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Discussion Paper

Refrigerator Star Rating Algorithms in Australia and New Zealand – Revised Proposal

Discussion draft for stakeholder comment issued under the auspices of the Ministerial Council on Energy

SEPTEMBER 2007

Prepared by Energy Efficient Strategies for AGO & EECA

Refrigerator Star Rating Algorithms in Australia and New Zealand – Revised Proposal, September 2007

Discussion paper prepared for the Equipment Energy Efficiency Committee (E3)
by Energy Efficient Strategies
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Introduction

This paper sets out new proposed energy labelling star rating algorithms (equations) for introduction in Australia and New Zealand during 2009. The paper flags the key issues for government and industry which need to be considered in the transition process to the new energy label and star ratings.

This paper is an update of the original version released for comment in January 2006 (E3 report 2006/01). The main differences from the original version of this paper are:

- A completely new approach for the determination of star rating equations has been developed based on a de facto surface area function which better represents the technical energy efficiency of products across a wide size range. This results in the loss of about 2 stars for almost all products except Group 6C (the reduction is less than 1 star) and Group 1 (the reduction is typically 4 stars, but varies)
- 2006 sales data for Australia and New Zealand has now been included in the analysis.
- The proposed year for implementation of the new label is 2009. More detail on the transition arrangements has also been included.

Comments received on the original 2006 paper have been included as Appendix G and responses to these comments have been incorporated into this version as far as is possible. This paper is a precursor to the release of a full cost benefit analysis (CBA) for the algorithm change because the issue of refrigerator and freezer star ratings is complex. The CBA is expected shortly and builds on the data included in this paper.

This paper also sets out plans by the Equipment Energy Efficiency Committee (E3) to introduce Energy Star as the primary high efficiency endorsement label for refrigerators in Australia and New Zealand. Draft eligibility criteria for the Energy Star for refrigerators and freezers based on the new star rating algorithm are not proposed in this paper, but a range of issues are canvassed in order to facilitate the development of suitable Energy Star levels in the near future.

If you have any comments on the proposed revision to the star rating system in Australia and New Zealand, please send these in writing by 31 October 2007 to:

Australia: Catherine Corver, at energy.rating@environment.gov.au
New Zealand: Gleb Speranski, at Gleb.Speranski@eeca.govt.nz

Postal addresses for the above contacts are available on www.energyrating.gov.au

Background

Governments have indicated their desire to review the energy labelling algorithm for refrigerators and freezers as early as 2003. Many of the lower efficiency products were eliminated in January 2005 with the introduction of new stringent MEPS levels. There are now no 1 or 1.5 star products on the market in any Group. To facilitate the development of a new energy labelling algorithm, a Stakeholder Working Group was formed in 2005 to review the issues and prepare recommendations for public release and consideration. An initial discussion paper was released in January 2006 (E3 report 2006/01). Various public responses to that paper were received and these are summarised in Appendix G.

During 2006 E3 agreed that the introduction of a new energy label algorithm for refrigerators should be delayed until 2009 following discussions with industry. This paper is an update of the 2006 version of the discussion paper and now includes 2006 sales data for Australia and New Zealand. A new set of star rating equations have also been included in this paper. As far as possible, the technical points raised in submissions on the previous paper have been taken into consideration in this paper.

Public feedback on this paper will be considered by E3 and the Stakeholder Working Group. Final recommendations will be included in the revision of AS/NZS 4474.2 which is expected as a public comment draft late in 2007, subject to the satisfactory progress with the regulatory impact process.

While the overall guiding principles for the development of an energy labelling algorithm have been documented in this paper, inevitably, some of these goals may be in conflict with one another. And while each of the stakeholder groups represented in the discussions to date often have personal or corporate positions on some of the issues covered in this paper, all stakeholders have attempted to contribute towards the development of a consensus energy labelling proposal for refrigerators that is technically sound and will provide a solid basis for the rating of products in Australia and New Zealand over the next 10 or more years. Ultimately the solution will be a compromise that maximises agreements between local manufacturers, importers, government and consumer groups. While the proposals in this paper have not been endorsed by individuals or their companies, they do represent a proposal appears to provide a sound basis for public discussion and feedback.

Key Issues Covered by this Paper

This paper documents the following issues and proposals:

- Provides background on energy trends for refrigerators and freezers in Australia and New Zealand since labelling began in 1986.
- Documents the star rating equations introduced in 2000 and provides a rationale as to why these equations need to be revised and upgraded in the light of MEPS 2005.
- Lists issues that need to be considered in the development of a new star rating algorithm.
- Details a new star rating equation for refrigerators and freezers that is proposed for implementation in 2009.

- Provides a breakdown of the number of models by Group under the new energy labelling algorithm as well as sales in 2006 for Australia and New Zealand.
- Provides an overview of the previous endorsement labelling system in Australia (TESAW) and details the proposed transition to Energy Star as the primary endorsement system in Australia and New Zealand.
- Documents the latest implementation and transition issues (including recommendations from the April 2007 round table and subsequent discussions) that are proposed for the introduction of the new star rating label and the transition from TESAW to Energy Star in 2009.
- Provides some information about the new test method for refrigerators and freezers, AS/NZS4474.1 was published on 15 August 2007.

This revised discussion paper documents the proposed new star rating algorithm for refrigerators and freezers for introduction in 2009. Other elements of the process up to the point of implementation are documented below.

Outline of Related Steps in the Regulatory Process

This discussion paper formally flags the intention of government to alter the star rating algorithms for refrigerators and freezers through 2009. The key steps that will need to be completed to implement the star rating algorithm are set out below.

Feedback on this discussion paper: This discussion paper will be open for comments until 31 October 2007. Public written submissions received will be considered in the preparation of the AS/NZS4474.2 revision.

Release of a Cost Benefit Analysis for the new Energy Labelling Algorithm: This will be a document for public comment that quantifies the costs and benefits associated with the proposals documents in this paper. It is expected for release in late September 2007. It will be a precursor to the formal Regulatory Impact Statement.

Release of a Regulatory Impact Statement: This will be a formal document that proposes the regulatory changes required to implement the new energy labelling algorithm as documented in this paper and the Cost Benefit Analysis. It takes into consideration feedback on both this paper and the CBA to prepare final proposals. Public comments on the RIS will be sought prior to making final recommendations to the Ministerial Council on Energy.

Label design investigations: The industry round table held in April 2007 (refer Appendix B) reviewed a number of label design options to be tested in focus groups. Research into the options for changes to the energy label design will be tested on various groups of consumers to make sure that any changes are effective and well understood. The focus groups were conducted in selected cities in Australia and New Zealand in mid 2007. A report on the findings will be publicly released by E3 in September 2007 prior to development of final recommendations for inclusion into the Part 2 standard.

Revision of AS/NZS4474.1 – test method: This was published on 15 August 2007. See Appendix C for more detail.

Discussion Paper on Impact of Test Method Change: A discussion paper documenting the energy impact of the change to the test method AS/NZS4474.1-2007 will be released for industry and public comment. The new test method now requires compartment temperature to be measured for the whole test period including any defrost, so the apparent compartment temperature will appear warmer in some cases (but may be colder in others). This is expected to have a small energy impact (of the order of 1%) when energy consumption for the same target temperatures are calculated. The outcome may be a small adjustment to MEPS levels for some groups (5 & 7 only). This change will not require a regulatory impact statement as it providing equivalent MEPS levels under a changed test method. The discussion paper is expected in September 2007. Some detail on this issue is covered in the body of this paper and in Appendix C.

Discussion Paper on Change of MEPS from Average Model Energy to Maximum Permitted Energy: A discussion paper proposing an adjustment to MEPS levels resulting in a change from the current MEPS definition of an average energy consumption of a model to a new requirement based on a maximum permitted energy consumption for a model will be circulated to refrigerator and freezer registration holders for comment. The main issue will be typical levels of production variability for refrigerators and freezers as these will be used as the basis to adjust current MEPS levels published in the revised Part 2 (see next point). It is expected that stakeholders will be reluctant to table data publicly, so meetings between interested parties and government officials will be organised on request. This change will not require a regulatory impact statement as it is intended to provide equivalent levels under a changed method of assessing MEPS and would only apply to new registrations. The discussion paper is expected in September 2007.

Preparation of a Revision to AS/NZS 4474.2: A revision to the Part 2 standard with the technical requirements of the new label and the energy labelling algorithm, together with the transition arrangements, will be prepared later in 2007 once feedback on this paper and the Cost Benefit Analysis are received. This will be subjected to the normal public comment processes for new Australian and New Zealand Standards. It will also include any adjustment to MEPS levels as a result of the change in test method and the change in the basis of MEPS from a population average to a population maximum.

Preparation of Regulations and Implementation of New Standard: On publication of the revised standard and approval of the Regulatory Impact Statement, regulations can be prepared and enacted to bring the new standard into force.

Transition to New Energy Label and Algorithm: The new label will be required on new products manufactured or imported after March 2009 but may be appear on some products as early as October 2008 (subject to certain conditions). A transition to the new label for products on display in retailers will occur over the period March to October 2009. Products manufactured or imported prior to October 2009 can be supplied directly to customers from warehouses with the old label for an indefinite period. More details on the proposed transition arrangements are contained in this paper.

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History: Development of Previous Star Rating Algorithms

The star rating energy label was first introduced for refrigerators and freezers in late 1986 and since that time, the energy label has been the key method of communicating to consumers the energy efficiency of household refrigeration products. Mandatory energy labelling of appliances is widely seen as a necessary element in a properly functioning market system as it forces the suppliers to declare, on a standardised basis, the energy consumption of their products so that consumers are able to compare them. The cost of energy is the major ongoing cost of operation for a refrigerator or freezer and the energy cost over the product's life is often rather more than the purchase cost. The energy consumption of a product is not visible by inspection, so a mandatory declaration is essential.

The original star rating algorithm, which was in use from 1986 to 2000, had a single equation to determine star ratings for all refrigeration product types and groups. In 2000, a more complex star rating system was introduced where, for the purposes of energy labelling, 5 categories of products had separate algorithms or equations for the determination of individual product star ratings.

Equations for the original (1986) and current (2000) star rating algorithms are shown in Appendix E.

The main motivation for the review of the refrigerator star rating algorithm leading up to 2000 was that many of the products in the late 1990's rated 4 or 5 stars, so the level of differentiation was reduced and the potential market pull from consumers was attenuated. With the introduction on MEPS levels in October 1999 for refrigerators and freezers for the first time, some of the star rating "bins" for many product groups were empty, thus reducing the impact of the star rating system further. However, the MEPS levels had a varying impact on different groups so there were still wide disparities in the energy consumption of products after these MEPS were introduced.

During the review of the star rating system in 1998, some issues associated with the original star rating system that required attention were also identified. These included:

- The star rating algorithm passed through the origin – the assumption behind the original star rating equations was that the energy consumption of a refrigerator or freezer was linearly proportional to the adjusted volume[1]. However physics suggests that the heat gain (which is the main driver for energy consumption) will be in proportion to surface area rather than volume. There is also a higher proportion of relatively fixed energy losses associated with smaller cabinets. Another way of considering this issue is size bias – it was technically easier to achieve a high star rating on a larger cabinet than a

[1] It should be noted that the current (2000) labelling algorithms do not pass through the origin and in many cases have a small energy allowance per additional litre of volume. While this effect is not the same as a true surface area factor (which is approximately volume to the power of 0.7), it certainly removes the obvious "efficiency" advantage for large models that was present in the original 1986 algorithm. Heat gain is complex. It is primarily a function of surface area but also of thermal transfer through penetrations and gaskets. A de facto surface area function has been used for the 2009 algorithm.

smaller cabinet under this original energy labelling algorithm. Correcting for surface area and other factors is quite complicated and was not attempted in 2000 but in fact has been included in the new algorithms proposed in this paper. (Correction for this effect is not attempted in other refrigerator standards.)

- The star rating bands were a linear progression – that is the kWh reduction to achieve each additional star remained constant for all stars. This effectively meant a larger and larger percentage energy reduction for each additional star. This was technically increasingly difficult to achieve. For some product categories, this meant a 6 star level in fact required energy generation (negative energy).

During the energy labelling review in 1998, a wide range of the key issues (including those listed above) were considered for all labelled products. These are documented in EES (1998), which sets out the key issues considered during the preparation of new star rating algorithms at the time, and EES (2004), which documents all of the transition issues of the 2000 energy label changeover.

The star rating revision for 2000 was intended to redress many of these issues. The major improvements for the 2000 refrigerator and freezer labelling algorithm included:

- Use of a geometric progression – this was adopted for labelling of all appliances (except air conditioners which are rated on a separate efficiency basis). In effect the star rating equation sets an energy consumption line for 1 star and there is a constant percentage energy reduction for each additional star.
- Alignment of the 1 star lines with MEPS levels where relevant – the concept was that under a MEPS regime no products could have a higher energy consumption than the MEPS line so this should define the 1 star level. The implementation of this for refrigerators and freezers is somewhat complex with amalgamation of various Groups for star rating purposes (and is even more complication in 2005 with various allowances for features). This issue is discussed in more detail below. The proposal developed in this paper deviates from this original concept as it appears that the MEPS lines implemented in 2005 do not always represent lines of equal technical efficiency.
- Introduction of half stars, the graphical outline of all stars (which are always visible irrespective of the achieved star rating) and an improved, more easily printed and clearer layout for the energy label was also introduced for all products in 2000.
- Reduction of size bias – as star rating equations were linked to MEPS lines, which were intended to be technically neutral across different cabinet sizes, the inherent impact of size on star rating was also reduced.

In the case of refrigerators and freezers, the improved label design, the introduction of a geometric progression of the star rating algorithm and the inclusion of half stars have all been successful and should be retained in any algorithm revision. The introduction of offsets into the algorithm has also reduced some of the previous problems of size bias in favour of larger cabinets. The actual offset proposed and the form of the 1 star lines for energy labelling are examined later in this paper.

This paper primarily considers the equations that are used to calculate the star ratings for refrigerators and freezers and does not explicitly discuss other aspects of the scheme such as MEPS, the scope of products covered and the energy label layout and design, although some of these issues are clearly important and will have some impact on the decisions made (eg minimum number of stars, maximum number of stars etc.). Where an aspect of the label design may impact on the calculation of the star ratings, this is explicitly stated in the discussion below.

Separate work is under way with regard to fine tuning the energy label design and issues associated with the transition to a new label design for refrigerators in 2009. Some of this work will be specifically commissioned for this project, while some is of a more general nature that will be applicable to several or all products that currently carry an energy rating label.

A later section in this paper summarises the labelling related issues and the transition arrangements during 2008 and 2009.

Issues for Consideration for a New Star Rating Algorithm

Many of the issues that need to be considered in the development of new algorithms for refrigerators and freezers have been canvassed in the previous version of this discussion paper. This section attempts to condense some basic principles and guidelines for the development of a new star rating algorithm which is proposed for introduction in 2009 in Australia and New Zealand.

The main considerations should be:

- Retention of the geometric progression for star rating – this involves defining a 1 star line and setting an energy reduction for each additional half star. It is assumed that 1 star is the minimum rating that can be depicted on the energy label, although a Star Rating Index can be less than 1 for individual products (such products always get a so called "courtesy" star[2], but generally the aim is to set the 1 star line so that few, if any, products fall below the 1 star line).
- Experience with the new star rating algorithms in force since 2000 suggest that the most workable star rating band size is about 15% to 25% reduction per additional star. If the star rating bands are smaller than this, the rating system depicts star rating differences between products that, in reality, only represent small changes in energy consumption. Star bands much larger than this are only warranted where there are very large differences between the least and most efficient products on the market. This is not yet the case under the relatively stringent 2005 MEPS regime for refrigerators and freezers (however, the case of refrigerators and freezers is somewhat complicated by the large number of different product groups and the associated scatter of energy consumption).

[2] One submission in response to the 2006 discussion paper suggested removal of the courtesy star, but research with consumers has consistently shown that depiction of no stars in a stand alone label is difficult, if not impossible.

- Half stars should continue to be used on the refrigerator label as for other star rated products (although this is not a critical assumption with respect to the determination of a star rating algorithm).
- The maximum number of stars should continue to be 6[3]. This is now well established with consumers and they appear to understand that star ratings are re-graded from time to time, as would result from the implementation of the recommendations in this paper. The concept of an undefined maximum number of stars has not been well received in market research of consumers. Further documentation on this point is contained in some of the references.
- No additional information is to be included on the refrigerator and freezer energy label for the time being (the issue of inclusion of compartment volumes on the energy label was canvassed within the Stakeholder Working Group but was put on hold for the time being until volume measurement approaches are rationalised). However, information on old and new star rating during the 2009 transition period is proposed
- New MEPS levels (and any associated energy allowances) that were introduced on 1 January 2005 need to be taken into account when developing a star rating system. But MEPS allowances should continue to be excluded from star rating algorithm calculations. An exception proposed is that the adaptive defrost allowance of 1.05 be included in the determination of the star rating (this is discussed in more detail below). A number of submissions on the original discussion paper were on this point.

Review of Market in mid 2007

Figure 1 depicts all groups and models which were registered for energy labelling in the period 1986 to 1990, the first 4 years of the energy labelling program, which commenced almost 20 years ago.

[3] A submission in response to the 2006 discussion paper suggested moving to a 5 star scale, but again research has shown that consumer are comfortable with an understand the current design, so no changes are proposed in this respect. A 6 star scale is geometrically more pleasing for consumers.

Figure 1: Refrigerators and Freezers in Australia Registered 1986-1990

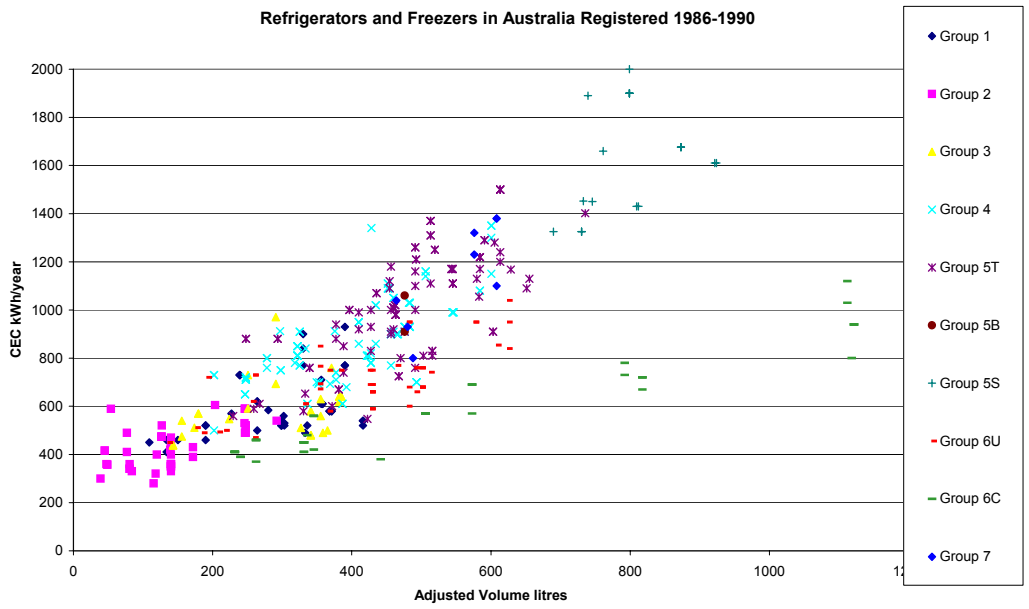
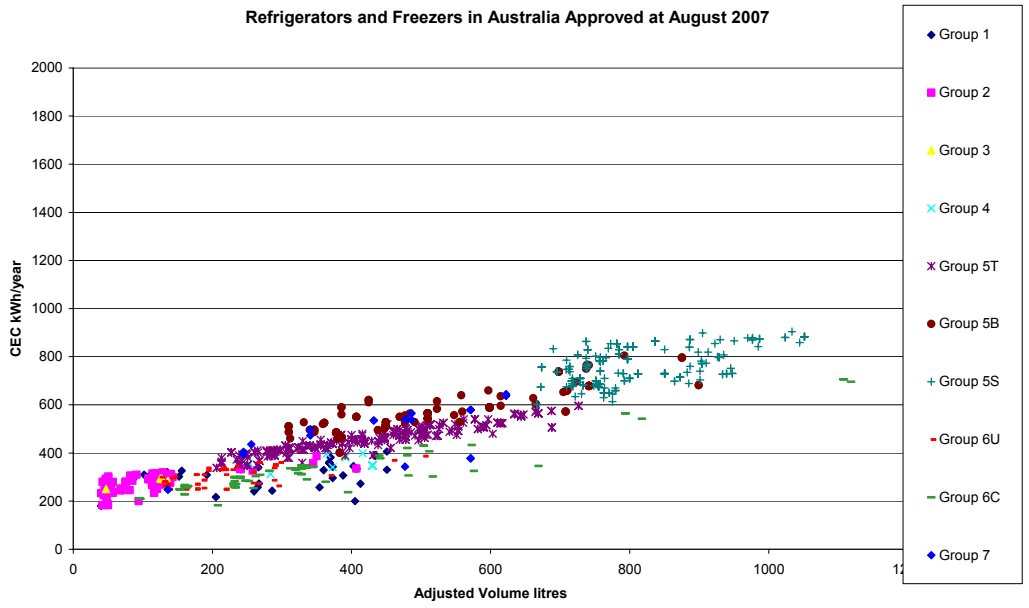


Figure 2 below depicts approved refrigerators and freezers on the market as of August 2007. All of these comply with the current MEPS requirements (introduced on 1 January 2005). AS/NZS4474.1 (the part of the standard that lays down the test procedure) has been revised but again, no changes are envisaged that would have a noticeable effect on results depicted.

Figure 2: Refrigerators and Freezers in Australia & NZ, Approved as at August 2007



Note: Products in Australia are registered, in New Zealand they are listed by the regulator

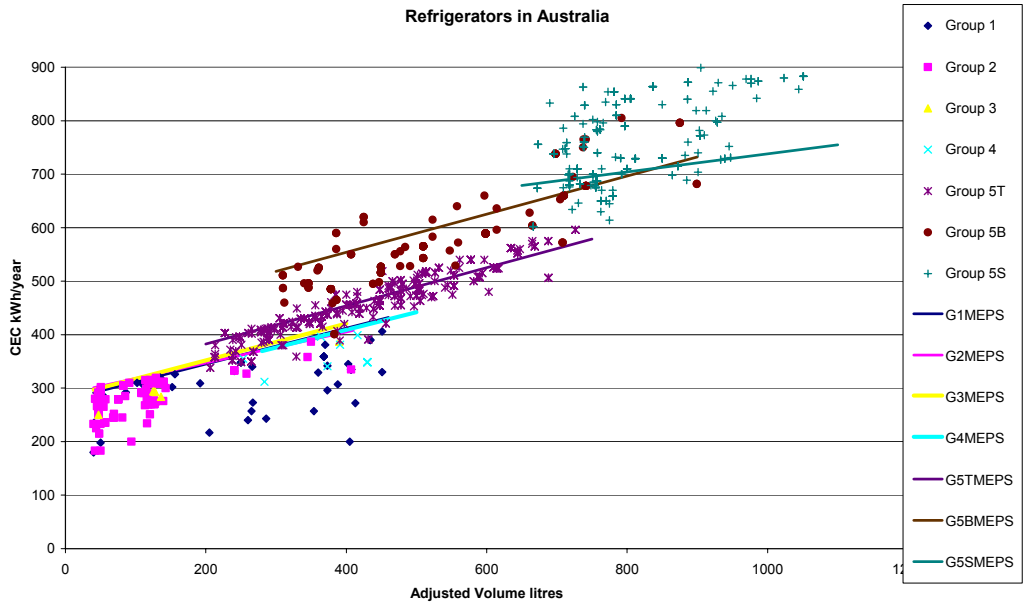
The most striking points to note with regard to these figures are:

- Group 2 and group 6U models are now generally smaller in size (adjusted volume) than products registered for energy labelling in the late 1980's. (more detail on Group definitions is included in Appendix E)
- Group 3 and 4 were quite prevalent in the late 1980's but almost no models are left on the market by 2005 (however, a couple of Group 3 models with substantial sales appeared on the market in 2005 and 2006).
- The number of Group 5S and 5B models has increased somewhat (the sales share for Australia and New Zealand is quite different for these products – see following analysis).
- The energy consumption of all groups has decreased dramatically (on average to 50% or less of the pre 1990 values), mainly due to MEPS but also due to energy labelling and some due to general technology improvements that might well have happened anyway. This is despite a small increase in average volume of new refrigerators sold over the past 20 years (noting that volumes have now stabilised for most groups and may fall in future).
- In terms of kWh/adjusted litre, Group 6C is still at the more efficient end of all models (lowest energy), but this group no longer stands clearly apart from the other groups in a plot of adjusted volume versus energy.
- The 1986-1990 models used CFC-12 refrigerant and CFC-11- blown polyurethane foam insulation. The 2007 models use zero ODP refrigerants (generally HFC-134a) and foam blowing agents (mostly hydrocarbon for locally produced products).

When developing an energy labelling algorithm, it is important to consider the influence of the MEPS requirements in 2005 for each group, which appear to have had a marked effect on the available energy consumption distribution, at least in the short term. The largest effect is in the years leading up to the MEPS introduction. All current models as of August 2007 together with the 2005 MEPS lines are depicted in the following figures. MEPS lines depict maximum permitted energy consumption by Group.

The energy distribution and MEPS lines by Group for refrigerators (Groups 1 to 5) for 2007 are shown in Figure 3.

Figure 3: Approved Refrigerators on the Market as of August 2007 with MEPS by Group



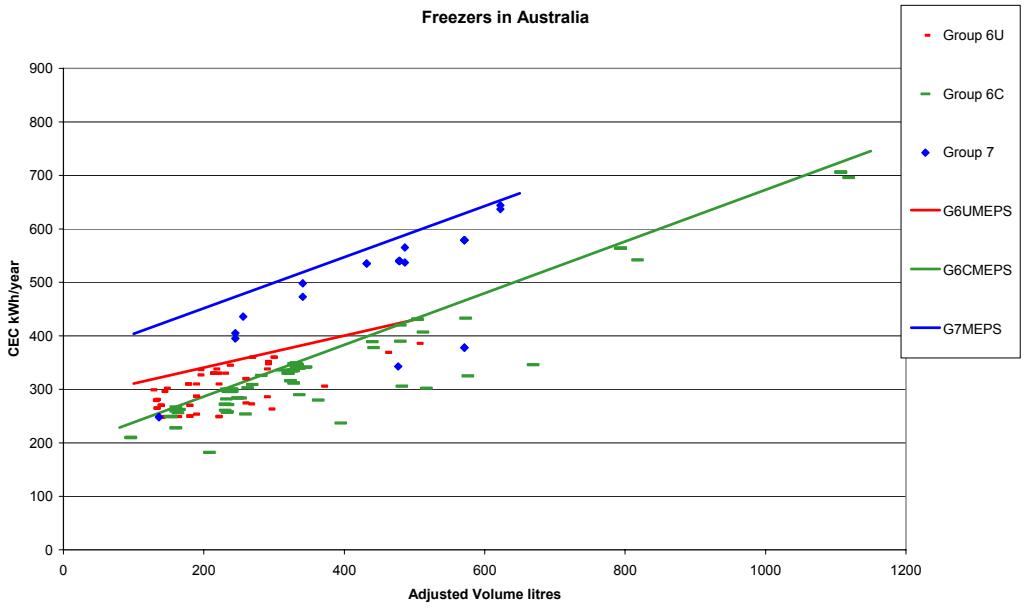
Note: This chart has a different Y axis scale to the previous 2 figures.

The most important points to note with respect to the distribution of refrigerator energy consumption shown above are:

- MEPS requirements for Groups 1, 2, 3 and 4 inclusive are almost the same for practical purposes.
- The MEPS lines for Groups 5T and 5B are parallel to Groups 1 to 4 but with an energy offset of about 50kWh/year and 150kWh/year respectively.
- Group 5S MEPS line has a flatter slope but this covers a relatively narrow range of product sizes (generally very large products).
- Some products within some groups (mainly 5T, 5B and 5S) appear to lie above the relevant MEPS lines – this is because they have one or more specified features for which they are permitted an energy allowance with respect to MEPS: these allowances are for adaptive defrost, additional doors and/or through the door icemakers. This allowance is NOT considered when determining star ratings and no change has been proposed in this respect (except for adaptive defrost, which is discussed further below).
- There is a range of energy efficiency for most groups except Group 5T (which interestingly make up about 50% of all refrigerator and freezer sales in Australia in 2006 and just under 30% of sales in New Zealand in 2006). Group 5T models are clustered on a relatively narrow band around the MEPS line which indicates that manufacturers have designed to just meet the regulator requirements.
- There appears to be a more pronounced overall impact of volume versus energy for all groups (when considered together), than is reflected in the MEPS lines (which are generally flatter). The impact of this mismatch is not all that great, however, as most product groups are clustered into narrow size ranges along the MEPS lines, which somewhat masks this effect.

The energy distribution and MEPS lines by Group for freezers (Groups 6C, 6U & 7) are shown in Figure 4 below.

Figure 4: Approved Freezers on the Market as of August 2007 with MEPS by Group



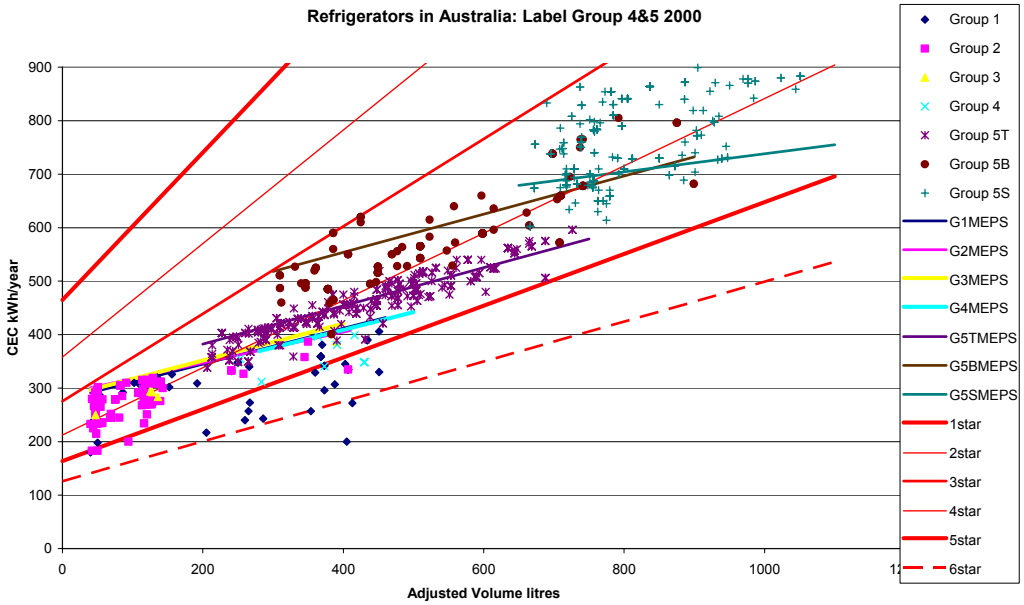
The most important points to note with respect to the distribution of freezer energy consumption shown above are:

- The size of Group 6U (volume of available products) is limited to generally small sizes. There is a strong growth in Australia towards small products (around 100 litres) for this product group. The driver for this recent market trend is unclear.
- Chest freezers have a more stringent MEPS level and are typically lower energy users than models in group 6U. There are quite a number of models that are well below MEPS.
- Some high efficiency Group 7 products have recently appeared.

In a general sense it appears (at least pictorially) that the MEPS lines implemented in 2005 for refrigerators and freezers have had a strong impact on the energy consumption of available models. It is important to note that the MEPS lines implemented in Australia and New Zealand in 2005 were in fact adaptations of the US 2001 MEPS levels, after taking into account major differences between the test method used in Australia/New Zealand and that used in the USA. While the engineering and economic analysis in the USA for the 2001 MEPS level was extensive, some elements of the MEPS levels there were negotiated between manufacturers and non government organisations, so these MEPS levels may not always be aligned with the expected technical efficiency curves for the various groups. It is known, for example, that the MEPS levels for products with a large market share (eg Group 5T) were made quite stringent compared to other products with only a small market share.

The other element of complexity is that the allowances for various features in the USA, such as icemakers and adaptive defrost, were simplified in the Australasian adaptation of these MEPS levels and some of the product groups defined in the USA had no clear equivalents in Australia/New Zealand and vice versa. In some cases where there were equivalent groups, the size of products in each country were quite different. To illustrate the complexity of the MEPS lines versus the star rating equations, the current approved models as of August 2007 and the Group 4 & 5 star rating lines are shown in Figure 5, noting that although this does not apply to all groups, it does show that the current system needs updating. (Appendix E provides an explanation of the star rating system.)

Figure 5: Refrigerator MEPS lines with 2000 star rating lines for Groups 4, 5T, 5B and 5S



Note: Groups 1, 2 and 3 use a different star rating algorithm to the one shown.

To provide more data, Table 1 below sets out the star rating of the 1130 products currently registered to MEPS 2005 in Australia and New Zealand under the 2000 energy labelling algorithm as at August 2007. The coloured cells in Table 1 show (approximately) the MEPS levels for that particular group. Red cells show that that star rating is below the MEPS level and yellow cells show that some products for these star ratings are affected by MEPS (depending on the size). Cells that have no colour are for star ratings that are better than the MEPS levels, indicating (comparatively) efficient products. The colours in the top row of cells containing the Group number show the groups that under the 2000 algorithm use the same star rating equations (ie Groups 2 and 3 have the same algorithm, whereas Group 6C is different from all others).

The main point is that MEPS 2005 has made the 2000 energy labelling algorithms fairly redundant and there is now a need to revise these to make them more relevant. MEPS also appears to have had a strong impact on the energy consumption of available products on the market (energy range is narrow) and many lie along the relevant MEPS lines. This needs to be carefully considered when developing a new

energy labelling algorithm. However, the number of available products and their sales has remained comparable after the introduction of MEPS.

Table 1: Group by 2000 Star Rating for August 2007 Approved Registrations

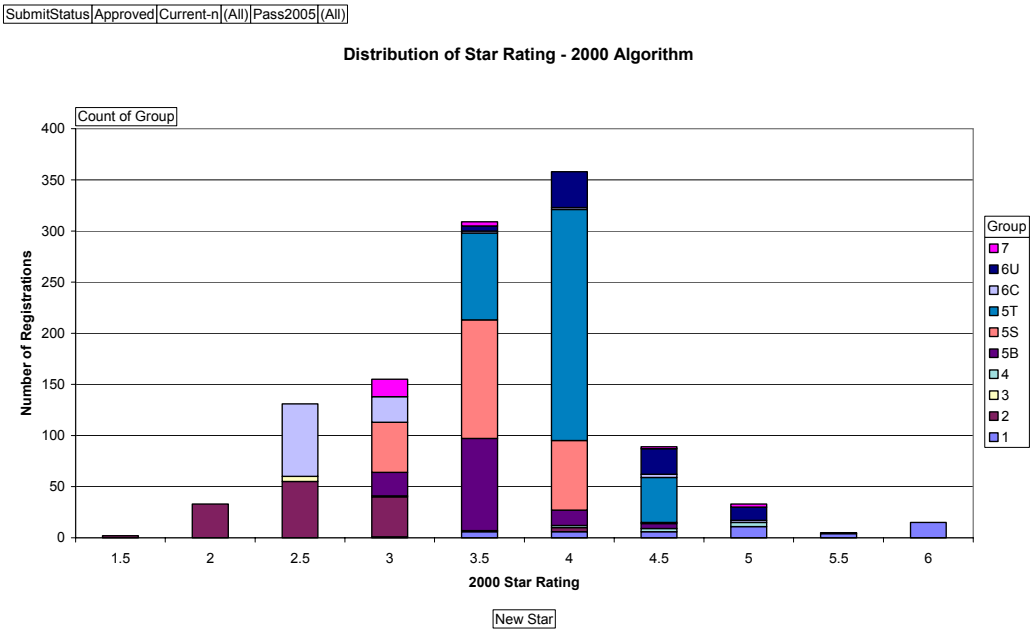
Group → 2000 Stars ↓	Group 1 (% / star)	Group 2 (%/ star)	Group 3 (%/ star)	Group 4 (%/ star)	Group 5B (%/ star)	Group 5S (%/ star)	Group 5T (%/ star)	Group 6C (%/ star)	Group 6U (%/ star)	Group 7 (%/ star)	Total (%/ star)
Approved Registrations (August 2007)											
Total (number)	**49**	**134**	**6**	**9**	**133**	**234**	**355**	**105**	**79**	**26**	**1130**
1											**0**
1.5		2									**2**
2		33									**33**
2.5		55	5					71			**131**
3	1	39	1		23	49		25		17	**155**
3.5	6	1			90	116	85	2	5	4	**309**
4	6	4		2	15	68	226	2	35		**358**
4.5	6			3	5	1	44	3	25	2	**89**
5	11			4				2	13	3	**33**
5.5	4								1		**5**
6	15										**15**
Models Sold in Australia, 2006											
Total ('000)	**57**	**117**	**47**	**0**	**121**	**140**	**479**	**103**	**87**	**41**	**1193**
1								0.1		1.5	**1.7**
1.5		5.4								1.1	**6.5**
2		22.9				0.1	0.3				**23.4**
2.5		45.4	47.2			0.1	1.4	73.4	0.1		**167.6**
3		42.6			0.8	12.4	1.7	13.7		29.7	**101.1**
3.5	3.2				78.3	61.2	83.6	15.5	32.0	8.6	**282.5**
4	1.9	0.6			41.5	63.4	311.7		28.2		**447.3**
4.5	13.6			0.1	0.7	3.1	80.0		26.3		**123.7**
5	26.4								0.1	0.1	**26.5**
5.5	7.4										**7.4**
6	4.8										**4.8**
Models Sold in New Zealand, 2006											
Total ('000)	**9**	**22**	**0**	**0**	**63**	**11**	**42**	**23**	**1**	**8**	**181**
1		1.3				0.6		0.1			**2.0**
1.5		0.2					0.3	0.2		0.1	**0.8**
2		2.6			1.1		6.1	0.4			**10.3**
2.5		15.8	0.3	0.1		0.1	0.0	17.5	0.2		**34.0**
3		2.6			4.6	2.5	0.2	5.0		7.0	**21.9**
3.5	0.2				56.0	3.7	5.7			0.5	**66.1**
4	1.5				1.6	4.1	29.5		0.1	0.0	**36.8**
4.5	2.3			0.1			0.3			0.4	**3.1**
5	2.5								0.8		**3.4**
5.5	2.0										**2.0**
6	0.1										**0.1**

Note: Groups with a common algorithm have the same colour in the first row. Red cells indicate that the star rating is below the MEPS level. Yellow cells show that some products for these star ratings are affected by MEPS (depending on the size). Clear cells indicate that the star rating is above the MEPS level. The Group 2 units in the red area are just below 2 stars and passes MEPS by about 1 kWh.

It is important to note that the 1 star and 1.5 star bins are virtually empty for all groups. The only products with a star rating of 2 stars is Group 2. Group 1 has a

relatively weak algorithm so low energy products now achieve very high star ratings. The distribution by stars and group is shown pictorially in Figure 6 below.

Figure 6: Distribution of 2000 Star Rating by Group for August 2007 Approved Registrations



Appendix H shows Table 1 depicted as a frequency distribution for each Group and star rating.

Proposed Algorithm for Refrigerators and Freezers

The most complex issue to consider for refrigerators and freezers is whether to continue to rate products in sub-groups (continuation of the so called "splitting" of groups for energy labelling which, was introduced in 2000) or whether to develop a more integrated labelling approach which can be applied across different groups (more of a "lumping" approach which is similar to the original labelling algorithm in 1986 which had a single set of equations for all Groups) while incorporating all of the improved features of the 2000 labelling system. After extensive analysis and careful consideration, a set of three rating equations which covers all product groups appears to be the most feasible and workable. This is a reduction from five categories in 2000 but most importantly will facilitate comparisons across a range of product types and sizes.

In 2005 the E3 Stakeholder Working Group considered a selection of possible energy labelling algorithm options during the development of the original discussion paper. The one agreed to be most promising was depicted in the original discussion paper (January 2006) – so called Option 14. While this algorithm offered some advantages over the existing algorithms and seems to provide a broad fit against the range of current products on the market, its non-alignment with many of the MEPS lines presented a serious longer term problem for the star rating system and for a high efficiency scheme such as Energy Star which needs to link with the star rating system. While the fit across all groups and sizes as a whole appeared to be reasonable, these lines did not appear to take account of the relative efficiency within groups and

probably did not represent true efficiency trends over a wide volume range as it was based on a series of straight lines.

After further discussions between EECA (Energy Efficiency and Conservation Authority, NZ) and the AGO (Australian Greenhouse Office) in mid 2007, extensive work and analysis was undertaken to develop new star rating algorithms to redress some of these issues. The new approach provides three separate equations which each cover specific collections of groups.

The fundamental principle of the new algorithm developed was to move from a system that was based on adjusted volume to one that is based on a de facto measure of the surface area of the cabinet. This should better represent the key driving factor for energy consumption of refrigerators. In geometrical terms, for simple rectangular prisms it can be shown that the relationship between surface area and volume is that surface area is proportional to volume to the power of 2/3. This is the factor that has been adopted as the basis for the new algorithms.

Three new algorithms were developed to cover products that were similar in design, function and operation as follows:

- Algorithm 1: Groups 1, 2 and 3 (typically single door, simple design);
- Algorithm 2: Groups 4, 5T, 5B and 5S (two door refrigerator-freezers)
- Algorithm 3: Groups 6U, 6C and 7 (separate freezers – all types).

The equations were developed to fit the products currently available on the market. For all three algorithms, the energy reduction per additional star is set to be the same as the energy reduction under the 2000 labelling algorithm for groups 4, 5T, 5B and 5S (ie ERF = 0.23, or 23% per additional star or 12.25% per additional half star). Figure 7 depicts energy labelling Algorithm 1 (Option 30) for refrigerator groups 1, 2 and 3.

Figure 7: Algorithm 1: 2009 Energy Labelling Algorithm for Refrigerator Groups 1, 2 and 3 (Option 30)

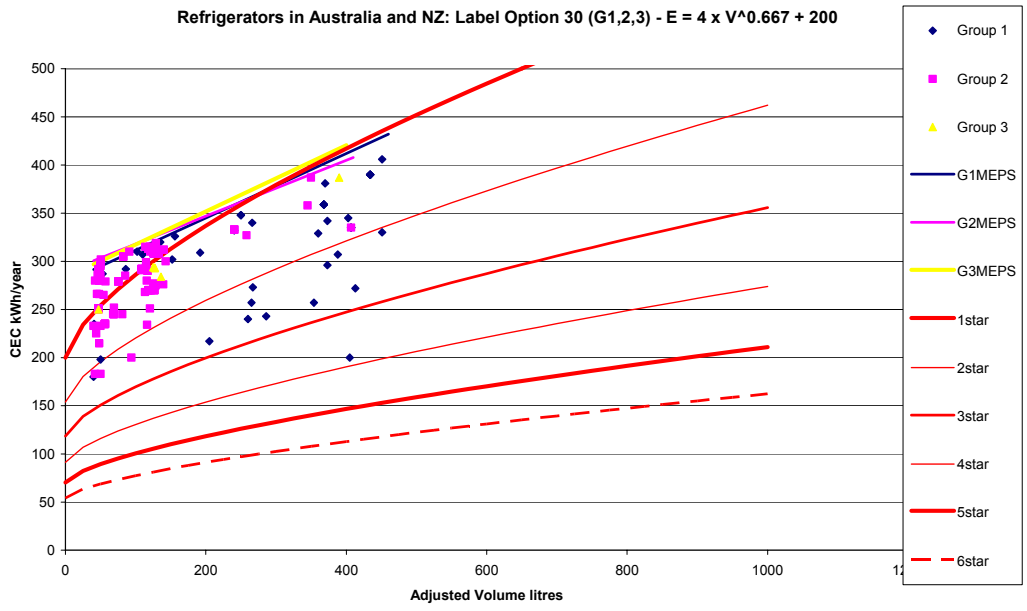


Figure 8 depicts energy labelling Algorithm 2 (Option 31) for refrigerator groups 4, 5B, 5T and 5S.

Figure 8: Algorithm 2: 2009 Energy Labelling Algorithm for Refrigerator groups 4, 5B, 5T and 5S (Option 31)

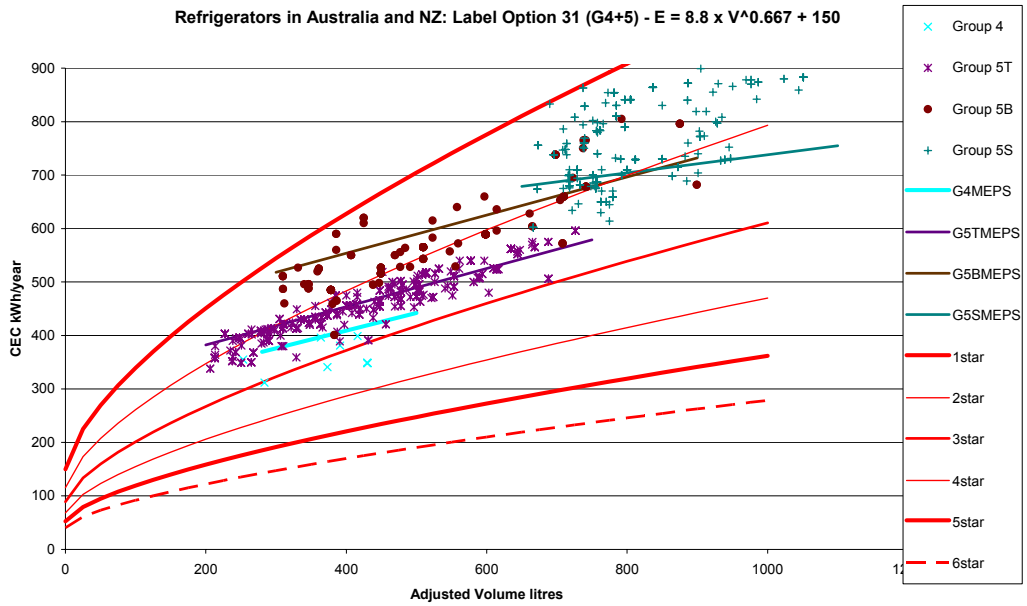
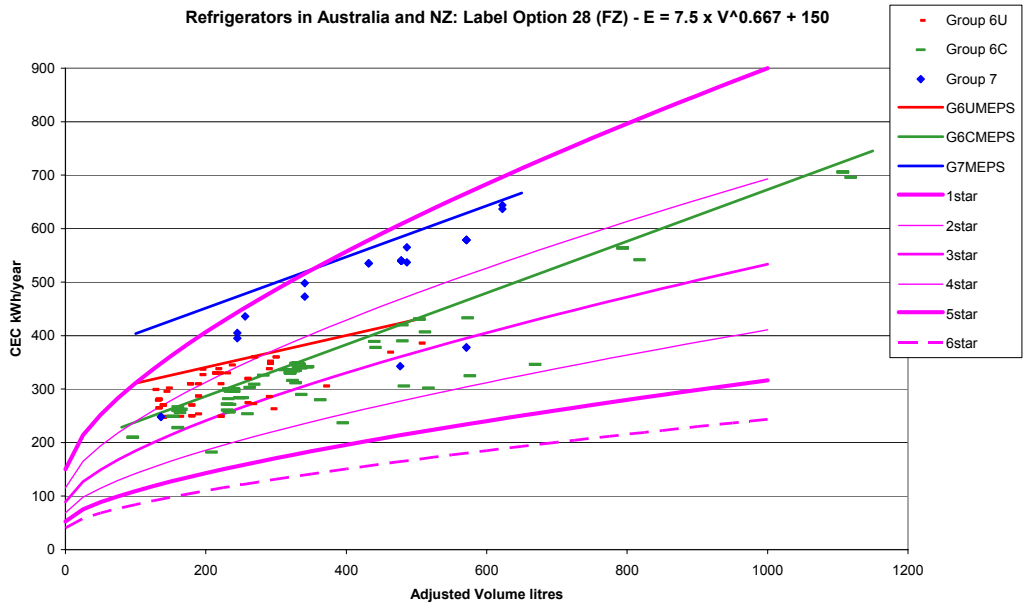


Figure 9 depicts energy labelling Algorithm 3 (Option 28) for freezers.

Figure 9: Algorithm 3: 2009 Energy Labelling Algorithm for Freezers (Option 28)



For refrigerators, these new algorithms have the following advantages:

- They appear to provide the basis for reasonable differentiation across different Groups and different size ranges and also within Groups.
- All products achieve a star rating of better than 1 star, except for very small Group 2 products which are by and large simple and in most cases very low efficiency (for their size). MEPS levels for these products are relatively weak as they are based on straight lines with a reasonable large fixed intercept.
- Most products lie in the range 1 star to 3 stars under the new system, but there are a significant number of models in several groups that already achieve 3 stars.
- There are already products or there are prospects for products in most Groups to reach more than 3 star level in the medium term, except for very large high energy products in Group 5B and 5S, although the best products in these groups already achieve 2.5 stars.
- The surface area function developed appears to provide a sound basis for describing the energy consumption of products across a very wide size range.
- The equations to determine the star rating appear to provide a fair basis for comparative energy efficiency and they simplify the requirements for energy labelling of refrigerators which allows a comparison of efficiency across comparable groups.
- These algorithms provide a sound basis for the development of future high efficiency criteria such as Energy Star. While there is some mismatch between the star rating lines and the MEPS lines, the inherent energy consumption trends of many products appear to track the proposed star rating lines in most groups.

Additional points for freezers include:

- The MEPS requirement for chest freezers is roughly parallel to the (curved) 2 star line.
- There are already some products in all Groups that achieve 3 stars and a few high-end chest freezers that already exceed 4 stars (noting that these have very low energy values and are very efficient).

The algorithms provide a consistent star rating system that consumers can use during the selection process to compare products that perform comparable tasks.

Conceptually, these algorithms can be seen as one star lines with a fixed energy consumptions at a volume of zero litres plus an additional energy allowances based on the surface area of the refrigerator. This is very similar to the approach for the 2000 algorithms except that instead of straight lines based on adjusted volume, these are now curves based on adjusted volume.

For all groups the equation for the Base Energy Consumption (BEC) is of the form:

$$BEC = a \times (V_{adj})^{b} + c$$

Where:

- a is a coefficient which is an indicator of the insulation thickness and the typical compartment geometry

- V_{adj} is the adjusted volume as defined in AS/NZS4474.2 and represents a total volume in terms of fresh food equivalent volume (colder compartments have their volume adjusted up based on the difference in temperature between the compartment and the ambient air temperature)
- b is the relationship between volume and surface area, which is 2/3.
- c is a constant in kWh/year (y intercept on the figures)

Note: The 2000 equations had exactly the same form except that b then had the value of 1.

The coefficients for the Base Energy Consumption (1 Star) equations are set out below:

Groups	a	c
1, 2, 3	4	200
4, 5T, 5B, 5S	8.8	150
6U, 6C, 7	7.5	150

The equation for star rating index in all Algorithms is the same as 2000 star rating equation:

$$SRI = 1 + \left[\frac{\log_e\left(\frac{CEC}{BEC}\right)}{\log_e(1 - ERF)} \right]$$

Where:
SRI is the star rating index (fractional star rating)
CEC is the comparative energy consumption (energy that appears on the energy label)
BEC is the base energy consumption – the equation for a product with an SRI of 1.0
ERF is the energy reduction factor – reduction in CEC for each additional star (0.23 in all cases for the new algorithms)

More details on the previous star rating algorithms for refrigerators and freezers are provided in Appendix E.

The following table sets out the star rating of the 1130 products currently registered for MEPS 2005 in Australia and New Zealand as they would be under the proposed 2009 energy labelling Algorithms 1, 2 & 3 (Options 30, 31 & 28 respectively).

Given that there are a considerable number of Group 5T, 5B and 5S models that have an energy consumption that exceeds the specified MEPS level for their groups (due to use of allowances for additional doors, ice-makers and adaptive defrost), some consideration could be given to a warning label or warning text placed on such products. This could be in the form of text in the bar at the bottom of the energy label. It would only be effective if it were a mandatory requirement under the energy labelling scheme.

Table 2: Group by 2009 Star Rating for August 2007 Approved Registrations

Group → 2009Stars ↓	1	2	3	4	5B	5S	5T	6C	6U	7	Total
Approved Registrations (August 2007)											
Total (number)	**49**	**134**	**6**	**9**	**133**	**234**	**355**	**105**	**79**	**26**	**1130**
1	30	126	6		18	73			1	16	**270**
1.5	7	5			75	123	39		31	5	**285**
2	6	3		1	35	38	256	43	32	2	**416**
2.5	5			3	5		60	52	10		**135**
3				5				4	5	3	**17**
3.5	1							4			**5**
4								2			**2**
4.5											
5											
5.5											
6											
Models Sold in Australia, 2006											
Total ('000)	**57**	**117**	**47**	**0**	**121**	**140**	**479**	**103**	**87**	**41**	**1193**
1	45.1	109	47.2		1.1	37.9	3.3	0.1	0.1	30.5	**274.5**
1.5	7.4	7.2			47.9	71.0	51.9		41.8	10.4	**237.7**
2	4.7	0.6			72.0	31.4	260	40.0	44.6		**453.2**
2.5	0.1				0.5		163.5	47.1	0.1		**211.3**
3				0.1				15.5		0.1	**15.7**
3.5											
4											
4.5											
5											
5.5											
6											
Models Sold in New Zealand, 2006											
Total ('000)	**9**	**22**	**0**	**0**	**63**	**11**	**42**	**23**	**1**	**8**	**181**
1	6.4	22.4	0.3	0.1	5.7	3.9	6.7	0.1	0.2	7.2	**52.9**
1.5	2.0				18.4	4.7	5.4	0.2	0.1	0.5	**31.3**
2					39.2	2.4	25.3	11.3		0.4	**78.6**
2.5	0.1						4.8	11.7	0.9		**17.5**
3				0.1							**0.1**
3.5								0.1			**0.1**
4											
4.5											
5											
5.5											
6											

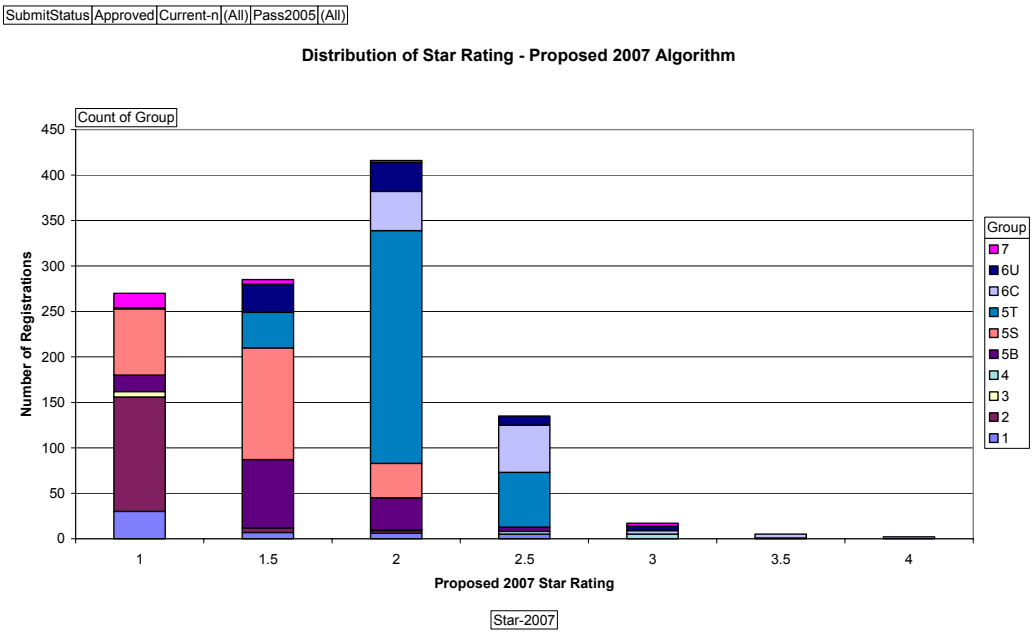
Note: Groups with a common algorithm have the same colour in the first row.

Under this algorithm, the lower star rating bins are filled more evenly, but there are a couple of groups with no 1 star products. These are Group 4 (only a handful of mostly higher end European products remain on the market), Group 5T (very stringent MEPS levels with only a few products at 1.5 stars) and Group 6C (chest freezers, which are an inherently efficient configuration, with the current MEPS level at about 2 stars or above). However, some groups continue to have a small available energy range as a result of MEPS – this is a key issue that this new algorithm is attempting to address. The majority of the 1 and 1.5 star products are Group 2, Groups 5B and 5S. This is not unexpected as Group 5S and 5B are generally higher energy configurations and most of the poorly rating products are well above their respectively MEPS levels. The

Group 2 products are mostly very small, low cost, simple and inefficient products. This distribution of this proposal by group and star rating is illustrated in Figure 10.

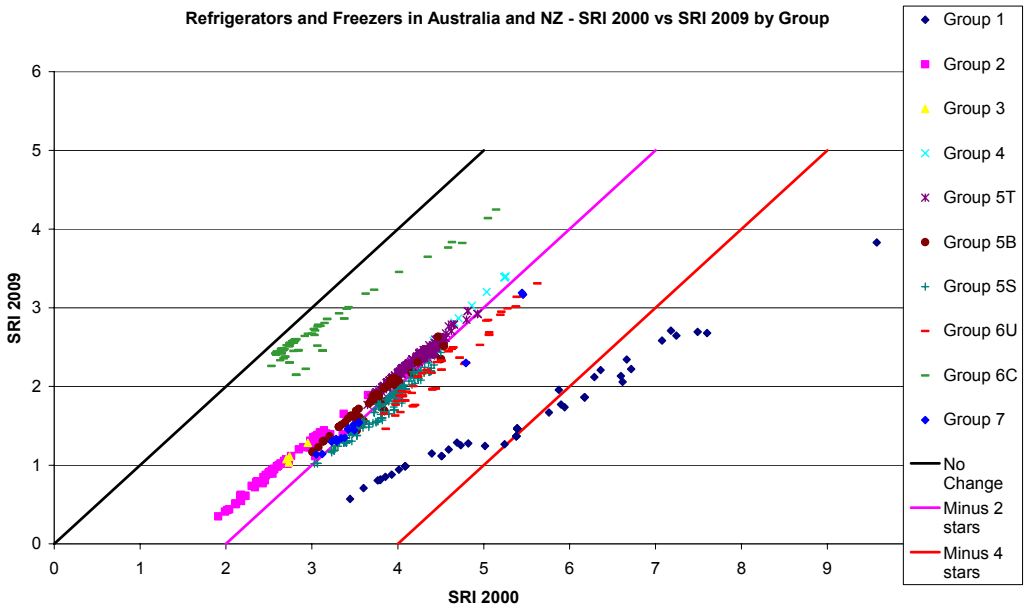
Appendix I shows Table 2 depicted as a frequency distribution for each Group and star rating for the proposed 2009 energy label algorithm for approved registrations as at August 2007 and sales for 2006 for each refrigerator and freezer group. Appendix F show these figures depicted as a frequency distribution for each Group.

Figure 10: Distribution of 2009 Star Rating by Group for August 2007 Approved Registrations



The new algorithms result in a reduction of about 2 stars for nearly all groups as illustrated in Figure 11. The exceptions to this general rule are Group 6C, where the reductions in star ratings fall less than 1 star (with new ratings falling by as little as -0.1 stars to as much as -1.0 stars) and for Group 1, where the reduction in star rating is typically 4 stars (with new ratings ranging from -3 stars for lower efficiency products to as much as -5 stars for higher efficiency products). One Group 1 product currently rates 9.5 stars (high end European product) and this is rated at almost 4 stars under the new algorithm. It is important to note that the Group 1 algorithm from 2000 was very weak and used an ERF of 0.12 (12% energy reduction per star), which is less than half the ERF in the new proposal. This was by far the lowest ERF of all groups.

Figure 11: Refrigerators and Freezers in Australia and New Zealand – SRI 2000 vs SRI 2009 by Group



A spreadsheet with a list of all approved models as at August 2007 with the 2000 Star Rating Index (decimal star rating or SRI) and the proposed 2009 SRI is available on request.

Adaptive Defrost

In the original discussion paper there was extensive discussion on the issue of adaptive defrost, which has not been replicated in this revision of the paper. A number of submissions on the issue of adaptive defrost on the original discussion paper were received (refer Appendix G). In essence, these submissions argued that adaptive defrost is likely to provide real energy savings during normal use and therefore some credit should be given in the Comparative Energy Consumption (and hence star rating) for this feature.

In principle, this approach is considered to be reasonable. The standards committee and E3 agree that features that provide real energy savings during normal use but which may not be apparent in the test method should be given credit where possible. However, there are a number of important practical issues to consider prior to implementation of such an allowance or factor for adaptive defrost products.

Firstly, the current allowance in AS/NZS4474.2 for MEPS is 5% of energy. While there is some test data upon which this number is based, this figure is basically a simplification of the US allowance for long time defrost that is part of the US 2001 MEPS levels. The allowance was included in the Australian/New Zealand MEPS levels for 2005 as we were attempting to replicate the US levels as closely as possible without changing our test method to theirs. It was not based on realistic measurements of savings in the field compared to laboratory test data.

Secondly, while there is probably some energy saving potential in the field (during normal use) that will result from a well designed adaptive defrost system, there is no measured data on the magnitude of these savings. Indeed there will be differences in the savings from different adaptive defrost systems (as a number of different parameters may be used), so at this stage there is little solid quantitative basis for providing a reduction of 5% in the Comparative Energy Consumption value determined under AS/NZS4474.1 for these systems. In fact, even under the 2007 revision of this standard, there are still issues (and potential uncertainty) around the definition of what constitutes a legitimate adaptive defrost system (ie models that qualify or not for the MEPS allowance in Part 2), let alone a quantification of the resulting energy savings.

So while E3 are favourably disposed to such an allowance in the future, this would need to be based on a range of representative field data that demonstrated energy savings of these types of controls. Ideally, different adaptive defrost systems should be rewarded on the basis of actual savings rather than a flat allowance for a system that meets specified criteria.

In order to progress this issue, standards committee EL15/23 is being asked to consider the issue in more detail and to undertake investigations to provide more quantitative data for these types of products.

Endorsement Labelling for Refrigerators and Freezers

Up to the end of 2006, high efficiency refrigerators and freezers were eligible in Australia for a Top Energy Saver Award (TESAW). The following sections outline this system and the intention of governments to migrate from TESAW to Energy Star in Australia and New Zealand as the primary endorsement labelling system for all major products.

Background on TESAW

The Top Energy Saver Award (TESAW) commenced in November 2003 and was discontinued in late 2006.

TESAW was an award system that governments created to recognise the most energy efficient, energy labelled products on the market. It was an endorsement label that does not show any detailed performance data. It applied to both electric and gas products that carried an energy rating label that displayed a star rating. It was an award system that helped consumers quickly identify the most energy efficient products on the market. The award criteria were reviewed and updated every year.

Energy Allstars (www.energyallstars.gov.au)

Energy Allstars is a database and website for top energy performing products. It is not an endorsement label, rather it is a single reference that makes it easier for buyers to find and compare the top energy performing products across a range of categories including:

1. TESAW's criteria for energy labelled products (or equivalent, Energy Star in the future)
2. Energy Star's criteria for office equipment
3. Australian Standards for products like distribution transformers, and
4. Other international standards for products such as lighting.

Energy Allstars commenced in January 2005 and it already covers a wide range of products. New categories for office equipment and, soon, lighting are now open for product registrations.

Energy Allstars adopted the TESAW 2005 criteria for products that carry a star rating energy label. Energy Star criteria will be progressively adopted for Energy Allstars as these are developed to replace TESAW in Australia.

Energy Star

The Energy Star Program commenced in the USA in 1992. It applies to a vast array of products in that country – including equipment, appliances, materials and even buildings. Australia became an Energy Star partner and adopted the program nationally in 1999 for office equipment and 2001 for consumer electronics. New Zealand is also an Energy Star partner for the same product ranges.

Common Energy Star criteria are used internationally for selected equipment types (mainly commodities such as office equipment and home entertainment equipment). Until recently, the requirements for products covered under the international program were based primarily on standby power requirements. However, energy consumption for other modes and tasks including on mode are gradually being introduced (e.g. for products such as imaging equipment, computers and monitors).

In contrast, a large part of the US Energy Star program is set up as a domestic endorsement labelling system that works in conjunction with other domestic programs such as MEPS and energy labelling or as a stand-alone program for selected unregulated products. The use of Energy Star as an endorsement of high efficiency products at this stage is used in North America only (USA and Canada).

Transition to a Single Endorsement Label in Australia and NZ

In 2005 detailed discussions and negotiations were held with the US Environmental Protection Agency and the US Department of Energy. These resulted in an in-principle agreement that Australia and New Zealand could set local Energy Star "high efficiency" criteria for products that were sold in the Australasian market (such as white goods where the USA had their own domestic Energy Star criteria), subject to

detailed review by EPA and DOE on a product by product basis. On this basis, E3 decided to move towards the use of the Energy Star label as the primary endorsement label for appliances and equipment in Australia and to discontinue TESAW as an endorsement label.

Energy Star Criteria for Refrigerators and Freezers

One of the key decisions made at the E3 Stakeholder Working Group meetings in 2005 was that any Energy Star criteria to recognise high efficiency refrigerators and freezers needs to be linked to the star rating system. This has been endorsed at subsequent meetings of government officials. This is critical as it provides a consistent message with regard to the relative efficiency of products for both program elements (comparative energy label and the Energy Star endorsement label). So in principle, an Energy Star qualification level should be defined in terms of star ratings under the new energy labelling algorithm. It is important to note that neither the US nor the Canadian energy labels have a star rating system or its equivalent categorical rating system so this potential information miss-match is not an issue there. In North America, they simply specify that products must use a certain % less energy than MEPS for each group. (This is currently 15% for all refrigerating appliances in our groups 1 through 5 and 10% for freezers – our groups 6U, 6C And 7) As a consequence, where the MEPS levels are vastly different from group to group, the Energy Star energy consumptions size for size are also vastly different.

At this stage, no draft Energy Star criteria have been proposed in this paper. Further analysis needs to be undertaken to refine the likely criteria. Further, approval of proposed levels needs to be sought from US authorities prior to their implementation. Energy Star levels that are comparable with or better than US levels (i.e. 10% to 15% better than current 2005 MEPS levels) and also where 20% to 30% of products on the Australia and New Zealand market can attain the criteria would be ideal. Using these criteria together with the new star rating index could create some mismatches and complications within Groups that may need to be examined and resolved.

Therefore, a number of issues will be considered in the development of Energy Star criteria. These are listed for information.

- Star rating index – while selection of half star levels might be considered preferable where possible (as these differences are visible to consumers on the energy label), it is more likely that it will be necessary to select Energy Star levels for some Groups at an SRI resolution of 0.1 at least in the first few years.
- Number of approved models by star rating index within each Group – this provides an indication of the potential availability of models different efficiency levels (noting that not all listed products are sold)
- Sales in Australia and New Zealand by star rating index within each Group – this provides a practical measure of where the market currently sits in terms of efficiency (sales by model vary considerably)
- Total sales by Group within Australia and NZ – groups with smaller sales will be considered as less important than groups with larger sales.
- The inherent energy efficiency of products within each group – there is little point in rewarding products that are known to have a very low practical efficiency even if they are (relatively) the most efficient products available in the market

currently. Therefore it is appropriate that until better models become available in such groups, few units may achieve an Energy Star rating.

The new star rating system in Australia and New Zealand will clearly have a significant impact in the ratings achieved by the products currently in the market and the new ratings need to be considered when setting Energy Star levels. The cumulative percentage of models registered and 2006 sales in Australia and NZ are set out in Table 3. This provides some basis for making an assessment of likely future Energy Star levels. It is anticipated that New Zealand will introduce Energy Star specifications for fridges and freezers in 2008.

Table 3: Group by 2009 Star Rating for August 2007 Approved Registrations (cumulative %)

Group → ↓ 2009 Star	1	2	3	4	5B	5S	5T	6C	6U	7	Total
Approved Registrations (August 2007) - % models that meet or exceed star rating											
Total	**49**	**134**	**6**	**9**	**133**	**234**	**355**	**105**	**79**	**26**	**1130**
1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	**100%**
1.5	38.8%	6.0%		100%	86.5%	68.8%	100%	100%	98.7%	38.5%	**76.1%**
2	24.5%	2.2%		100%	30.1%	16.2%	89.0%	100%	59.5%	19.2%	**50.9%**
2.5	12.2%			88.9%	3.8%		16.9%	59.0%	19.0%	11.5%	**14.1%**
3	2.0%			55.6%				9.5%	6.3%	11.5%	**2.1%**
3.5	2.0%							5.7%			**0.6%**
4								1.9%			**0.2%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**
Models Sold in Australia, 2006 - % sales that meet or exceed star rating											
Total ('000)	**57**	**117**	**47**	**0**	**121**	**140**	**479**	**103**	**87**	**41**	**1193**
1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	**100%**
1.5	21.3%	6.7%		75.2%	99.1%	73.0%	99.3%	99.9%	99.9%	25.5%	**77.0%**
2	8.4%	0.5%		71.8%	59.7%	22.4%	88.5%	99.9%	51.6%	0.1%	**57.0%**
2.5	0.2%			71.8%	0.4%		34.2%	61.0%	0.2%	0.1%	**19.0%**
3	0.1%			71.8%				15.1%		0.1%	**1.3%**
3.5	0.1%										**0.0%**
4											**0.0%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**
Models Sold in New Zealand, 2006 - % sales that meet or exceed star rating											
Total ('000)	**9**	**22**	**0**	**0**	**63**	**11**	**42**	**23**	**1**	**8**	**181**
1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	**100%**
1.5	24.4%			65.7%	91.0%	64.4%	84.2%	99.7%	82.3%	11.0%	**70.6%**
2	0.8%			65.7%	61.9%	21.7%	71.4%	98.7%	77.6%	5.1%	**53.3%**
2.5	0.6%			65.7%			11.5%	50.5%	76.4%		**9.8%**
3				52.1%				0.3%	0.5%		**0.1%**
3.5								0.3%			**0.0%**
4								0.1%			**0.0%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**

Note: Groups with a common algorithm have the same colour in the first row.

Design and Implementation Issues for Energy Star

There are a number of issues to be addressed regarding the implementation of Energy Star in Australia and New Zealand. These are listed briefly here to generate discussion.

The first issue relates to verification criteria. A number of comments received on the original discussion paper (January 2006) requested clarification on how Energy Star levels would be enforced. The options are to treat the Energy Star level as a star rating (a declared performance parameter) which would then be treated in the same way as normal declarations. The alternative approach would be to treat the Energy Star level as a MEPS level and therefore there would be no tolerance applicable to the level during a checktest (other than the potential uncertainty of measurement).

Given that Energy Star levels are likely to be based on a specified minimum star rating value under the new 2009 algorithm as proposed above, it would appear to be the more logical option to treat Energy Star verification as a normal performance declaration. However, this is not entirely straight forward as under the current checktesting program, there is no specified tolerance specified for star rating. The main criteria which is used to assess refrigerators and freezers under a checktesting regime is energy consumption (which in turn is used to calculate star rating). Under the current verification regime, a declared energy consumption is permitted to vary by up to 10% during a checktest (noting that this value includes measurement uncertainty, systematic and random errors and production variability). As mentioned previously, a proposal to reduce this to 7.5% for refrigerators and freezers will be circulated for discussion in due course.

To put this in perspective, half a star for Group 1 is 7.25%, for Group 2, 3, and freezers is 10.55% and for Groups 4 & 5 is 12.25% under the 2000 algorithm. Half a star would equate to 12.25% under the proposed 2009 algorithm for all groups. So under the new labelling algorithm, the current allowable energy variation during verification tests (10%) would be somewhat less than half a star under the 2009 algorithm for all groups. If the tolerance on energy consumption were reduced to 7.5%, this would equate very roughly to about a quarter of a star (a quarter of a star would in fact be 6.33%), which seems reasonable. If this approach were adopted, the normal verification procedures for energy consumption would be considered adequate for verification for Energy Star. It may be possible to have a separate energy average tolerance of 7.5% (or something in the range 5% to 7.5%) in the first instance as part of the Energy Star validity criteria before the normal validity criteria are reviewed. This would complicate check testing and validity somewhat, but it may have the desired effect of ensuring that Energy Star endorsed products achieve the required performance levels. This approach is recommended.

A MEPS style approach, where the energy consumption threshold for a certain star rating level would be treated as a MEPS level (ie no products are permitted below the nominated threshold), would create all sorts of problems. It would mean that products that (just) legitimately qualify for the Energy Star nominated star rating threshold by achieving the required average energy consumption level could be subjected to verification challenges for Energy Star qualification even though their claimed star

rating may be confirmed as legitimate during a check test. This approach is not recommended.

Other issues for implementation that require some consideration are frequency of review of qualification levels and whether there should be any tag or identifier on the Energy Star label used for locally developed high efficiency levels to distinguish this from the standard EPA Energy Star label which is used internationally.

The frequency of review for qualification criteria is an important consideration. It is fairly straight forward to evaluate the program against registrations and sales for Australia and New Zealand on an annual basis as the data is routinely collected and analysed in any case. This will provide continuous monitoring for the program. However, some threshold criteria should be developed regarding the need for an adjustment of qualifying levels (for example where the number of complying models or sales exceeds 40% to 50% of approved models). Clearly it is not desirable to adjust levels on an annual basis, but conversely the criteria should not be left unchanged for a very long period allowing a majority or even all products in a group to qualify. A related question is if there are likely to be occasional changes to the criteria, is it desirable to identify the Tier level that is used on the Energy Star label itself? (in small inconspicuous type). This could be particularly important where there may be a mix of qualifying levels on display during transition periods. It would be expected that Energy Star criteria would be updated more often that energy labelling algorithms (which are typically of the order once every 10 years). Note that the purpose of indicating the tier is for verification – it is not intended to be a communication tool to the consumer.

For TESAW, the year was shown on the label to indicate the year of eligibility. However, it is known that manufacturers do not generally favour the year on labels as any date that is previous to the current year is seen as undesirable for stock which retailers have on display. So a proposal from the Stakeholder Working Group has been to indicate a "tier" level on the Energy Star label in some form (this could be in the form of a letter or number that is perhaps not obvious to the consumer, but which could help policing of labels in the field). Some options could be developed to indicate the tier level which the product has achieved. Note that the term "tier levels" is used for Energy Star in the USA ***but these are not indicated on their labels***. Details on the required notice for a new tier level and the detailed transition arrangements are still to be fully documented in discussions with industry. However, industry favours notice of at least a year for any change in the requirements.

Another related issue is whether the Energy Star label used as a high efficiency label for products such as whitegoods and air conditioners only in Australia and New Zealand should have some sort of regional identifier (again inconspicuous). US Environmental Protection Agency has approved, in principle, the use of locally developed Energy Star criteria for refrigerators and freezers. It is understood that this has been agreed on the basis that the energy star label would be available for use on products that are for sale in Australia and New Zealand, that are specific to this market and such products would not appear in the USA. Some discussions may be required for products which are destined for the Pacific Islands and parts of Asia. The status and arrangements for more global products (eg air conditioners) is less clear. In any case, it may be advisable to use a version of the Energy Star label that is unique to

this region to indicate that regional criteria have been used – this could then only be used to endorse products that are specific to the Australian and New Zealand markets. Some design options have been explored, but a very small stylised Australia and New Zealand map on the bottom of the label could be suitable. Any such option would need to be agreed locally and would have to be approved by the US EPA prior to use.

Energy Label Design and Transition Issues

If the new energy labelling algorithm is to be successfully implemented in 2009, careful planning and organisation will be required. This section sets out some of the key issues that will need to be addressed with respect to label design and how new labels are displayed during the transition process.

The industry government round table in April 2007 (see Appendix B) made a number of proposals regarding the new energy label transition. These are broadly supported by government and are summarised in the following sections.

Label Design Issues

Both refrigerators and air conditioners will have a new energy label and new algorithm in 2009. A range of possible energy label design options were tested in consumer focus groups in mid 2007. The options tested in these focus groups included:

- No major changes to the overall label design
- Trial different colours for the bottom band to distinguish products that carry labels with the new star rating algorithm – a purple band at the base of the label seemed to be a favoured option to trial
- Trial a range of wording for transition information (star rating on old scale) – look at options for having this transition wording separate from the core of the new label (eg as a green band below the label which can be easily removed after the transition without the need to relabel).
- Look at enhancement of the website wording on the label, trial option of replacing ENERGY RATING in black at the top with www.energyrating.gov.au or other variants
- Assess understanding of Energy Star as an endorsement label

A report which summarises the findings of the focus group research will be in the near future. The recommendations from this work will be considered for inclusion into the Part 2 revision to be prepared later in 2007.

Transition Issues

The industry government round table held in April 2007 developed the following detail regarding transition arrangements for the introduction of the new energy label.

Start date for the transition: Manufacturers may elect to register products for the new energy label from October 2008 provided such products manufactured or imported (and on display or supplied to customers) until the end of March 2009 also

have the agreed transition wording displayed (possibly a green band as a separate strip at the bottom of the new label showing the old star rating under the 2000 algorithm). From April 2009 products can be manufactured or imported with the new energy label affixed with no transition wording. However, transition wording can be included on products manufactured or imported up to October 2009.

End date for the transition: All products imported or manufactured after October 2009 must be registered to and have the new energy label affixed. It is recommended that transition wording be removed from stock on display in retail outlets by October 2009. Transition wording should not be affixed to products manufactured or imported after October 2009.

As with all transitions for energy labelling and MEPS, so called standard "grandfathering" provisions will apply to all refrigerators and freezers across the transition period. Registrations to the previous energy label or where test reports have been used to Part 1 which are prior to the 2007 edition will be grandfathered on 30 September 2009. This means that products which are imported or manufactured with an approved registration prior to that date can be sold for an indefinite period. Products that are imported or manufactured after that date must have an approved registration to the new energy label and using a test report to the new 2007 test method.

It was recommended that suppliers be encouraged to provide some indication such as a new energy label (or a stylised version) on the product box (packaging) or a change in the packaging colour to indicate that the product inside has a new energy label attached to assist retailers to clear older stock. A guideline will be prepared for retailers to encourage them to move all older floor stock during the transition to avoid problems later.

Other issues:

- Communicate with retailers to try to ensure a smooth transition so that all products on display carry a new label by October 2009.
- E3 will write to all registration holders (and CESA and AEEMA) proposing a conversion from a MEPS average to maximum for refrigerators (with a supporting discussion paper). Suppliers will be invited to contact E3 if they wish to discuss this issue in more detail.
- Test reports to AS/NZS4474.1-2007 will be a pre-requisite for all registrations for the new energy label (see following section for more detail).
- A separate discussion paper analysing the energy impact of the change in test method will be circulated in the near future – this may result in changes to the MEPS levels to maintain equivalence (see following section for more detail).

A related issue will be to show both the old and new star ratings on the energy rating website site for an extended period (perhaps starting October 2008 until at least the end of 2009 and possibly into 2010). This was suggested at the Whitegoods Forum in February 2007 and E3 has agreed in principle to this request.

Test Method Change and Transition Issues

Since 2003, EL15/23 and its test method working group have been developing a revision of AS/NZS4474.1. The test method was originally published in 1997 and a number of issues needed to be addressed in terms of new configurations and technologies, particularly electronic controls.

The test method was issued for public comment as DR06500 in August 2006. A list of the changes to the standard, which were included in the original draft, are included as Appendix C. While the number of changes is substantial, the basic approach of the test method and the results were expected to be equivalent to the published standard. The main issues were to deal with new technology and configurations and to close a number of loopholes where cheating appeared to be apparent.

There were a substantial number of public comments on the draft, but the majority of these were editorial or minor in nature. However, some significant issues were raised. EL15/23 decided to release the test method for a second round of comment as some new requirements to thwart circumvention (cheating) were included and a fundamental change to one parameter – the temperature determination period – was also made.

Under the published standard AS/NZS4474.1-1997, the temperature in a compartment was determined over the stable 3 hour period prior to a defrost. However, the energy consumption was measured over a whole defrost cycle. It became obvious in recent years that some manufacturers were introducing control strategies that sought to reduce energy consumption by maintaining warm temperatures outside of the temperature determination period. While the 2007 revision of the standard introduced some performance requirements in an attempt to stop these practices, the mismatch between the temperature determination period and energy consumption determination period was always going to create some potential problems. This also has some potentially dangerous consequences – extended periods of warm temperatures inside the refrigerator can result in degradation of food quality and possible growth of pathogens.

The 3-hour temperature determination period was really a hangover from old technology when temperatures were manually determined from chart readings. Collection of data at 1-minute intervals (or less) is now mandatory, so the use of a 3-hour period is now irrelevant.

After intense discussion, EL15/23 decided to change the test method to make the temperature determination period the same as the energy determination period (ie from the start of a defrost event until the start of the next defrost event in most cases). This approach has several advantages:

- It is simple – the energy determination period is well defined and a simple average over the same period means there is less chance of numerical mistakes.
- It almost completely removes any incentive for manufacturers to design products that cheat by operating at warm temperatures for extended periods (even though these may meet the new temperature performance requirements) as the whole control cycle is used to determine the average temperature.

- It provides a strong incentive for manufacturers to limit temperature rise in compartments during the defrost operation, which is good for food quality.
- It provides credit to those manufacturers that pre-cool prior to a defrost in order to limit temperature rises during defrost which limitation results in improved food quality.
- It aligns with the likely approach that will be adopted in the new international test method which is being developed by IEC.

The revised public comment draft was released on 20 March 2007 as a combined procedure (parallel voting and comment) – DR07173CP. An overview of the additional changes in the public comment draft is included as Appendix C. The new standard AS/NZS4474.1-2007 was published on 15 August 2007.

So there are many sound reasons why this new approach was adopted. The only disadvantage is that compartment temperatures determined under the existing test method AS/NZS4474.1-1997 may be slightly different to those determined under the 2007 revision where the product is automatic defrost. The impact is generally small but unfortunately, the exact difference varies a bit at the individual product level.

Investigations on 15 cabinets have found that the temperature impact varies from zero (even a colder temperature in some cases) to 0.5K warmer in the freezer in some models. The energy impact of such a temperature change is also variable at a cabinet level, with a typical range of less than 1% per degree K increase to as much as 5% per degree K increase. So the overall energy impact could be as low as zero up to a few percent for some models as a result in the change in the test method. Note that the test method change only affects Group 5 (5T, 5B, 5S) and Group 7.

No adjustment to energy labelling algorithms is proposed as a result of this test method change. However, a change to the MEPS levels is being considered. Detailed data on a range of refrigerators is being compiled and a detailed discussion paper will be circulated to industry for comment in the near future. Any adjustment to the MEPS levels will be included in the Part 2 revision to be released for public comment in late 2007. A regulatory impact statement will not be required as any adjustment will be to achieve equivalent MEPS levels under the new test method.

The change in the temperature determination period does not impact on the actual testing of products – it is purely a change in the post test evaluation of the data. If test labs hold the original 1-minute data for products previously tested, they would be able to recalculate the values to the new revision (in most cases) and could then reissue a new test report to the 2007 revision without the need to retest.

The new test method AS/NZS4474.1-2007 is an important step forward in the testing of refrigerators in Australia and New Zealand, not the least because it introduces a range of measures to reduce or eliminate cheating. The committee agrees that this new test method should be implemented as soon as practicable.

In order to minimise inconvenience and costs to industry, it is proposed to bundle the transition to the new test method with the introduction of the new energy label in 2009. So a test report to AS/NZS4474.1-2007 would be a mandatory requirement for registrations for the new energy label.

It is envisaged that the new test method would be accepted by regulators immediately on publication. Manufacturers will be encouraged to use the new test method for new models from its publication in 2007. This will further reduce the need for any retesting during the transition to the new energy label in 2009.

References and Key Documents

The following documents have been essential references in the development of this discussion paper and provide recommended background information when considering the preparation of comments on the issues raised in this paper.

Artcraft Research 1998a, Final Report on a Qualitative Market Research Study regarding Appliance Energy Rating Labels, by Artcraft Research for E3. Reports on the initial series of focus groups during new label redesign, looks at a wide range of design options. April 1998. See http://www.energyrating.gov.au/library/detailsfocus298.html

Artcraft Research 1998b, Summary of Key Findings From the Second Qualitative Market Research Study regarding Appliance Energy Rating Labels, by Artcraft Research for E3. Summary report on the second series of focus groups during new label redesign. August 1998. See http://www.energyrating.gov.au/library/detailsfocus898.html

Artcraft Research 2003, A Major Research-Based Review and Scoping of Future Directions for Appliance Efficiency Labels in Australia and NZ, prepared by Artcraft Research for E3. See http://www.energyrating.gov.au/library/details2003-applabelreview.html

Brown 1998, Energy Labelling Review - Options for Improvements of Labels, R.A. Brown report for the E3, January 1998. See http://www.energyrating.gov.au/library/details1998-brownlabelreview.html

Draft Standard DR06500: Revision to AS/NZS 4474.1 - Performance of household electrical appliances— Refrigerating appliances Part 1: Energy consumption and performance (Revision of AS/NZS 4474.1:1997). Major review of the test procedure for refrigerators. This has a number of new performance requirements, but most changes have a minor technical impact and are intended to update technical requirements for measurement and to reduce circumvention of the standard requirements. Comments close 20 October 2006.

Draft Standard DR06501: Amendment 4 to AS/NZS 4474.2 - Performance of household electrical appliances— Refrigerating appliances Part 2: Energy labelling and minimum energy performance standard requirements. Most changes are a consequence of the Part 1 revision. It also has clarification to the scope of products which are regulated. Specifies requirements for multi-group products. Includes some minor corrections and an updated registration application form. Comments close 20 October 2006.

Draft Standard DR07173CP: Revision to AS/NZS 4474.1 - Performance of household electrical appliances— Refrigerating appliances Part 1: Energy consumption and performance (Revision of AS/NZS 4474.1:1997). Re-issue of DR0500 with changes to test method. Has new technical requirements to reduce circumvention of the standard requirements. Comments close 1 May 2007. Note that is a combined procedure with parallel voting and comment.

Draft Standard DR07172CP: Amendment 4 to AS/NZS 4474.2 - Performance of household electrical appliances— Refrigerating appliances Part 2: Energy labelling and minimum energy performance standard requirements. Mostly changes which are a consequence of the Part 1 revision. Re-issue of DR0501 with changes to test method with new requirements regarding anti-circumvention. Comments close 1 May 2007. Note that is a combined procedure with parallel voting and comment.

EES 1998, Appliance Energy Labelling Review Committee: Support Documentation. Prepared by Energy Efficient Strategies for E3. Provides an overview of all major issues considered in the label redesign leading up to 2000. See http://www.energyrating.gov.au/library/detailslabellingreview1998.html

EES 2004, Energy Label Transition - The Australian Experience, prepared by Energy Efficient Strategies for E3. Report 2004/05. See http://www.energyrating.gov.au/library/details200405-labeltransition.html

EES 2006, Refrigerator Star Rating Algorithms in Australia and New Zealand, discussion paper prepared for E3 by Energy Efficient Strategies, January 2006. First comment draft of this paper.

EES 2006, Greening Whitegoods 2005, prepared by Energy Efficient Strategies for E3. Report 2006/06. See http://www.energyrating.gov.au/library/details200606-greening.html

EnergyConsult 2006, Retrospective Analysis of the Impacts of Energy Labelling and MEPS: Refrigerators and Freezers, prepared by EnergyConsult for E3. Report 2006/14. Undertakes an historical assessment of the impact of energy labelling and MEPS for refrigerators. See http://www.energyrating.gov.au/library/details200614-meps-rf-fz.html

Patterson 1998, Energy Labelling Review - Consumer Research, report by Neill Patterson for the E3, January 1998. See http://www.energyrating.gov.au/library/details1998-pattersonlabelreview.html

UD DOE CFR430, US Department of Energy Code of Federal Regulations: Part 430—Energy Conservation Program For Consumer Products, updated annually, Available from www.gpo.gov

Winton 2005a, Discussion Paper: Energy Labelling Possibilities for refrigerators and freezers in the context of the 2005 MEPS levels, background paper prepared by Les Winton, Artcraft Research, for the E3 Whitegoods Forum, 3 August 2005. See http://www.energyrating.gov.au/forums-2005-whitegoods.html

Winton 2005b, Labelling and Star Ratings - How Consumers Make Decisions and How They Use the Star Rating System, presentation by Les Winton, Artcraft Research, at the Annual National Air Conditioning and Energy Forum, 20-21 September 2005. See http://www.energyrating.gov.au/forums-2005-aircon.html

Winton Sustainable Research 2006, Appliance Performance Labelling In Australia and New Zealand. Report for E3. Report 2006/08. See http://www.energyrating.gov.au/library/details200608-labelling.html

Appendix A: Outcomes of the September 2005 E3 Stakeholder Working Group Meeting

At the E3 refrigerator working group meeting held on 14 September 2005 in Canberra a number of issues were discussed and agreed. The main agreements regarding a new refrigerator algorithm were:

- Where possible, a consistent system of star rating across different groups should be developed.
- An option to achieve this was identified by the working group. This has been documented in detail in this discussion paper.
- Gross volume to be used for the moment as the basis for model numbers and for all MEPS and labelling calculations.
- There needs to be input into ISO to develop an acceptable volume measure which is more consumer relevant than the current gross and storage measures. If and when this becomes available, it may be possible to review whether the volume on the energy label is relevant and whether the basis for MEPS/labels calculations should be changed.

The general agreement on the issue of Energy Star as a new endorsement label for Australia and New Zealand and the appropriate criteria to qualify included:

- Energy Star criterion should be tied to the (new) star rating system to provide a consistent efficiency message to consumers.
- Current US Energy Star criteria did not appear to provide a sound basis for an endorsement system in Australia because they are based on MEPS levels for individual groups and these do not line up with the proposed revised star rating criteria.
- The 3 star line under the new star rating algorithm above appeared to provide a possible Energy Star qualification criterion initially.
- An Energy Star criterion should be implemented in the short term which broadly fits within the framework of a revised star rating system, which will be implemented afterwards.
- The Energy Star criterion should be reviewed annually and changed if required.
- There is a need to resolve the issue of validation criteria for Energy Star.
- Issue of showing different labels for different Energy Star tiers (where these are upgraded) needs to be considered (and how these transitions are handled).

Appendix B: Summary of Industry-Government Round Table – April 2007

Note: This is an extract which includes information relevant to refrigerators only.

Key industry representatives met on 12 April 2007 with AGO staff to discuss a range of issues mainly relating to energy labelling and MEPS for whitegoods and air conditioners. While the meeting was informal, the intent was to plan a range of forthcoming changes which will affect the regulatory requirements for these products. The meeting had no particular status, but the recommendations should be considered by the relevant committees and parties as required for ratification and implementation.

New Energy Label for Refrigerators and Air Conditioners

Both refrigerators and air conditioners will have a new energy label and new algorithm in 2009. The group reviewed a range of possible design options for testing with consumer focus groups which are planned within the next month. Main points agreed were:

- No major changes to label design
- Trial different colours for the bottom band – purple seems a favoured option
- Trial a range of wording for transition information (star rating on old scale)
- Look at enhancement of the website wording on the label, trial option of replacing ENERGY RATING in black at the top with www.energyrating.gov.au
- Assess understanding of Energy Star as an endorsement label

Other Transition Issues

All products imported or manufactured after October 2009 to carry the new energy label. Start dates – from October 2008 new label with old star also displayed in a separate band (transition wording) can be affixed, from April 2009 new label with no green bar can be affixed, green bars not on display after 2009 (recommended). Place a new label (or generic version) on product box (packaging) to indicate the product inside has a new label attached to assist retailers to clear older stock. Prepare guideline for retailers to move all older floor stock during the transition to avoid problems later.

Other issues:

- Communicate with retailers to try to ensure a smooth transition and all products on display carry a new label by October 2009
- Simone Tiele to write to all refrigerator registration holders (and CESA. AEEMA and AREEMA) proposing a conversion from average to maximum and to contact us if they wish to discuss in more detail – attach discussion paper with proposal.

Appendix C: Summary of Key Changes to AS/NZS4474.1 – 2007 Revision

AS/NZS4474.1-2007 was published on 15 August 2007. The following sections outline some of the steps in its development.

Introduction from DR06500 (first public comment draft)

This Part 1 revision mostly maintains the main existing elements of AS/NZS 4474.1-1997. However, a large number of minor technical points have been tidied up and many changes have been made in the light of cabinet designs that have appeared on the market in recent years. This is the only major technical review of this Standard since its publication in 1997 (10 years).

This revision is not a substantive technical change and in most cases the results under the revision for tests such as pull down, energy and operation will be the same as under the 1997 edition. However, many loopholes and inadequacies in the 1997 edition of the Standard have been redressed in this revision.

This document outlines the most significant changes in the revision and provides some rationale for the basis of these changes. Minor editorial changes within the revision are not discussed in this document. At this stage, the document is only just past the public comment draft stage and further changes may be made prior to publication, depending on public comment. (see DR06500 for a list of detailed changes by clause number)

Introduction from DR07173CP (second public comment draft)

A public comment version of the revision of AS/NZS4474.1 was issued on 18 August 2006 as DR06500 and comments closed on 20 October 2006. A total of 110 public comments were received on this draft, mainly from committee members. However, the majority of comments pertained to editorial and minor technical matters. Standards Committee EL15/23 met in November 2006 and considered all of the comments. This draft includes the committee resolution of all of these comments submitted on DR06500.

The most significant technical change in this draft is the alteration of the temperature determination period to align with the energy determination period. The average compartment temperature now includes any defrost and recovery operation (previously it only included the stable period prior to a defrost). The committee acknowledges that this will impact on the average temperature results for some refrigerators and compartment types that have automatic defrost. However, the change is relatively small in most cases and will result in a substantial simplification with respect to data collection and analysis. The change also now provides some incentive for manufacturers to minimise any temperature rise in compartments during a defrost, which will result in improved conditions for the storage of foodstuffs. The new

performance requirements in Clause 3.7.3 were refined based on a further review of data.

Given the technical significance of this change, the committee decided to reissue this draft for parallel public and voting (combined procedure), mostly as a courtesy to stakeholders outside of the standards committee.

Energy regulators have undertaken to analyse data on the impact of this change of the test method for a range of refrigerator types with a view to adjusting the MEPS levels where required for selected groups. This adjustment would be included in the revision of Part 2 which is expected in late 2007.

Appendix D: Terms used in this paper

For the purposes of this discussion paper, the energy labelling algorithm is the detailed equation which is used to determine the star rating of a product.

AS/NZS 4474.1 sets out the method of test for the determination of a number of refrigerator attributes for registration purposes. The main attributes required to determine the star rating are:

- the gross volume of each compartment (usually referred to as volume).
- the temperature of operation of each compartment.
- the energy consumption under standardised conditions.

The gross volume and temperature of operation for each compartment are combined to determine the total adjusted volume. The total adjusted volume is the main measure used to determine the comparative volume for refrigerators and freezers operating under different conditions and is the basis for determining energy efficiency which is used for energy labelling and MEPS. The adjusted volume is an equivalent volume of fresh food (at 3^{o}C) where the temperature of operation is used to scale the actual volume using a freezer adjustment factor (FAF). For example, the FAF for a fresh food compartment is 1.0, while for a freezer operating at -15^{o}C it is 1.6.

Appendix E: Previous Energy Labelling Algorithms

Group Definitions Under AS/NZS4474.1

The following table sets out a brief description of each of the main refrigerator and freezer groups. See AS/NZS4474.1 for a more detailed definition.

Appliance group	Group description	Notes
1	All refrigerator	Automatic defrost
2	Refrigerator with ice maker	Most common configuration for small bar refrigerators, usually small (<150L)
3	Refrigerator with short term freezer	Becoming rare, but some new products appearing in 2005/6, usually small size
4	Refrigerator with long term freezer	Automatic defrost fresh food, manual defrost freezer, used to be common, now rare
5T	Top mounted frost free refrigerator-freezer	Both compartments are automatic defrost, freezer at top, majority of sales
5B	Bottom mounted frost free refrigerator-freezer	Both compartments are automatic defrost, freezer at bottom, growing sales
5S	Side×side frost free refrigerator-freezer	Both compartments are automatic defrost, growing sales
6C	Chest freezer	Includes all configurations and frost types
6U	Manual defrost vertical freezer	Door at front, manual defrost
7	Frost free vertical freezer	Door at front, automatic defrost

Refrigerators and Freezers – AS/NZS 4474.2 Pre 2000 (1986-2000)

The Australasian refrigerator and freezer star rating system started in 1986.

The test standard assumes continuous use at test conditions (32^{o}C, no door openings). Actual in-use energy will vary somewhat by type and model but an assumed energy of about 0.65 to 0.9 of the energy label CEC would be a reasonable average estimate, depending on the group, model and the climate/operating conditions.

The key parameter is the adjusted volume, which is the equivalent volume of fresh food space when adjusted for the temperature of operation (colder compartments are assumed to be larger than measured).

Adjusted volume V_{adj} = Σ Ks $\times$ compartment volume (no change)

For each compartment in the refrigerator or freezer as set out in the table below.

Compartment type	Volume adjustment factor (K_s)
Cellar	0.7
Fresh food	1.0
Chill	1.1
Ice-making	1.2
Short term frozen food storage	1.4
Freezer	1.6

Star rating for all types of refrigerators and freezers is done of the same basis as follows:

$$\text{EER (SRI)} = \frac{23}{3} - \left(\frac{2}{3} \times \frac{1000}{365} \times \frac{CEC}{V_{adj}} \right)$$

Where
EER is the star rating index of the appliance (energy efficiency rating)
CEC is the comparative energy consumption (based on continuous use)

Post 2000 Star Rating System – Electrical Products (2000-2009)

The revised algorithms for all star-rated electrical appliances was introduced on 1 October 2000.

The clothes washers, clothes dryers, dishwashers, refrigerators and freezers, the general form of the star rating algorithm is as follows:

$$SRI = 1 + \left[\frac{\log_e \left(\frac{CEC}{BEC} \right)}{\log_e (1 - ERF)} \right]$$

Where:

SRI is the star rating index (fractional star rating)
CEC is the comparative energy consumption (energy that appears on the energy label)
BEC is the base energy consumption – the equation for a product with an SRI of 1.0
ERF is the energy reduction factor – reduction in CEC for each additional star

Refrigerators and Freezers – AS/NZS 4474.2 Post 2000

The test procedure for the 2000 labelling algorithm remained unchanged. The adjusted volume is determined using the same factors as previously described.

$$BEC = C_f + (C_v \times V_{adj\ tot})$$

Other factors by groups are set out below:

Appliance group	Group description	Fixed allowance factor (C_f) kWh/year	Variable allowance factor (C_v) kWh/year/L	Energy Reduction Factor (ERF)
1	All refrigerator	368	0.892	0.14
2	Refrigerator with ice maker	330	0.800	0.20
3	Refrigerator with short term freezer	330	0.800	0.20
4	Refrigerator with long term freezer	465	1.378	0.23
5T	Top mounted frost free refrigerator-freezer	465	1.378	0.23
5B	Bottom mounted frost free refrigerator-freezer	465	1.378	0.23
5S	Side×side frost free refrigerator-freezer	465	1.378	0.23
6C	Chest freezer	248	0.670	0.17
6U	Manual defrost vertical freezer	439	1.020	0.20
7	Frost free vertical freezer	439	1.020	0.20

Note: Groups 1, 5 and 7 are fully automatic defrost. Groups 2, 3, 4 and 6 have manual defrost freezer.

Note that MEPS factors are separate from energy labelling factors and are set out in http://www.energyrating.gov.au/rf2.html MEPS for refrigerators also includes factors for additional doors and adaptive defrost. MEPS factors are not included when determining the star rating of products.

It should be noted that several groups have common energy labelling rating factors (eg Groups 2 & 3, Groups 4, 5T, 5B, & 5S, Groups 6U & 7). This has been done on the basis that these products are interchangeable and can provide more or less equivalent energy service and so should be rated for the energy label on the same basis. Note that the MEPS levels for each Group are different, even when the labelling equations are the same. For many of the group combinations, the 1 star line was set to be approximately the 1999 MEPS for the weakest group (highest energy).

Appendix F: Star Rating Distributions for Refrigerator and Freezer Groups for Proposed 2009 Algorithm

This appendix show the distribution of models, sales in Australia and sales in New Zealand for each group for the 2009 proposed algorithm. Sales in 2006 of products that are less than the MEPS level are permitted if the product was in the country and legally registered prior to MEPS, which came into effect on 1 January 2005.

Figure 12: Group 1 Star Rating Distribution under Proposed 2009 Algorithm

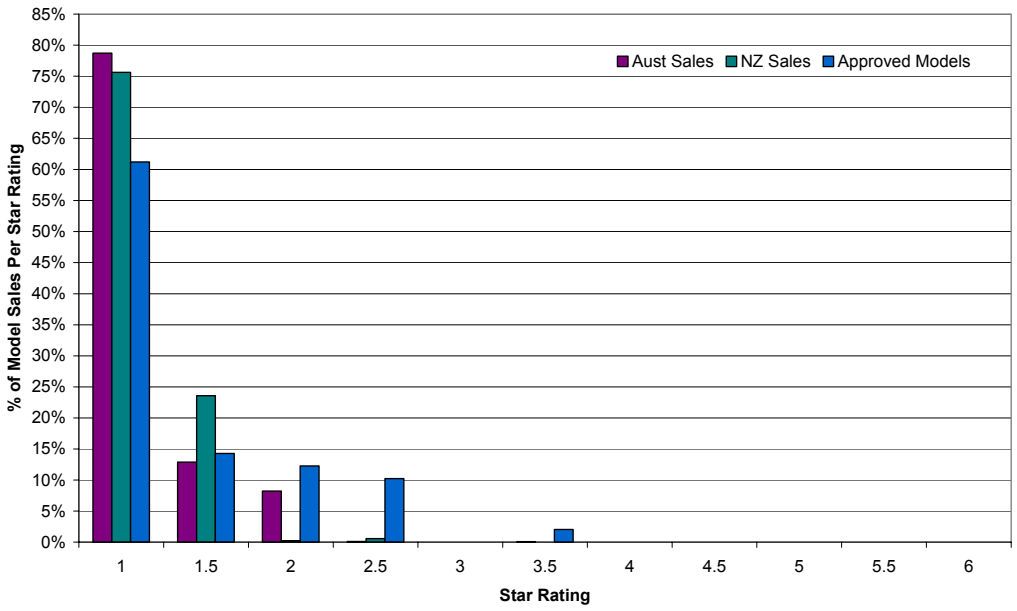


Figure 13: Group 2 Star Rating Distribution under Proposed 2009 Algorithm

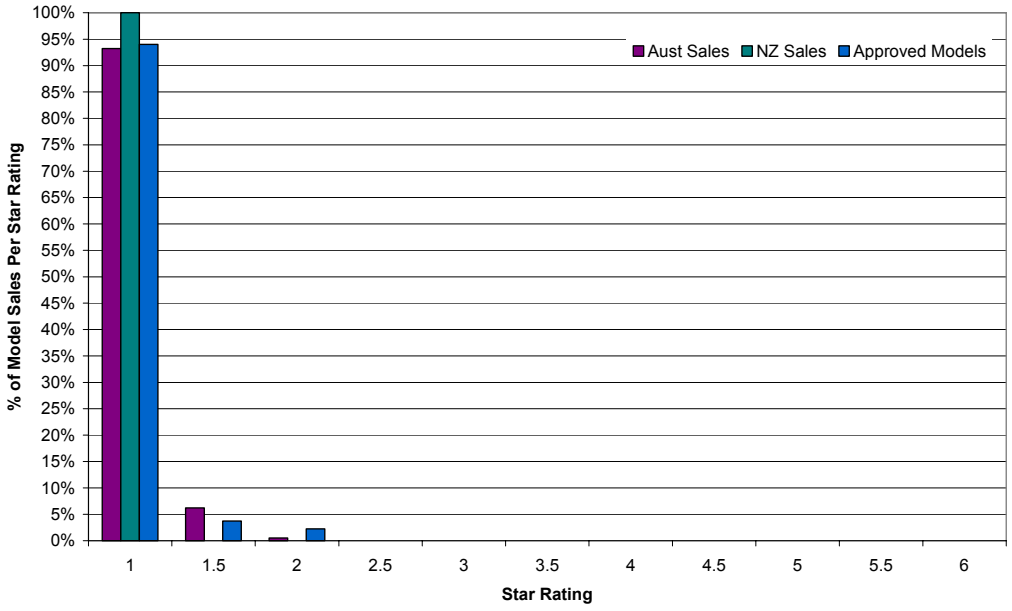


Figure 14: Group 3 Star Rating Distribution under Proposed 2009 Algorithm

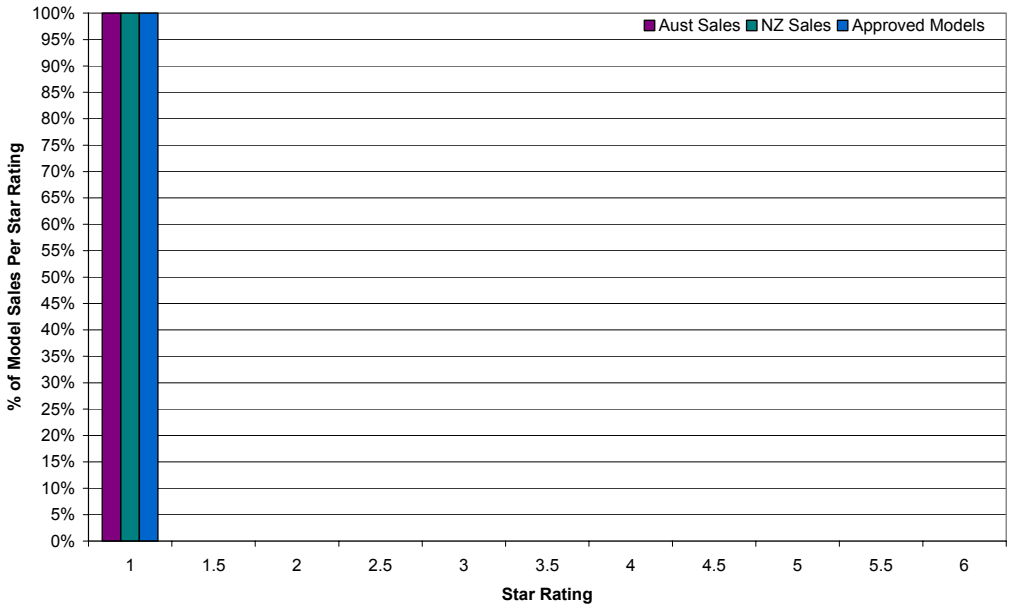


Figure 15: Group 4 Star Rating Distribution under Proposed 2009 Algorithm

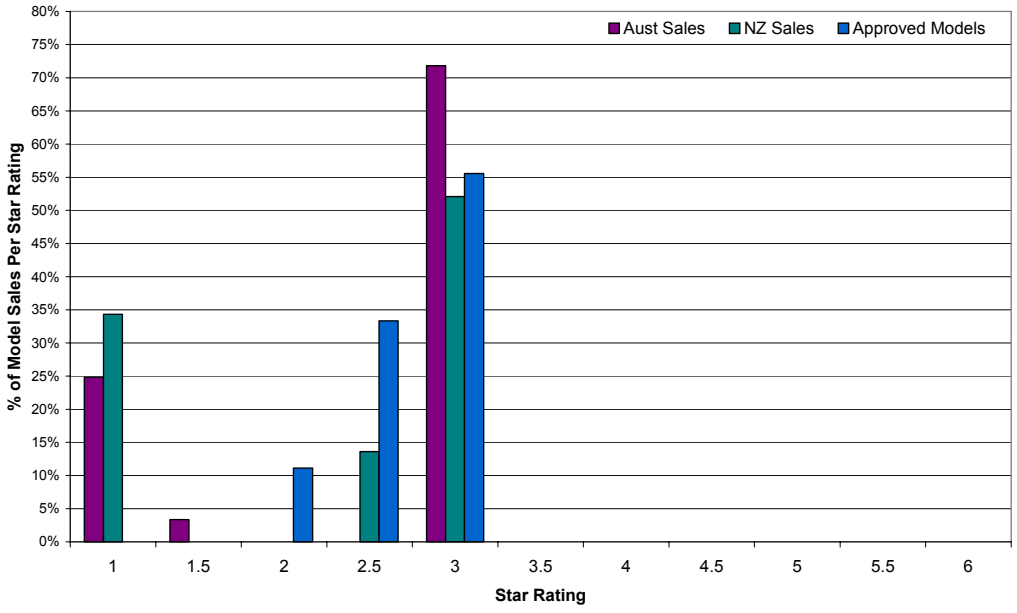


Figure 16: Group 5B Star Rating Distribution under Proposed 2009 Algorithm

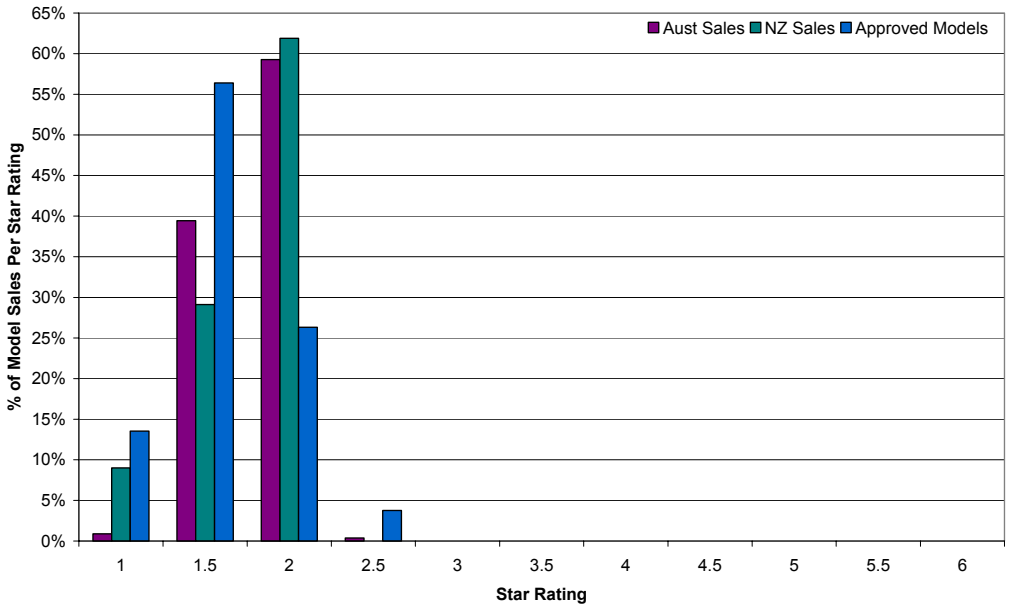


Figure 17: Group 5S Star Rating Distribution under Proposed 2009 Algorithm

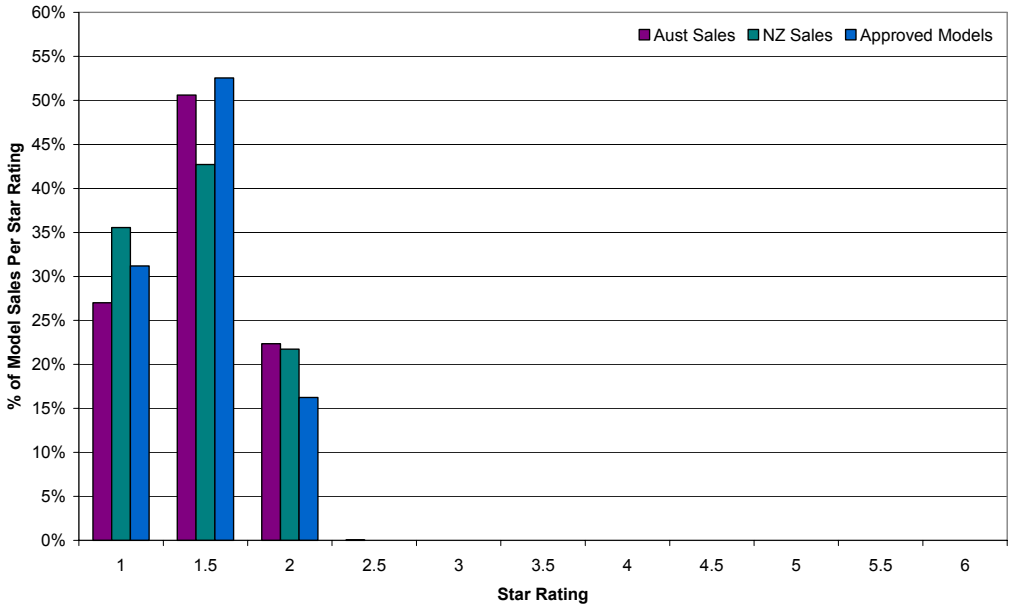


Figure 18: Group 5T Star Rating Distribution under Proposed 2009 Algorithm

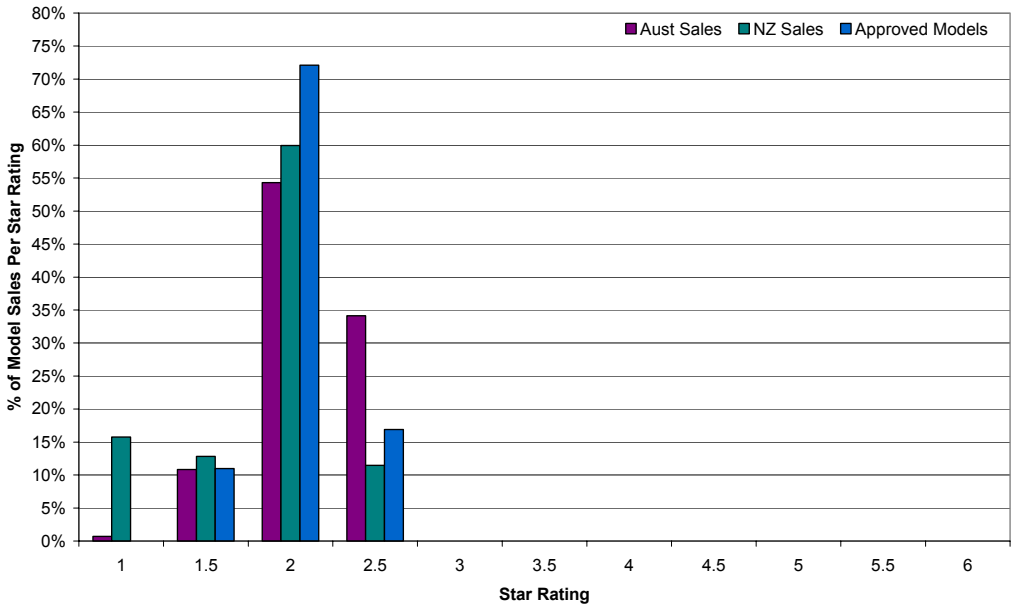


Figure 19: Group 6C Star Rating Distribution under Proposed 2009 Algorithm

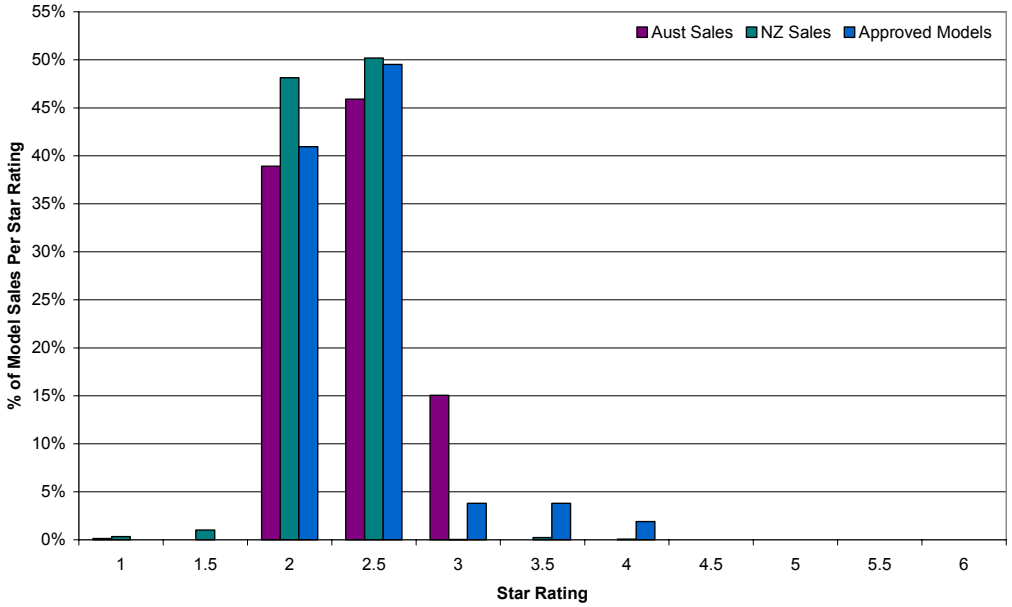


Figure 20: Group 6U Star Rating Distribution under Proposed 2009 Algorithm

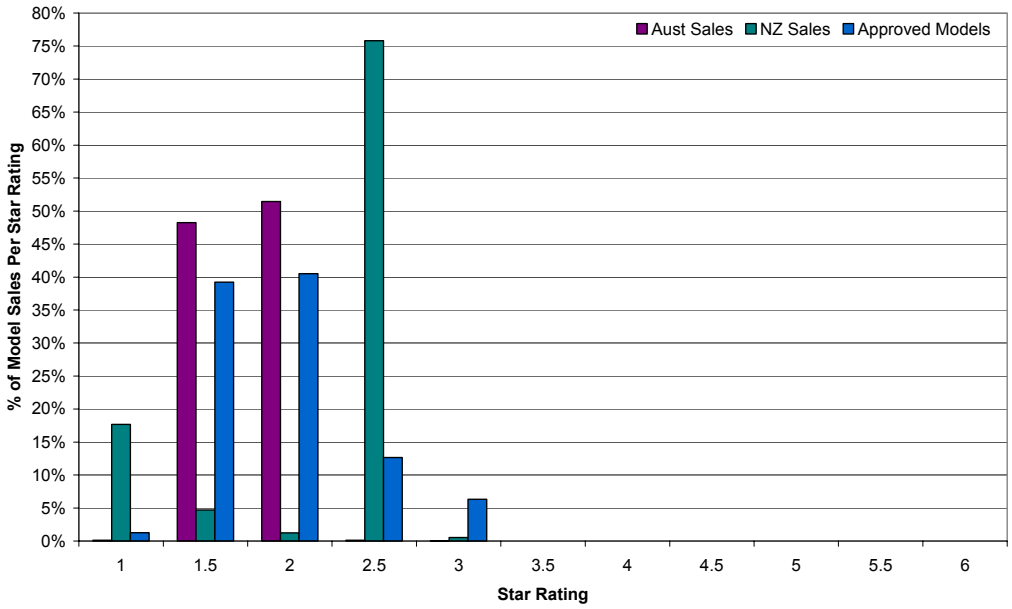
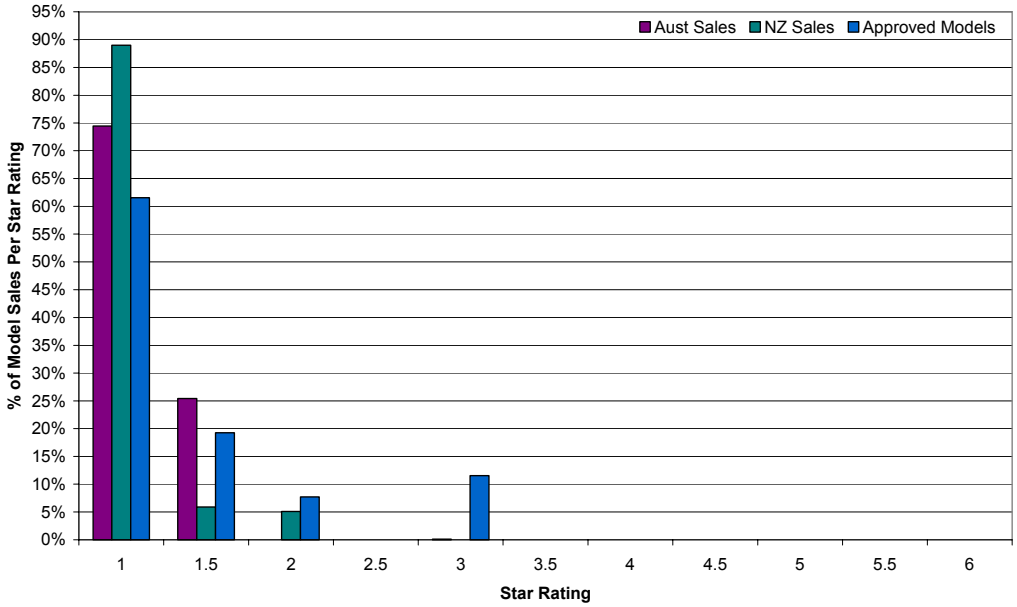


Figure 21: Group 7 Star Rating Distribution under Proposed 2009 Algorithm



Appendix G: Summary of Submissions on 2006 Paper

This section provides a very brief summary of the issues raised in submissions on the original algorithm discussion paper released in January 2006. Some of these comments are relevant (and have been addressed as far as possible in this version of the paper) while some need to be addressed as part of a separate item of work.

The commentators and the main points raised are noted below, together with a brief response. E3 thanks the commentators for their submissions.

Brian Douglas – AEEMA
Supportive of the proposal. Opposed to the Energy Star levels becoming a future MEPS level.

E3 response: Noted

Bruce Buchtmann – Electrolux

- Broadly supported the proposal but suggest a flow chart outline all the related processes would add clarity
- Felt the algorithm would be easily understood
- Suggested further work to quantify energy savings in the field for adaptive defrost is warranted.
- Validity criteria for Energy Star levels need to be clarified – treated as MEPS (no unit less than level) or as declared value (star rating)
- Made some suggestions on label design transition issues

E3 response: Work on adaptive defrost to be referred to EL15/23. Validity for Energy Star covered in revised paper. Steps in the process and related processes more fully documented in this version. Other points are noted.

Alan Pears – RMIT University

- Supported a single algorithm but suggested that a surface area correction rather than a volume correction would be more appropriate. Felt that more emphasis should be place on energy rather than litres per unit of energy (nominal efficiency).
- Opposed 1 star as a courtesy star and felt rating system should be moved "back" to 5 stars.
- Recommended an expert panel to be established to approve adjustments to results where a manufacturer demonstrates 'real world' energy savings for adaptive defrost.
- Felt that TESAW and Energy Star were ineffective and that annual awards should be reintroduced (e.g. Galaxy Award).
- Require all types of refrigerator to comply with MEPS and carry energy labels and/or carry a clear warning sign stating they do not comply and comparing their energy consumption to a product of the same capacity that would comply with MEPS (and/or showing how large a MEPS compliant appliance would use the same amount of electricity).

E3 response: New algorithms proposed in this paper now use a function that is based on surface area. Star rating design (1 to 6 stars) is now well established and well understood, graphically 6 stars works better than 5 stars – depiction of less than 1 star is difficult graphically, except through use of a warning. Work on adaptive defrost to be referred to EL15/23. Point on TESAW/Energy Star to be considered by government. Requirement for a label/MEPS for non-vapour compression is not covered by the scope of the discussion paper but should be considered by government as a separate issue. Issue of a warning label for products that do not pass MEPS raised in this paper.

Lindsey Roke – Fisher & Paykel

- Argued that adaptive defrost allowance should be included in the CEC and therefore star rating but acknowledged that little field data was available.
- Felt that Energy Star levels should also be assessed on the basis of sales volume, not just number of models.
- Made some comments about on line printing issues for labels.
- Felt that a regional Energy Star label would not be productive but acknowledged to possible problem of leakage to other markets where Energy Star criteria may be different.
- Validity criteria for Energy Star levels need to be clarified – treated as MEPS (no unit less than level) or as declared value (star rating). If Energy Star was treated as a MEPS level, then manufacturers would need to be cautious about claiming compliance.
- Noted that the basis for MEPS will be changing (from average model energy to a maximum permitted value for all units within a model) and suggested current labelling validity criteria for refrigerators and freezers could be tightened from 10% to 7.5%.

E3 Response: Work on adaptive defrost to be referred to EL15/23. Sales volumes have been assessed in revised discussion paper and will be used in conjunction with registered models to set Energy Star crtieria. Validity for Energy Star covered in this revised discussion paper. Proposal to tighten validity criteria to be raised in paper on changes to MEPS validity criteria. Other points are noted.

Appendix H: Star Ratings and Sales Tables – 2000 Algorithm

Table 4: Group by 2000 Star Rating for August 2007 Approved Registrations (%)

Group → 2000 Stars ↓	Group 1 (% / star)	Group 2 (%/ star)	Group 3 (%/ star)	Group 4 (%/ star)	Group 5B (%/ star)	Group 5S (%/ star)	Group 5T (%/ star)	Group 6C (%/ star)	Group 6U (%/ star)	Group 7 (%/ star)	Total (%/ star)
Approved Registrations (August 2007)											
Total (number)	**49**	**134**	**6**	**9**	**133**	**234**	**355**	**105**	**79**	**26**	**1130**
1											**0.0%**
1.5		1.5%									**0.2%**
2		24.6%	0.0%								**2.9%**
2.5		41.0%	83.3%					67.6%			**11.6%**
3	2.0%	29.1%	16.7%		17.3%	20.9%		23.8%		65.4%	**13.7%**
3.5	12.2%	0.7%			67.7%	49.6%	23.9%	1.9%	6.3%	15.4%	**27.3%**
4	12.2%	3.0%		22.2%	11.3%	29.1%	63.7%	1.9%	44.3%		**31.7%**
4.5	12.2%			33.3%	3.8%	0.4%	12.4%	2.9%	31.6%	7.7%	**7.9%**
5	22.4%			44.4%				1.9%	16.5%	11.5%	**2.9%**
5.5	8.2%								1.3%		**0.4%**
6	30.6%										**1.3%**
Models Sold in Australia, 2006											
Total ('000)	**57**	**117**	**47**	**0**	**121**	**140**	**479**	**103**	**87**	**41**	**1193**
1								0.1%		3.7%	**0.1%**
1.5		4.6%								2.6%	**0.5%**
2		19.6%		11.4%		0.1%	0.1%				**2.0%**
2.5		38.8%	100%	12.1%		0.1%	0.3%	71.5%	0.1%		**14.1%**
3		36.4%		3.4%	0.7%	8.9%	0.4%	13.4%	0.0%	72.5%	**8.5%**
3.5	5.6%			1.3%	64.5%	43.6%	17.5%	15.0%	36.9%	21.1%	**23.7%**
4	3.3%	0.5%		0.0%	34.2%	45.2%	65.1%		32.5%		**37.5%**
4.5	23.7%			71.8%	0.5%	2.2%	16.7%		30.3%		**10.4%**
5	46.0%								0.1%	0.1%	**2.2%**
5.5	12.9%										**0.6%**
6	8.4%										**0.4%**
Models Sold in New Zealand, 2006											
Total ('000)	**9**	**22**	**0**	**0**	**63**	**11**	**42**	**23**	**1**	**8**	**181**
1		5.7%				5.4%		0.5%		0.5%	**1.1%**
1.5		0.7%		0.6%			0.7%	0.9%		1.6%	**0.4%**
2	0.4%	11.6%		1.2%	1.8%		14.5%	1.7%			**5.7%**
2.5		70.4%	100%	32.5%		0.8%	0.1%	75.1%	17.5%		**18.8%**
3		11.5%			7.2%	22.4%	0.5%	21.5%		87.0%	**12.1%**
3.5	2.0%				88.5%	33.9%	13.4%			5.9%	**36.6%**
4	17.5%			5.9%	2.5%	37.6%	69.9%	0.1%	4.7%		**20.4%**
4.5	26.6%			32.5%			0.8%	0.2%	2.5%	5.1%	**1.7%**
5	29.1%			27.2%				0.1%	74.2%		**1.9%**
5.5	23.6%										**1.1%**
6	0.8%										**0.0%**

Note: Groups with a common algorithm have the same colour in the first row. Red cells indicate that the star rating is below the MEPS level. Yellow cells show that some products for these star ratings are affected by MEPS (depending on the size). Clear cells indicate that the star rating is above the MEPS level. The Group 2 units in the red area are just below 2 stars and passes MEPS by about 1 kWh. The columns showing sales may include some grandfathered and cancelled registrations. Australia 2006 is for calendar year, NZ 2006 is for the year to 31 March 2006.

Appendix I: Star Ratings and Sales Tables – 2009 Algorithm with ERF = 0.23

Table 5: Group by 2009 Star Rating for August 2007 Approved Registrations (%)

Group → 2009 Stars ↓	Group 1 (% / star)	Group 2 (%/ star)	Group 3 (%/ star)	Group 4 (%/ star)	Group 5B (%/ star)	Group 5S (%/ star)	Group 5T (%/ star)	Group 6C (%/ star)	Group 6U (%/ star)	Group 7 (%/ star)	Total (%/ star)
Approved Registrations (August 2007)											
Total (number)	**49**	**134**	**6**	**9**	**133**	**234**	**355**	**105**	**79**	**26**	**1130**
1	61.2%	94.0%	100%		13.5%	31.2%			1.3%	61.5%	**23.9%**
1.5	14.3%	3.7%			56.4%	52.6%	11.0%		39.2%	19.2%	**25.2%**
2	12.2%	2.2%		11.1%	26.3%	16.2%	72.1%	41.0%	40.5%	7.7%	**36.8%**
2.5	10.2%			33.3%	3.8%		16.9%	49.5%	12.7%		**11.9%**
3				55.6%				3.8%	6.3%	11.5%	**1.5%**
3.5	2.0%							3.8%			**0.4%**
4								1.9%			**0.2%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**
Models Sold in Australia, 2006											
Total ('000)	**57**	**117**	**47**	**0**	**121**	**140**	**479**	**103**	**87**	**41**	**1193**
1	78.7%	93.2%	100%	24.8%	0.9%	27.0%	0.7%	0.1%	0.1%	74.5%	**23.0%**
1.5	12.9%	6.2%		3.4%	39.5%	50.6%	10.8%		48.3%	25.4%	**19.9%**
2	8.2%	0.5%			59.3%	22.4%	54.3%	38.9%	51.4%		**38.0%**
2.5	0.1%				0.4%		34.2%	45.9%	0.1%		**17.7%**
3				71.8%				15.1%		0.1%	**1.3%**
3.5	0.1%										**0.0%**
4											**0.0%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**
Models Sold in New Zealand, 2006											
Total ('000)	**9**	**22**	**0**	**0**	**63**	**11**	**42**	**23**	**1**	**8**	**181**
1	75.6%	100%	100%	34.3%	9.0%	35.6%	15.8%	0.3%	17.7%	89.0%	**29.3%**
1.5	23.6%				29.1%	42.7%	12.8%	1.0%	4.7%	5.9%	**17.3%**
2	0.2%				61.9%	21.7%	59.9%	48.1%	1.2%	5.1%	**43.5%**
2.5	0.6%			13.6%			11.5%	50.2%	75.8%		**9.7%**
3				52.1%					0.5%		**0.1%**
3.5								0.2%			**0.0%**
4								0.1%			**0.0%**
4.5											**0.0%**
5											**0.0%**
5.5											**0.0%**
6											**0.0%**

Note: Groups with a common algorithm have the same colour in the first row.