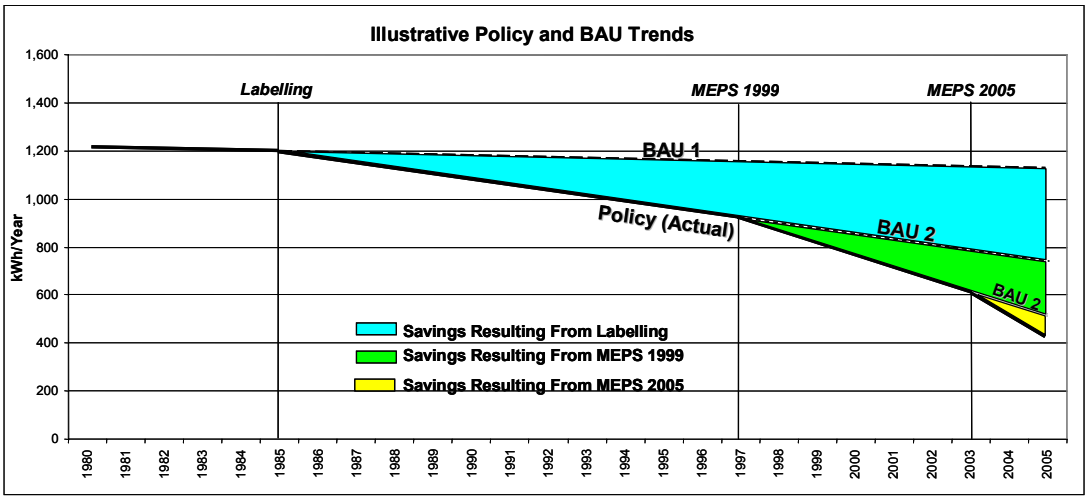
3.7 Estimated Energy Saved as a Result of Mandatory Labelling, MEPS 1999 and MEPS 2005

3.7.1 BAU and Policy Approach

The differences between estimated sales weighted average annual energy consumptions and projected trends for business as usual scenarios, corresponding to 3 policy implementations, for each group of refrigerator and freezer were used to estimate energy savings resulting from the implementation of different policy options. The value of energy savings for a group in a given year were calculated as product of annual sales of the group and difference between policy and BAU values in that given year.

The energy savings resulting from three regulatory options were estimated separately based on the assumption that a policy implementation changes the previous trend and sets a new trend so that the pre-policy trend becomes BAU trend and post policy trend becomes the policy trend. However, when a new policy is implemented in addition to previous policy or as a replacement of older policy, the previous policy trend becomes BAU trend and the policy trend is determined by the new values. Hence the resulting savings for each policy implementation can be estimated separately as illustrated in Figure 37. As can be seen from the figure, the savings are a function of difference between the policy (actual) value and the BAU for a given year. Hence, the savings due to implementation of labelling between the period 1986 and 1997 can be estimated simply as a function of difference between the policy and BAU1 values. However, the savings due to labelling between 1997 and 2003 are the function of Policy – BAU1 – BAU2, where as the savings due to MEPS 1999 for the same period would be Policy – BAU2.

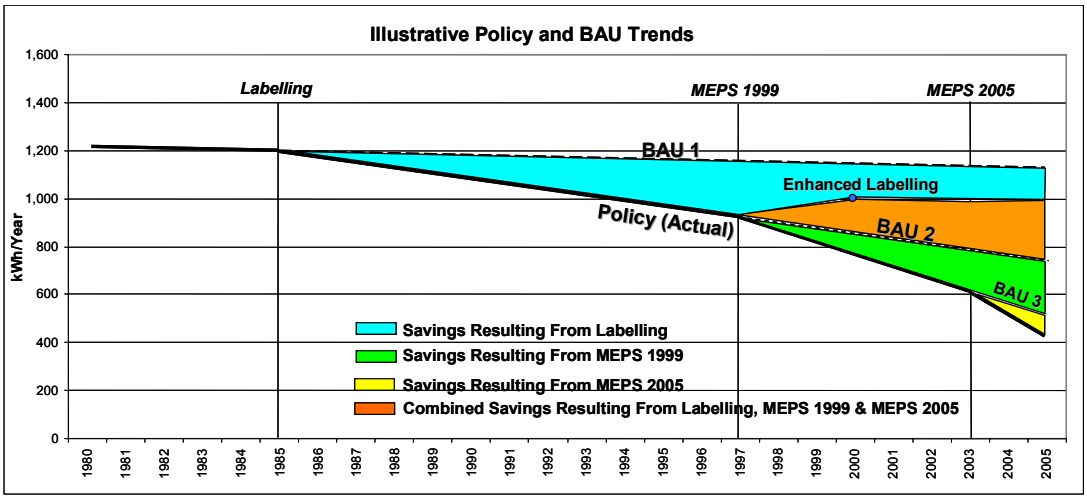
Figure 37: Illustrative example of separation of savings resulting from 3 policy implementations



It is worth noting that some regulatory policies have specific life span when they produce benefits. The resulting benefits gradually decline as policy becomes a market standard. For example, the efficiency of refrigerators is improved by the policy implementation; however the BAU efficiency would eventually "catch up" to the policy setting. This is also the case when a more stringent regulation is introduced in parallel with the existing regulation.

The introduction of MEPS 1999 essentially reduced the effectiveness of labelling, and consequently the resulting impacts, as the MEPS 1999 eliminated a number of low star machines from the market. The enhanced labelling that followed immediately after MEPS 1999 would have improved the declining effectiveness of labelling by providing a broader spread of star ratings among MEPS 1999 qualifying machines. In such case the resulting impact can be divided into direct impact of labelling, direct impact of MEPS 1999, direct impact of MEPS 2005 and combined impact of the 3 wherever an overlap occurs. Such potential breakdown is illustrated in Figure 38.

Figure 38: Illustrative example of separation of savings resulting from 3 overlapping policy implementations



In order to reliably estimate the real direct impact of labelling, different type of data was required e.g. market research surveys of the consumers and attributes of products that they purchased. In the absence of such data it was only logical for us to use the trend lines technique to separate the estimated direct impacts resulting from 3 policy options as illustrated in Figure 37.

Obviously, the BAU is a trend that is built on the basis of historic values and can never be verified, as conditions driving that trend were altered with the implementation of the policy. Also while the BAU trends are often smooth lines, the policy trends are the actual trends influenced by evolving market situations and therefore are often characterised by small and large variations. The policy trends will be affected by several factors, such as competition, new technological developments, changes in sources of overseas manufacturing and markets etc, and these factors can not possibly have been influenced by labelling and MEPS policy regulations.

Consequently, as can be seen from various assessments presented in previous sections, the policy trend could be higher (in other words the policy trend line may be above the BAU trend line) than the corresponding BAU trend, indicating that BAU might have been a more efficient solution than the policy option.

It is not possible to determine what the actual BAU trend would have been if the policy were not implemented. However, while not necessary true, it is very likely that if the policy trend shows an upward trend the corresponding BAU trend would have followed similar or even more adverse trend in the absence of the policy option.

Therefore, when estimating energy savings as a function of difference between policy trends and BAU trends, only those energy savings were included where the policy trend was higher than the BAU trend. The difference was set to zero (and consequently no energy savings realised) if BAU was higher than the policy value.

3.7.2 Estimated Energy Saving Impacts

Table 5, Table 6, and Table 7 provide the detailed estimated savings resulting from the implementation of mandatory labelling, MEPS 1999, and MEPS 2005. Table 8 provides combined savings resulting from all three policy options.

Figure 39 illustrates the trends of energy savings resulting from the three policy options. It can be noticed that the combined total savings rise steadily before attaining a stable level before a new policy option is implemented. More recently due to the impact of MEPS 2005 the overall savings have grown at a significantly higher rate between 2004 and 2005.

Figure 39: Summary of energy savings resulting from 3 policy options

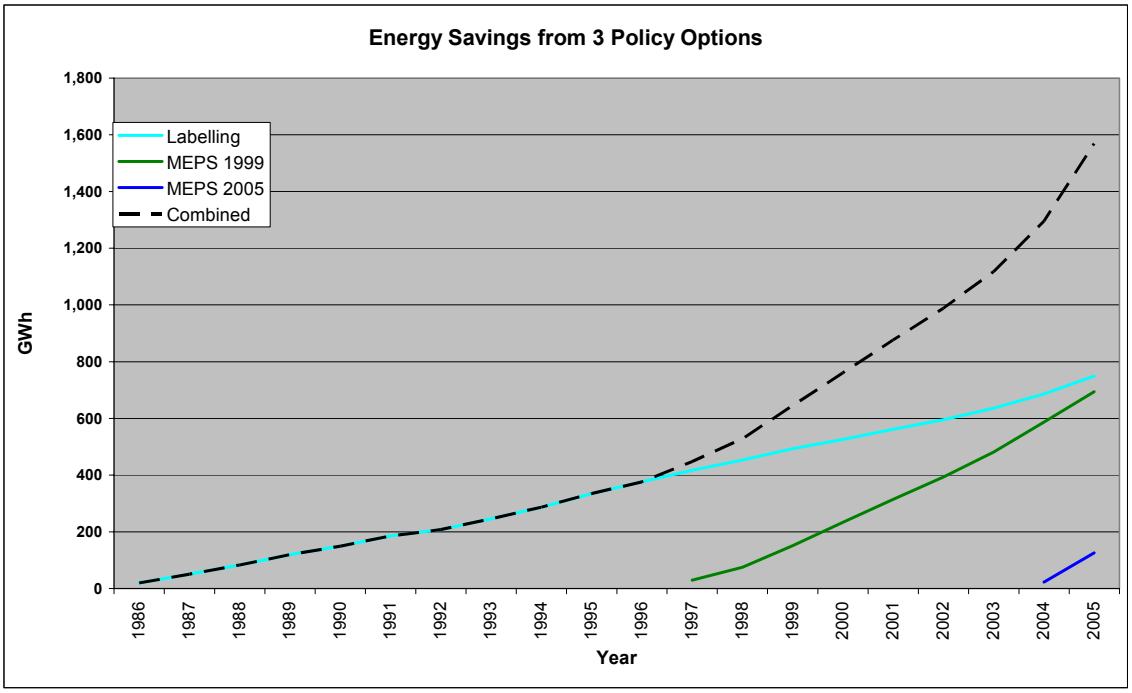


Table 5: Estimated energy savings from implementation of mandatory labelling

YEAR	Group1	Group2	Group3	Group4	Group5B	Group5S	Group5T	Group6C	Group6U	Group7	Total
1986	2.5	-	-	3.4	-	-	14.0	-	-	-	19.9
1987	7.8	-	0.2	3.4	2.5	0.7	25.8	8.9	-	1.1	50.4
1988	10.1	-	0.2	7.4	2.5	1.6	38.5	19.9	-	2.5	82.7
1989	11.0	-	0.6	17.1	2.5	2.9	54.2	25.9	-	5.6	119.8
1990	12.2	-	2.2	21.4	2.6	4.3	67.4	29.4	-	9.4	149.0
1991	17.1	-	2.4	35.9	2.6	5.9	74.3	33.4	-	13.7	185.2
1992	21.3	-	2.4	39.9	2.5	7.7	81.2	34.6	-	18.5	208.1
1993	21.9	0.3	2.4	56.0	2.5	9.7	87.8	42.4	0.6	22.4	246.0
1994	21.4	1.3	2.4	71.2	2.4	12.3	96.6	51.1	0.6	27.6	286.9
1995	20.8	1.8	2.6	89.2	8.0	16.8	102.1	57.4	1.5	34.8	334.9
1996	19.9	2.7	2.5	102.5	15.9	21.9	105.0	61.3	1.9	42.1	376.0
1997	18.8	4.9	2.4	118.8	19.5	26.8	107.8	65.6	2.2	50.3	417.3
1998	17.4	6.5	2.3	127.6	27.5	30.8	111.5	68.3	2.2	58.7	452.8
1999	15.8	8.9	2.1	136.6	35.8	37.2	113.1	71.9	3.2	68.3	493.0
2000	14.0	12.6	1.9	140.0	43.9	42.5	111.4	76.4	5.1	78.5	526.3
2001	12.1	17.0	1.7	141.1	51.7	57.2	104.9	79.2	7.6	88.8	561.3
2002	10.2	22.3	1.5	138.5	59.7	75.7	96.6	83.0	9.9	97.6	594.9
2003	8.3	28.1	1.2	133.6	68.6	104.1	87.2	87.5	11.2	106.0	635.8
2004	6.5	35.9	1.0	126.3	78.6	141.0	77.9	91.5	13.9	113.1	685.8
2005	5.0	45.4	0.8	116.0	89.6	186.3	68.9	97.2	21.0	119.0	749.1
Total	**274.0**	**187.9**	**32.9**	**1,626.0**	**518.9**	**785.6**	**1,626.3**	**1,084.9**	**80.8**	**958.0**	**7,175.2**

All values in GWh

Table 6: Estimated energy savings from implementation of MEPS 1999

YEAR	Group1	Group2	Group3	Group4	Group5B	Group5S	Group5T	Group6C	Group6U	Group7	Total
1997	0.9	0	0.2	-	0	-	27.9	0	-	0.7	29.7
1998	3.9	0	0.5	-	0	-	70.0	0	-	0.7	75.1
1999	8.7	0	0.6	-	0	1.5	139.8	0	-	0.7	151.2
2000	14.2	0	0.6	0.7	0	4.6	211.9	0	1.1	0.7	233.7
2001	20.6	0	0.7	0.7	0	11.8	279.0	0	1.1	0.6	314.6
2002	27.9	0	0.9	0.7	0	24.6	337.5	0	1.1	0.6	393.4
2003	37.1	0	1.2	0.7	0	39.5	401.4	0	1.1	0.6	481.6
2004	46.0	0	1.3	0.7	0	60.9	476.1	0	1.1	0.6	586.7
2005	57.7	0	1.3	0.7	0	90.3	542.2	0	1.1	0.6	693.8
Total	**217.1**	**0**	**7.1**	**4.1**	**0**	**233.2**	**2,485.8**	**0**	**6.8**	**5.7**	**2,959.7**

All values in GWh

Table 7: Estimated energy savings from implementation of MEPS 2005

YEAR	Group1	Group2	Group3	Group4	Group5B	Group5S	Group5T	Group6C	Group6U	Group7	Total
2004	-	-	0.1	0.0	1.3	0	21.0	-	-	0.1	22.5
2005	3.9	2.8	0.1	0.1	17.9	0	87.3	4.2	2.6	7.0	125.8
Total	**3.9**	**2.8**	**0.1**	**0.1**	**19.2**	**0**	**108.4**	**4.2**	**2.6**	**7.1**	**148.3**

All values in GWh

Table 8: Estimated energy savings from implementation of three policy options

YEAR	Group1	Group2	Group3	Group4	Group5B	Group5S	Group5T	Group6C	Group6U	Group7	Total
1986	2.5	-	-	3.4	-	-	14.0	-	-	-	19.9
1987	7.8	-	0.2	3.4	2.5	0.7	25.8	8.9	-	1.1	50.4
1988	10.1	-	0.2	7.4	2.5	1.6	38.5	19.9	-	2.5	82.7
1989	11.0	-	0.6	17.1	2.5	2.9	54.2	25.9	-	5.6	119.8
1990	12.2	-	2.2	21.4	2.6	4.3	67.4	29.4	-	9.4	149.0
1991	17.1	-	2.4	35.9	2.6	5.9	74.3	33.4	-	13.7	185.2
1992	21.3	-	2.4	39.9	2.5	7.7	81.2	34.6	-	18.5	208.1
1993	21.9	0.3	2.4	56.0	2.5	9.7	87.8	42.4	0.6	22.4	246.0
1994	21.4	1.3	2.4	71.2	2.4	12.3	96.6	51.1	0.6	27.6	286.9
1995	20.8	1.8	2.6	89.2	8.0	16.8	102.1	57.4	1.5	34.8	334.9
1996	19.9	2.7	2.5	102.5	15.9	21.9	105.0	61.3	1.9	42.1	376.0
1997	19.7	4.9	2.6	118.8	19.5	26.8	135.7	65.6	2.2	50.9	446.9
1998	21.3	6.5	2.8	127.6	27.5	30.8	181.5	68.3	2.2	59.4	528.0
1999	24.5	8.9	2.7	136.6	35.8	38.8	252.9	71.9	3.2	69.0	644.2
2000	28.2	12.6	2.5	140.7	43.9	47.1	323.3	76.4	6.3	79.1	760.1
2001	32.7	17.0	2.4	141.8	51.7	69.0	383.9	79.2	8.8	89.4	875.9
2002	38.0	22.3	2.4	139.2	59.7	100.4	434.2	83.0	11.0	98.2	988.3
2003	45.3	28.1	2.4	134.3	68.6	143.6	488.6	87.5	12.3	106.6	1,117.4
2004	52.6	35.9	2.3	127.0	79.9	201.9	575.0	91.5	15.0	113.8	1,295.0
2005	66.5	48.2	2.1	116.7	107.4	276.7	698.5	101.4	24.6	126.5	1,568.7
Total	**494.9**	**190.7**	**40.1**	**1,630.3**	**538.1**	**1,018.8**	**4,220.5**	**1,089.0**	**90.1**	**970.8**	**10,283.2**

All values in GWh

* BLUE cells provide estimated impacts resulting from labelling, GREEN cells contain combined impacts of labelling an MEPS 1999, YELLOW cells show combined impacts of labelling, MEP1999 and MEPS 2005

3.7.3 Comparison of Results with Past Forecasts and Projections

One of the objectives of this study is to establish the difference between the projected/forecasted benefits that were expected from implementation of three policy options and the actual impacts that may have resulted from the implementation of such policy options.

The anticipated impacts and benefits of implementation of a regulation are provided in Regulatory Impact Statement (RIS) before such regulation is approved and implemented. A RIS provides a comprehensive forecast of anticipated impacts of implementation of the regulation.

However, in the case of labelling a number of factors prevented a production of projected benefits at national level. These included the following;

- Labelling started as a state specific activity. NSW introduced labelling in December 1986 joined only by Victoria in early 1987. In 1986/7 the labelling became mandatory in 2 states, and because of the market share of the two states the impact was spread at national level. Suppliers had to label all products as they could not control the destination of products that were shipped.

- The state governments at that time did not carry out formal RIS for introducing such regulatory requirements. As long as a program made had worked elsewhere (in this case in the USA) and was likely to save some energy, it was implemented after customisation to local conditions.

- Some cost benefits analysis were carried out at the time of implementation of these policies in NSW and Victoria, however such analysis were never released in public documents.

Hence no forecasts of labelling impacts could be used to compare with the actual impacts as estimated in this study.

The RIS associated with the introduction of MEPS 1999, provided the combined forecasted impacts of MEPS 1999 and enhanced labelling. In 2000, the algorithms that are used to calculate the star ratings for refrigerators and freezers were modified – this was termed enhanced labelling. These modifications re-scaled the star ratings of all products and essentially raised the efficiency levels required to obtain stars. Therefore, a comparison between the actual estimated impacts of MEPS 1999 and the forecast combined impacts of MEPS 1999 and enhanced labelling was possible.

The RIS for the MEPS 2005 was used as the source of the projected MEPS impacts. Hence a comparison of actual and estimated impacts for MEPS 2005 could be undertaken.

Table 10 provides a detailed comparison between the estimated actual and forecasted impacts of labelling, MEPS 1999 and MEPS 2005. The table shows the energy savings

projections starting in the year of the MEPS implementation, however the implementation of both the MEPS 1999 and MEPS 2005 were delayed after an initial announcement.

In the case of MEPS 1999, the initial study into the proposal suggested an implementation date of 1996; however the final announcement of the intended MEPS (and agreement with the major industry suppliers) was made in 1996, with implementation in October 1999. In effect, the industry had approximately 6 years notice of the intended MEPS and effectively planned for the introduction of new models much earlier than the anticipated 1999 date. So to correctly show the forecasted impacts against the actual impacts, the forecast impacts were shifted back in time, to begin in 1997 – as shown in Table 9.

MEPS 2005 were to be implemented in 2004 and industry were given notice of the intended MEPS levels in 2000, however, due to delays the implementation date was set to 2005. Again, it was found to correctly compare the forecast impacts with the actual estimated impacts, the forecast impacts were shifted back to begin in 2004, when the actual impacts were first noticed. Table 9 provides a comparison of the estimated actual and forecast impacts.

Table 9: Comparison between forecasted and estimated actual energy savings from MEPS – Summary

Year Actual	Actual MEPS 1999	Year Projected (MEPS 1999)	Projected MEPS 1999	Actual MEPS 2005	Year Projected (MEPS 2005)	Projected MEPS 2005	Total Actual MEPS	Total Projected MEPS
1997	29.7	2000	42				29.7	42.0
1998	75.1	2001	76				75.1	76.0
1999	151.2	2002	110				151.2	110.0
2000	233.7	2003	175				233.7	175.0
2001	314.6	2004	240				314.6	240.0
2002	393.4	2005	305				393.4	305.0
2003	481.6	2006	352				481.6	352.0
2004	586.7	2007	399	22.5	2005	45.0	609.2	444.0
2005	693.8	2008	446	125.8	2006	136.8	819.6	582.8
Total	2959.7		2145	148.3		181.8	3108.0	2326.8
GWh Diff	814.7			-33.5			781.2	
% Above/below	38%			-18%			34%	

All values in GWh

3.7.3.1 Summary

The estimated actual impacts were found to be 38% above the projected MEPS 1999 impacts over the 9 years from 1997. The estimated actual impacts of MEPS 2005 were found to be approximately 18% below the projected impacts over the 2 year from 2004.

Overall, the actual impacts from MEPS 1999 and MEPS 2005 were 34% above the forecasted impacts. Figure 40 shows differences between the projected and actual savings. The projected impacts from Energy Labelling were not available; hence they can not be compared to the actual estimated savings shown in Table 8.

The actual estimated impacts were found to be greater than the projected impacts for MEPS 1999, however this would be expected. The analysis and projections undertaken in the RIS are generally conservative due to the uncertainties associated with usually limited data and various assumptions that are required. These unknown attributes are typically shown as scenarios or the most conservative values are used to ensure that assessments of costs/benefits can be easily met when challenged.

The actual estimated impacts for MEPS 2005 are early in developing but appear to be tracking well with the projected impacts, even though there are only 2 years of data points.

Figure 40: Comparison of Actual and Projected Energy Savings from MEPS

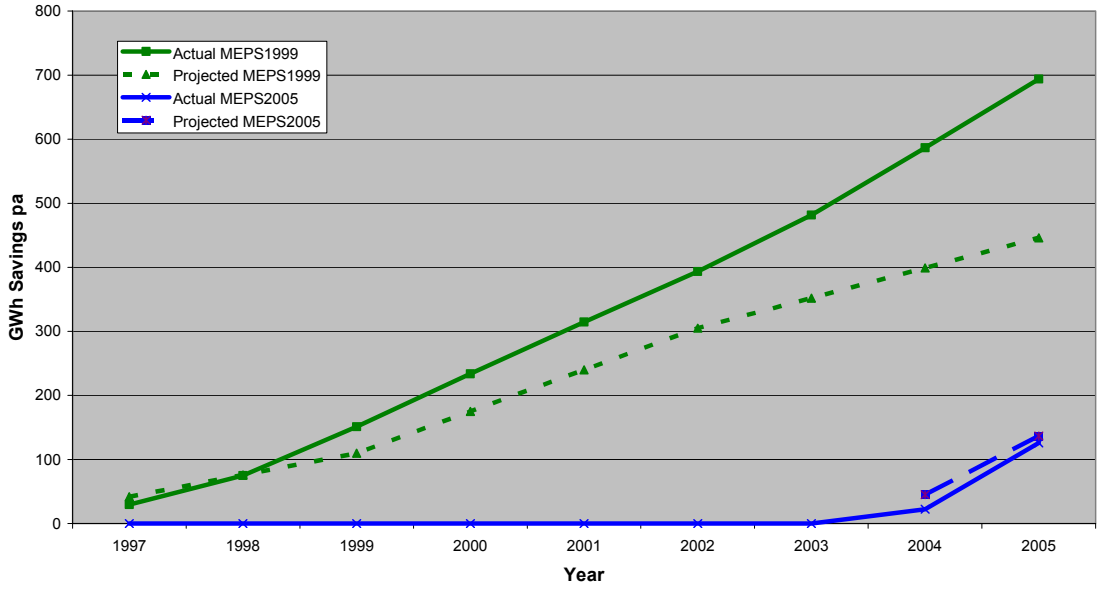


Table 10: Comparison between forecasted and estimated actual energy savings from implementation of three policy options

YEAR	Actual Labeling	Actual MEPS1999	Actual MEPS 2005	Total Actual	Projected Labeling[1]	Projected MEPS 1999[2]	Projected MEPS 2005	Total Projected	Difference Labeling[1]	Difference MEPS 1999[2]	Difference MEPS 2005	Difference Total
1986	19.9	-	-	19.9	N/A	-	-	-	N/A	-	-	-
1987	50.4	-	-	50.4	N/A	-	-	-	N/A	-	-	-
1988	82.7	-	-	82.7	N/A	-	-	-	N/A	-	-	-
1989	119.8	-	-	119.8	N/A	-	-	-	N/A	-	-	-
1990	149.0	-	-	149.0	N/A	-	-	-	N/A	-	-	-
1991	185.2	-	-	185.2	N/A	-	-	-	N/A	-	-	-
1992	208.1	-	-	208.1	N/A	-	-	-	N/A	-	-	-
1993	246.0	-	-	246.0	N/A	-	-	-	N/A	-	-	-
1994	286.9	-	-	286.9	N/A	-	-	-	N/A	-	-	-
1995	334.9	-	-	334.9	N/A	-	-	-	N/A	-	-	-
1996	376.0	-	-	376.0	N/A	-	-	-	N/A	-	-	-
1997	417.3	29.7	-	446.9	N/A	-	-	-	N/A	-	-	-
1998	452.8	75.1	-	528.0	N/A	-	-	-	N/A	-	-	-
1999	493.0	151.2	-	644.2	N/A	-	-	-	N/A	-	-	-
2000	526.3	233.7	-	760.1	N/A	42.0	-	42.0	N/A	191.7	-	191.7
2001	561.3	314.6	-	875.9	N/A	76.0	-	76.0	N/A	238.6	-	238.6
2002	594.9	393.4	-	988.3	N/A	110.0	-	110.0	N/A	283.4	-	283.4
2003	635.8	481.6	-	1,117.4	N/A	175.0	-	175.0	N/A	306.6	-	306.6
2004	685.8	586.7	22.5	1,295.0	N/A	240.0	0.0	240.0	N/A	346.7	22.5	369.2
2005	749.1	693.8	125.8	1,568.7	N/A	305.0	45.0	350.0	N/A	388.8	80.8	469.6
Total	7,175.2	2,959.7	148.3	10,283.2		948	45	993		2,011.7	103.3	1,859.1

All values in GWh

1 Projected/forecasted impacts of labelling were not available. See explanation in Section 3.7.3.

2 Combined impact of MEPS 1999 and Enhanced Labelling. Also note that the projected impacts were estimated past the year of implementation. In reality there is sufficient evidence to suggest that suppliers would often introduce regulation compliant products prior to the date of implementation of the regulation.

4 Findings and Conclusions

4.1 Findings

4.1.1 Energy Labelling

The impact of Energy Labelling for refrigerators and freezers on energy is significant, with savings rising from 20 GWh in 1986 to over 750 GWh pa in 2005. No comparison can be made with projected impacts as these were not calculated when Energy Labelling was introduced. These results show that energy labelling does make a significant impact, especially in the long term.

As energy labelling progresses and the spread of star ratings by model decreases, there is a need for the star rating algorithms to be revitalised (as in the case of enhanced labelling in 2000 for refrigerators and freezers). Without the enhanced labelling, it is likely that the BAU energy consumption may have improved and perhaps caught up with the labelling policy BAU after 15 or 20 years.

4.1.2 MEPS Impacts

The combined forecast impacts of labelling and MEPS 1999 may have been conservative, while the projected impacts of MEPS 2005 appear to be tracking close to the estimated actual impacts. This result provides evidence that the RIS projections undertaken before a MEPS policy option is implemented are usually conservative, which is to be expected.

The impact of MEPS is substantial, and savings continue to increase in line with projections. The MEPS 1999 has achieved annual energy savings of just under 700 GWh pa in 9 years, which is almost equivalent to annual savings attributed to energy labelling after 20 years. The vast amounts of impacts from MEPS 2005 are still to be achieved and it would be valuable to review the evaluation of the impacts of this MEPS in a further 2 to 3 years.

4.1.3 Price and Volume Attributes

There appears to be no direct effect from the implementation of Energy Labelling and MEPS on refrigerator/freezer volume or price. Contrary to conventional hypothesis and the assumptions in both MEPS RISs prepared to date, there does not appear to be any evidence to suggest that average market prices of refrigerators or freezers have been affected by the introduction of MEPS 1999 or MEPS 2005. This is quite remarkable considering that MEPS 2005 resulted in an average decrease in energy consumption of around 30% in the 2 years prior.

Although some groups have shown a decline in average adjusted volume over time, the sales weighted analysis performed on all refrigerator groups, suggests that there has been a consistent and gradual overall increase in the average adjusted volumes of refrigerators. While for freezers, there is a slightly upward trend in average adjusted freezer volumes

over the period between 1997 and 2003, followed by sharp decline since 2003, due to a surge in sales of very small group 6U products in 2004 and 2005.

4.1.4 Efficiency

In the majority of cases there was an upward or stalled trend before the implementation of MEPS. Such trends then appear to be taking the downwards trends at the time (assumed years of responsiveness) of implementation of MEPS. In general the sales weighted trends for the efficiency indicator, defined as average annual energy per unit of adjusted storage volume, show consistent efficiency improvements since the introduction of labelling in 1986 and two rounds of MEPS in 1999 and 2005.

4.2 Conclusions

The following conclusions are to be considered as a result of this study:

1. **Projections made in Regulatory Impact Statements are relatively accurate for this product group.** The projections made in the two domestic refrigerator Regulatory Impacts Statements have largely been supported by the findings of this retrospective analysis. The original estimates were based on conservative assumptions resulting in more modest impacts being predicted but they remain robust economic analyses upon which Ministers took informed decisions at the time. They underestimated the benefits or impacts of the two regulations which, with the benefit of hindsight, should have been expected because low-end assumptions were used as a means of garnering widespread stakeholder support for the regulatory proposals.

2. **Future RIS impacts and benefit cost analysis should be conservative** - Future projections in Regulatory Impact Statements should continue to adopt assumptions in accord with the "worst case scenario" based on plausible but conservative assumptions. For example, the findings on pricing establish little evidence exists to support the plausible assumption that more efficient products should result in higher prices. Over the seven year period studied in detail, no correlation between efficiency and price could be established from the data leading to a conclusion that the improved efficiency of domestic refrigerators and freezers was delivered by a competitive market to the consumer at no real cost increase. This conclusion, however, should not lead to future economic analysis predicting a similar outcome, far from it. The assumption of a 1.6% to 8% increase in product prices was reasonable and should, in all probability, be used in any future regulatory impact statement associated with this product

3. **Prices did not to increase after the implementation of MEPS for refrigerators**. Evidence from the implementation of MEPS 1999 for refrigerators shows no impact on price. This was true even for MEPS 2005 which had a substantial energy impact on new products. However, this does not

mean that efficiency levels can be increased indefinitely with no impact on industry or prices. However, it does demonstrate that new efficiency standards which are within the realms of current technological limits can be introduced at almost no marginal cost where industry has sufficient notice of the requirements and time to plan their transition in an orderly fashion. It is important to note that while MEPS 2005 levels were very stringent (almost no products on the market in 2000 met the levels when they were first announced), the levels had been adopted for implementation in the USA and they were technically feasible using only existing technologies.

4. **Projected impacts from MEPS often occur earlier than anticipated.** Timing of projected impacts should consider the fact that industry typically responds some years before a new regulatory requirement takes effect. While registrations occur well ahead of any new regulatory requirements, the sales volume of such products can be slower to reach the market. However this effect should be considered on a product by product basis, as the lead time for response is highly dependent on the level of stringency of the MEPS, sales volume, product life and the adaptive nature of the industry.

5. **Limitations of this type of study depend on data**. This type of retrospective analysis can only be confidently undertaken where detailed information is available about the product and marketplace (e.g., model energy usage, sales data and product performance data is available) and agreement is reached on the methodology of the study. The methodology used in this study will be shared with other nations with a view to developing a robust methodology suitable for use in any developed economy for any given product.

6. **Possible new CoAG Guideline** - When a methodology is determined after comparable studies in other economies, jurisdictions should consider proposing it to the Council of Australian Governments as a candidate for a future guideline to benchmark regulatory impact analyses undertaken to support nationally-consistent rule making

7. **Alternative methodologies may provide useful insights** - Based on the comparative findings for this product, scope exists to use a model-weighted approach as a simple retrospective analysis tool, especially given the difficulties and cost associated with attempting sales weighted analysis (where the data does not exist). This more affordable methodology could provide some timely comparisons from which to broadly compare pre and post regulation impacts. Jurisdictions should consider commissioning further work in this field. Product energy and performance characteristic data is required for retrospective analysis. The data is usually contained in registration databases associated with energy efficiency programs and includes energy performance test results, model identification, size/price and other attributes. The obvious limitation is that a full estimate of market impact for a new energy program is more difficult for a product that has not previously been regulated as good market data at a model level is usually difficult to obtain (as well as attributes of each model).

8. **Repeat this study in 3 years** - A further retrospective analysis should be undertaken in 3 years (i.e., so a decade of sales data is used) to benchmark developments in this product which would also potentially verify the early trends for MEPS 2005 and validate the on-going projected energy savings. This work might address the volatility seen in the annual sales figures for some product types.

5 References

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9 *Household Energy Use in Australia: End Uses, Greenhouse Gas Emissions and Energy Efficiency Program Coverage*. For the Appliance Energy Labelling Review Committee, National Appliance and Equipment Energy Efficiency Committee, George Wilkenfeld and Associates, Mar-1998

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Appendix A: Original TOR

Retrospective analysis of the impact of Energy Labelling and Minimum Energy Performance Standards (MEPS) on trends in the energy efficiency of household refrigerators and freezers in Australia and the United Kingdom[5]

Background

Government decisions to implement programs such as energy labelling and minimum energy performance standards (MEPS) are usually based on estimates of the reduction in energy consumption that the programs are expected to achieve, and the impact on product costs. Benefits (ie the value of the energy reductions) and costs are usually expressed as the difference between a 'Business as Usual' (BAU) projection and a 'with-measures' projection.

These projections are rarely reviewed after the fact. The aim of this study is to:

- collect and analyse the relevant data accumulated since program implementation
- assess the accuracy of the prior estimates of benefits and costs
- make recommendations regarding future modelling
- identify, to the extent possible, unforseen impacts on particular groups (eg low-income households), whether beneficial or adverse
- assess, to the extent possible, the impact on the observed trend of compliance levels (eg proportion of products actually carrying labels) and compliance modes (eg the absolute MEPS cutoff approach implemented vs the alternative of sales-weighted compliance).

Scope and approach

The study will cover all purchases of household refrigerators, refrigerator-freezers and freezers in Australia and the UK from the early 1980s (before labelling started to impact either market) to the most recent year for which data are available (2003 or later) This period is intended to cover the following program events:

	Australia	UK (EU program)
Mandatory energy labelling starts	1986	1994
MEPS take effect (first round)	1999	1999

The following distinct trends should be identified, if possible:

[5] These original terms of reference were used as a guide for this study. The study objectives changed during the timeframe due to availability of new data, changes in the analysis methodology and other reports published that were pertinent to the MEPS program.

- Sales-weighted BAU average energy consumption trend (kWh/yr), projected prior to program implementation (different projections may have been made at different times)
- Sales-weighted BAU energy efficiency trend (ie average kWh/yr moderated by changes in product volume or utility) projected prior to program implementation;
- Sales-weighted BAU average price trend, projected prior to program implementation;
- Sales-weighted average energy consumption and efficiency trends *with labelling* projected prior to the implementation of energy labelling;
- Sales-weighted average energy consumption and efficiency trends *with labelling and MEPS* projected prior to the implementation of energy labelling;
- Actual sales-weighted energy efficiency trends (ie average kWh/yr moderated by changes in product volume or utility) monitored since program implementation;
- Actual sales-weighted energy product price trends, moderated by changes in product volume or utility, monitored since program implementation;
- 'Revised' BAU trend (ie what would have happened in the absence of labelling or MEPS) taking into account factors and changes in the market not foreseen at the time the initial BAU projections were made.

The analysis should be carried out at the product sub-category classification, if possible (with classifications to follow local standards and legislation), and then aggregated for all refrigerators, all refrigerator-freezers, all freezers and all cold appliances.

On the basis of the above analysis:

- Estimate the actual impacts, costs and benefits of energy labelling, and compare with prior projections;
- Estimate the actual impacts, costs and benefits of MEPS, and compare with prior projections.

The methodology should be consistent for Australia and the UK. Where there are differences in data types and quality these should be clearly identified. The Australian and UK components of the study may be carried out by different parties, by the same party or by a consortium. If more than one consultant is involved, the clients may designate one as the 'co-ordinating' consultant with responsibility for maintaining consistency in approach and methodology.

Data sources and factors to be considered

The study should use existing reports and data sources: no new data collection will be necessary. In explaining projected and observed changes in energy efficiency and costs, the following additional factors (at least) should be taken into account:

- Changes in market structure over the period that could influence energy efficiency (eg shift in local vs import market shares)
- Changes in product design over the period that could influence energy efficiency (eg the phaseout of CFCs as refrigerant gases and foaming agents)
- Indirect indicators of the effectiveness of energy labelling: eg user awareness of labels, compliance with labelling requirement, use of label data in advertising etc

- Indirect indicators of MEPS compliance levels, eg rates of check test failures.

Report

The written report should concisely address all of the points in these terms of reference, including recommendations for future projections. If findings need to be limited or qualified because of data inadequacies, recommendations for new data collections should be made. There should be a separate detailed methodology and data report, and a comprehensive bibliography of data sources and studies used.

Appendix B: Methodology Options Considered

Literature Review

In order to establish a robust methodology a literature review was conducted of similar studies. This review informed the methodology and analysis techniques. The studies reviewed, included:

1. ***"The Induced Innovation Hypothesis and Energy-Saving Technological Change"*** by Richard G. Newell, Adam B. Jaffe and Robert N. Stavins, published in Oct 1998 in the Resources for the Future. The study was aimed at testing the hypothesis that increased energy prices would place pressure on manufacturers to introduce innovative more energy efficient products. Using the similar underlying reasoning the study also attempted to test a similar hypothesis of effects of government regulations on inducement of technological innovations.

The study used data on heating/cooling capacities, energy flow, energy efficiency, listed prices for 735 models of room air conditioners, 275 models of central air conditioners and 415 models of gas water heaters from *Sears* catalogues and some other sources between the period 1958 and 1993 and other publicly available data sources.

The study aimed at establishing the pace and direction of technological development and changes in model mix offered in the marketplace as a result of autonomous evolution of technology, increase in price of energy and introduction of energy performance regulations such as appliance labelling and minimum energy performance standards.

The study concluded that the substantial observed increases in the energy efficiency of room air conditioners and electric water heater over the last several decades appear to be associated with overall technological advance. In the early part of the period examined, autonomous improvement in these products appears to have been biased away from energy-efficiency. That is, the up-front costs of the products was decreasing faster than their operating costs. But the significant increase in energy prices that occurred in the 1970s and 1980s had noticeable effects, slowing or reversing this process. Second, increasing energy prices had an observable effect on which technically feasible models were offered for sale. Third, this effect of energy-price increases on "model substitution" was particularly strong after product-labelling requirements went into effect. The simulations suggest that the post-1973 energy price increases account for one-quarter to one-half of the observed improvements in the mean energy efficiency of models offered for sale over the last two decades. Fourth and finally, government energy efficiency standards also had a significant impact on the average energy efficiency of the product menu.

It is interesting to note that the data used in the analysis covers the period between 1958 and 1993. The first set of federal level MEPS introduced in the USA, that affected the products included in the study, was approved in 1987 but did not come into effect until 1990. Consequently the researchers have used the assumption that manufacturers would

have started acting earlier to meet MEPS requirements from 1987, and hence their model would have picked up such changes.

Furthermore, some states had implemented minimum energy performance standards for many residential appliances far earlier than the federal level standards. For example California introduced initial standards on 15 products in the 1977-79 period[6]. Similarly Florida, New York, Connecticut, and Massachusetts adopted such standards during 80s. Considering the market size of these states, it is highly likely that such state level standards would have affected the products market at national level. However, it is not clear if the researches made any attempts to isolate or include the effects of state level standards in their analysis.

The analytical methodology involved estimation of parameters for simple log-linear models, that intended to estimate the changes in appliance attributes (innovation) as a result of change in price of energy and introduction of regulatory requirements, using regression techniques on available data such as energy flow, market price, production costs etc.

2. *"Projecting the Impacts of Energy Programs: How Good Were the Estimates?"* by Dr. George Wilkenfeld, presented at Collaborative Labelling and Appliance Standards Program (CLASP) Asia Regional Symposium on Energy Efficiency Standards and Labelling, Bangkok May 2001. This conference paper reviews the trends in appliance efficiency and compares them with the previous estimates and projections. The paper also provided descriptions of various techniques used to compare the actual and estimated trends together with examples of differences between the actual trends and projections and estimates.

3. *"Regulatory Impact Statement: Revised Minimum Energy Performance Standards for Household Refrigerators and Freezers"*, Prepared for the Australian Greenhouse Office by George Wilkenfeld and Associates with Energy Efficient Strategies August 2001. This comprehensive document provides significant historic information about market of refrigerators and freezers and evolution of energy efficiency trends.

4. *"Review of Residential Appliance Energy Labelling for The State Electricity Commission of Victoria"*, by George Wilkenfeld and Associates with Test Research and Artcraft Research, Final Report, September 1991. This study covers several aspects of introduction of labelling for major household appliances. The study also provides an assessment of impacts of labelling on markets of refrigerators and freezers. However, such assessment is limited to some qualitative analysis on limited amount of data.

5. *"Energy efficiency: The European manufacturers' achievements in year 2004"*. Luigi Meli - CECED director general, Tallin, July 6th 2005. This presentation on behalf of appliance manufacturer provides review of changes in energy efficiency of refrigerators and freezers sold in countries included in European Union.

[6] American Council for an Energy-Efficient Economy (http://www.aceee.org/pubs/a951.htm)

6. *"UK Market for A+ and A++ Refrigeration Products"*, Market Transformation Program (http://www.mtprog.com/Publications.aspx). This paper provides substantial amount of data on transformation of refrigerators and freezers markets as shares of more efficient models continue to increase. The paper provides trends of changing energy efficiency, storage volumes and average market prices for various categories of refrigerators and freezers.

Summary of Literature

These studies and papers show a wide range of approaches to the estimating of program impacts, with most providing analysis resulting in indications of efficiency gains rather than direct quantification of the energy impacts of the MEPS or Labelling programs. Overall, none of the studies could match the level of data and potential analysis that was available for this study, with 3000 models and 12 year of sales data.

Proposed Methodology

In view of the literature review the following methodology was identified to be the most suitable approach to achieve the objectives of this study.

1. Collect, process and organize the following data for the years 1975 – 2005 for all groups as described in Section 1.3;
    a. Total annual national sales
    b. Average retail price
    c. Actual storage volume of freezer compartment
    d. Actual storage volume of fresh food compartment
    e. Average annual energy consumption when tested under Australian Standards

2. Produce sales weighted historic trends of sales, annual energy consumption, average price, adjusted volumes, average energy consumption per unit of adjusted volume, average price per unit of adjusted volume by group at national level.

3. Put markers at two points of policy implements; at 1986 when labelling was introduced; and at 1999 when MEPS were introduced.

4. Estimate BAU conditions by using trend projection methods, replace actual data after 1985 (when first policy implement was introduced) with projections based on historical data.

5. Compare the difference between actual and projected values for the period between 1986 and 2005 to estimate the effects of two policy implements.

6. Estimate the impacts in the form of following parameters;
    a. Impact on Sales Weighted Average Price
    b. Impact on Sales Weighted Price per unit of Adjusted Volume
    c. Impact on Average Annual Energy Consumption

d. Impact on Average Annual Energy Consumption per unit of Adjusted Volume

Using the methodology above and provided the type of data available, it was not possible to accurately ascertain how much of the deviation from BAU is the direct result of any policy implementation. Yet, if the BAU line changes significantly prior to the year of introduction of a policy option, it is highly likely that the implementation of the regulation was the major contributor to this change. Nonetheless the impact assessment provided in this report assumes that the difference between the actual values (policy) and the BAU (projected trend) is due to the introduction of a regulation.

Availability of Data

Primarily the following data has been used.

1. **Comprehensive GfK technical and supply data from 1993 to 2005.** The data comprised of make, model, group allocation, registration number, fresh food and freezer volumes, average annual energy consumption when tested under AS/NZS4474.1, number of units sold each year by each state, average unit price by each state.

   Because of the commercial sensitivity of actual sales data, the appliance manufacturers do not provide such data. GfK compiles the data through comprehensive annual market research surveys of major retail outlets that control over 80% of the sales of the household appliances. Only those models that attained a sufficient share in a given year are included. The remaining models are lumped together in one category as "Others". Consequently the database tend to contain different mix of models for consecutive years.

2. **Appliance Labelling Registration Data:** This database was developed and maintained to register details of all models of refrigerators and freezers sold in Australia, for the purpose of mandatory labelling and later labelling and MEPS. The key data available in the database included; labelling registration number, brand, model, group allocation, fresh food volume, freezer volume, total volume, average annual energy consumption when tested under AS/NZS4474.1, country of origin, date of registration, and star rating. The data covered the period from 1986 to 2005.

   Due to regulatory requirements, all refrigerators sold in Australian markets must be registered and provide required information, hence the appliance labelling registration data included almost entire population of refrigerators and freezers sold in Australia.

3. **Data Supplied by Australian Consumer's Association (ACA):** In order to serve the interest of its members and focus groups, ACA has been conducting performance tests of various household appliances for several decades. These tests, together with assessments of various other attributes of performance such as ease of operation etc, typically included tested energy performances of such

appliances. Upon request ACA provided printed copies of their test reports for various models of refrigerators and freezers for the period between 1975 and 2000. It is worth noting that ACA would test only those machines that have special interest among its members and focus groups. For example the most popular models and new technological developments (e.g. when frost free refrigerators were introduced).

It is understood that the machines selected for the purpose of testing did not constitute a representative sample. Furthermore, ACA conducted and published such tests on irregular basis with several years between tests. Hence, unlike the appliance labelling registration and GfK data, the application of ACA data is not intended to provide assessment for the entire market of refrigerators and freezers. The utility of ACA data was limited to providing some indicative assessments and estimates.

Data Processing

GfK Data: A number of issues were identified and addressed with the assistance of Energy Efficient Strategies (the Australian Government contractor responsible for maintaining the Energy Labelling database). A major issue, not a concern though, was identified at a later stage of the study. It was revealed that the coverage of GfK data roughly included 75% of the total market before 2004. However, the sampling was found to be adequate enough to ensure actual market shares by brands and models. The data supplied to the consultants included the actually compiled data and was not scaled up to provide the net market situation.

The original data was therefore scaled up to ensure 100% market coverage. In order to ensure the reliability of scaling, the GfK estimate of its market coverage were compared against BIS Shrapnel estimates of refrigerators and freezer annual sales figures. Some differences between the scaled up GfK data and BIS Shrapnel estimates were found. In such cases the middle value between the two estimates was considered as the actual value.

Appliance Labelling Registration Data: One of the major issues associated with the data was the inability to determine the market life of a model. Since the key purpose of the data was to "register" new models introduced in the market, it did not keep track of the availability of registered models in the market afterwards. Analysis provided the following observations concerning the data;

a. Majority of the models appeared only once in the database when they were first registered.

b. Several models were re-registered, some years after the year of first registration, with same model name but different technical specifications i.e. change in storage volume and/or energy consumption.

c. Some models were re-registered several times with gaps of several years between the consecutive registrations.

d. The original data comprised of 2,948 records.

To ensure the continuity of the models in available in the market, significant data processing was required. The following approach was used for this purpose;

a. For any model that appeared only once, it was assumed that the model was also available in the market the following year.

b. Similarly for models that appeared to be re-registered, it was assumed that the model was also available in the market the following year from the last year of registration.

c. For models that were re-registered more than once with gaps of several years, it was assumed that the model was available in the market with its old specifications for the period until the new registration was made.

Using the approach the model database was expanded to include additional entries as above. The enhanced database included 5,720 entries.

Issues and Obstacles in Executing Proposed Methodology

Gaps in Available Data

Lack of historic data was a major constraint in executing the proposed methodology. It appears that, contrary to the statement in ToR, all of the required data is not available in readily useable format. For example the appliance labelling registration data (1986 to 1992) did not include the components of the required data namely; national sales with state level breakdown, and average price. Only the GfK data, that were available for the period between the years 1993 and 2005, provided all components of the required data. Such length of data is not sufficient to produce trends and assess impacts of the two policy options (labelling introduced in 1986 and MEPS introduced in 1999). In order to establish the effects of two policy implements (labelling in 1986 and MEPS in 1999) it was important to use substantial historic data.

The ACA data on the other hand provided energy performance attributes of selected models of refrigerators and freezers with gap in broken strings separated by several years.

Consequently, the proposed methodology could only provide the following impact assessments;

1. All intended impacts, as described in Section 1.2, as a result of introduction of MEPS 1999.

2. Some estimates of impacts, as a result of introduction of labelling, in the form of following parameters;
    a. Changes in Average Annual Energy Consumption by group
    b. Changes in Average Energy Consumption per unit of Adjusted Volume
    c. Change in model mix available in the market

3. Some crude estimate of a combination of all impacts that would be based on several untested assumptions.

Techniques used to Overcome Issues

Three methodology pathways were explored to enable the study to meet the required objectives. These included the use of previously estimated historical data, the adjustment of historical estimates with published reports and undertaking a model weighted assessment only. These methodology options were explored extensively and are reported below. The final methodology chosen for the study is reported in the following section.

Revised Methodology

Due to the lack of reliable and complete historic data there was a need to develop a robust methodology that would ensure a reasonable level of reliability and accuracy of results even with limited data. The final methodology was therefore developed on the basis of the following order of priority of the study objectives and for various considerations to ensure reliability of results;

1. Sales weighted results are required to produce results that would ensure achievement of objectives of this study with reasonable level of accuracy

2. Calculation of estimates of sales weighted energy savings is more important than calculation of estimates of changes in average price and average storage volume that may have resulted due to the introduction of the three policy options.

The sales weighted annual energy savings can be calculated if sales weighted average annual energy consumptions and annual sales figures for all groups of refrigerators and freezers are known under the actual market conditions (after the implementation of a policy option) and under the BAU scenario (likely market conditions in the absence of policy option).

However, as stated previously only the GfK data offered the ability to conduct sales weighted assessments from 1993. The labelling registration data only provided the ability to conduct model/market weighted analysis, although this data set was available from 1986. In order to make the labelling registration data suitable for sales weighted analysis it was essential that annual sales values for each model entry in the labelling registration database (5,720 entries) were estimated. While the annual sales values for each group of refrigerator and freezer could be estimated reliably on the basis of sales trends from available GfK data, breaking group sales estimates at brand and model levels was not possible without introducing significant level of unknown errors.

It was established that the final methodology must provide an approach to reliably estimate the sales weighted average annual energy consumptions for each group of refrigerators and freezers. In order to identify such approach, the GfK data was used to create a sales weighted result and this was compared to the model/market weighted assessments at group, brand and model levels. In this way, it was possible to conduct an

analysis of data using different techniques and compare the results with the more accurate sales weighted analysis. The following example illustrates the approach.

Using GfK data calculate the following;

$$SWE_a = \frac{\sum_{i=1}^{n} AAE_{Mi\,a}\ AS_{Mi\,a}}{TAS_a}$$

Where for a given year;
SWE_a = Sales Weighted Average Annual Energy of Group a
$AAE_{Mi\,a}$ = Average Annual Energy Consumption of Model *i* in Group *a*
$AS_{Mi\,a}$ = Annual Sales of Model *i* in Group *a*
TAS_a = Total Annual Sales of Group *a*
n = Total Number of Models in Group *a*

and,

$$MWE_a = \frac{\sum_{i=1}^{n} AAE_{Mi\,a}}{n}$$

Where for the same year;
MWE_a = Model Weighted Average Annual Energy of Group a
$AAE_{Mi\,a}$ = Average Annual Energy Consumption of Model *i* in Group *a*
n = Total Number of Models in Group *a*

Thus if the difference between SWE_a and MWE_a is not significant, MWE_a can be substituted for SWE_a without compromising much on reliability of results, and provide trend data form 1986. In other words, if analysis conducted on GfK data showed little difference between the SWE_a and MWE_a from 1993, the group level consolidated model weighted average annual energy consumptions from labeling registration data could be used instead of sales weighted values from 1986.

Unfortunately a comparison between sales weighted and model weighted average annual energy consumptions yielded differences of up to 600% between the two, suggesting that such interchange would produce results that were significantly unreliable. Further variables were used to group models using the model weighted approach and these alternative approaches were compared to the sales weighted analysis. These approaches included the following;

1. Model weighted to sales weighted average annual energy consumption by groups.

2. Model weighted and sales weighted annual energy per unit of adjusted storage volume by groups.

3. Model weighted and sales weighted annual energy per unit of adjusted storage volume by star rating for each group.

4. Model weighted and sales weighted average annual energy by star rating for each group.

The comparative assessment revealed that the last technique provided least amount of difference between the model and sales weighted values. When compared to the use of GfK data for all groups, this approach provided up to a maximum of 30% difference between the sales weighted and model weighted values. In almost 85% cases the difference was found to be less than 10%. Hence this approach was used to estimate sales weighted average annual energy consumptions for various groups of refrigerators and freezers in the labeling registration data. The following methodology was used;

1. Based on trends established through GfK data, aided with estimates provided in other secondary sources e.g. BIS Shrapnel reports, estimate average annual sales for each group by star rating and by year for the period between 1986 and 1992.

2. Estimate model weighted average annual energy consumptions by star rating and by year for each group using labeling registration data. Based on approach 4 above the model weighted values would be roughly equivalent to sales weighted average annual energy consumptions.

3. Multiply average annual energy consumptions by star ratings (as 2 above) with corresponding estimated annual sales by star ratings (as 1 above)

4. Sum all the energy x sales products for each star rating to obtain total energy for the entire group to obtain energy x sales product for the group for each year

5. Estimate sales weighted average annual energy for a group by dividing total energy x sales product of a group for a year with corresponding total group sales for that year as described in 1 above.

The estimated sales weighted average annual energies for each group were then used to produce trends and analysis was conducted as described in the Results section.

The above approach provided the ability to conduct sales weighted analysis of average annual energy consumption for the period between 1986 and 2005. However, pre-labelling (pre 1986) data was still required to establish trends before labelling was introduced in 1986. For this purpose a combination of data sources were used. This included ACA tests and market survey results, and studies that reported pre labelling market conditions. Based on these data we concluded that generally there was a trend of decline in average annual energy for almost all groups of refrigerators and freezers. However, the rate of decline was reported to be different for different group. Consequently we estimated such declining trends for each group separately and thereby estimated average annual energy consumptions for each group for the period between 1980 and 1985 by using 1986 as base year and calculating previous years backwards.

Table 2 summarizes our estimates of average annual rates of declines in average annual energy consumption for various groups.

Table 11 Estimated average annual rates of decline in average annual energy consumptions of refrigerators and freezers between 1980 and 1985

Group 1	Group 2	Group 3	Group 4	Group 5B	Group 5S	Group 5T	Group 6C	Group 6U	Group 7
1.14%	0.48%	0.58%	0.61%	0.45%	1.13%	1.69%	1.02%	1.24%	0.59%

Alternative Methodology Options

These methodologies were explored to attempt to overcome the data availability issues and meet the objectives of the study.

Methodology Option 1

1. The use of EES datasets that contained information at Groups level (Group 1, Group 2, Group 5T etc.) about sales, cabinet volumes, and some indicative prices.

2. Some estimates were used to fill gaps in EES data. For example total annual sales of refrigerators and freezers was projected backwards to apply EES's estimated sales shares by machine groups into actual sales figures.

Preliminary results were produced using this data, with the warning that the trend lines appeared to be based on pre-conception than estimation. These results were shared with EES and GWA. EES noted that the data was not very reliable and largely comprised of estimates based on data provided by ACA, and previous work conducted by George Wilkenfeld and Associates (GWA). It was also remarked that the BAU trends did not appear to be realistic and potentially the historic data was based on some pre-conceptions which created the BAU trends. It was subsequently suggested that recreation of historic data, and consequently the BAU line, on the basis of some limited historic data would provide a more realistic result. This approach forms basis for Methodology Option 2.

Methodology Option 2

To overcome lack of historic data in the EES model, the test results of refrigerators and freezers by ACA since 1980 were obtained from the GWA study "Residential Appliances in Australia: An Assessment of Markets and Technology Developments, With Particular Reference to Energy Efficiency",. However, the material from the report provided only selective dimensions of the data used to produce results. For example segment shares of total refrigerator market by configuration, size and major brands has been provided for 1989 only. Similarly, some results were provided by technology, while others were provided by model, brand and technology, without necessarily providing a path between results based on technology and results based on technology and model. Some of the issues encountered with this data and the approach were:

- The breakdown of share in annual sales is of particular importance, since the sales shares have changed dramatically in the past. The GfK data suggests that the share of Group 5 refrigerators, which is of very high importance in the study, has grown from 36% to over 73% between 1993 and 2003.
- Similarly the material from the GWA 1999 (as above) tends to combine group 3, 4 and 5 refrigerators. This would require that all the analysis be conducted by combining nine groups in 4, i.e. All Refrigerators, Refrigerators and Freezers, Chest Freezers, and Vertical Freezers.
- The data also appears to be sourced from different origins e.g. from ACA tests and from labelling register.
- The data is also very patchy, with results available for 1980, 1984, 1986 and 1990 only. Even then, results for 1980 and 1986 have been represented with results for 1982 or 1987 on some occasions.
- Most of the study (GWA) results are based on unweighted, simple averages of the four machines tested by ACA. In the absence of any information on market shares, the use of such results may create unrepresentative relationships.

It was concluded that the recreation of historic data, based on the GWA study results, would require the use of gross assumptions which may critically affect the reliability of results. Provided the above, the GWA data is generally useful to make descriptive analysis, for which it has been used in the GW report. However, use of this data to produce any analytical results (e.g. measurement of impacts of two policy options) would not be adequate for this current study.

Methodology Option 3

A third approach involved the use of the labelling registration data to conduct a "model weighted analysis".

EES has supplied a complete list of all models registered for labelling between 1986 and 2005. The list is comprised of 2,948 model in all. The data included allocation to machine class (1, 2, 3, 4, 5, 6C, 6U, and 7), fresh food and freezer volumes, and annual energy consumption, in addition to a number of other fields e.g. year of registration, star rating etc. Issues encountered included:

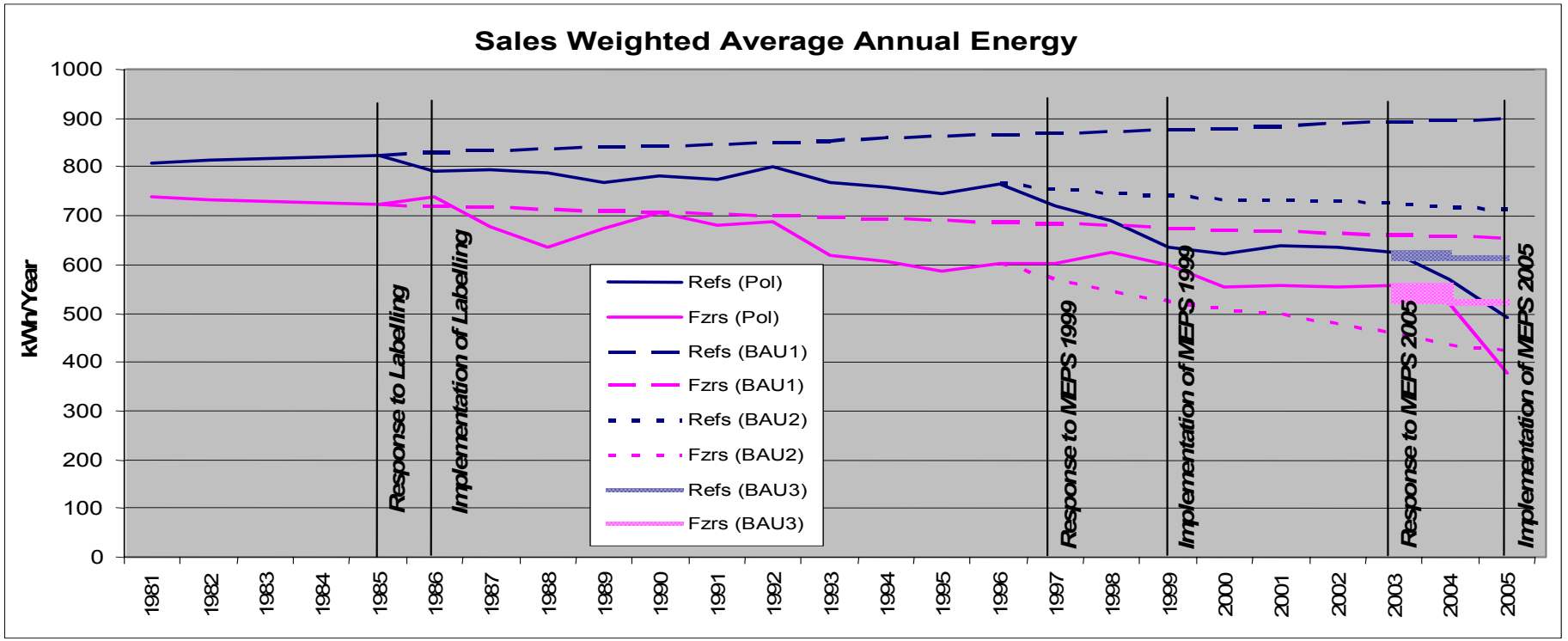
- The labelling data does not include annual sales figures, Unlike the GfK data, consequently it was not possible to ascertain the model churn or in other words how many years the model stayed in the market.
- EES suggested to use 2-3 life per model. However, an analysis conducted on GfK data (1993 to 2003) suggested different duration of lives and different life patterns for various models of between 1 year and 7 years.
- Gaps in recurrence of a model between consecutive years were also identified. However, this could be explained by the fact that only top models were

included in the GfK data. Hence a model included in one year may not have made it to the top the following year. On this basis, a simple allocation of 2-3 year life to all models in labelling registration was not sufficiently robust to enable reliable results.

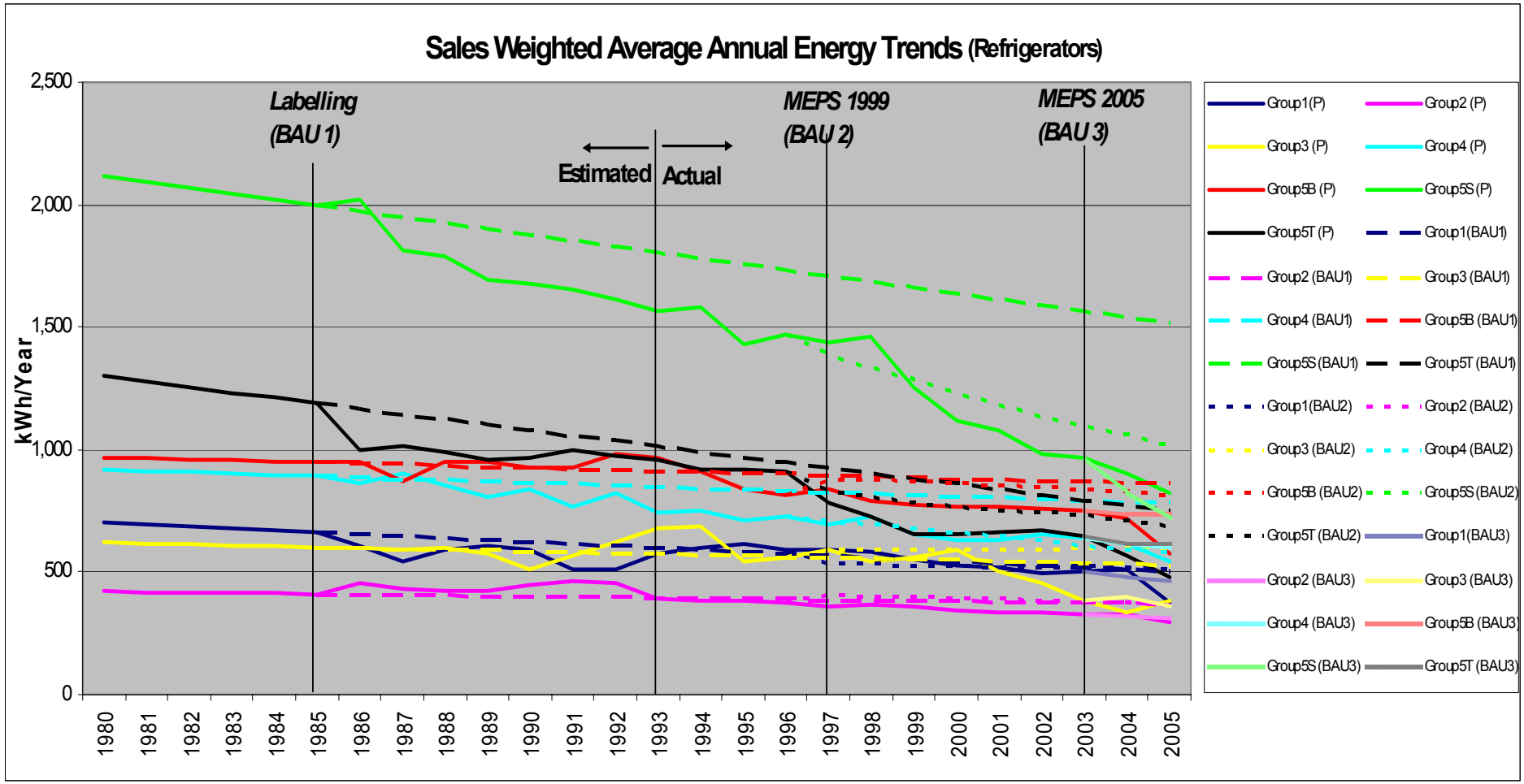
- The absence of sales data also required estimates of market shares in order to conduct weighted analysis on the data.
- The other issue encountered in "model weighted analysis" was allocation of market shares. It is possible to first establish the market shares at group level (1, 2, 3, 5T, 6U, 7 etc) and then further breakdown at model level. However, there can be as many as 150 models in a group in the list of a year's registration. To assume equal shares for all models in a group can be grossly erroneous and allocation of estimated shares by model number would be prone to gross errors.
- A further refinement would be the constrain the group share by known brand shares when performing a model weighted analysis. Although not conducted for this study as actual sales weighted data was available for most of the analysis period, this may be refinement that is worthy in cases where less information on actual model level sales is known.

Appendix C: Graphical Results - Enlarged

Sales Weighted Average Annual Energy Trends for All Refrigerators and Freezers under different scenarios



Sales Weighted Average Annual Energy Trends for Groups of Refrigerators under different scenarios



Sales Weighted Average Annual Energy Trends for Groups of Freezers under different scenarios