December 2010

E3 Report no 2010/10

Evaluation of Energy Efficiency Policy Measures for Household Refrigeration in Australia

An assessment of energy savings since 1986

Prepared by Energy Efficient Strategies

FOREWORD

Aim of document: To provide a quantitative evaluation of the energy saved by various energy programs such as energy labelling and minimum energy performance standards (MEPS) for household refrigerators in Australia since their progressive introduction in 1986. In particular, the study examines the accuracy of previous projections and assesses these against actual trends over the past ten years. The study provides details of the evaluation calculations and quantifies the impact of a wide range of elements on the savings estimates. The study examines the change in purchase price and product availability over the period of policy implementation.

ACKNOWLEDGEMENTS

This report was commissioned by Australia's Department of Climate Change and Energy Efficiency (DCCEE). The authors, Kevin Lane and Lloyd Harrington would like to thank George Wilkenfeld, Mark Ellis, Robert Tromop and Ian McNicol for their detailed reviews. In addition, this report has benefited from a workshop which included the above reviewers and Hilton Taylor, Melanie Slade and Tim Farrell (DCCEE).

EXECUTIVE SUMMARY

Refrigerators and freezers consume approximately 12% of the residential electricity in Australia, and there is a long history of regulating such products to improve efficiency, mainly through introducing Energy Rating Labels and in more recent years, through setting Minimum Energy Performance Standards (MEPS).

Ongoing evaluation of these previous policy measures is an integral part of the process of good regulation and policy making. It is important to establish whether projected energy savings prior to the implementation of a program are actually realised after implementation. There are many factors that can change over time that can affect future energy savings projections. Therefore, it is important from time-to-time to examine these factors to understand what has changed and to review whether more robust assumptions are required when conducting future appraisal studies and evaluations. These types of comparisons, although somewhat complex, help to ensure that we improve and refine our projections in the future.

The main aims of this study are to:

- Estimate the historical energy savings to 2009 from previous policy measures; and
- Re-appraise the likely energy savings to 2020 from all program measures implemented to date.

In addition, the study also aims to examine changes in the:

- Average real purchase prices; and
- Range of available products on the market in terms of type, size and efficiency.

This analysis updates and builds on a previous impact evaluation by EnergyConsult (2006), which assessed the impact of a range of previous policy measures and made preliminary estimates of energy savings from the 2005 MEPS levels as well as energy savings from previous program elements. As this current study has been done several years later than the original study conducted by Energy Consult, the impact assessment for MEPS 2005 undertaken for this study has the benefit of more recent data, both for efficiency and other inputs into the modelling such as size of products, number of households, ownership levels and volume of sales.

As an additional component of analysis, this study has used every available data source for refrigerators back to the early 1980s to refine the energy saving estimates arising from all previous program measures for household refrigeration introduced since the introduction of energy labelling in 1986.

Energy savings

The present evaluation analysis shows that Australian energy efficiency policies for household refrigeration products have reduced energy consumption significantly, even more than previously estimated. By the end of 2009, the annual energy savings due to all policy measures on refrigerators was around 5.9 TWh/year. Most (around 4.1 TWh/year) is attributed to energy labels introduced from 1986, thus policies from the late 1990s onwards will have realised an estimated energy savings of around 1.8 TWh/year per annum by 2009. By 2020, the projected energy savings from these later policy measures will more than double, with savings attributed to the policies from the late 1990s onwards at around 4 TWh/year.

The savings accrued from the 1986 energy labels have more uncertainty associated with them (i.e. wider confidence intervals) as this first regulatory transition and baseline occurred more than 20 years ago and establishing what would have happened without regulation is more difficult to estimate. However, being the first regulatory program, those energy savings were most probably easier to realise (early efficiency improvements are generally easier and cheaper to realise).

The savings from all energy programs for household refrigeration are so substantial that not only has the average unit energy consumption fallen, but the total energy consumption of these products has been decreasing since about 2003, despite increasing average size and increases in the total stock of refrigerators and freezers installed in houses.

The energy savings from these measures can be expressed as financial savings for consumers in energy costs avoided, as well as reductions in greenhouse gas emissions. The 5.9 TWh/year of electricity savings in 2009 was based on a more conservative scenario represents reduced carbon emission in excess of 5 $MtCO_2$, or about 1% of Australia's total greenhouse gas emissions. These savings represent considerable financial savings to Australian households from reduced electricity bills. By 2009 the policies considered have saved around AUD$1billion. These financial savings and carbon emissions reductions will continue to accrue through to 2020 and beyond.

The approach taken to estimate projected savings and actual (historical) energy savings are based on the same end-use model. However, the key difference is that the actual energy savings uses updates to the input variables. The latest efficiency data are used to generate a trend line to 2009 illustrating what has happened to date, together with the latest ownership, sales share data (by group) and household estimates. Multiple historic efficiency scenarios were made to estimate the influence of changes in energy policies on the earlier baselines for energy consumption. For some of these earlier scenarios it is of course difficult to know what would have happened if the policy measures were not introduced. These scenarios, which are done separately for all ten refrigerator groups, are the key to undertaking a good retrospective analysis or a re-appraisal of policy impact.

Comparison of projected and actual energy savings

Once the energy savings have been estimated and attributed to each policy measure, it is useful to compare the evaluated savings with those in the original Regulatory Impact Statement (RIS) that were prepared to justify the proposed regulation. The projected energy savings data are readily available for both the 1999 MEPS RIS (which includes the 2000 label revision) and the 2005 MEPS RIS. The actual energy savings for MEPS and energy labels were significantly higher than originally estimated in the RIS. By 2010, savings from the MEPS 1999 were 250% higher than originally projected (1,250 GWh/year actual vs 550 GWh/year projected), while in 2010 savings from the MEPS 2005 was 50% higher than originally projected (750 GWh/year actual vs 500 GWh/year projected).

The increase in estimated savings from these two measures was due to:

- Increases in the total stock of refrigerators and freezers (the product of household ownership and the number of households) above previous projections, resulting in an increased volume of sales.
- Improvements in the energy efficiency of new products which have been greater than those originally projected.

- Larger than expected increase in the size of refrigerators sold (mostly though a change in the share of each group rather than increases in size within each group).
- Revisions of assumptions about the baseline trend in the absence of these program measures.

Decomposition analysis for 2005 MEPS

This study has been able to improve the estimates of energy savings (compared to an improving efficiency baseline) from all energy programs targeting household refrigerators. In addition, for the MEPS 2005 a quantitative assessment has been made for the changes in factors using a decomposition analysis. The increase in the number of households and ownership (resulting in increased sales) were responsible for a large share of increase in expected savings in 2009.

Competition (number of products available over time)

One concern often raised with regulatory proposals is that energy efficiency will restrict consumer choice with respect to the number of products available on the market. A quantitative analysis of the energy labelling registration database and GfK market sales data was undertaken to assess the range of consumer choice as various regulatory changes were introduced over the period. The energy labelling registration database provided estimates of the number of (approved) models on the market from 1987 to 2010, whilst the GfK sales data gives an estimate of the models actively sold from 1993 through to 2009.

Despite the large apparent impacts of the regulatory requirements at the time of their introduction, the number of available models is continuing to increase at a rapid rate over time, indicating that consumer choice in terms of available models is growing quite quickly, despite the introduction of increasingly stringent regulatory requirements. The noticeable reductions in models registered just prior to MEPS/labelling change in 2000/2005/2010 is a result of a ‘cleaning out’ of the registration database rather than a reduction in choice of models being offered to consumers – the number of models actually sold has continued to rise. Therefore consumer choice, in terms of the number of models on the market, appears to have been unaffected by the regulatory regimes, even after the introduction of stringent MEPS levels in 2005.

Spread in market efficiency over time

In order to assess the level of difficulty in achieving the policy target levels and the likely efficiency potential, the current study examined the models registered each year. It also examined the sales-weighted average efficiency (based on GfK sales data where available) by year as well as the best products available on the market (based on the most efficient model registered in the previous five years).

As expected, both the sales-weighted average and the best available product series trend downwards over time. The impacts of MEPS 1999 and the MEPS 2005 are usually visible in these trends for all product groups. It is interesting to note that, in very general terms, the best available product is usually about half the energy intensity of the sales-weighted average for most groups and most years.

Purchase price analysis

An important issue raised during the proposal stage of MEPS is whether stricter efficiency requirements will mean higher purchase prices. Conceptually, the price of appliances should increase as more stringent efficiency requirements are mandated through regulation. To gain an insight into this aspect, the current study undertook an analysis of historic sales data at a group level for each year from 1993 to 2008 using actual prices paid by consumers for the whole appliance market (corrected for changes in CPI over this period). The results of this analysis show that real prices for most groups have declined rapidly in real terms over the past 15 years. Many of the larger groups have experienced real declines in prices of 2.5% to 5% per annum or more over the entire 15 year period, which equates to real price falls in the range of 20% to 50% or more. Overall, this is an extraordinary trend as the energy consumption of all groups has also declined at about 3% per annum during the same period. Energy efficiency has also improved at approximately this rate, which is an overall 40% energy reduction in parallel with a 20% to 50% price reduction. This demonstrates that technology improvements are delivering lower energy at reduced purchase prices, with both parameters falling rapidly over time.

Previous RISs have undertaken an analysis of the current market relationships between energy and price in a particular year in order to estimate price impacts resulting from more stringent energy regulations. For all groups (except Group 7), the expected price impacts appeared to be well within the predicted range (less than expected), but generally these could not be accurately estimated and quantified due to the large and rapid falls in underlying prices over time. For Group 7, the expected price impact estimated in the RIS appears to have occurred with the introduction of MEPS in 2005. There are certainly no significant increases in purchase prices that can be attributed to regulatory actions over this period. The existing RIS approach appears to deliver reasonable estimates of price increases arising from changes in proposed efficiency requirements and this approach should continue in future RISs.

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GLOSSARY

Term	Meaning
ABS	Australian Bureau of Statistics
ACA	Australian Consumers' Association
CEC	Comparative Energy Consumption (energy label value)
DCCEE	Department of Climate Change and Energy Efficiency
DEWHA	Department of the Environment, Water, Heritage and the Arts
E3	Equipment Energy Efficiency Committee
EES	Energy Efficient Strategies (consultants)
ERL	Energy Rating Labels
Formative evaluation	Evaluation of a policy process
GWA	George Wilkenfeld & Associates (consultants)
MEPS	Minimum energy performance standards
NAEEEC	National Appliance and Equipment Energy Efficiency Committee (now E3)
OBPR	Office of Best Practice Regulation
Ownership	*Ownership* – the ratio of stock to the total number of households. This value is usually given as a decimal number and can exceed 1.0. *Penetration* – the proportion of households in which one or more of a particular appliance type is present (irrespective of the number of units of that appliance in the household). This value is usually given as a percentage and the maximum value is 100%. *Saturation* – the average number of appliances per household only for those households with one or more of the appliance. The minimum value is 1.0. *Stock* – the total number of a particular appliance type in use within households. This value is given as an integer (usually thousands or millions). The stock refers to the number of appliances in regular use, or a proxy for the number in regular use.
RIA	Regulatory Impact Assessment
RIS	Regulatory Impact Statement
Summative evaluation	Evaluation of outcomes and impacts (the main focus of this report)

The terminology for the scenarios developed in this study are summarised below:

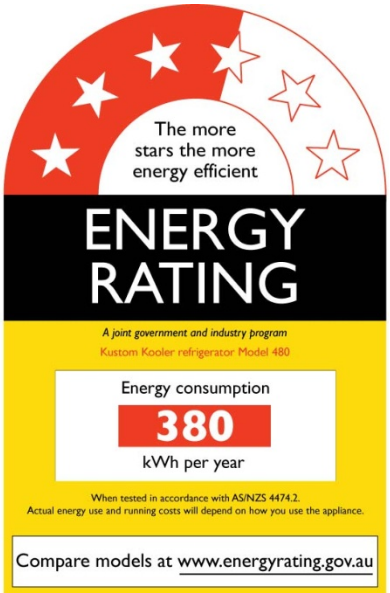
Scenario label	Description
Baseline (Low)	The starting baseline to assess all policy measures. It uses actual data to 1983 then projects forwards based on trends prior to 1983. A low improvement in autonomous efficiency is used.
Baseline (High)	Similar to Baseline (Low) except that a higher improvement in autonomous efficiency is assumed going forward. This is the baseline that the report uses to quantify the impacts of the label 1986 policy measure (using Baseline (Low) would give higher savings estimates).
PolicyL1986	This scenario shows the impact of the label 1986, but with no other subsequent policy measures. To estimate the energy savings due to labels 1986, the difference between this scenario and the Baseline (High) is calculated.
PolicyM1999	The impact of MEPS 1999: it includes all early policy measures but no subsequent policy measures.
PolicyL2000	The impact of Labels 2000, which were developed at the same time as MEPS 1999.
PolicyLM1999	Shows the combined impact of PolicyM1999 and PolicyL2000, since it is difficult to attribute the changes that occurred to either policy measure as they were implemented in close proximity.
PolicyM2005	The impact of MEPS 2005.
PolicyL2010	The projected energy consumption trend taking into account the impact of new labels in 2010. It is the best projection or appraisal of what will happen in the future with no further policy intervention after Labels 2010 based on actual data to 2009. The difference between this scenario and the Baseline (High or Low) is the sum of all electricity savings due to E3 policy measures to date.

1. INTRODUCTION AND BACKGROUND

1.1 Aim and Background

Refrigerators and freezers consume around 12% of electricity in the residential sector in Australia (DEWHA, 2008). Combined with significant potential for efficiency improvements, refrigerators have been targeted for regulation. Almost every national energy labelling and Minimum Energy Performance Standards (MEPS) program in the world has started with refrigerators. Governments in Australia have a long history of regulating these products. The most significant policy measures are the mandatory Energy Rating Labels (ERL) and MEPS. An example of the current ERL for refrigerators and freezers is shown in Figure 1. The savings from these programs are significant, and there are likely to be scope for additional measures to further increase the efficiency for these products.

Figure 1: An example of the 2010 Energy Rating Label for refrigerators and freezers in Australia.



As part of good governance, there is a need to evaluate the actual impact of these types of policies once implemented. The Department of Climate Change and Energy Efficiency (DCCEE) has undertaken some initial impact assessments on behalf of the Equipment Energy Efficiency Committee (E3), and is also developing a generic guidance framework to ensure consistency across evaluations.

As part of the regulatory requirements in Australia, all new proposals relating to nationally applied regulation are subjected to a Regulation Impact Assessment (RIA) to assess the costs and benefits of the regulatory proposal for individuals, businesses and the economy, and to consider alternative proposals to achieve comparable energy savings. All proposals for nationally applied regulation have to be in the form of a Regulatory Impact Statement (RIS), which must meet the criteria established by the

Council of the Australian Governments (see COAG 2007). In addition, these must be cleared by the Office of Best Practice Regulation (OBPR) in the federal Department of Finance and Deregulation. A RIS is required by the Council of Australian Governments when a regulatory proposal is likely to have significant impacts on business, individuals or the economy. MEPS and labelling requirements are currently imposed through state and territory legislation in Australia, and while state governments also have requirements for RIAs, they have agreed that any proposal for a uniform national approach can be covered by a single national RIS.

The Best Practice Regulation Handbook (OBPR, 2010) sets out the broad requirements and processes associated with regulatory proposals and is summarised in Appendix 3.

As part of the process of assessing the costs and benefits arising from regulatory proposals for energy, it is usually necessary to project future impacts of the regulatory proposal on energy consumption, energy purchase costs and the capital cost of equipment. This projection is contained in a RIS. Therefore previous RISs are a useful embodiment of the assumptions that guided policy makers in the past. The two main RISs for refrigerators of interest that have been conducted to date are GWA (1999) which assessed the potential energy savings from the introduction of MEPS in 1999 and the associated energy label algorithm regrade in 2000, and GWA (2001) which assessed the potential energy savings from the introduction of more stringent MEPS levels in 2005. Both of these projections are compared to a detailed (decomposition) examination of the energy consumption trends that actually occurred over this period. A subsequent RIS (EES, 2008) projected the energy impacts from an energy label algorithm regrade in 2010, as well as a number of technical changes to test methods and regulatory definitions. The 2010 label regrade is not assessed in this report as it has only been just implemented (April 2010) and its likely impacts were unlikely to be observed in 2009 (which is the last year of historical data included in this report). The evaluation analysis in this document goes to December 2009, though projected energy trends based on the latest data are also shown through to 2020.

This is the second evaluation of the impacts of Australian energy efficiency programs targeting refrigerator and freezers. The first study, covering the period to the end of 2005, was prepared by EnergyConsult (EC 2006) and showed significant reductions due to the program measures introduced. That study compared the actual energy impacts with those estimated by the relevant COAG RIS regime. In particular, MEPS and labelling changes in 1999/2000 and the introduction of more stringent MEPS levels in 2005 were examined (preliminary assessment only in 2005).

EnergyConsult (2006) also made initial estimates of savings from ERL introduced in 1986. The introduction of ERL was not subject to a formal appraisal at the time by the governments of NSW and Victoria, so there are no savings estimates for comparison.

A short review and comparison with an estimate of UK energy savings due to MEPS and labels was also done by Lane *et al* (2007). Both show significant savings due to MEPS and ERLs, but also suggested that the approach to evaluation could be refined, for example to explicitly include various scenarios such as the change in the size of refrigerators and freezers.

As governments come to consider further interventions aimed at increasing the efficiency of energy use (and possibly limit absolute energy consumption), they will need to be confident that the methods of analysis on which these types of decisions are based are reliable. This confidence can be increased if there is evidence that previous projections have been borne out in practice. Thus, there is likely to be a growing demand for evaluating the impacts of program measures already implemented. For example, a 2005 Productivity Commission enquiry into energy efficiency recommended the evaluation of the impact of policies that had been implemented (PC, 2005).

The evaluation of MEPS and labelling was discussed in a Sydney workshop in February 2009, where E3 decided to develop some generic evaluation guidelines and also update the refrigerator retrospective analysis (see workshop summary in E3, 2009) and undertake a retrospective analysis of refrigerator and air conditioning policy measures. This report forms the updated refrigerator retrospective analysis, coupled with some additional analysis.

There are two types of evaluations: impact analysis (sometimes called summative evaluation) and process analysis (sometimes called formative evaluation). Impact evaluations focus on the quantitative outcomes and changes that result from an implemented policy such as changes in energy consumption, emissions and associated energy costs. On the other hand, process evaluations assess elements of the program operation and implementation. These include aspects such as communication issues (marketing, websites, up-to-date information), clarity of requirements and understanding by affected parties, speed and ease of processes such as registration and issues such as monitoring, verification and enforcement of requirements (although changing levels of compliance can have some impacts on energy savings). Process analyses are an essential complement to impact analyses. If there was no evidence that the process envisaged actually took place, then it would not be possible to link it to any changes in energy use. Also, if implementation processes are poor or ineffective, the expected energy impacts will also be reduced.

The aim of this report is to conduct an evaluation of the actual energy savings attributable to energy labelling and MEPS programs for household refrigeration products which have already been implemented in Australia, and to compare and contrast these estimates from the original policy RISs (where available). This study is not an evaluation of the policy processes used to deliver these program measures.

Following this introduction, the report is structured as follows:

- Background information providing:
  - A review of refrigerator policy measures to date
  - Brief description of the Australian refrigeration market
  - Review of data available for impact assessment
- Summary of the methodological approach
- Key outcome of the impact analysis:
  - Energy savings

  - Financial and greenhouse gas savings
  - Comparison with RIS for the recent policy measures
  - For MEPS 2005, provide a decomposition of savings to explain changes since the RIS
  - Purchase price changes
  - Range of products on the market
- Appendices which include the following:
  - Modelling approach
  - Background data on each of the ten refrigerator/freezer groups
  - Scenarios for each of the ten groups
  - Purchase price analysis for each of the ten groups
  - Efficiency spread for each of the ten groups

1.2 Review of policies for household refrigeration products

Australia has a long history of policy measures to improve the efficiency of household refrigeration products. The significant national policies are listed in Table 1.

Table 1: Main end-use policies to promote refrigeration efficiency

Measure	Summary
Labelling 1986	Introduced by NSW and Victoria, other states followed over the period to 1995. Labelling of other products followed. GWA technical review in 1990. No formal RIS. Technical requirements initially included in state regulations only. Some requirements were included in AS1430 and AS2575 but these were not referenced by regulations.
MEPS 1999	GWA report in 1993 examined initial feasibility. Levels adjusted and finalised in 1996 and introduced nationally in October 1999 for refrigerators, freezers and electric storage water heaters. RIS GWA (1999). Requirements included in AS/NZS4474 in 1997 (new 2 part structure – included 1986 energy labelling requirements).
Label revision 2000	Algorithm revised to take into account MEPS 1999 and overall improvement in product efficiency. Moved from a linear to geometric progression with volume offset. All labelled products had an algorithm change in 2000. RIS GWA (1999).
MEPS 2005	Stringent new MEPS levels introduced to align with USA 2001 requirements. RIS GWA (2001).
Label revision 2010 and MEPS adjustment	New labelling algorithm to take account of impact of MEPS 2005. Mandates new test method AS/NZS4474.1-2007. Adjustment to MEPS levels to take into account change in definition from average to maximum energy. Label validity margin decreased to 7.5%. New labelling algorithm based on function of adjusted volume to the power of 0.67 (to better reflect surface area which is a more relevant driver of energy consumption than volume). RIS EES (2008).

For these above policies, refrigeration products are split into ten categories of products (called Groups in the standard), and an efficiency metric based on the volume (size) of the product. In addition to any energy efficiency requirements, the products must also pass performance tests (operation temperature test and 'pull down'), and changes in refrigerants regulation (phase out of CFCs in the mid 1990s). As part of the energy labelling scheme, information on all registered refrigeration products on the Australian market is also contained in a centralised database. Individual products are actually registered at state level, though the registration database is operated at a national level through E3).

There are some other policy measures which may have had a direct impact on the efficiency of products sold in Australia, though their direct impact is deemed to be small and therefore not included in the policies examined in this report (see Table 2).

Table 2: Supporting end-use policies to promote refrigeration efficiency

Measure	References
Rebates	None of significance
Information	Reach for the Stars, retailer liaison and support, advertising
Efficiency targets	Initiated by a number of states in recent years (eg VEET in Victoria)

All these end-use policies, when combined appropriately and strategically, can transform the market in an effective way. Where multiple policies are introduced, it can be difficult to attribute impact to specific measures when actors (consumers) may be responding to multiple policy measures over time.

Additionally, other factors such as appliance purchase prices and energy prices have an effect on the uptake and usage of appliances. Capital costs for some products may also be affected by measures such as rebates (as currently applied to solar water heaters and water-efficient clothes washers).

1.3 Background - Energy labelling classification of products

For the purpose of end-use policy measures, refrigeration products are classified into ten groups as defined in AS/NZS4474. These classifications are reflected in the end-use models that perform impact appraisal and evaluations. The ten groups for regulatory purposes are shown in Table 3. When undertaking sophisticated investigation of this end-use, it is usually necessary to perform analysis at this level of detail.

1.4 Data sources

The main data sources used in this evaluation study are listed in Table 4. Much of the historical data had already been analysed by EES and published in a report entitled Energy Use in the Australian Residential Sector 1986-2020 (DEWHA 2008b). The current report updated some of the data sources and made use of the same modelling approach.

Table 3: Classification of refrigeration appliances in Australian product policy

Name	Classification/description
Group 1	Refrigerator without a low temperature compartment, automatic defrost
Group 2	Refrigerator with or without an ice-making compartment, manual defrost
Group 3	Refrigerator with a short term frozen food compartment, manual defrost
Group 4	Refrigerator-freezer, fresh food compartment is automatic defrost, freezer manual defrost ("partial automatic defrost")
Group 5T	Refrigerator-freezer, both compartments automatic defrost (frost free), not side by side configuration or bottom mounted freezer (usually top freezer)
Group 5B	Refrigerator-freezer, both compartments automatic defrost (frost free), bottom freezer
Group 5S	Refrigerator-freezer, both compartments automatic defrost (frost free), side by side configuration
Group 6U	Separate vertical freezer, manual defrost
Group 6C	Separate chest freezer, all defrost types (practically only manual defrost exists)
Group 7	Separate vertical freezer, automatic defrost (frost free)

Table 4: Main data sources for evaluation

Type	Source	Data
Market Sales	GfK annual 1993-2000 (only larger selling models provided, covered 75% of sales)	For each model on the market: • brand • model number • group allocation number • registration number • fresh food and freezer volumes • average annual energy consumption • number of units sold by state • average unit price
Market Sales	GfK annual 2001-2009 (100% sales provided, some private models were masked)	For each model on the market: • energy label consumption (CEC) • star rating • maximum price • nominal total gross volume • number of external doors • defrost type (manual, frost free, auto, push button) • refrigerator type (standard, all refrigerator, upside down, side by side – or chest/upright for freezers)
Ownership	ABS4602 for 1994, 1999, 2002, 2005 and 2008. Earlier ABS surveys from 1980s also used.	For each state: • ownership, saturation and penetration (see glossary for definitions)

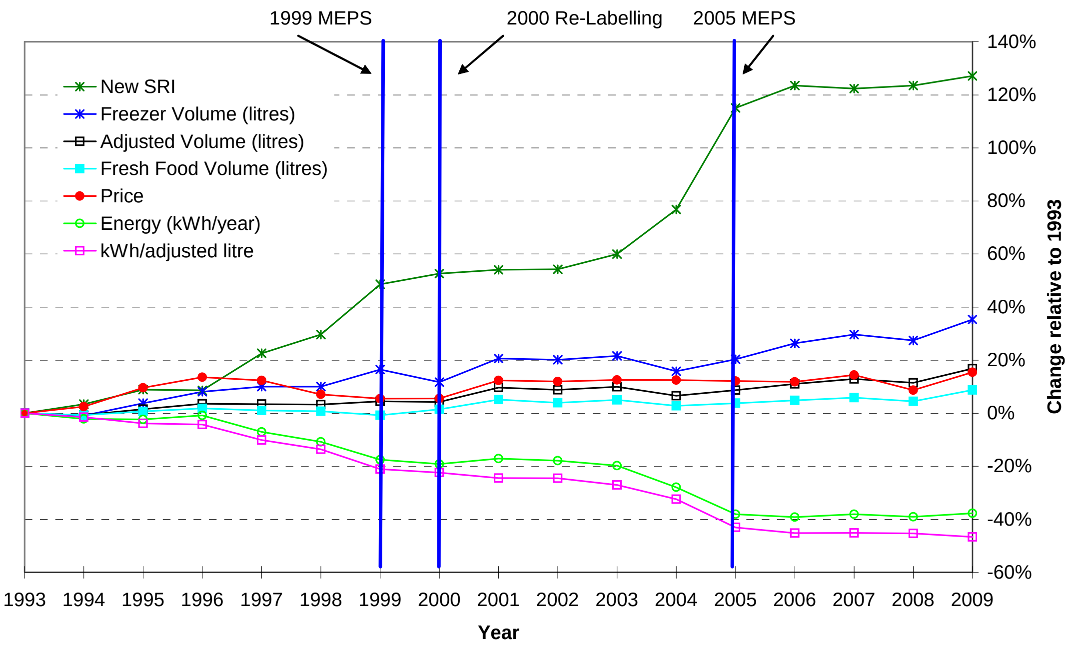
Type	Source	Data
Household numbers	ABS 3263.0	For each state number of households. Does not contain recent rapid projected increases in population debated in media. Pre 1990 data based on census data adjusted to obtain household numbers and ERP estimates by state.
Products registration database	Regulator's central register (years 1986 to date)	For each product on the market: • energy label consumption (CEC) • star rating • nominal total gross volume (split by freezer, refrigerator, other) • number of external doors • defrost type (manual, frost free, auto, push button) • refrigerator type (standard, all refrigerator, upside down, side by side – or chest/upright for freezers)

The Australian Bureau of Statistics (ABS) data used in this report is available on its public website (www.abs.gov.au). The sales data is purchased by E3 from a sales marketing company, GfK, and is used by consultants engaged by E3. Analyses of these are presented in the Greening Whitegoods report (EES, 2010). A useful overview of indicators developed; updated to include data to 2009 is given in Figure 2.

Following the introduction of MEPS in 1999, and again after more stringent levels in 2005, the average new energy consumption tends to remain stable for a period. The largest and most rapid increases in the SRI (star rating index) occur a few years prior to the introduction of MEPS in 1999 and 2005. Additionally, it is interesting to note that the size of refrigerators has marginally increased over the observation period. This will mean that the savings per unit (and from the total stock of refrigerators) from efficiency measures for these products will be slightly larger than previous expected (if the assumption in the previous RIS was for the same sized appliances). These figures are a composite value for all refrigerator types, so include some effects from the change in share by group over time.

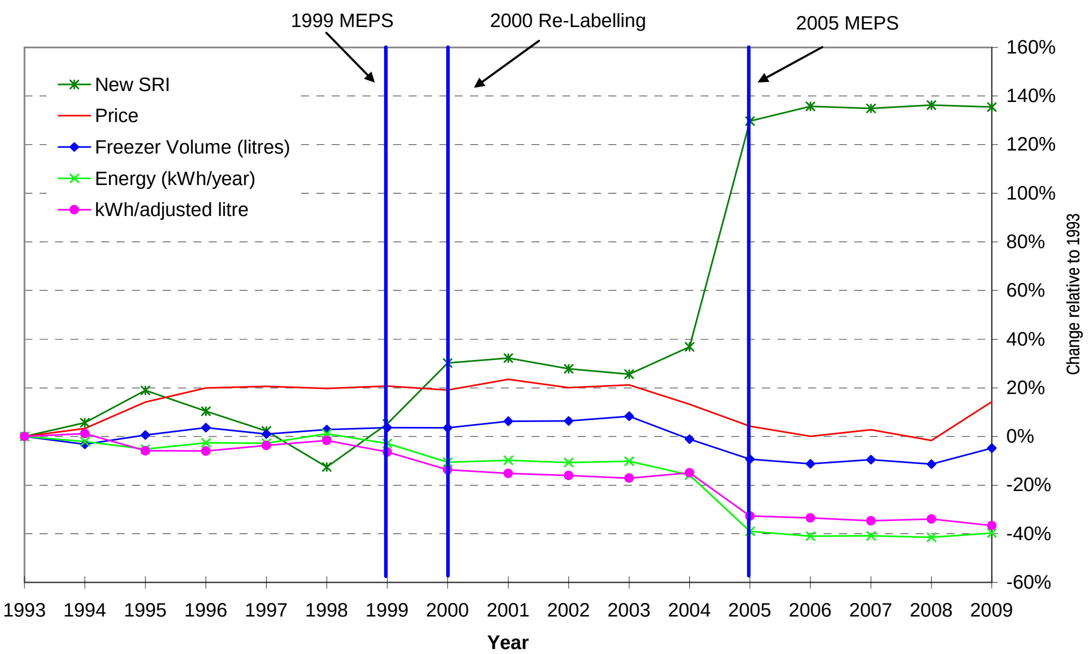
Conversely, the size of freezers has decreased noticeably over the observation period. This is largely due to the fall in the average volume of Group 6U and an increase in sales share of Group 6U since 2004 (Figure 4). The market driver for this trend is unclear.

Figure 2: Annual indicators for all new refrigerators on sale in Australia, 1993 to 2009



Source: EES (2010)

Figure 3: Annual indicators for new freezers on sale in Australia, 1993 to 2009



Source: EES (2010)

The report *Greening Whitegoods* (EES 2010) provides extensive data at a group level for the period from 1993 to 2009 and is one of the key data sources for this report. That report should be consulted for more details on historical data.

Since 1993 the average nominal purchase price paid for refrigerators is relatively unchanged and in fact has reduced in real terms if inflation (based on the ABS Cost Price Index) is taken into account. This is an important observation since the usual analysis presented in RISs assumes that purchase costs will increase when pushing the market towards more efficient products. A slightly faster fall in real purchase prices may have occurred in the absence of MEPS, but it is not possible to prove this one way or the other, although the trend in prices is generally smooth[1] and does not show any significant reaction to the introduction of stringent MEPS in 2005. This does not mean that infinite efficiency gains can be made at zero marginal purchase cost. However, it does imply that mandatory increases in efficiency, within the bounds of what is technically available on the market (best available technology) can, with sufficient notice to industry, continue to be made at very low marginal costs. Section 3.7 examines price trends at a group level over the study period to assess whether the various policy measures to date have caused any measurable impacts.

2. METHODOLOGY OVERVIEW

This section provides a summary of existing evaluation guidelines with specific implication for domestic refrigeration product evaluation. This section is followed by a list of data requirements to implement a successful evaluation of refrigeration policy measures.

2.1 Evaluation guidelines

To date there are no formally published generic guidelines on the evaluation of product policy in Australia. There are a few case-study evaluations which are worth examining. For refrigeration product policy, the analysis by EnergyConsult (2006) is an obvious starting point. The approach for the current analysis is similar. The main differences are that the analysis is undertaken by changing efficiency (rather than energy consumption values) of appliances at the product group level, and that alternative approaches for generating the efficiency scenarios have been considered. In addition a decomposition analysis has been undertaken to explain the difference between this re-appraisal (impact evaluation) and the original RIS. Of course, the current evaluation has more years of actual market data to improve the level of confidence in the savings estimates. This study goes beyond energy impacts and includes an examination on purchase price, model availability and spread of efficiency on the market over time.

[1] The purchase price trend at a group level needs to be examined as the aggregate price depicted in the figures includes the effect of changes in group share over time (share of frost free products, which are larger and more expensive has increased over time). These are examined in more detail in Section 3.7.

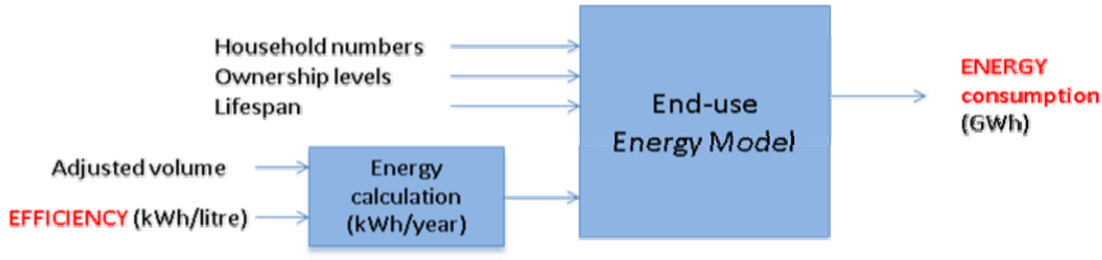
It is likely that generic impact evaluation guidelines will follow and the current analysis can feed into that development process.

2.2 Approach for end-use modelling

To undertake a sophisticated product policy impact evaluation requires the use of an end-use stock model. Appendix 2 provides greater detail of how such a modelling approach works, and is also shown schematically in Figure 4 below.

Ideally, an analyst would use or have access to the same models as employed for the original impact appraisals, and then update all the input variables (with a later and better knowledge of what actually happened). An assessment of the impact of each updated variable (apart from energy efficiency changes) can then be assessed by comparing the stock model energy savings when using the original estimated parameters. Once the impact of these elements has been assessed, a range of different efficiency scenarios can then be used to drive the model to examine energy consumption impacts under different energy efficiency responses.

Figure 4: Generic modelling approach



The modelling of program impacts for refrigerators and freezers should be done at the classification (group) level of the refrigeration types that is described in the policy measure legislation. There are currently ten groups of refrigerators and freezers. The impact of changes in the efficiency of each product type (Group 1, 2, 3 etc.) under different scenarios can then be assessed.

Such a model requires a large amount of data. The following data inputs are essential for a robust energy impact assessment:

- Stock of refrigerators by type by year by state (at a minimum of freezer and refrigerators). Ownership of refrigerators is fairly uniform at a state level, however, there are significant variations in the ownership (stock) of separate freezers by state.
- Sales of new refrigerators by group. This is not often used directly in a stock model but this data is necessary to accurately weight the attributes of new products entering the stock by year and information of total market sales provides an indirect indication of average product lifespan.

- Sales by group to include attributes of volume/size, energy and any features to allow an assessment of energy efficiency at a model level.
- Distribution of refrigerators by climate zone (although all evidence in Australia suggests that this effect is generally negligible – sales-weighted attribute averages for all states are close to identical).
- Correction functions to convert 'test' data as declared by the manufacturer to actual consumption in the home, relating to climate zone.

The current analysis is undertaken at the state level (as is the case with the studies being reviewed), although the main report presents aggregate findings for all of Australia to simplify the evaluation process. Detailed outputs at a state level by year are included in Appendix 6 for reference.

In terms of the impact evaluation, the most important variables are:

- The no-impact baseline which may be the impact baseline at the time of the original RIS.
- The trend in the energy efficiency of products sold over time.

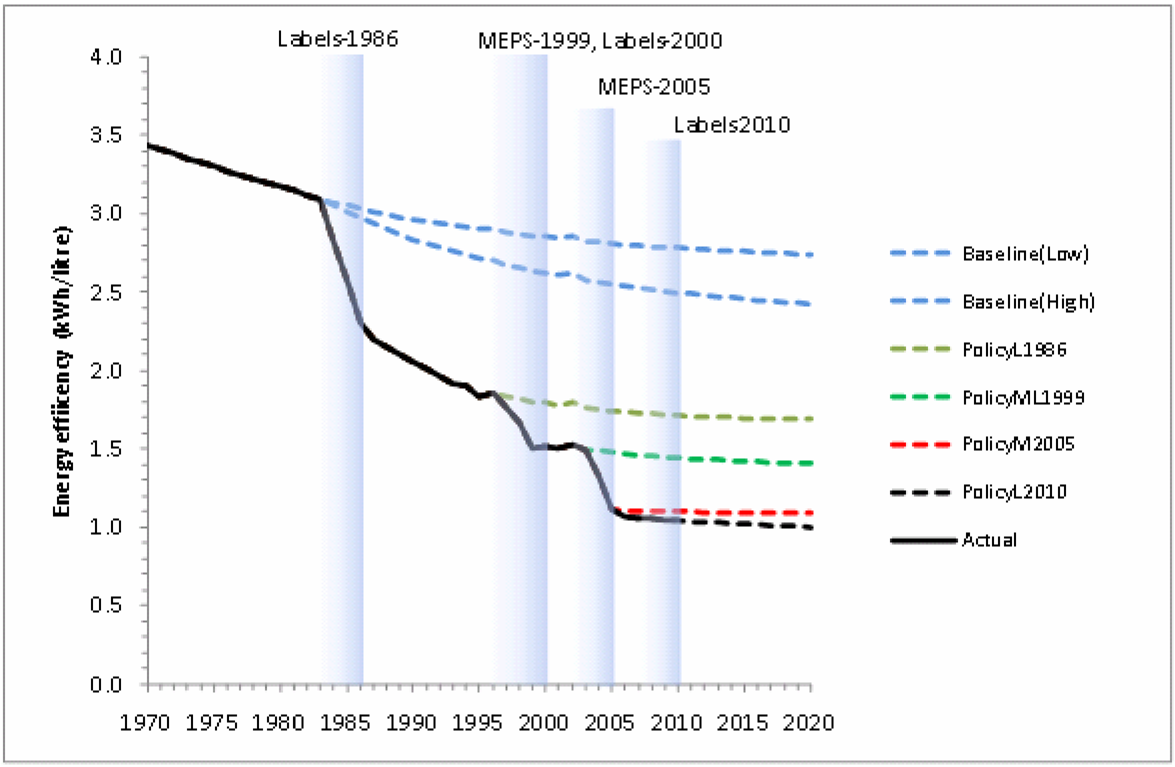
When conducting an assessment or evaluation of the impact of energy efficiency on future energy consumption, it is usual to construct a base case where all key variables are set to the expected values over time[2] and these remain the same for the range of different efficiency scenarios. It is then possible to develop different efficiency performance profiles that could occur in response to different policy measures that may be implemented over time (or assess the absence of future policy measures). As an example, various efficiency scenarios for Group 5T are shown in Figure 5. The solid black line shows the actual energy intensity (measured as kWh/year/litre of adjusted volume) of new Group 5T products sold each year over the period 1970 to 2008. This 'actual' energy intensity is based on historical data to 2008 is then projected to 2020 and includes all program measures that have been implemented for household refrigerators to that point (PolicyL2010). The coloured lines above this scenario are a range of alternate efficiency scenarios that have been developed to estimate the efficiency of products in the absence of energy policy measures from various points in time. The practical workings of a detailed example follow.

The first Baseline (Low) uses historic data to 1983 (solid black line) and then includes a projection forwards (dashed blue line) assuming a similar rate of historic autonomous efficiency improvement which then declines into the future. This baseline is different to actual measured data prior to 1986 (the year of labelling introduction) as it appears that the supply chain responded in advance of the labels being introduced (this is a well known effect in all new labelling schemes). The Baseline (High) is similar

[2] Typical parameters that are normally set to expected values for modelling purposes are household projections, ownership projections, product size trends, group sales share and product lifetime. To examine the impact of changes in these non-energy parameters, it is usual to assess the energy impact on the base case efficiency scenario (where multiple efficiency scenarios are assessed) and assess the impact of each non-energy parameter in the form of a sensitivity analysis relative to the base case efficiency scenario.

to Baseline (Low) except a higher rate of autonomous efficiency improvement is assumed. The first baseline is difficult to assess, as we do not know with much certainty what would have happened if the first policy measure of energy labelling was not introduced. It should be noted that since this is the first baseline, it has a significant impact on the aggregate impact assessment. In addition, as this program measure was introduced a long time ago, any small annual impacts accumulate into large cumulative energy impacts over time. Since there is little historic data to accurately establish "no program" trends from 1986, two baselines have been provided to enable a range of estimates for the first labelling policy in 1986, though the report will use the Baseline (High) as the initial baseline. This assumes a higher autonomous rate of efficiency improvement and therefore provides a lower and more conservative energy savings estimate – it attributes more of the savings to efficiency improvements that industry would have made in any case without energy labelling.

Figure 5: Average new efficiency of Group 5T refrigeration products for different scenarios



The next scenario (labelled PolicyL1986) includes the impact of introducing energy labelling in various Australian States (Victoria and NSW, which was effectively a *de facto* national scheme even at this early stage). It does not include any subsequent policy or any anticipation of the introduction of MEPS in 1999. The impact of MEPS 1999 is reflected in the scenario PolicyM1999. The PolicyL2000 is the additional impact of the energy labelling algorithm regrade in 2000 (over and above MEPS in 1999). As these two policies (MEPS 1999 and Labels 2000) were developed in parallel and implemented within a year, they have been aggregated in the above figure into scenario PolicyML1999. The PolicyM2005 scenario includes anticipation of new stringent MEPS levels for 2005, so shows impact from 2003 onwards. The PolicyL2010 scenario includes the estimates for the 2010 policy measures, including an updated appraisal of energy savings out to 2020.

The energy impact of each of these efficiency scenarios can be assessed with a stock model by progressively modelling each energy efficiency scenario. The differences between the scenarios provide an estimate of the impact of each program measure over time. It is quite straight forward to assess the efficiency of products sold in 1980 and products in 2010 and see that they have changed substantially. Energy consumption per litre is 30% of what it was 30 years ago (i.e. a 70% reduction). The 'size of the savings from the efficiency improvement pie' is known - what is more difficult is to attribute these actual changes in energy consumption to each of the energy programs implemented during this period and to determine any underlying rate of improvement which may have happened if no (more) policy measures were introduced at each point. Autonomous efficiency improvements that occur in the absence of energy programs include improvements in manufacturing, components and materials. Some estimate of these effects can be made before energy labelling was introduced in 1986 but there is only a limited amount of data from which trends can be established sourced from Choice testing in the late 1970s and early 1980s, which have been carefully reassessed for this report. Additionally, there is good anecdotal evidence that industry responded to the challenge of energy labelling some years before it was actually introduced. Given the emphasis on energy issues in the present political environment, it is hard to imagine a reality where energy played no role in product selection. So at best, this must be regarded as a somewhat hypothetical baseline case.

Development of efficiency scenarios requires some expert judgement to make sure that they are as accurate as possible. The authors have analysed the most comprehensive data set and detailed market knowledge from the past 25 years in order to develop the scenarios presented in this report.

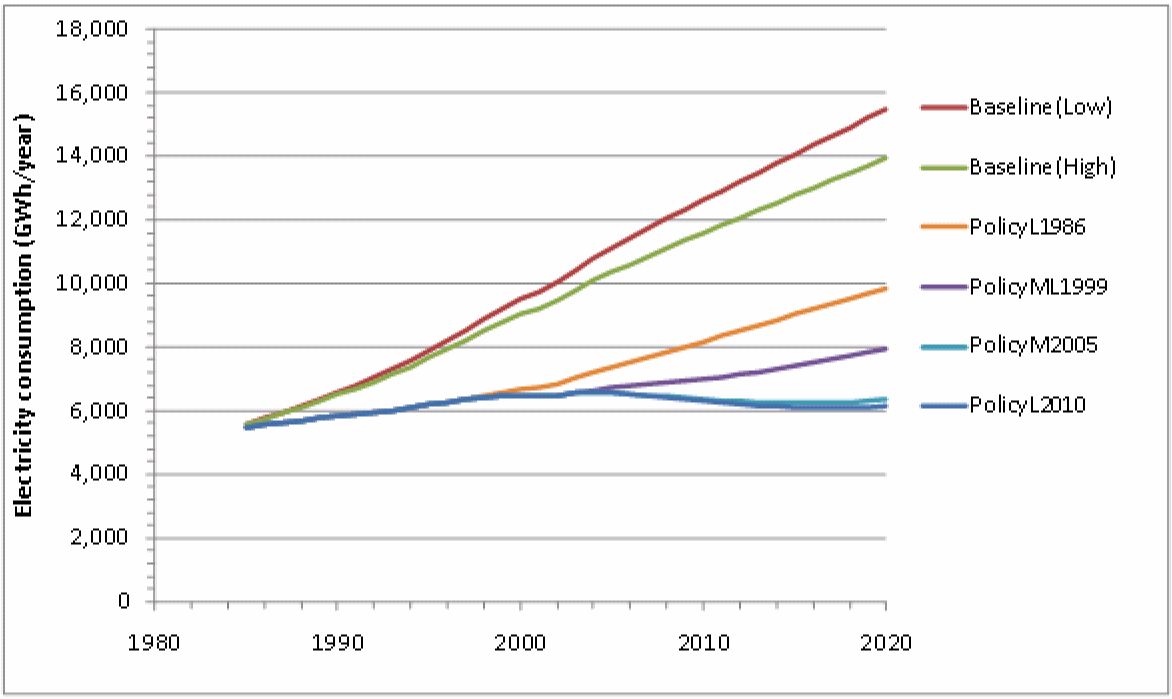
3. KEY RESULTS

The present analysis has made use of historic scenarios as the basis to estimate the impact of past policies on refrigerators in Australia. The first baseline, whether Baseline(Low) or Baseline(High), serves to establish the overall 'size of the cake' of the energy savings accrued from energy efficiency policies, while the other policy scenarios determine the amount of savings attributed to each of the various policy measures implemented. These energy impacts resulting from these different efficiency scenarios have been generated using a conventional stock model as previously described, are presented in this section. These savings are then compared with previous estimates of savings for the main policies (MEPS 1999, Label 2000, MEPS 2005) with a detailed decomposition of the revised energy savings attributed to MEPS 2005 savings. An additional analysis on the purchase price, model availability and spread of efficiency over time is also provided in this results section.

3.1 Energy impacts

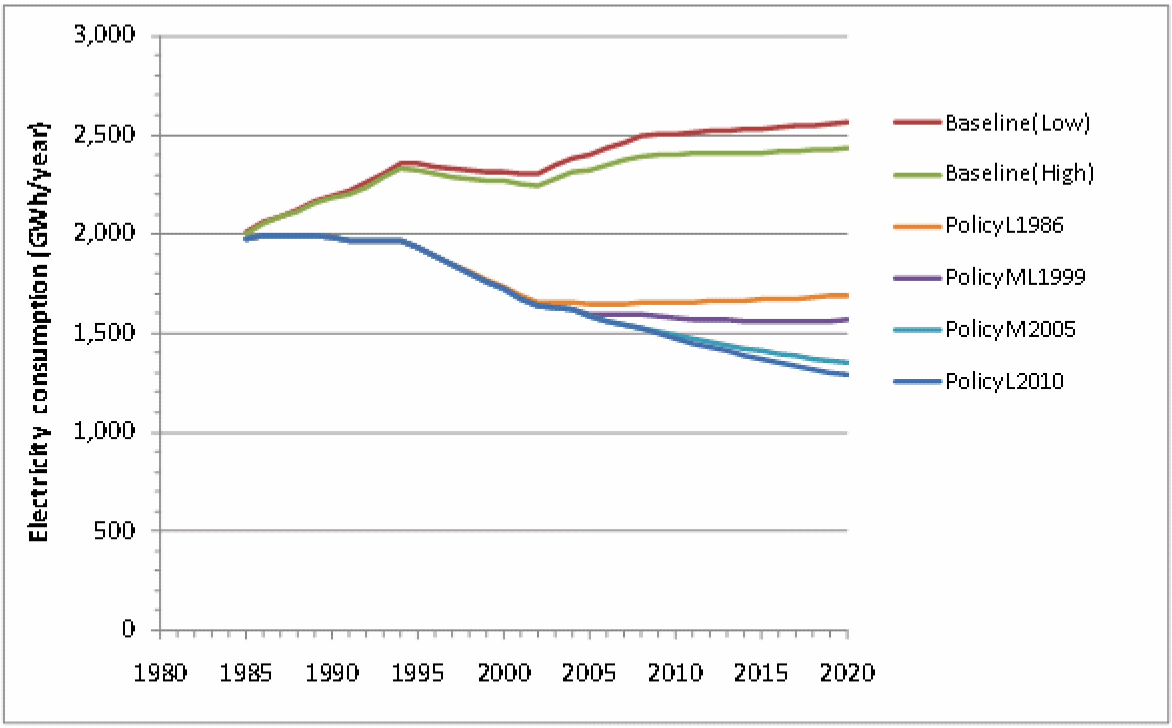
The energy consumption outputs (GWh/year) of the end-use stock models are given for all refrigerators (Figure 6) and all freezers (Figure 7). These show that without any increase in the efficiency of appliances sold, energy consumed by these products would be substantially higher. Furthermore, the energy saving impact of the policy measures being evaluated is significant.

Figure 6: Estimated annual electricity consumption by refrigerators (GWh/year)



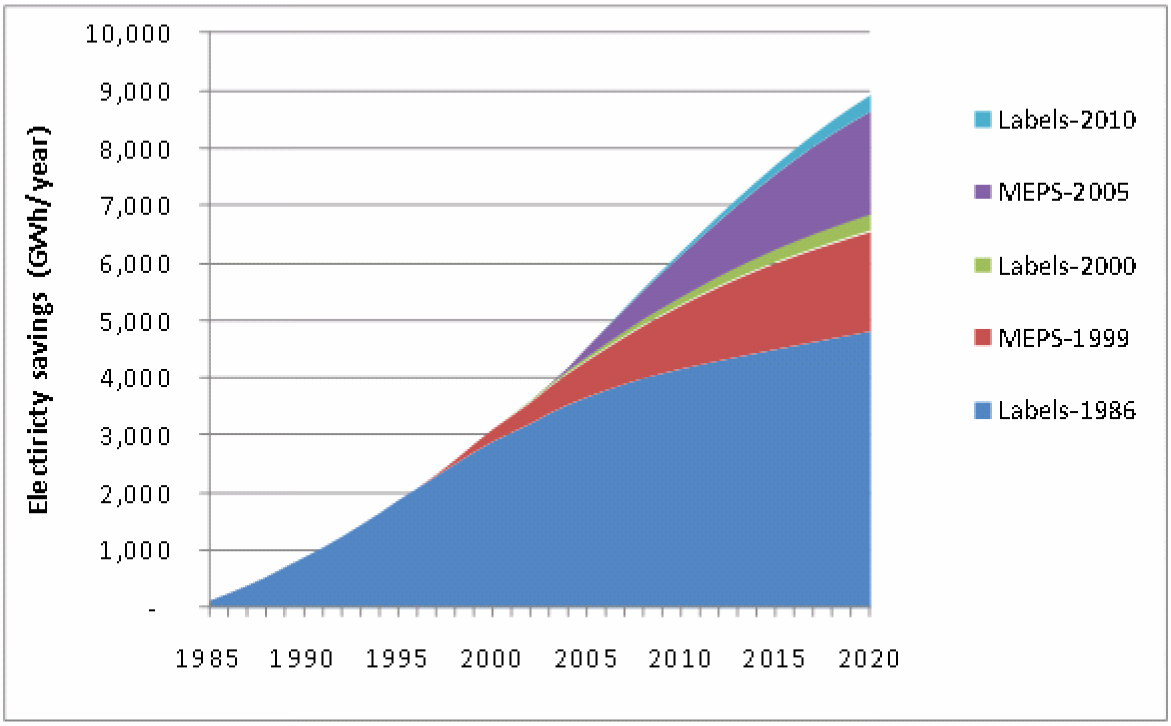
The analysis for freezers shows that without any policy measures the increase in consumption would not be as large. This is explained by a general reduction in average size of freezers over time (though some of this reduction in the size of freezer frozen space will be observed in larger freezer compartments in refrigerators).

Figure 7: Estimated annual energy consumption by freezers (GWh/year)



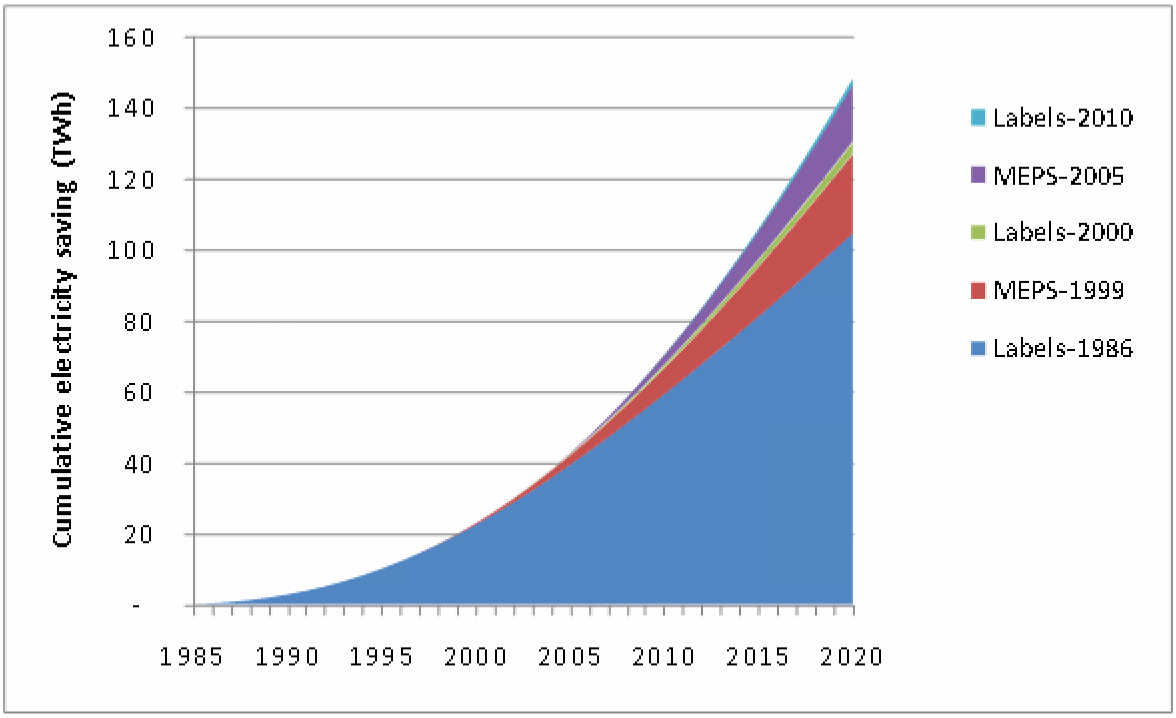
By taking the differences between the energy consumption scenarios it is possible to show the likely energy savings impact from each of the policy measures (Figure 8). The Labels 1986 policy measure shows the greatest electricity saving. This is due to the easier savings that were able to be made earlier and the long duration before the subsequent program measure (1999). The energy savings attributed to the more recent MEPS 1999 and MEPS 2005 also show significant savings.

Figure 8: Estimated annual energy savings for all refrigeration appliances



These savings are annual electricity savings, not cumulative. It is possible to show the cumulative savings from these policy measures, and these are presented in Figure 9.

Figure 9: Estimated cumulative energy savings for all refrigeration appliances



Note – these are cumulative energy savings from 1985, and the units are TWh.

3.1.1 Value of savings

Using the energy savings estimated above it is possible to convert these into carbon emission reductions and average household financial savings from reduced household electricity running costs. Since these financial and carbon values of the energy savings are not the main focus of this report simple conversion factors have been used. For financial savings an energy price of 17c/kWh has been used, whilst for carbon emissions a conversion factor of 0.92kgCO_2/kWh has been used.

Using these simple conversion factors it is possible to get an indication of the financial and greenhouse gas value of the national energy savings from all policy measures for refrigerators since 1986 (Table 5). This suggests that refrigeration policy measures are currently reducing household electricity costs by over $900m per annum (in 2008). If the early measures (Labels 1986) are excluded, these savings are still significant at $265m per year. These annual savings will continue to increase as refrigeration equipment is replaced, such that the value of savings in 2020 could be around $1.5bn per year (or $688m per year if the early measures are excluded).

In terms of carbon dioxide emissions from electricity generation, the reduction in carbon dioxide emissions is already over 1 MtCO_2 per year in 2008 (1.4 MtCO_2) and this could be as much as 5 MtCO_2 if earlier labels are included. These emissions reductions are expected to increase and could almost double by 2020.

Table 5: Summary of national savings for Australia

Item	Labels-1986	MEPS-1999	Labels-2000	MEPS-2005	Labels-2010	TOTAL (all)	Total (excluding 1986-labels)
Annual energy savings (2009) (TWh)	4.09	1.01	0.13	0.62	0.05	5.9	1.8
Annual carbon emission reductions (2009) (MtCO_2)	3.76	0.93	0.12	0.57	0.04	5.4	1.7
Residential sector financial value of savings (2009) ($m)	695	171	22	106	8	1,002	307
Annual energy savings (2020) (TWh)	4.82	1.73	0.30	1.79	0.29	8.9	4.1
Annual carbon emission reductions (2020) (Mt CO_2)	4.43	1.59	0.28	1.65	0.27	8.2	3.8
Residential sector financial value of savings (2020) ($m)	819	294	51	305	49	1,518	699

These savings at a national level can be converted to household level savings by assuming these savings accrue equally to each Australian household (Table 6). The estimated average household annual electricity saving is around 688 kWh/year; resulting in annual financial savings of over $100 per household in Australia. The future financial savings are likely to be larger than shown, as these estimates are based on current prices.

Table 6: Summary of average savings per Australian household

Item	Labels-1986	MEPS-1999	Labels-2000	MEPS-2005	Labels-2010	TOTAL (all)	Total (excluding 1986-labels)
Annual energy savings (2008) (kWh)	490	121	15	75	6	707	217
Annual carbon emission reductions (2008) (kg CO_2)	451	111	14	69	5	650	199
Residential sector financial value of savings (2008) ($)	83	21	3	13	1	120	37
Annual energy savings (2020) (kWh)	481	173	30	179	29	891	410
Annual carbon emission reductions (2020) (kg CO_2)	442	159	28	165	27	820	378
Residential sector financial value of savings (2020) ($)	82	29	5	30	5	152	70

3.2 Comparison with previous energy saving estimates

It is possible to compare these estimates against the two original RIS figures shown in Figure 10 and Figure 11.

The comparison done for the combined MEPS 1999 and Labels 2000 RIS suggests that it is likely that these measures delivered considerably more savings than was originally estimated in the RIS (GWA 1999). Without access to the original data and a detailed decomposition, it is difficult to explain the difference between these two estimates.

Similarly for the MEPS 2005, the current analysis suggests that the energy savings are likely to be higher than estimated in the original RIS undertaken in the year 2001 (GWA 2001). Since the original input data is available for this RIS, it is possible to explain the differences between the original estimate and the current evaluation, as set out in the following section.

Figure 10: Estimated energy savings for MEPS 1999 (RIS and present analysis)

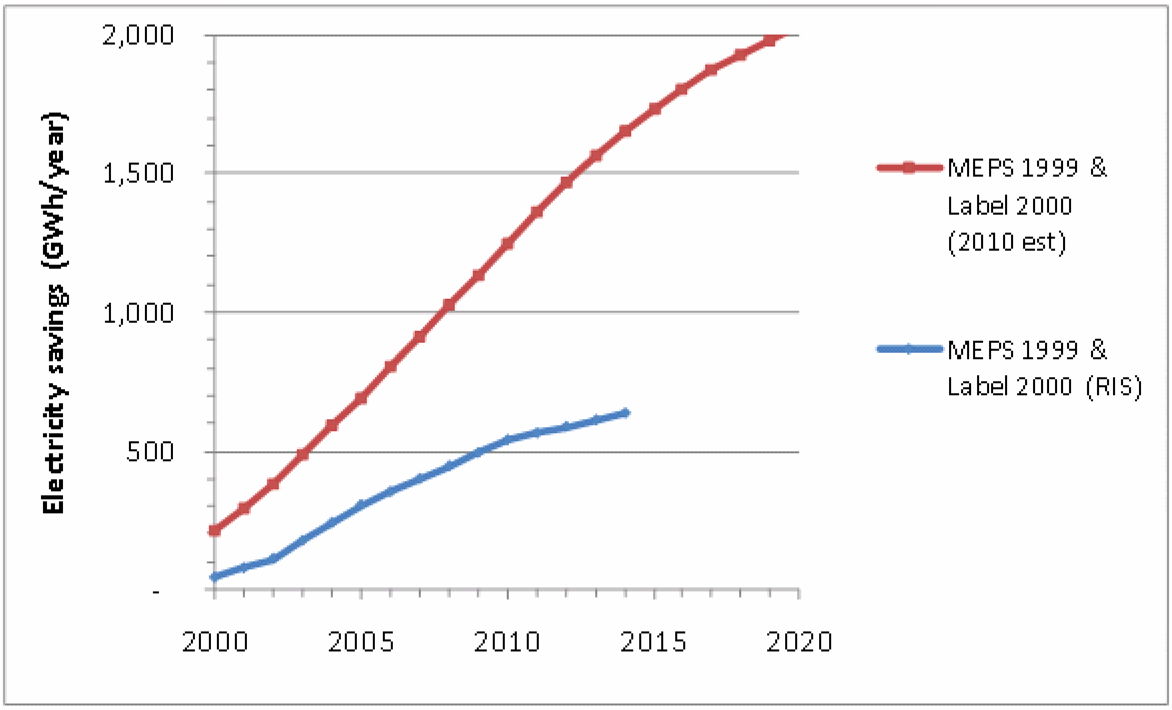
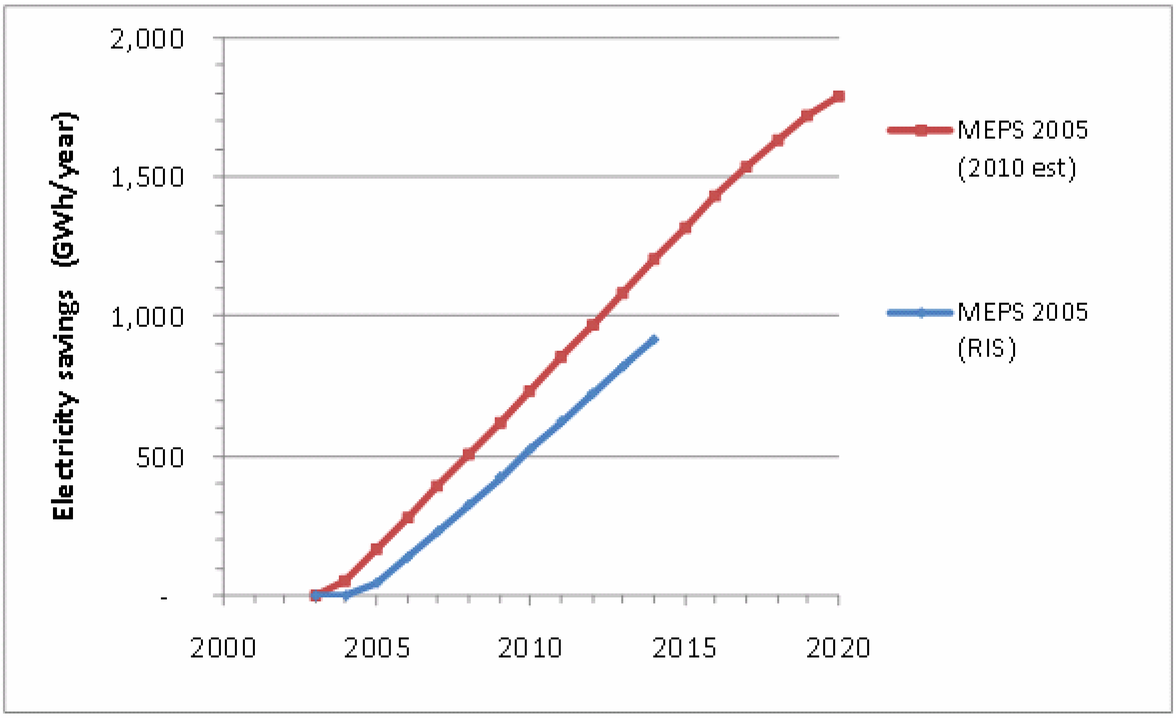


Figure 11: Estimated energy savings for MEPS 2005 (RIS and present analysis)



It is interesting to note that the MEPS 2005 RIS does not show any savings prior to 2005, although it is very likely that manufacturers and the supply chain brought products to the market in advance of the standard coming into effect and this would seem to be reflected in the plots of the average SRI values over time. Some of this impact has been attributed to MEPS 2005 (as early as 2003 in the current evaluation).

Since the RIS analysis for the MEPS 2005 was done using a similar modelling approach by EES, and the input data used at the time are available, it is possible to undertake a decomposition analysis to explain where the estimates have changed. Such a decomposition analysis is considered further in Section 3.4, though the changes in underlying variables used in the model are described first.

3.3 Changes since original RIS estimates for MEPS 2005 savings

Part of revised energy savings attributed to policy measures is due to changes in some of the underlying non-energy efficiency data, specifically:

- household numbers;
- household ownership levels[3]; and
- the average size of appliances sold.

It is useful to show how these have changed from the original RISs compared to the best available data or estimate in the current evaluation.

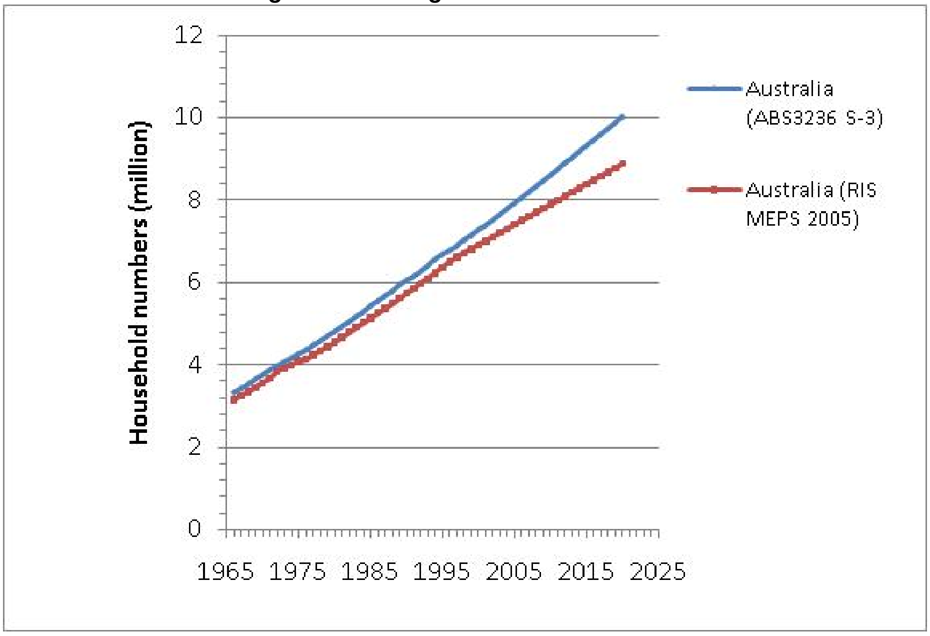
Until 2004, the Australian Bureau of Statistics (ABS) only provided forecasts of population in ABS3222 – they made no future estimates of households. Some Australian states provided forecasts of households, but they were highly variable and often not in the public domain. Prior to 2004, in order to estimate future household numbers, it was necessary to look at household size trends by state and project these forward. A compounding issue was that the ABS did not publish historical household numbers. The census gave some indication of household numbers, but these were never precise as a number of corrections needed to be applied to the raw data to get occupied private households. ABS4602 and the earlier ABS8212 gave historical estimates of households for some years.

In 2004, ABS released ABS3236 that looked at historical population (estimated resident population = ERP) and households and projected these to 2026. This was the first time an integrated historical base and forecast of households and population had been provided. This was a significant improvement to previous approaches. Prior to 2004, all studies including GWA (2001) and GWA (1999) used indirect estimates of future household numbers. In general terms, the ABS3236 estimates were about 300,000 household more that the indirect estimates used previously. The latest ABS3263 projections to 2020 were up to 1 million households higher than the earlier implied numbers. These differences explain some of the differences between this current study and previous energy saving estimates.

[3] Changes in household numbers and ownership levels will also be revealed in changes in the volume of sales.

Therefore previous impact appraisals did not have access to reliable household data. The RIS for MEPS 2005 used ABS3222 Series 1 whereas it now appears that the number of households by 2026 is estimated to be more than 5% higher than when ABS3236 is used (Figure 12). In this case, if the analysts who undertook the original RIS for MEPS 2005 had access to these data, the expected savings from this policy measure would have been higher. Note that the ABS3236 estimates used for the all scenarios do not include higher immigration rates that have been prevalent in recent years that could lead to faster increases in projected population.

Figure 12: Changes in household numbers



Changes in refrigerator and freezer stock levels are driven by household numbers (which have increased as shown above), and also in ownership levels per household. Figure 13 shows current ownership levels (and projections) and those used in the 2005-MEPS RIS (based on the latest ABS data from surveys undertaken in 1999). This shows that ownership of both refrigerators and freezers is actually higher than was expected during the development of the MEPS 2005 RIS development in 2001. The latest figures for this study (2010) are based on state trends documented by ABS4602 in years 2002, 2005 and 2008.

Over the same period, the sales of refrigeration appliances have significantly increased. If these are real increases in sales and not a reflection of appliances being kept for shorter times, this should be apparent in changes in stock levels.

Similarly the projected size of appliances will now be different when compared to the 2000 estimates. The current data and projections (PolicyL2010) are compared with projections made in 2000 (used for the MEPS 2005 RIS). For refrigeration appliances both the fresh and frozen space are noticeably higher which means that energy savings will be higher than anticipated (along with absolute energy consumption). In contrast, the size of freezers has fallen substantially from about 2003, but this appears to be unrelated to the introduction of MEPS (Figure 14).

Figure 13: Changes in ownership levels (done in 2000 and 2010)

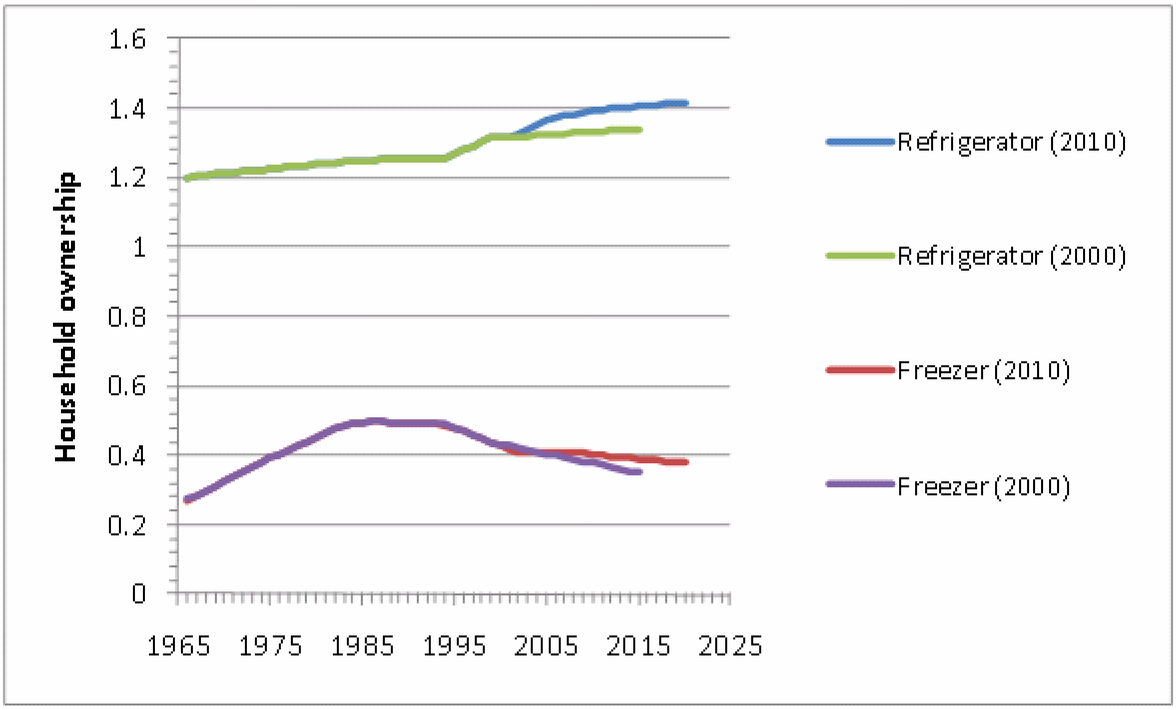
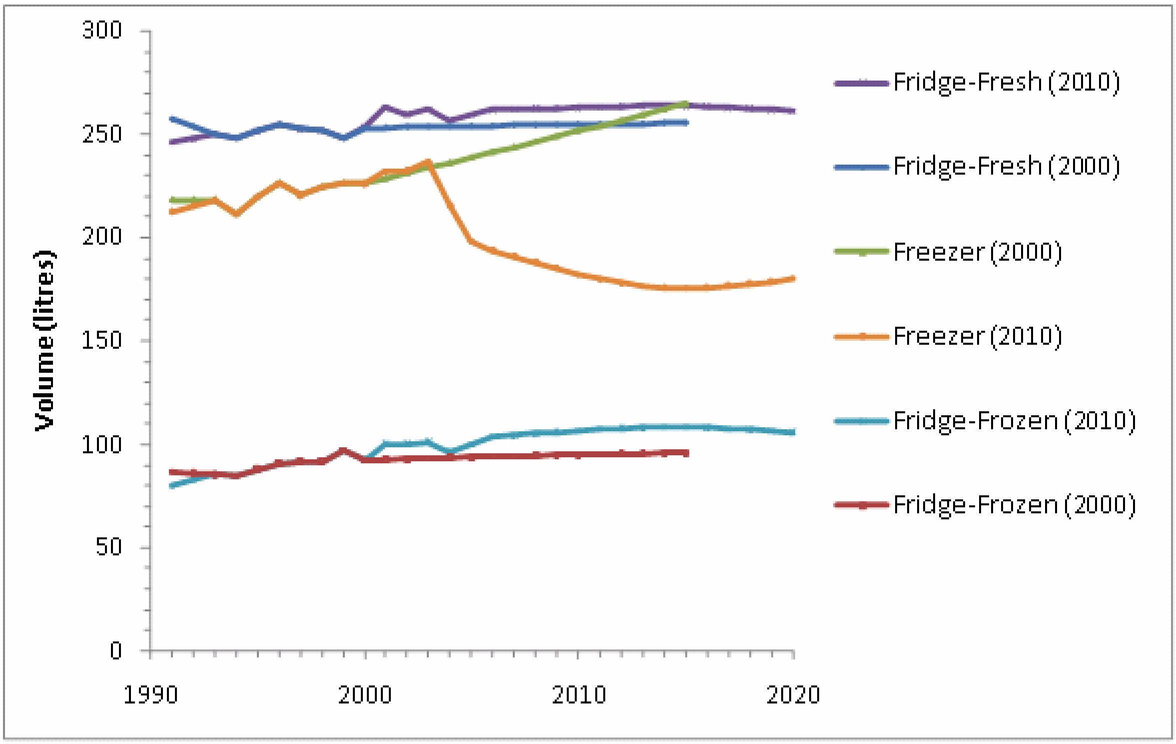


Figure 14: Changes in size of refrigeration appliances



Other aspects may also have changed over time. These include:

- The sales split between the groups. This will be noticeable for the MEPS 2005 re-appraisal and has an impact on the energy consumption calculations.
- The lifespan function and its parameter values. For the current analysis there is no significant difference for the MEPS 2005 re-appraisal approach, though the values used in the original RIS are slightly different. For reference, the 2000 RIS (GWA 2001) assumed a lifetime of 17 years and 21 years for refrigerators and freezers respectively, while the PolicyL2010 scenario assumes a lifetime of 16 years and 20 years for refrigerators and freezers. The only impact that this small decrease in lifetime is that the efficiency effects of policy measures flow through the stock slightly faster. But to some extent these differences are reduced by the different retirement functions used in 2000 and now.
- The 'reference' projection post MEPS 2005 will also be different since the current analysis now has access to additional years of data post the MEPS implementation.

It would also be possible to show the change in carbon factors used, although this would be an intricate analysis and ultimately not the focus of this report.

It is possible to examine the effect of these 'counterfactuals' further in a decomposition analysis, which is considered in Sub-section 3.4.

3.4 Decomposition of change in expected MEPS-2005 impact

Using the different inputs from current models and the previous MEPS 2005 RIS input data it is possible to show how the estimated energy savings have changed since the original RIS and importantly to attribute the changes to resulting from different input data.

As a first indication it is possible to run the latest scenario (PolicyL2010) using the best currently available data and then show the same baseline scenario but independently changing each of the main input variables (households, ownership, size) available in 2000. The effect of this is presented in Figure 15, which shows the relative importance of each of these input parameters. The household and ownership data are the most prominent - the implication of the underestimate of these input variables is that energy consumption in the PolicyL2010 scenario is much higher than expected (using 2000 data, at the time of the RIS development). The overall effect of size is negligible as the reduction in the average size of freezers is mostly balanced out by the increase in the average size of refrigerators.

It is possible to repeat such an analysis for the estimated savings from the MEPS 2005 (the difference between the 2003 and 2005 baselines). Figure 16 below shows the expected impact for the MEPS 2005 from the present analysis and where the changes in impact have occurred since the original appraisal for the RIS was first undertaken. The decomposition is shown for the year 2009.

Figure 15: PolicyL2010 scenario using current data, changing input data (household numbers, ownership, size) from data available in 2000

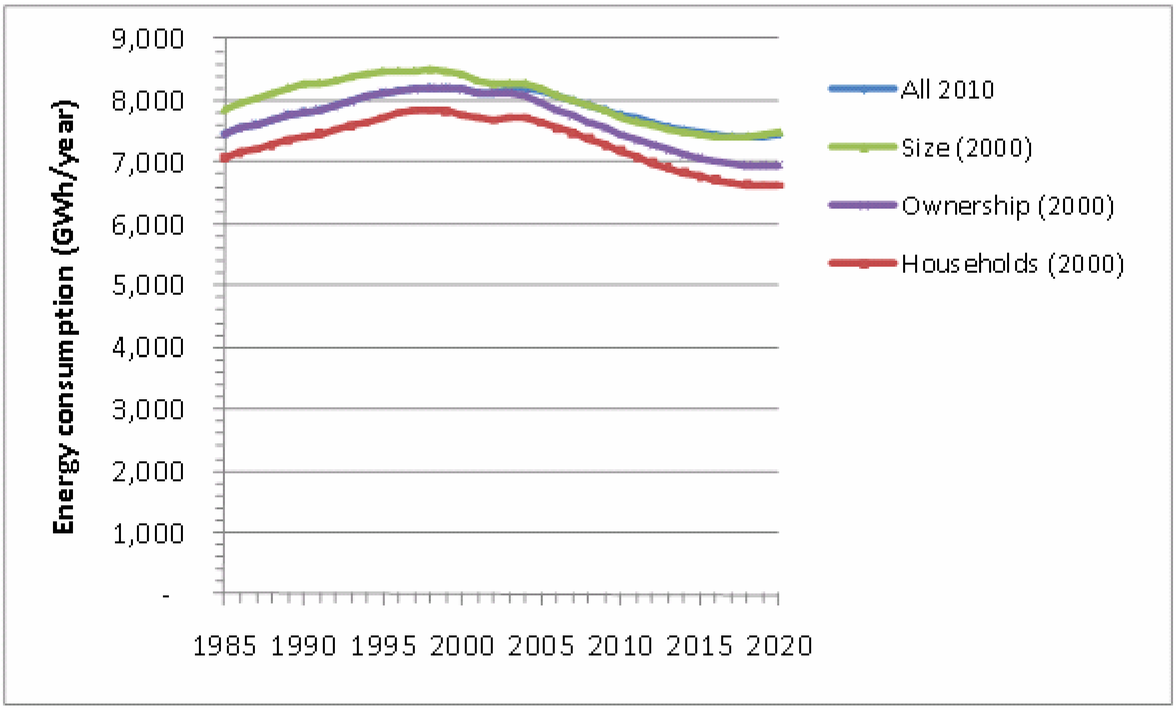
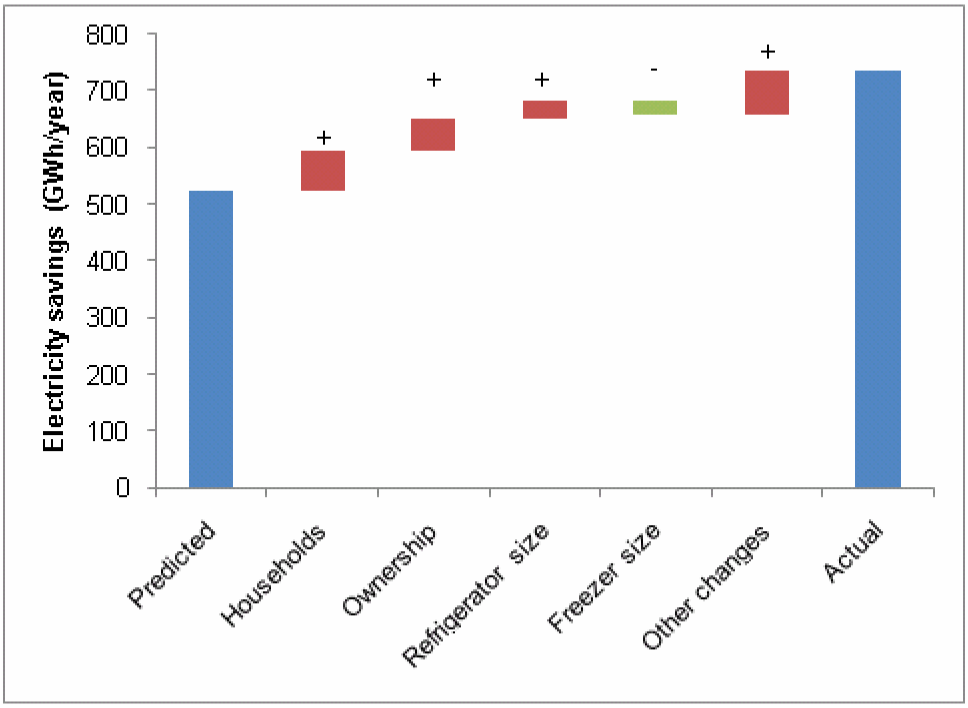


Figure 16: Decomposition of changes in 2009 energy savings from MEPS-2005 for refrigeration appliances

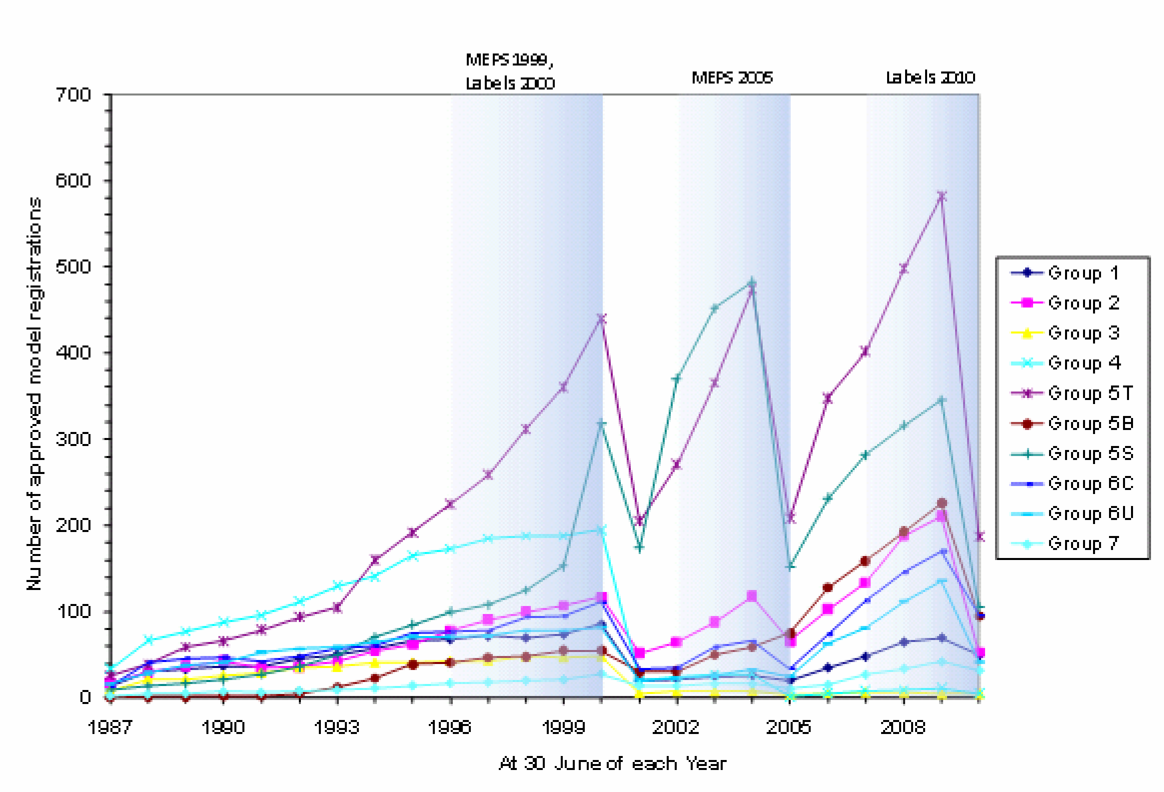


The 'other' change represents the sum of all the other differences that have changed since the original modelling was undertaken. The two main changes are that the lifespan is slightly shorter (for refrigerator and freezers an assumed life of 20/16 years in the current model, versus an assumed life of 21/17 years for the original assessment as noted above) and the sales split across the different groups is also different to what was expected (this is the largest effect). Differences in the projected efficiency scenario (which are generally quite small) are included in 'other'.

3.5 Competition/market (product availability)

One concern often raised with regulator proposals is that energy efficiency will restrict consumer choice with respect to the number of products on the market. This report undertook a quantitative analysis of the registration database to estimate the number of models on offer on the market from 1987 to 2010. The results are shown in Figure 17.

Figure 17: Number of approved models in Australia at 30 June for each year



The number of models on the market through the mid 1990s will be somewhat over-estimated by this analysis as the registration system did not have a mechanism to remove or identify old registrations in the system until 2000. The data shows that transitions in 2000 (introduction of MEPS 1999 and a new label and labelling algorithm in 2000) as well as MEPS 2005 and Labelling 2010, had a significant short term impact on the number of models currently approved. To some extent this is expected, as a typical period for a refrigerator model to be supplied to the market without change is only about three or four years. So at times of regulatory transition, the registration system shows a large change in approved models many of which are already obsolete as far as manufacturers are concerned. Registrations now have a nominal expiry date of five years from registration (subject to any regulatory changes in the mean time).

However, despite the large apparent impacts of the regulatory transitions, the number of available models is continuing to increase at quite a rapid rate over time indicating that consumer choice in terms of models is growing quickly. Thus, the long term growth of models on the market appears to be unaffected by stringent regulatory regimes such as MEPS 2005.

The number of approved models by year can also be compared with GfK data over some of the same period (where data are available) as illustrated in Figure 18.

Figure 18: Total approved registrations and number of models recorded by GfK

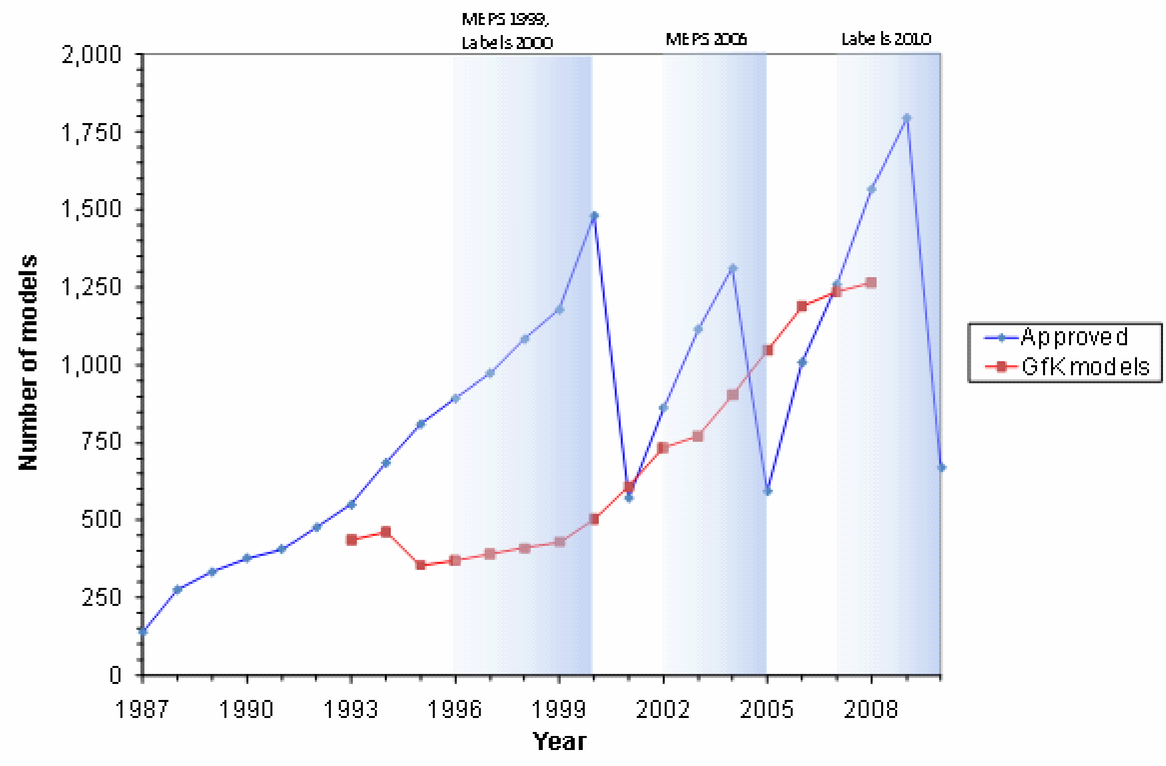


Figure 18 illustrates a couple of interesting facts. Firstly, the GfK data shows that there has been an increasing trend in the number of models available in the market (more or less a three-fold increase in 15 years). This confirms the underlying trends illustrated by the registration system analysis which also shows a dramatic increase in available models. The second point is that the number of models available and sold on the market - as seen by retailers - does not appear to be affected by regulatory transitions (especially those in 2000 and 2005, where data are fairly complete). This confirms that regulatory transitions, even where tough new requirements like MEPS 2005 are introduced, do not unduly restrict the supply of product choice on the market. This is also partly explained by the transition provisions that permit the sale of existing stock after new regulatory requirements come into force to minimise impact on retailers (i.e.

models can no longer be imported, but sales of that model from existing warehouse stock can still legitimately be recorded by GfK). The last observation from this figure is confirmation that the number of approved registrations at any point in time is somewhat more than the actual number of models available on the market. Matching of GfK sales data to registrations usually results in about 30% of current approved models not recording any sales. In addition, GfK record some duplicate models (which retailers identify as different models but which from an energy perspective are equivalent and use the same registration). The registrations database provides an indication of models that could be sold (rather than are actually sold) so is an overestimate. In addition, the transition regulatory arrangements have a lead time of several years so the supply chain has time to adapt to the new requirements in an orderly fashion. It needs to be recognised that the number of models is not a reflection of sales. In 2009, the 40 top selling models (out of a 1050 models recorded by GfK) accounted for 50% of all refrigerator sales.

Thus, the overall conclusion of this analysis is that efficiency requirement regulations are not having any noticeable impact on consumer choice. The data suggests that market competition is growing and the number of models available is increasing rapidly, even during the introduction of more stringent energy efficiency regulations.

3.6 Efficiency spread on market over time

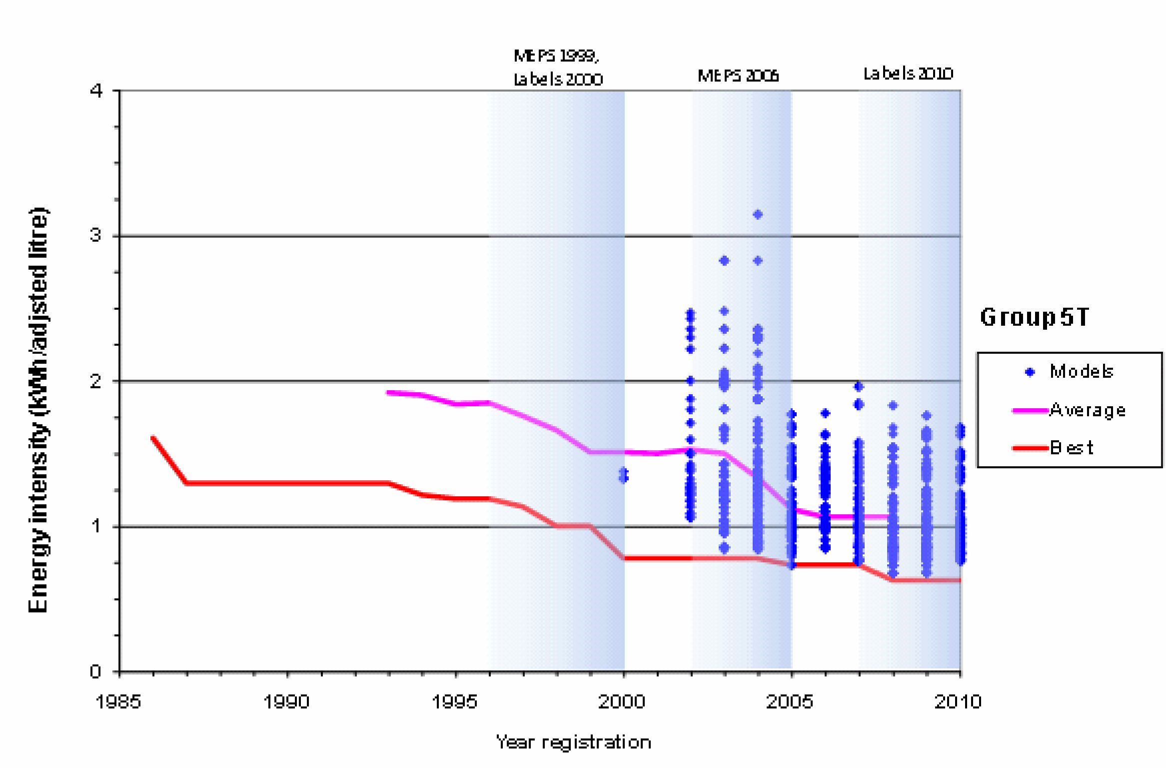
Since energy labelling commenced in 1986, it has been mandatory to register all new models to be sold in the Australian market with a state regulator. This provides a useful database of information that allows the spread of energy efficiency to be tracked over time.

The energy efficiency for each model registered (depicted as energy intensity in terms of kWh per year per adjusted litre of volume) has been analysed and plotted, as illustrated in Figure 19, with figures for all groups included in Appendix 6. Each chart shows, by product group, the range of energy intensity for all registrations made in each calendar year. It also shows the sales-weighted average value (based on GfK sales data, where available) by year as well as the best product available on the market (based on the most efficient model registered in the previous five years). The results for Group 5T, which still make up more than 50% of all sales, is illustrated in Figure 19.

As expected, both the sales-weighted average and the best available trend down over time. The impacts of MEPS 1999 and MEPS 2005 are usually visible in these trends. In general terms, the best available product is usually about half the energy intensity of the sales weighted average for most groups and most years.

Some care is required in the interpretation of data for individual models (individual dots) shown in Figure 19 as the energy intensity can be influenced to some extent by the size (volume) of the model.

Figure 19: Group 5T – model, sales weighted average and best energy intensity by year



3.7 Purchase price analysis

One concern amongst policy makers with increasing the efficiency of appliances sold is that there may be an increase in the purchase price of equipment, even if these costs are ultimately recouped by householders by lower running costs. There are few end-use studies on the link between increased efficiency and purchase price for example Ellis *et al* (2007). This section aims to add to this area by providing some comment on the changes in purchase prices during a period of significant improvements in energy efficiency by refrigeration equipment.

3.7.1 Analysis in previous Regulatory Impact Statements

Previous RISs (EES 2008, GWA 2001) have conducted detailed analyses of the relationships between purchase price and energy efficiency for refrigerators. These analyses are based on actual product specifications (energy consumption and efficiency) and the actual price paid at a model level in a particular year (usually the latest year of available data). The data source for these analyses is GfK sales data. This report does not intend to replicate or verify these analyses as they are based on comprehensive data that are available in particular years.

These types of analyses are undertaken as part of a RIS because it is expected that forcing an increase in energy efficiency through regulations will have some impact on the resulting prices of products paid by consumers. However, these analyses often find that the statistical correlation between price and efficiency is quite weak and in some cases non-existent or even negative (i.e. more expensive products are less efficient). However, it is only possible to undertake such an analysis within the bounds of what is currently available on the market in any one year. In reality, efficiency is continually changing over time as new models enter the market and old ones become obsolete. An analysis in a particular year is necessarily bounded by what is currently on the market in that year. Typically, products on the market lie within ±20% of the average price and ±20% of the average energy consumption (corrected for size). The only thing that can be established from such an analysis is whether there is any price-energy relationship within these bounds. It is impossible to make any estimate of price impacts for efficiency levels that are outside these limits with this type of analysis. Going beyond what is currently on the market requires a more in depth engineering analysis.

If no correlation or relationship is assumed between price and efficiency, the cost benefit analysis will correctly push the optimum efficiency levels beyond what is technically feasible, which will have large market impacts. So some sensible bounds on price impacts need to be estimated.

Both GWA (2001) and EES (2008) undertook detailed price-efficiency analyses at a group level on the most current market data available at the time. The evaluation of price impacts in this report concentrates on GWA (2001) for a range of reasons:

- Market data that completely straddles the regulatory change (MEPS 2005) is now available.
- MEPS 2005 was a substantial step in the regulated efficiency level – when the levels were first developed in 2000, almost no products on the market at the time were able to meet the levels (the levels were adapted from US 2001 MEPS levels) – typically most groups were forced to reduce energy consumption by 30% or more in the period of a few years.
- Labelling 2010 (EES, 2008) was for an energy label star rating regrade in April 2010, which is still being implemented – market data to assess the impact of this change will not be available for at least two more years (from the time of writing). In any case the resulting change (label algorithm regrade) is relatively mild and does not force major changes in efficiency (and therefore price effects are small to very small).

GWA (2001) predicted a range of price increases at a group level that were based on the expected increase in energy efficiency resulting from the regulation and the corresponding price – efficiency analysis of the market at the time (in 2000). These are documented in Table 13 of that report, with the main values reproduced below.

Table 7: Estimate price impacts by Group (GWA 2001)

Group	Price no MEPS	Energy no MEPS	Price with MEPS	Energy with MEPS	Price impact MEPS
Group 1	$866	489	$921	384	$35
Group 2	$299	337	$303	310	$5
Group 3	N/A	N/A	N/A	N/A	N/A
Group 4	$751	593	$794	412	$42
Group 5T	$994	616	$1025	477	$31
Group 5B	See 5T	See 5T	See 5T	See 5T	See 5T
Group 5S	$2140	1033	$2310	693	$171
Group 6U	$469	375	$485	336	$16
Group 6C	$492	408	$512	345	$20
Group 7	$1042	808	$1143	600	$101

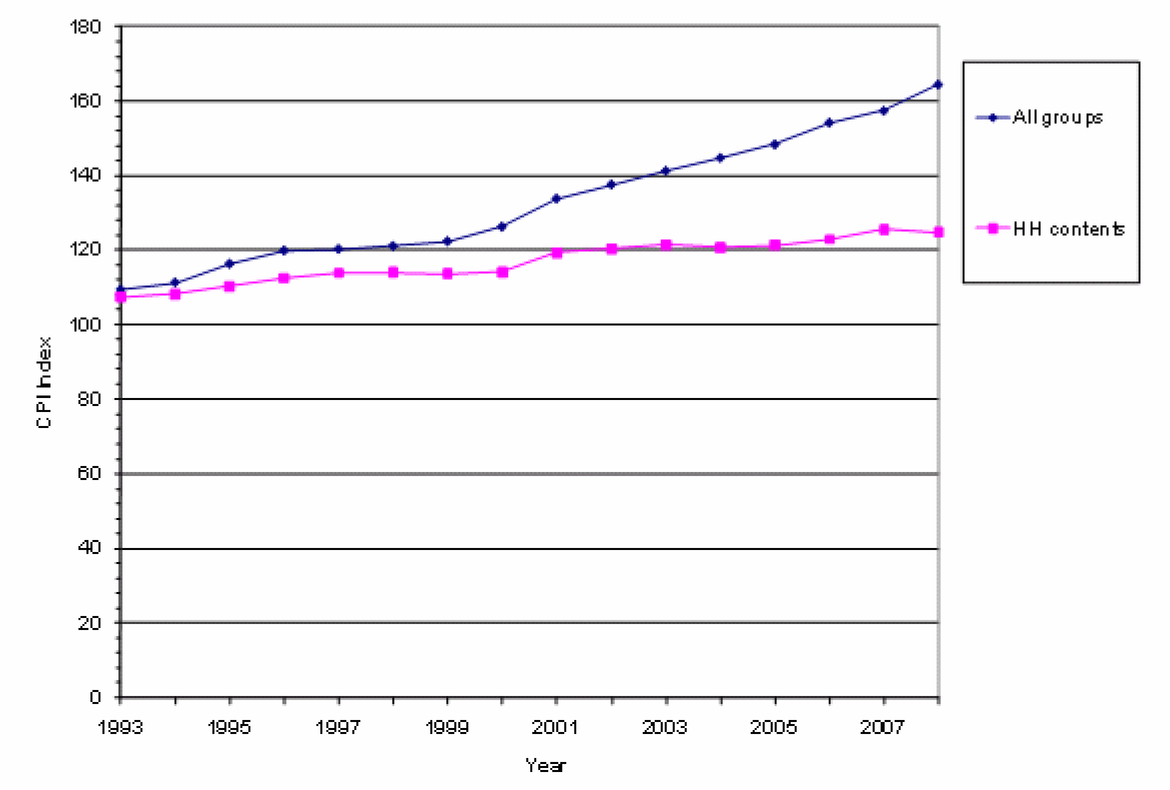
The price impacts for most groups were relatively small, both in absolute and percentage terms. Only prices for Group 5S and Group 7 were significant in relative terms. These two groups deserve close attention to see whether the expected price increases occurred.

3.7.2 Analysis approach

Actual prices paid for every model sold on the Australian market are available from a data subscription service offered by GfK Australia. The federal government purchases these data and detailed analysis on the data is conducted for E3 by EES (see Greening Whitegoods – EES, 2010). This provides a highly accurate basis for tracking trends in actual appliances prices paid by consumers over time. GfK report actual price paid at a model level, together with sales by model, so sales-weighted trends in price can be examined.

Note that the prices recorded by GfK are in nominal dollars at the time (year) of sale. It is important to correct prices over a long period of time using the ABS consumer price index (CPI), which is a widely accepted measure for correcting costs for inflation. ABS publishes its CPI as ABS6401. ABS publishes consumer price indexes for a range of parameters, including one called “household contents and services”. The most common index used is ‘all groups’ as this is a weighted average of all goods and services and is a reasonable representation of the relative purchasing power of money available to households over time. The indexes for ‘all groups’ and ‘household contents and services’ are illustrated from 1993 to 2008 in Figure 20, the period for which accurate appliance price data are available from GfK.

Figure 20: Consumer Price Index from 1993 to 2008 (ABS6401)



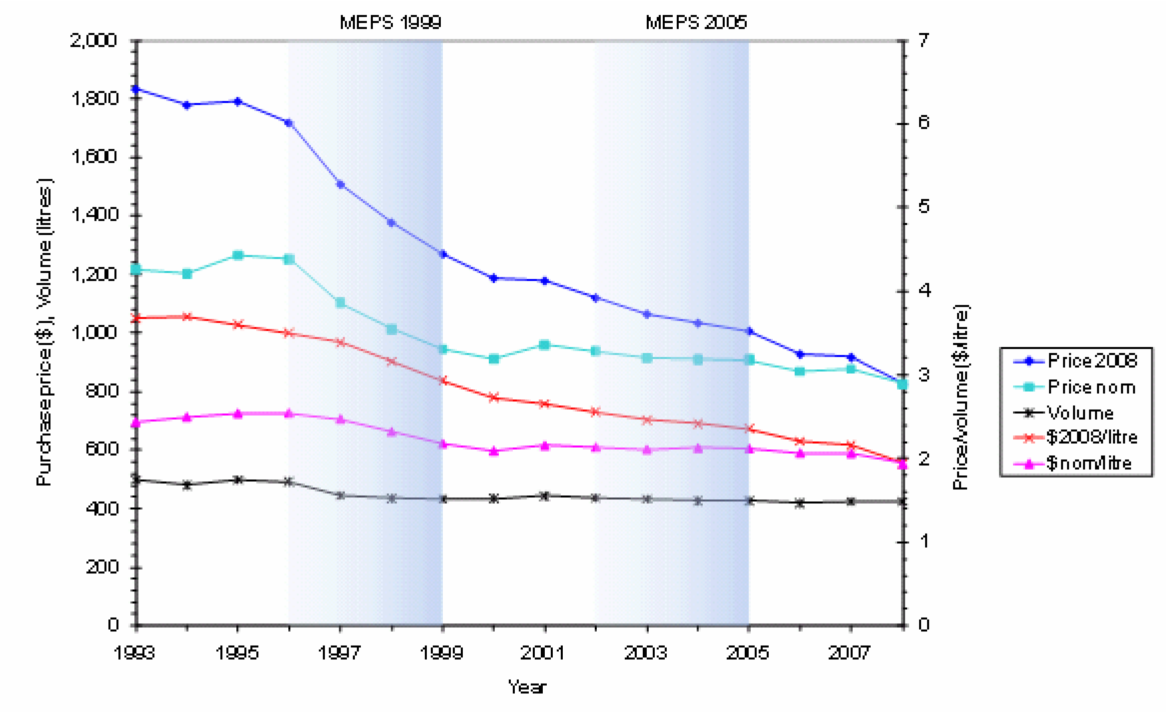
The pink line ('household contents and services', labelled HH contents) has climbed at a much slow rate than 'all groups', which tends to suggest that "household contents and services" are becoming relatively cheaper over time.

In order to assess whether MEPS had any significant price impact over time, the following parameters have been calculated for each group for each year from 1993 to 2008 (latest year of available data which is fully analysed):

- Average price in nominal dollars by year
- Average price in 2008 dollars (corrected using CPI 'all groups') by year
- Total volume in adjusted litres
- Average price per adjusted litre in nominal dollars by year
- Average price in 2008 dollars per adjusted litre (corrected using CPI all groups) by year

It is necessary to track volume (size) over time as changes towards smaller or larger sizes can impact on prices. Where cabinet sizes are changing quickly, price per adjusted litre of volume gives a better indication of price trends over time. The analysis for Group 5T, which currently constitutes more than 50% of all sales, is illustrated in Figure 21. From this chart no deviations are apparent around the introduction of MEPS in either 1999 or 2005, nor the years leading up to these MEPS.

Figure 21: Group 5T – purchase price analysis



Figures for all the groups are provided in Appendix 7, along with a commentary on likely explanations on price changes.

It should be noted that this analysis is a different approach to earlier price energy analyses as it examines longitudinal prices at a group level over time with a view to assessing whether any price related impacts are visible in the trends at the time regulatory changes were made.

3.7.3 Overall results of price analysis

The above data for each of the groups was examined for years 1993 to 2008. These changes per annum are summarised in Table 8.

Table 8: Changes in prices from 1993 to 2008 by group

Group	Actual price change per year (nom $)	Real price change per year (2008 $)	Volume change per year	Actual $/litre change per year (nom $)	Real $/litre change per year (2008 $)
Group 1	1.83%	-0.89%	-0.37%	2.19%	-0.52%
Group 2	-1.71%	-4.53%	-1.32%	-0.38%	-3.16%
Group 3 *	0.23%	-2.53%	-2.98%	3.12%	0.44%
Group 4 *	8.35%	5.81%	-1.39%	9.61%	7.11%
Group 5T	-2.61%	-5.45%	-1.07%	-1.52%	-4.32%
Group 5B	1.66%	-1.06%	0.55%	1.11%	-1.63%
Group 5S **	-8.04%	-11.28%	-1.33%	-6.62%	-9.82%
Group 6U	-2.00%	-4.82%	-2.72%	0.71%	-2.04%
Group 6C	0.17%	-2.60%	0.17%	0.00%	-2.77%
Group 7	1.25%	-1.49%	-0.51%	1.75%	-0.97%

Notes: * Group 3 and 4 almost disappeared by 2008 and prices were volatile as few models remained. ** Data for Group 5S are from 2001 to 2008 only.

Price trends can be broadly grouped as follows:

- Moderate price decreases: Group 1, Group 5B and Group 7 (around 1% per annum decrease in real terms);
- Fast price decreases: Group 2, Group 5T, Group 5S, Group 6U and Group 6C (2.5% to 11% per annum decrease in real terms);
- Volatile and unstable: Group 3 and Group 4 (mainly because these Groups have almost disappeared from the market and only a few models remain).

Each of the groups is discussed in more detail in Appendix 8.

3.7.4 Conclusions on price impacts

Analysis at a group level for each year from 1993 to 2008 using actual prices (corrected for CPI) show that real prices for most groups have declined rapidly in real terms over the past 15 years. Many of the larger groups have experienced real declines in prices of 2.5% to 5% per annum or more over the entire period, which equates to real price falls in the range of 20% to 50% or more. Overall, this is an extraordinary trend as the energy consumption of all groups has also declined at about 3% per annum over the whole period (energy efficiency has improved at approximately this rate), which is a 40% energy reduction in conjunction with a 20% to 50% price reduction. This demonstrates that technology improvements are delivering lower energy at reduced prices, with both parameters falling rapidly over time.

Previous RISs have undertaken an analysis of the current market relationships between energy and price in a single year in order to estimate price impacts resulting from more stringent energy regulations. These prior RIS price impact estimates can only be verified for MEPS 2005 for Group 7, as the expected price impact for this group was large and the overall trend in prices over time for this Group were slow. For Group 7 the price impact estimated by the RIS appears to be reasonable. For all other groups, the expected price impacts appeared to be well within the predicted range (less than expected), but generally these could not be accurately estimated and quantified due to the large and rapid falls in underlying prices over time. There are certainly no significant increases in prices that can be attributed to regulatory actions over this period. The existing process appears to deliver reasonable estimates of price increases arising from changes in proposed efficiency requirements and should be continued in future RISs.

4. REFERENCES

ABS3222 - *Population Projections*, Australia

ABS3236 - *Household and Family Projections, Australia: Projected Households*, Australian Bureau of Statistics.

ABS4602 - *Environmental Issues: Energy Use and Conservation*, Australian Bureau of Statistics.

ABS6401.0 - *Consumer Price Index*, Australia, Australian Bureau of Statistics.

ABS8218 – *Household energy surveys*, Australian Bureau of Statistics (1980, 1983 and 1986).

AGO (2004) *AGO Factors and Methods Workbook for use in Australian Greenhouse Office Programs including the Greenhouse Challenge Program*, 2004 edition.

AS1430 (1986) *Household Refrigerators and Freezers*. Published by Standards Australia. Superceded.

AS2575 (1989) *Energy labelling of appliances - Refrigerators, refrigerator/freezers and freezers - Specification for appliance energy rating label*. Published by Standards Australia. Superceded.

AS/NZS 4474.1 (2007) *Performance of household electrical appliances - Refrigerating appliances - Energy consumption and performance*. Published by SAI Global. Available for purchase from http://infostore.saiglobal.com

AS/NZS 4474.2 (2009) *Performance of household electrical appliances - Refrigerating appliances - Energy labelling and minimum energy performance standard requirements*. Published by SAI Global. Available for purchase from http://infostore.saiglobal.com

COAG (2007) *Best Practice Regulation: A Guide For Ministerial Councils And National Standard Setting Bodies,* Council of Australian Governments (endorsed April 1995, amended November 1997 and June 2004, revised October 2007). See http://www.coag.gov.au/ministerial_councils/docs/COAG_best_practice_guide_2007.pdf

DEWHA (2008), *Energy Use in the Australian Residential Sector 1986 – 2020*, prepared by Energy Efficient Strategies for the Department of the Environment, Water, Heritage and the Arts, June 2008. Available from www.energyrating.gov.au in the electronic library.

E3 (2009), Ex post Evaluation of Energy Efficiency Programs, E3 workshop, Sydney, 4 February 2009. Meeting papers are available from http://www.energyrating.gov.au/meeting-2009-ex post-eval.html

EES (2006) *Greening whitegoods*: *a report into the efficiency trends of major household appliances in Australia from 1993 to 2005*. A report for the Equipment Energy Efficiency Committee (E3), report number 2006/06. July 2006.

EES (2008) *Consultation Regulatory Impact Statement of proposed revisions to the method of test and energy labelling algorithms for household refrigerators and freezers*. E3 Report no. 2008/04. June 2008. Available from www.energyrating.gov.au in the electronic library.

EES (2010) *Greening whitegoods*: *a report into the efficiency trends of major household appliances in Australia from 1993 to 2009*. A report for the Equipment Energy Efficiency Committee (E3), report number 2010/08. October 2010. Available from www.energyrating.gov.au in the electronic library.

Ellis, M; Jollands, N; Harrington, L and Meier, A (2007) Do energy efficient appliances cost more? *Proceedings of the European Council for an energy efficient economy summer study*, June 2007.

EnergyConsult (2006) *Retrospective Analysis of the Impacts of Energy Labelling and MEPS: Refrigerators and Freezers*. Report for the Department of the Environment, Water, Heritage and the Arts, Oct 2006. Available from www.energyrating.gov.au in the electronic library.

GWA (1991) *Review of Residential Appliance Energy Labelling*, George Wilkenfeld & Associates with Test Research and Artcraft Research, for State Electricity Commission of Victoria, September 1991.

GWA (1992) *Household Refrigeration Energy-Efficiency in Victoria (Australia) - Technology Costs and Prospects*, George Wilkenfeld & Associates, for the State Electricity Commission of Victoria, August 1992.

GWA (1993) *Benefits and Costs of Implementing Minimum Energy Performance Standards for Household Electrical Appliances in Australia*, by George Wilkenfeld & Associates (with Lawrence Berkeley Laboratory), for State Electricity Commission of Victoria, July 1993. Chapter 7 – electric water heaters. See http://www.energyrating.gov.au/library/detailsgwa-meps1993.html

GWA (1999) *Regulatory Impact Statement: Energy Labelling and Minimum Energy Performance Standards for Household Electrical Appliances in Australia*. George Wilkenfeld and Associates with assistance from Energy Efficient Strategies, for Australian Greenhouse Office, February 1999.

GWA (1999a) *Regulatory Impact Statement: Energy Labelling and Minimum Energy Performance Standards for Household Electrical Appliances in Australia*. Supplementary cost-benefit analysis on transition to a revised energy label. George Wilkenfeld and Associates, for Australian Greenhouse Office, November 1999.

GWA (2001) *Draft for Public Comment: Regulatory Impact Statement: Revised minimum energy performance standards for household refrigerators and freezers*, George Wilkenfeld and Associates with Energy Efficient Strategies, for Australian Greenhouse Office, October 2001 http://www.energyrating.gov.au/library/pubs/ris-rf2004.pdf

GWA (2005) *National Appliance and Equipment Energy Efficiency Program: Projected Impacts, 2005 – 2020*, George Wilkenfeld and Associates, for the Australian Greenhouse Office, January 2005.

Harrington (2009) Energy consumption of whitegoods - what is improving and what is not: analysis of 15 years of data in Australia, *EEDAL*, Berlin, Germany

IEA (2009) *Energy Use in the New Millennium: Trends in IEA Countries (Energy Indicators)*. OECD/IEA

Lane, K, Harrington, L and Ryan, P (2007) Evaluating the impact of energy labelling and MEPS – a retrospective look at the case of refrigerators in the UK and Australia. *Proceedings of the European Council for an energy efficient economy summer study*, June 2007.

Lane, K and Harrington, L (2010) *An assessment of compliance of refrigerators with energy labelling and MEPS requirements in the Australian market*, in preparation for E3 by Dr Kevin Lane and Lloyd Harrington (EES).

McMahon (2004) *Comparison of Australian and US Cost-Benefit Approaches to MEPS*, James E. McMahon, PhD, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, April, 2004.

NAEEEC (2005) *Administrative Guidelines for the Appliance and Equipment Energy Efficiency Program of Mandatory Labelling and Minimum Energy Performance Standards for Appliances*. Version 5, June 2005. Available from www.energyrating.gov.au

OBPR 2010, *Best Practice Regulation Handbook*, available from http://www.finance.gov.au/obpr/proposal/ria-guidance.html, Office of Best Practice Regulation, Department of Finance and Deregulation.

PC (2005) *The private cost effectiveness of improving energy efficiency*. Productivity Commission Inquiry report No. 36, 31 August 2005.

Appendix 1: TASK SPECIFICATION

Based on meeting in Sydney 2009:

http://www.energyrating.gov.au/pubs/2009-ex post-eval-summary.pdf

Lead consultant**:**

Energy Efficient Strategies with Kevin Lane (Oxford) Ltd

Overview:
Conduct an evaluation of household refrigerators and freezers in Australia in line with the new guidelines developed.

Tasks:

1) Review new guidelines and tailor to be specific to cold
2) List cold product policies, including historic RIS information for each cold policy
3) Summarise previous evaluations on cold
4) Collate relevant data (GfK, ABS, etc)
5) Setup energy model for energy impact analysis
6) Run model with latest data (counterfactuals, etc) and historic data, scenarios, attribution
7) Write up results in report on energy impact
8) Critique of evaluation approach (comparison of approach from UK/other, where differences)
9) Comparison of impact previously done (explanation of why)

Note: Energy impact only (not covering process evaluation).

Draft report structure:

Exec summary (impact of program)

1. Introduction and aim
2. Methodology
3. Review policies for cold products (include RIS, existing analysis)
4. Analysis - Impact of cold product policy on energy consumption (findings, issues)
5. Conclusions and recommendations
6. References

Appendix A: Glossary
Appendix B: Energy modelling approach

Reviewers meeting and workshop, Melbourne, 3 June 2010:

Attendees: Ian McNicol, Robert Tromop, Mark Ellis, George Wilkenfeld, Tim Farrell, Melanie Slade, Murray Pavia, Shahab Qureshi, Hilton Taylor, Paul Ryan, Lloyd Harrington, Kevin Lane.

Suggested changes to report:

- Revised terminology and approach to efficiency scenarios
- Additional price analysis, efficiency spread, model availability
- Revised report structure

Revised report structure (3 June 2010):

Exec summary (impact of program)

1. Introduction, aim
2. Methodology
3. Key findings
4. References

Detailed appendices

Appendix 2: OBPR REQUIREMENTS FOR RIS

The Office of Best Practice regulation (OBPR) website sets out the broad requirements and processes associated with regulatory proposals, which include:

- Application
- Preliminary Assessment:
  - Business Cost Calculator (BCC)
  - Regulation Impact Statements (RISs)
  - Regulatory impact analysis guidance material
  - Summary of regulatory impact analysis process
- Consultation requirements:
  - Consultation policy and principles
  - Annual Regulatory Plans
- Reviews of regulation
- Compliance reporting

A Regulatory Impact Statement has seven key elements:

- the problem or issues which give rise to the need for action
- the desired objective(s)
- the options (regulatory and/or non-regulatory) that may constitute viable means for achieving the desired objective(s)
- an assessment of the impact (costs, benefits and, where relevant, levels of risk) on consumers, business, government and the community of each option
- a consultation statement
- a recommended option
- a strategy to implement and review the preferred option

All seven elements of a RIS should contain a degree of detail and depth of analysis that is commensurate with the magnitude of the problem and the size of the potential impacts of the proposal. The emphasis of the RIS should be on analysis. It is not intended to be an advocacy document. Hence, supporting evidence (preferably quantified) should be used in the RIS wherever possible. More details are set out in the Best Practice Regulation Handbook (OBPR 2010).

Appendix 3: ENERGY MODELLING APPROACH

To estimate the energy consumption, appraise and evaluate energy-saving policy measures for refrigeration equipment, an end-use stock model is required (sometimes called a bottom-up modelling approach).

An appliance stock model is a mathematical construct that draws new products into the existing stock (pool) of products each year. The characteristics (attributes) of these new products and the number entering the pool are weighted and added to the pool of existing products. Each year, products are also retired from the pool of products according to the selected retirement function (age and distribution) for that product. The retirement function is based on a normal distribution curve which is used to define the average age and the standard deviation of the age for each product.

For refrigeration stock model the following input data at a state level are required:

- Stock or number of products (state household ownership × number of households)
- Relevant appliance attributes (assumed to be uniform nationally) (confirmed by GfK state analysis)
- Usage parameters – uniform except for climate adjustment factor by state for refrigerators
- Assumed average appliance life and standard deviation of the normal distribution for the retirement function. (the latest RIS assumed 17 years and 21 years as averages for refrigerators and freezers respectively)
- The attributes of the ‘pool’ of products in any year is determined by the pool’s previous year plus new products less retired products.

Since ownership data are only available at the refrigerator and freezer level (i.e. no ownership data is available at the Group level), the energy model itself is constructed at that level of detail, and these are shown schematically in Figure 22 and Figure 23. The weighting of attributes for refrigerators is done by using sales-weighting of the seven refrigerator Groups for each year (Figure 22). For freezers, the three defined freezer Groups are included for the attributes of the freezer model, and the schematic structure of the model is shown in Figure 23.

Figure 22: Refrigerator energy consumption model schematic

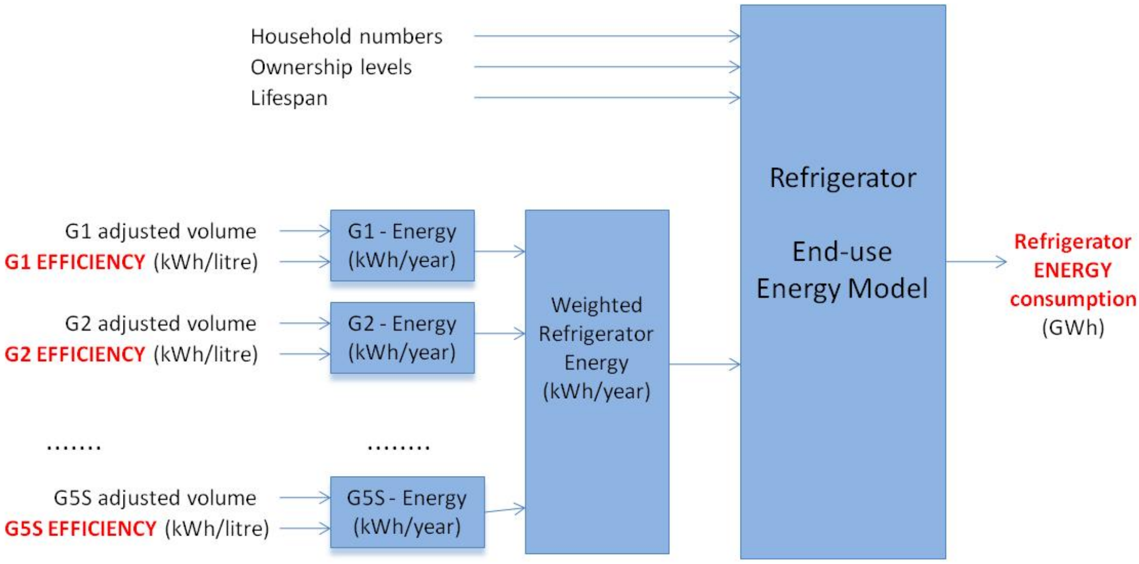
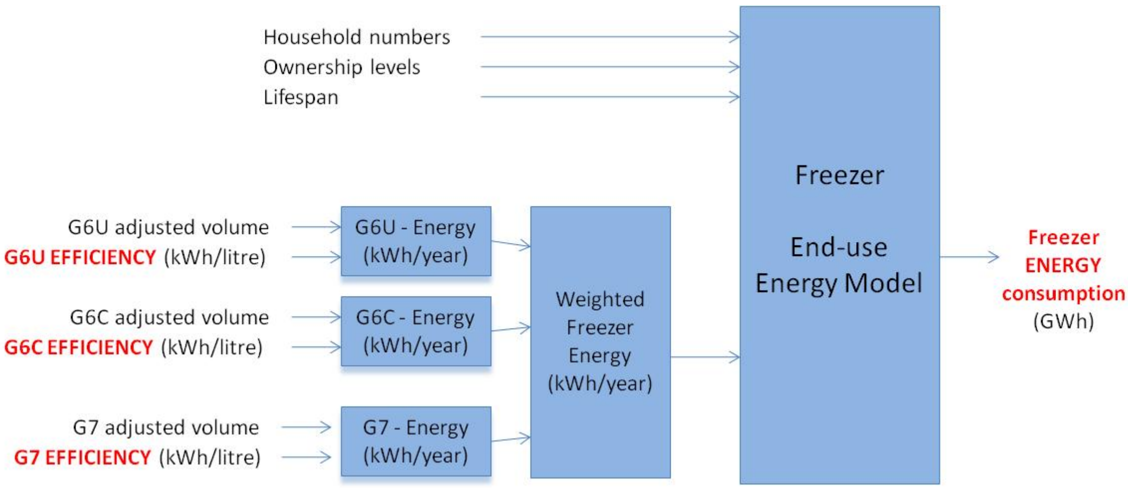


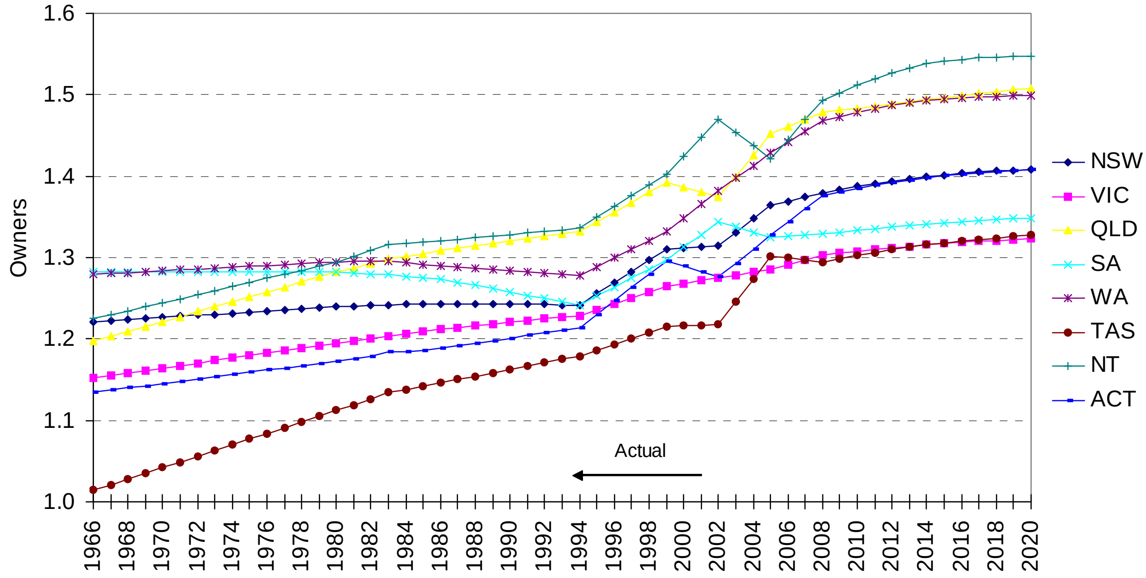
Figure 23: Freezer energy consumption model schematic



The main data sources are used to populate these two end-use models, both to construct historic trends for each variable, and then to project energy trends to 2020. The data for these are shown below.

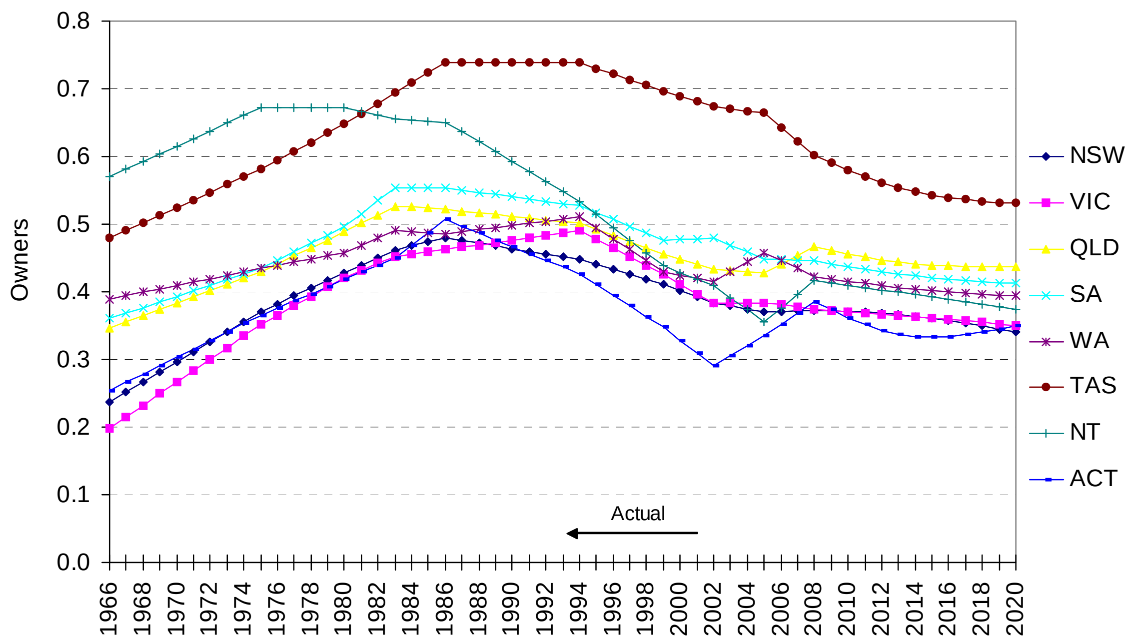
In terms of the scale of energy consumption, it is the stock of appliances that drives consumption. Household ownership of refrigerators by each state is shown in Figure 24.

Figure 24: Refrigerator ownership (Stock/household)



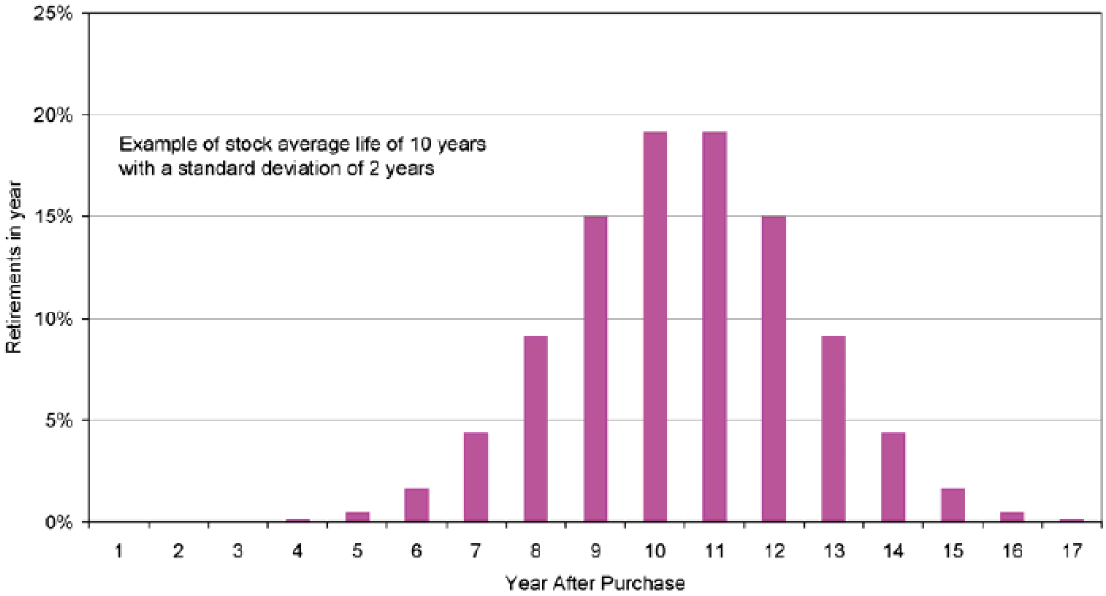
Household ownership for freezers is shown in Figure 25. The decline in ownership is expected to continue, with household frozen space being increasingly provided by combined fridge-freezers, which are included in the refrigerator ownership figures.

Figure 25: Separate freezer ownership (Stock/household)



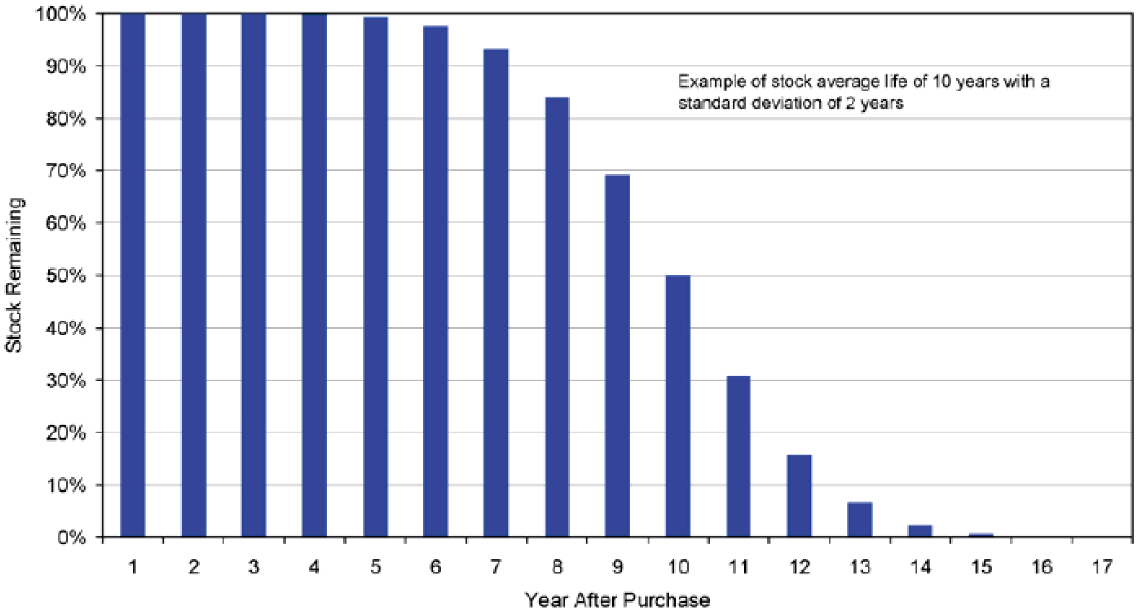
By multiplying the household ownership by the number of households it is possible to get an estimate of national stock of equipment. A decay function is used, which will enable an estimate of sales over time and into the future to be made. This function takes the form of a normal distribution, and an example is given in Figure 26. This shows that on average a product will remain used in the stock (in people's homes) for an average of 10 years, though some will expire earlier and some later.

Figure 26: Normal distribution retirement function – stock model (example 10 year life)



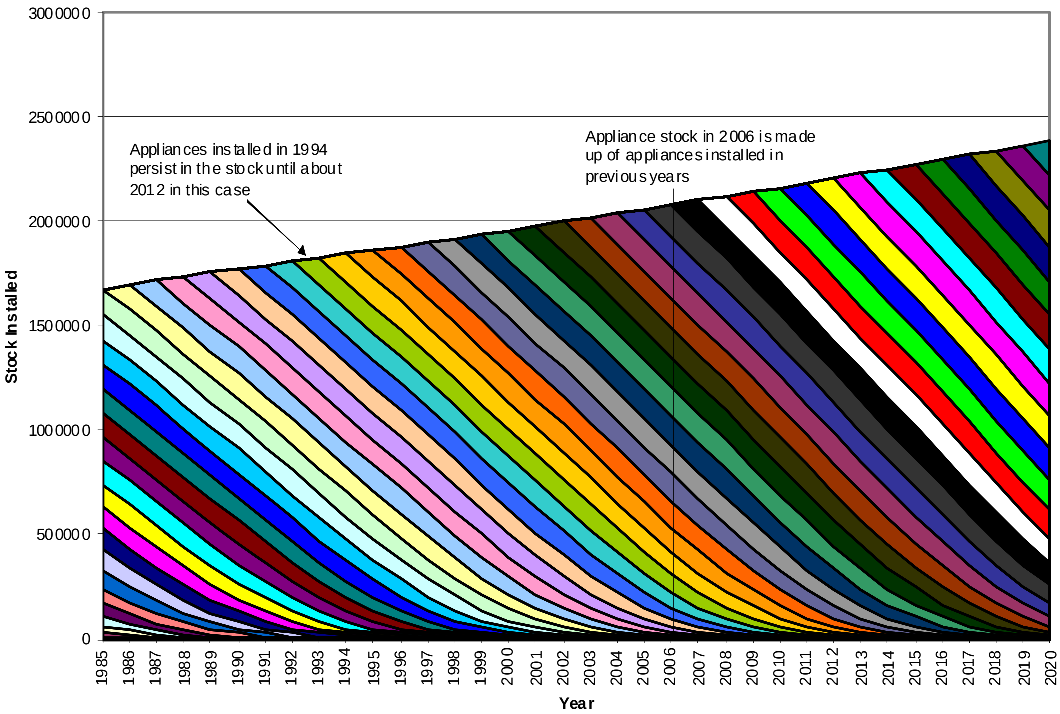
This function can also be considered in terms of the number of products remaining in stock from the number sold in a particular year (Figure 27). In this example, after 10 years 50% of the original number installed in any year will remain. The assumption is that the decay function is consistent for sales in any year.

Figure 27: Normal distribution stock remaining – stock model (example 10 year life)



Using the above function to estimate sales, these can be compared against actual sales values over time. Using an optimisation routine it is possible to change the lifespan figures such that the estimated sales and actual sales match as close as possible (usually using a least squares fit). It is then possible to aggregate the estimated sales along with the number remaining in the stock to get an age distribution curve (Figure 28). Thus for any one year it is possible to assign a percentage of stock to each year of purchase. Using data from the year of purchase it is then possible to weight attributes (size, efficiency, consumption) to give a stock average values. These stock average values can be multiplied by stock levels to provide national estimates.

Figure 28: Installed stock by estimated age



The attributes in the model have been measured at the Group level, thus the model input requires the proportion of sales by refrigerator and freezer Group. This is then used to estimate the sales-weighting of each of the attributes in the two energy models (refrigerator and freezer). The proportions of sales by each Group for refrigerators and freezers are given in Figure 29 and Figure 30.

Figure 29: Proportion of sales of refrigerator by group (%)

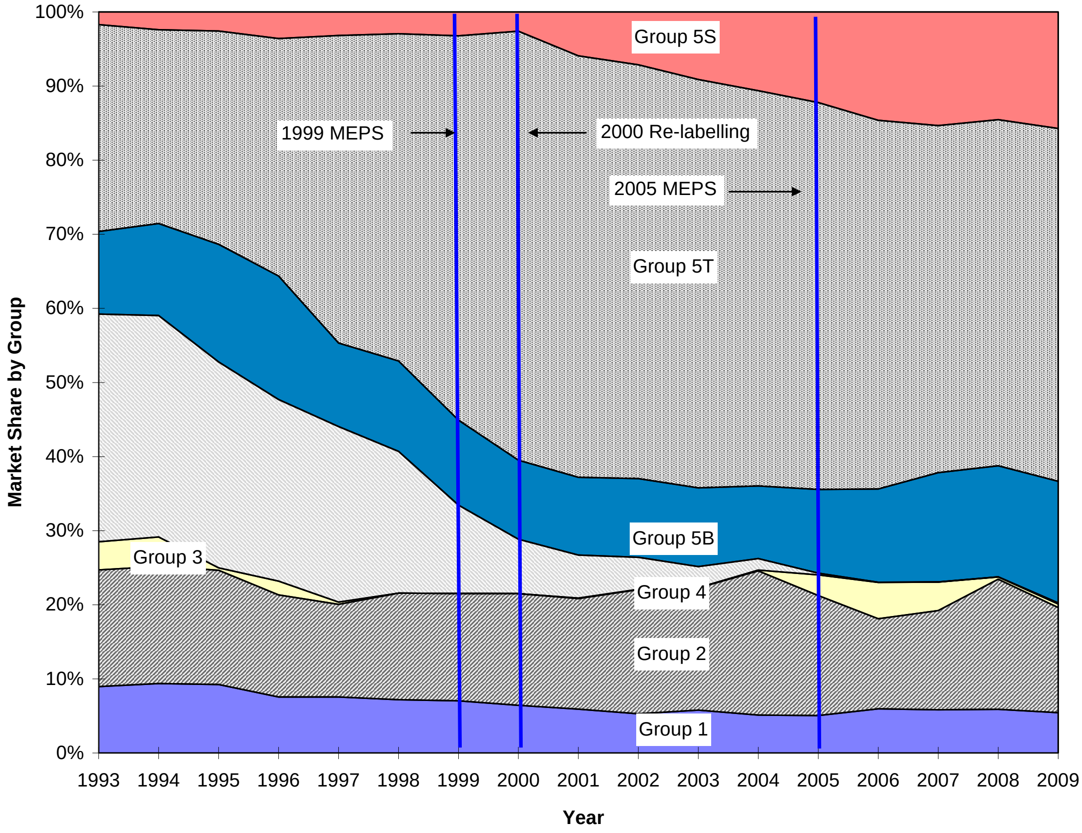
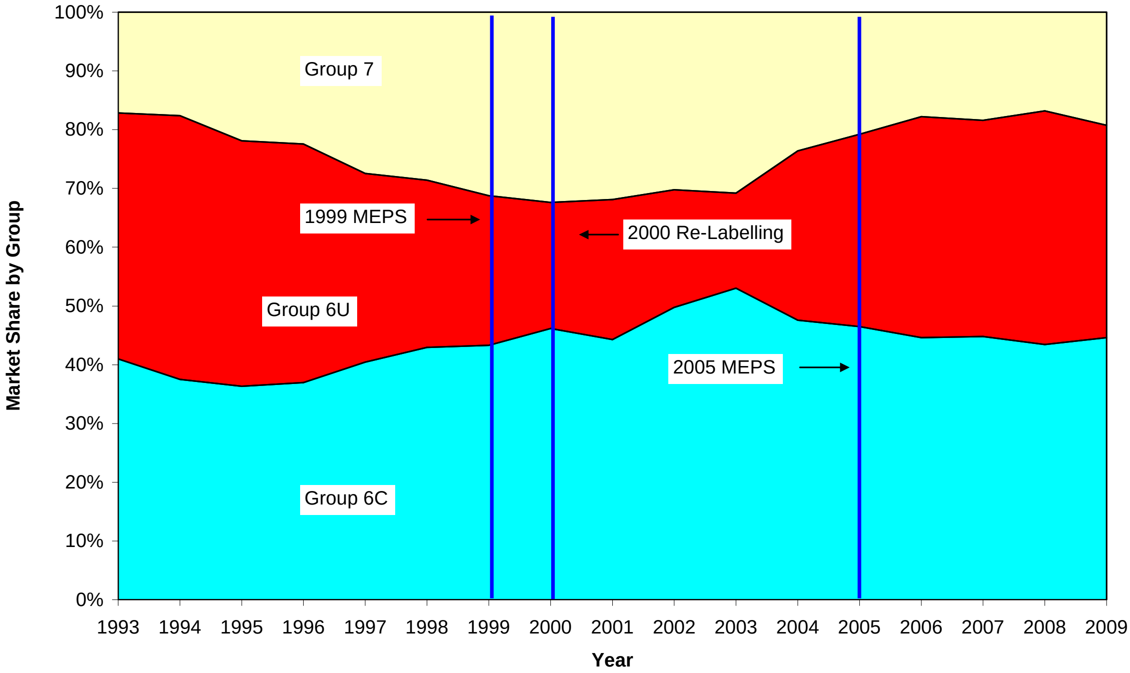


Figure 30: Proportion of sales of freezer by group (%)



The main attribute of interest in refrigerator energy modelling is the energy consumption (kWh/year) which has been measured under standard test conditions. Since these do not exactly reflect actual annual consumption when installed in people's homes, adjustment (or scaling) factors are used. These are best estimates and are assumed to remain fixed over time. Furthermore, they vary by state – the warmer the state the more energy they are likely to consume. The adjustment factors used for each state are presented in Table 9.

Table 9: Climatic adjustment factors by state for refrigerators and freezers (all years) (%)

Product	NSW	VIC	QLD	SA	WA	TAS	NT	ACT
Refrigerator	90	85	95	90	90	80	100	90
Freezer	85	80	90	85	85	75	95	85

Data for the average new size (volume in litres), efficiency (kWh/litre) and energy consumption (kWh/year) are given in other appendices in this report. Using these and the data described in this annex it is possible to estimate energy consumption for each of the scenarios.

Appendix 4: REVIEW REFRIGERATION DATA MODELLING

Processing and analysis of model input data

All of the data listed in the introduction section have been processed to present an integrated end-use energy model. These are already included in the current model used for the DEWHA (2008) residential report, prepared by EES with actual historical data available to 2009.

Historical data improved to include data from early GWA/ACA data enables an estimate of the early labelling programs to be undertaken.

Furthermore, the EES 2008 model has been updated to include new data not available at the time of the DEWHA (2008) report, specifically this includes:

- Ownership data from ABS (2008 survey, the previous survey was 2005)
- Sales data from GfK (2008 and 2009 sales data, the previous cut-off date was 2007)
- Changes in the sales of group types up to 2009
- Size (volume) of each refrigeration group up to 2009

The changes in the latest reference scenario are essentially similar to the data in the greening the Whitegoods report, but with projections to 2020 based on trends at a group level.

The following sub-section describes the development of the counterfactual efficiency (of new products sold) scenarios. These are the scenarios of what is likely to have happened to the efficiency of new refrigerators and freezers sold if the policy measures had <u>not</u> been introduced at various time in the past. The PolicyL2010 scenario includes the actual historical data to 2009 and then projections to 2020 and includes the likely impact of all energy policies measures to date.

Initial examination of energy and efficiency data

Efficiency scenarios have been generated for each of the ten classifications (Groups) of refrigeration appliances. As an example of the process followed for Group 4 will be examined, though all the analysis data for all ten groups is contained in Appendix 4.

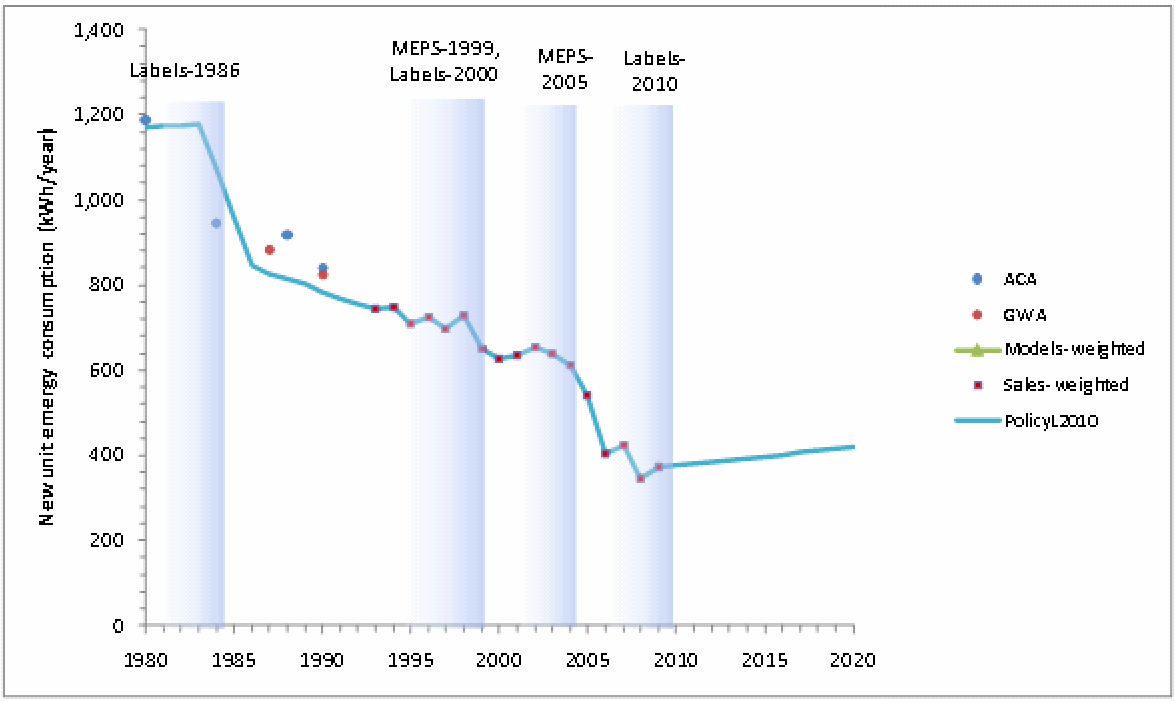
As mentioned earlier, there are various sources of energy/efficiency data on products sold in Australia:

- Registrations from 1986 onwards have data on the energy label energy consumption (and the related test procedure) as well as other product attributes of products on the market.
- 1993 to 2009, GfK sales data, which has been cross matched to the registration database, gives good data on sales share by model and Group.

- Various pre-1986 data prior to the introduction of energy labelling, reported in GWA (1992), including ACA data (some of these test data were conducted under different test procedures so adjustments to energy and energy efficiency were necessary) as published in Choice magazine. These sources are limited in number and potentially employ different metrics, so they have been used as an indication only.

Initially, the average new kWh/year data (as reported on the energy label) are examined as these ultimately drive the end-use model. The sales-weighted data are used where known (from 1993). Usually, a general decline in average annual consumption of new products sold is observed. The smoothed line (PolicyL2010) is the best estimate made in 2010.

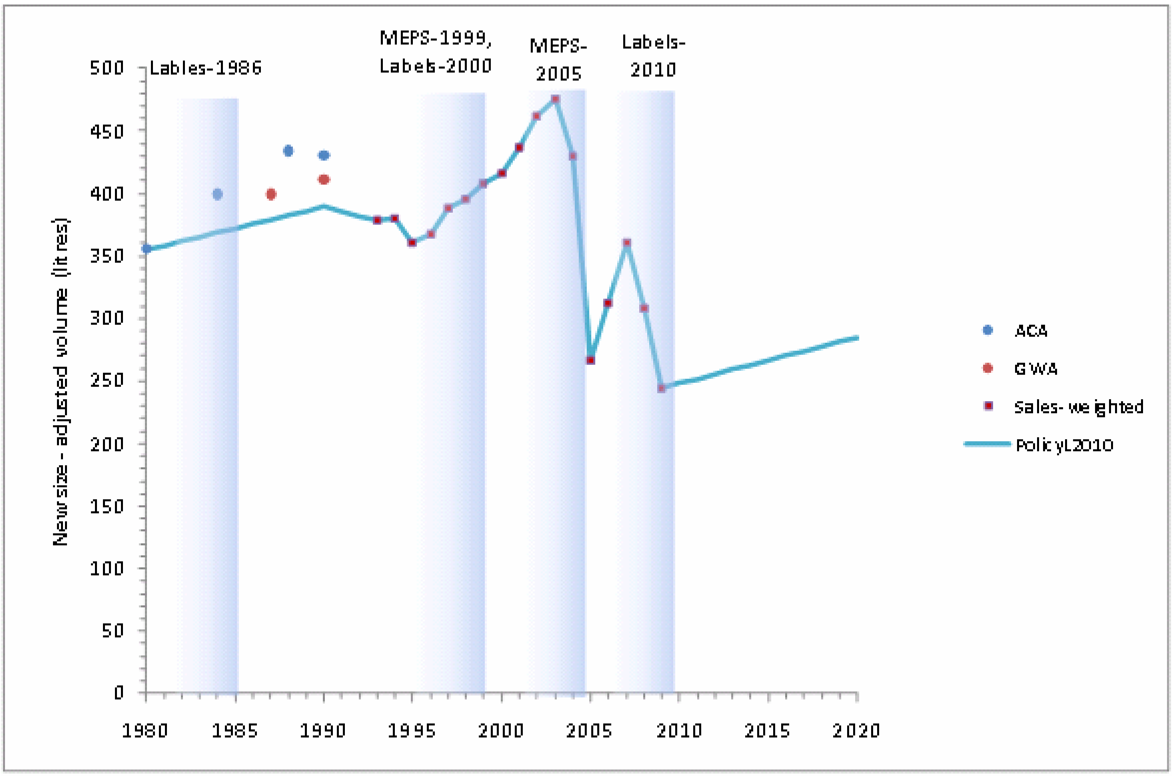
Figure 31: Average new kWh/year (Group 4)



The PolicyL2010 reference scenario has been updated with additional sales data from 2007, 2008 and 2009.

Since the policy measures focus on energy efficiency (i.e. energy per unit of volume) the analyst needs to be aware of size (adjusted volume) of the equipment being sold. This is shown below. In this group (4), a general rise has been stopped by a sudden drop in 2005 and again by 2009.

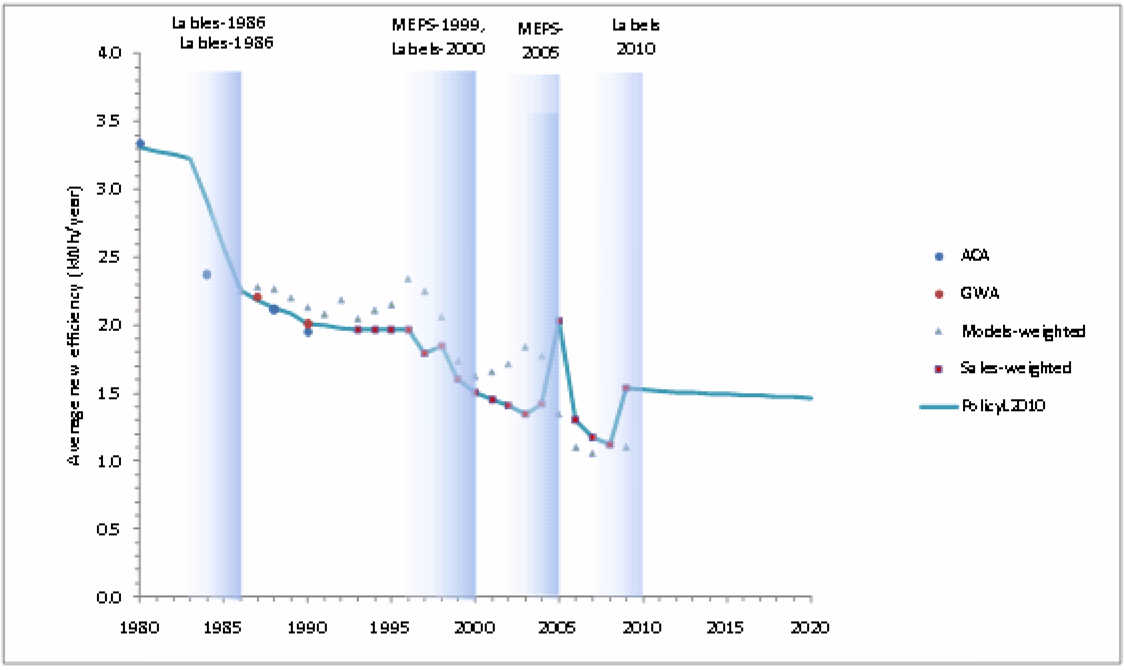
Figure 32: Average new adjusted volume (Group 4)



These two sharp drops in size are also responsible for an increase in the 'efficiency' indicator (which is fact is an energy intensity indicator in kWh/litre adjusted volume) in 2005 and 2009. The main reason for this noticeable change is that the sales of Group 4 have reduced considerably, such that the statistical variance of the data is much higher in later years as only a handful of models with few sales are present in the market. It may also be an anticipated response to the MEPS 2005, although this response was not present in any other group.

Using the average consumption and average size of equipment sold in each year it is possible to derive the average (inverse) 'efficiency', in terms of average kWh per litre of adjusted volume, as per Figure 33.

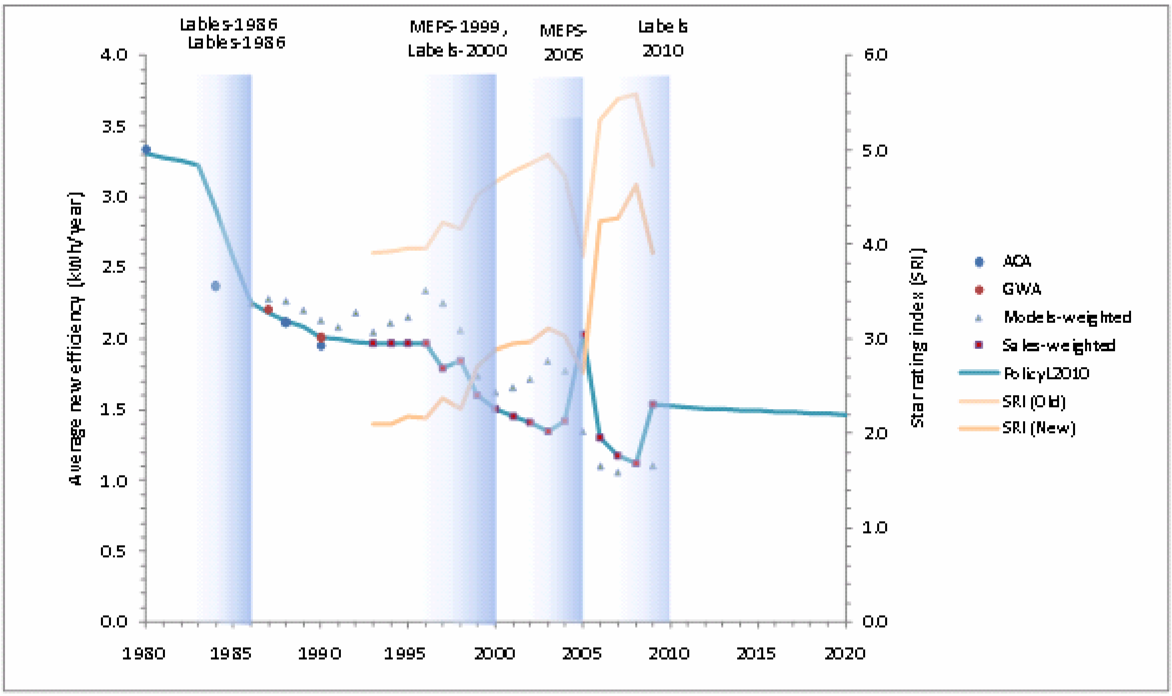
Figure 33: Average new efficiency (kWh/year per adjusted volume) (Group 4)



As a check, the efficiency (kWh/adjusted volume) metric has been checked against energy label Star rating index (SRI) figure which is a more sophisticated measure of efficiency, and the metric quoted in the labelling regulations (Figure 8). The 2005 (and 2009) dip is also evident in the average SRI metric, so this suggests that it is a real effect. This significant decrease in size in 2005 (and 2009) results in an apparent 'decrease' in efficiency for this product, which is counter-intuitive in a policy environment that is promoting increased efficiency[4]. This is however, an artefact of such a large change (decrease) in size. For the creation of the historic baselines this was considered and 'corrected', as explained later.

[4] The use of kWh/adjusted litre as a measure of the inverse of energy efficiency is useful where the average size within a group is fairly stable or changing slowly. However, as an absolute measure of efficiency it is less useful as smaller products will always look less efficient on a volumetric basis as energy is driven more by surface area than volume. So this measure is of reduced value in tracking efficiency where there are large size changes or for comparing different groups.

Figure 34: Average new 'efficiency' (kWh/year per adjusted volume) versus label star rating index (SRI) (Group 4)



Generation of the efficiency scenarios

This section describes the process used to generate the historic counterfactual scenarios. Group 4 will be used as the continued example, though the data developed for the nine other refrigerator groups are placed in Appendix 5.

The following historic efficiency scenarios have been developed (for each group):

- Baseline (Low) – small increase in efficiency after 1983, following the earlier rate of efficiency improvement, then levelling off.
- Baseline (High) – Similar to Baseline (Low) but a higher rate of efficiency improvement after 1983.
- PolicyL1986– to reflect the consumption due to 1986 labels, but no subsequent policy. The level of savings for this policy is the difference between this scenario and the Baseline (High) or Baseline (Low) scenario. This scenario also acts as the baseline for the following policy scenario.
- PolicyLM1999 – reflects the introduction of labels in 1999 and MEPS in 2000, which were developed and announced in parallel.
- PolicyM2005 – reflects the inclusion of all policy up to the inclusion of MEPS in 2005, with no further policy measures. It also acts as the baseline for additional labelling introduced in 2010.

- PolicyL2010 – includes all policy introduced to date, and expected impacts into the future from these, but assumes no further policy measures.

The final scenario is the PolicyL2010 scenario which is based on actual measured sales data, along with projections of what we expect to happen without any further policy measures. All the other scenarios are historic 'counterfactual' efficiency scenarios. For the first baseline, prior to any policy measures, it is likely that some efficiency improvement would have occurred. This 'autonomous' rate of improvement is unknown and can be included in several ways:

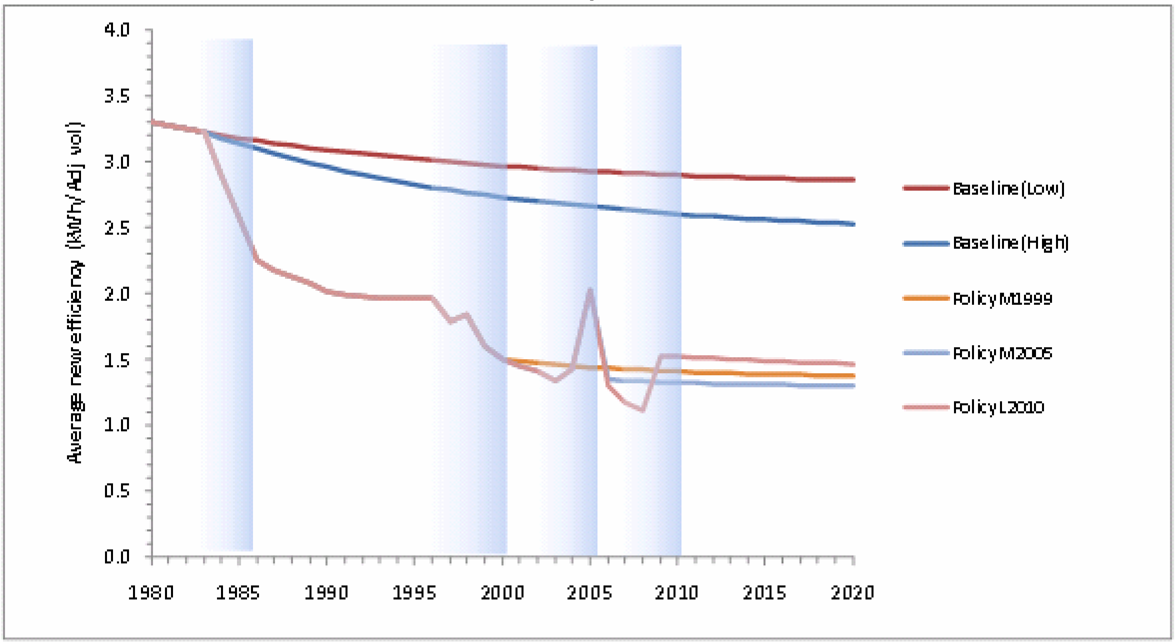
- No improvement in efficiency
- Fixed efficiency improvement (e.g. 1% per annum)
- Changing efficiency improvement (e.g. 1%, then reducing each year after)
- Simple extrapolation of the last two data points
- Extrapolation based of several data points
- Efficiency improvement fixed by analyst, e.g. a declining autonomous rate, and different for each appliance group.

The same decision needs to be made for subsequent policy scenarios. In all cases a fixed efficiency improvement was chosen, which then declined over time. The earlier scenarios have a higher rate of improvement since it is likely that it is easier (cheaper) to make efficiency improvements on less efficient appliances.

For later scenario, the same issue applies, though it is likely that there will be less increase in autonomous efficiency (without further program measures). By examining the data it appears that the efficiency/consumption almost levels off following the introduction of refrigeration product policy measures, which is especially noticeable for the case MEPS in 1999 and 2005.

As an example, the projections for each scenario are shown in Figure 35 for Group 4.

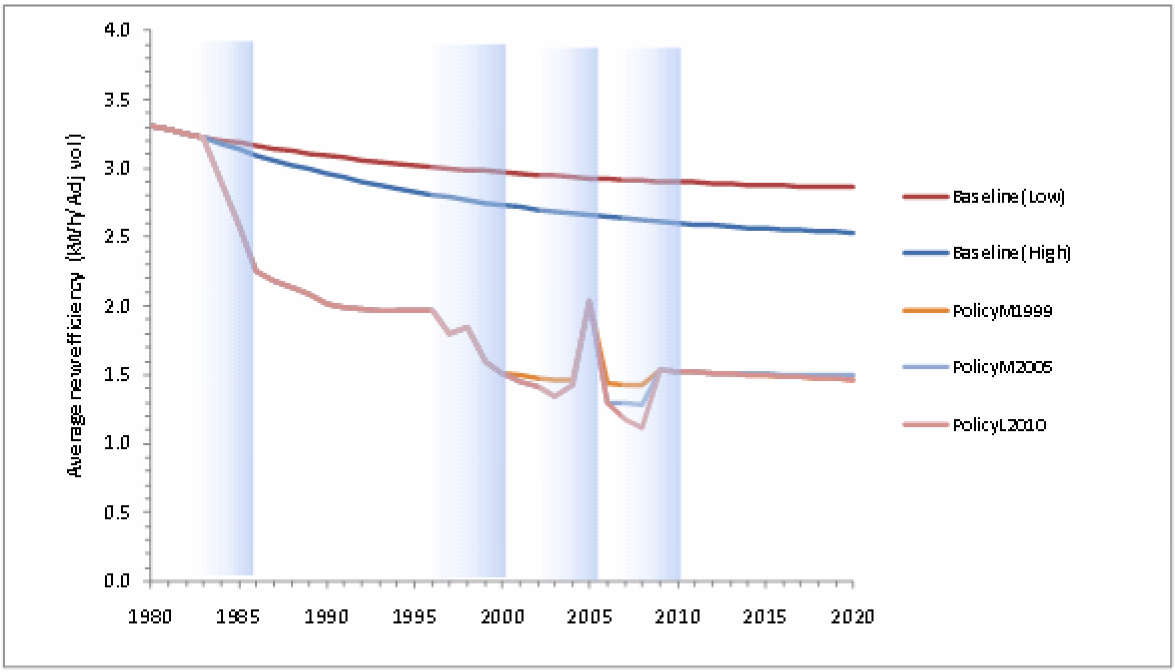
Figure 35: Average new 'efficiency' (kWh/year per adjusted volume)for each historic scenario (Group 4)



The measured 'blip' in 2005 (and 2009) needs further consideration. As highlighted earlier this is an artefact of rapid decrease in average volume (size) for this particular product group, which occurred as the sales share declined to less than 1% (only a couple of models were left on the market). If this is not accounted for, the MEPS-2000 baseline will show a lower amount of energy than the PolicyL2010 reference scenario, which is unlikely to be the case.

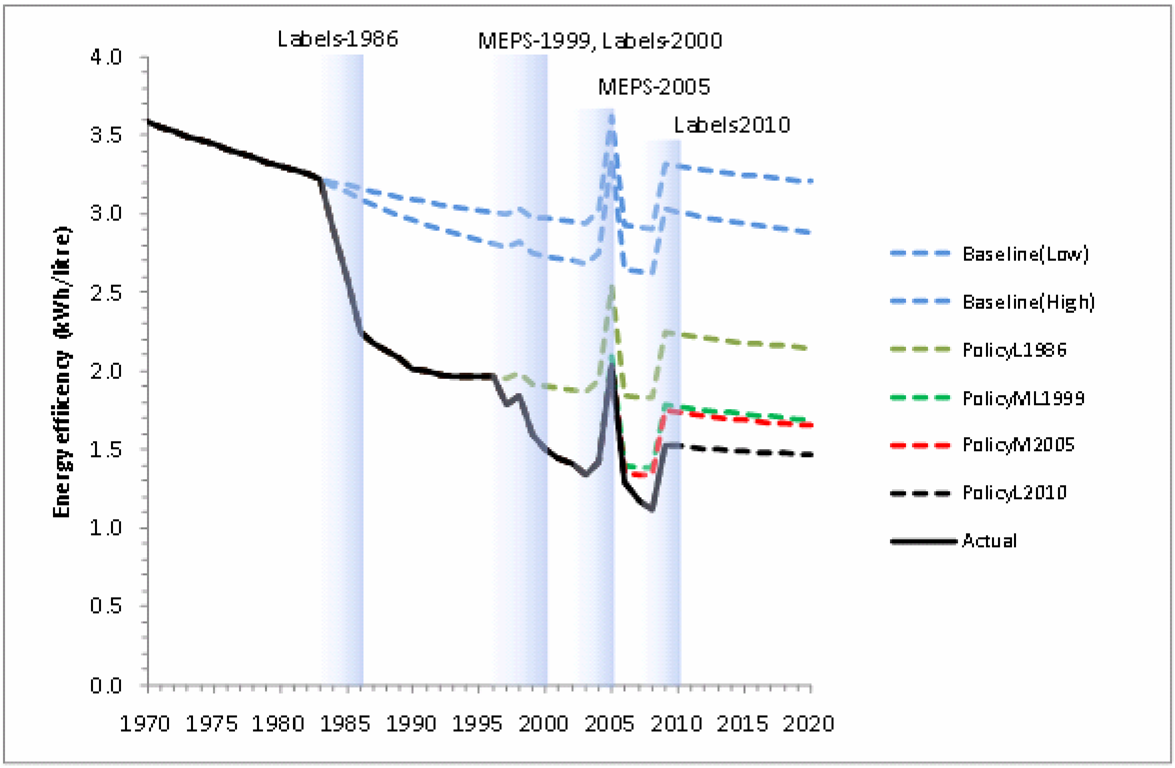
A simple 'correction', shown in Figure 36, would be to ensure that the historic scenarios do not go lower than the actual figures (i.e. if they are less than the PolicyL2010 scenario, then the values are made equal to that value). This may be considered a conservative 'correction' as it is likely that the historic scenario would be higher (e.g. the Baseline (Low) in red could be raised in 2005/2009 to better reflect the 2005/2009 artefact).

Figure 36: Average new 'efficiency' (kWh/year per adjusted volume) for each historic scenario, correcting for 'blips' (Group 4)



A less conservative 'correction' would be to adjust some of the earlier baselines to include this change in efficiency (which was due to a size artefact and not a real efficiency change) shown in the figures below. This 'correction' approach has been used for all ten groups. To be specific, any decrease in efficiency in the reference PolicyL2010 scenario has been reflected in the earlier baseline series by the same amount (superimposed over any underlying decrease assumed).

Figure 37: Average new 'efficiency' (kWh/year per adjusted volume) for each historic scenario, correcting for 'blips' (Group 4)



The level of efficiency improvement post any new policy measure is unlikely to revert back to the 1% per annum level, especially where the measure like MEPS has forced a large decrease onto the market. The scenarios post intervention will be dependent on the stringency of the previous measure, and if there are reasons for increased efficiency (e.g. the label has sufficient range to appeal to manufacturers and supply chain to easily include further efficiency improvements). The above analysis also assumes a somewhat independent impact of each of the policy measures. To some extent label regrades and increases in MEPS levels are likely to have impacts on other program elements, so these are not mutually exclusive. As previous noted the introduction of very stringent MEPS levels in 2005 appears to have slowed the autonomous rate of label improvement to be close to zero in the following years. This is not surprising, as most of the easy and low cost energy savings will have been implemented for MEPS 2005 and the market pull of the 2000 label becomes very weak (as most products appear quite efficient on the label). It is important to note that when announced in late 2000, no products on the market in Australia would have met the 2005 MEPS levels. This means that every product on the market had to be re-engineered to meet these new levels in a period of four years. It is hardly surprising that in the absence of a label regrading post 2005, the underlying rate of efficiency improvement fell to almost zero in the following few years.

Second order impacts, and attribution, could be examined further. For example, it is possible to examine the:

- Impact of MEPS in the case where all products on the market do not meet the level required by MEPS in the year they become effective. It is possible to ascertain the level of late compliance from the registration database.
- Overlapping impacts of labels and MEPS prior to MEPS becoming effective. Differing levels of attribution to MEPS and labels could be considered.

Additional sophistication could include examining the level of policy compliance over time – i.e. examine the extent to which criteria are being met by incorrect labelling and compliance claims. The level of compliance is difficult to ascertain and few studies (globally) have been done, mostly due to the cost of checking market activity. However, Australia does undertake check testing and the Australian Consumer Association (ACA) does undertaken random checks. Using this data, a study to determine the level of compliance by products on the market is underway and close to completion. The analyses of that data may provide an insight on the extent to which this needs to be considered in impact evaluations. A recent study has attempted to evaluate the level of compliance in the household refrigerator and freezer market in Australia (Lane and Harrington, 2010). As noted previous issues associated with compliance are generally considered to be related to process evaluation, although poor compliance can reduce actual savings achieve in an impact evaluation.

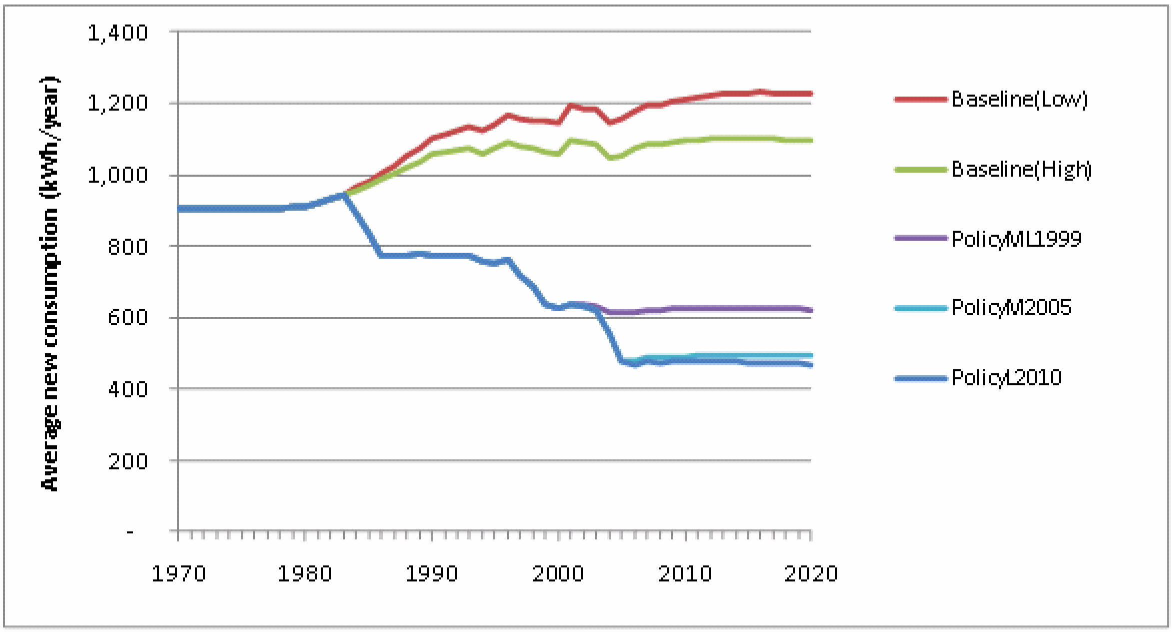
However neither of these two second order impacts nor the compliance issues has been considered further in the present analysis.

The efficiency scenarios for the ten refrigeration groups, presented in Appendix 5, are then used to generate energy consumption data as input to the energy models (Section 4.5) to generate the energy consumption outputs (Section 5).

Energy model input data

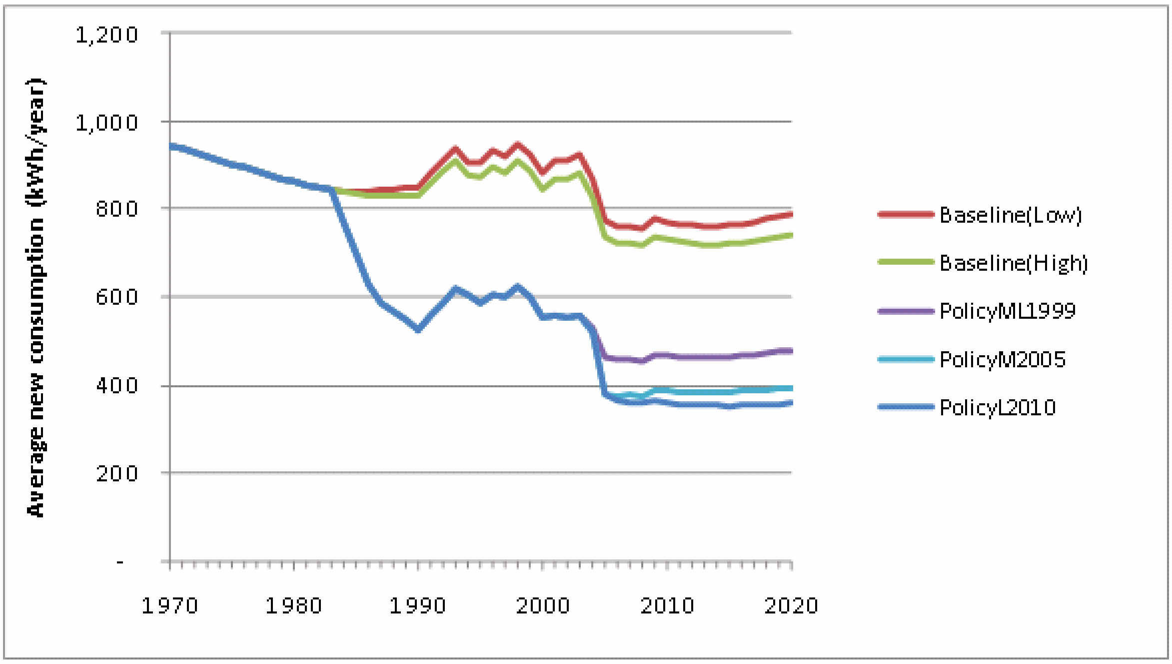
Using the above approach it is possible to generate average new kWh/year figures for each of the ten refrigeration types (Groups). These can be merged into two sets of attribute input data: one for refrigerators and one for freezers. The energy stock model only has an aggregated model for refrigerators and freezers (since ownership data are only available to this level of disaggregation and attempting to model all ten groups for eight states while maintaining consistency with stock, sales and ownership would be very difficult). Energy attributes used in the stock model to generate different scenarios are shown for refrigerators (Figure 38).

Figure 38: Average new kWh/year for refrigerators on sale in Australia



The analysis for freezers is done in the same way, noting that some of the reduction in average new electricity consumption is due to these appliances becoming noticeably smaller over the observation period (especially prior to 2005).

Figure 39: Average new kWh/year for freezers on sale in Australia



Appendix 5: INPUT DATA ANALYSIS

Charts will be shown for each product group which show the data used for the main reference scenario (PolicyL2010). This scenario includes all the policy measures to date, along with projections to 2010. The following three charts are shown for new products sold:

- Average energy consumption per product (kWh/year)
- Adjusted volume (litres/kWh)
- Estimated 'energy efficiency' (kWh/adjusted volume) and the Star rating indexes (new and old).

Note: The parameter kWh/adjusted litre is strictly the inverse of energy efficiency (i.e. energy intensity), but this is a common measure used to express efficiency of household refrigeration products.

The charts include plots of raw data and the smoothed data used in the current evaluation models.

Group 1

Figure 40: Group 1 energy trends

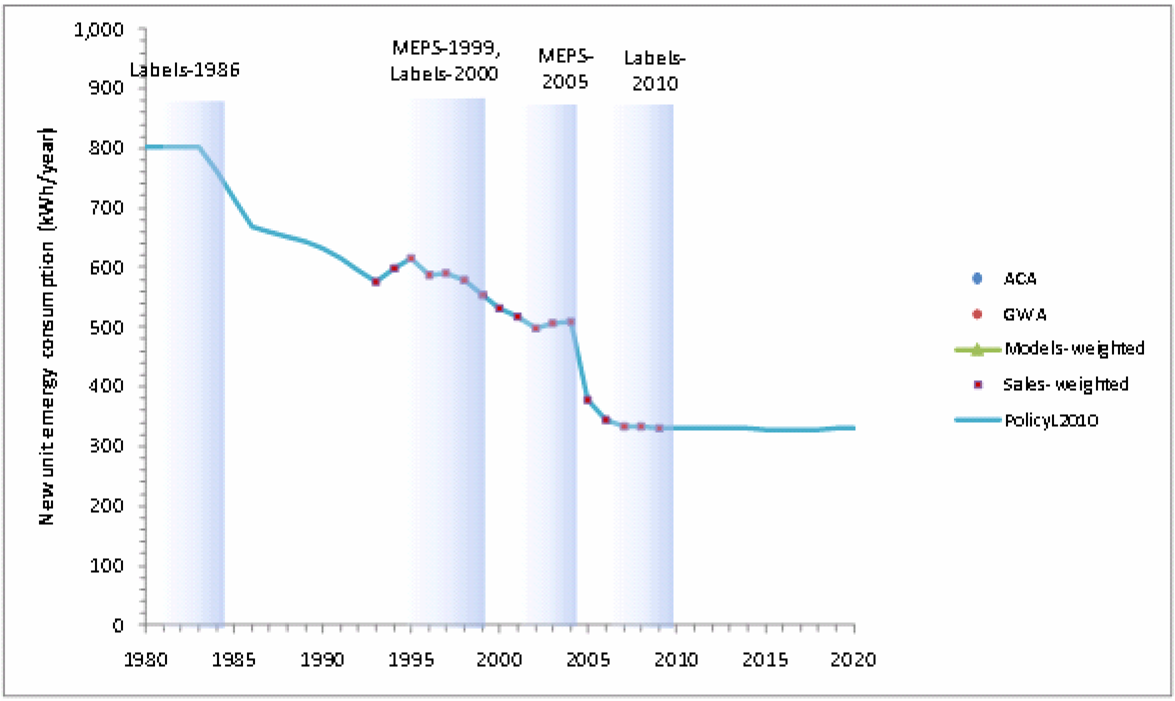


Figure 41: Group 1 size trends

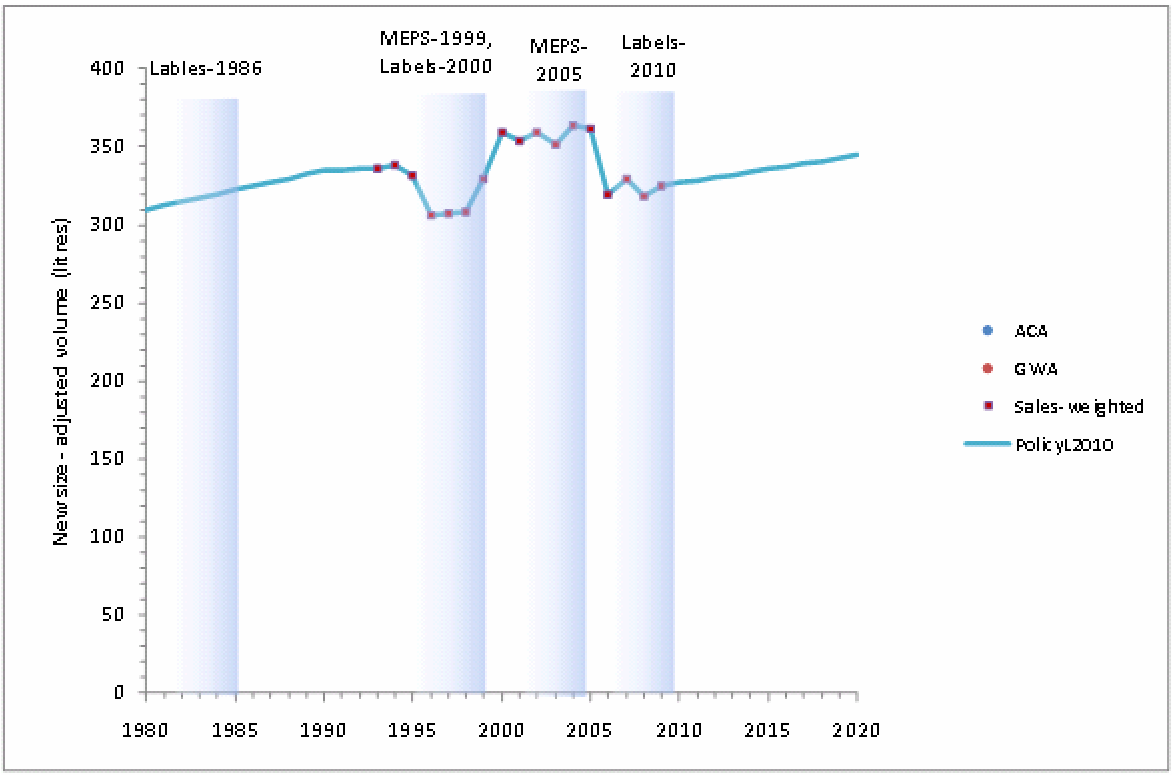
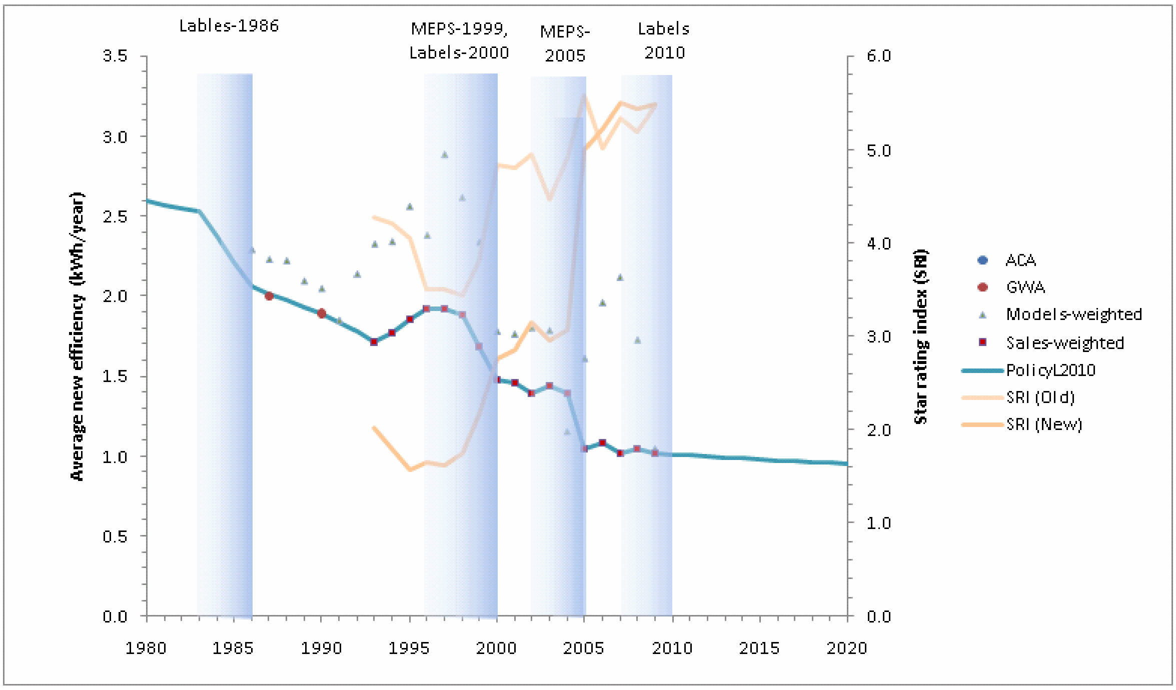


Figure 42: Group 1 energy efficiency trends



Group 2

Figure 43: Group 2 energy trends

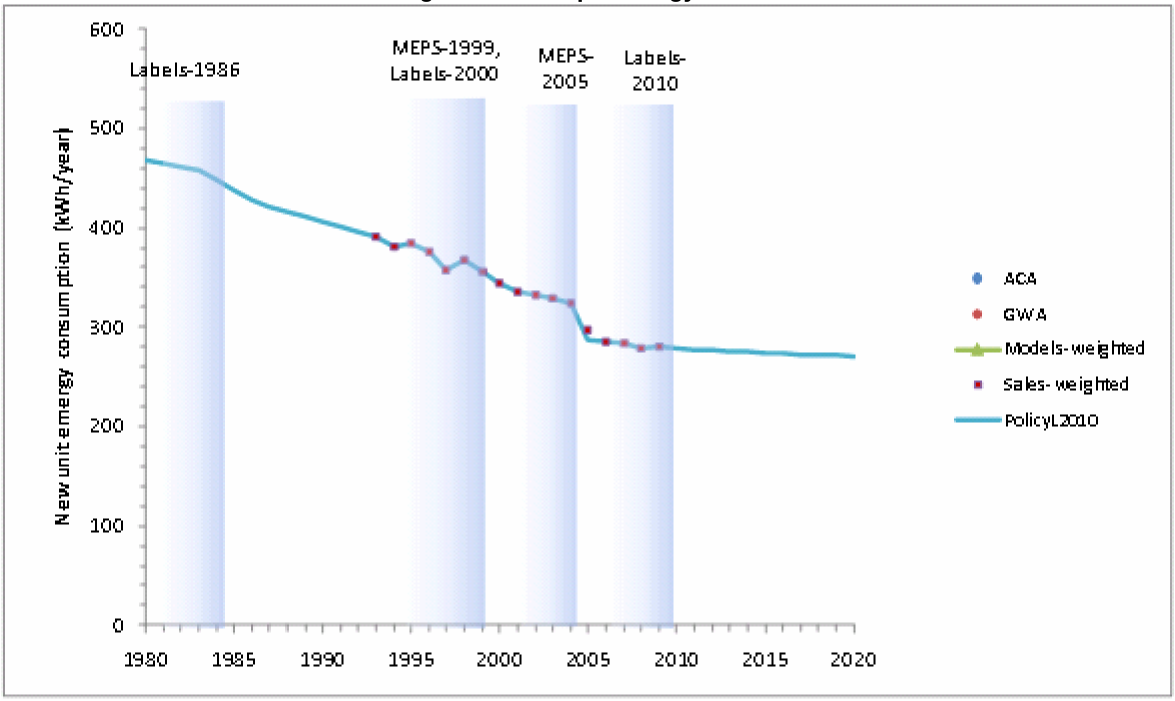


Figure 44: Group 2 size trends

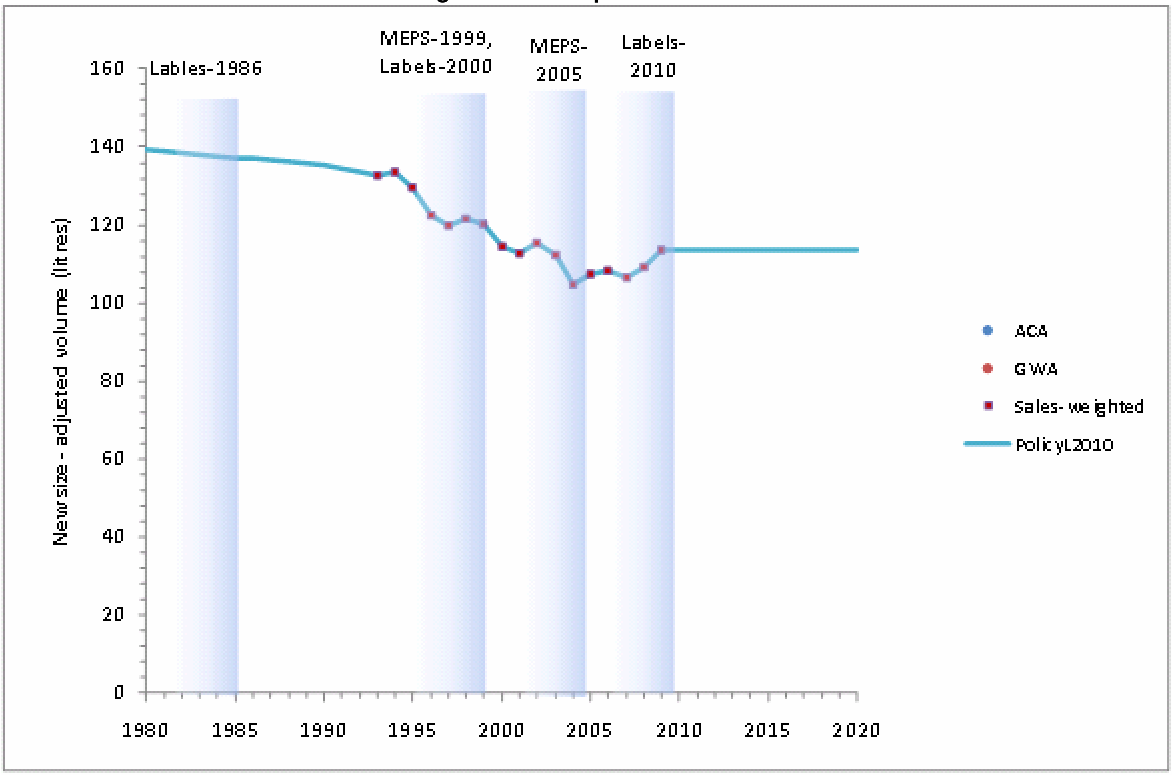
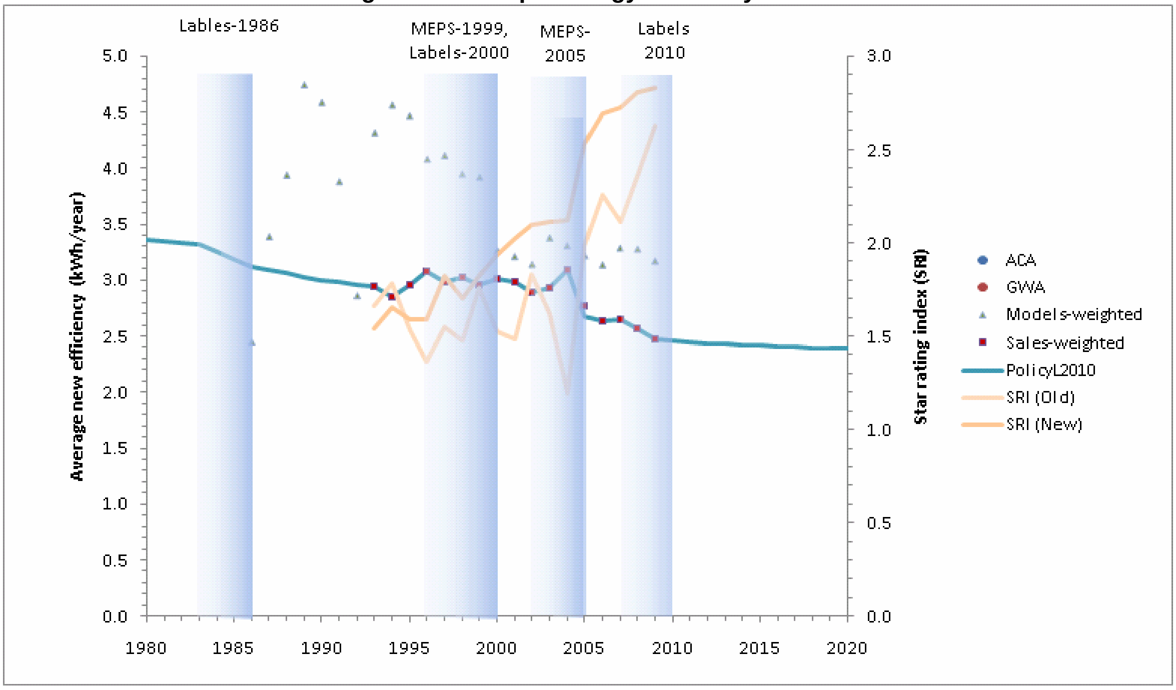


Figure 45: Group 2 energy efficiency trends



Group 3

Figure 46: Group 3 energy trends

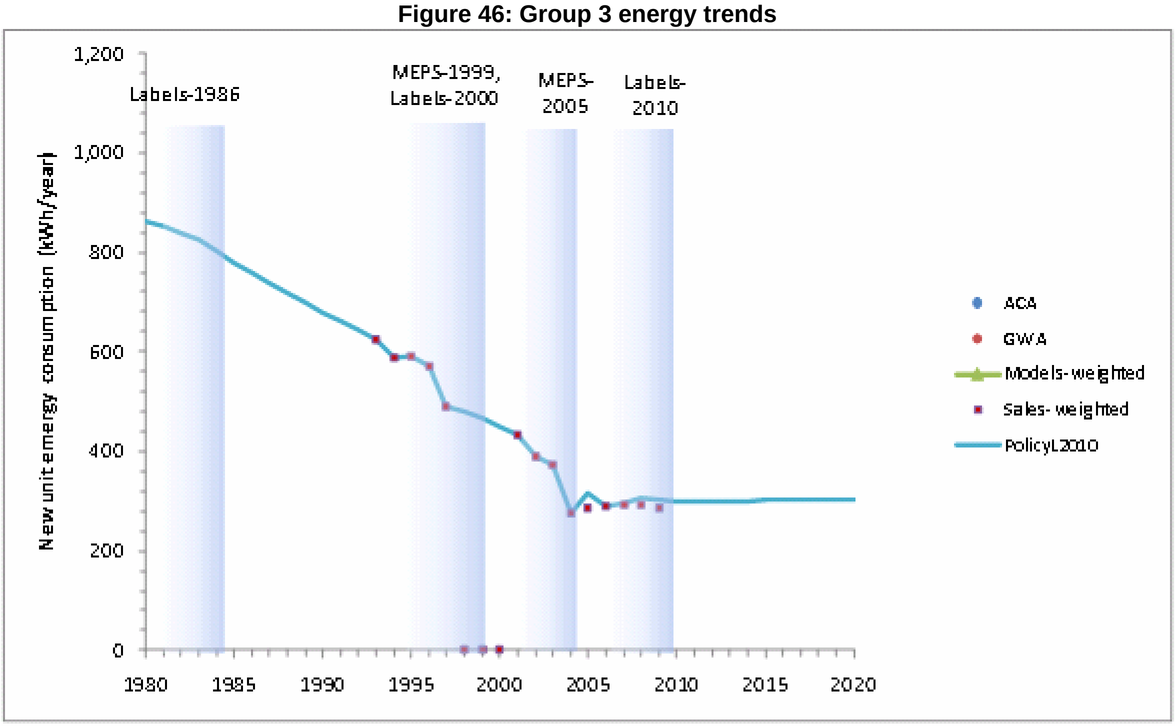


Figure 47: Group 3 size trends

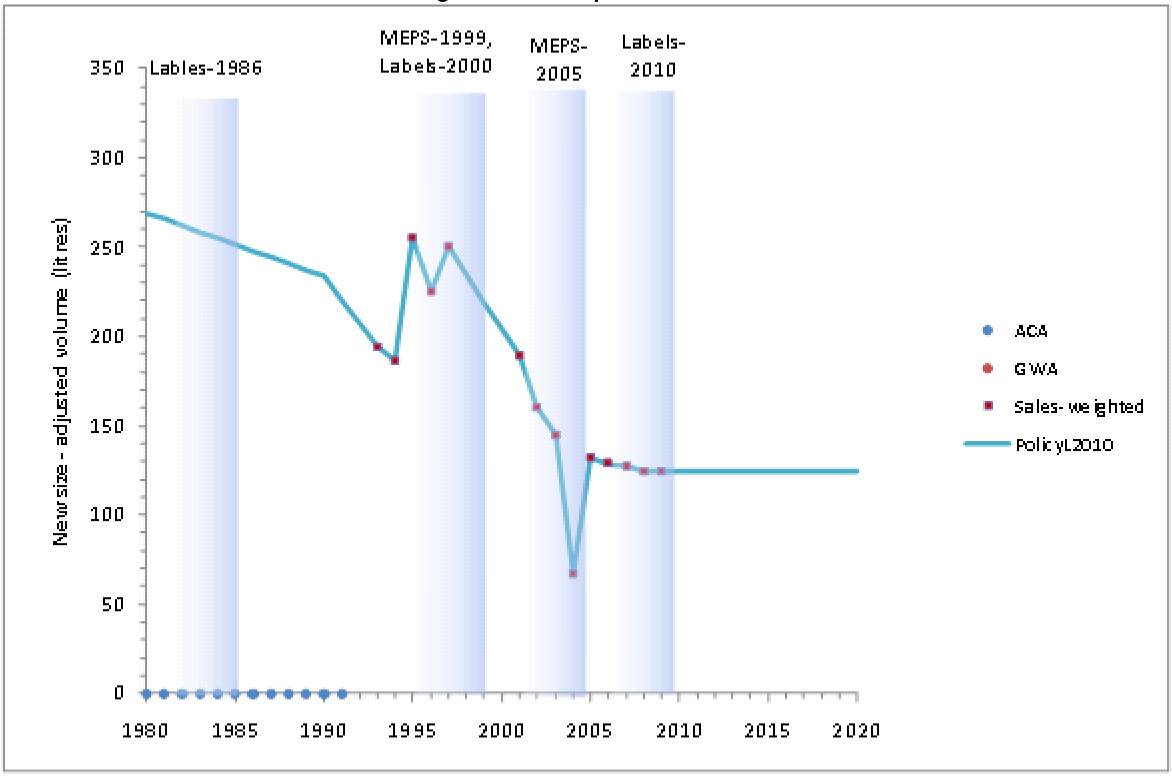
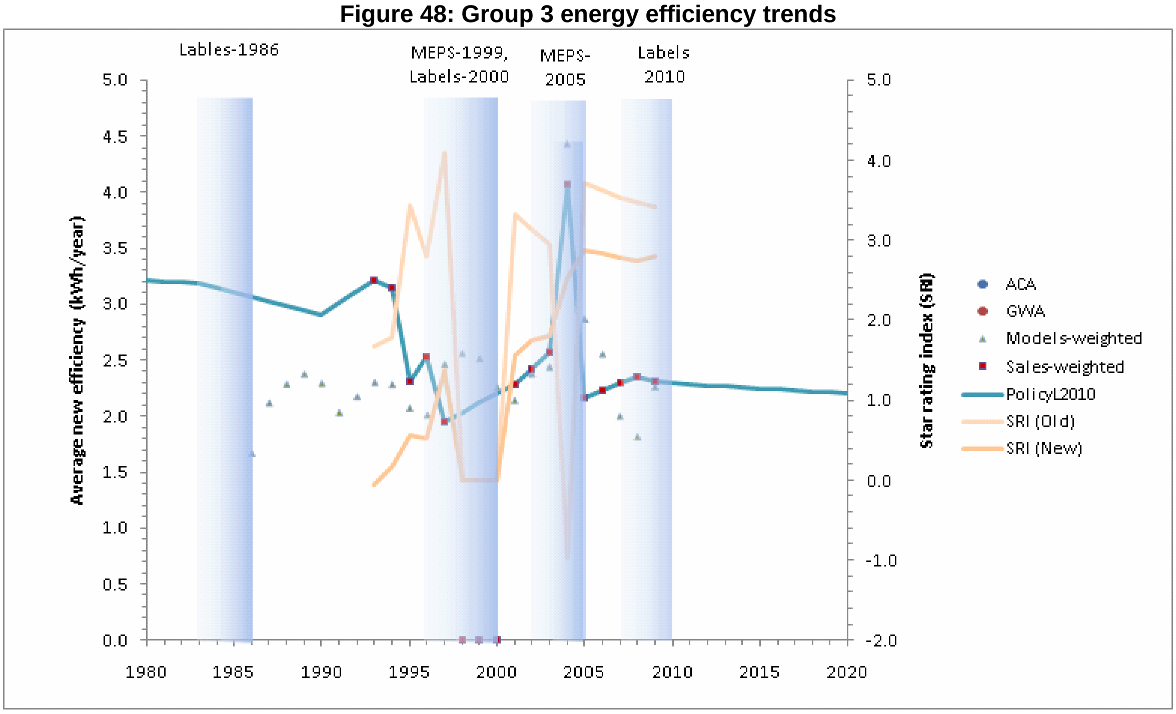


Figure 48: Group 3 energy efficiency trends



Group 4

Figure 49: Group 4 energy trends

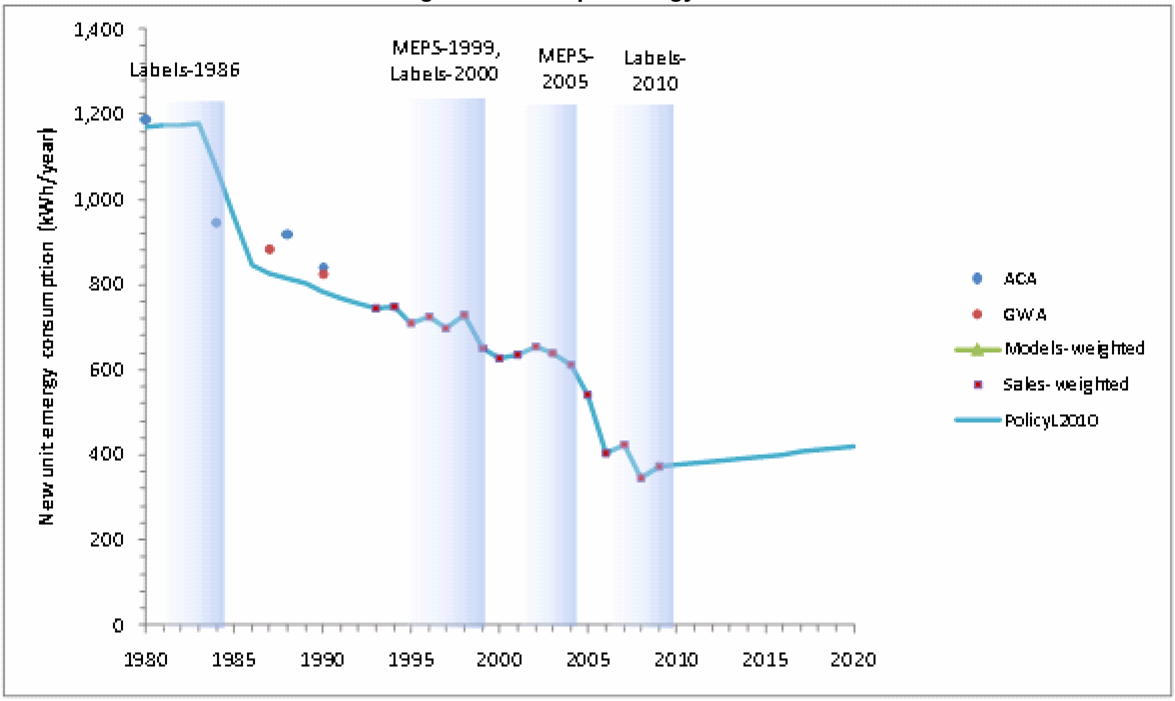


Figure 50: Group 4 size trends

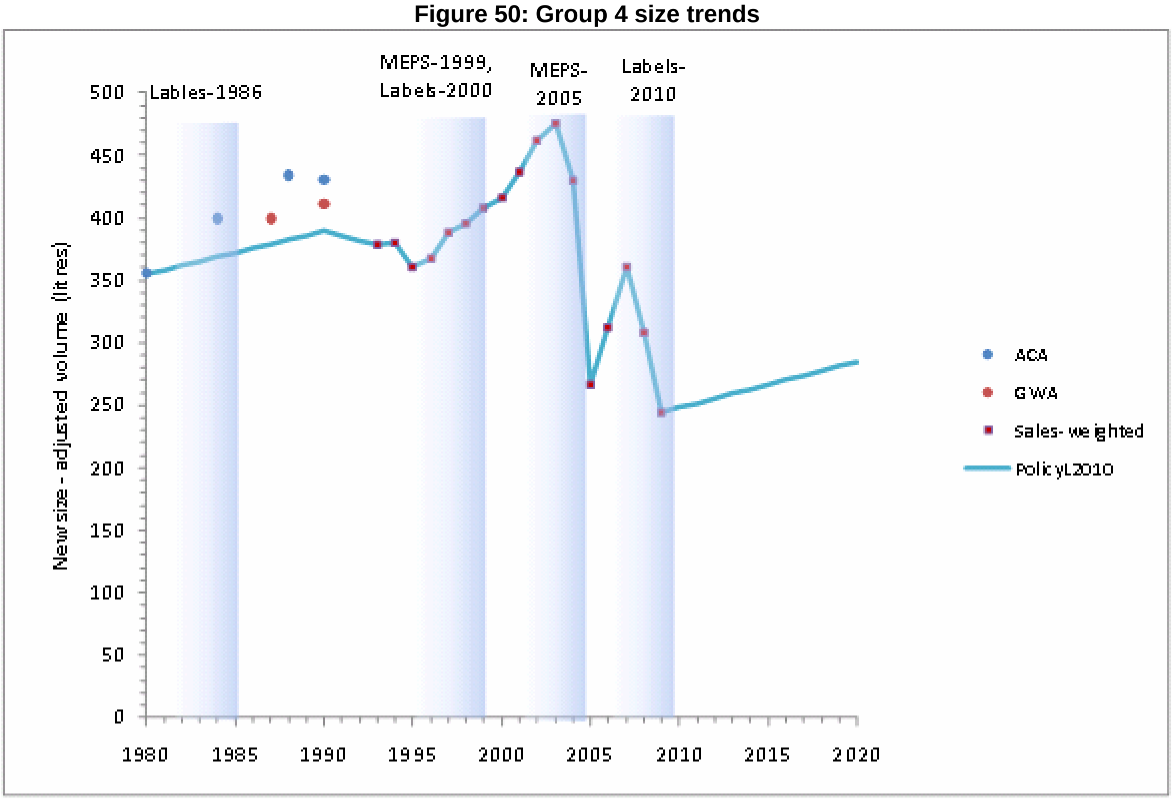
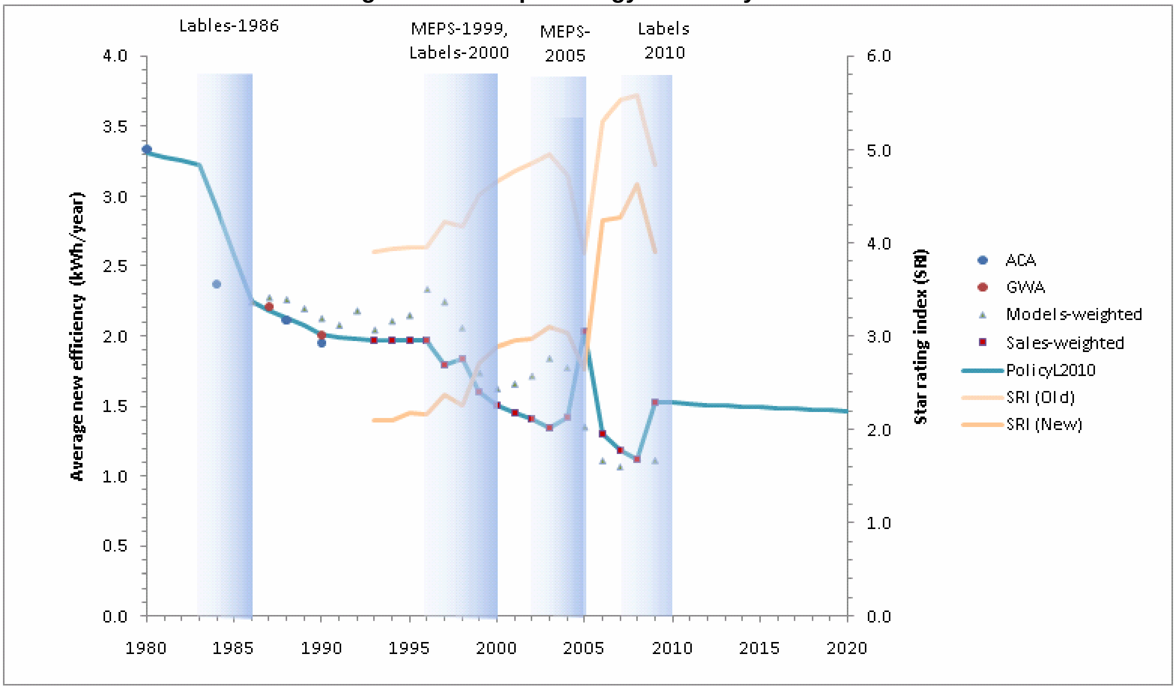


Figure 51: Group 4 energy efficiency trends



Group 5T

Figure 52: Group 5T energy trends

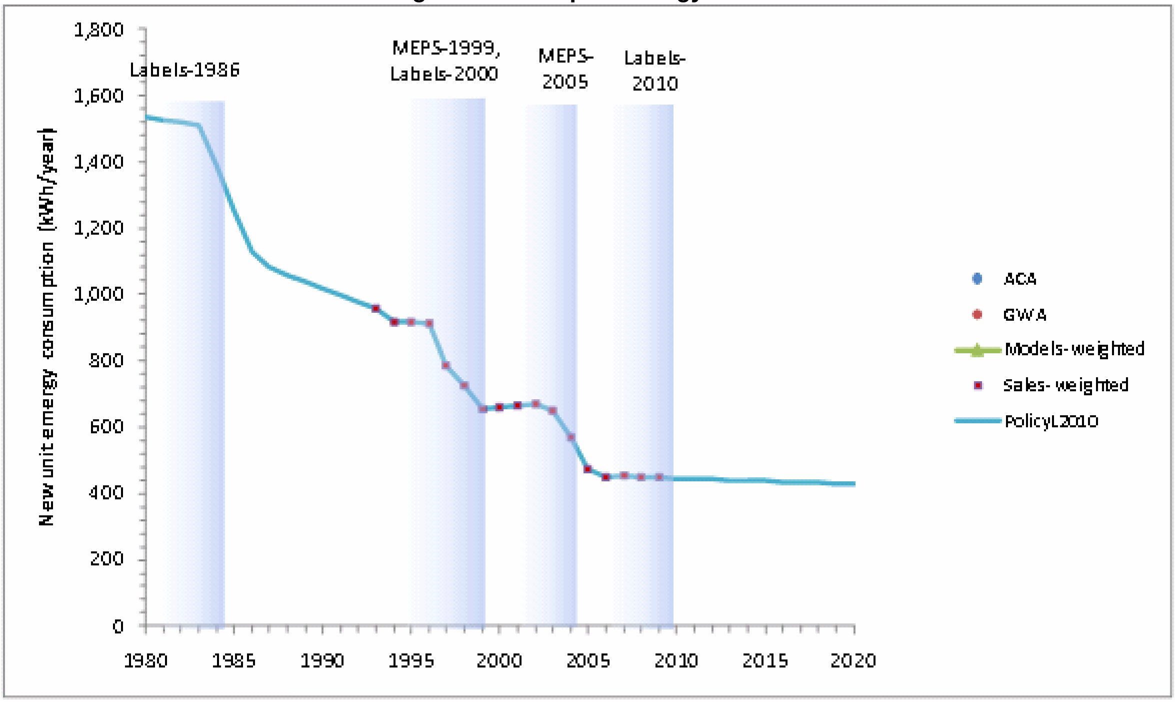


Figure 53: Group 5T size trends

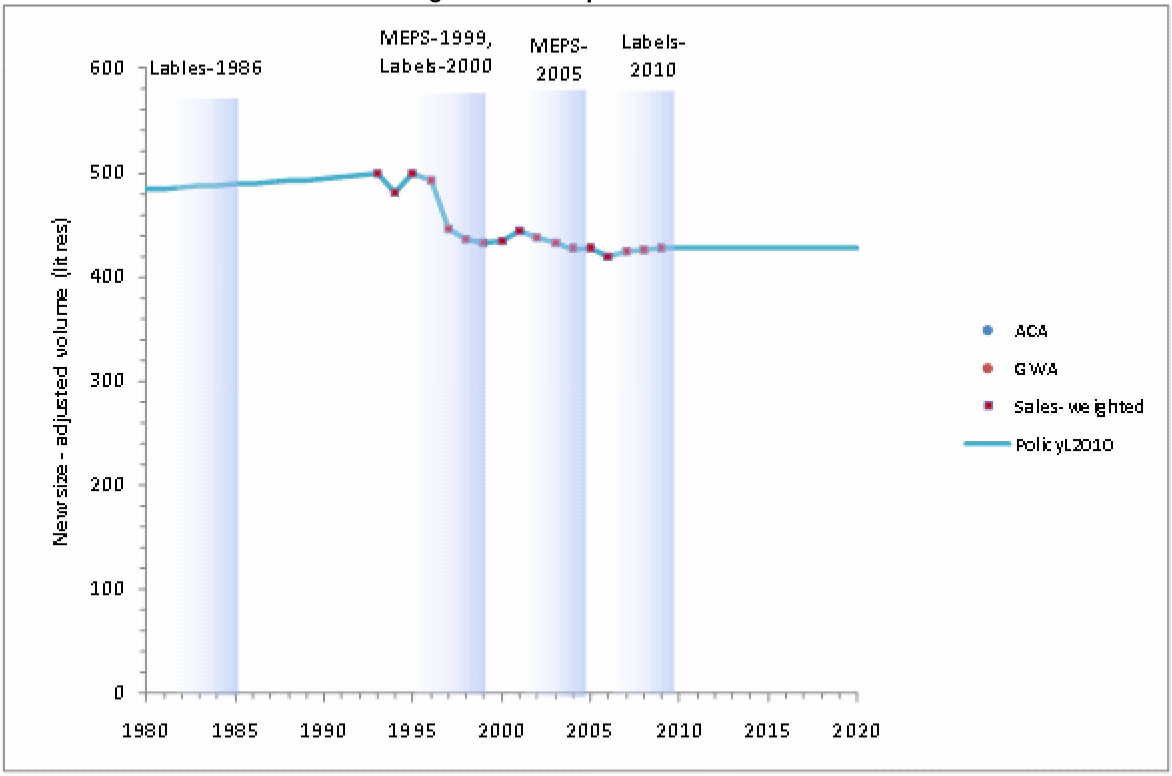
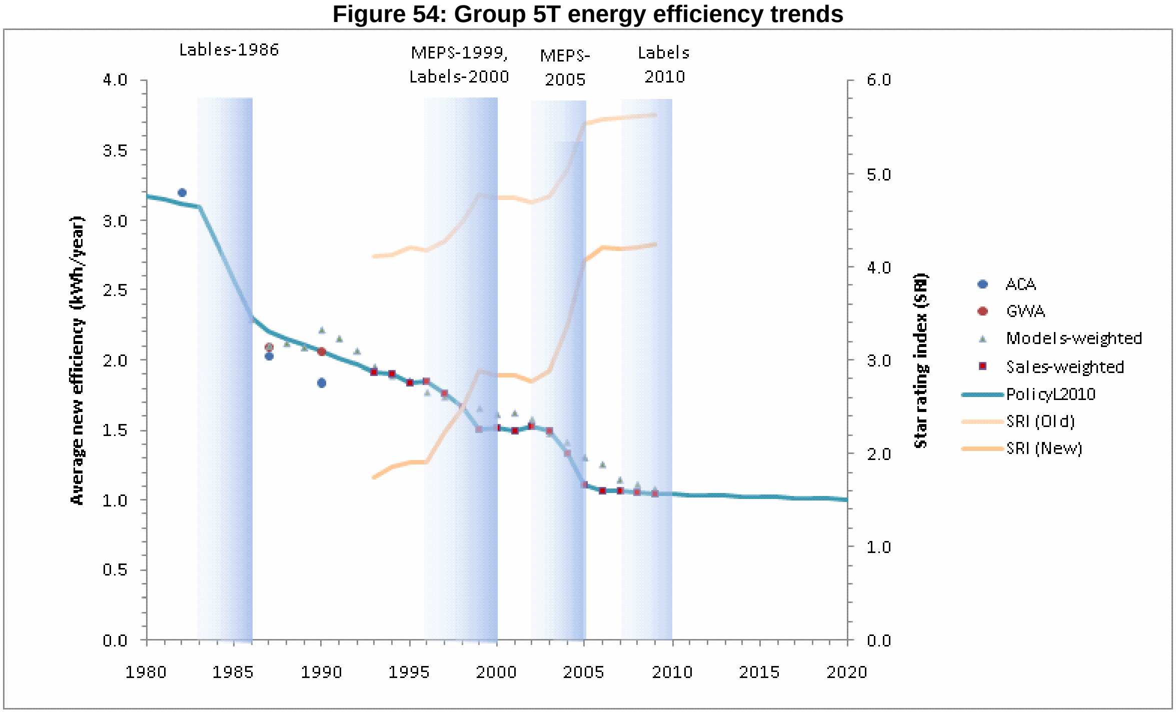


Figure 54: Group 5T energy efficiency trends



Group 5B

Figure 55: Group 5B energy trends

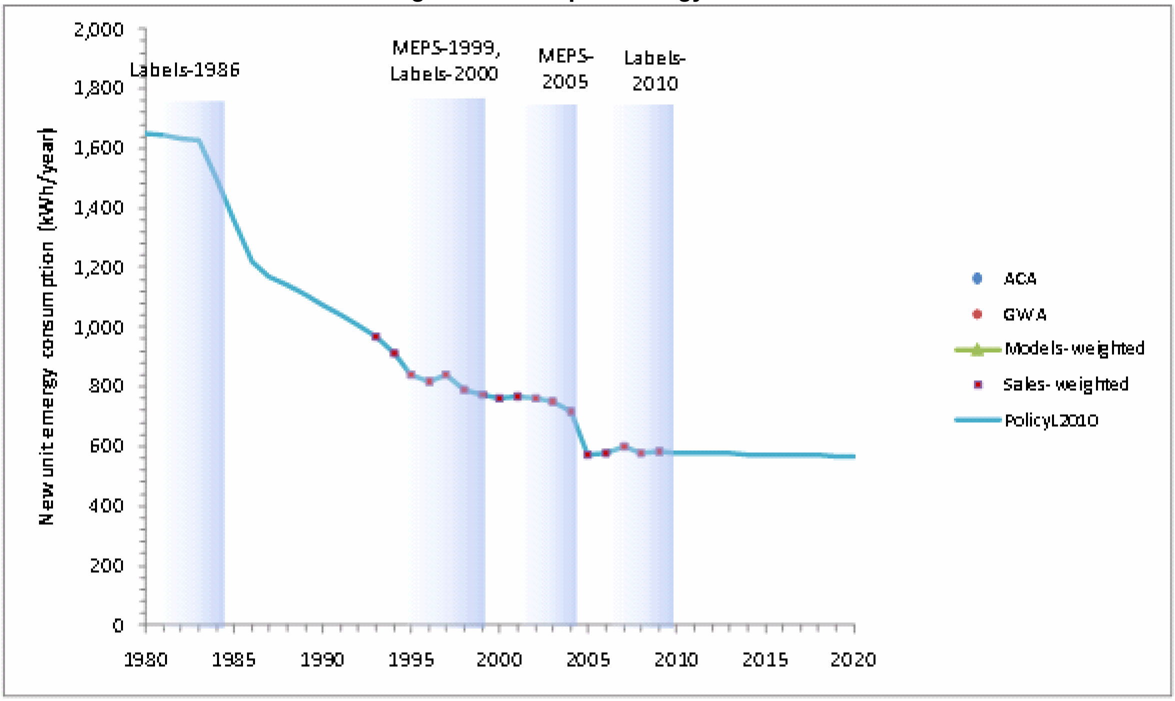


Figure 56: Group 5B size trends

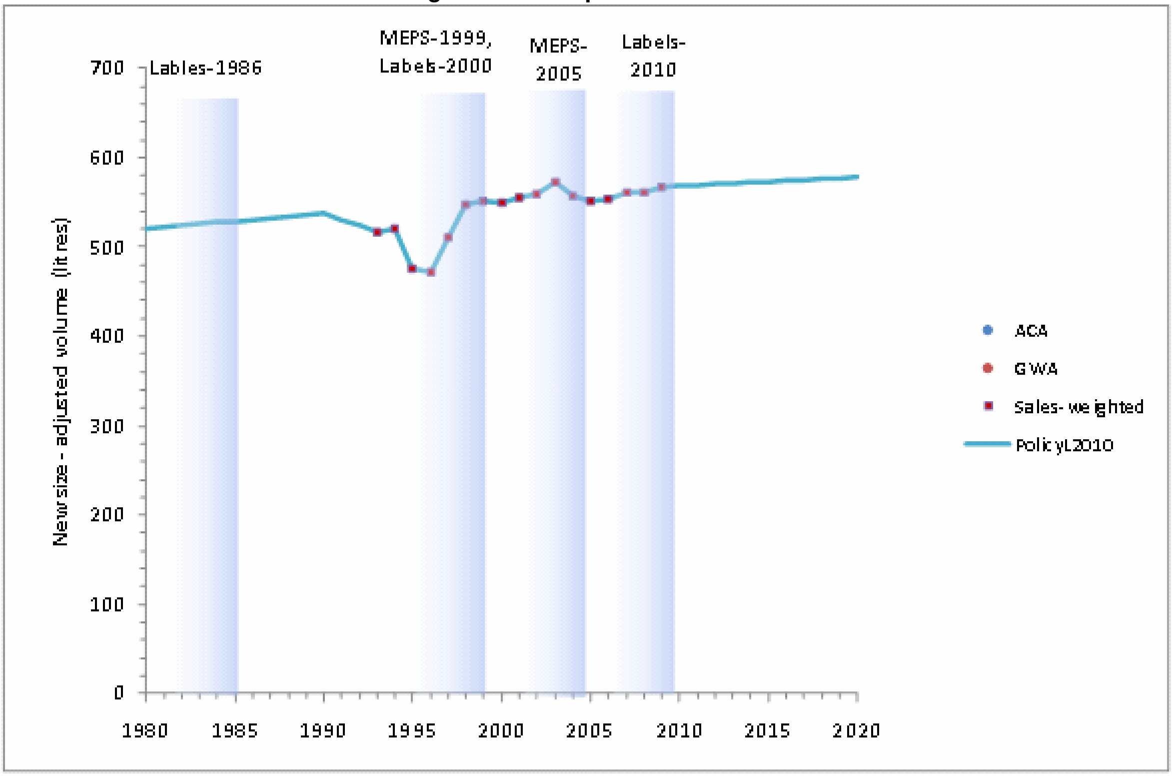
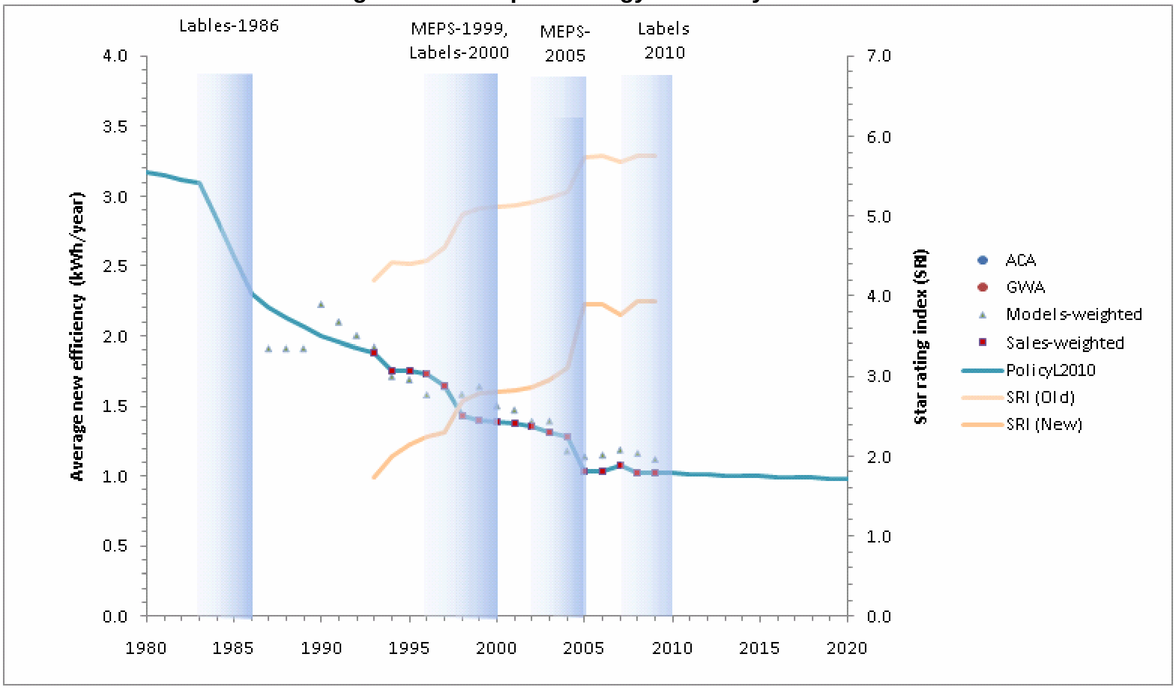


Figure 57: Group 5B energy efficiency trends



Group 5S

Figure 58: Group 5S energy trends

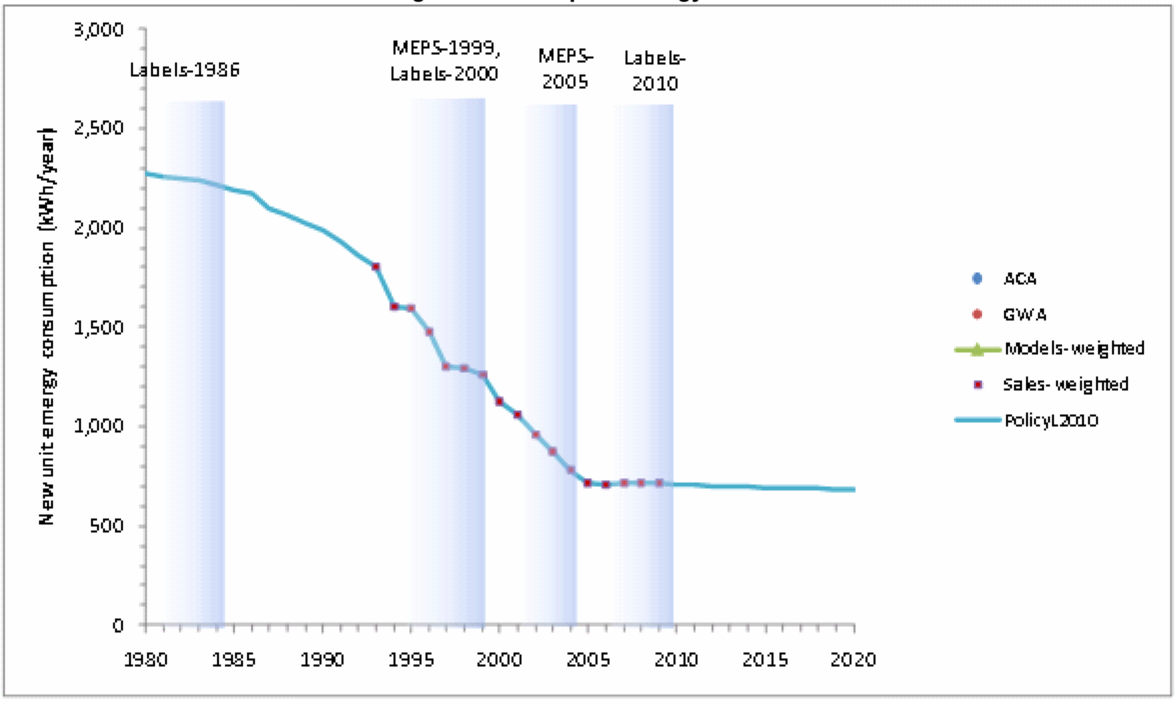


Figure 59: Group 5S size trends

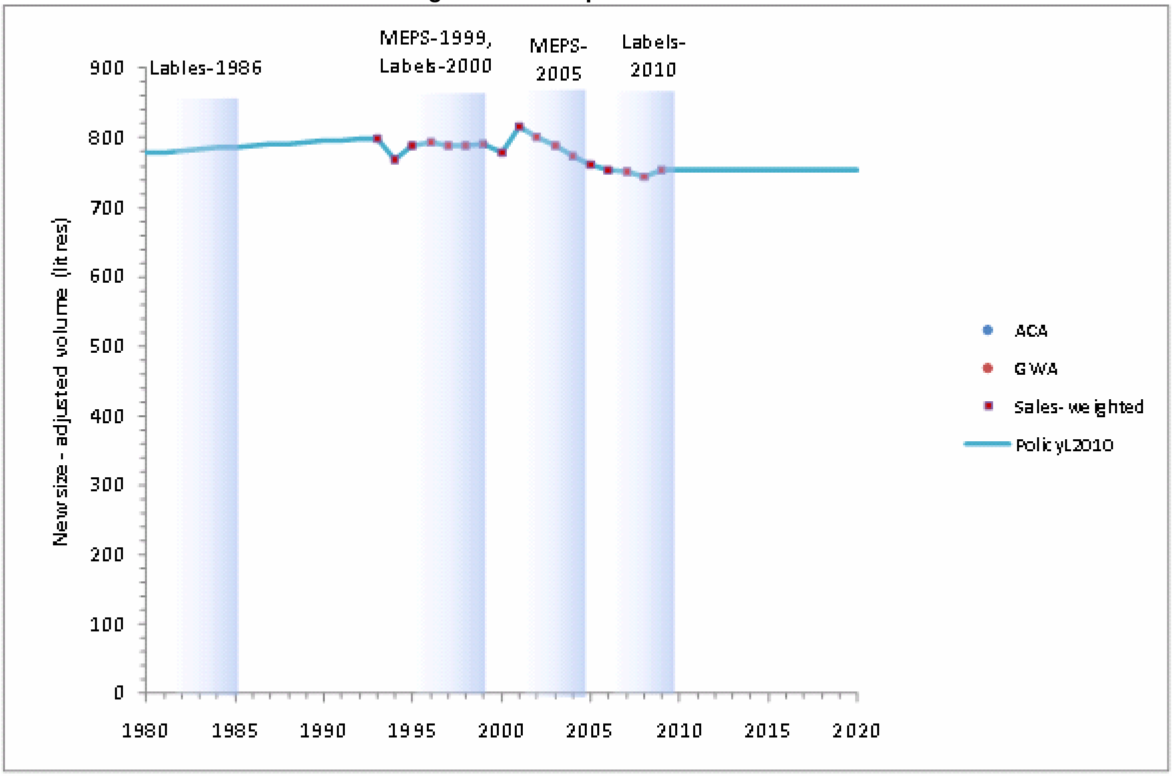
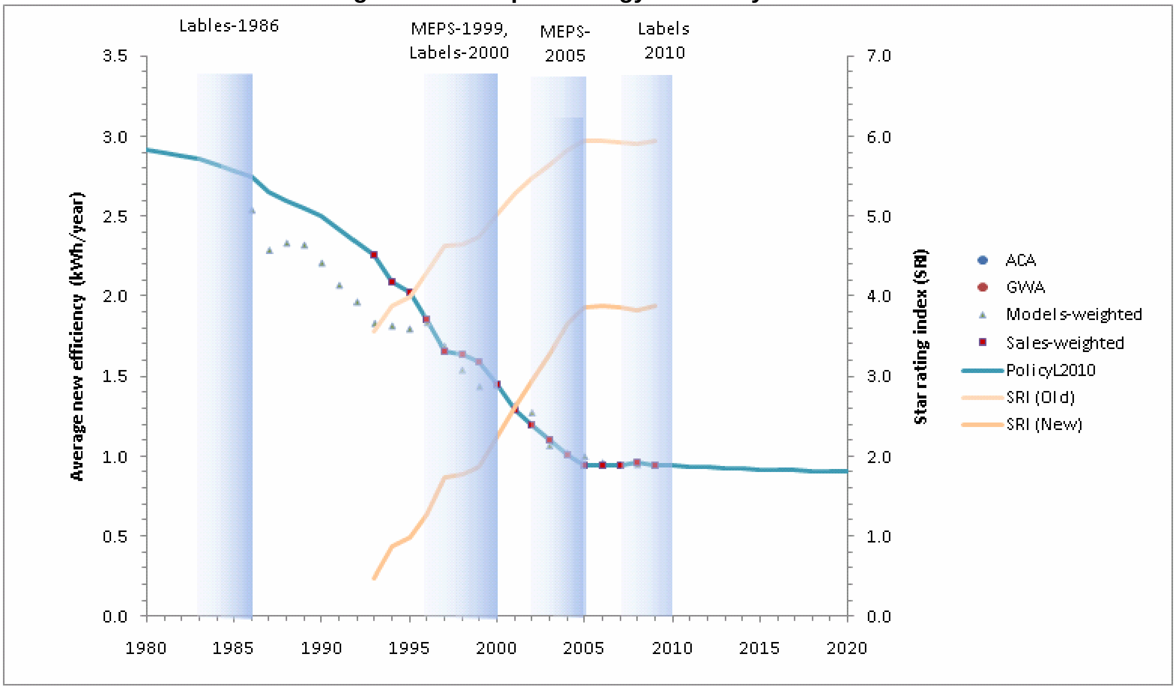


Figure 60: Group 5S energy efficiency trends



Group 6U

Figure 61: Group 6U energy trends

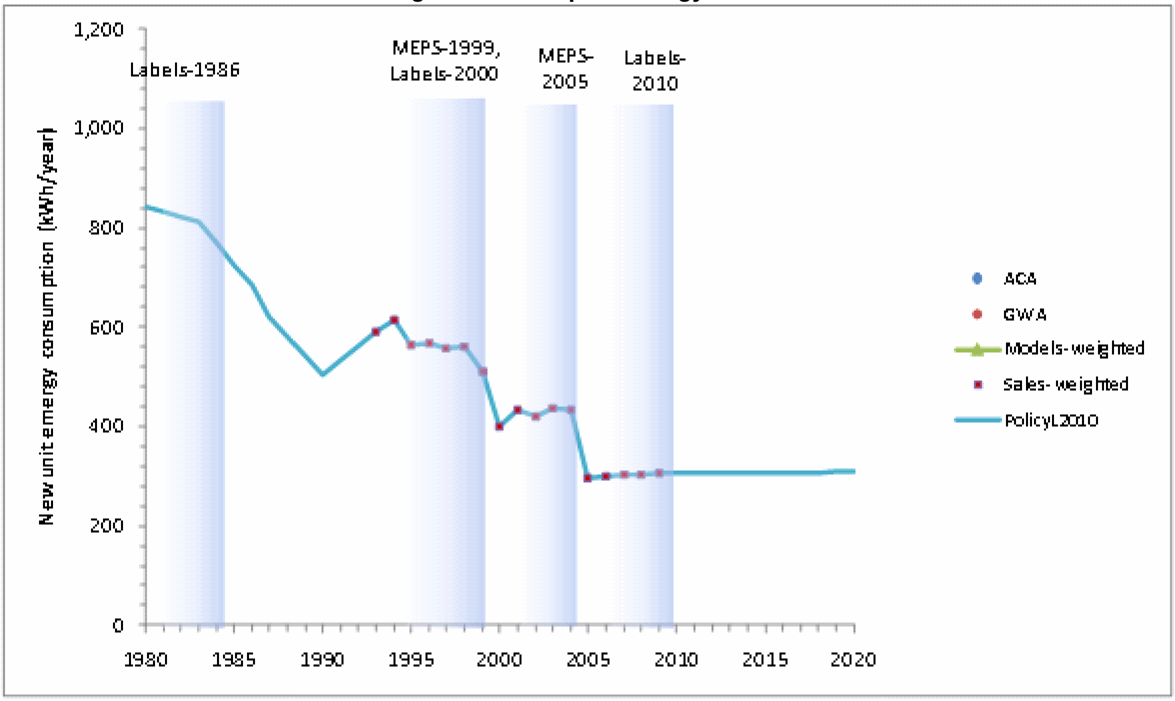


Figure 62: Group 6U size trends

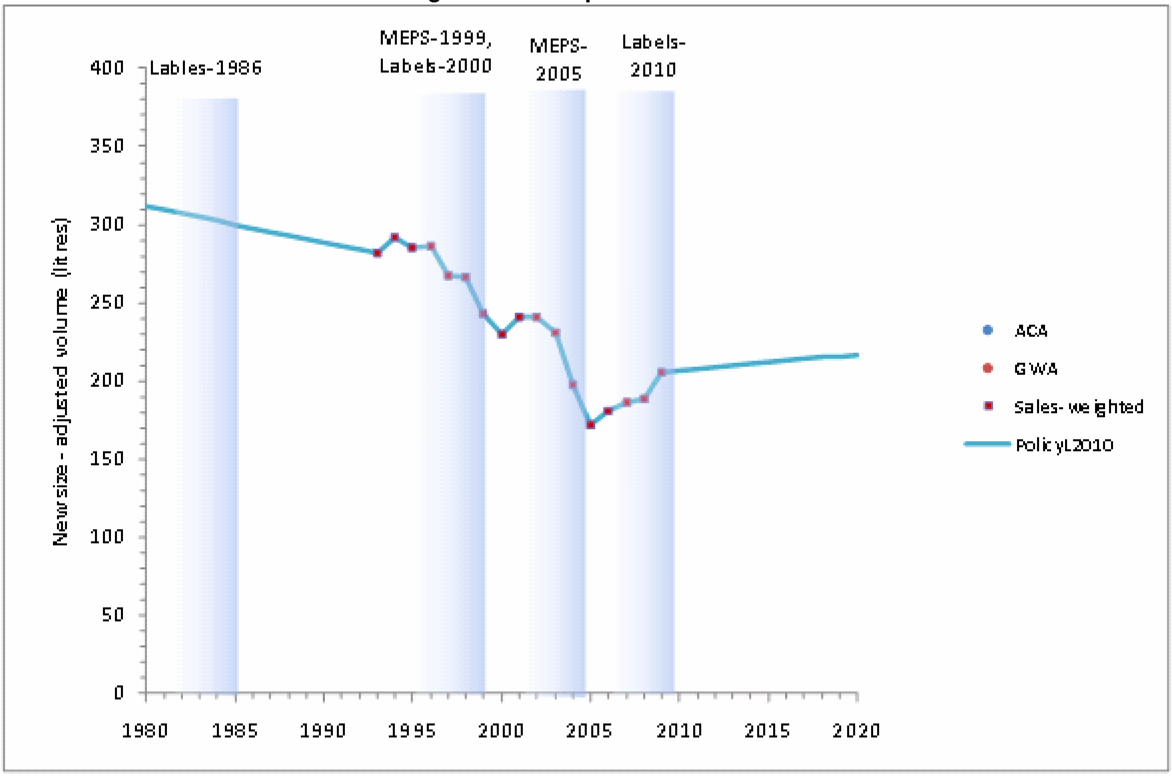
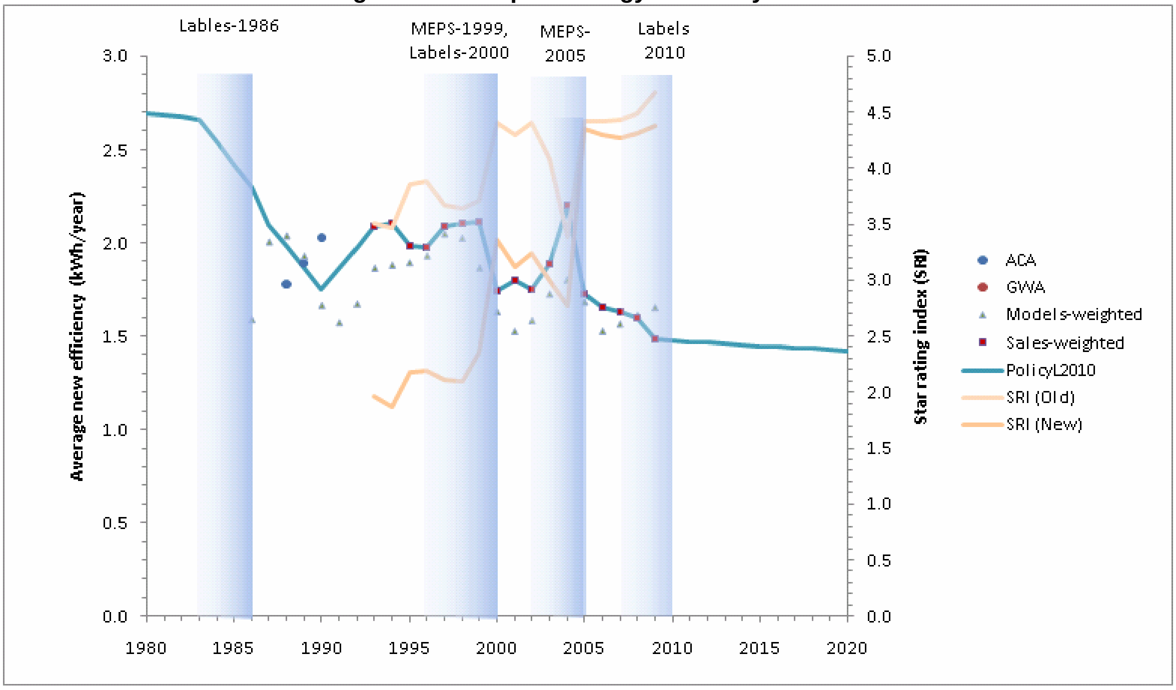


Figure 63: Group 6U energy efficiency trends



Group 6C

Figure 64: Group 6C energy trends

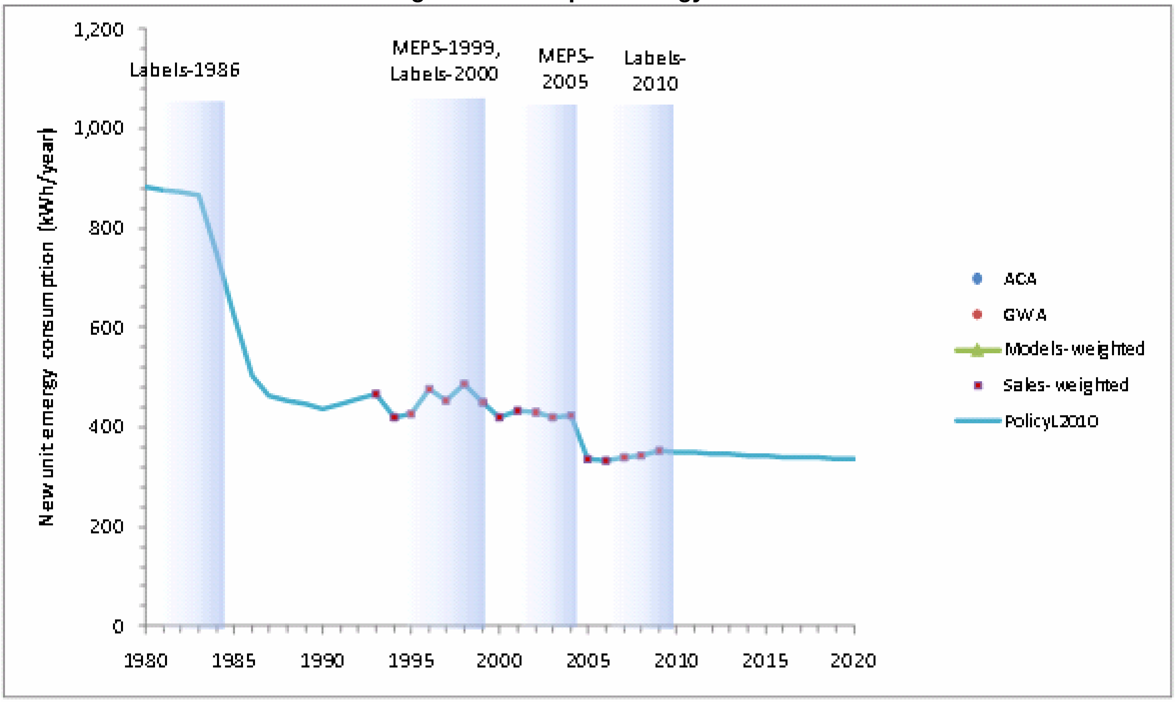


Figure 65:- Group 6C size trends

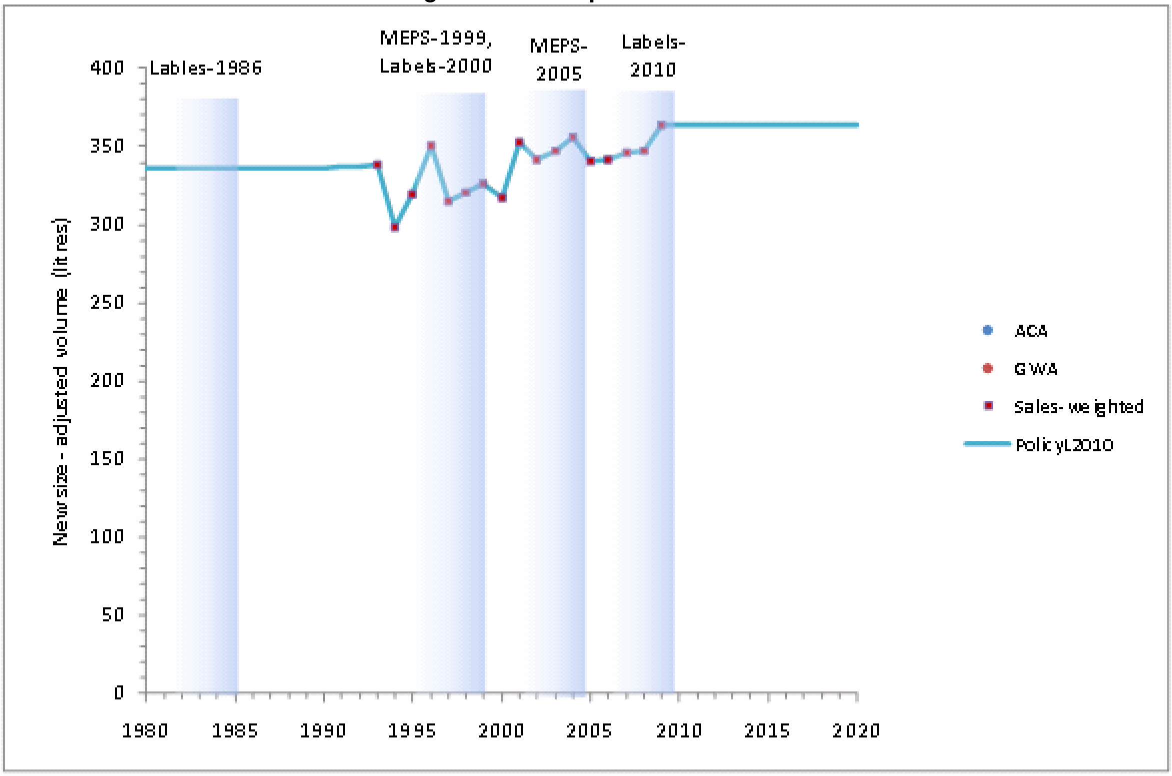
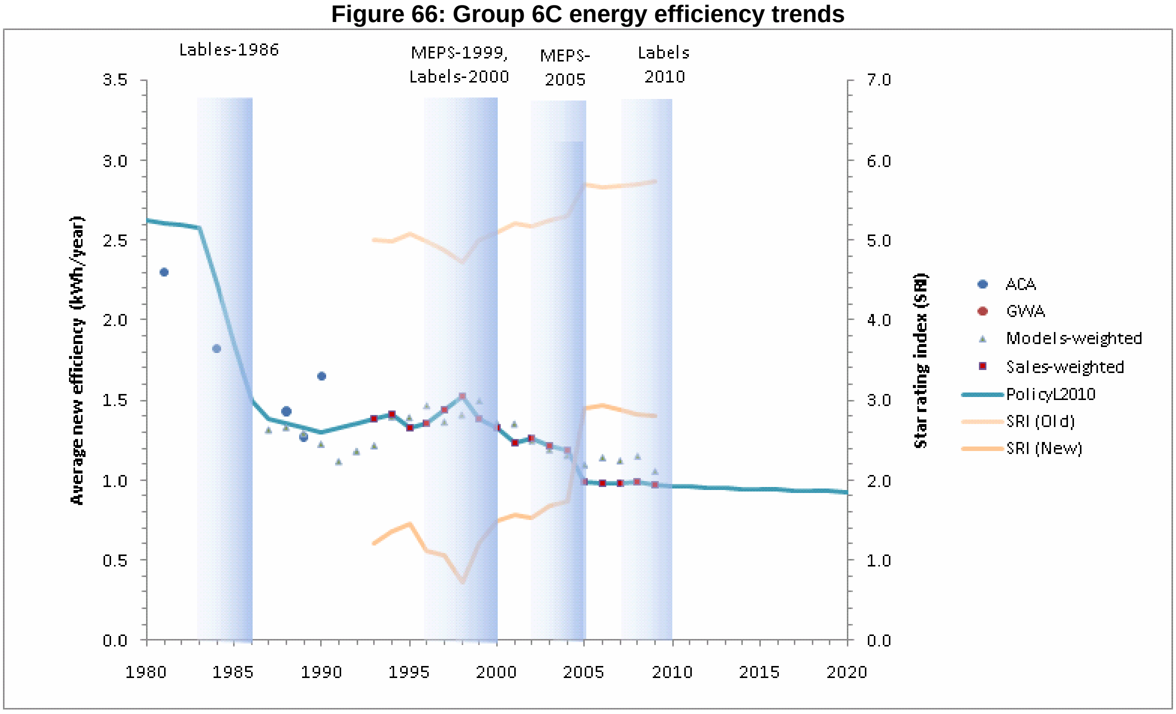


Figure 66: Group 6C energy efficiency trends



Group 7

Figure 67: Group 7 energy trends

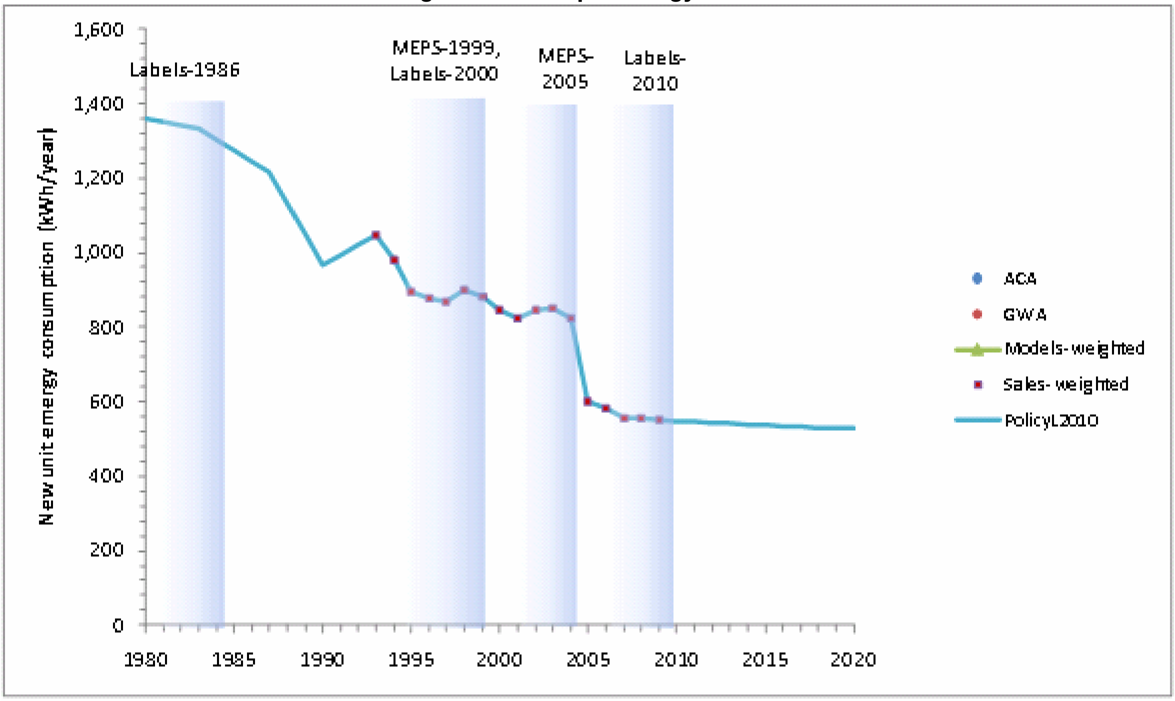


Figure 68: Group 7 size trends

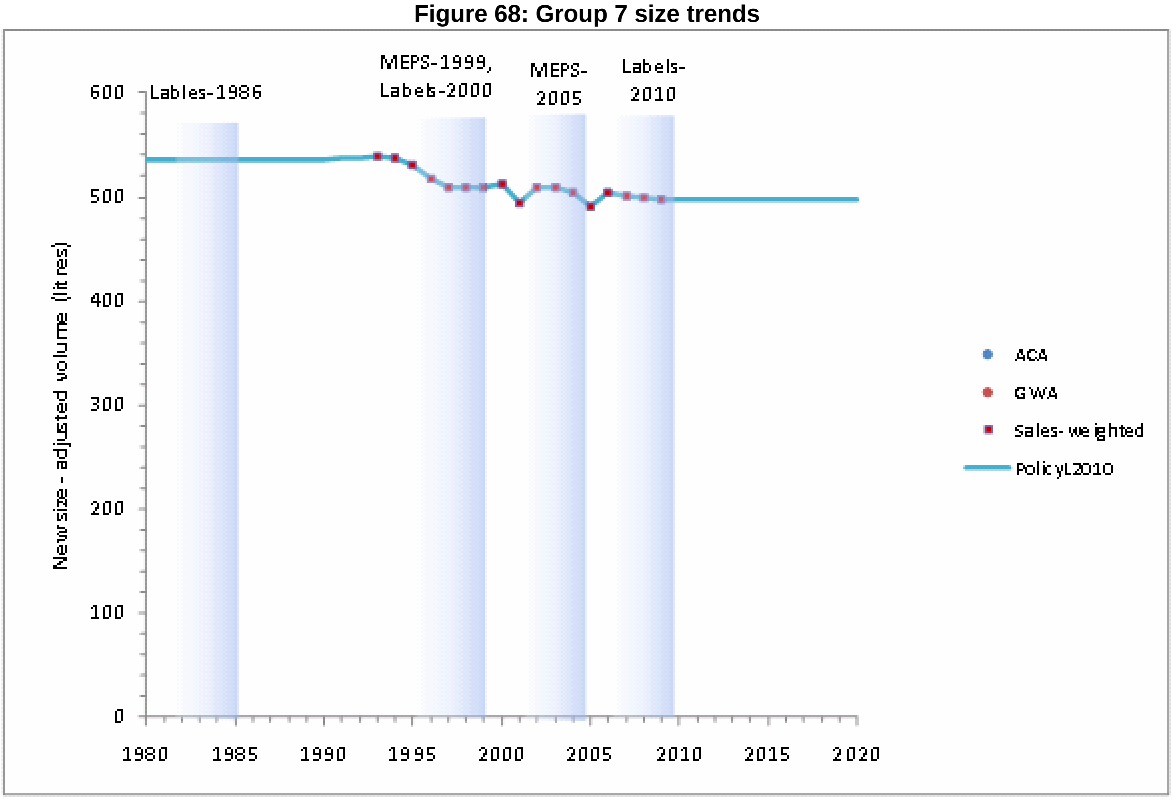
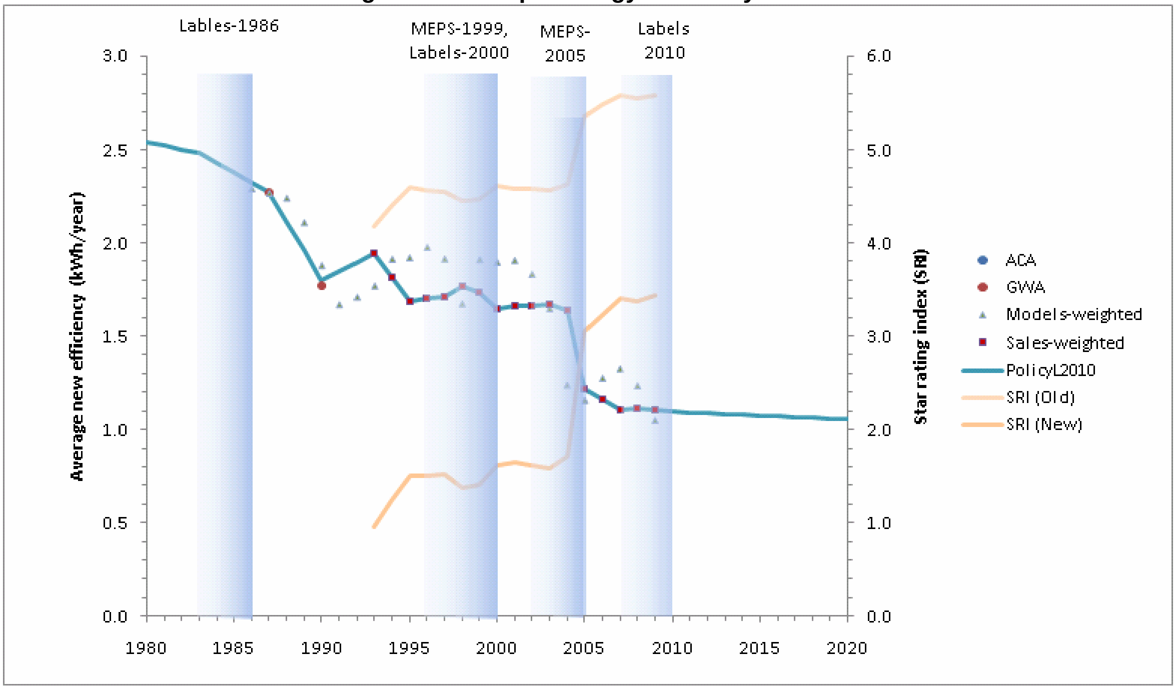


Figure 69: Group 7 energy efficiency trends



Appendix 6: EFFICIENCY SCENARIOS BY PRODUCT GROUP

For each of the ten groups, the efficiency scenarios are presented below.

Figure 70: Average efficiency for new refrigerators on sale in Australia, Group 1

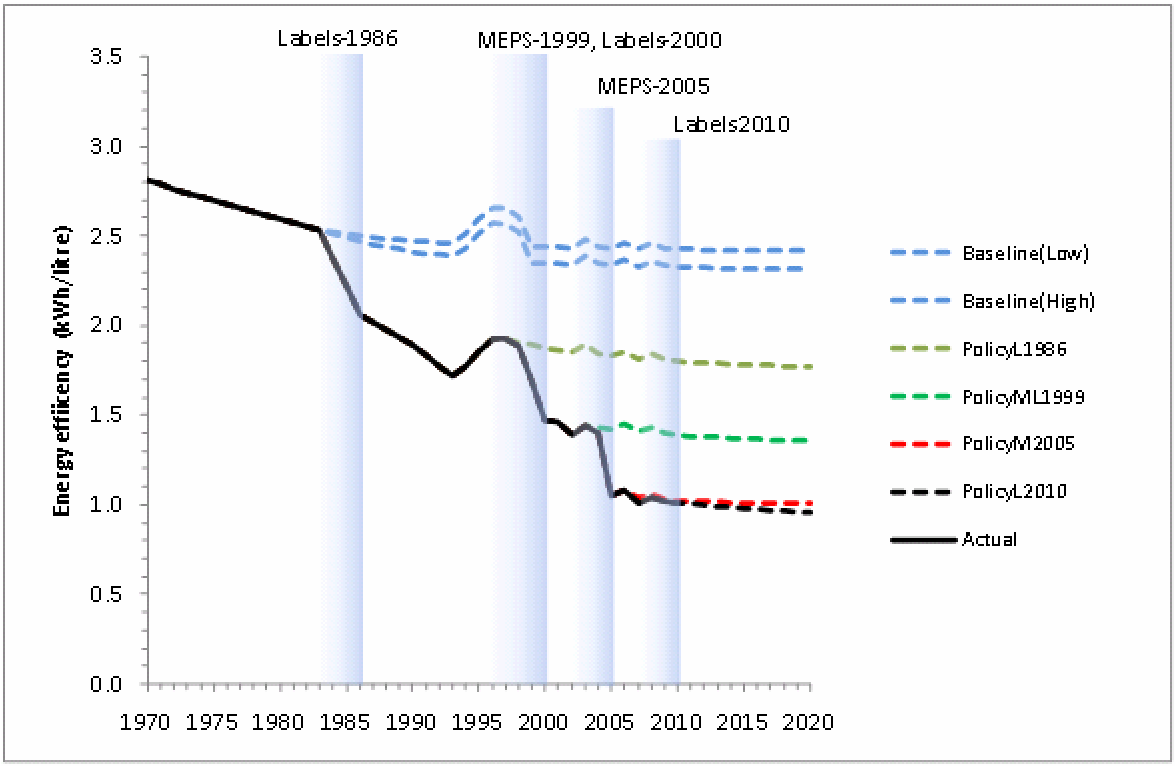


Figure 71: Average efficiency for new refrigerators on sale in Australia, Group 2

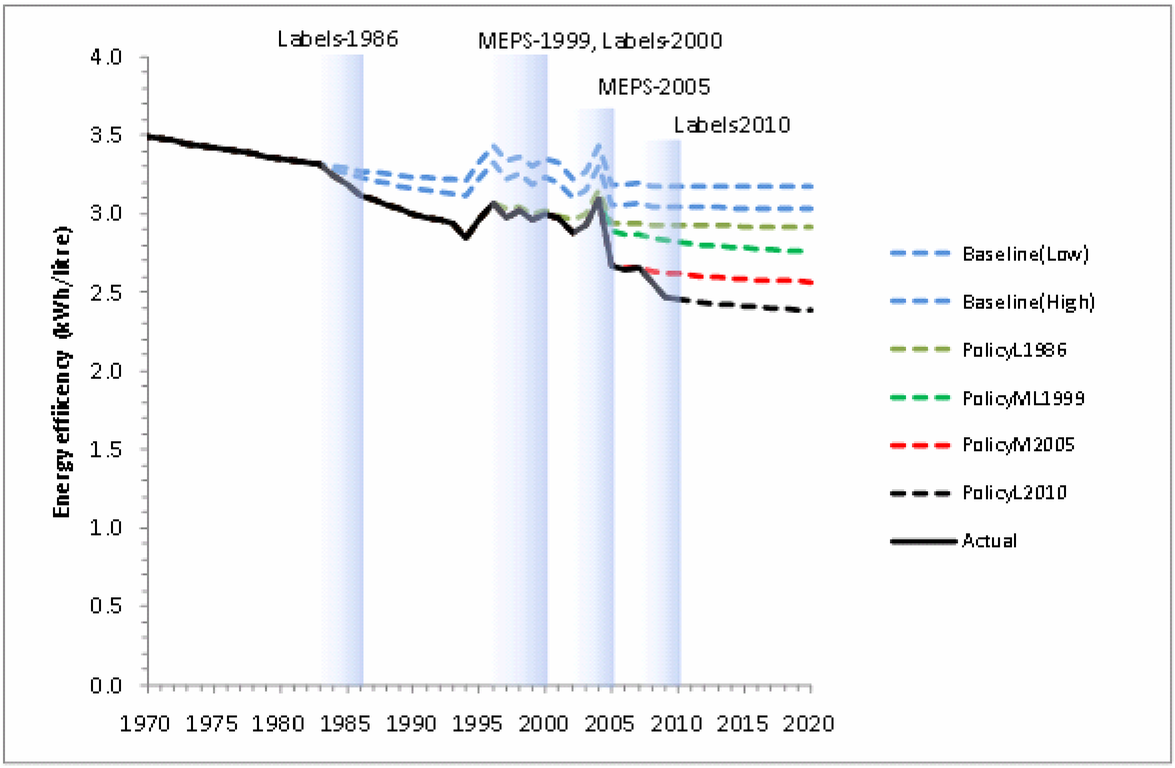


Figure 72: Average efficiency for new refrigerators on sale in Australia, Group 3

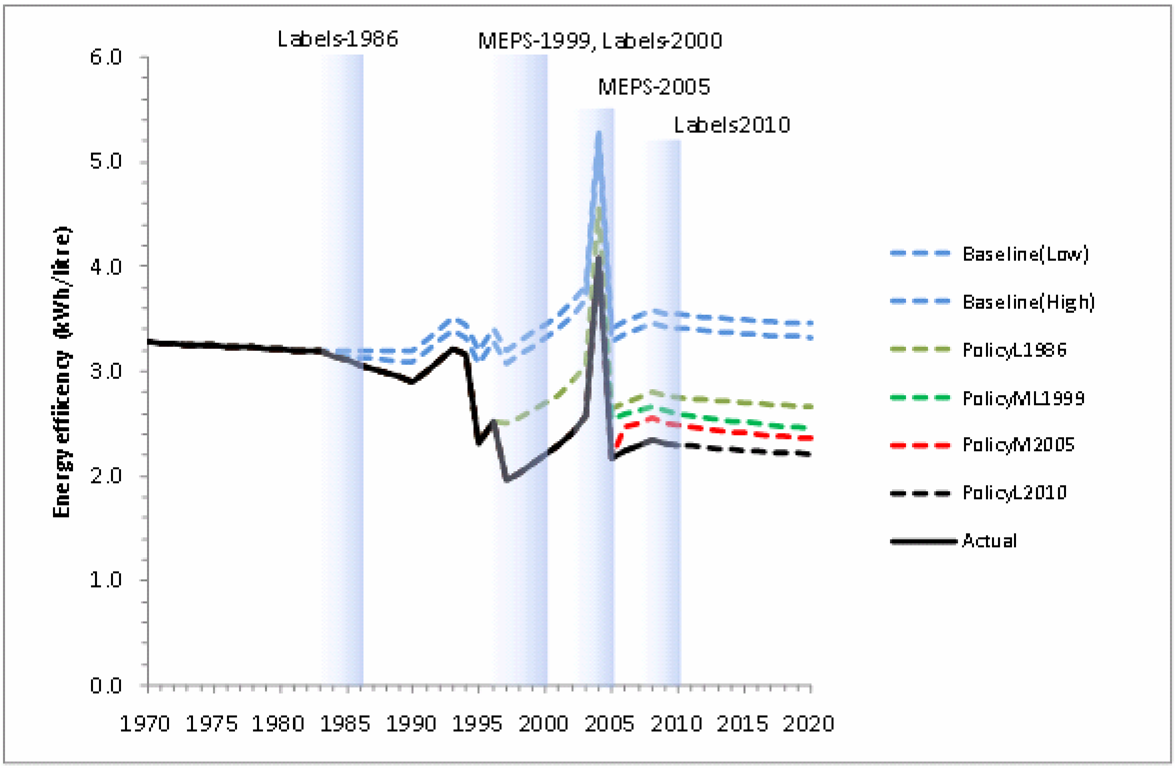


Figure 73: Average efficiency for new refrigerators on sale in Australia, Group 4

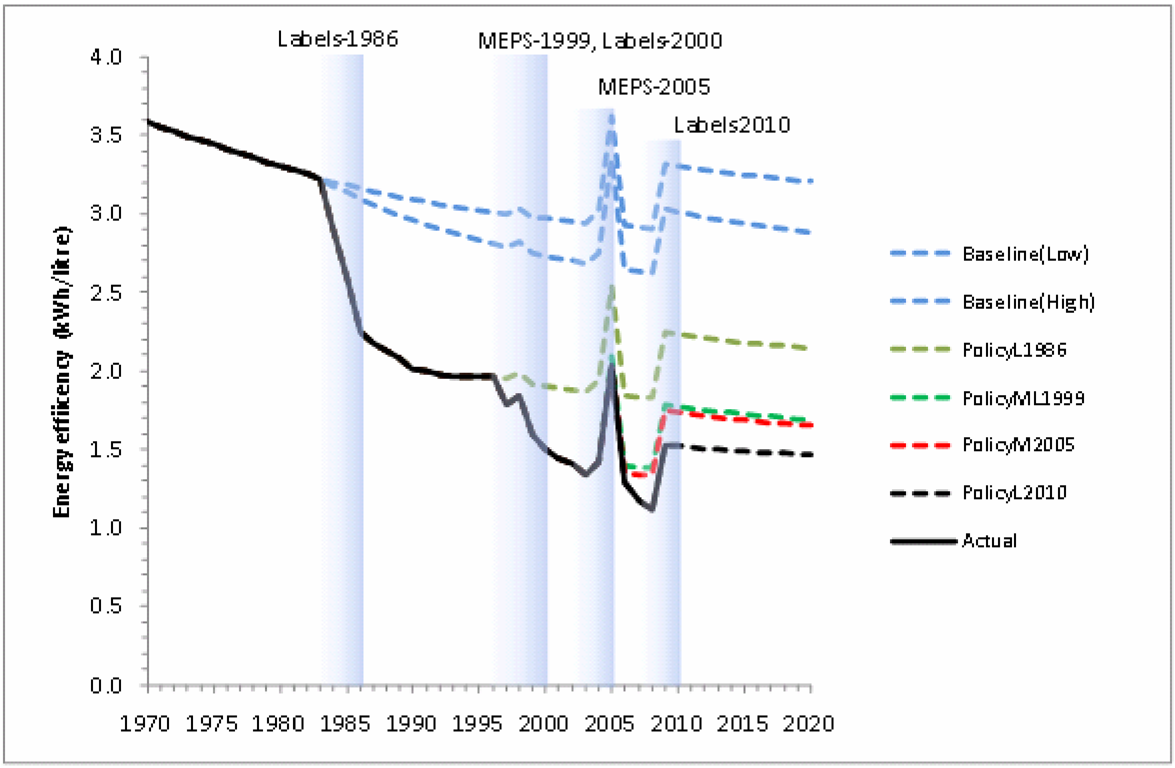


Figure 74: Average efficiency for new refrigerators on sale in Australia, Group 5T

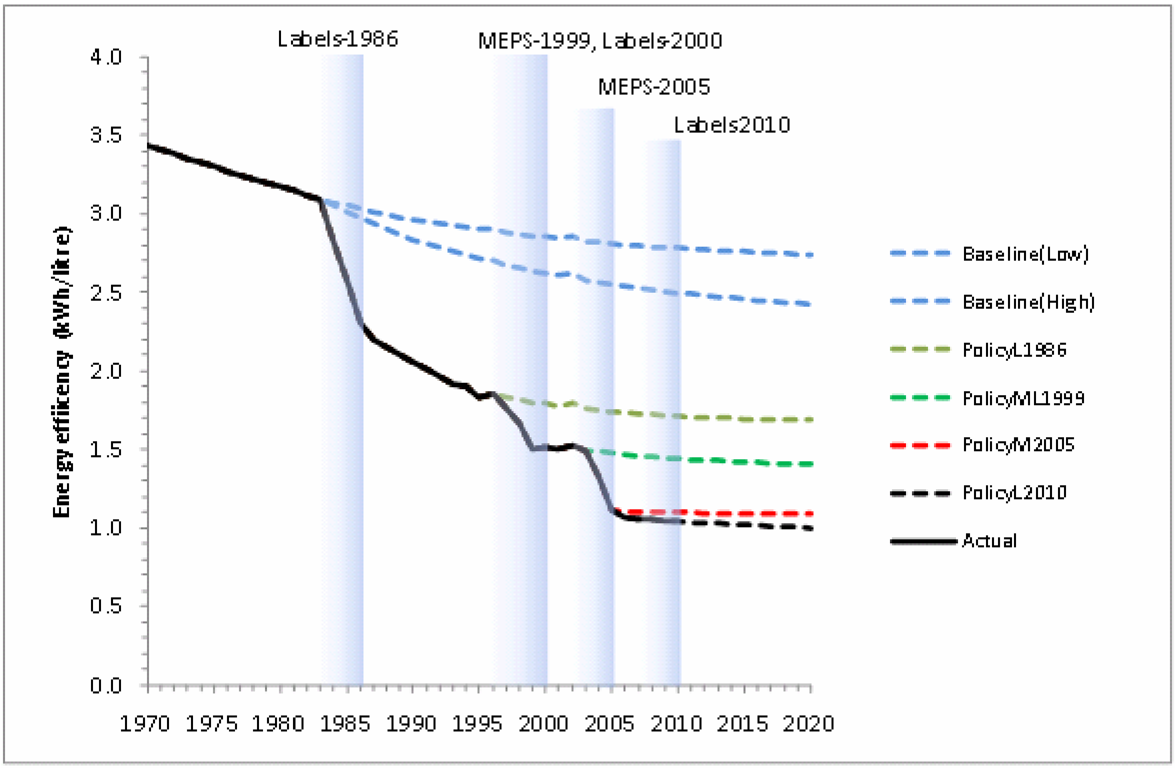


Figure 75: Average efficiency for new refrigerators on sale in Australia, Group 5B

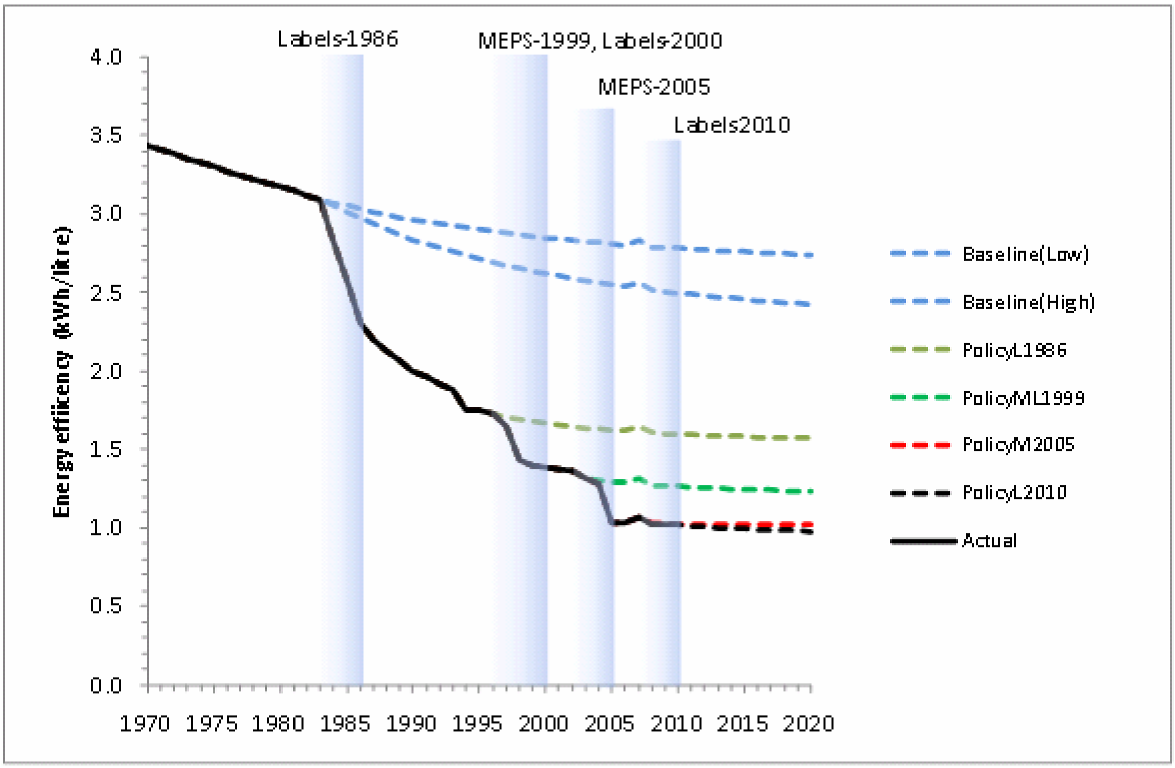


Figure 76: Average efficiency for new refrigerators on sale in Australia, Group 5S

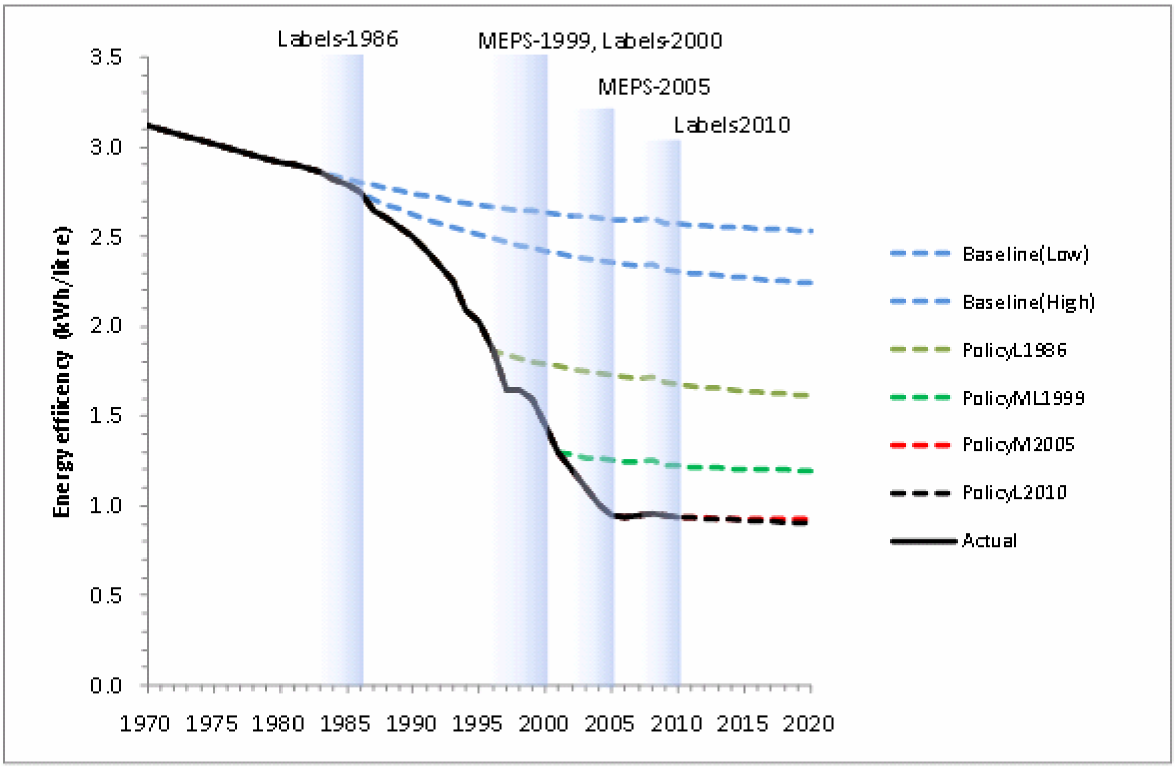


Figure 77: Average efficiency for new refrigerators on sale in Australia, Group 6U

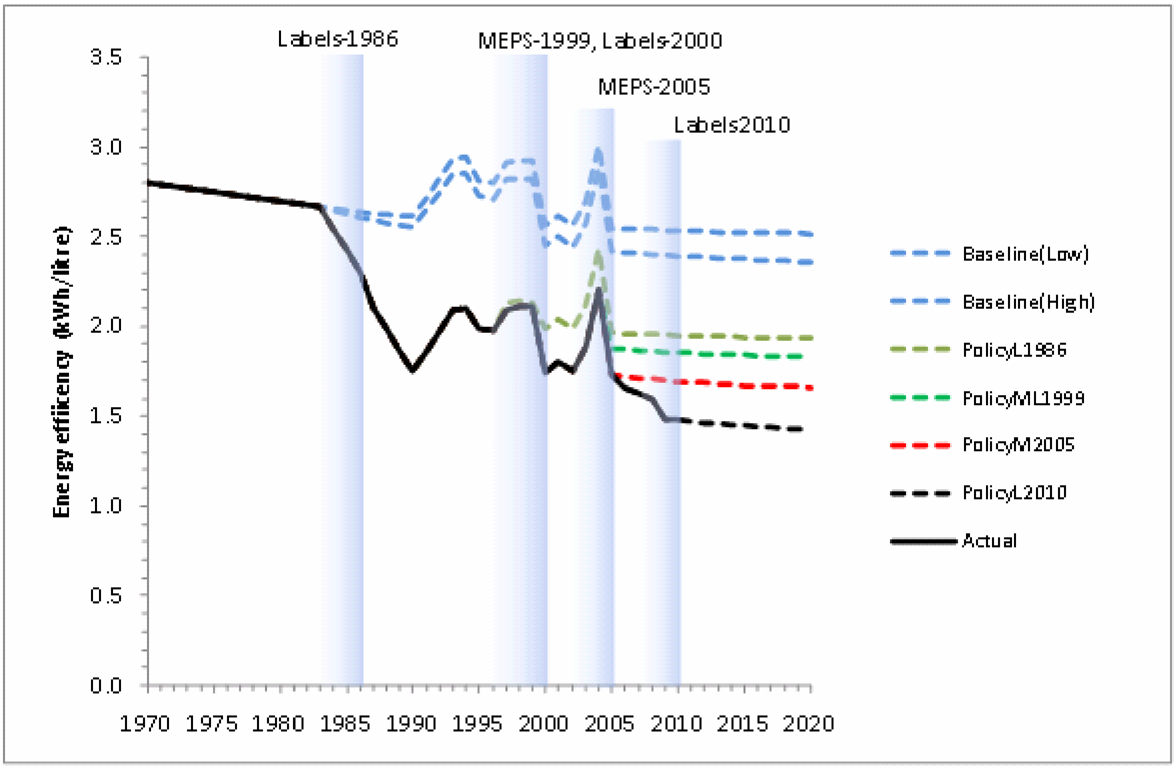


Figure 78: Average efficiency for new refrigerators on sale in Australia, Group 6C

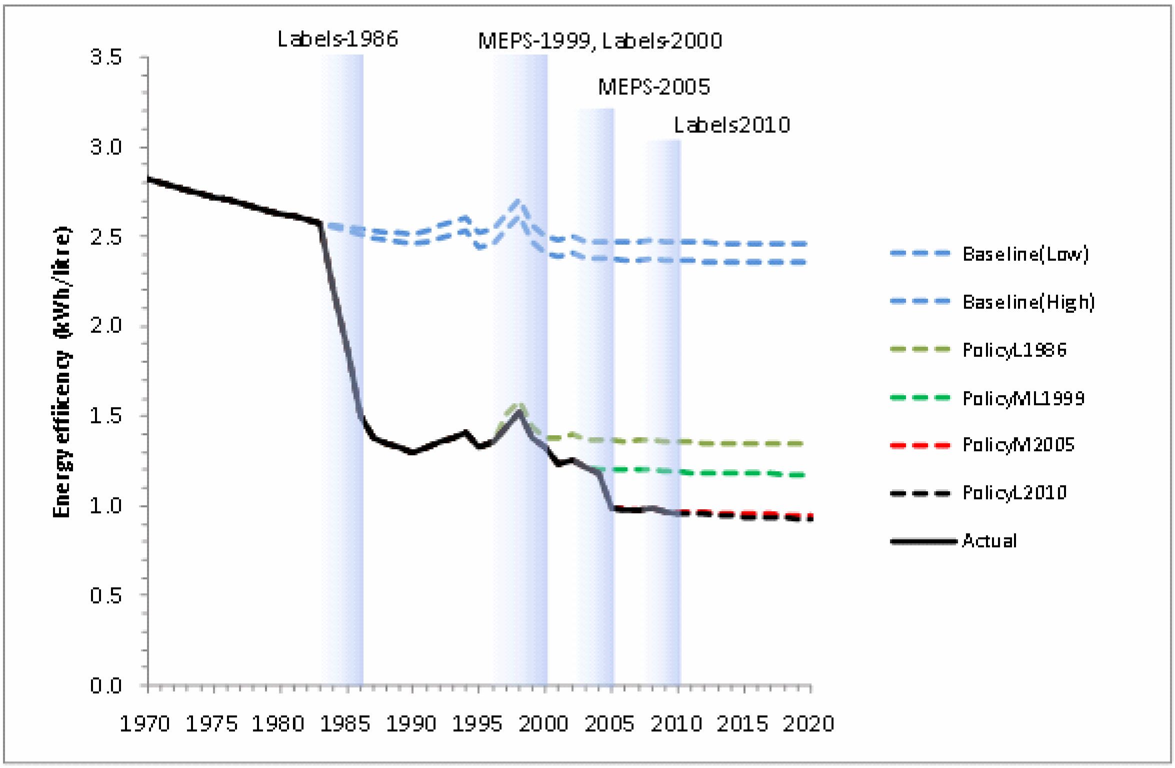
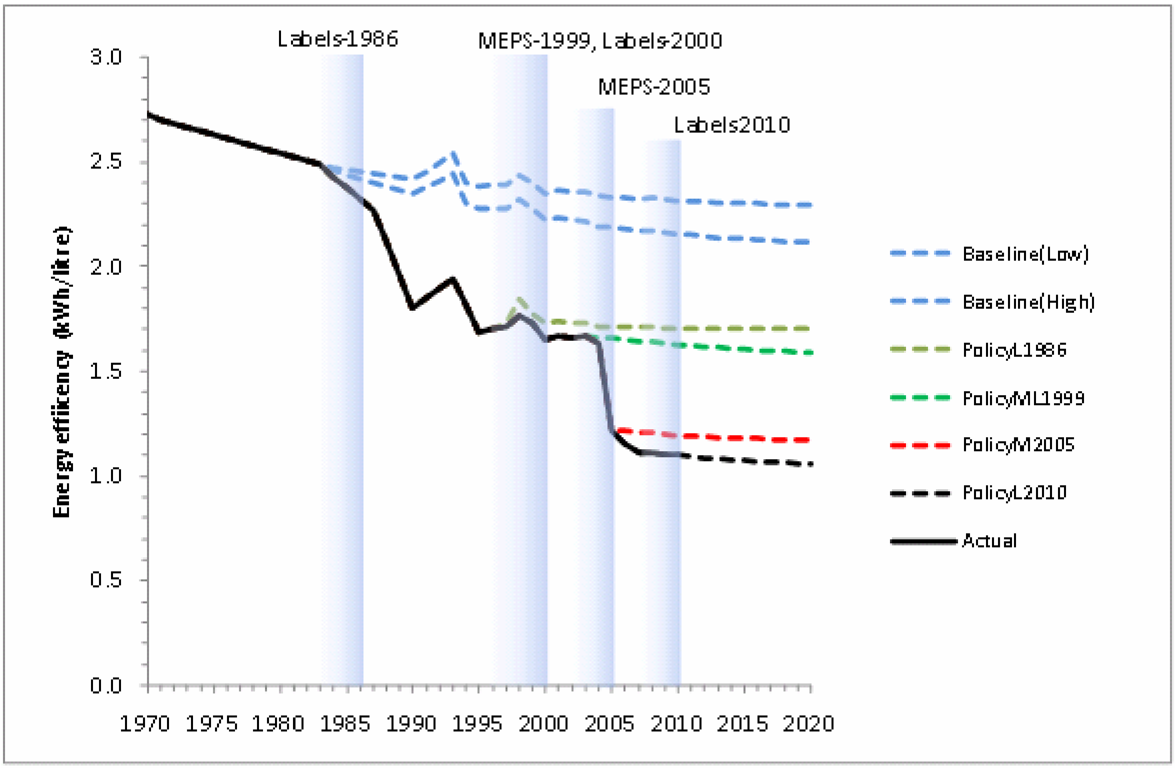


Figure 79: Average efficiency for new refrigerators on sale in Australia, Group 7



Appendix 7: CHANGES IN EFFICIENCY BY PRODUCT GROUP

This appendix illustrates the changes in product energy intensity (kWh per year/ adjusted litre) (strictly, this is the inverse of energy efficiency) over the period from 1987 when registrations began, to mid 2010 when this report was prepared.

Each chart shows, by product group, the range of energy intensity for all registrations made in each calendar year. It also shows the sales-weighted average value (based on GfK sales data) by year (pink line) as well as the best product available on the market (based on the most efficient model registered in the previous five years).

As expected, both the sales-weighted average and the best available trend down over time. The impacts of MEPS 1999 and/or MEPS 2005 are usually visible in these trends. It is interesting to note that, in very general terms, the best available product is usually about half the energy intensity of the sales weighted average for most groups and most years.

Care is required when examining individual model data for kWh per adjusted litre. This is a useful parameter for comparing trends in products of similar or average size, but the comparison may not be valid for individual models that are very large or very small when compared to the market average. However, the overall trends do provide a useful illustration of policy impacts.

Figure 80: Group 1 – models, sales-weighted average and best energy intensity by year

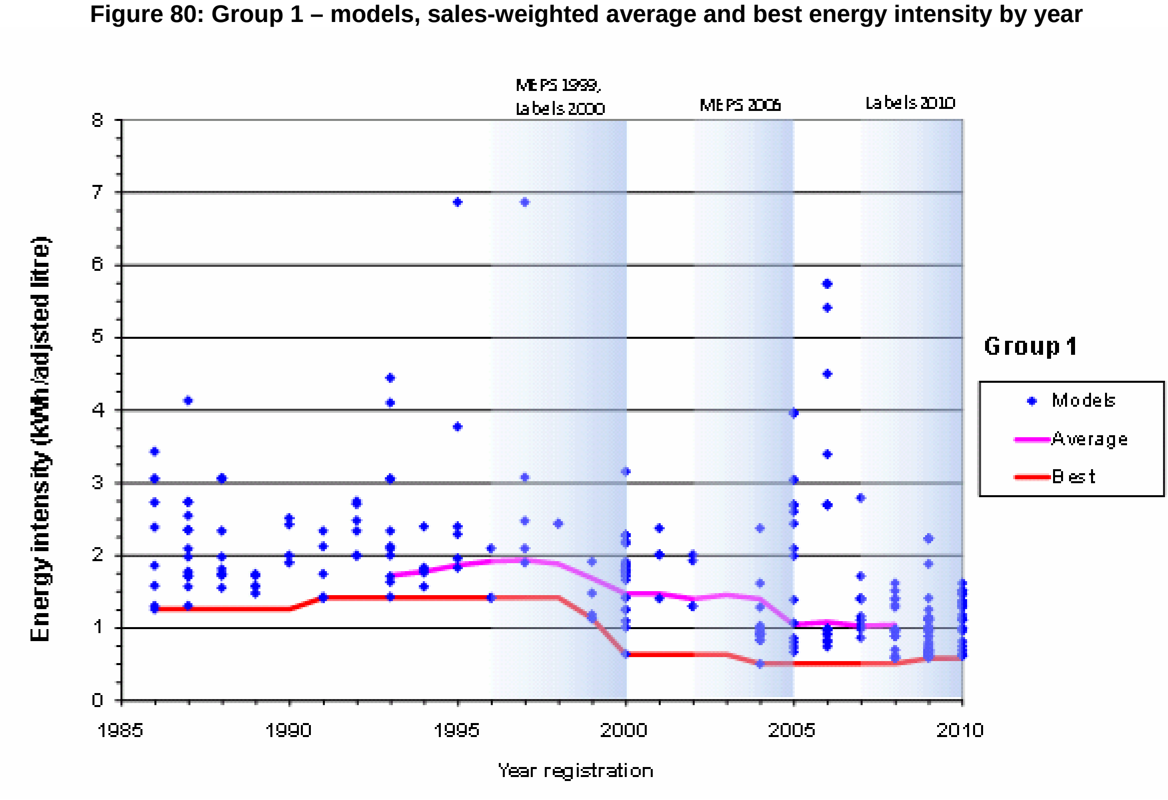


Figure 81: Group 2 – models, sales-weighted average and best energy intensity by year

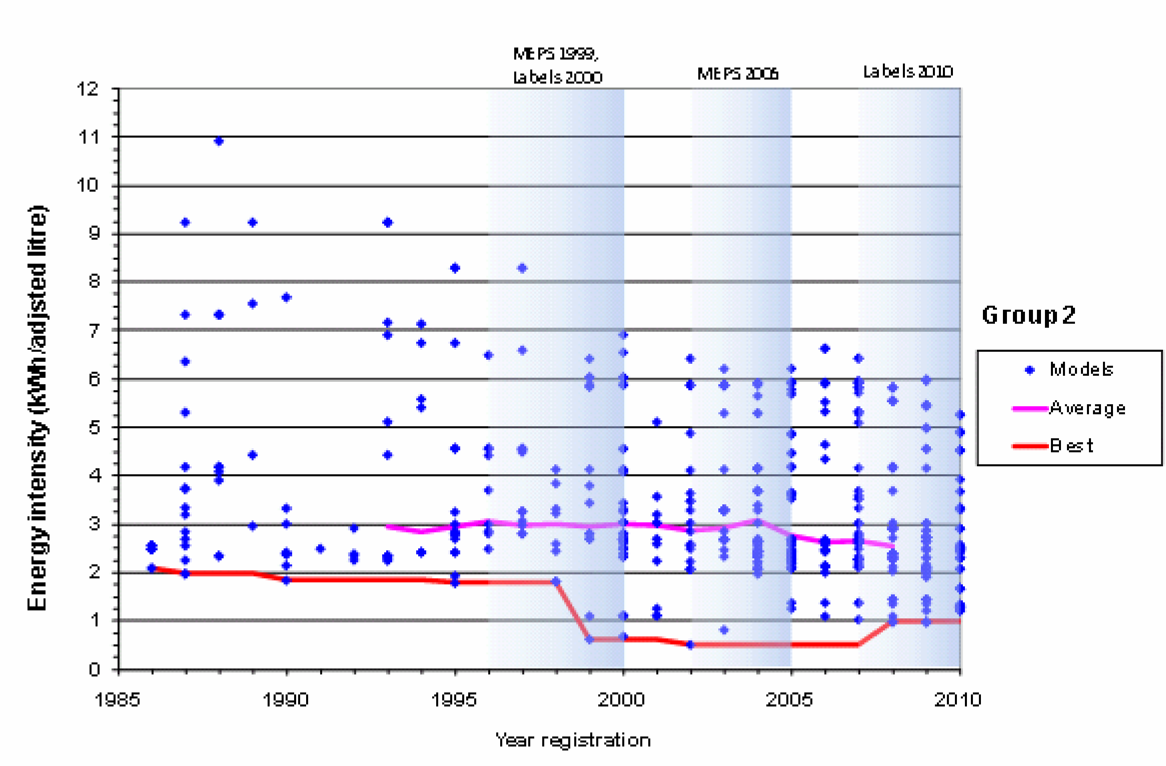
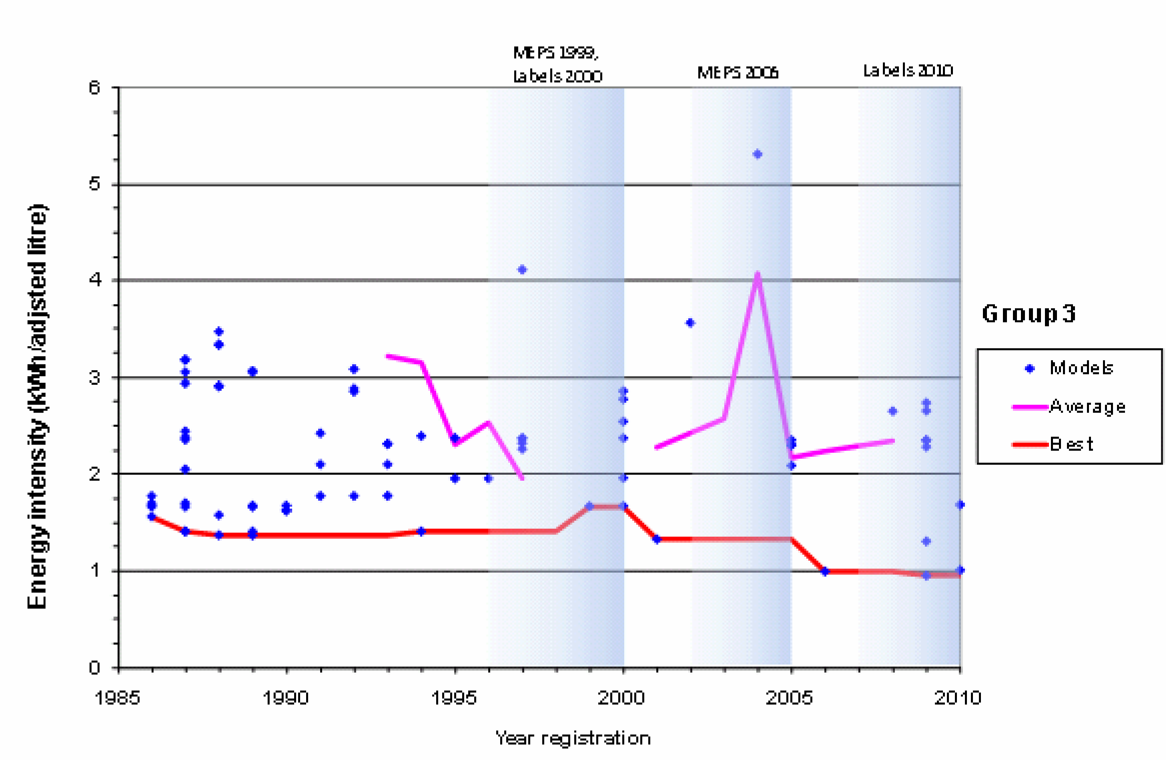
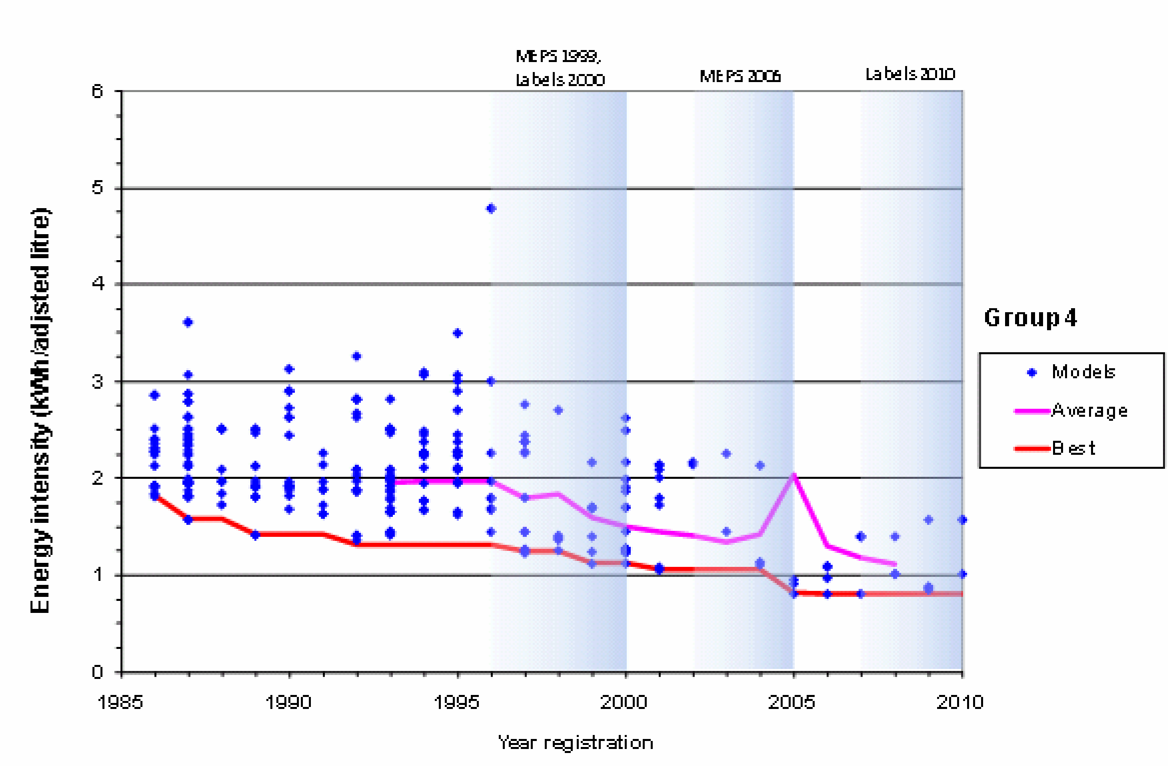


Figure 82: Group 3 – models, sales-weighted average and best energy intensity by year



Note: GfK recorded no sales for Group 3 from 1998 to 2000. Only a few models remained on the market after 2006, with almost no sales in 2004.

Figure 83: Group 4 – models, sales-weighted average and best energy intensity by year



Note: The number of Group 4 models on the market declined throughout the period, with just a few models with almost no sales remaining in the late 2000s.

Figure 84: Group 5T – models, sales-weighted average and best energy intensity by year

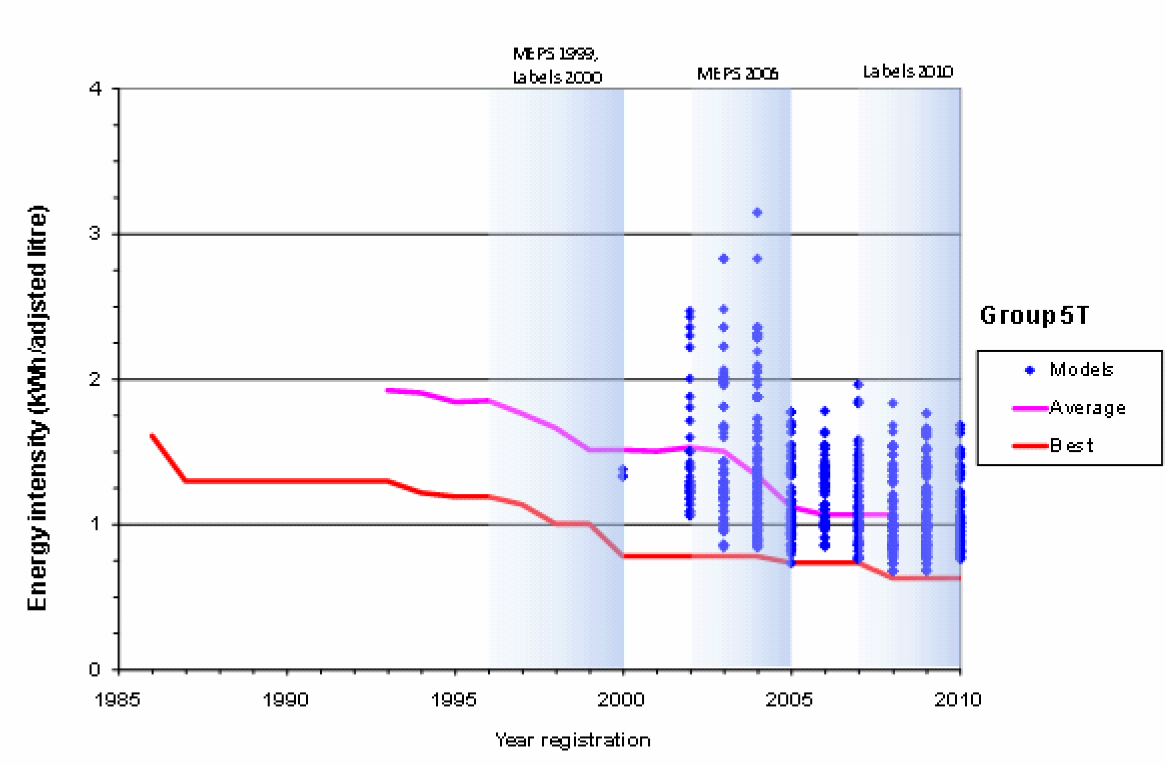
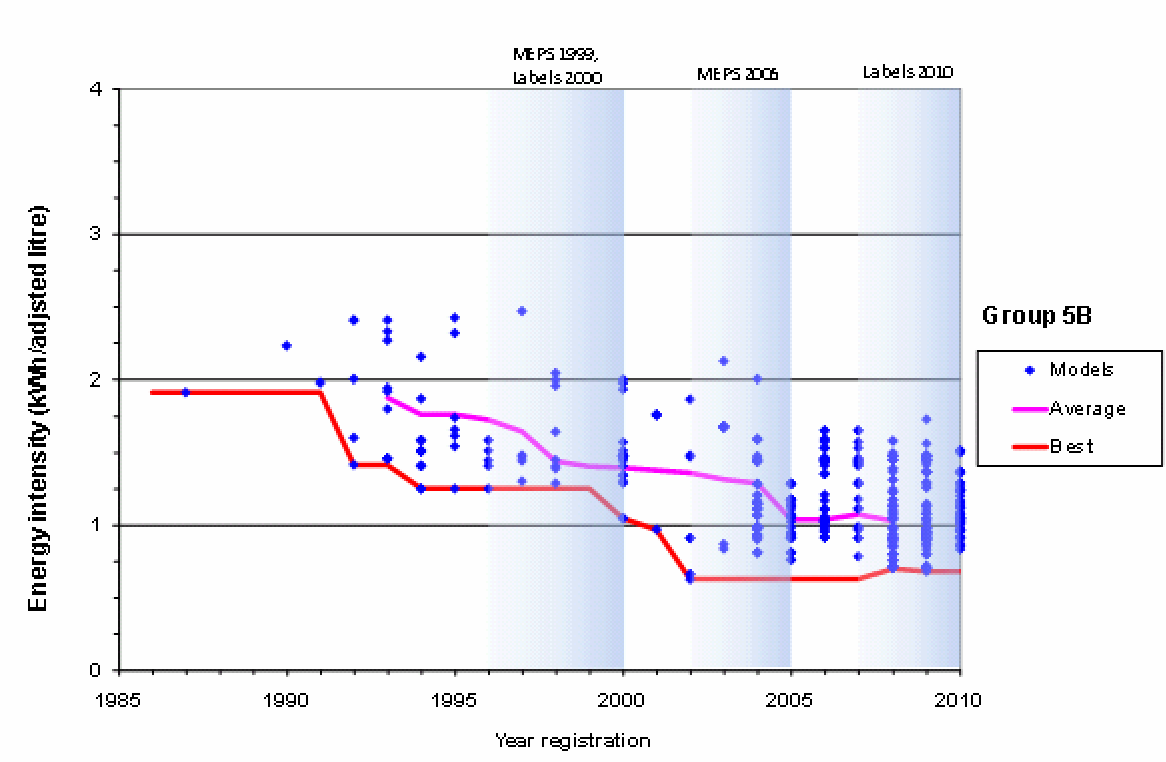


Figure 85: Group 5B – models, sales-weighted average and best energy intensity by year



Note: The number of Group 5B models on the market increased rapidly from 2004.

Figure 86: Group 5S – models, sales-weighted average and best energy intensity by year

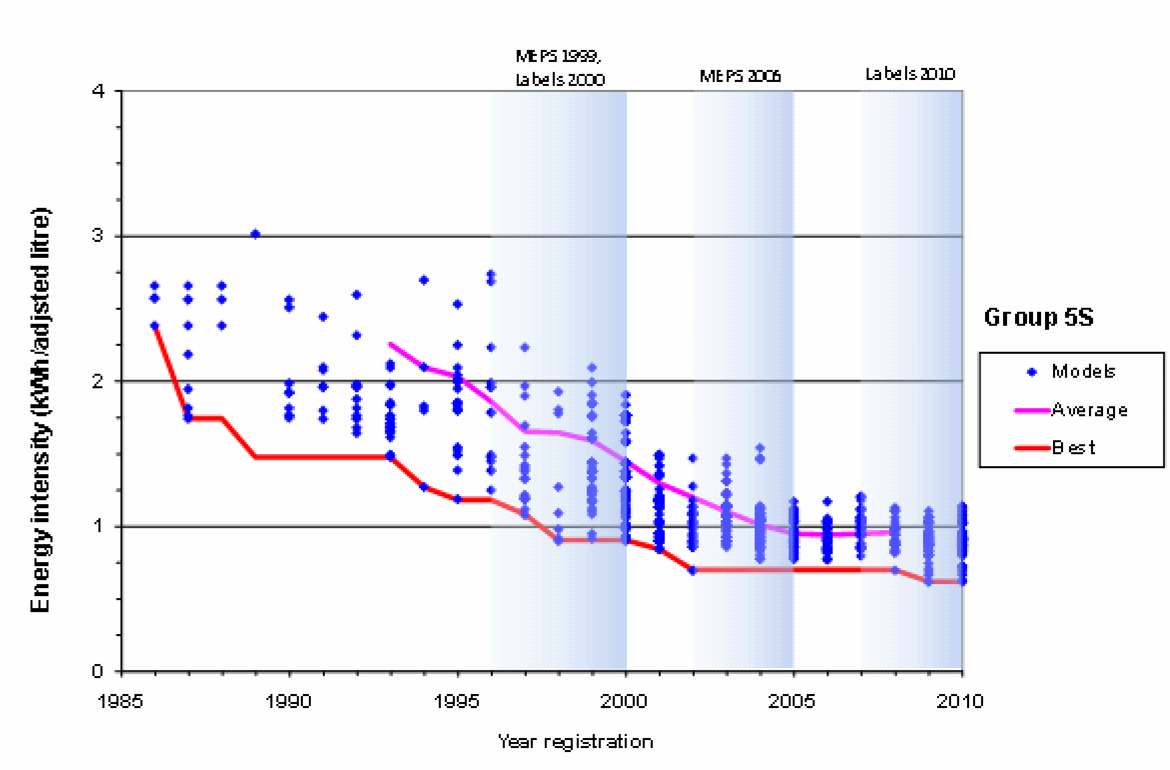
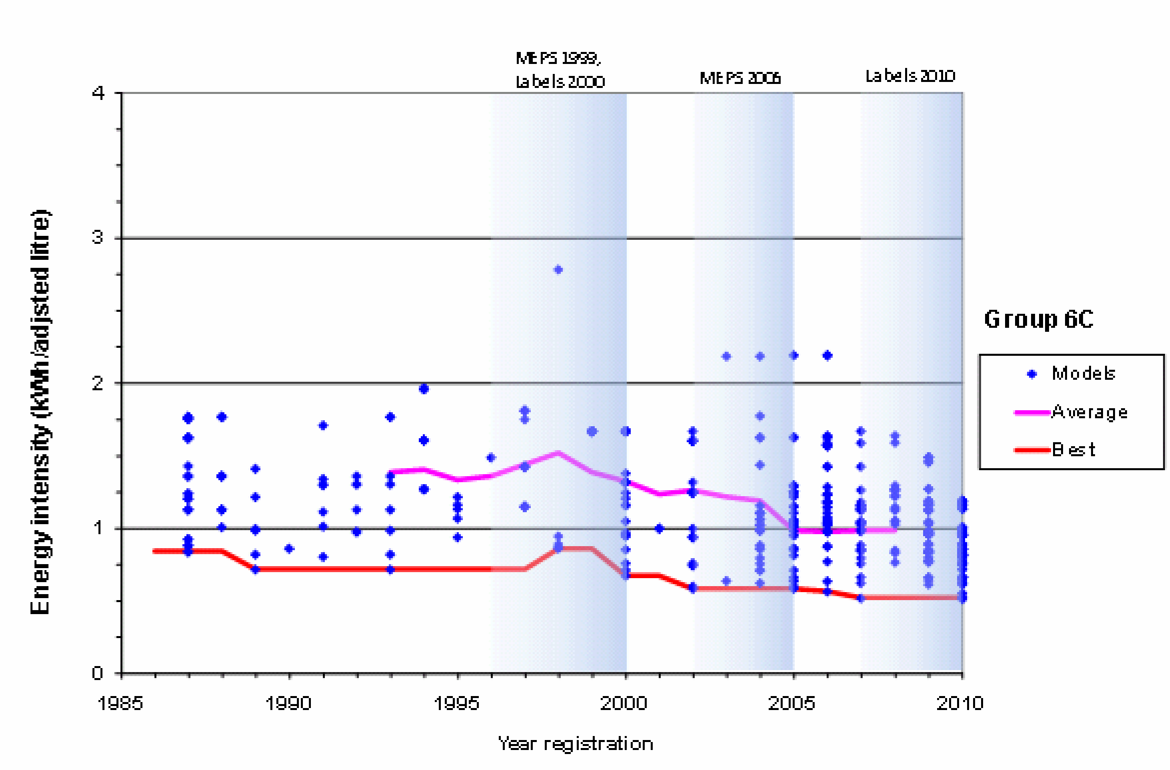
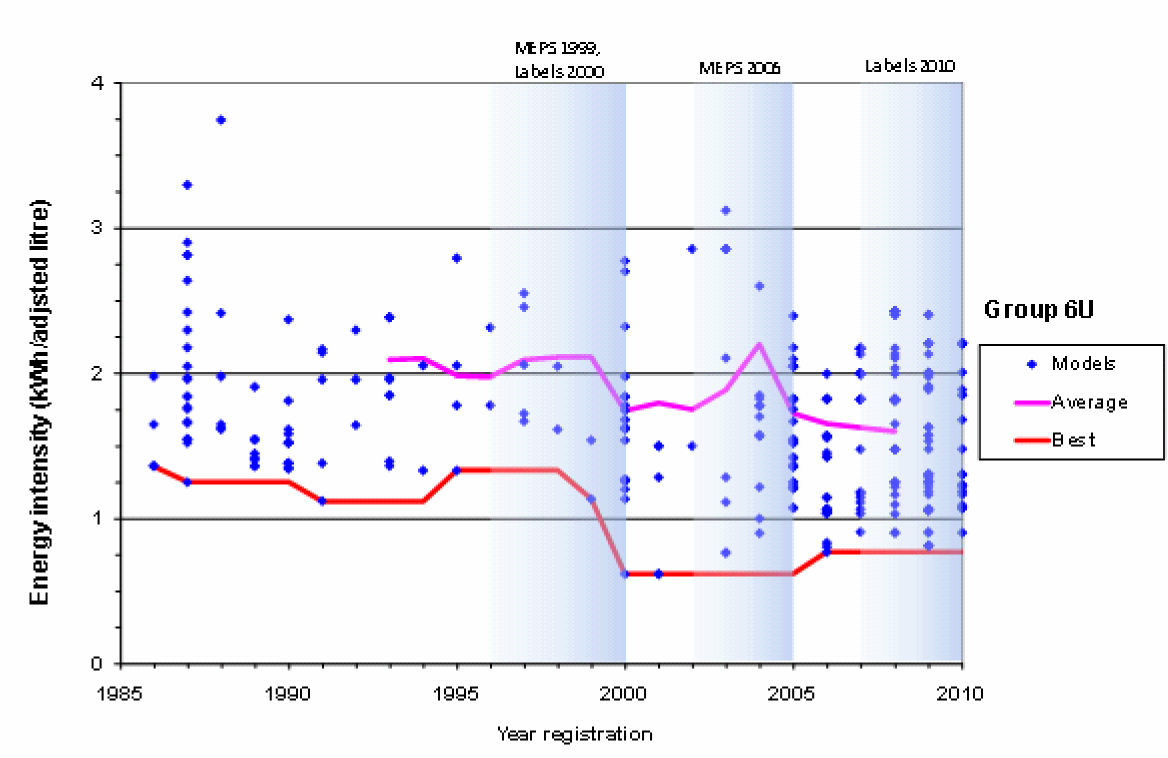


Figure 87: Group 6C – models, sales-weighted average and best energy intensity by year



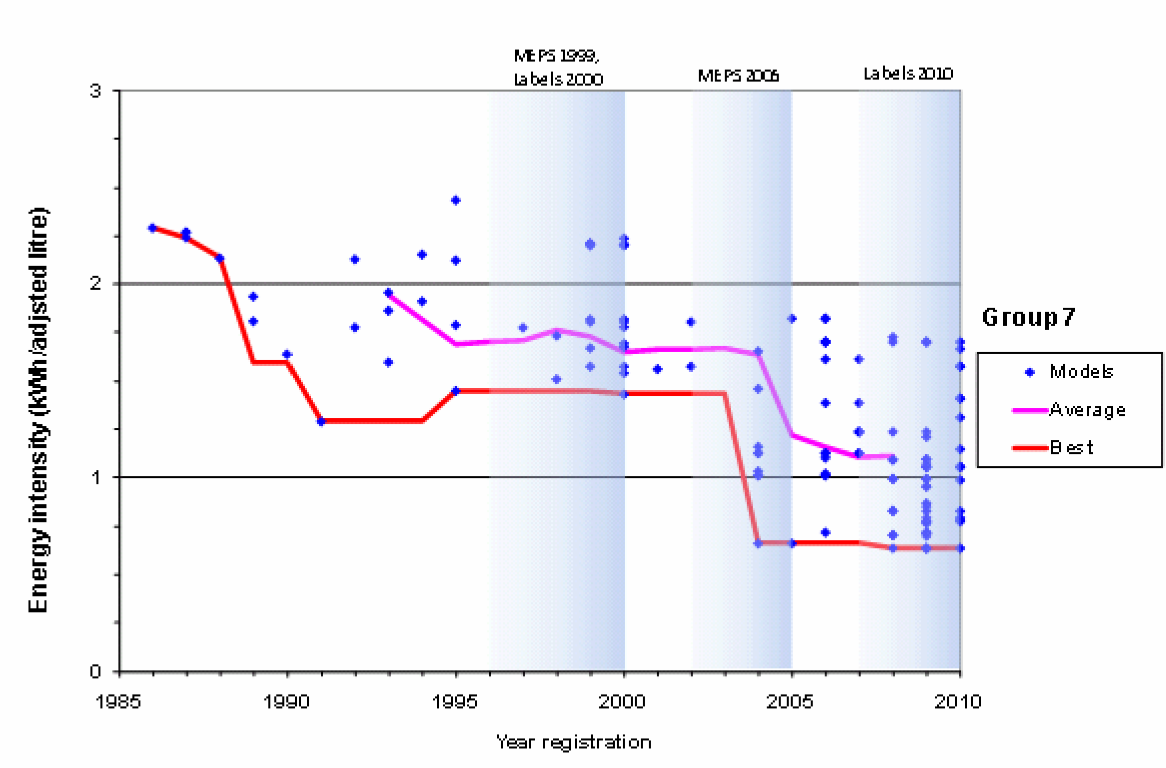
Note the deterioration of efficiency with the CFC phase out in the mid 1990s.

Figure 88: Group 6U – models, sales-weighted average and best energy intensity by year



Note the deterioration of efficiency with the CFC phase out in the mid 1990s. The average size of this group has changed significantly since 2003.

Figure 89: Group 7 – models, sales-weighted average and best energy intensity by year



Appendix 8: CHANGES IN REAL PRICES BY PRODUCT GROUP

This appendix illustrates the changes in real and nominal product prices from 1993 to 2008, the period for which accurate data is available. Detailed background and discussion on this analysis is provided in Section 3.7.

Note that the prices recorded by GfK are in nominal dollars at the time (year) of sale and include GST from 2000. It is important to correct prices over a long period of time using the ABS consumer price index, which is a widely accepted measure for correcting costs for inflation. ABS publishes its cost price index as ABS6401. ABS publishes consumer price indexes for a range of parameters, including one called ‘household contents and services’. The most common index used is “all groups” as this is a weighted average of all goods and services and is a reasonable representation of the relative purchasing power of money over time. The indexes for ‘all groups’ and ‘household contents and services’ are illustrated from 1993 to date in Figure 20, the period for which accurate appliance price data are available.

In order to assess whether MEPS had any significant price impact over time, the following parameters have been calculated for each group for each year from 1993 to 2008 (latest year of available data which is fully analysed):

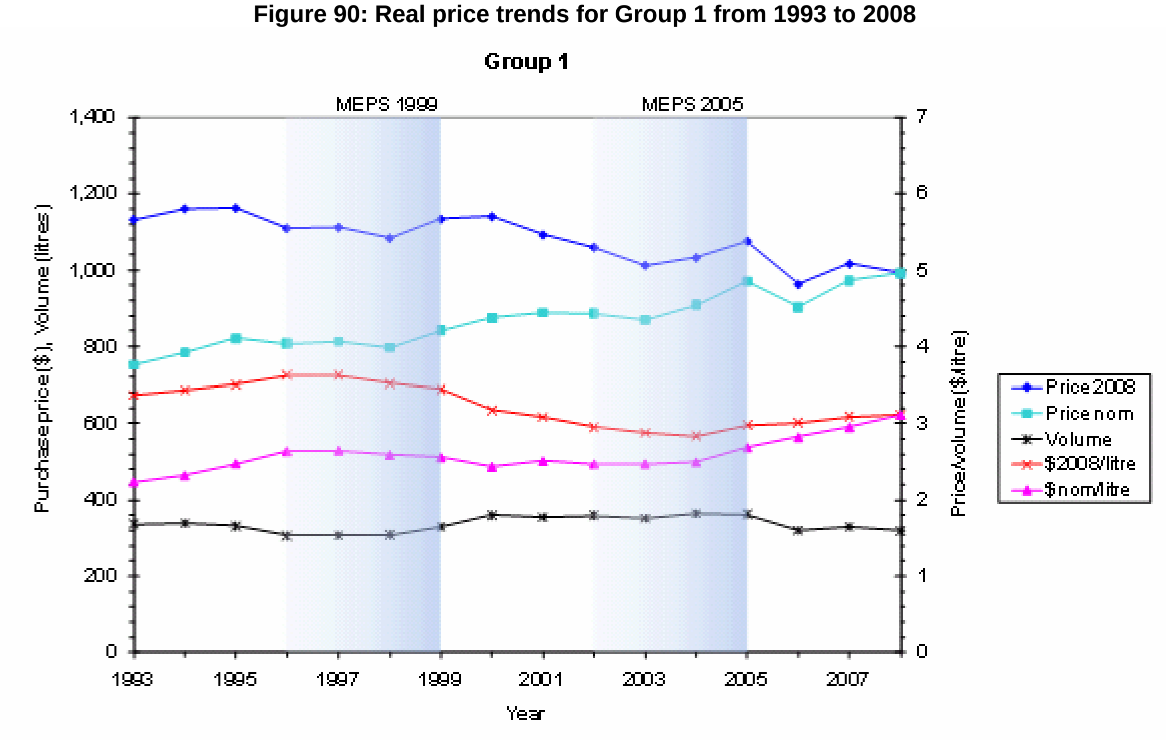
- Average price in nominal dollars by year
- Average price in 2008 dollars (corrected using CPI all groups) by year
- Total volume in adjusted litres
- Average price per adjusted litre in nominal dollars by year
- Average price in 2008 dollars per adjusted litre (corrected using CPI all groups) by year

It is necessary to track volume over time as changes towards smaller or larger sizes can impact on prices. Where volumes are changing, price per adjusted litre of volume gives a better indication of price trends.

Group 1 price trends

Group 1 is fairly unusual as many models are higher end local product or higher end products from Europe, sometimes used as 'pigeon pairs' (matched all refrigerator and separate freezer). Real prices are falling at about 0.9% per annum. Expected price increase from MEPS 2005 was $35. Actual prices appeared to increase about $60 over two years in the lead up to MEPS 2005, but fell in 2006 on trend. Based on the trend in $/litre, MEPS 1999 had no visible impact while MEPS 2005 may have had some impact, but within the predicted price rise parameters.

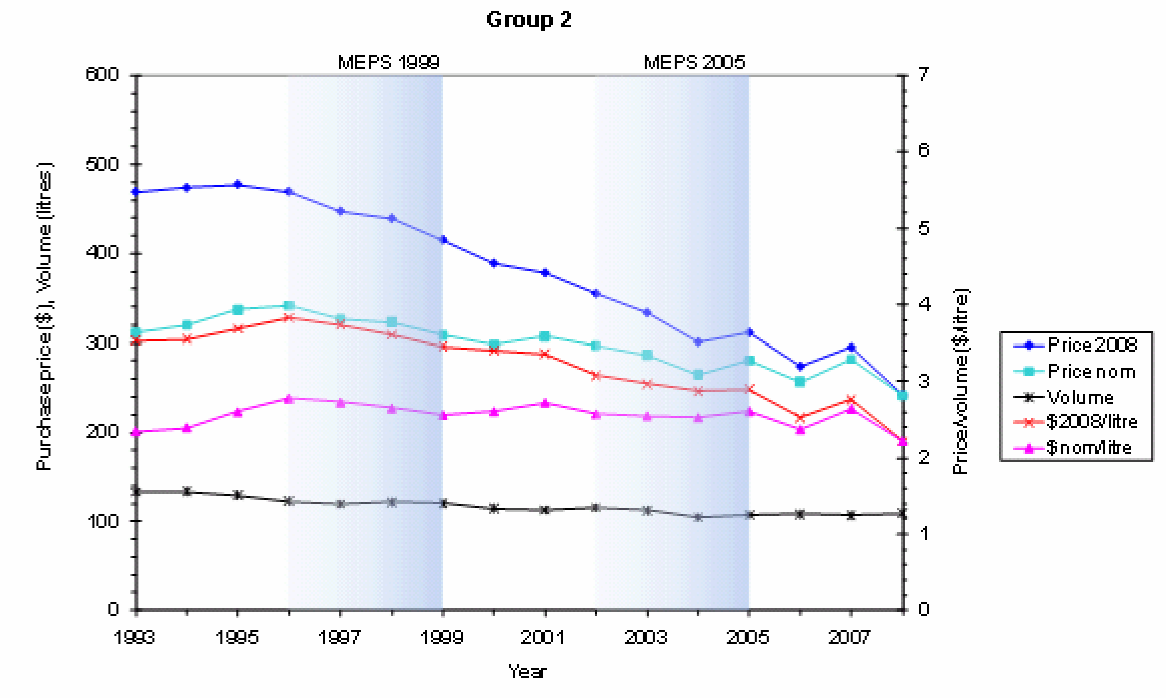
Figure 90: Real price trends for Group 1 from 1993 to 2008



Group 2 price trends

Group 2 are small low-cost 'bar' refrigerators that are commonly used in commercial offices and as second household refrigerators. Real prices are falling at 4.5% per annum, which is very rapid (probably explained by low cost products from Asia now dominating the market). The expected price increase from MEPS 2005 was $5, which is not visible in the noise from the data. The actual prices decrease appeared to slow at 2005 but trend line then continues at same rate on trend after 2006. It appears that there was no obvious effect from MEPS 1999 or 2005, which is as expected.

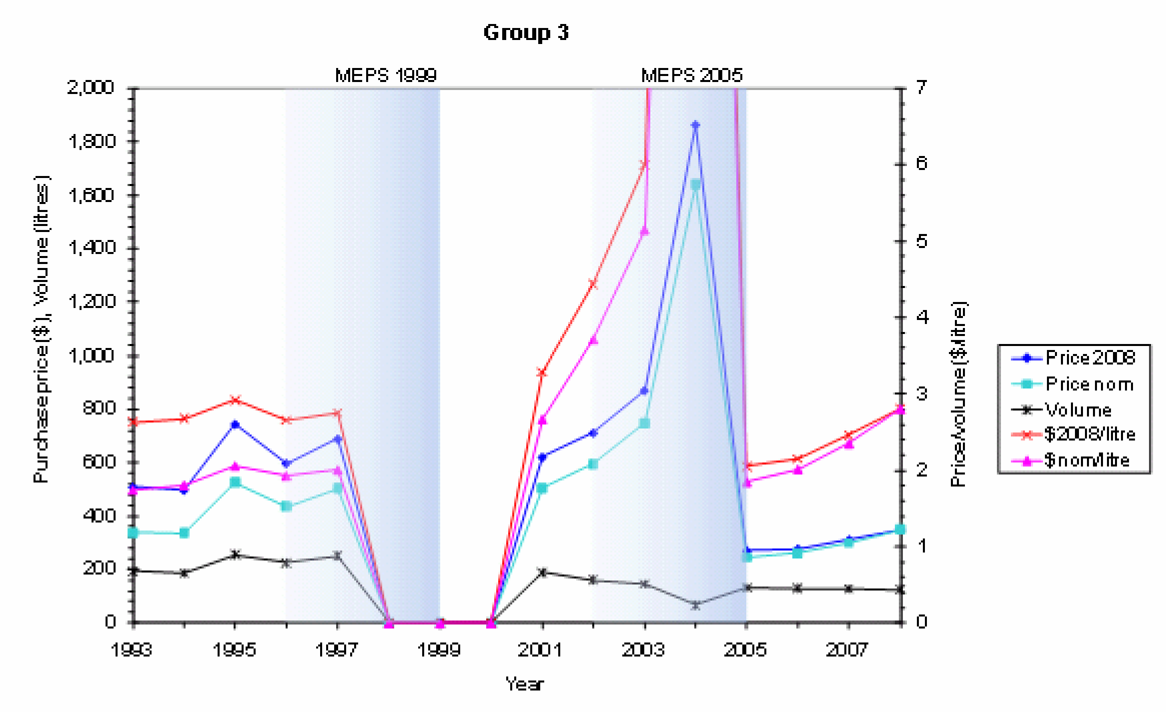
Figure 91: Real price trends for Group2 from 1993 to 2008



Group 3 price trends

Group 3 are typically large single door refrigerators with a small short term frozen food compartment inside. These products have all but disappeared from the market after 2000 so any price analysis is fairly meaningless. A few models come and go (a couple of low end low cost models and a couple of high end European products that do not qualify as Group 4) so the year to year price variation is highly volatile.

Figure 92: Real price trends for Group 3 from 1993 to 2008

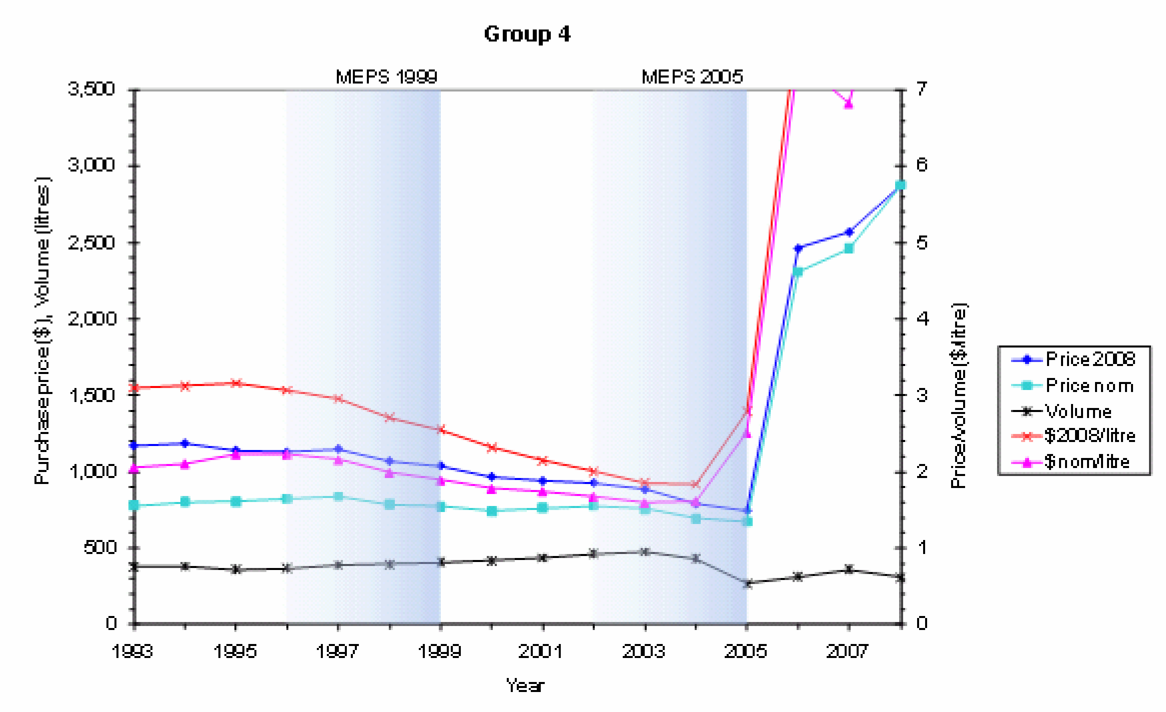


Note: Sales of group 3 ceased 1998 to 2000 and only a couple of models remained on the market after 2003, hence the price volatility.

Group 4 price trends

Group 4 are 2 door refrigerator freezers with a cyclic defrost fresh food compartment and a manual defrost freezer. Back in 1993 these had a 30% share of the market but declined until 2005 when they virtually disappeared, so any price analysis is fairly meaningless towards the end of the series. Less than 200 units were sold each year from 2006 to 2008 (out of total refrigerator sales of 800,000 per year). The handful of models left tend to be high-end European models, so the apparent average price of this group skyrocketed in 2006 as mainstream products disappeared.

Figure 93: Real price trends for Group 4 from 1993 to 2008

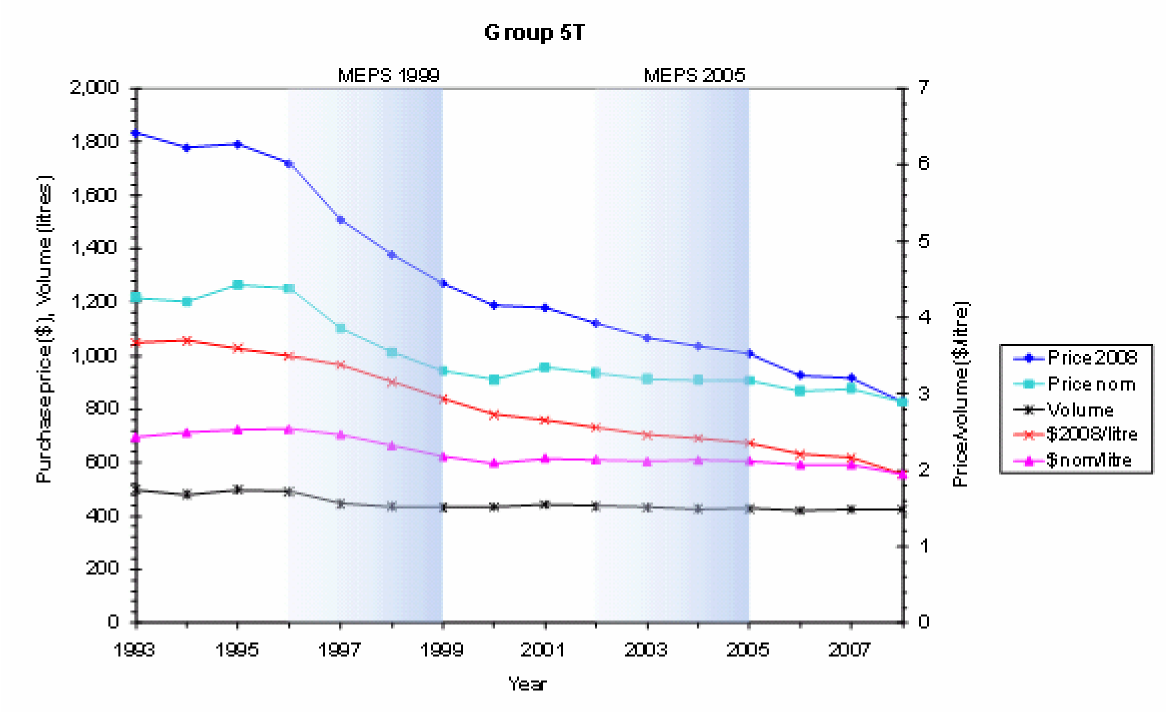


Note: Only a couple of high end expensive models remained on the market after 2005, hence prices rise rapidly. Only a few hundred units were sold in 2008.

Group 5T price trends

Group 5T are two-door refrigerator freezers which have fully automatic defrost with a freezer at the top. This group has had over 50% market share since 1999. Real prices are decreasing very rapidly at 5.5% per annum. The expected price increase from MEPS 2005 was $31. Actual prices declined smoothly and continuously since mid the 1990s. Based on analysis of all parameters there was no obvious effect on price from MEPS 1999 or 2005. If there was any price rise due to MEPS 2005, it is within the predicted bounds set out in the RIS. However, given the rapid falls in price over the period, the expected price increase may not be clearly visible.

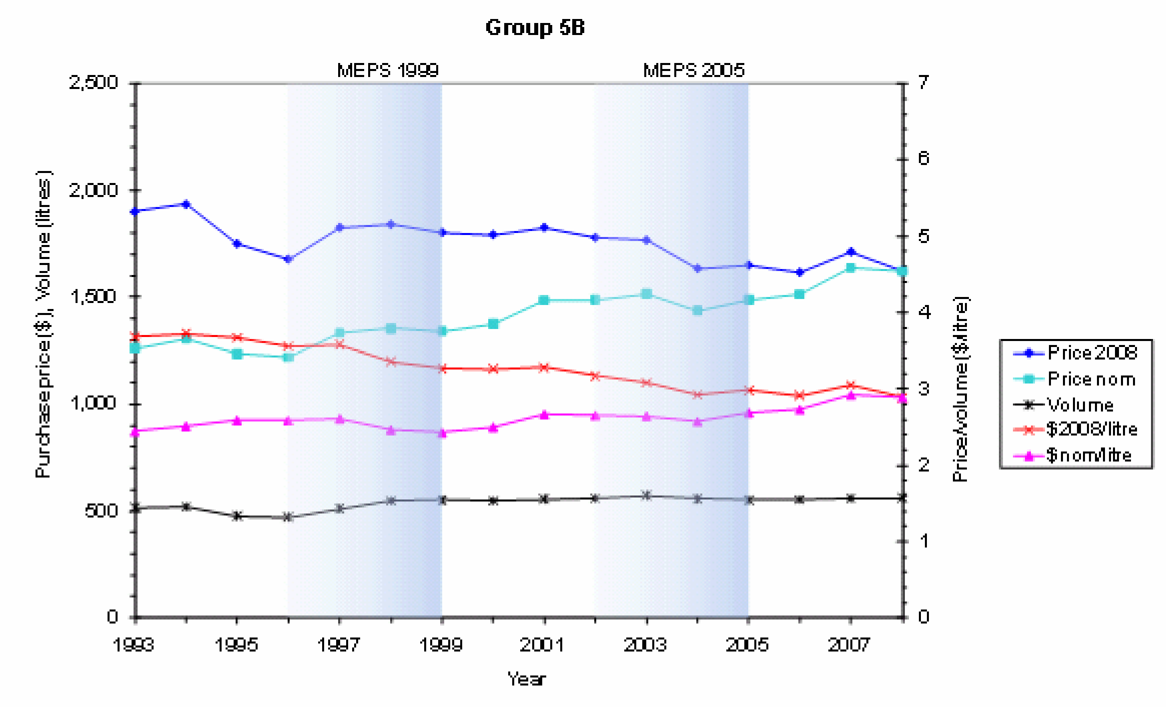
Figure 94: Real price trends for Group 5T from 1993 to 2008



Group 5B price trends

Group 5B are two-door refrigerator freezers which have fully automatic defrost with a freezer positioned at the bottom. This group typically has about 10% to 15% market share, but is increasing in recent years. This is an unusual group as it is larger products that tend to be at the higher end of the market with a large share of local production. Real prices are decreasing at a moderate 1.1% per annum. No explicit price impact was provided in the RIS for MEPS 2005 for this group (it was combined with Group 5T, so a nominal average price increase of $31 is assumed, even though on average these products cost twice as much as Group 5T products). Actual prices decreased from 2004 to 2006 but were again on the trend line by 2007. Even with the gradual price falls, there was no obvious effect from MEPS 1999 and possibly a small effect 2005, but within the expect price impacts.

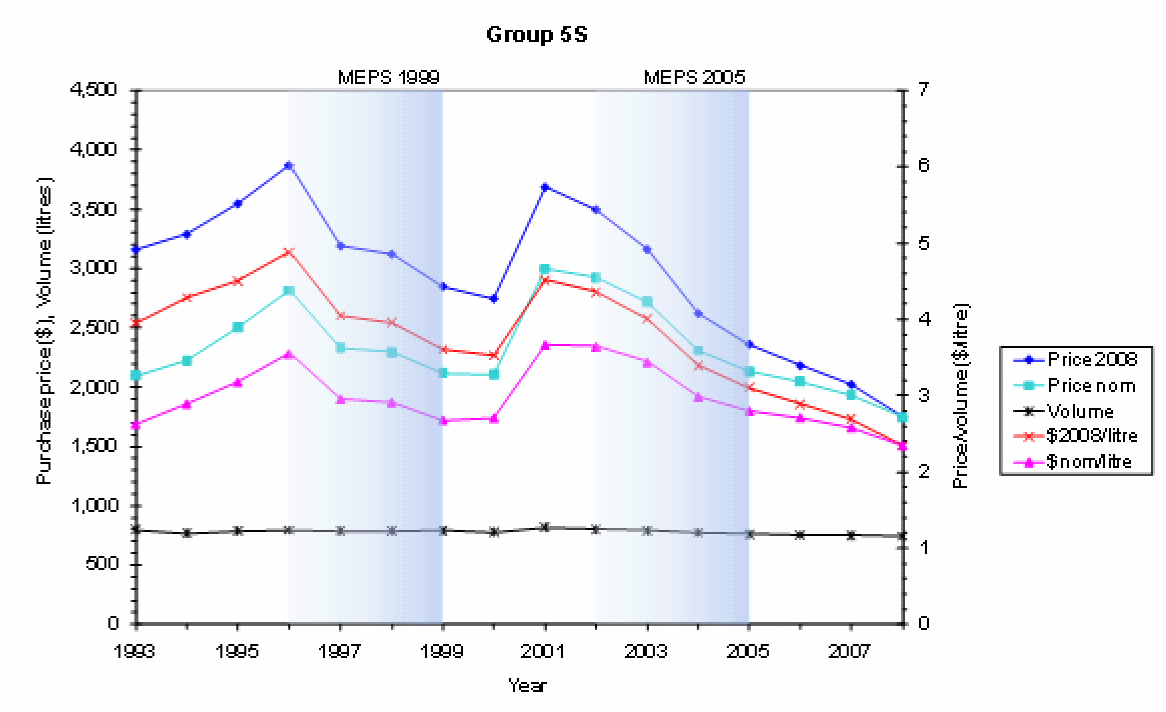
Figure 95: Real price trends for Group 5B from 1993 to 2008



Group 5S price trends

Group 5S are two-door refrigerator freezers which have fully automatic defrost in a side-by-side configuration. This group was about 5% market share in the 1990s but has climbed to 15% market share by 2008. Even though there are some price data before 2001, the data sets before and after 2001 are not comparable. Before 2001 data were only available for a few larger selling models, so the average price was under-stated. This market segment is characterised by a large number of models with few sales. Full market data were only available from 2001. There is also evidence that strong price competition from Asian suppliers increased during this period, hence the very strong decline in real prices from 2001 to 2008 (50% reduction in seven years). The expected price increase from MEPS 2005 was $171, which is significant. If there was any price rise due to MEPS 2005, it is within the predicted bounds set out in the RIS. However, given the rapid falls in price over the period, even this significant expected price increase is not clearly visible.

Figure 96: Real price trends for Group 5S from 2001 to 2008

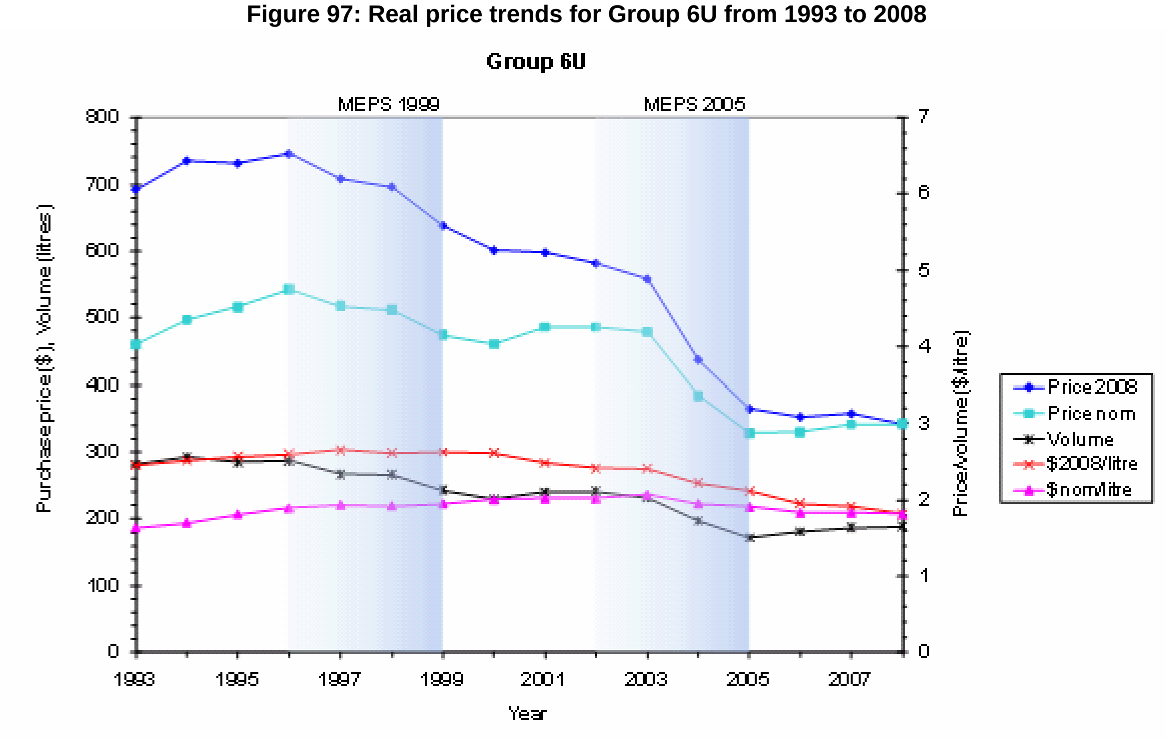


Note: Even though there are some price data before 2001, the data sets before and after 2001 are not comparable. Before 2001 data were only available for a few larger selling models, so the average price was under-reported. This market segment is characterised by a large number of models with few sales. Full market data was only available from 2001. There is also evidence that strong price competition from Asian suppliers increased during this period, hence the very strong decline in real prices (50% reduction in seven years).

Group 6U price trends

Group 6U are upright manual defrost freezers. Through the 1990s these had a declining market share in favour of frost free (Group 7) freezers. However, since 2003 there has been an explosion in the sales of very small low-cost units (about 100 litres in size). It is unclear what is driving this trend. Real prices are falling at a dramatic 5% per annum; however, much of this price trend is being driven by changes in the average size: the decrease in price per litre is a more modest 2% per annum in real terms. The expected price increase from MEPS 2005 was $16. An examination of the $/L trend is smooth over the whole period, so it is reasonable to conclude that there was no price impact of MEPS 1999 and the price impact from MEPS 2005 was within the expected limits.

Figure 97: Real price trends for Group 6U from 1993 to 2008

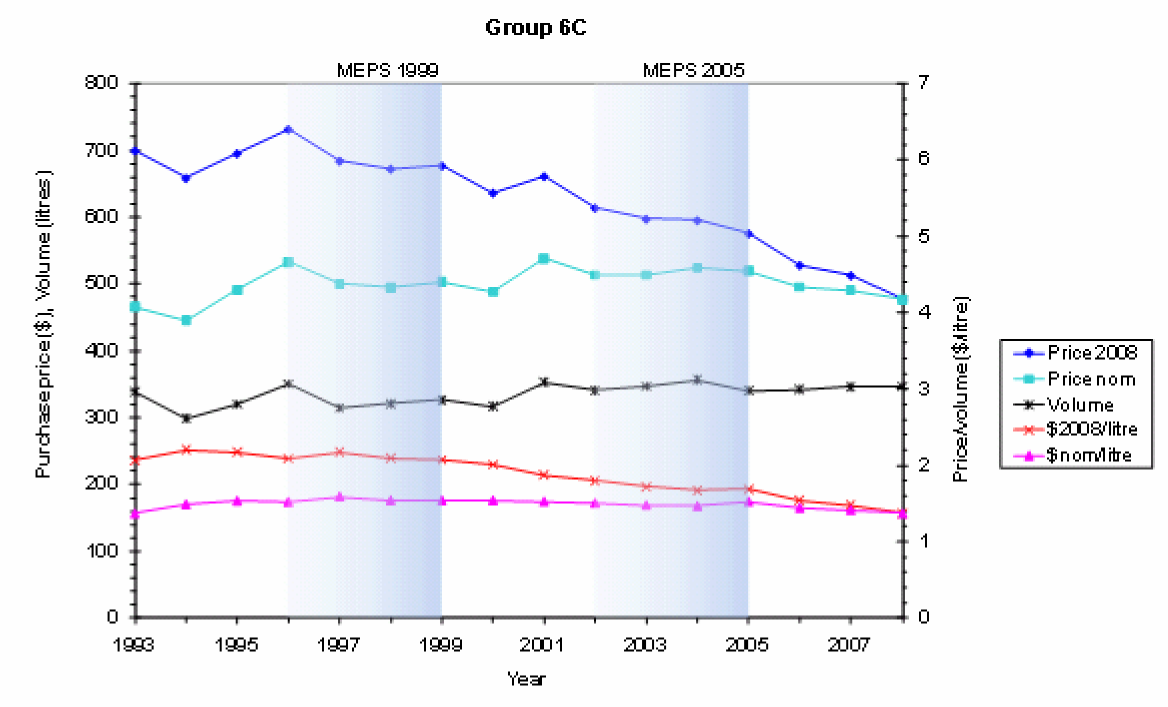


Note: There is a rapid decline in size after 2003 for this group, which appears as a fast price decline. Price per litre shows a more consistent trend.

Group 6C price trends

Group 6C are manual defrost chest freezers. These products have maintained about a 40% share of the separate freezer market across the whole period. Sizes have remained steady and prices have declined in real terms at 2.5% per annum. The expected price increase from MEPS 2005 was $20. Prices have been consistently trending down, although as expected there is some noise from year to year. An examination of the $/L trend is smooth over the whole period, so it is reasonable to conclude that there was no price impact of MEPS 1999 and the price impact from MEPS 2005 was within the expected limits.

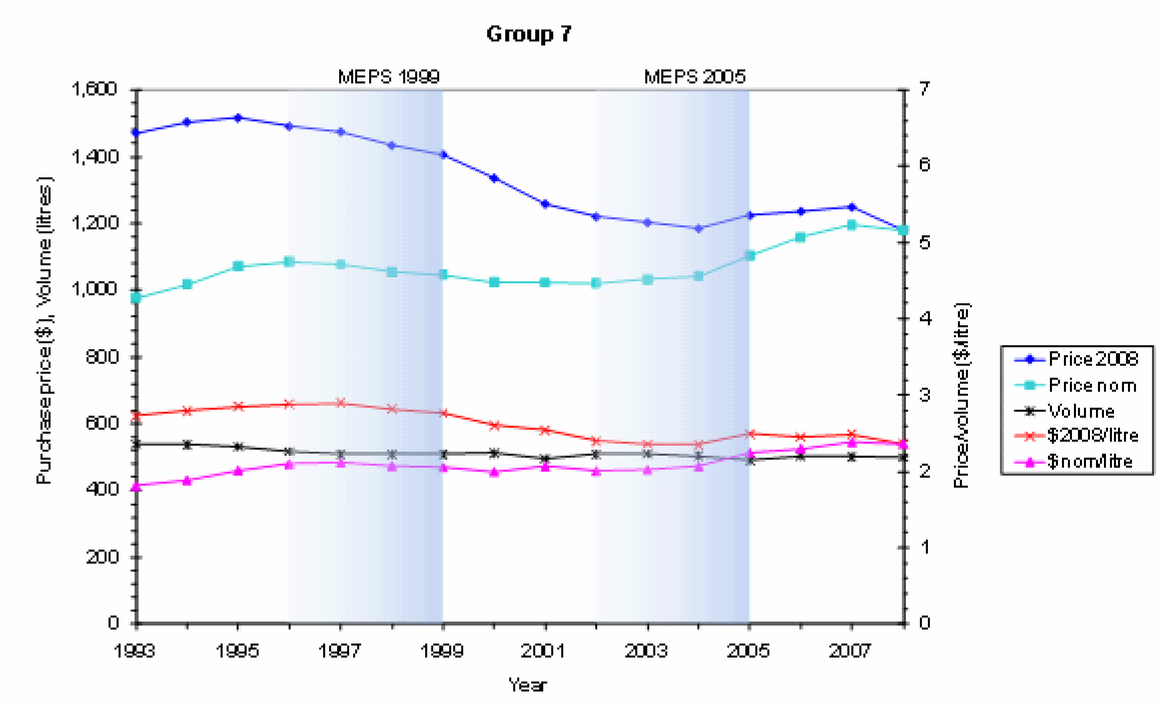
Figure 98: Real price trends for Group 6C from 1993 to 2008



Group 7 price trends

Group 7 are upright automatic defrost (frost free) freezers. Through the 1990s to 2008 these had increasing sales, although their share of the freezer market has declined in recent years due to a surge in Group 6C sales. These products tend to be larger, higher end products and local suppliers dominate the market. Price falls have been a modest 1.5% per annum (about 1% per litre when corrected for size changes). The expected price increase from MEPS 2005 was $101, which is significant. Prices from 2004 to 2007 showed a small increase in prices of about $70. Given the previous downward trend of prices before 2004, this tends to confirm that the expected price rise in the RIS for this group was quite reasonable. This is the only group where the expected price impact can be confirmed as the price changes over time are quite slow and the price change from MEPS 2005 was significant. In contrast, there was no obvious impact of MEPS 1999 on prices (if anything, prices have reduced due to other factors).

Figure 99: Real price trends for Group 7 from 1993 to 2008



Appendix 9: SAMPLE STOCK MODEL OUTPUTS

Stock Model: Refrigerators Australia by State (example)

Appliance life = 16 years	
Appliance attributes:	[Attributes-2020.xls]RF
Appliance Scenario:	PolicyL2010
Population Scenario	ABS3260 (Series III)
Ownership data:	[Ownership-2008.xls]RF

Stock Model: Freezers, Australia by State (example)

Appliance life = 20 years	
Appliance attributes:	[Attributes-2020.xls]FZ
Appliance Scenario:	PolicyL2010
Population Scenario:	ABS3260 (Series III)
Ownership data:	[Ownership-2008.xls]FZ

Table 10: Australian energy consumption for refrigerators (PolicyL2010) by state

Year	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
1985	1921	1320	958	514	508	129	48	80	5477
1986	1938	1333	986	517	516	130	51	81	5552
1987	1951	1342	1015	519	525	132	52	83	5619
1988	1964	1354	1041	520	536	134	52	85	5686
1989	1984	1370	1078	522	551	136	53	86	5780
1990	1994	1378	1103	525	559	137	54	88	5837
1991	2002	1381	1126	527	564	139	55	89	5882
1992	2014	1387	1156	527	571	140	56	91	5942
1993	2028	1394	1192	529	580	142	57	94	6015
1994	2041	1401	1232	528	592	143	58	96	6090
1995	2076	1412	1270	533	605	144	59	98	6196
1996	2104	1420	1296	534	614	144	61	99	6273
1997	2128	1426	1321	535	621	144	62	101	6339
1998	2151	1434	1346	536	628	144	63	102	6403
1999	2164	1437	1361	535	635	142	64	103	6441
2000	2160	1443	1364	537	645	141	64	103	6456
2001	2150	1444	1361	538	651	139	65	103	6450
2002	2151	1452	1364	542	662	138	66	102	6476
2003	2173	1458	1399	538	673	140	65	104	6549
2004	2181	1456	1427	531	681	141	65	105	6586
2005	2167	1440	1436	521	683	141	64	104	6557
2006	2144	1426	1436	513	683	138	64	104	6507
2007	2123	1412	1437	505	683	136	64	103	6463
2008	2101	1399	1437	496	683	133	64	103	6418
2009	2078	1383	1433	489	681	131	64	102	6361
2010	2055	1368	1429	481	679	129	64	101	6306
2011	2033	1354	1426	474	677	127	64	100	6254
2012	2012	1341	1425	466	675	126	63	99	6206
2013	1992	1329	1426	460	674	124	63	98	6164
2014	1975	1318	1429	454	673	123	63	97	6130
2015	1961	1310	1434	448	673	121	63	96	6106
2016	1950	1303	1443	444	673	120	62	96	6091
2017	1943	1299	1453	440	675	119	62	96	6087
2018	1940	1297	1467	437	677	119	62	95	6094
2019	1940	1298	1483	435	681	118	63	96	6113
2020	1945	1302	1502	434	686	118	63	96	6146

Table 11: Australian energy consumption for freezers (PolicyL2010) by state

Year	NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Australia
1985	667	457	349	203	174	73	22	30	1976
1986	675	460	355	203	175	75	23	31	1996
1987	670	461	358	202	178	75	22	31	1996
1988	663	463	361	200	180	74	22	30	1993
1989	658	464	365	198	183	74	22	30	1994
1990	649	463	366	196	184	74	21	30	1981
1991	640	461	366	194	184	74	21	29	1968
1992	633	461	369	192	186	73	20	29	1963
1993	627	462	375	191	189	73	20	29	1966
1994	622	463	382	189	192	73	20	28	1969
1995	612	450	381	184	188	72	19	28	1933
1996	599	435	376	179	182	71	19	26	1887
1997	588	421	372	174	177	69	18	26	1844
1998	578	409	369	169	172	68	18	24	1806
1999	566	397	364	164	166	66	17	23	1763
2000	550	383	359	162	165	64	16	22	1722
2001	531	368	352	160	162	63	16	21	1673
2002	516	355	348	158	161	61	15	19	1634
2003	507	355	349	154	167	60	15	20	1626
2004	497	353	350	149	172	60	14	21	1616
2005	480	346	345	143	175	58	13	21	1582
2006	471	338	349	140	170	56	13	21	1559
2007	464	330	354	137	165	53	14	22	1538
2008	457	323	360	134	160	51	14	22	1521
2009	450	317	356	131	158	49	14	21	1496
2010	444	311	352	128	156	48	14	20	1472
2011	438	306	348	125	154	46	13	20	1450
2012	431	301	345	122	152	45	13	19	1429
2013	424	296	342	120	150	44	13	19	1408
2014	417	292	340	117	148	42	13	19	1388
2015	410	287	338	115	147	41	13	18	1370
2016	402	283	337	113	146	40	12	18	1351
2017	394	279	336	111	145	39	12	18	1334
2018	385	275	335	109	144	39	12	18	1317
2019	377	271	335	107	143	38	12	18	1301
2020	369	268	336	105	142	37	12	19	1287

Stock Model: Refrigerators energy consumption by scenario (baselines and policies)

Table 12: Australian annual electricity consumption for refrigerators (GWh/year)

	Baseline-(Low)	Baseline-(High)	Policy-L1986	Policy-ML1999	Policy-M2005	Policy-L2010
1985	5,575	5,567	5,477	5,477	5,477	5,477
1986	5,756	5,739	5,552	5,552	5,477	5,552
1987	5,941	5,913	5,619	5,619	5,477	5,619
1988	6,137	6,095	5,686	5,686	5,477	5,686
1989	6,383	6,323	5,780	5,780	5,477	5,780
1990	6,595	6,514	5,837	5,837	5,477	5,837
1991	6,798	6,694	5,882	5,882	5,477	5,882
1992	7,033	6,902	5,942	5,942	5,477	5,942
1993	7,297	7,135	6,015	6,015	5,477	6,015
1994	7,575	7,378	6,090	6,090	5,477	6,090
1995	7,913	7,675	6,196	6,196	5,477	6,196
1996	8,214	7,935	6,273	6,273	5,477	6,273
1997	8,532	8,207	6,362	6,339	5,477	6,339
1998	8,872	8,497	6,466	6,403	5,477	6,403
1999	9,205	8,779	6,574	6,441	5,477	6,441
2000	9,496	9,021	6,660	6,456	5,477	6,456
2001	9,745	9,222	6,729	6,450	5,477	6,450
2002	10,038	9,463	6,841	6,479	5,477	6,476
2003	10,415	9,781	7,018	6,561	5,477	6,549
2004	10,767	10,075	7,191	6,639	5,477	6,586
2005	11,096	10,349	7,357	6,709	5,477	6,557
2006	11,402	10,600	7,512	6,763	5,477	6,507
2007	11,713	10,856	7,677	6,822	5,477	6,463
2008	12,024	11,112	7,846	6,883	5,477	6,418
2009	12,313	11,348	8,005	6,931	5,477	6,361
2010	12,604	11,585	8,168	6,983	5,477	6,306
2011	12,898	11,826	8,337	7,041	5,477	6,254
2012	13,191	12,066	8,507	7,103	5,477	6,206
2013	13,483	12,305	8,678	7,173	5,477	6,164
2014	13,774	12,543	8,849	7,250	5,477	6,130
2015	14,064	12,781	9,022	7,336	5,477	6,106
2016	14,351	13,017	9,192	7,428	5,477	6,091
2017	14,634	13,249	9,361	7,525	5,477	6,087
2018	14,912	13,478	9,526	7,625	5,477	6,094
2019	15,188	13,705	9,690	7,728	5,477	6,113
2020	15,460	13,928	9,852	7,832	5,477	6,146

Table 13: Australian annual electricity consumption for freezers (GWh/year)

	Baseline-(Low)	Baseline-(High)	Policy-L1986	Policy-ML1999	Policy-M2005	Policy-L2010
1985	2,007	2,006	1,976	1,976	1,976	1,976
1986	2,058	2,055	1,996	1,996	1,996	1,996
1987	2,091	2,086	1,996	1,996	1,996	1,996
1988	2,123	2,116	1,993	1,993	1,993	1,993
1989	2,166	2,157	1,994	1,994	1,994	1,994
1990	2,194	2,183	1,981	1,981	1,981	1,981
1991	2,219	2,205	1,968	1,968	1,968	1,968
1992	2,258	2,240	1,963	1,963	1,963	1,963
1993	2,307	2,285	1,966	1,966	1,966	1,966
1994	2,357	2,331	1,969	1,969	1,969	1,969
1995	2,355	2,325	1,933	1,933	1,933	1,933
1996	2,339	2,306	1,887	1,887	1,887	1,887
1997	2,327	2,291	1,845	1,844	1,844	1,844
1998	2,323	2,283	1,810	1,806	1,806	1,806
1999	2,317	2,272	1,769	1,763	1,763	1,763
2000	2,316	2,266	1,732	1,722	1,722	1,722
2001	2,303	2,249	1,690	1,673	1,673	1,673
2002	2,302	2,242	1,656	1,634	1,634	1,634
2003	2,349	2,282	1,657	1,626	1,626	1,626
2004	2,387	2,314	1,657	1,617	1,616	1,616
2005	2,403	2,324	1,644	1,598	1,582	1,582
2006	2,433	2,348	1,645	1,592	1,560	1,559
2007	2,462	2,372	1,650	1,590	1,543	1,538
2008	2,491	2,395	1,659	1,591	1,529	1,521
2009	2,501	2,400	1,657	1,584	1,508	1,496
2010	2,508	2,404	1,657	1,577	1,489	1,472
2011	2,514	2,406	1,658	1,572	1,471	1,450
2012	2,519	2,408	1,660	1,568	1,454	1,429
2013	2,524	2,409	1,662	1,564	1,439	1,408
2014	2,528	2,411	1,665	1,562	1,424	1,388
2015	2,533	2,413	1,668	1,560	1,410	1,370
2016	2,538	2,416	1,672	1,559	1,397	1,351
2017	2,545	2,419	1,676	1,559	1,384	1,334
2018	2,551	2,424	1,681	1,559	1,373	1,317
2019	2,559	2,429	1,686	1,561	1,363	1,301
2020	2,569	2,436	1,693	1,565	1,354	1,287