Matching World's Best Regulated Efficiency Standards: Australia's Success in Adopting New Refrigerator MEPS

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ABSTRACT

In 1999 Australian state and federal governments adopted a policy of matching world's "best regulatory practice" for minimum energy performance standards (or MEPS) for residential appliances and commercial and industrial equipment. The policy involves:

- reviewing mandatory and quasi mandatory MEPS levels in force around the world;
- assessing the requirements on a common basis (typically in terms of the Australian/New Zealand (AS/NZS) test procedures); and
- selecting the most stringent levels currently in force (or in the process of adoption) for implementation in Australia at an agreed date in the future.

The first major product in Australia to be tackled using this new policy approach was refrigerators and freezers in late 1999. The US MEPS levels for 2001 were identified as the world's most stringent and Australian governments worked with local manufacturers and importers to finalize equivalent levels for implementation in January 2005 in Australia.

The new 2005 MEPS levels are compared to the existing 1999 Australian MEPS levels and the market structure and efficiency levels in 2000. Projections indicate that the new MEPS levels will require an *average 40%* drop in the energy consumption of refrigerators-freezers over the period 2000 to 2005. In the period 1980 to 2005, it is estimated that sales-weighted energy consumption of new refrigerator-freezers in Australia will have fallen by around 70%.

Background

Codes and standards programs, where legislation and regulation are used to improve product energy efficiency, are amongst the most cost effective and widely used measures employed to reduce greenhouse gas emissions. The Australian program embraces two mandatory elements:

- Comparative energy labeling: enabling consumers to choose energy efficient products when considering a purchase; &
- Minimum energy performance standards: where government enforces predetermined energy efficiency levels for specified products.

Mandatory appliance labeling commenced in 1986 for refrigerators and freezers. By 1990, air conditioners, dishwashers, clothes dryers and clothes washers were also labeled. Introducing MEPS has proven to be slower and more difficult. In October 1999 MEPS commenced for three domestic products: refrigerators, freezers and electric storage water

heaters. In October 2001, MEPS commenced for electric motors and packaged commercial air conditioners and MEPS for fluorescent lamp ballasts will commence from 1 January 2003. A range of other commercial and industrial equipment is currently being examined for MEPS (e.g. distribution transformers, commercial refrigeration) to commence in the next few years (NAEEEC 2002 provides details).

Matching World's Best Practice – The Policy

In 1999, the Australian Ministerial Council of Energy agreed to:

"*….develop(ing) MEPS for Australia that match best practice levels imposed by our major trading partners for internationally traded products that contribute significantly to Australia's growth in greenhouse gas emissions*" (NAEEEC 1999, p8).

By adopting an existing MEPS level from a major trading partner, the arguments regarding the technical "feasibility" of meeting the proposed MEPS level can be essentially transcended. The existence of a "default" MEPS level from a major trading partner provides a focus for both government and industry and allows the discussions to quickly move forward into the negotiation of detail regarding any adjustments that are necessary for local product configurations and differences in the test method. Details of the new policy were outlined in Holt et al (2000) at ACEEE 2000.

Identifying the Most Stringent MEPS Level – Refrigerators and Freezers

Refrigerators and freezers were the first product to be subject to this new policy approach in Australia. A review by government consultants, Energy Efficient Strategies (EES), of the MEPS levels for refrigerators and freezers in mid-1999 revealed that, at that time, the US MEPS levels proposed for July 2001 appeared to be the most stringent level proposed or in force around the world (US MEPS levels are defined in DOE 1997). Canadian and Mexican MEPS levels for refrigerators are generally harmonized with US requirements, although the implementation dates vary.

The analysis was not limited to the US DOE announced MEPS levels and examined other economies that regulate refrigerator and freezer efficiency. At about this time, Japan had just released details of its "Top Runner" program, which has stringent requirements for refrigerators, especially those incorporating new technology such as variable speed drives and vacuum panels. The Top Runner program, developed and announced in 1999, identified the most efficient models on the Japanese market that year for a range of products and set this level as a sales weighted target for all manufacturers at a future date (the refrigerator target is January 2005). The program is nominally "voluntary", but the implementation method is quite coercive in nature and can be regarded as effectively " quasi mandatory". Little information was available on the new test method at the time of the initial analysis, so it was not possible to compare these levels under the Australian test method without extensive investigative testing. The new Japanese method is similar to ISO in terms of compartment temperatures and ambient temperature, but has the added complication of door openings, which makes simulation modeling and comparisons very difficult. The presence of

test packs for convectively cooled appliance types but not for forced air models also makes direct comparisons difficult for the former types.

Korea has had MEPS in place since about 1996, but the levels in force since 1999 were weaker than the US 2001 levels. The Korean test method can be compared through modeling, although the test conditions are different to that used in Australia. In late 2000 (after the initial comparative analysis), Korea announced new MEPS levels for refrigerators, which will be analyzed when Australia looks beyond the 2005 MEPS level.

The EU MEPS levels for refrigerators that came into force in 1999 were found to be generally more stringent than the Australian MEPS levels for 1999. The EU levels are comparable to the US 1993 MEPS levels for convectively cooled products (the European market is still dominated by convectively cooled refrigerator products) but are weaker than US 1993 MEPS for frost free products (forced air).

Other MEPS levels reviewed for the international comparison were from Taiwan, China and Russia, although obtaining the technical details of the latter two proved difficult. MEPS in all of these countries were found to be weaker than US 2001 levels. Details of all MEPS levels in force as at mid 1999 and a detailed comparison of the test methods in each country used can be found in APEC (1999). A comparison of the main MEPS levels considered (USA and Europe) are discussed in more detail in the section on International Comparisons.

The Australian Refrigerator Market

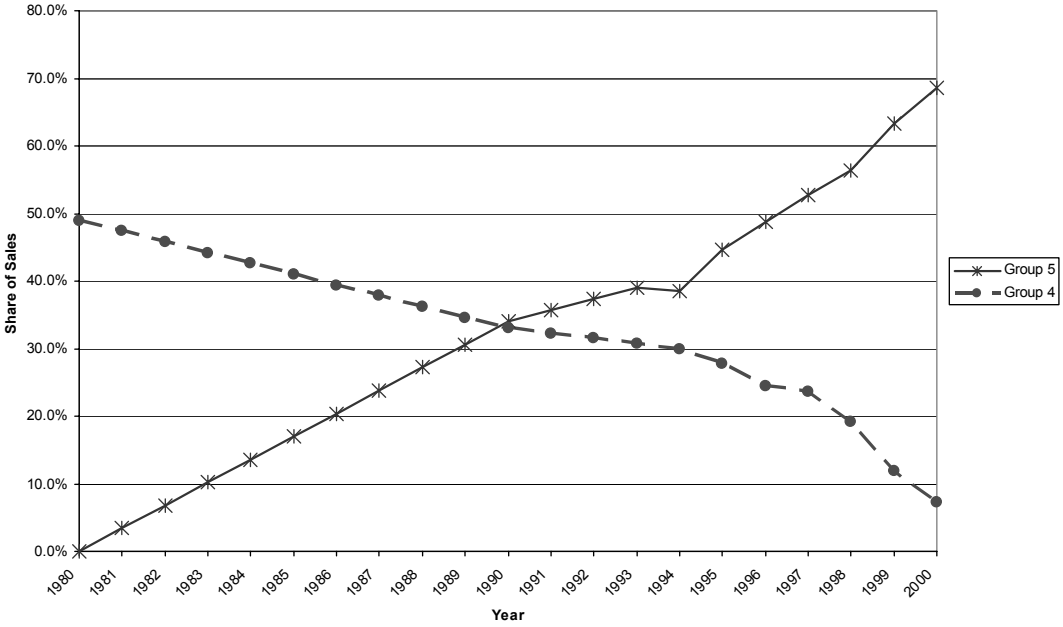
Average refrigerator sizes in Australia are larger than Europe (<300 litres) but smaller than in the USA (typically 500 litres). The sales weighted average fresh food size for all types of refrigerators sold in Australia in 2000 was 253 litres while the average freezer size for refrigerators was 92 litres. The average size for separate freezers was 226 litres. The typical family refrigerator-freezer is typically around 400 litres but there are also significant sales of small models used in the commercial sector.

The Australian refrigerator market has sales of around 700,000 units per year. A majority of units are manufactured in Australasia by two suppliers with local manufacturing facilities, Fisher & Paykel and Electrolux with the balance imported from a wide range of countries including North America, SE Asia, Japan, Korea, China and Europe.

Refrigerator-freezers (mostly 2 door models top and bottom mount models) make up about 65% of sales. Stand-alone freezers account for about 14% of total sales. Small bar fridges (usually less than 200 litres) and refrigerator-only models account for the remaining sales. The Australian refrigerator-freezer market in the past 10 years has moved strongly towards frost free models as shown in Figure 1.

Australia divides refrigerators and freezers into 9 “group” classifications. Two groups dominate refrigerator sales. Group 5 are (usually) 2 door refrigerator-freezers (top or bottom mount) with an automatically defrosted fresh food *and* freezer compartment (both usually forced air or frost free) and increasingly dominate sales. Group 4 are convectively cooled 2 door refrigerator-freezers with essentially a cyclic defrost fresh food compartment and a manual defrost freezer. By 2005, sales of Group 4 models are expected to be negligible but they constituted half the market 20 years ago. A full analysis of the Australian refrigerator market (and for other labeled appliances) and efficiency trends can be found in EES (2001).

Figure 1. Sales Share of Group 4 & 5 Refrigerator-Freezers in Australia



International Comparison

Refrigerators are probably the most regulated product around the world with respect to energy efficiency and yet, ironically, are probably the product subject to the most complex and diverse range of national and regional test procedures (i.e. the least harmonized). Refrigerators are one of the most common products, both in businesses and households, and energy consumption is affected by climatic and temperature conditions, which vary considerably by region. This of course makes international comparisons difficult and, in part, explains the proliferation of national test methods and standards.

While it is possible to make intelligent estimates of the energy impact of differences (such as ambient temperature and internal temperatures) in test procedures, there is a wide range of test parameters and elements that make any conversion potentially inaccurate. Things such as position of temperature sensors, differences in methods for calculating temperatures (means versus maximums), door openings (or not), having freezers loaded or unloaded, electronic controls, in particular, adaptive defrost, prescriptive requirements regarding controls settings/adjustments and so forth mean that such conversions are potentially inaccurate. Probably the biggest limitation is that energy consumption measurements for most refrigerators test procedures are done at a single ambient temperature, so it not possible to estimate the temperature energy response coefficient from most publicly available data. An in depth discussion on these issues is contained in Harrington (2001) and APEC (2000).

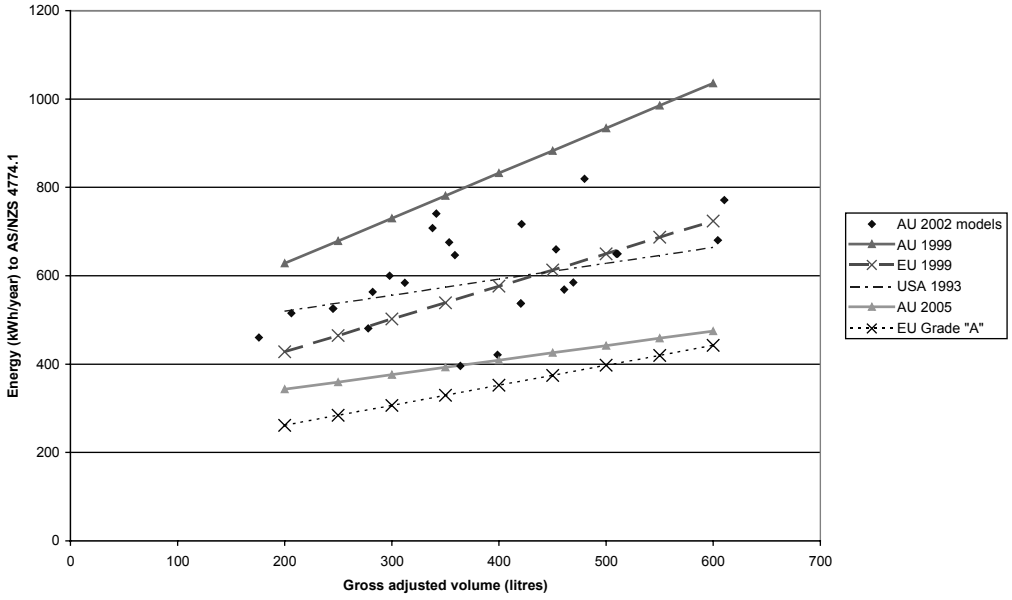
As part of the international review of the world's best practice some limited analysis was undertaken to compare some of the major refrigerator efficiency standards. But these comparisons need to be treated with caution – unless the "native" test procedures are closely related (e.g. USA and Australia), the results are, at best, "indicative" only. Results for individual models sometimes reveal issues with respect to their specific design, which will have an impact on the energy consumption under different test methods. One such common

issue is the temperature balance between fresh food and freezer compartments (and the temperature adjustment available) and the requirement to meet certain (different) compartment temperature targets under different test procedures. Only with a great deal more data at the model level could a universal conversion be contemplated through simulation. While this concept is attractive, there is much work to be done. Bansal (2000) discusses options for an integrated testing/simulation approach for refrigerator testing.

In order to compare MEPS levels from different countries (and test procedures), it is necessary to convert energy consumption values under each test method to a common basis. For this analysis, the Australian/New Zealand test procedure AS/NZS 4474.1 has been used as the basis for comparison. Historically AS/NZS was originally based on the US AHAM procedure currently used in the USA, but it has progressed substantially over the past decade. Technical differences in the test procedures for USA, Australia and ISO are outlined in Harrington (1994).

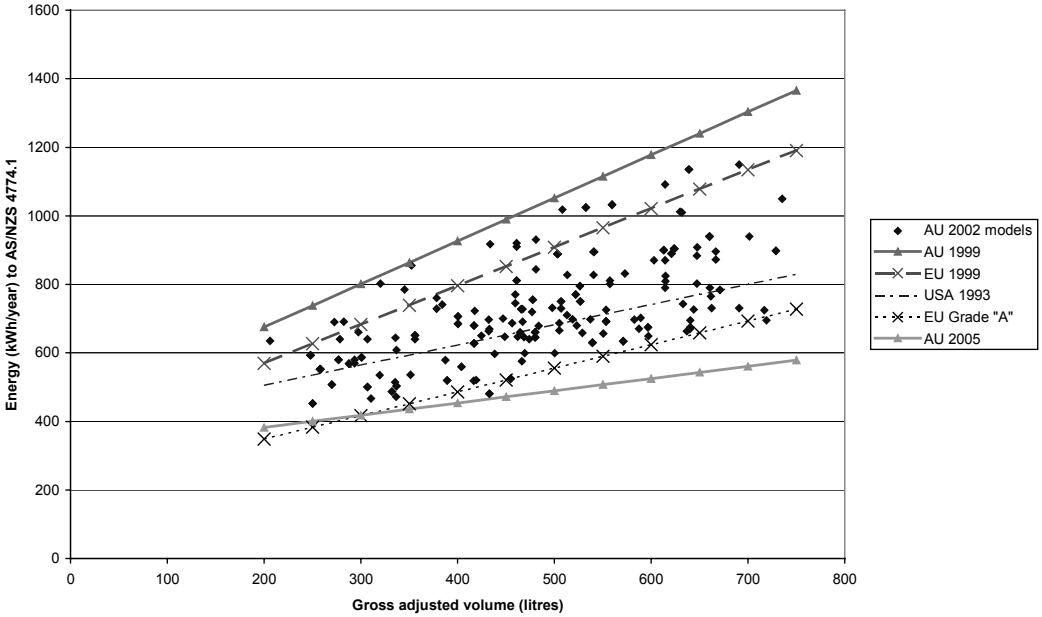
In 1999 and 2000, a detailed comparative analysis was undertaken and the results for Groups 4 (cyclic defrost) and 5 (automatic defrost) are shown in Figures 2 and 3 respectively. Note that differences in volume determination under the different test procedures create significant problems in the conversion for some product types.

Figure 2. International Comparison - Group 4: Manual Defrost Refrigerator-Freezers



Note: Graph shows individual models registered for energy labeling in February 2002. EU values assume freezer compartment runs at an average of -21^{o}C to meet ISO requirements. US 2001 is equivalent to AU 2005.

Figure 3. International Comparison - Group 5: Frost Free Refrigerator-Freezers



Note: Graph shows individual models registered for energy labeling in February 2002. EU values assume freezer compartment runs at an average of -21°C to meet ISO requirements. US 2001 is equivalent to AU 2005.

The initial levels under AS/NZS test methods were determined using a theoretical modeling approach based on known differences in the ISO, Australian and US test methods. A working group then reviewed and verified those levels (as far as possible) against a wide range of actual test data to ISO, US and AS/NZS test methods.

A number of interesting issues and problems were encountered:

- categorization of products and the differences in market structure between USA, Europe and Australia (products common in Europe are uncommon in Europe and vv);
- treatment and impact of differences in temperature measurement positions (this applies to all methods);
- the impact of adaptive defrost mechanisms and how these are treated under different test methods (particularly length of time between defrosts allowed in the test method);
- (lack of) ability of products to meet their optimum temperature requirements for energy consumption under different test procedures;
- volume measurement issues and differences (mostly between ISO and US/AHAM);
- problems and opportunities raised by the US energy test for refrigerators.

These issues are detailed in Harrington (2001).

Figures 2 and 3 show that the Australian MEPS levels introduced in 1999 were relatively weak in comparison to either the 1993 USA levels and the 1999 European levels. However, as a result of the adoption of the new NAEEEC policy on matching world's best practice, the revised MEPS levels for Australia in 2005 have become dramatically more stringent, typically to around 60% of the 1999 level (depending of the size of unit and group). The Australian levels for 2005 shown in Figures 2 and 3 are essentially "equivalent" to the

USA 2001 levels (hence these are not separately shown on the figures). It is important to note that the new 2005 MEPS levels for Australia are quite stringent and will mean that virtually every Group 4 and 5 model will have to be re-engineered for a dramatically lower energy consumption within 3 years. The same applies to most other groups: there are only a handful of models (less than 10) on the Australian market at the beginning of 2002 that comply with MEPS 2005 requirements (out of a total of around 400 models registered). Full details of the equations for all refrigerator and freezer types for both MEPS and energy labeling are set out in AS/NZS 4474.2.

It is important to note when comparing levels between Europe and the USA that there is very little product overlap. For example, virtually all USA refrigerator-freezers sold are frost free whereas these make up around 5% of the European market. The average product size in the EU is also substantially smaller than that in the USA. While this makes comparison between US and European levels somewhat hypothetical, real comparisons are possible in Australia as both product types have a significant market share.

One of the benefits for the international community of this Australian work is "benchmarking" the MEPS proposals of the major economies. For example, the EU label "Grade A" level for energy labeling (an energy efficiency index of ≤ 0.55) is shown on the figures above. This is being proposed (but not yet confirmed) as the new revised MEPS level for Europe in 2005-2007 (Waide 2001). For non-frost free products, the EU Grade A levels appear more stringent than US 2001 levels. For frost free products, the EU Grade A is comparable to US 2001 levels for smaller products common in Europe, but is less stringent for larger products more common in the US. The EU MEPS directive contains a rather extraordinarily generous additional volume "adjustment" factor of 1.2 for compartments cooled with forced air (EU 1996). The EU is unique in its adoption of such a factor, but given the current market structure (relatively low market share of frost free products), this has little impact in Europe at this stage. Australia considered this factor during its 2005 MEPS deliberations but it was rejected as unfounded. If this factor is removed from the comparison, EU Grade A becomes equivalent to US 2001 levels for all sizes (slightly more stringent for sizes below 500 litres and slightly less stringent for larger sizes).

How does the tested AS/NZS energy consumption translate to actual use? There has been some comparison of tested and in-use data for a range of refrigerators, refrigerator-freezers and freezers. While the ambient temperature-energy consumption coefficients vary between different models, for most refrigerator-freezers the AS/NZS energy test appeared to over-estimate typical in-use consumption by about 10%. Of course it will provide a better estimate for warmer climates and will tend to overstate energy more in cooler climates, especially where homes are not fully conditioned (e.g. New Zealand and southern parts of Australia). However, the issue of food loads and door openings does complicate such generalizations.

Australian regulators acknowledge that the AS/NZS test methodology may not reflect consumer usage throughout the continent, but it still provides an accurate form of comparison between competing models within the various groups. While the label energy consumption may not reflect even average consumer use, it still allows a fair comparison of models by the individual consumer contemplating purchase.

Assessing the Energy Impact

Market Influences

There are a wide range of factors that influence the intrinsic energy consumption of appliances in general, and refrigerators and freezers in particular. Some of these include improvements in technology (better compressors, evaporators and condensers, improved and thicker insulation, use of electronic controls etc) while others undoubtedly include energy labeling and MEPS. The problem from an evaluation perspective is that separating these influences is not simple or even possible in many cases. Good evaluation techniques can help to establish the extent of influence for each element, but it is hard to be completely definitive. For this paper, we examine the overall impact of all influences on energy consumption without trying to apportion the energy savings to the various influences.

Why Energy Information Is Important

Some product attributes are readily observable on inspection by the consumer, or readily available in product literature, while other attributes are not at all obvious. For example, in the case of a refrigerator, the volume available for the storage of food is clearly visible to a consumer when the unit is inspected in a showroom (although this too can be deceptive in some cases). Product information also gives storage volumes and external dimensions (this information is essential for installation). Conversely, inspection of an appliance such as a refrigerator does not reveal its energy consumption, energy efficiency or standard of performance. In fact, the determination of these performance attributes requires careful testing and sophisticated equipment, which is not readily accessible to the consumer. Energy consumption is the key determinant of operating cost for most appliances and is therefore of primary concern to the consumer.

Information on non-observable attributes can only be obtained by consumers where the manufacturer chooses to provide such information or where governments require the information to be disclosed, such as through an energy labeling program. Where such non-observable attributes are declared (and therefore become visible to consumers) and where even a small market segment (so called “informed” or energy conscious consumers) responds to these attributes, manufacturers tend to concentrate on improving the rating of those observable and visible attributes at the expense of other non-observable attributes. Energy labeling has brought the energy issue to the attention of both consumers and manufacturers.

The Energy Impact of Labeling and MEPS

Energy labeling for refrigerators and freezers was introduced in late 1986 in Australia. This appeared to have an influence on energy consumption of both group 4 and 5 refrigerator freezers through the period until 1995. Prior to 1985, group 5 energy consumption appeared to be increasing, primarily due to the rapid growth in average refrigerator-freezer size. Australia, as part of the Montreal Protocol, agreed to a rapid phase out of CFC’s by the end of 1994. This appeared to slow energy efficiency improvements for a short period in the mid 1990’s (this effect is more noticeable for separate freezers – see EES 2001 for more details). Part of this slow down may also have been the waning effect of

energy labeling on consumers, at least for group 4. There is a related factor here; the market share of group 4 started to decline markedly from the mid 1990's and as a result, it appears that manufacturers reduced their engineering research and development of energy efficiency of this increasingly unimportant group (this has been confirmed to some extent through anecdotal discussions with manufacturers). In contrast, the energy consumption of group 5, with its increasing market share, decreased at a more consistent rate through this period. It is also true that the conversion from CFC to HFC134a had less impact on forced air systems (group 5) than convective cooling designs (group 4), so this is a secondary factor. Note that by 2000, the average size of group 4 and 5 models had essentially converged and both are expected to remain stable or decline over the next decade as household sizes continue to decline.

In the late 1990's, efficiency began to improve rapidly again, probably to some degree as a result of the introduction of MEPS in 1999, which although weak, eliminated a significant number of less efficient models from the market (40% of models on the market in 1994 did not meet MEPS 1999 levels). These influences are illustrated in Figure 4.

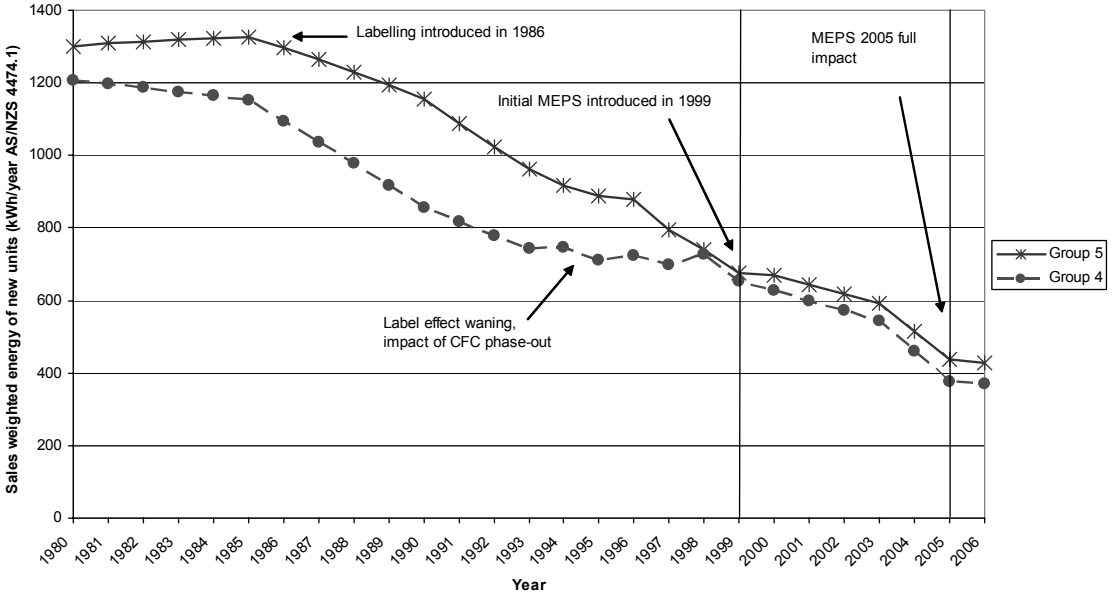
MEPS is effectively a mandatory maximum energy consumption, which is specified as a function of group and product size. At the time of introduction of MEPS in 1999, the sales weighted average energy consumption of new models in that year was substantially below the maximum allowable energy consumption. For group 4 models, the actual market average value was around 650 kWh/year (under AS/NZS 4474.1) compared to the sales weighted MEPS level of 840 kWh/year (a ratio of around 75%). For group 5 models, the actual market average value was around 674 kWh/year compared to the sales weighted MEPS level of 990 kWh/year (a ratio of around 67%). The lower ratio for group 5 is presumably a reflection of the relative "weakness" of the MEPS level for that group and the fact that labeling was continuing to drive energy consumption down through increased demand.

As MEPS levels become more stringent, it is expected that the sales weighted market average energy consumption of new refrigerators will trend closer to the MEPS level itself. Another factor that affects this ratio appears to be market demand for product: if demand is low, there is little scope for research and development on energy consumption and little point in differentiation beyond the MEPS level through energy labeling. An example of this situation is in the USA for separate freezers – most products on the market just meet the required MEPS levels and even the ACEEE buyers guide states that all freezers are "acceptable" with respect to energy consumption.

Given that the new Australian 2005 MEPS levels are quite stringent, it would be expected that the sales weight trend will pass close to, but just under, the target MEPS level. When estimating benefits and costs in the regulatory impact statement for the new MEPS levels (GWA 2001), it was assumed that all new models would exactly meet the 2005 MEPS level in this year. Clearly this is quite conservative and not even feasible, as prudent suppliers will ensure product efficiency overshoots the MEPS level for most models. Given the potential ramifications, most manufacturers are wary of vending models that lie very close to the MEPS requirements because of the variation within the manufacturing process. It was also assumed that, in the wake of the introduction of a stringent MEPS level in 2005, the impact of energy labeling would decrease, at least for a short period, as most products would just meet the MEPS level.

For this analysis, it has been assumed that the market average energy consumption in the MEPS year 2005 will be 0.90 of the MEPS target. The resulting energy trends from 1980 to 2006 for groups 4 & 5 are shown in Figure 4. Values from 2001 to 2006 are of course projections while data prior to 2000 is based on market data.

Figure 4. Energy Consumption Trends in Australia – New Refrigerator-Freezers



Note: Group 5 (frost free) energy trends from 1993 are for top mounted models only

Conclusions

The energy consumption of refrigerator-freezers has decreased steadily since the introduction of energy labeling in 1986. Over the period from 1980 to the introduction of MEPS in 1999, the energy consumption of refrigerator-freezers decreased by around 50%. It is expected that in the period 1999 to 2005, when new stringent MEPS levels that match USA 2001 levels are introduced, the energy consumption of refrigerator-freezers will have to further decrease by 40%, meaning that in the 25 year period 1980 to 2005 there will have been an overall reduction in energy consumption of around 70% for both main refrigerator-freezer groups.

In many ways, this is a remarkable achievement attributed to both the energy labeling and MEPS programs, although manufacturers must be given due credit for their response to consumer demands and their cooperation with the programs. Adoption of new technology has also played a role. What is even more remarkable is that during this period the average size of new units was increasing (although from the late 1990's size is expected to be stable).

It would appear from the data available that Australia's energy efficiency program for refrigerators and freezers have been highly successful and it appears that the new practice of adopting world's best practice offers a fast and effective mechanism of delivering real energy savings. While the policy has limitations where there are no "world leaders" in terms of setting stringent energy efficiency standards, it does provide a fast track path for a range of products in smaller economies such as Australia. If such a policy were more widely adopted

by other nations, it would tend to lead to a more harmonized MEPS regime for many products, at least in countries that have a similar economic structure and development.

The process would also be greatly assisted by harmonized test procedures, but this is a topic worthy of substantial effort and discussion in its own right (APEC 2001). So too is the Australian regulators' experience in negotiating MEPS levels for other products using this policy of matching world's best regulatory MEPS; to date, all signs are very encouraging.

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