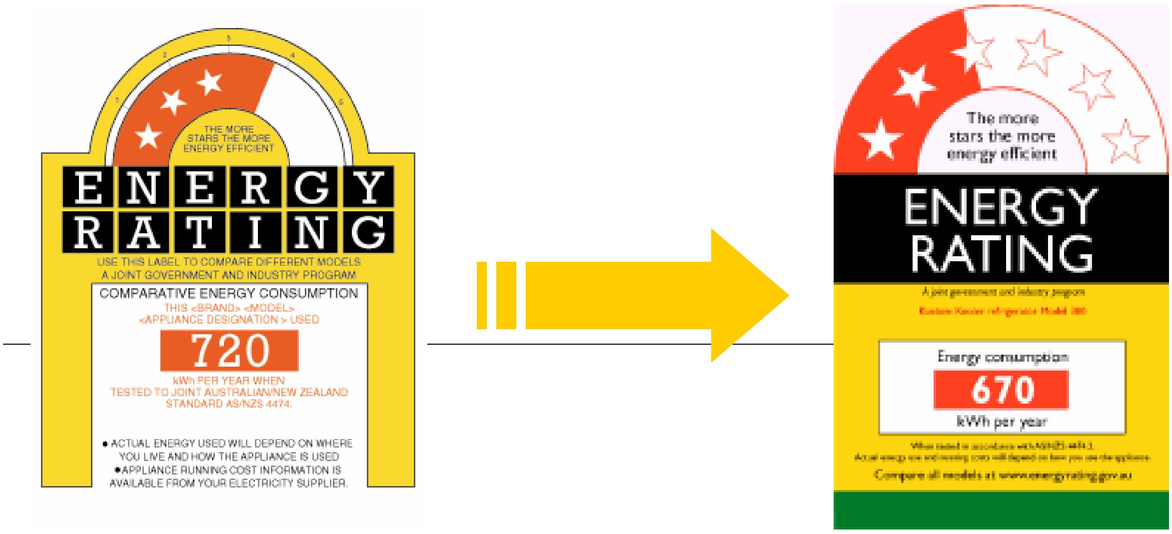
NAEEEC Report 2004/05

July 2004

Report for the
Australian
Greenhouse Office

Energy Label Transition – The Australian Experience:

APPENDICES



Prepared by Energy Efficient Strategies

FOREWORD

This report was prepared by Robert Foster of Energy Efficient Strategies under contract to The Australian Greenhouse Office (AGO). Editorial contributions were provided by:

- Lloyd Harrington (Energy Efficient Strategies)
- Tony Marker (AGO)
- Shane Holt (AGO)

Further information is available from Mr Shane Holt of the Australian Greenhouse Office, energy.rating@greenhouse.gov.au

References cited in this report are available electronically. The References section in the main report lists the reports cited and has direct links to the relevant web page to enable documents to be downloaded. Appendices cited in the main report are available in this file.

These are the Appendices. The main report is available as a separate file.

Energy Efficient Strategies
Warragul, Victoria
July 2004

LIST OF APPENDICES

The following appendices are available in this document. PDF Page

Notes: For Appendix 10, reference is made to document EES, March 1998 which is listed in the reference in the main report. The relevant parts of this document are also included in Appendices 11, 12 and 13 above. Appendix 15 reviews the recommendations of the original dishwasher algorithm discussion paper (included in Appendix 14) in the light of the revised dishwasher test method and the requirement to label on Normal program. All of Appendix 15 recommendations were accepted. The transition to the new test method and program was completed in April 2004.

Appendix 1: NAEEEC Workshop Report - December 1997

NAEEEC WORKSHOP REPORT

Topic 1 - Review of the Existing National Appliance Labelling Scheme

Sydney, 3 December 1997

Introductions & Attendees: John Hughes (WSAA), Gerard Putt (Big W), Les Winton (Artcraft Research), Simon Coultas (Email), Rick Boykett (Southcorp), Richard Bollard (F&P), Bev Smith (Energy Victoria), Graeme Jessup (SEDA), Ian Walsh (NSWDOE), Philip Kenny (Standards Australia), Dick Brown (consultant), Norm Crothers (ACA), Peter Steele (Hitachi), Robert Wooley (Sharp), Neill Patterson (consultant), Ted Durham (AGA), Jill McCarthy (DPIE), Heidi James (facilitator), Lloyd Harrington (EES), Robert Foster (EES, rapporteur), Alan Faulks (QDME), Simon Ramm (Southcorp, part of meeting).

Note : Individual concerns were expressed regarding the very late or non delivery of conference papers prior to the conference.

Consultants Reports

Neill Patterson gave a brief presentation on his consultancy task - this was a project to look at the energy label from the consumers' perspective. It was a desk research project only, looking at data from the past 14 years. He was interested in how the energy label is used by the consumer. Report final recommendations include a redesign of the label - some information is missing, other information seems superfluous. Recommended some options for further research to test various options for label redesign. Inclusion of $ running costs is recommended. Water consumption on the label is a possibility. A range of star rating options were considered including 10 stars, 5 stars and no stars. It was recognised in the report that overseas label formats may not work in the Australian context. The report is yet to be released and is currently with the project management committee.

Les Winton noted that consumers have become a lot more sophisticated since the introduction of labelling 10 years ago and this needs to be taken into account when any research into the design of the label. The most recent label design research known was 1992 - this older research may now be irrelevant.

Dick Brown gave a brief presentation on his consultancy task - his report is a technical review of the labelling program with a view to assessing the accuracy and relevance of the data on the energy label. The report generally presents a range of options to address identified problems rather than making very specific recommendations regarding changes to the labelling program. The two areas of focus relate to the actual energy consumption of the appliance - firstly the energy consumption of the appliance per load (etc.) and secondly the frequency and duration of use. In this case, is energy shown as per hour, per cycle, per year or per 10 years? The option of energy costs on the label was also examined. Also an efficiency rating scale was also examined to indicate to a consumer in a simple fashion as to whether the unit was efficient or not. Fixed and variable scales were examined. It was noted that there is now crowding at the top end of the products for higher star ratings. Such crowding is seen as a dis-incentive to manufacturers to make further efficiency improvements. A separate endorsement label for high efficiency products is a possible option. The size bias in the current refrigerator algorithm was noted there is a need for a capacity neutral star rating.

General comments

Regulators noted that there have been a lot of resources put into the energy labelling program in the past and governments are unlikely to walk away from this completely without good cause. The program has been very successful in moving manufacturers in terms of improving energy efficiency, and consumers are now familiar with the existing system. A concern was expressed that changes might jeopardise these past gains. However there needs to be care to not stick with something that is not working well. The group agreed to keep an open mind when considering the redesign of the labelling. There is a need to consider different consumer types and how they use the label when a redesign is considered (at least three main types). It was noted that the energy label is generally a low order priority issue for most consumers during the purchase decision.

Issue 1 - Future management of the project

It was noted that the current project management committee's terms of reference only covered the project up to finalisation of the commissioned reports and that it was not a representative group that could deal with report outputs.

The concept of a steering group was discussed. It was agreed that a steering group should be formed and that this will manage the project overall. It should have a broad focus upon commercial, consumer and government perspectives. It should be able to appoint working groups to deal with product specific issues on an as needs basis.

The basic structure of the working group was agreed as follows:

AEEMA 3 positions - F&P (RB), Email (SC), Southcorp (RB)
CESA 2 positions - Sharp (RW), Sanyo (Colin Doyle, not present) - or other product specific as appropriate
ACA 1 position - (NC)
Government = 5 positions - nominally EECA (David Cogan, not present), SEDA (GJ), EV (BS), QDME (AF), DPIE (JM).

There was agreement that members from WSAA (JH) would be included if water issues were seriously discussed. Similarly, members from the retailer and gas industries would be consulted if issues affecting their members were raised.

Group agreed that attendees would fund their own participation.

Issue 2 - Further or additional work required by steering committee before reporting to NAEEEC.

Other tasks were considered in detail. The issue of how consumers see the label currently is an important base position to commence any review - there is a need to collect all available data on consumer use of the label. It was agreed that Bev Smith will look at the need for this work and prepare a scope for the work.

It was agreed that a review of overseas experience would be of great interest. This would include a review of processes to develop energy labels overseas, a summary of the information included on overseas labels and a summary of any evaluations of energy labelling programs undertaken to date.

It was agreed to provide a summary of energy end use in the residential sector in Australia to get some idea of the relative importance of various labelled appliances within the big picture.

It was agreed not to undertake specific consumer research on new labels until outputs from the above consultancies could be considered in detail and used as a basis for developing specific proposal for consumer testing. However it was agreed that any specific proposals for a new label would need to be tested before final recommendation.

The group agreed to circulate all reports and papers coming into/out of this process to all participants today.

Issue 3 - Establishing some short term goals for the project &
Issue 4 - Stakeholders developing a timetable to finish the project

It was noted that the Ministers need some outline of action by April or May 1997. A timetable was agreed as follows:

TOR for label focus studies prepared by EV and circulated for comment to the steering group, finalised by 17 December, report to be delivered by late February.

EV to undertake work on review of existing data on the energy label in conjunction with Neill Patterson in December (incorporated into his final report or to be delivered as a separate package by late February, preferably before).

DPIE to manage and instigate O/S label study in December, report to be delivered by late February.

Brown and Patterson reports to be circulated to the steering group in early January 1998.

Initial meeting of the steering committee ("The Big Group") on 5 February 1998 in Sydney to primarily consider technical recommendations arising from Brown report. (Note that EL15 is scheduled for 4 February in Sydney). A second meeting is targeted for 11 March 1998

Possible draft recommendation to NAEEEC by 30 April 1998.

A broad indication of cost for a comprehensive focus group session was mentioned - up to about $30,000 for a series of around 12 focus groups in several cities/country areas. This would cover three major consumer types. This could be cut down to a lower level if necessary for the first round to benchmark the existing label as there will be a need for a follow up study if label changes are proposed. It was agreed that Melbourne and Sydney at least would have to be separately surveyed.

There is a need to acknowledge the infrastructure costs for the labelling program to date. There will be a need to consider the costs and benefits of change and be sure that these are justified before any major changes are undertaken.

Finally a Mission Statement was developed - Purpose of energy labelling is to influence consumers to buy the appliance which will result in the lowest energy consumption and which meets their needs. The weaknesses and strengths of the energy label needs to be examined within this process.

It was agreed to prepare a list of attendees and circulate names, addresses and contact details.

Consensus Recommendations from Energy Labelling Meeting (summary)

Mission: *Purpose of energy labelling is to influence consumers to buy the appliance which will result in the lowest energy consumption and which meets their (energy service) needs.* The weaknesses and strengths of the energy label need to be examined within this process. Investment in the labelling program to date has been substantial and the costs and benefits of proposed changes need to be carefully considered.

Future management - it was agreed that a new broadly based steering committee is needed to deal with the output from the Brown and Patterson consultant's reports as well as taking into account inputs from other relevant sources. It was agreed that the new steering committee should be concerned with the "big picture" and have a broad focus on commercial, consumer and government perspectives. Product specific sub-groups would be commissioned by the steering committee on an as needs basis. It was agreed that the steering committee should consist of the following stakeholders - three from AEEMA , two from CESA , one consumer (ACA) and up to five government representatives. This was viewed as a representative and balanced committee structure. If input was required from other sectors such as retailers, gas and/or water, that they would be seconded by the committee as required. Specific steering committee members are likely to be Simon Coultas (Email), Rick Boykett (Southcorp), Richard Bollard (F&P), Robert Wooley (Sharp), Colin Doyle (Sanyo), Norm Crothers (ACA), and up to 5 NAEEEC members (nominally Alan Faulks, Bev Smith, Graeme Jessup, David Cogan & Jill McCarthy).

It was agreed that the steering committee participants will fund their own attendance.
It was agreed that the steering committee will require the services of a secretariat and that DPIE will be responsible for its organisation.

Additional work, goals and timetable - Two major consultant reports have been commissioned by NAEEEC and these are due to be completed at the end of December 1998. The workshop identified additional work that will be necessary as input into the energy labelling steering group - funding for this should be requested from NAEEEC. This work is specifically as follows (complete by end Feb):

- Energy Victoria to consult with Neill Patterson to ensure that all current EV data on labelling awareness and use is incorporated either into his report or compiled as a small separate stand alone piece - cost small (unclear, $0 to $5,000)
- Energy Victoria to prepare a TOR in conjunction with other members of the steering group by 17 Dec to commission some focus groups to benchmark the use and acceptance of the current energy label - estimated cost of the consultancy of around $15,000 to $30,000 (depends on size and scope).
- review of current overseas energy labelling activities, examination of information contained on O/S labels, review of any overseas labelling evaluations - DPIE to commission - possible budget around $15,000.
- brief overview of energy consumption by end use in Australia to assist in prioritising energy labelling activities (use Schipper IEA benchmark data as main input).

A (draft) delivery program was developed and the steering group is scheduled to meet in February and March 1998. It is hoped that draft recommendations for changes to the program will be delivered to NAEEEC by the end of April 1998.

This summary was prepared by Energy Efficient Strategies for NAEEEC.

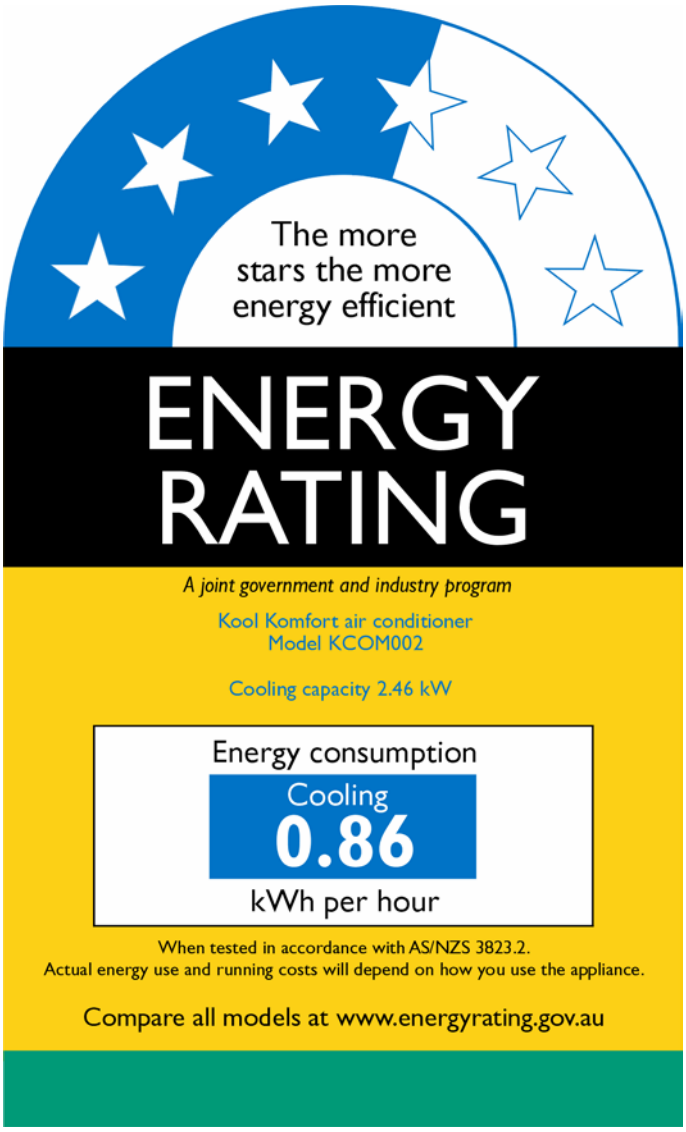
Appendix 2

Energy Label Review Committee Members

FirstName	LastName	JobTitle	Company
Richard	Bollard	Groups Standard and Approvals Manager	Fisher & Paykel
Rick	Boykett	Product Development Manager, Dishwashers	Southcorp Appliances
David	Cogan	Standards Engineer	EECA
Simon	Coultas	Product Line Manager	Email Limited
Norm	Crothers	Development Manager Research	Australian Consumers' Association
Colin	Doyle	Technical and new business manager	Sanyo Australia
Alan	Faulks	Principal Electrical Approvals Officer	Department of Mines and Energy
Graeme	Jessup	Program Manager	Sustainable Energy Development Authority
Jill	McCarthy	ELRC Chair	DPIE Energy Division
Beverly	Smith	Manager Strategy & Business Development	Energy Victoria
Robert	Wooley		Sharp Corporation
Megan	Smith	ELRC Secretary	DPIE Energy Division
Lloyd	Harrington	Consultant to DPIE	Energy Efficient Strategies

Appendix 3:
Examples of New Energy Labels – All categories

Air – Conditioner – Cooling Only



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Kool Komfort air conditioner
Model KCOM002

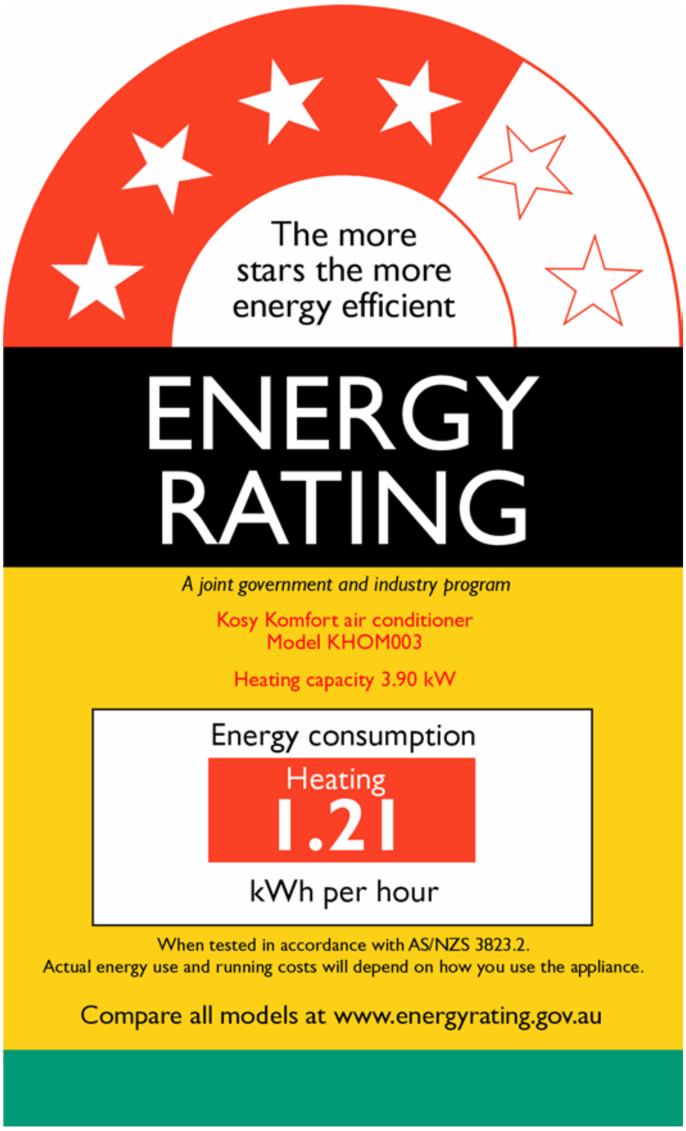
Cooling capacity 2.46 kW

Energy consumption
Cooling
0.86
kWh per hour

When tested in accordance with AS/NZS 3823.2.
Actual energy use and running costs will depend on how you use the appliance.

Compare all models at www.energyrating.gov.au

Air – Conditioner – Heating Only



The more stars the more energy efficient

ENERGY RATING

A joint government and industry program

Kosy Komfort air conditioner
Model KHOM003

Heating capacity 3.90 kW

Energy consumption

Heating

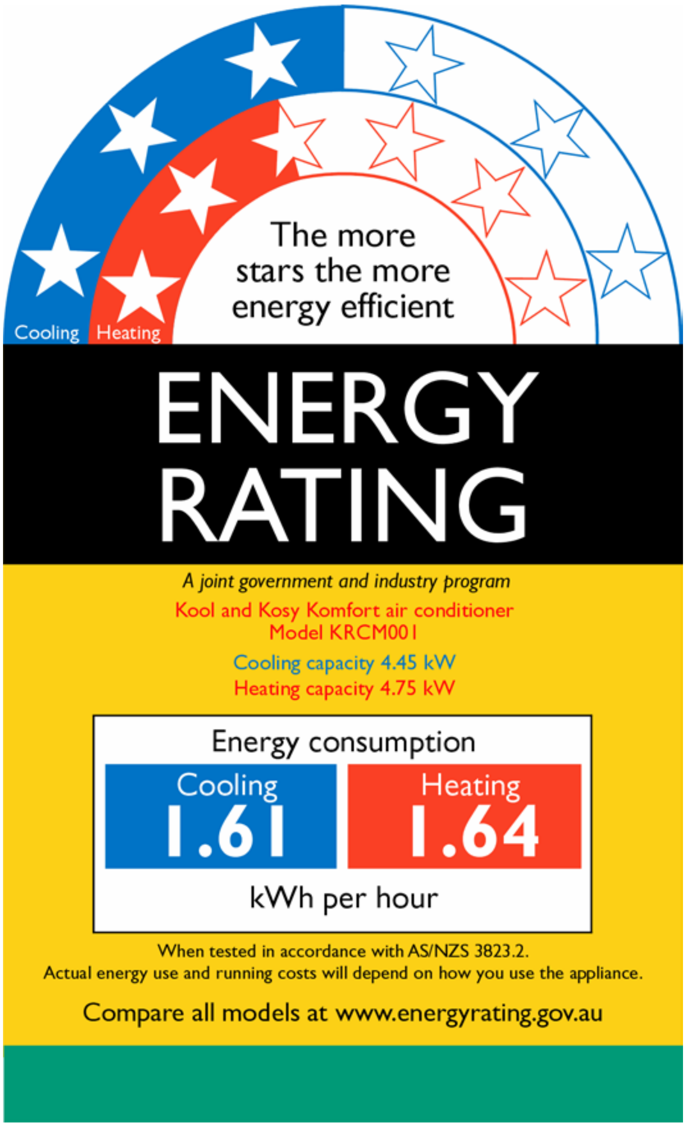
1.21

kWh per hour

When tested in accordance with AS/NZS 3823.2.
Actual energy use and running costs will depend on how you use the appliance.

Compare all models at www.energyrating.gov.au

Air – Conditioner – Reverse Cycle



Cooling Heating

The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Kool and Kosy Komfort air conditioner
Model KRCM001

Cooling capacity 4.45 kW
Heating capacity 4.75 kW

Energy consumption

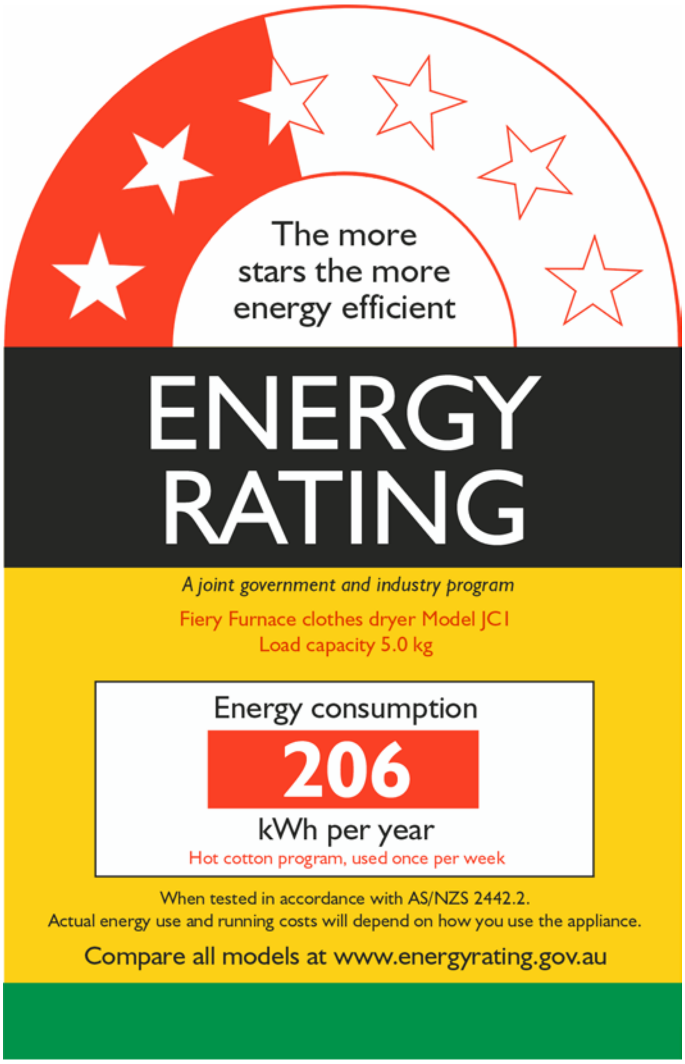
Cooling	Heating
1.61	1.64

kWh per hour

When tested in accordance with AS/NZS 3823.2.
Actual energy use and running costs will depend on how you use the appliance.

Compare all models at www.energyrating.gov.au

Clothes Dryer



The more stars the more energy efficient

ENERGY RATING

A joint government and industry program

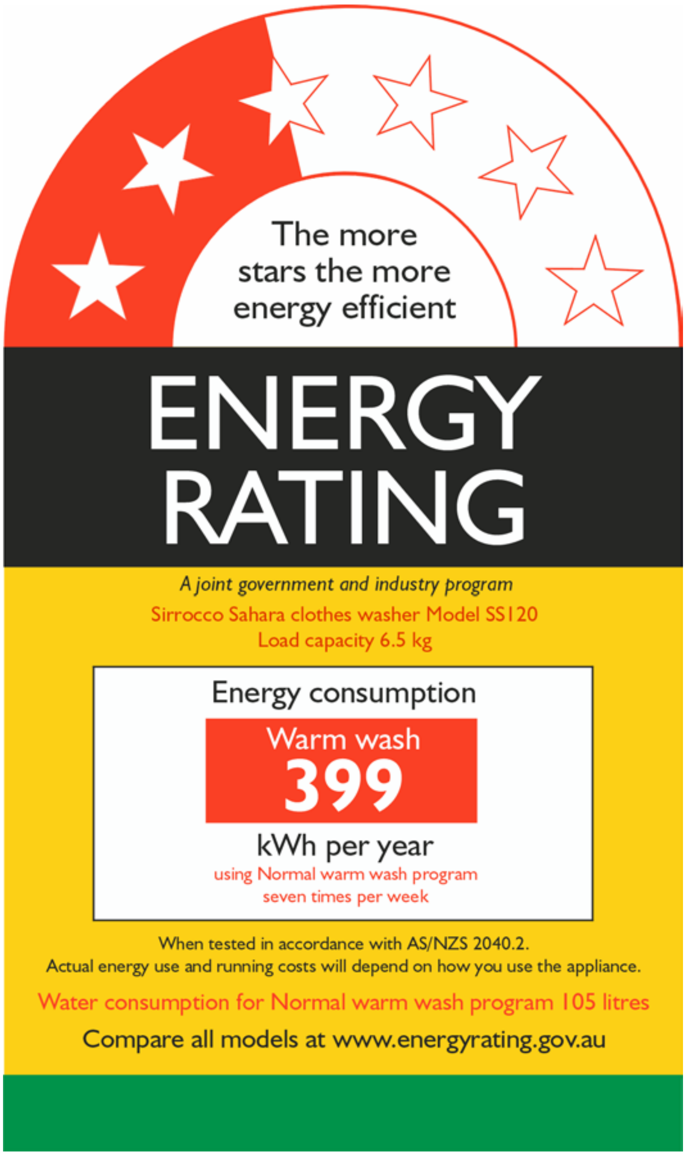
Fiery Furnace clothes dryer Model JC1
Load capacity 5.0 kg

Energy consumption
206
kWh per year
Hot cotton program, used once per week

When tested in accordance with AS/NZS 2442.2.
Actual energy use and running costs will depend on how you use the appliance.

Compare all models at www.energyrating.gov.au

Clothes Washer – Warm Wash Only



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Sirrocco Sahara clothes washer Model SS120
Load capacity 6.5 kg

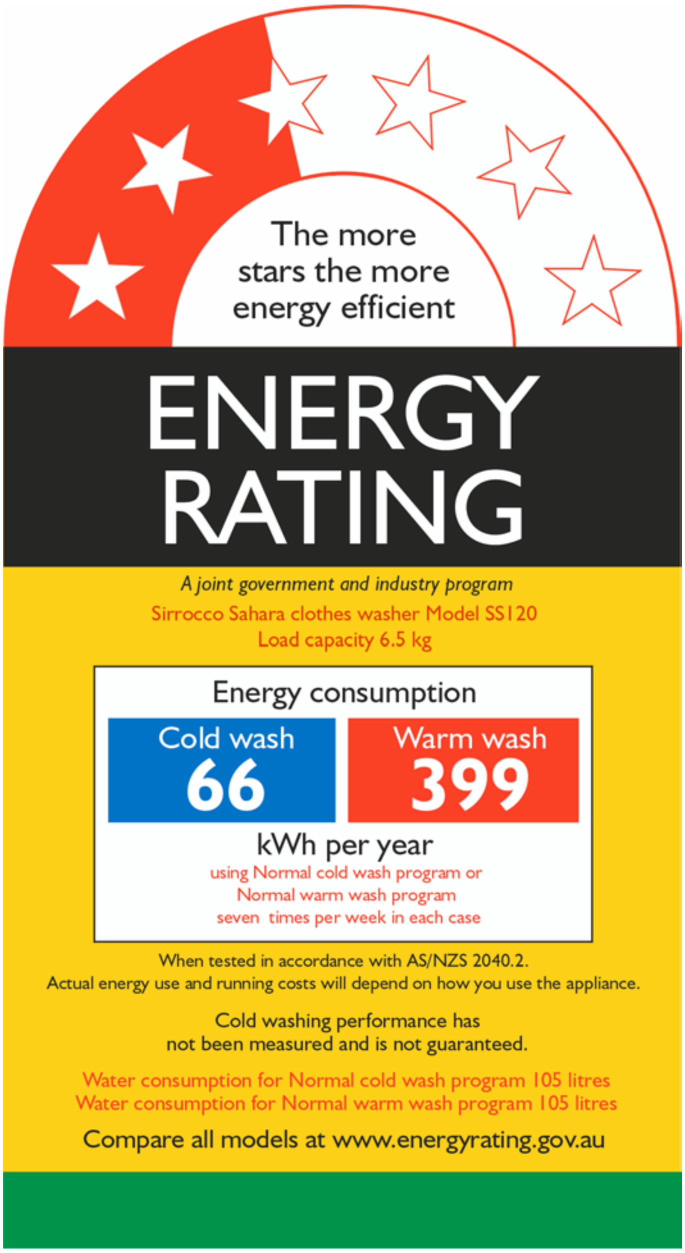
Energy consumption
Warm wash
399
kWh per year
using Normal warm wash program
seven times per week

When tested in accordance with AS/NZS 2040.2.
Actual energy use and running costs will depend on how you use the appliance.

Water consumption for Normal warm wash program 105 litres

Compare all models at www.energyrating.gov.au

Clothes Washer – Warm an Cold Wash



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Sirrocco Sahara clothes washer Model SS120
Load capacity 6.5 kg

Energy consumption

Cold wash	Warm wash
66	399

kWh per year
using Normal cold wash program or
Normal warm wash program
seven times per week in each case

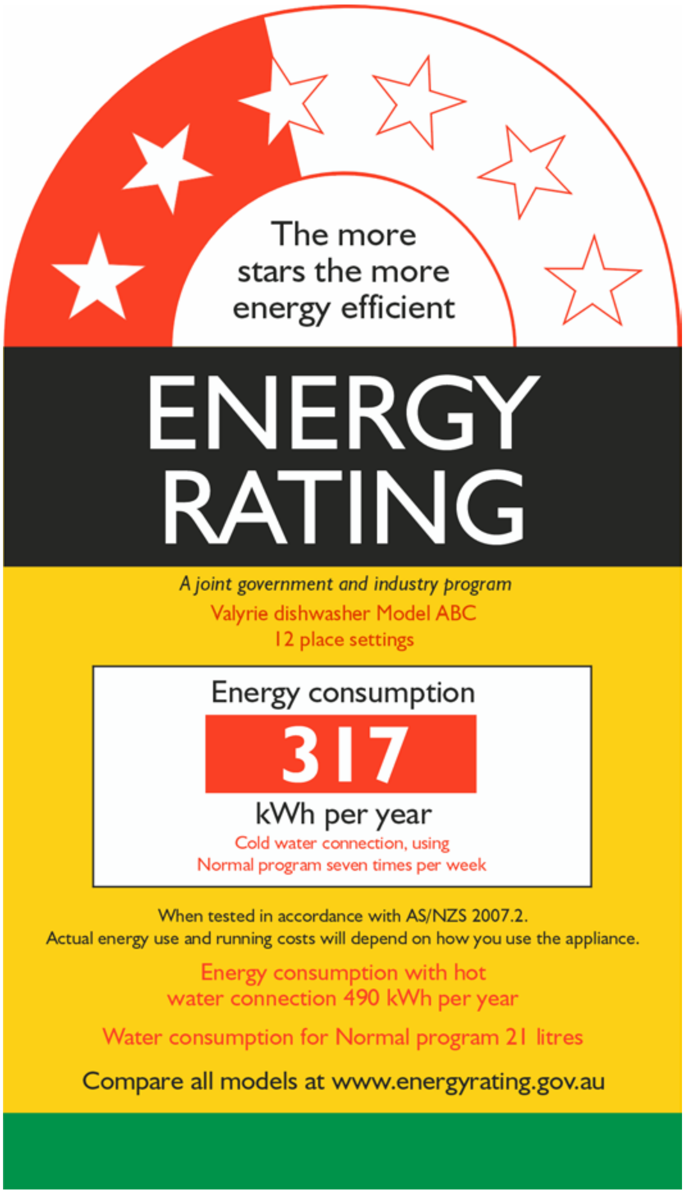
When tested in accordance with AS/NZS 2040.2.
Actual energy use and running costs will depend on how you use the appliance.

Cold washing performance has
not been measured and is not guaranteed.

Water consumption for Normal cold wash program 105 litres
Water consumption for Normal warm wash program 105 litres

Compare all models at www.energyrating.gov.au

Dishwasher



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Valyrie dishwasher Model ABC
12 place settings

Energy consumption
317
kWh per year
Cold water connection, using
Normal program seven times per week

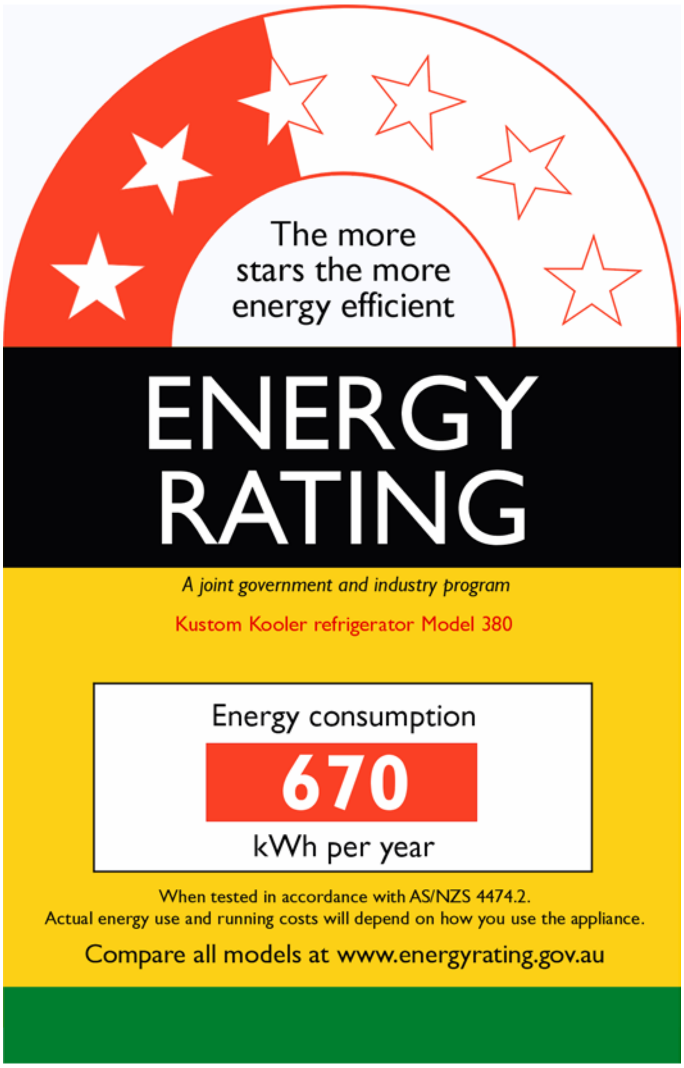
When tested in accordance with AS/NZS 2007.2.
Actual energy use and running costs will depend on how you use the appliance.

Energy consumption with hot
water connection 490 kWh per year

Water consumption for Normal program 21 litres

Compare all models at www.energyrating.gov.au

Refrigerator / Freezer



The more
stars the more
energy efficient

ENERGY
RATING

A joint government and industry program

Kustom Kooler refrigerator Model 380

Energy consumption
670
kWh per year

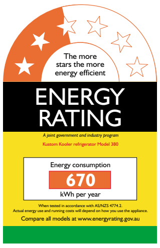
When tested in accordance with AS/NZS 4474.2.
Actual energy use and running costs will depend on how you use the appliance.

Compare all models at www.energyrating.gov.au

April 2000

Label Update

Introducing the Revised Appliance Energy Rating Label



Helping you comply with the revised label laws

Label Update has important information for everyone who produces, imports or retails appliances in Australia. After more than 10 years in use, the familiar red and yellow 'star' energy rating is changing, with the bar for appliance energy efficiency being raised. Label Update provides the key dates and details on the changes.

This bulletin is part of a national education campaign that will inform the appliance industry and consumers about the 'transition' to the revised label, which will be phased-in under the following timetable:

DATE	STAGE	ACTION
1 April 2000	Labelling starts	Manufacturers/importers may start attaching revised labels at the factory.
15 May 2000	Retailer education	Retailers receive staff & customer education material via buying groups / head office.
1 July 2000 - 30 September 2000	Transition period	Stock with revised label appears on shop floor. Consumer education material available.
1 October 2000	Legal compliance	From this date, all stock* displayed on shop floors must carry the revised label. Manufacturers can no longer produce 'old' label.
1 October 2001	Legal compliance	All stock* delivered from warehouse to customers must display revised label.

* *Please note that air conditioners are subject to different compliance dates. Please contact the 'Energy Rating Label Hotline' on 1800 155 244 for more information.*

April 2000 kick-off for manufacturers / importers

Following several years of negotiation between government and the industry, manufacturers and importers should now be well aware of their obligations under the revised label code, and may start attaching new labels from 1 April 2000. Details of your company's obligations are included in the following documents:

- Proposed administration guidelines for the appliance and equipment energy efficiency program of mandatory labelling and minimum performance standards for appliances.
- Proposed Model Regulation.

- ★ Regulatory Impact Statement (Energy Labelling & Minimum Performance Standards).
- ★ AS/NZS 2007.2:2000. Performance of household electrical appliances-Dishwashers, Part 2: Energy labelling requirements.
- ★ AS/NZS 2040.2:2000. Performance of household electrical appliances-Clothes washing machines, Part 2: Energy labelling requirements.
- ★ AS/NZS 2442.2:2000. Performance of household electrical appliances-Rotary clothes dryers, Part 2: Energy labelling requirements.
- ★ AS/NZS 4474.2:2000. Performance of household electrical appliances-Refrigerating appliances, Part 2: Energy labelling and minimum energy performance standards requirements.
- ★ AS/NZS 3823.2:2000. Performance of household electrical appliances-Room air conditioners, Part 2: Energy labelling requirements.

If your company hasn't received these documents or is unsure of its obligations, check the comprehensive information at www.energyrating.gov.au or contact the 'Energy Rating Label Hotline' on 1800 155 244.

Manufacturers will also have an important role to play in retailer education. A Fact Sheet explaining key points relating to the revised label that can be discussed with sales staff at 'product nights' or store visits over the transition period is available to manufacturers by contacting the 'Energy Rating Label Hotline' on 1800 155 244.

Education for retailers & their customers

As most appliances will be awarded less stars under the revised label program, a major challenge will be to reduce confusion amongst consumers considering, purchasing and taking delivery of appliances. To maintain sales levels and customer satisfaction, it's important that retail managers and floor staff are well informed about the revised label. In late May 2000, every store should receive an education kit for staff (including a short video, reference booklet and staff poster) and point-of-sale (POS) material for customers, ready for the 'transition period' commencing 1 July 2000.

If you do not receive an education kit by mid-June, contact your Buying Group or Department Store head office. You should also contact your Buying Group if you need to replenish your point-of-sale information. Non-aligned stores should contact the 'Energy Rating Label Hotline' on 1800 155 244 for additional POS material.

Many thanks to Buying Groups

Buying Groups and Department Stores will play a vital role in the transition to the revised label, having agreed to distribute Label Update, retail staff education kits and consumer point-of-sale material to their client stores.

A limited number of expert speakers on the label transition are available to present at Buying Group and Department Store state or regional sales meetings. Alternatively, a Microsoft PowerPoint© presentation is available by email (or in hard copy) for managers to present to their members. Contact the 'Energy Rating Label Hotline' on 1800 155 244 to take advantage of these offers.

To encourage consumers to ask sales staff about the label changes, Buying Groups and Department Stores will also be offered small information icons for inclusion in their catalogues or print advertising. Companies will be contacted directly regarding this offer.

Further Information

Visit the label website at: www.energyrating.gov.au

Call the 'Energy Rating Label Hotline': 1800 155 244

Label Update is produced on behalf of the National Appliance and Equipment Energy Efficiency Committee. The label transition program is a cooperative initiative between the Federal, State and Territory Governments.

Appendix 5: Air conditioners – algorithm discussion paper

Appliance Labelling Review Committee
Air Conditioner Algorithm Working Group
Discussion Paper

prepared by EES, April 1999

Background

During 1998, the Appliance Energy Labelling Review Committee considered a wide range of issues associated with the possible revision of the appliance energy labelling program. A number of issues relating to specific products were referred to algorithm working groups. An extract from the Appliance Energy Labelling Review Committee support document for air conditioners (and the corresponding decisions of the Energy Labelling Review Committee) is attached as Appendix A.

This paper reviews the issues associated with air conditioners. Only issues that require additional discussion have been included (ie topics are not included where a final decision has already been agreed). Where necessary, additional data has been analysed and the results summarised. Some preliminary recommendations are presented for further consideration by the working group.

The opinions offered within this document are those of EES and are not intended to bind the committee to any particular course of action.

Key Issues Considered in this Paper

- **Test Procedure**
- **Scope of Energy Labelling for Air Conditioners**
- **Provision of Latent and Sensible Cooling Data**
- **Determination of Air Conditioner CEC**
- **Bunching of Star Ratings**
- **Part Load Operation**
- **Highlighting Capacity on the Energy Label**
- **Standby Power Consumption**

Summary of Key Recommendations

Test Procedure

The Energy Labelling Review Committee decided that a multi split clone should be adopted as soon as possible so that these systems can be included into the energy labelling program. If there is an inordinate delay in the publication of ISO15042, then consideration should be given to publishing the draft as a national standard (harmonised with ISO5151).

Scope of Energy Labelling for Air Conditioners

It is possible that MEPS may be introduced for commercial packaged air conditioners. Also, consideration is being given to extending labelling to 12kW units. These policies, if implemented would most likely be implemented through the existing Part 2 Standard and through EL15/16.

Provision of Latent and Sensible Cooling Data

It is not recommended that sensible cooling capacity be included on the energy label. Inclusion of the sensible and latent cooling capacity on brochures and on the Internet may still be possible, but this will need to be supported by some technical explanations regarding the meaning of the values and how they may be applied to particular situations. The working group needs to give some consideration to this task and make specific recommendations for implementation.

Determination of Air Conditioner CEC

The Energy Labelling Review Committee decided to put kW (or Watts) on the label instead of energy consumption per X hours, plus the provision of local advice regarding expected hours of use for various house types and climate types. Advisory information for each region needs to be developed. How such advisory information should be developed needs to be considered by the committee.

Bunching of Star Ratings

A revised algorithm in the same format as the existing rating system is proposed.

For cooling, Option C is recommended as follows:

$$\text{Star Rating Index} = \text{CCOP} \times 3.333 - 5.666$$

For heating, Option H is recommended as follows:

$$\text{Star Rating Index} = \text{HCOP} \times 3.333 - 6.666$$

These are summarised in the following table.

Proposed Star Rating	**CCOP Option C**	**HCOP Option H**
1 Star	< 2.15	< 2.45
1.5 Star	<2.3	< 2.6
2 Star	< 2.45	< 2.75
2.5 Star	< 2.6	< 2.9
3 Star	< 2.75	< 3.05
3.5 Star	< 2.9	< 3.2
4 Star	< 3.15	< 3.35
4.5 Star	< 3.2	< 3.5
5 Star	< 3.35	< 3.65
5.5 Star	< 3.5	< 3.8
6 Star	> 3.5	> 3.8

The proposal meets the broad criteria set out by the Energy Labelling Review Committee.

Part Load Operation

The Energy Labelling Review Committee considered the issue and agreed that the part load issue needs to be addressed in some form, although this will be difficult in the short term. Ideally the test procedure should be used to calibrate a computer model, but even where this had been developed, it is still unclear how the additional information could be used in an energy labelling context. Work under way for AGO at UNSW (part of a package air conditioner study) to exploring modelling options in more detail for air conditioners.

Highlighting Capacity on the Energy Label

The Energy Labelling Review Committee decided that different formats for displaying capacity should be trialed through focus groups.

Standby Power Consumption

It is recommended that standby power consumption be incorporated into the energy consumption shown on the energy label. Actions required to achieve this are:

- defining the possible power consumption states;
- defining the instrument accuracy requirements;
- deciding on the composition of the standby power states when the appliance is not in use.

Standby power consumption should eventually be shown in brochures and the Internet. It is recommended that the work and proposals of IEC TC74 working group 9 be followed and incorporated into the wet product test procedures as appropriate.

Detailed Discussion

Test Procedure

A new air conditioner standard based on ISO5151 has been published (AS/NZS 3823-1998). The new AS/NZS standard is a "clone" of the ISO standard, with a number of minor amendments for clarification. Most of these changes are being incorporated into the next version of the ISO standard in any case.

The Energy Labelling Review Committee decided that a multi split clone should be adopted as soon as possible so that these systems can be included into the energy labelling program. Representations should be made to ISO to get that standard moving. If there is an inordinate delay in the publication of ISO15042 then consideration should be given to publishing the draft as a national standard (harmonised with ISO5151).

Scope of Energy Labelling for Air Conditioners

Current regulations nominally apply to all air conditioners under 7.5 kW cooling capacity. The new AS/NZS test procedure (ISO clone) only applies to non-ducted air conditioners with a single refrigeration circuit. It is not currently possible to test multi-split or ducted models under the current standard. The scope of Part 2 (energy labelling requirements) has been modified to exclude these types for the time being. Note also that ducted spot coolers and mobile splits are not covered by the new standard. ISO are currently considering an Australian request that ISO5151 and ISO13253 be merged into a single standard.

It is possible that MEPS may be introduced for commercial packaged air conditioners. Also, consideration is being given to extending labelling to 12kW units. These policies, if implemented would most likely be implemented through the existing Part 2 Standard and through EL15/16. The committee should seek direction from NAEEEC on this matter.

Provision of Latent and Sensible Cooling Data

The cooling effect of an air conditioner is the result of both lower air temperatures (sensible cooling) and reduced humidity (latent cooling). In dryer climates, there is likely to be little benefit from latent cooling. In more humid areas, the requirements are less clear. Significant discussion on this issue is contained in Appendix A.

The Energy Labelling Review Committee decided that the cooling capacity rating should continue to be based on total capacity. However, the sensible capacity could be included in brochures. It was agreed in principle to include sensible capacity in kW in small print on the label.

However, focus groups conducted in mid 1998 showed that consumers had absolutely no understanding of the concept of latent cooling versus sensible cooling. Given that this is the case, there is probably a strong case for ***not*** putting sensible cooling capacity on the energy label. Inclusion of the sensible and latent cooling capacity on brochures and on the Internet may still be possible, but this will need to be supported by some technical explanations regarding the meaning of the values and how they may be applied to particular situations. The working group needs to give some consideration to this task and make specific recommendations for implementation.

Determination of Air Conditioner CEC

The Comparative Energy Consumption (CEC) for air conditioners is currently based on 500 hours for heating and 500 hours for cooling. The actual use of air conditioners varies considerably in different climate regions. One thing is clear - actual use is almost never 500 hours. Appendix A contains considerable documentation on this issue.

The Energy Labelling Review Committee decided to put kW (or Watts) on the label instead of energy consumption per X hours, plus the provision of local advice regarding expected hours of use for various house types and climate types. Other energy options favoured by consumers at focus groups were per day or per week. The precise data to be included on the energy label needs to be finalised.

Advisory information for each region is to be developed. How such advisory information could be developed needs to be considered by the committee.

Bunching of Star Ratings

Star ratings are starting to bunch around 5 and 6 under the current algorithms. The Energy Labelling Review Committee decided to refer the issue to an air conditioner working group for further consideration. This section details further analysis undertaken by EES on air conditioners currently on the market in Australia and proposes new energy labelling algorithms.

Data on all models was compiled from the energy labelling registers up to and including those registered in late February 1999. A database of models currently on the market as at April 1998 (from brochures) plus those models subsequently registered up to February 1999 was compiled for analysis. This list will contain some obsolete models, but this will not unduly affect the analysis. While current models are being identified during April 1999, this compilation was not finalised in time for this paper.

Some 796 air conditioner models are, or have recently been, on the Australian market. The breakdown of these models is shown in the following table.

Current Air Conditioner Models - Australia February 1999

Air Conditioner Type	Models	Proportion
Window Wall Cooling Only	184	23.1%
Split System Cooling Only *	225	28.3%
Total Cooling Only	**409**	**51.4%**
Window Wall Reverse Cycle	121	15.2%
Split System Reverse Cycle *	266	33.4%
Total Reverse Cycle	**387**	**48.6%**
Total All Models	**796**	**100.0%**

Note * includes a small number of other systems

Of the models on offer, about half are cooling only models while half are reverse cycle models. Split systems constitute roughly about two thirds of all models offered for sale. This is thought to very approximately reflect the sales pattern of air conditioners in Australia as well.

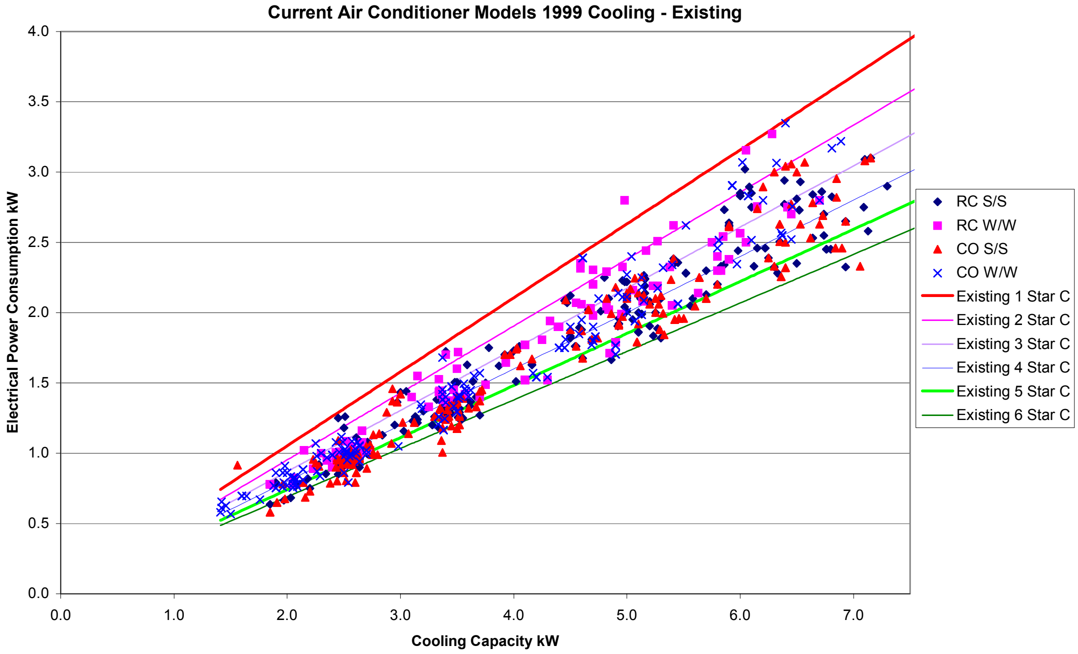
The existing star rating system is based on the heating and cooling coefficient of performance (referred to as CCOP and HCOP respectively - note that ISO use the terms EER and COP respectively). The equations for star rating are as follows:

Cooling Energy Efficiency Rating = (CCOP × 5) - 8.5
Heating Energy Efficiency Rating = (HCOP × 5) - 9.5
where:
CCOP is the cooling coefficient of performance
HCOP is the heating coefficient of performance

This effectively gives the star ratings as set out in the following table.

Current Star Rating	CCOP	HCOP
1 Star	< 2.1	< 2.3
2 Star	< 2.3	< 2.5
3 Star	< 2.5	< 2.7
4 Star	< 2.7	< 2.9
5 Star	< 2.9	< 3.1
6 Star	> 2.9	> 3.1

The cooling capacity and electrical energy consumption for all models on the market are shown in the following figure. Note that the current star bands all pass through the origin (ie there is no correction for size).



The important point to note is that the current star rating system is a geometric progression (declining energy per additional star), unlike the current system that was used on other labelled products such as refrigerators, clothes washers, clothes dryers and dishwashers, which is linear in nature (constant energy reduction per additional star). However, unlike the new labelling systems proposed for refrigerators, clothes washers, clothes dryers and dishwashers[1], the percentage air conditioner energy reduction per additional star varies (declines) as star ratings increase (see following table).

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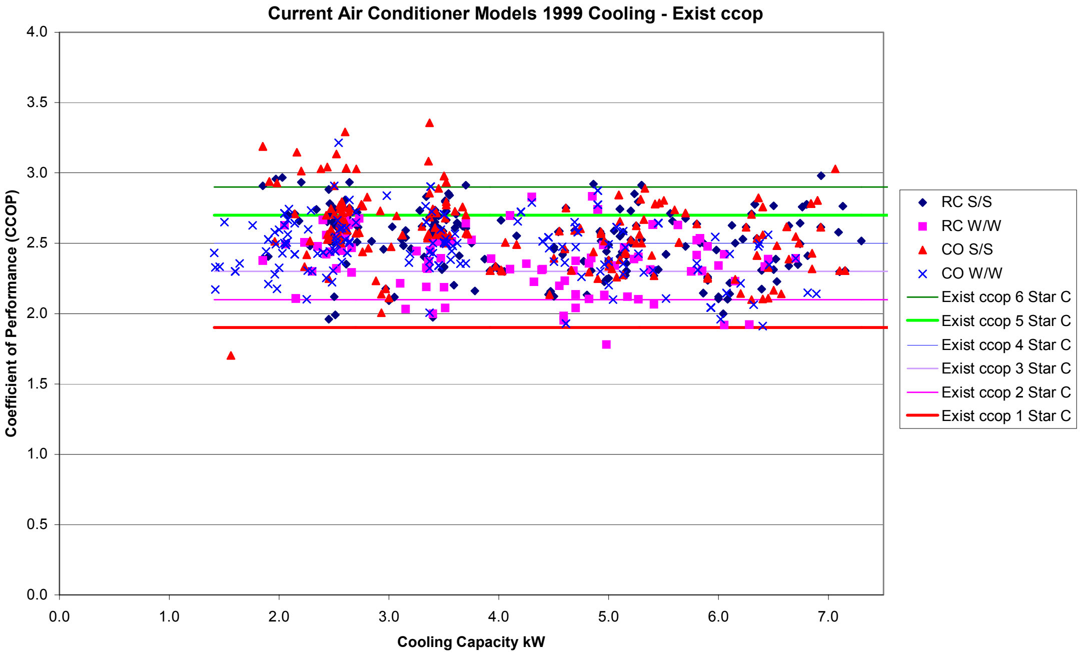
[1] Proposed new star ratings for these products use a fixed percentage energy reduction per star.

Energy Reductions for Current AC Star Ratings

Current	Cooling Energy red/star	Heating Energy red/star
1=> 2 star	9.5%	8.7%
2 => 3 star	8.7%	8.0%
3 => 4 star	8.0%	7.4%
4 => 5 star	7.4%	6.9%
5 => 6 star	6.9%	6.5%

For air conditioners, it is more intuitive to plot cooling (or heating) capacity versus coefficient of performance (a direct measure of efficiency) as shown in the following figure. This data format will be used throughout the remainder of this paper. The current star rating bands specify of constant coefficient of performance (energy efficiency) for all cooling capacities. As can be seen, there are numerous models that rate well over 6 stars under the current system (=CCOP of > 2.9).



In terms of the market analysis, a linear regression analysis for each type of air conditioner has been performed and these are summarised in the following tables.

Regression Analysis for Cooling Performance

Type	**Slope CCOP/kW**	**Fixed CCOP**
S/S CO	-0.049	2.806
W/W CO	-0.038	2.612
S/S RC	-0.033	2.663
W/W RC	-0.030	2.528

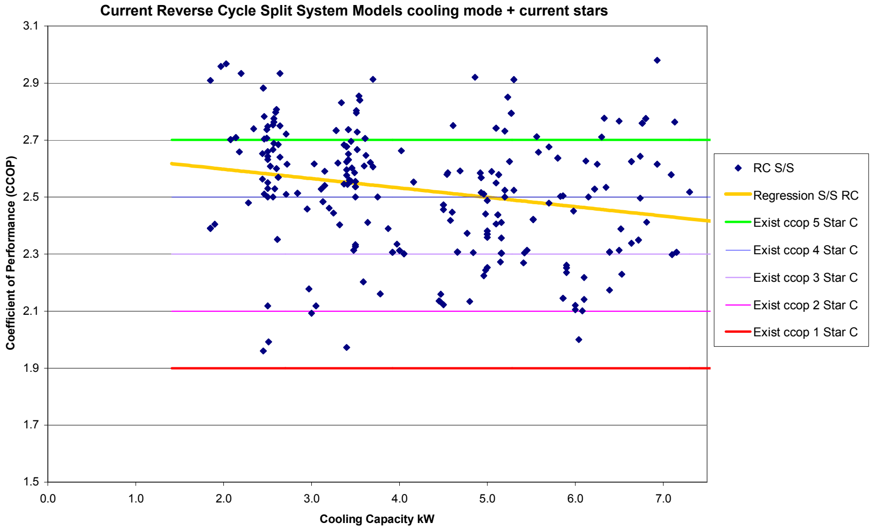
Regression Analysis for Heating Performance

Type	Slope HCOP/kW	Fixed HCOP
S/S RC	-0.059	3.107
W/W RC	-0.022	2.724

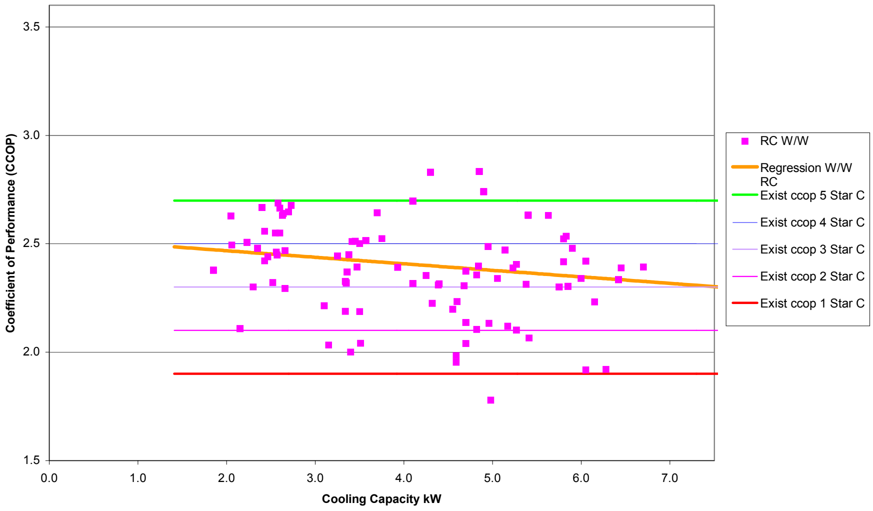
Interestingly, the slope of all types is of the order of -3% to -4% (ie the efficiency declines as the size increases). The traditional explanation for this has been that size constraints in the unit's casing or housing (particularly for window wall units) have limited the size of condensers and evaporators; therefore for larger capacities the efficiency reductions resulting from undersized condensers and evaporators have overwhelmed any increases in compressor COP with size.

However, the largest size related decline in efficiency appears to be occurring in split systems, which tend to have less constraints in this respect. The explanation for this is likely to be the international flow on effects of the recently introduced stringent efficiency target values in Japan (where split systems dominate) - these mandate significantly higher COPs for smaller sized models (although the results are not strictly comparable because of difference in the test procedure - Japan uses seasonal and part load ratings in their calculations).

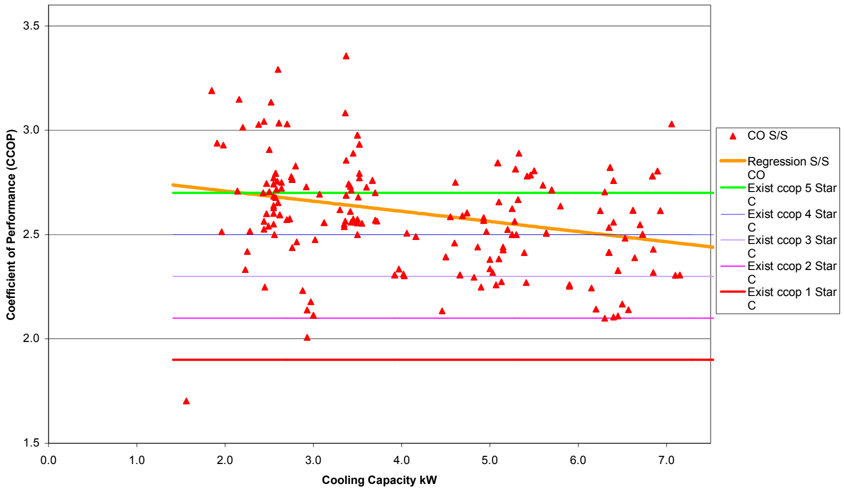
The regression for each of the air conditioner types is shown in the following figures.



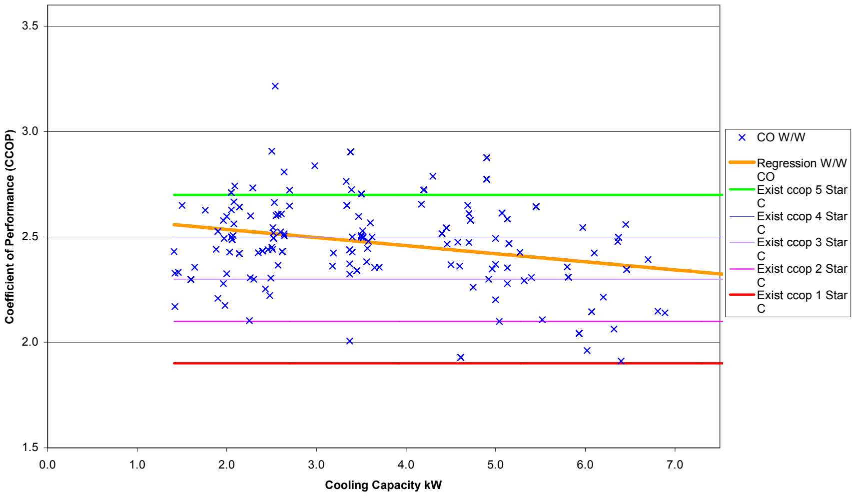
Current Reverse Cycle Windown Wall Models cooling mode + current stars

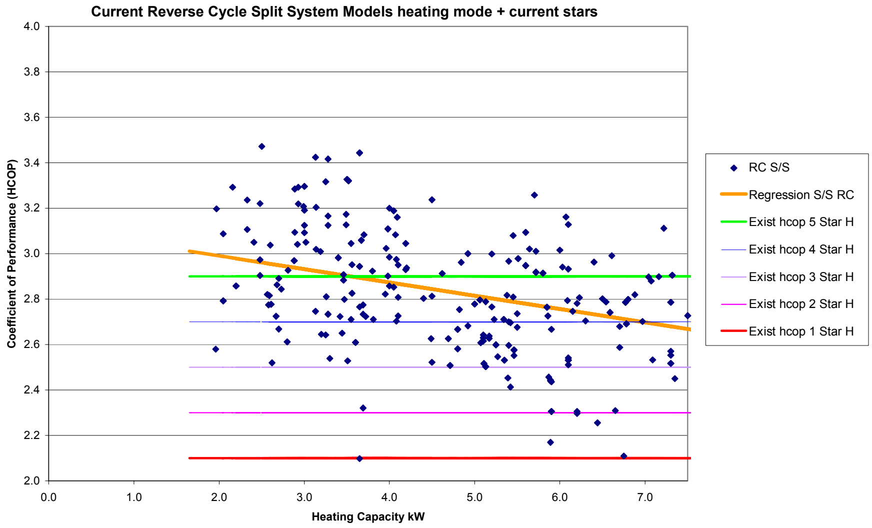


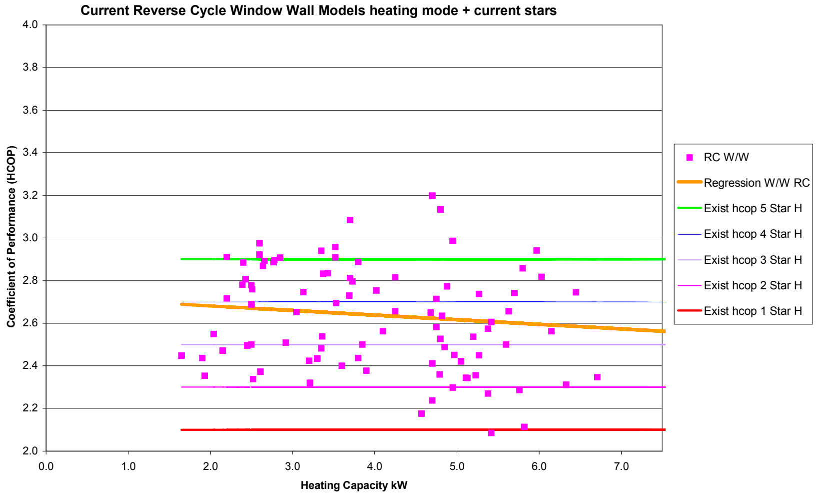
Current Cooling Only Split System Models cooling mode + current stars



Current Cooling Only Windown Wall Models cooling mode + current stars







As shown in the above regressions, size bias for air conditioners is opposite to that for most other appliances (where there tends to be an increase in apparent efficiency with increasing size). Given that there is not likely to be a strong technological reason for decreasing efficiency with increasing size for air conditioners, it is proposed to retain the existing system of constant energy efficiency thresholds for all sized units (ie star rating bands will continue to pass through the origin on a kW/kW basis).

In reviewing the star rating algorithm for products, the Energy Labelling Review Committee provided working groups with some general guidelines:

- new star ratings should be a geometric progression
- best products currently on the market should not generally exceed 4 stars
- 5 star should be set as difficult but achievable in the next 5 years
- worst products on the market (or MEPS level where applicable) should generally be around 1 star
- star rating to be shown in half stars on the new label
- elimination of size bias where this is significant

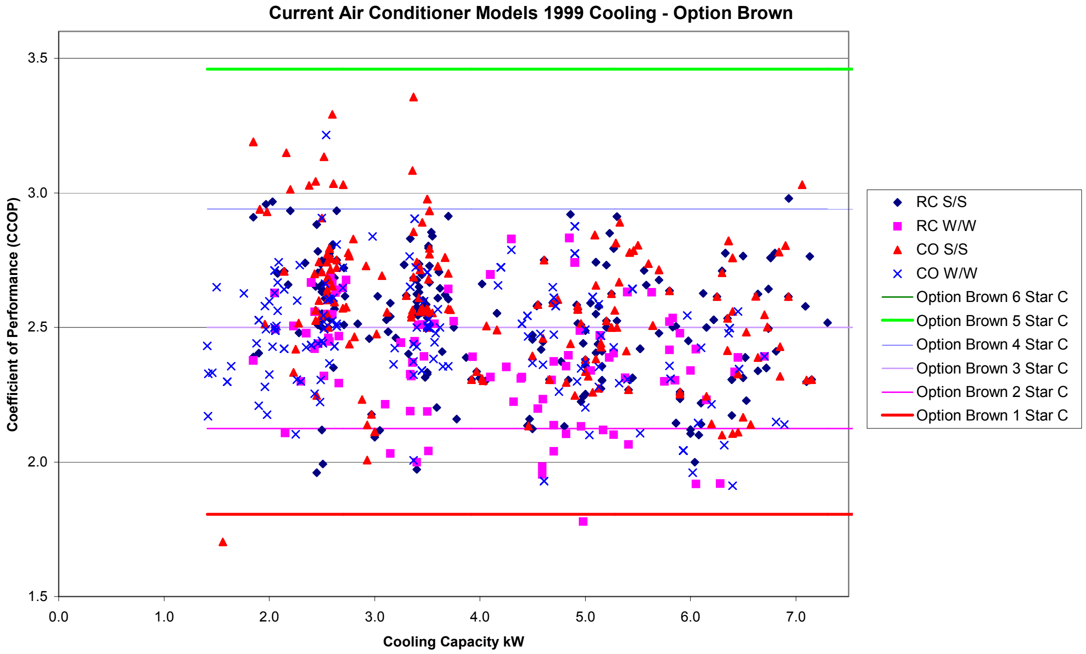
Cooling Options

In his review of the energy labelling program during 1997, Brown (1998) analysed the current market for air conditioners. He suggested that the following equation as a possible new algorithm for energy rating of air conditioners:

$$1 \text{ star} = \quad CCOP \geq 1.806$$

with a 17.6% increase in CCOP per additional star (he notes that this equates to a 15% decrease in energy per star).

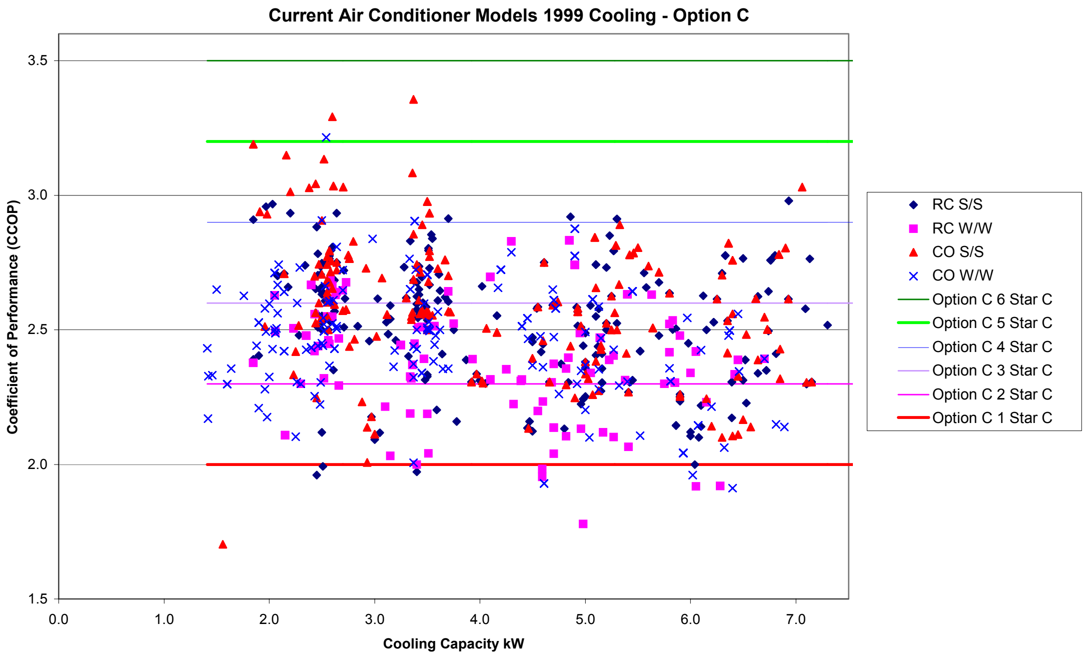
This option is titled Brown and is shown in the following figure.



The option proposed by Brown meets the broad criteria set out by the energy labelling review committee. However, due to the nature of the geometric progression, the CCOP steps increase in size for each additional star. This means that the lower star rating bands are more narrow than the higher star rating bands (in terms of CCOP).

Given that the CCOP is a reasonable measure of energy efficiency for air conditioners and it is unlikely that increases in energy efficiency become easier to achieve at higher overall efficiency levels, it is proposed to retain the existing system of even sized CCOP steps between star rating levels. If this were adopted, this means that the rating system is geometric, but that the energy reduction per star declines as efficiency increases. While this means that the star rating system is slightly different in approach to other products, this should not be terribly problematic.

EES developed a number of rating options for air conditioners for evenly spaced CCOP steps for each star for further consideration by the working group. The most promising system is shown as Option C in the following figure.



The equation for Option C is as follows:

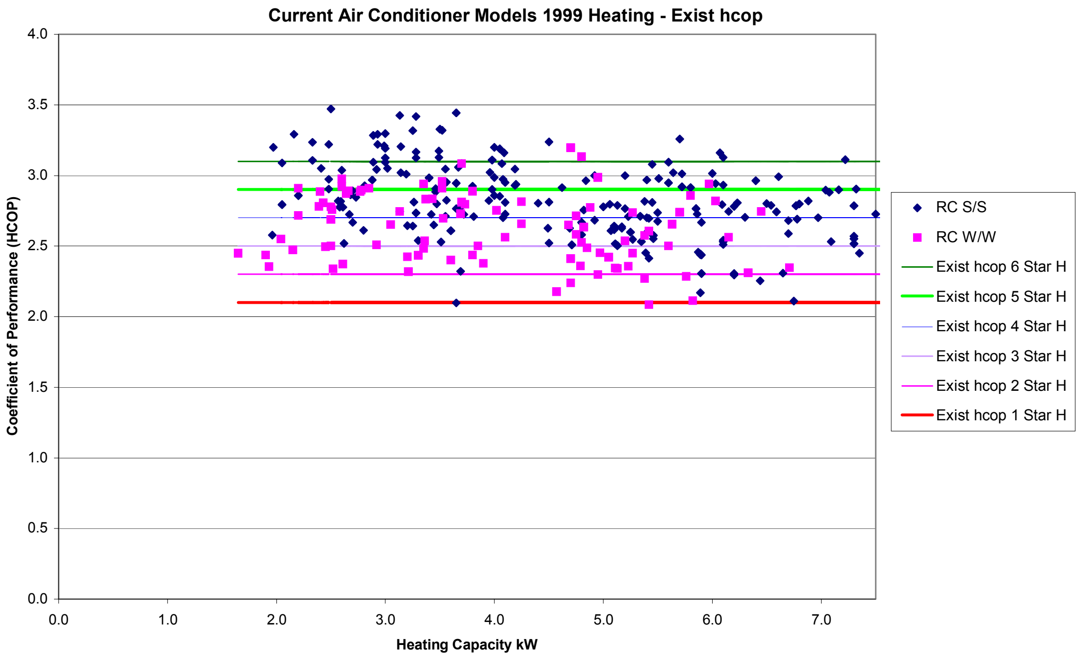
Star Rating Index = CCOP × 3.333 - 5.666

While Option C has a couple of units which rate more than 5 stars, these are very few in number as shown in the following table.

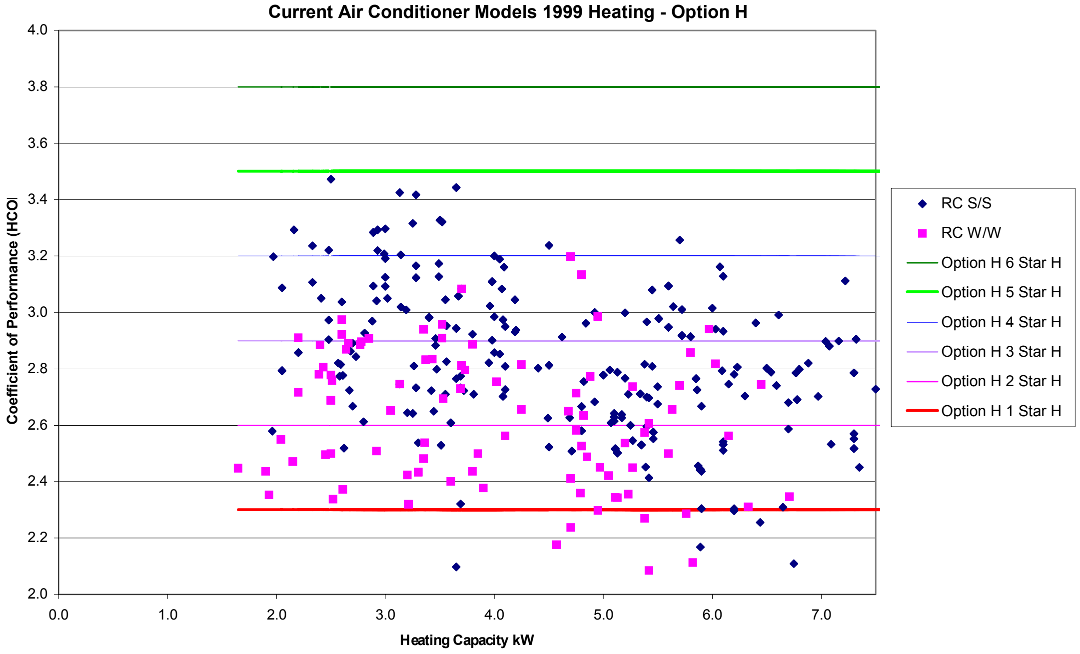
Star Rating Option C	Models	% Models
1 star	64	8.0%
1.5 star	56	7.0%
2 star	189	23.7%
2.5 star	195	24.5%
3 star	168	21.1%
3.5 star	86	10.8%
4 star	30	3.8%
4.5 star	5	0.6%
5 star	2	0.3%
5.5 star	1	0.1%
6 star	0	0.0%
Total	796	100.0%

Heating Options

The current star rating system for heating for reverse cycle models is shown in the following figure. While a number of models rate only 1 star, there are now numerous models which rate 6 stars, particularly split systems.



Brown (1998) did not outline any proposals for heating star ratings for air conditioners. Adopting the same general principles, EES developed Option H for heating mode for consideration by the working group. This is shown in the following figure.



The equation for Option H is as follows:

Star Rating Index = HCOP × 3.333 - 6.666

Under Option H, the best models are 4.5 stars for heating. There are also a number of models of less than 1 star, but this is not a problem.

Star Rating Option H	**Models**	**% Models**
1 star	51	13.2%
1.5 star	57	14.7%
2 star	72	18.6%
2.5 star	80	20.7%
3 star	70	18.1%
3.5 star	35	9.0%
4 star	17	4.4%
4.5 star	5	1.3%
5 star	0	0.0%
5.5 star	0	0.0%
6 star	0	0.0%
Total	387	100.0%

The 6 star threshold is set a difficult but possibly achievable CCOP of 3.8. Proposed Options C & H are summarised in the following table.

Proposed Star Rating	**CCOP Option C**	**HCOP Option H**
1 Star	< 2.15	< 2.45
1.5 Star	<2.3	< 2.6
2 Star	< 2.45	< 2.75
2.5 Star	< 2.6	< 2.9
3 Star	< 2.75	< 3.05
3.5 Star	< 2.9	< 3.2
4 Star	< 3.15	< 3.35
4.5 Star	< 3.2	< 3.5
5 Star	< 3.35	< 3.65
5.5 Star	< 3.5	< 3.8
6 Star	> 3.5	> 3.8

Note: Half stars will be shown

International Issues

It is useful to examine MEPS for air conditioners in other countries. The USA and Canada set MEPS levels for room air conditioners (cooling mode only). The USA and Canada also set MEPS levels for packaged terminal air conditioners (split systems in our terminology) for both heating and cooling modes. MEPS are also set for various other technologies such as central air conditioners, large air conditioners, various ground and water source heat pumps and water loop heat pumps, but these are not relevant to this paper.

The USA and Canadian MEPS levels for room air conditioners for cooling modes only are set out in the following table (not these values have been converted from empirical units).

US and Canadian MEPS levels for Room Air Conditioners (cooling mode)

Type	from kW	to kW	Min CCOP
CO with louvres	0.00	1.76	2.34
CO with louvres	1.76	2.34	2.49
CO with louvres	2.34	4.10	2.64
CO with louvres	4.10	5.86	2.58
CO with louvres	5.86	8.79	2.40
CO without louvres	0.00	1.76	2.34
CO without louvres	1.76	2.34	2.49
CO without louvres	2.34	4.10	2.49
CO without louvres	4.10	5.86	2.49
CO without louvres	5.86	8.79	2.40
RC with louvres	all		2.49
RC without louvres	all		2.34

Notes: With louvres are window mounted, without are wall mounted
Reverse cycle limits are applicable only to USA.
All values are for cooling modes. Note US values in Btu/h/W

Packaged terminal air conditioner (split system) MEPS levels in USA are as follows:

Min EER = 10 - 0.00016 × CAP

EER in Btu/h/W
CAP in Btu/h

Where capacity is less than 7000 Btu/h (2.05 kW), min EER is 8.88 (CCOP = 2.6)
Where capacity is more than 15000 Btu/h (4.39 kW), min EER is 7.6 (CCOP = 2.23)

Min COP = 1.3 + 0.16 × Min EER

For example, a 10000 Btu/h air conditioner (2.93 kW) has a minimum EER of 8.4 (CCOP = 2.46) for cooling and a minimum COP of 2.64 for heating. For cooling, the requirements are broadly similar to those for room air conditioners.

Packaged terminal air conditioner (split system) MEPS levels in Canada are as follows:

Min EER = 9.115 - 0.0000638 × CAP

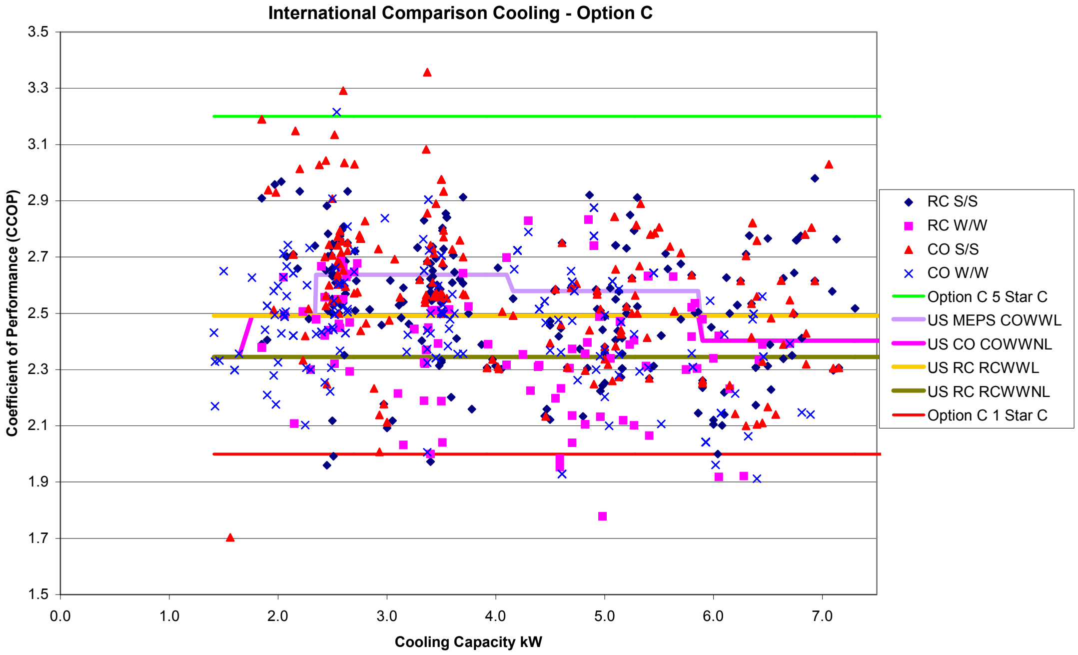
EER in Btu/h/W
CAP in Btu/h

Min COP = 2.75 - 0.00001 × CAP

COP in W/W
CAP in Btu/h

Similarly, a 10000 Btu/h air conditioner (2.93 kW) has a minimum EER of 8.48 (CCOP = 2.48) for cooling and a minimum COP of 2.65 for heating (which is almost the same as the US requirements).

The USA MEPS levels for room air conditioners for cooling mode, together with Option C, are shown in the following figure. Most of these levels are between a star rating of 2 and 3 under Option C.



MEPS levels for air conditioners are also set in Korea and stringent target efficiencies have recently been set in Japan. However, direct comparisons with these values are not possible because the test procedure is significantly different (part load tests are also incorporated into the rating system). Philippines also set MEPS levels for air conditioners, but these are somewhat weaker than USA/Canada levels.

The only other significant issue for consideration by the working group is water cooled condenser units. A number of these are on the market in Europe (possibly mainly targeted at the small commercial sector) and appear to be able to achieve significantly higher cooling efficiencies in comparison with air cooled units (CCOP up to 5 for some models - however the impact of the test procedure on CCOP for this type is unknown). These type of units do not appear to be on the Australian market in any significant numbers at this stage and it is unclear whether they will appear in the near future.

Part Load Operation

Air conditioners are rated under full load conditions. Air conditioners typically only spend a small proportion of their normal operating hours at rated capacity. This issue is discussed in some detail in Appendix A.

The Energy Labelling Review Committee considered the issue and agreed that the part load issue needs to be addressed in some form, although this will be difficult in the short term. Ideally the test procedure should be used to calibrate a computer model, but even where this had been developed, it is still unclear how the additional information could be used in an energy labelling context. Work under way for AGO at UNSW as part of a package air conditioner study is exploring modelling options in more detail.

Highlighting Capacity on the Energy Label

Heating and cooling capacity are key variables of concern to consumers. Although the capacities are currently shown on the label, they are in small print. The Energy Labelling Review Committee decided that different formats for displaying capacity should be trialed through focus groups.

Standby Power Consumption

A large number of appliance models now on the market have electronic controls and switches and many of these require a small but constant power consumption, even when the unit is nominally “off”. This is particularly applicable to air conditioners that have remote controls or timer functions which require small but continuous amounts of power. This energy consumption can be significant (of the order of 20 to 100 kWh per year). The wet products working group agreed in principle to incorporate standby power consumption into the test procedure for wet products as soon as is practicable. It is also recommended that a similar (and coordinated) approach be undertaken for air conditioners.

In practical terms this means:
- defining the possible power consumption states whilst the unit is not in operation (these could include: “off”, on or standby, delay start power consumption, other intermediate states such as powering down to off);
- defining the instrument accuracy requirements for the measurement of energy consumption in these states (noting that power consumption may be less than 1 Watt in many cases and that the current waveforms may be very non-sinusoidal - high speed electronic power integration methods would be required to accurately measure power and energy in these cases);
- estimation of typical hours of operation;
- the composition of the standby power states which would be typical when the appliance is not in use (implying some base usage pattern would be required).

In terms of procedures and instrumentation required for the measurement of standby power consumption, there is a range of work being undertaken on the measurement of standby power consumption of office equipment by IEC TC74 working group 9. They will specifically consider measurements for low power states with poor harmonics. It is recommended that the work and proposals of this group be followed and incorporated into the wet product test procedures as appropriate.

References

10CFR430, *US Code of Federal Regulations - Energy Conservation Programs for Consumer Products*, US Department of Energy, 1 January 1998.

16CFR305, *US Code of Federal Regulations - Energy Labelling Requirements for Consumer Products*, US Federal Trade Commission, 1 January 1998.

Brown 1998, *Energy Labelling Review - Options for Improvement of Labels*, R.A Brown & Associates, Torrens Park, January 1998.

NRC 1999, *Guide to Canada's Energy Efficiency Regulations*, Natural Resources Canada.

Appendix A - Support Documentation - Air Conditioners

Note that the decisions of the Energy Labelling Review Committee are shown in blue text after each issue. These are extracted from the minutes of the meeting in April 1998.

New Test Procedure

Issue: A new air conditioner standard based on ISO5151 has been published (AS/NZS 3823-1998).

Discussion on the Issue: The new AS/NZS standard is a "clone" of the ISO standard, with a number of minor amendments for clarification. Most of these changes are being incorporated into the next version of the ISO standard in any case.

There are a number of differences between the new ISO clone and AS1861.1 (old test procedure for energy labelling in Australia), mainly with respect to definition of tolerances and test duration which are of minor consequence. For cooling, the new test procedure is essentially identical with the old AS1861.1. For heating, there are some differences with respect to dealing with frosting conditions (ie where the outdoor unit either enters a defrost mode or where ice accumulates). The ISO clone requires indoor temperatures to be maintained at 20°C under all conditions, even where frost or defrost action occurs. AS1861.1 requires the indoor temperature be 21°C under non-frosting conditions. Where defrost action or frost occurs, the indoor temperature is raised until this stops (as per old ISO859). For some models the difference in capacity and energy may be significant, but this has not yet been quantified. The ISO test condition is more reflective of consumer behaviour, so is preferred for energy labelling purposes. The committee should not have to consider this issue in any detail.

Data Sources: A pre-publication draft of the new AS/NZS standard Parts 1 & 2 should be available shortly. See Brown (1998) Section 7.1 (page 39) for a brief overview.

Energy Labelling Review Committee Decision: New ISO standard - accepted that new test procedure is adequate. Agreed that multi split clone should be adopted as soon as possible. Representations should be made to ISO to get that standard moving. If there is an inordinate delay in the publication of ISO15042 then consideration should be given to publishing the draft as a national standard (harmonised with ISO5151).

Scope of Energy Labelling for Air Conditioners

Issue: Current regulations nominally apply to all air conditioners under 7.5 kW cooling capacity. It is proposed to clarify the scope of energy labelling to eliminate certain types of units.

Discussion on the Issue: The new AS/NZS test procedure (ISO clone) only applies to non-ducted air conditioners with a single refrigeration circuit. This means that it will not be possible to test multi-split or ducted models when the standards are republished. The scope of Part 2 (energy labelling requirements) has been modified to exclude these types for the time being. Few ducted systems under 7.5 kW cooling capacity are on the market in any case. Multi-split systems can be included once ISO publish a multi-split test procedure which we can clone as AS/NZS. A committee draft for multi-splits (ISO CD 15042-1) has been circulated and should proceed once the current revisions of ISO5151 (non-ducted) and ISO13253 (ducted) are complete.

It should be noted that there is government interest in energy labelling for all air conditioners up to 20 kW under the commercial and industrial equipment efficiency program. Any changes to the energy label should also bear in mind requirements for this sector. An ISO clone for ducted models could be prepared in a short time frame if necessary for use within this program. Note that ISO are currently considering an Australian request that ISO5151 and ISO13253 be merged into a single standard.

Data Sources: AS/NZS 3823 Parts 1 & 2. See Brown (1998) Sections 7.2 and 7.3 (page 39) for a brief overview. Copies of the various ISO standards are available on request.

Energy Labelling Review Committee Decision: Scope of labelling - it was noted that the scope of Part 2 now excludes ducted and multi-split. Multi-split should be re-included once a part 1 standard is available (see 2.1). Chair noted that there was a study on the possible introduction of MEPS for commercial and industrial equipment which covered packaged air conditioners. It was recommended that if labelling is to be extended to 12kW units that this should be done through this committee. There is a need to clarify whether the scope of the regulations for ACs will be altered so that this is specified in the standard (regulations will only pick up issues not covered by standard). It was noted that the ducted spot coolers and mobile splits are covered by the new standard.

Improved Repeatability of Test Method

Issue: A round robin of air conditioner test laboratories showed some significant differences in measured capacity and energy consumption. The test procedure needs to be highly reproducible if energy labelling requirements are to be enforceable.

Discussion on the Issue: This issue is being treated as a high priority by NAEEEC and a major comparative test program between UNSW and Uni of SA is currently under way. There is ongoing liaison with EL15/16 (air conditioners) as necessary.

Data Sources: There are no additional data sources for this issue.

Energy Labelling Review Committee Decision: Repeatability - labs are basically adequate but there is ongoing work to improve repeatability and reproducibility. Requests from industry for assurances that NAEEEC will review the adequacy of laboratories for ACs. It was noted that NAEEEC had a substantial inter-laboratory test program for air conditioners under way.

Provision of Latent and Sensible Cooling Data

Issue: The cooling effect of an air conditioner is the result of both lower air temperatures (sensible cooling) and reduced humidity (latent cooling). In dryer climates, there is likely to be little benefit from latent cooling. In more humid areas, the requirements are less clear.

Discussion on the Issue: The energy label currently shows total cooling capacity (in kW), which is the sum of both sensible and latent cooling capacities. In dry climates where humidity is low, there is likely to be little benefit from the latent component (moisture removal). In humid climates, moisture removal can increase comfort levels and can result in a higher dry bulb temperature being acceptable when the inside humidity is low. However, feedback from Queensland (hot and humid climate) has indicated that the most important factor is probably still sensible capacity, which results in reduced temperature of the air. Many houses in Queensland have high ceilings and it appears that a large airflow (which maximises sensible cooling) is an important factor. While some latent cooling capacity is required, indoor humidity is generally not a problem and almost all units will exceed the minimum latent cooling requirements to control humidity (in a sealed room with limited humidity sources).

Data on latent and sensible cooling is available both through test reports and via product literature. However, latent cooling data in product literature is generally provided in terms of moisture removal per hour (generally in kg or litres per hour). Moisture removal can be converted to latent cooling capacity by multiplying by 683 to get Watts cooling, but this is not generally known by consumers. In any case, the raw data is of little direct benefit for consumers.

If sensible capacity is the most critical value for households in both dry and humid climates (as initial data suggests), there may be a case for revising the energy label star rating to be based on sensible capacity or placing some limits on the latent capacity that can be included in the calculation of the star rating.

A related question is whether better advice can be provided for purchasers of air conditioners. It seems fairly clear that such advice is not suitable for inclusion on the energy label. However, consideration could be given to other mechanisms for delivery of such information. Possible options may include brochures and information on the energy labelling web site. Types of guidelines that could be considered are:

- for dry climates: size systems primarily on the basis of sensible cooling capacity as there may little latent cooling capacity available under dry indoor conditions;
- for humid climates: ensure that the sensible cooling capacity is sufficient for your requirements (as a guide - sensible heat ratio >80%);
- for humid climates: the moisture removal effect is increased when the fan speed is set at on slower speed.

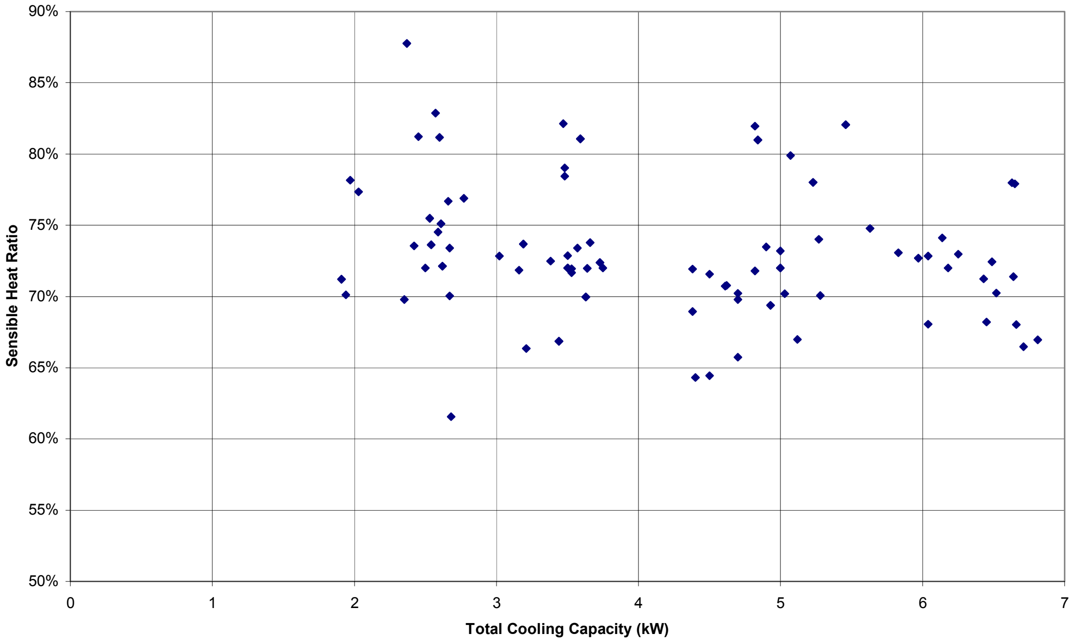
Such brochures or advice can be tailored for local climatic requirements.

If sensible and latent data is to be presented, this should be based on rated values, as the rated total cooling capacity is the value that is shown on the energy label.

Data Sources: Brown (1998) discusses the issue in Section 7.4 (page 40). Brown suggests that total capacity continue to be used for energy labelling and that sensible cooling not be added to the label. However, the action to be taken in response to this issue should be reviewed by the committee.

Sensible heat ratio is defined as the ratio of sensible cooling to total cooling. A lower sensible heat ratio implies a higher proportion of dehumidifying performance. Data from 100 energy labelling registrations (circa 1993) have been analysed to show the range of sensible heat ratios on the market. These are shown in Figure 1. As can be seen, there is considerable variation for all cooling capacities. The Queensland argument is that units with a sensible heat ratio of lower than about 80% will have a sensible capacity which is inadequate if total capacity is used to size the units.

Figure 1: Sensible Heat Ratio for 100 Air Conditioner Registrations



Source: NSW air conditioner register.

Consumers and advisers in Queensland and manufacturers should be further consulted regarding suitable advice for humid climates.

Energy Labelling Review Committee Decision: Sensible vs latent cooling capacity - it was noted that the issue of sensible and latent cooling is a complex one. There was general agreement that the rating should be based on total capacity. However, the sensible capacity could be included in brochures. It was agreed to include sensible capacity in kW in small print on the label.

Determination of Air Conditioner CEC

Issue: The Comparative Energy Consumption (CEC) for air conditioners is based on 500 hours for heating and 500 hours for cooling. The actual use of air conditioners varies considerably in different climate regions. One thing is clear - actual use is almost never 500 hours.

Discussion on the Issue: The use of air conditioners is dependent on a range of factors including climate, daily temperature profiles and building shell performance. Given the huge variation in climates around Australia, it would seem impossible to put onto an energy label a figure which is representative of annual energy consumption for air conditioners.

It is unclear how the 500 hours currently in use was derived. However, changing the label energy to input power during operation (kW or Watts) has a number of supporters. If this was to be undertaken, it would be important to provide guidance to consumers regarding the expected range of use in different regions. The best delivery mechanism for this data may be through local state based brochures.

A related issue is that air conditioners in normal use tend to operate at rated capacity for only part of their total operating time.

Data Sources: Brown (1998) discusses the issue in some detail in Section 7.5 (pages 40 to 43). Pacific Power (1996) provides directly metered energy consumption for both heating and cooling air conditioners for one year in 1993/94. It is expected that hours of operation will be available from the raw data, but it is unclear whether additional data on each appliance monitored will be available as well. Note that the Pacific Power data is for NSW households only.

ABS 8218.0 (1988) collected diary data from 19,331 households over the period from 17 June 1995 until July 1996. A new group of about 750 households collected one week's diary data commencing at the start of each fortnight over the period, so that usage patterns for the whole year were covered. A summary of the data is shown in Table 1 to Table 3.

Table 1: Air Conditioner Penetration by State

State	**Households '000**	**Own AC '000**	**Penetration**
NSW	1744.5	538.2	30.9%
Victoria	1300.2	524.7	40.4%
Queensland	811.1	141.7	17.5%
SA	475.1	295.5	62.2%
WA	462.6	179.2	38.7%
Tasmania	145.1	0.7	0.5%
NT	26.7	15.5	58.1%
ACT	78.8	23.8	30.2%
Australia	**5044.1**	**1719.3**	**34.1%**

Source: ABS8218.0-1988, see also EES (1998) for more recent data and ownership estimates.

Table 2: Proportion of all air conditioners used on at least one day in seven

State	Spring	Summer	Autumn
NSW	5.1%	54.3%	20.2%
Victoria	9.6%	40.3%	15.0%
Queensland	26.6%	63.0%	29.2%
SA	10.2%	45.9%	18.5%
WA	14.2%	55.5%	9.8%
Tasmania	0.0%	50.0%	0.0%
NT	90.4%	91.7%	58.3%
ACT	6.0%	32.1%	3.3%
Australia	10.9%	49.7%	18.0%

Source: Table 17, ABS8218.0-1988. Winter use was recorded as essentially zero.

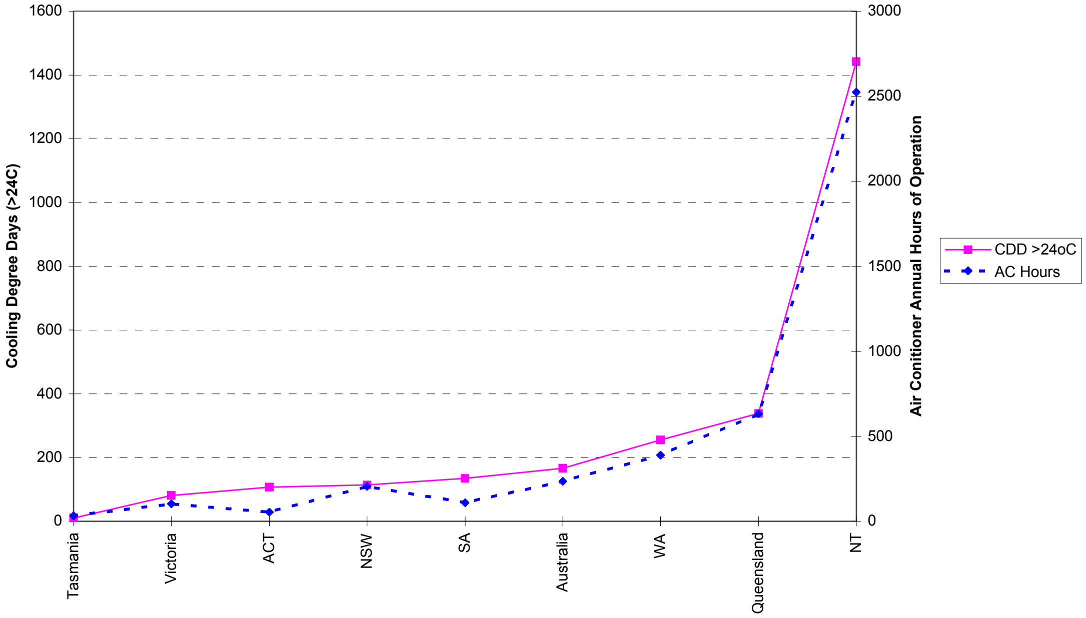
Table 3: Annual air conditioner use by state during 1985/86

State	Annual Average Use (Hours)
NSW	206
Victoria	102
Queensland	632
SA	108
WA	389
Tasmania **	33
NT	2525
ACT **	53
Australia	235

Source: Table 17, ABS8218.0-1988. Assumes 13 weeks per season.
Note**: Values for Tasmania and ACT are estimates only due to small sample size.

Actual hours of air conditioner operation by state and cooling degree days (based on degree hours over 24^{o}C in capital cities only) are shown in Figure 2. On a weighted basis, it would appear that use of air conditioners are on average 1.4 hours per cooling degree day (based on a threshold of 24^{o}C), with a range typically from 0.8 in South Australia (dry) to 1.9 in Queensland and Northern Territory (humid). Data for Tasmania and ACT are suspect due to the small sample size in the ABS survey. There is no data on the load level during these hours of operation (ie full or part load).

Figure 2: Hours of AC Operation and Cooling Degree Days by State for 1985/86



Source: Table 17, ABS8218.0-1988 and EES (1998).
Note: CDD based on capital cities only, hours are for the whole state.

Long term heating and cooling degree data by capital city (EES 1998) for 27 years from 1970 to 1996 is shown in Table 4. Other values are available in CSIRO (1980).

Table 4: Heating and Cooling Degree Days for Australian Capital Cities (1970 to 1996)

City	HDD <18°C	HDD <15°C	HDD <12°C	CDD >24°C
Brisbane	445	199	72	279
Sydney	641	273	84	102
Canberra	2272	1522	930	118
Melbourne	1283	658	255	114
Hobart	1867	1092	519	25
Adelaide	1153	585	230	177
Perth	819	391	147	308
Darwin	3	0	0	1371

Source: EES 1998

Energy Labelling Review Committee Decision: CEC - Agreed to put kW on the label. Put local advice regarding expected hours of use for various houses. Advisory information for each region to be developed.

Bunching of Star Ratings

Issue: Star ratings are starting to bunch around 5 and 6 under the current algorithms.

Discussion on the Issue: The coefficient of performance is used to determine star ratings for air conditioners. It would be a straight forward task to revise the air conditioner algorithm to provide a greater spread of the models on the market.

Consideration should also be given to introduction of a geometric progression instead of a linear progression.

Data Sources: The main data source is the energy and capacity characteristics on the market at present, which is available from the energy labelling register. These are shown in the energy labelling brochures (copy attached). An electronic copy is of course available for further analysis.

Energy Labelling Review Committee Decision: Bunching of star ratings - proposal from Brown was considered. Median COP line runs through the origin (which indicates minimal size bias). Need to consider all product groups such as reverse cycle, cooling only, split and WWs. Convene an algorithm WG out of session to prepare a paper which canvasses various option of AC labelling. This paper should be circulated to EL15/16 for their input prior to submission to the Review Committee.

Part Load Operation

Issue: Air conditioners are rated under full load conditions. Air conditioners typically only spend a small proportion of their normal operating hours at rated capacity. For those units with a single speed compressor, the nominal efficiency at part load will be similar to full load as the compressor cycles on and off with the thermostat. However, for multi-speed compressors or those which use a variable speed drive (eg inverter systems), the apparent efficiency will increase substantially under part load conditions.

Discussion on the Issue: This issue is really only a serious concern for models with multi-speed compressors, variable output compressors or those with variable speed drives (most commonly inverter based systems). Inverter systems now dominate the market in Japan and they are now appearing on the Australian market as well.

For a standard single speed compressor, the overall efficiency remains fairly stable at part load (typically a slight decline in efficiency) because the thermostat is essentially making the compressor run for short periods at rated capacity. For variable speed compressors, as the cooling load declines, the compressor output also declines to the level required (the unit does not cycle like a single speed compressor) and the efficiency of the unit starts to climb, because although the condenser and evaporator size remains constant, the relatively smaller compressor output increases the overall system efficiency (air conditioner efficiency is broadly proportional to the ratio of the evaporator/condenser area to the compressor output).

Although this is a real issue for multi-speed compressors, there are two serious problems at the moment. Firstly there is no adequate test procedure which defines the performance at part load (apart from multiple direct measurements) and secondly there is virtually no data on how air conditioners are used in real households, so even where there was a method to determine performance under part load conditions, it is unclear how this could be implemented through an energy label.

A step forward will be to develop a test procedure which can characterise the air conditioner under a wide range of conditioners (a simulation model which can be calibrated with a few physical tests). The issue of part load testing has been raised with ISO, but a clear direction is yet to emerge. Note the Japan and USA have part load testing procedures, but these are extremely involved and prescriptive and are not recommended for use in Australia at this stage. A number of computer models are currently available which could be used to form the basis of a new test procedure, but there is still a good deal of development work to be done.

Data Sources: Brown (1998) discusses the issue in some detail in Section 7.7 (page 45). Pacific Power (1996) provides directly metered energy consumption for both heating and cooling air conditioners for one year in 1993/94. It is expected that hours of operation and the power used during operation will be available from the raw data, but it is unclear whether data on each appliance monitored will be available as well. Note that the Pacific Power data is for NSW households only.

Energy Labelling Review Committee Decision: Part load operation - Robert Wooley argued that the part load issue needs to be addressed as manufacturers are saying that the label is not accurate so there is a credibility problem (label is being undermined in the marketplace). It was acknowledged that this issue needs to be addressed. Ideally the test procedure should be used to calibrate a computer model, but even where this had been developed, it is still unclear how the additional information could be used in an energy labelling context. The air conditioner working group should prepare a brief to for a consultant to examine the issues regarding the preparation of a test procedure that will take account of part load operation of air conditioners particularly inverter based units.

Highlighting Capacity on the Energy Label

Issue: Heating and cooling capacity are key variables of concern to consumers. Although the capacities are currently shown on the label, they are in small print.

Discussion on the Issue: Consideration should be given to highlighting capacity on the energy label. If recommended, this should be tested on consumers.

Data Sources: The international review of energy labelling provides examples of air conditioner labels for consideration.

Energy Labelling Review Committee Decision: Highlighting capacity - different formats for displaying capacity should be trialed through focus groups (especially the addition of sensible capacity).

Appendix 6: Air conditioners – algorithm recommendations

Air Conditioner Algorithm Working Group

Summary of Recommendations - May 1999

7 May 1999

The following draft recommendations have been prepared by the Air Conditioner Algorithm Working Group following their meeting on 6 May 1999. Some of these are subject to further comment by working group members until 21 May 1999.

Summary of Key Recommendations

Test Procedure

The Working Group agreed that AS/NZS 3823 Part 1.1 is adequate as a test procedure for the time being.

Scope of Energy Labelling for Air Conditioners

The Working Group made the following recommendation with respect to the scope of the Part 2 standard:

- Energy labelling should be changed from non-ducted 7.5kW cooling capacity to single phase non-ducted. The scope would remain applicable only to refrigerative systems intended for household or similar use. This change would effectively capture household systems up to around 10kW to 12kW cooling. This change to the scope should occur two years after the date of publication of the standard (nominally early 2002).
- The Working Group had no recommendation for air conditioner MEPS in the range 7.5kW to 12kW, but felt that the change with respect to the scope of labelling above should be communicated to the group examining packaged air conditioner MEPS.
- The Working Group had no recommendation on whether to include ducted systems at this stage.
- The Working Group agreed that ISO should be encouraged to progress multi-split test procedure (ISO15042) and the inclusion of these types in the scope of labelling should be revised when this test procedure is available.

Provision of Latent and Sensible Cooling Data

While it was acknowledged that sensible and latent cooling data could be useful in some cases (with additional supporting information for specific situations and climates) it was recommended that this data ***not*** be included on the energy label. It was recommended that sensible and latent cooling capacity be included on the Internet site with supporting information. No recommendation was made whether to include latent and sensible cooling data on the labelling brochures at this stage.

Determination of Air Conditioner CEC

It was recommended that the label CEC should show rated input power in kW to 2 decimal place so that the units are consistent with cooling and heating capacity.

Bunching of Star Ratings

Revised algorithms in the same format as the existing star rating system were recommended by the Working Group:

For cooling, Option C is recommended as follows:

$$\text{Star Rating Index} = [\,EER \times 10 - 17\,] \div 3$$

For heating, Option H is recommended as follows:

$$\text{Star Rating Index} = [\,COP \times 10 - 20\,] \div 3$$

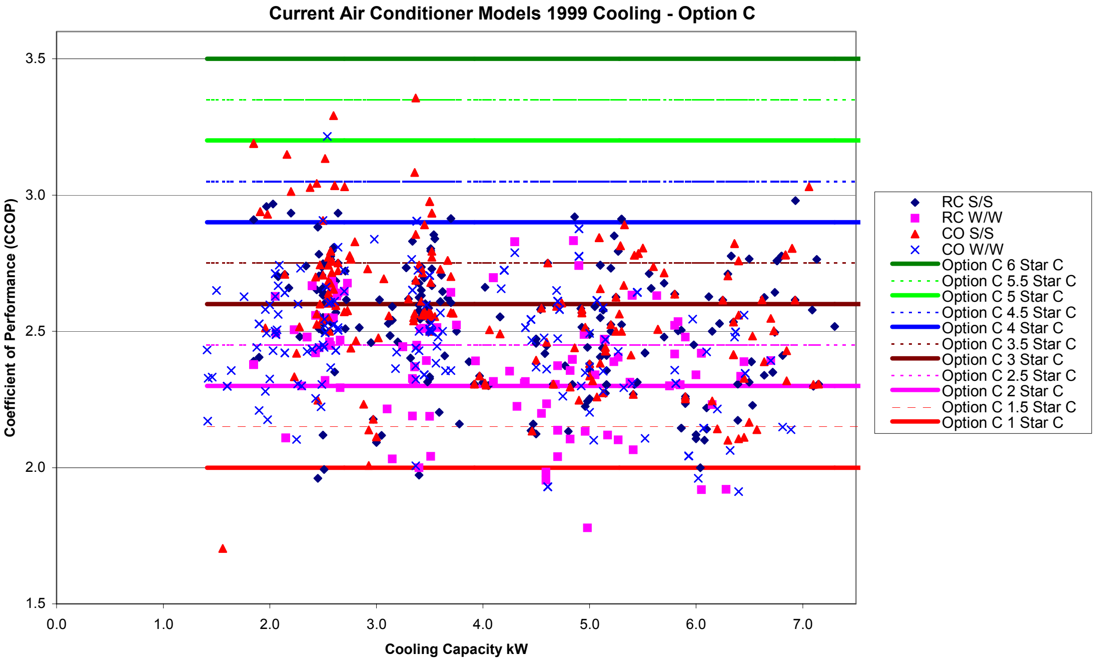
Where:
EER is the energy efficiency rating (cooling) as determined under AS/NZS 3823.1.1
COP is the coefficient of performance (heating) as determined under AS/NZS 3823.1.1
Star rating index is the decimal value of the star rating (called EEV in AS/NZS 3823.2-1998)

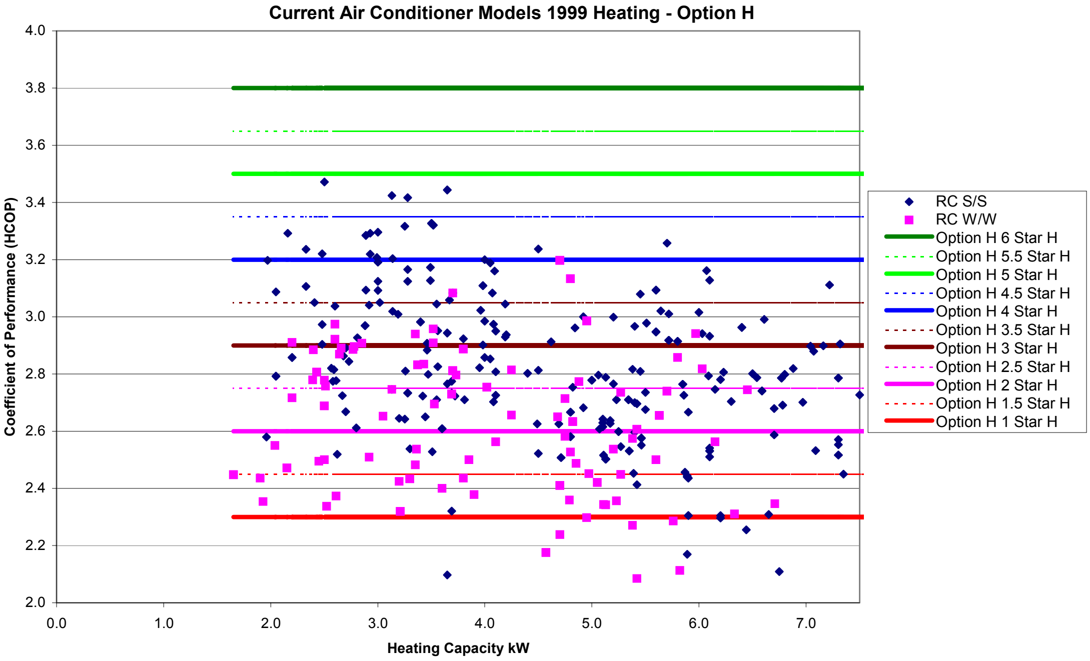
The star rating values for various EERs and COPs are summarised in the following table.

Proposed Star Rating	**EER Option C**	**COP Option H**
1 Star	< 2.15	< 2.45
1.5 Star	<2.3	< 2.6
2 Star	< 2.45	< 2.75
2.5 Star	< 2.6	< 2.9
3 Star	< 2.75	< 3.05
3.5 Star	< 2.9	< 3.2
4 Star	< 3.05	< 3.35
4.5 Star	< 3.2	< 3.5
5 Star	< 3.35	< 3.65
5.5 Star	< 3.5	< 3.8
6 Star	> 3.5	> 3.8

The proposal meets the broad criteria set out by the Energy Labelling Review Committee.

Options C and H are shown in the following figures.





Part Load Operation

The Air Conditioner Algorithm Working Group noted that the issue of part load operation for inverter units is critical. The Working Group recommended that work in this area should be accelerated, although it was noted that government is unlikely to be the main initiator of this work. It was felt that industry need to make representations through the standards committee to drive this process. It was noted that computer modelling work under way at the University of NSW may provide some options with respect to deal with part load operation in a systematic manner.

Highlighting Capacity on the Energy Label

The Working Group agreed that the capacity needs to be highlighted on the energy label, but that details should be completed by the energy label design group.

Standby Power Consumption

The Working Group agreed to refer the issue of measurement of standby energy consumption to EL15/16. It was noted that an EL15 subcommittee may prepare general recommendations for inclusion into all applicable EL15 standards or there may be a separate standard on the measurement of standby energy consumption. Once a methodology to measure standby has been developed, policy options to address the issue can then be developed by government.

Appendix 7: Refrigerators – algorithm discussion paper 1

Refrigerator Algorithm Discussion Paper

Prepared by Energy Efficient Strategies, 11 May 1998

Background

During 1996 & 1997, RA Brown & Associates was commissioned by DPIE (on behalf of NAEEEC) to undertake a review of energy labelling program in Australia. A final report with a range of recommendations and suggestions was submitted in early 1998 (Brown 1998). Following a series of workshops in late 1997, the Appliance Labelling Review Committee was formed to consider the report by Brown, as well as other material, and to make final recommendations to NAEEEC regarding changes to the energy label. The Review Committee met in early February and early April 1998.

A range of issues regarding the refrigerator labelling algorithms were identified and these have been referred to an Algorithm Working Group for further development. This discussion paper is a first attempt at trying to consolidate the data collected to date and propose some preliminary draft recommendations regarding refrigerator algorithms to NAEEEC.

As this document is an internal working document, much of the background material is omitted for the sake of brevity as working group participants will be familiar with this information. However, the relevant section of the April Review Committee minutes are attached as Appendix A.

It is proposed to review the material contained in this discussion paper at an algorithm working group in May 1998.

Graphs

A series of graphs are included in this paper. All graphs have adjusted gross volume as the X axis and energy consumption to AS4474.1 in kWh/year on the Y axis. Wherever possible, energy consumption and MEPS lines by Group are shown in different colours. The graphs are not numbered, but the applicable Groups are indicated in the heading and in the Legend. Where star ratings are shown under various options, the top heavy green line is one star while the bottom dotted green line is 5 stars (as per the Legend). The Legend also indicates the labelling algorithm scenario and Groups that it applies to (eg Option B67 is the algorithm scenario developed by Brown for Groups 6 and 7). These Options are fully discussed and described in the text below (including the equations of the lines). Graphs are printed in Landscape format to maximise the size and clarity.

For all Star Rating lines (which are green), a geometric progression has been used, as recommended by Brown and accepted by the Labelling Review Committee. This means that each Star rating line has a different slope and intercept. The geometric progression used is a set percentage reduction in energy for each increase in star rating for all sizes (eg if a particular refrigerator volume means that 400 kWh/year = 2 stars and the energy reduction per star is 20%, then the 3 stars will be 320 kWh/year).

Calculating EER for Each Model

Under the geometric progression used, the EER for a model is calculated as follows:

Calculate ratio of CEC to 1 Star Energy for the model:

$$E_{ratio} = CEC \div (V_{adj} * Slope + Intercept)$$

Where:
CEC is the Comparative Energy Consumption shown on the energy label kWh/year
V_{adj} is the adjusted volume of the model in litres (as per AS4474.2)
Slope is the slope of the 1 Star line (kWh/year/adjusted litre)
Intercept is the Y intercept of the 1 Star line (kWh/year at zero litres)

The EER of a model can be calculated as follows:

$$EER = 1 + (\ln (E_{ratio}) \div \ln (1 - Reduction))$$

Where ln is the base e log of the number in brackets (base 10 can be used if desired)
Reduction in CEC (Energy) per star rating (eg 20% is used in most cases)

Current Market Status

As of May 1998, some 291 refrigerators and freezers were registered and listed as be currently available on the Australian market. A full Listing is shown in Appendix B.

All current models for sale in Australia and the relevant MEPS lines by Group are shown in the first figure. Clearly, the overall volume/energy trend line does not pass through the origin, nor do the MEPS lines.

The current star rating system versus model energy consumption and MEPS lines are shown in the next three figures (Legend = Current). As can be seen, the current star rating system is based on a simple kWh per litre of adjusted volume and all star rating lines pass through the origin. The current star system is very volume skewed - most larger models and freezers rate 4 & 5 stars, while most small models rate 1 to 3 stars.

A range of proposals to redress these problems are outlined below.

Brown 1998

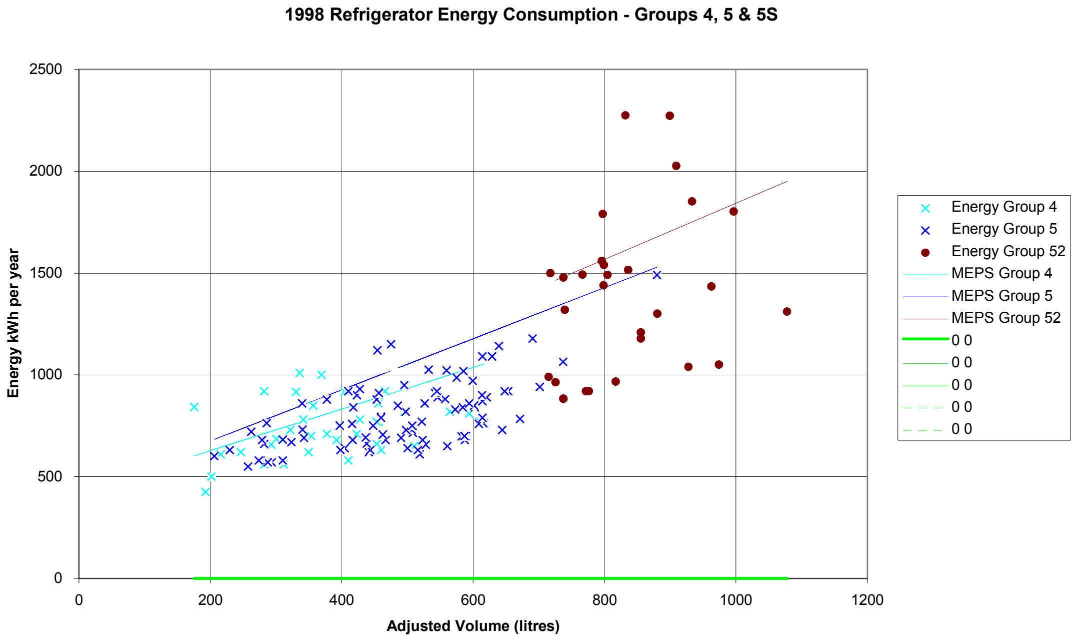
The report titled "Energy Labelling Review - Options for the Improvement of Labels" by RA Brown & Associates (January 1998) outlines a number of possible refrigerator algorithm approaches. Options outlined are titled A to D. These are detailed in Section 6 of the report (pp 14 to 17). Options A and C use the MEPS lines by Group as the basis for labelling, while Options B and D were developed using an empirical approach to setting the one star line (separate lines for Groups 1 to 5S and for Groups 6U to 7).

These Options are reviewed in EES 1998 (Appliance Energy Labelling Review Committee - Support Documentation, 20 March 1998). The Energy Labelling Review

Committee considered Option B as the most likely candidate, with the additional possible separation of rating systems for Groups 1-3 and 4-5S.

Brown suggested that Frost Free models be given an additional adjusted volume allowance of 1.2, citing the European Commission directives for MEPS and labelling which contain this factor. Subsequent discussions with the European Commission have revealed that they have virtually no experience with frost free models (sales are still less than 5% total) and this factor was at best an educated guess. The factor appears to have been adopted primarily in response to US manufacturers to give them some chance in the European market (in general US models rate very poorly in comparison with European models).

The following graph for Groups 4, 5 and 5S also shows that for those sizes where Group 4 models are available (ie about 200 to 600 litres adjusted volume), that frost free models (Group 5) are generally at the lower end of the available energy range, if not the lowest energy. On this basis an additional frost free adjustment has been rejected for this analysis. Also, the market share of frost free models is increasing markedly, so this Group needs to be rated competitively with Group 4 models to ensure that pressure is maintained on efficiency improvements. Note that nearly 50% of all refrigerators and freezers sold in 1996 were Group 5.


1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S

Brown Option B

Option B from Brown (1998) is shown in the Graphs as Option B15 for Groups 1 to 5S and Option B67 for groups 6U to 7.

Option B15 equation for 1 Star is 250 + 1.66 * AV, 20% energy reduction per star
Option B67 equation for 1 Star is 425 + 0.97 * AV, 20% energy reduction per star

Note that no frost free allowance is included.

Discussion on Brown Option B

For Groups 1 to 3, the slope of the Option B15 1 Star line is significantly steeper than the MEPS lines for these Groups. For Groups 1 and 2, the MEPS lines are well below the 2 star line for the larger sizes. Some Group 2 product is rating nearly 4 stars under this scenario.

Similarly, for Groups 4 to 5S, the Option B15 1 Star line is also somewhat steeper than the MEPS lines for these Groups. Some Group 5 product in the intermediate size range (400 to 600 litres adjusted) is rating nearly 4 Stars under this scenario.

For Groups 6 to 7, the Option B67 1 star line is approximately equal to the Group 7 MEPS line and the 3 star line is approximately equal to the chest freezer MEPS line (Group 6C). Under this scenario, most Group 7 models rate 1 star, most Group 6U models rate 2 stars and most Group 6C models rate 3 stars (some rate 4 stars). The very wide variation in energy consumption is an inherent problem with freezers. One option would be to separately rate vertical freezers (Groups 6U and 7) and chest freezers (Group 6C). Brown (1998) suggests this and shows the results in Figure REF-8 (page 37). The values suggested by Brown (without the frost free allowance) are reproduced in this report (Legend = BRef8) and this is shown in the Graphs.

Option B REF-8 equation for 1 Star is 439 + 0.85 * AV, 15% energy reduct. per star

Note that this proposed rating only applies to Groups 6U and 7. In this case most Group 6U models rate at 2 stars with some at 3 stars (virtually no 1 star), while for Group 7, most will be 1 star (with a couple of 2 stars). If the Brown REF-8 Option were to be adopted for Groups 6U and 7, presumably the star rating system for Group 6C would be based on the MEPS line with a fixed similar energy reduction per Star (assumed 15%). This is shown as Option 6C.

Option 6C equation for 1 Star is 248 + 0.67 * AV, 15% energy reduct. per star

Under this Option, one freezer model just rates at 3 Stars while there are 4 models of various sizes at 2 Stars. Smaller decreases per Star band were tried (eg 12% and 10%), but these resulted in very narrow rating bands.

Other Approaches

To examine the volume energy trend for each group, a linear regression was performed for Groups, 1 to 3, Groups 4 to 5S and Groups 6 to 7. The regression essentially derives the relationship between adjusted volume and energy of models which are on the market in Australia in 1998. Note that the regression will give an average market value for each Group (which is not necessarily the 1 Star line). The results of the regressions on various Group combinations are shown below in Table 1.

Table 1: Regression of 1998 Refrigerator and Freezer Models

Groups	Intercept	Slope	R^2
Groups 1 to 3	264	1.1236	0.6181
Groups 4 to 5S	257	1.1999	0.5312
Group 1 to 5S	254	1.2037	0.6762
Groups 6U, 6C and 7	372	0.5383	0.5230
Groups 6U and 7 only	237	1.1378	0.7252
Group 6C only	276	0.5699	0.8805

These regressions are useful starting points when investigating other labelling algorithm options.

Interestingly, the regression for Groups 1 to 3 and Groups 4 to 5S are very similar in terms of both intercept and slope. Note that the regression of Groups 1 to 5S is dominated by Group 5, which has over 100 models and is almost identical to the regression for Group 4 to 5S.

The regression values for Groups 1 to 5S were tried as a trial (Option R15).

Option R15 equation for 1 Star is 305 + 1.4 * AV, 20% energy reduction per star (this is equivalent to 2 Stars at 254 and a slope of 1.20 as per the above regression)

For Groups 1 to 3, Option R15 does not fit very well with the slope of the MEPS lines (the 1 Star, 2 Star and 3 Star lines are all steeper than the MEPS lines for these Groups). One Group 2 product rates 4 star under this scenario.

For Groups 4 to 5S, Option R15 fits reasonably nicely with the slope of the MEPS lines (the 1 Star line is slightly steeper than the Group 4 and 5 MEPS - it crosses Group 4 at the bottom end and Group 5 at the top end), while the 2 Star line (= regression) is more or less parallel with the MEPS lines for these Groups. A number of models (including some of each of Group 4, 5 and 5S) lie in the low to mid 3 Star range with none higher than 3.5.

Refinement of Options for Groups 1 to 3

Even where the regression values in Table 1 for Groups 1 to 3 are used to set the 2 Star level (see Legend = Option R13a), the slope of the 1 Star line is still much steeper than the MEPS line for these Groups. Given the fact there are not that many models in Groups 1 to 3 and given that a significant number of these do not pass MEPS, the regression is skewed to be significantly steeper than it would be after MEPS.

Option R13a equation for 1 Star is 317 + 1.34 * AV, 20% energy reduction per star

The basis of the original MEPS submission by AEEMA was that the new MEPS lines where developed on an engineering basis (rather than a market average basis). Given that the slope of MEPS lines for Groups 1, 2 and 3 are all roughly similar, Option X13 was developed for consideration where the slope of 1 Star line is parallel with the Group 1 to 3 MEPS lines and the intercept is set so as to make the 1 Star line lie below Group 1 & 3 and just above Group 2.

Option X13 equation for 1 Star is 320 + 0.74 * AV, 20% energy reduction per star

Under Option X13, most models rate 1 star, while some Group 2 models rate 2 stars. A couple of Group 2 models rate 3 stars, as does the Coola Can (40 litres). This is the recommended Option for Groups 1 to 3 in the first instance.

Refinement of Options for Groups 4 to 5S

For Groups 4 to 5S, a 1 Star line was developed that was approximately equal to (but slightly steeper than) the Group 4 MEPS line. Note that the slope of the MEPS lines for Groups 4, 5 and 5S are approximately equal (at least in a visual sense).

Option X45 equation for 1 Star is 420 + 1.10 * AV, 20% energy reduction per star

A 1 Star line with a lower intercept with 18% energy reduction per star was also trialed, but it was felt that maintaining a consistent 20% reduction in energy per star across Groups was a desirable concept.

Under Option X45, about half of the post MEPS models will rate 1 star and about half will rate 2 stars. A couple of Group 4 and 5 models rate 3 stars. While no 1998 5S models rate 3 Stars, 7 of the more efficient models of various sizes and brands rate around 2.5 Stars. This is the recommended Option for Groups 4 to 5S in the first instance.

Refinement of Options for Groups 6U to 7

Freezers are a difficult area because the energy consumption across Groups for each volume varies by up to a factor of 2 or more. The least "efficient" Group from a volumetric perspective are those in Group 7, followed by 6U. Group 6C are the most efficient by a considerable margin for nearly all size ranges. There is very little overlap between these groups in terms of energy consumption for a given size, meaning that under Option B67 (discussed above), most of Group 7 rate 1 star, most of Group 6U rate 2 stars and most of 6C rate 3 or 4 stars. Because these Groups have such diverse energy consumption, any option will to some degree be arbitrary in nature and will need to be developed with further consultation.

Another option developed for consideration is setting the 2 Star line approximately equal to the MEPS line for Group 6C - this is shown as Option X67 (here the 1 Star line is roughly midway between the MEPS for Group 7 and the MEPS for Group 6C). For this Option, all post MEPS chest freezers will be 2 or 3 Stars. One 6U freezer will rate 2 stars, and another is very close to the 2 Star line. All Group 7 models in 1998 would rate at about 1 Star (their EER would be less than 1).

If the above options for putting Groups 6U, 6C and 7 together are deemed unacceptable, there appears to be little alternative to this approach other than to split out ratings for Groups 6U and 7 from Group 6C. The problem with this is that it does not provide a comparative rating system for products that, at least superficially, provide a similar energy service (ie freezer space). Strong arguments would need to be presented to override this consideration.

Anecdotaly, it would appear that Group 7 models are lagging somewhat in terms of energy efficiency in comparison with both Group 6U and Group 5.

Next Steps

These Options will be further considered in detail and refined by the refrigerator algorithm working group meeting before recommendations are presented to NAEEEC.

Question or further information can be obtained from:

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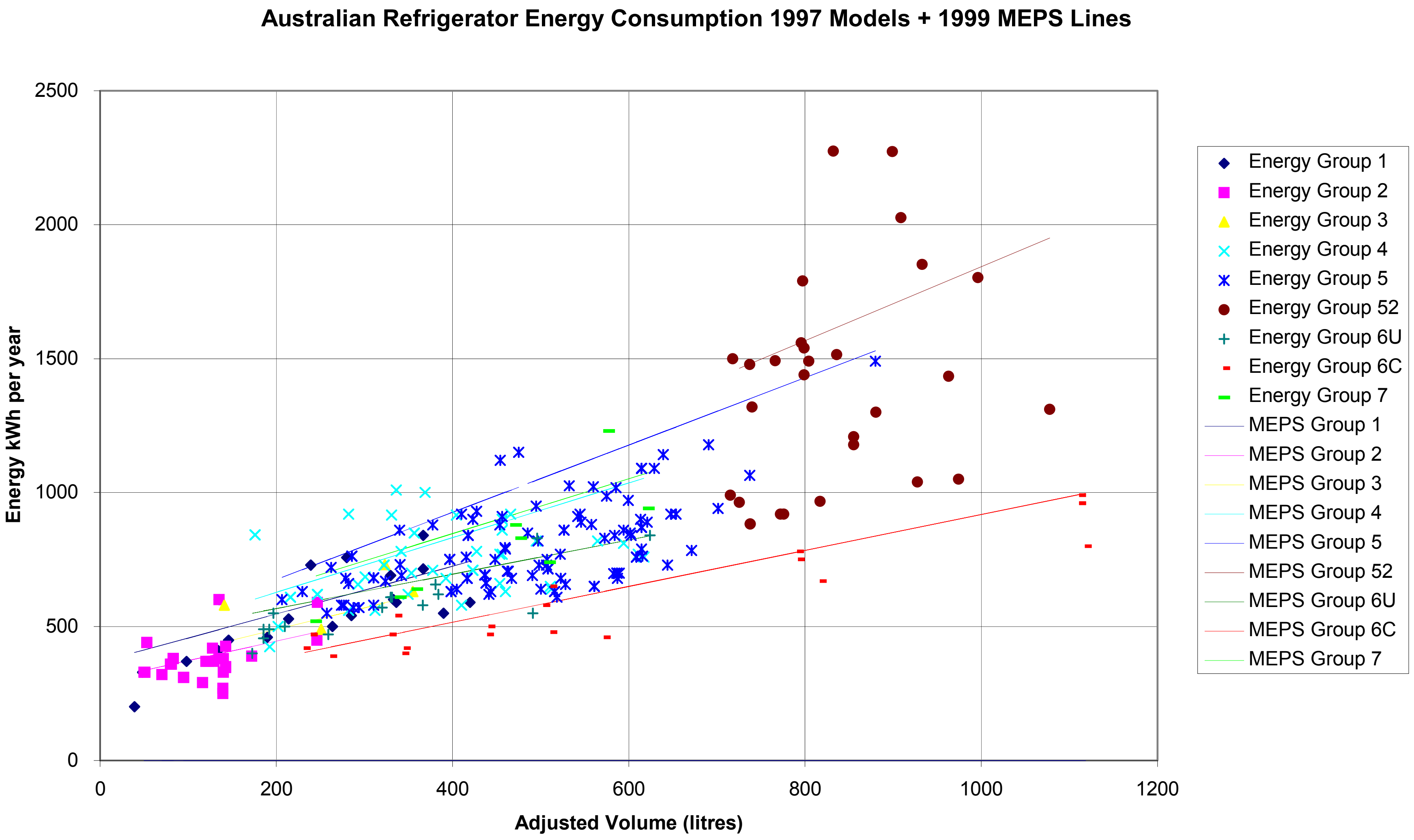
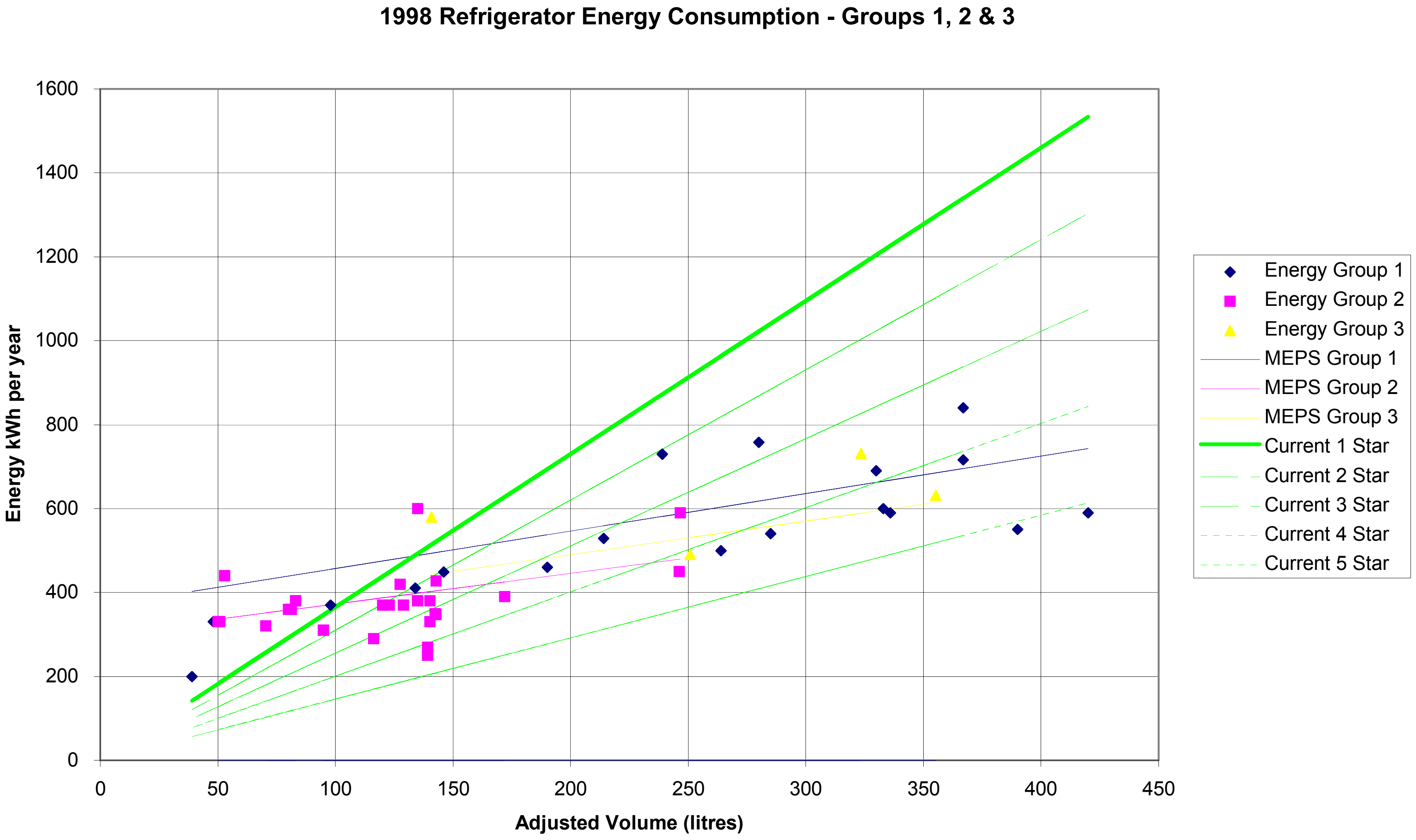
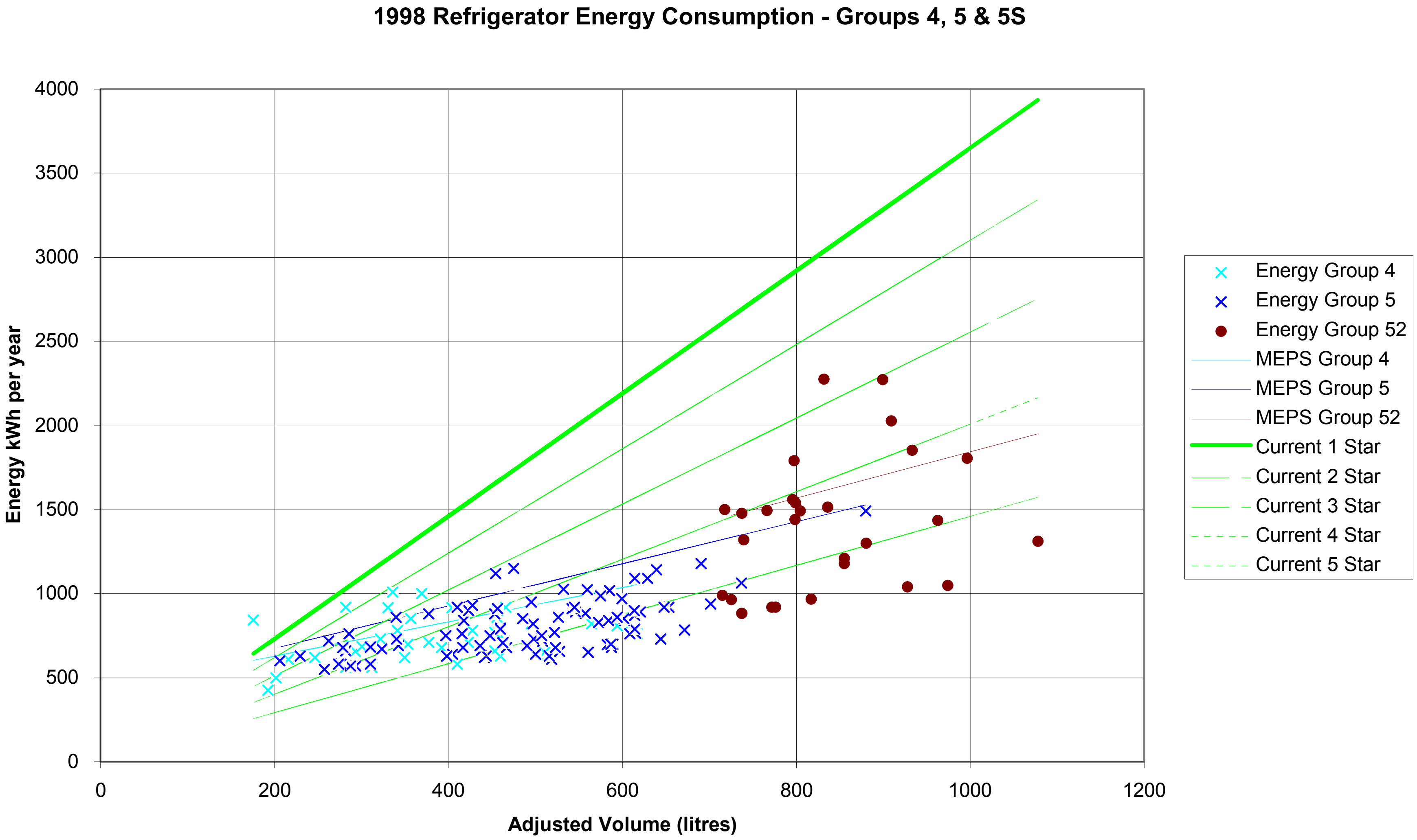
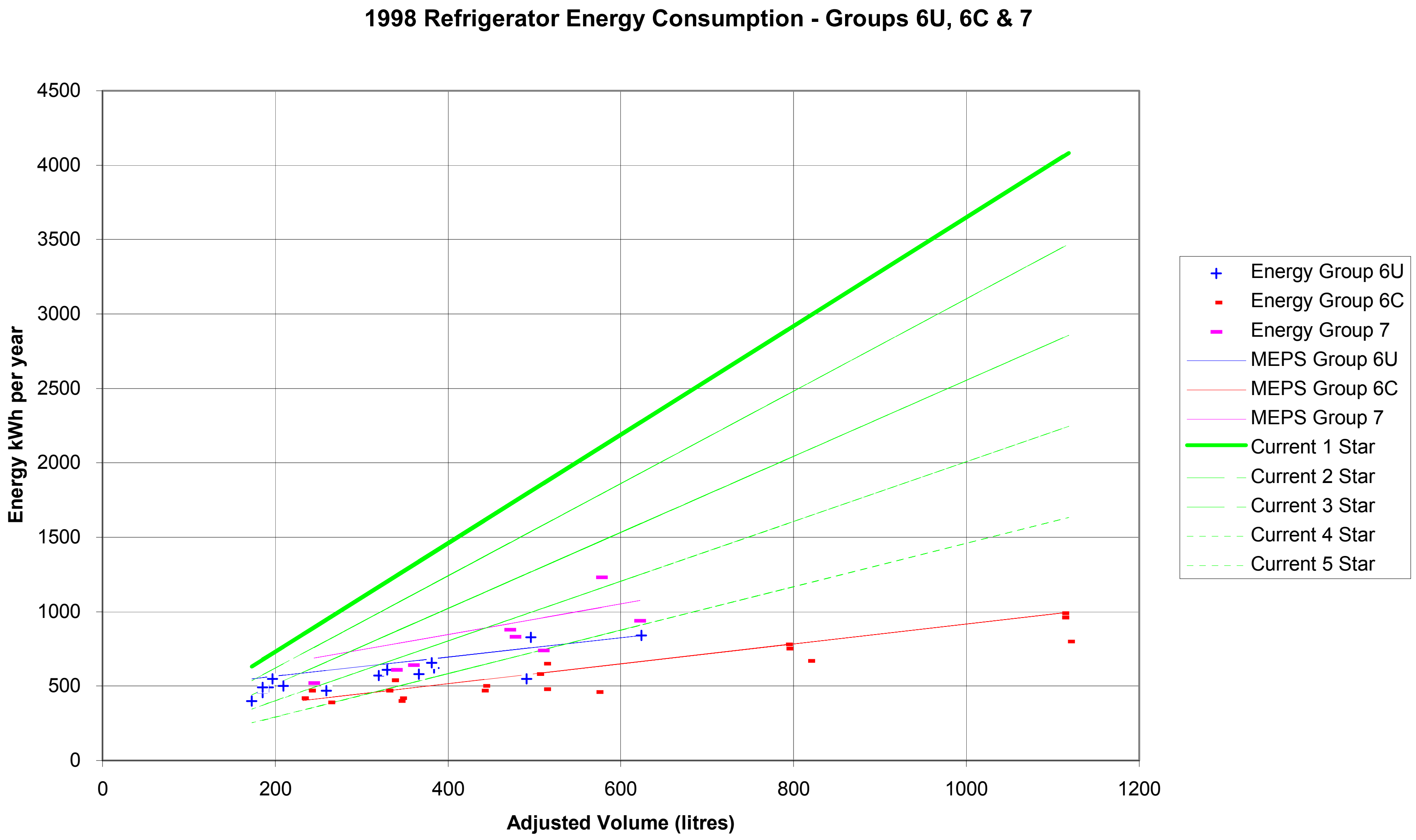
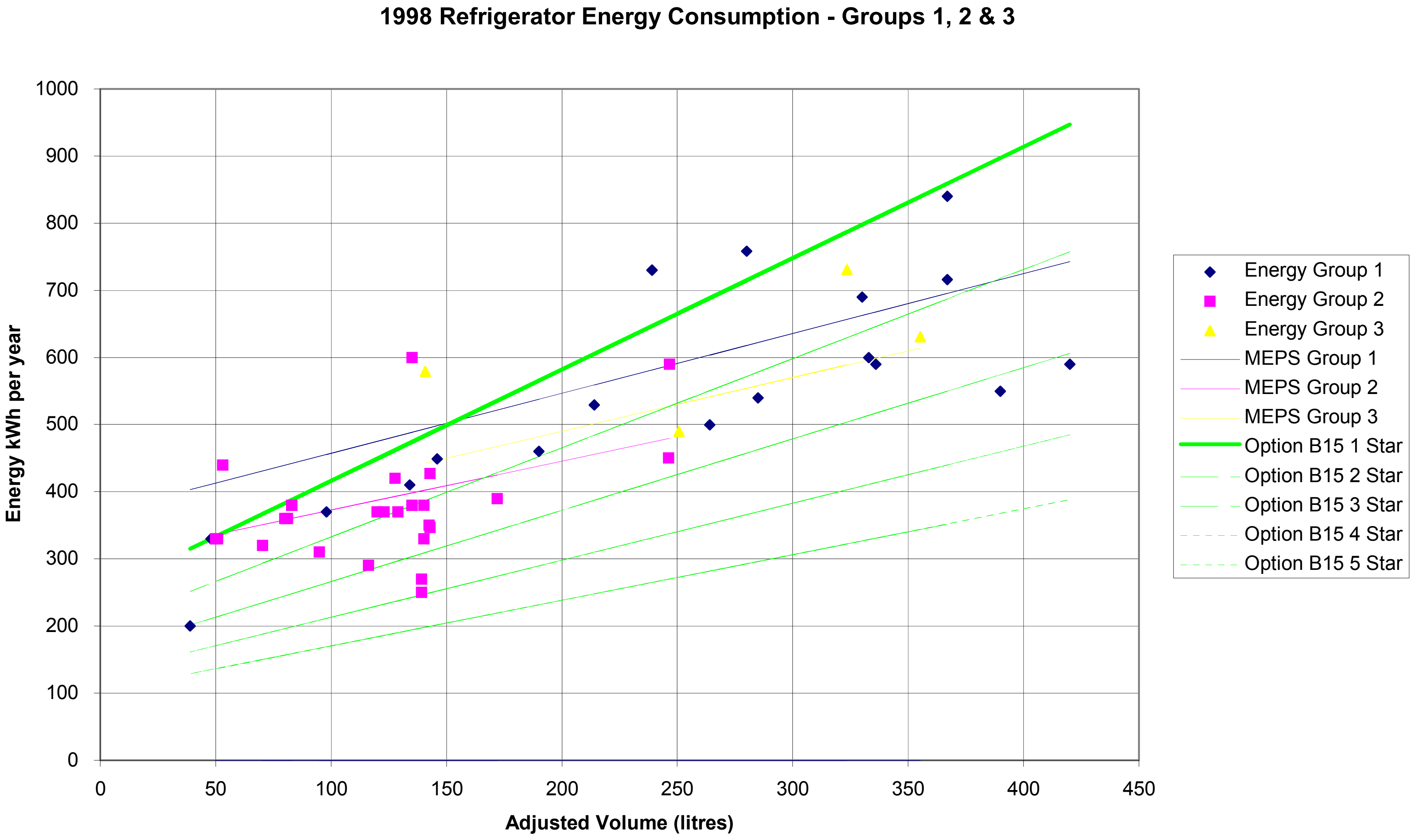

Australian Refrigerator Energy Consumption 1997 Models + 1999 MEPS Lines
Energy kWh per year
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 1
Energy Group 2
Energy Group 3
Energy Group 4
Energy Group 5
Energy Group 52
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 1
MEPS Group 2
MEPS Group 3
MEPS Group 4
MEPS Group 5
MEPS Group 52
MEPS Group 6U
MEPS Group 6C
MEPS Group 7

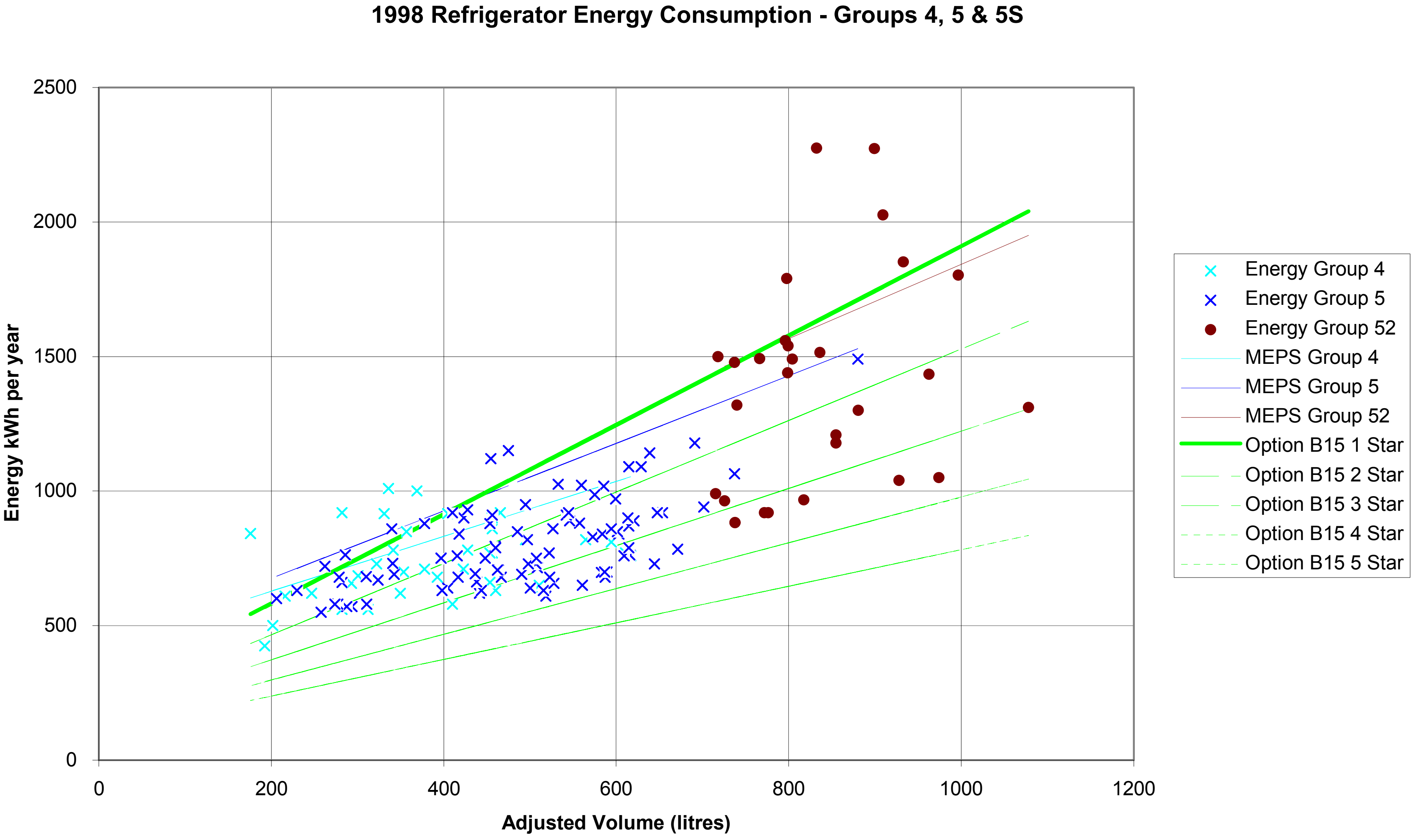

1998 Refrigerator Energy Consumption - Groups 1, 2 & 3
Energy kWh per year
1600
1400
1200
1000
800
600
400
200
0
0
50
100
150
200
250
300
350
400
450
Adjusted Volume (litres)
Energy Group 1
Energy Group 2
Energy Group 3
MEPS Group 1
MEPS Group 2
MEPS Group 3
Current 1 Star
Current 2 Star
Current 3 Star
Current 4 Star
Current 5 Star

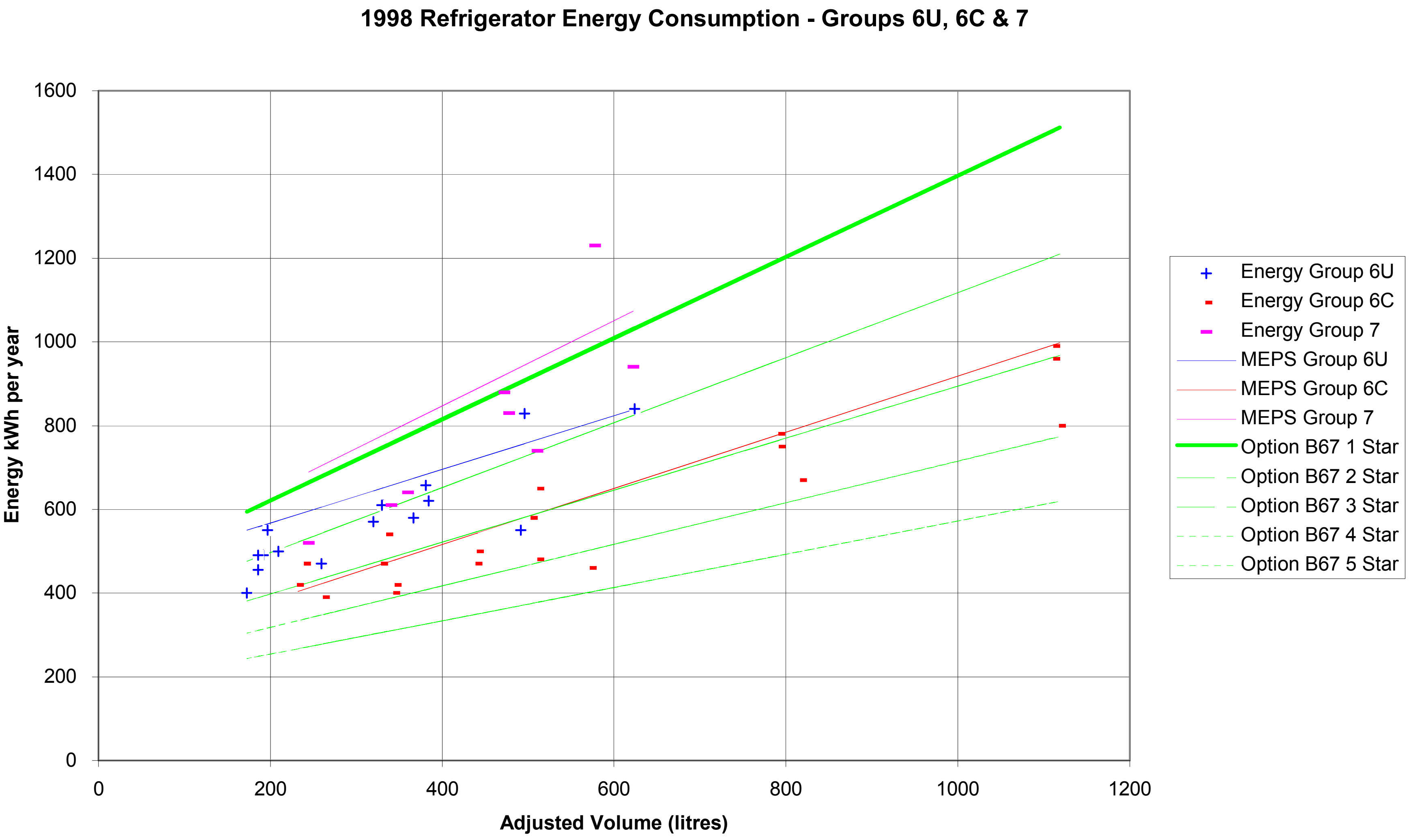

1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S
Energy kWh per year
4000
3500
3000
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 4
Energy Group 5
Energy Group 52
MEPS Group 4
MEPS Group 5
MEPS Group 52
Current 1 Star
Current 2 Star
Current 3 Star
Current 4 Star
Current 5 Star

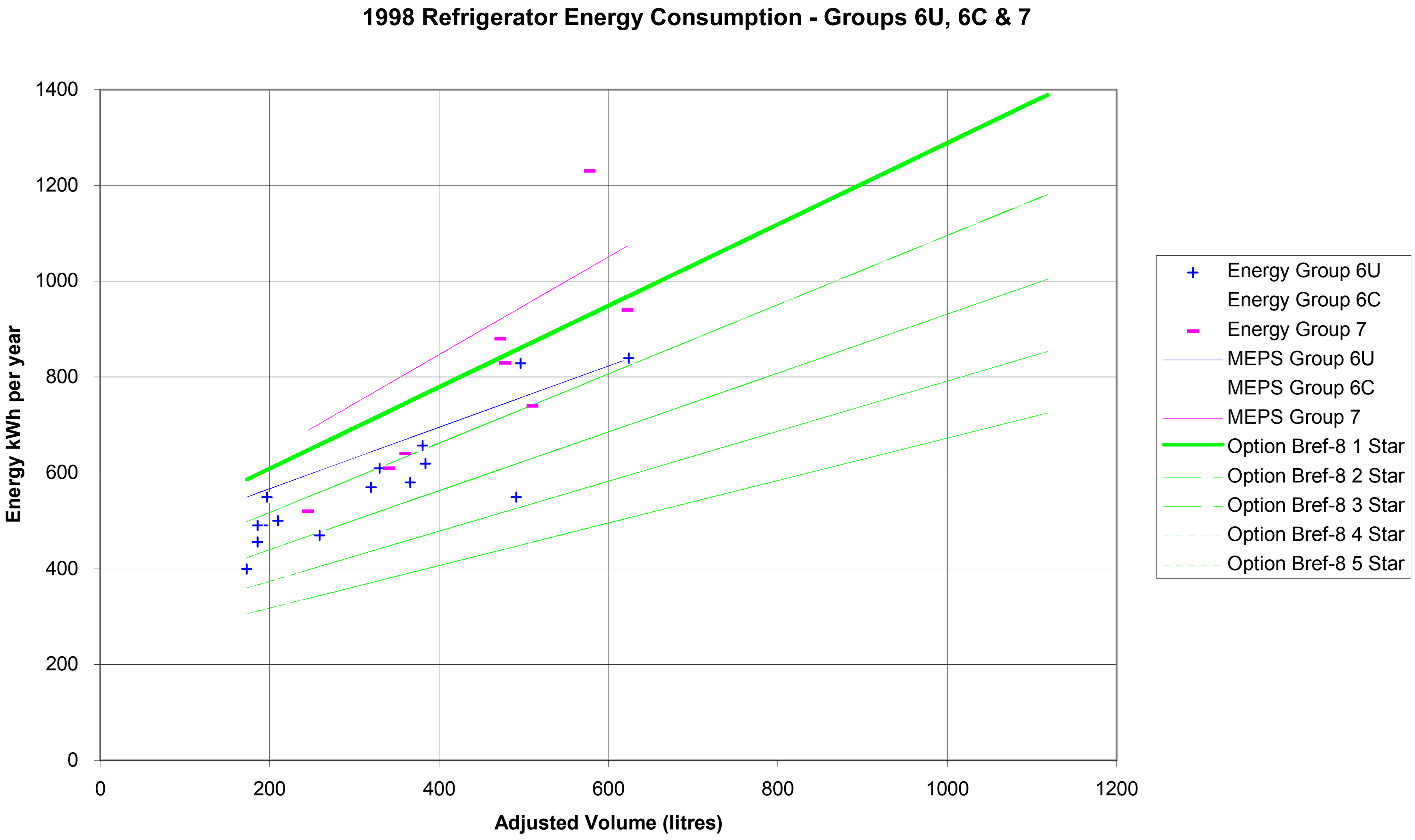


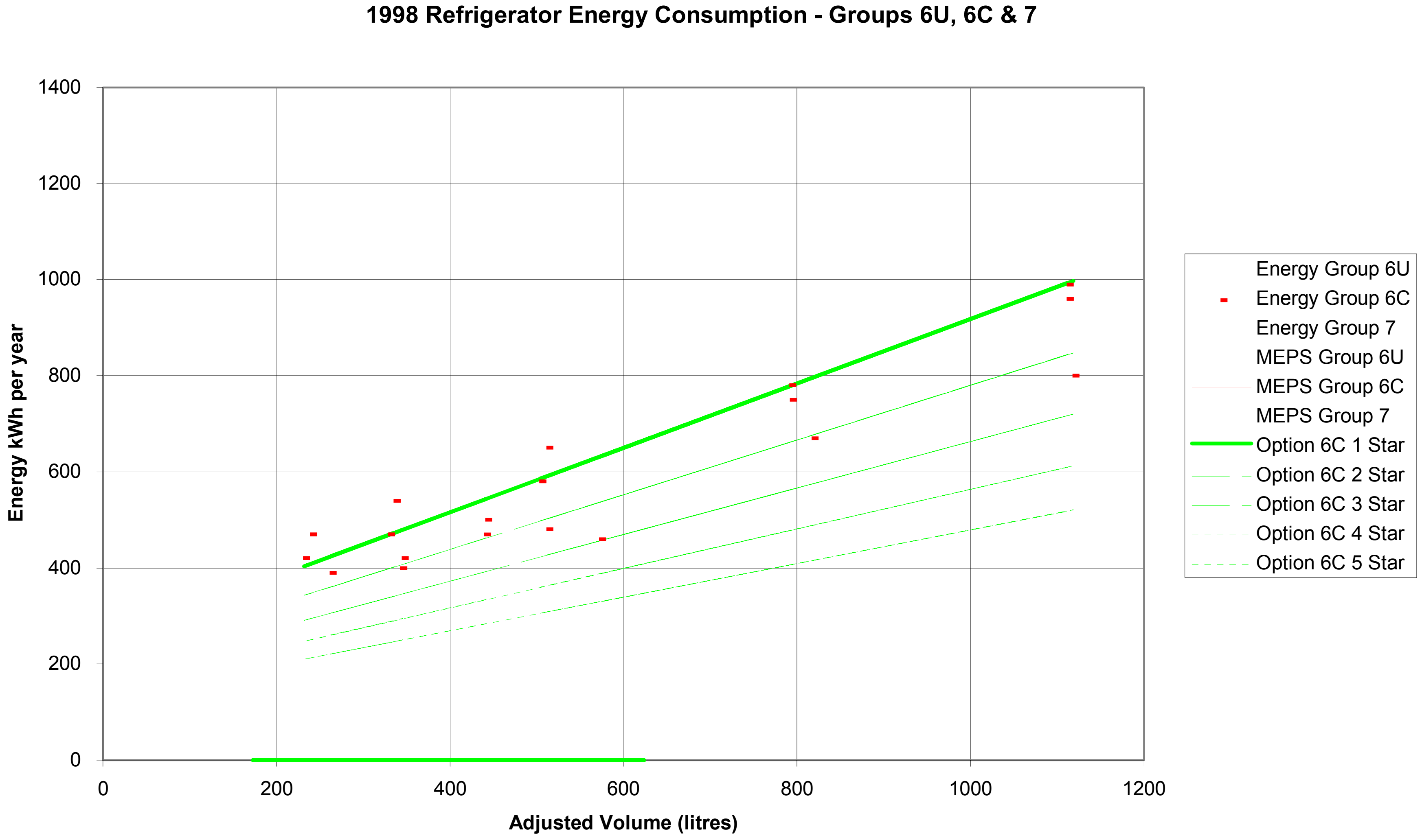
1998 Refrigerator Energy Consumption - Groups 6U, 6C & 7
Energy kWh per year
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Current 1 Star
Current 2 Star
Current 3 Star
Current 4 Star
Current 5 Star


1998 Refrigerator Energy Consumption - Groups 1, 2 & 3
Energy kWh per year
1000
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Adjusted Volume (litres)
Energy Group 1
Energy Group 2
Energy Group 3
MEPS Group 1
MEPS Group 2
MEPS Group 3
Option B15 1 Star
Option B15 2 Star
Option B15 3 Star
Option B15 4 Star
Option B15 5 Star

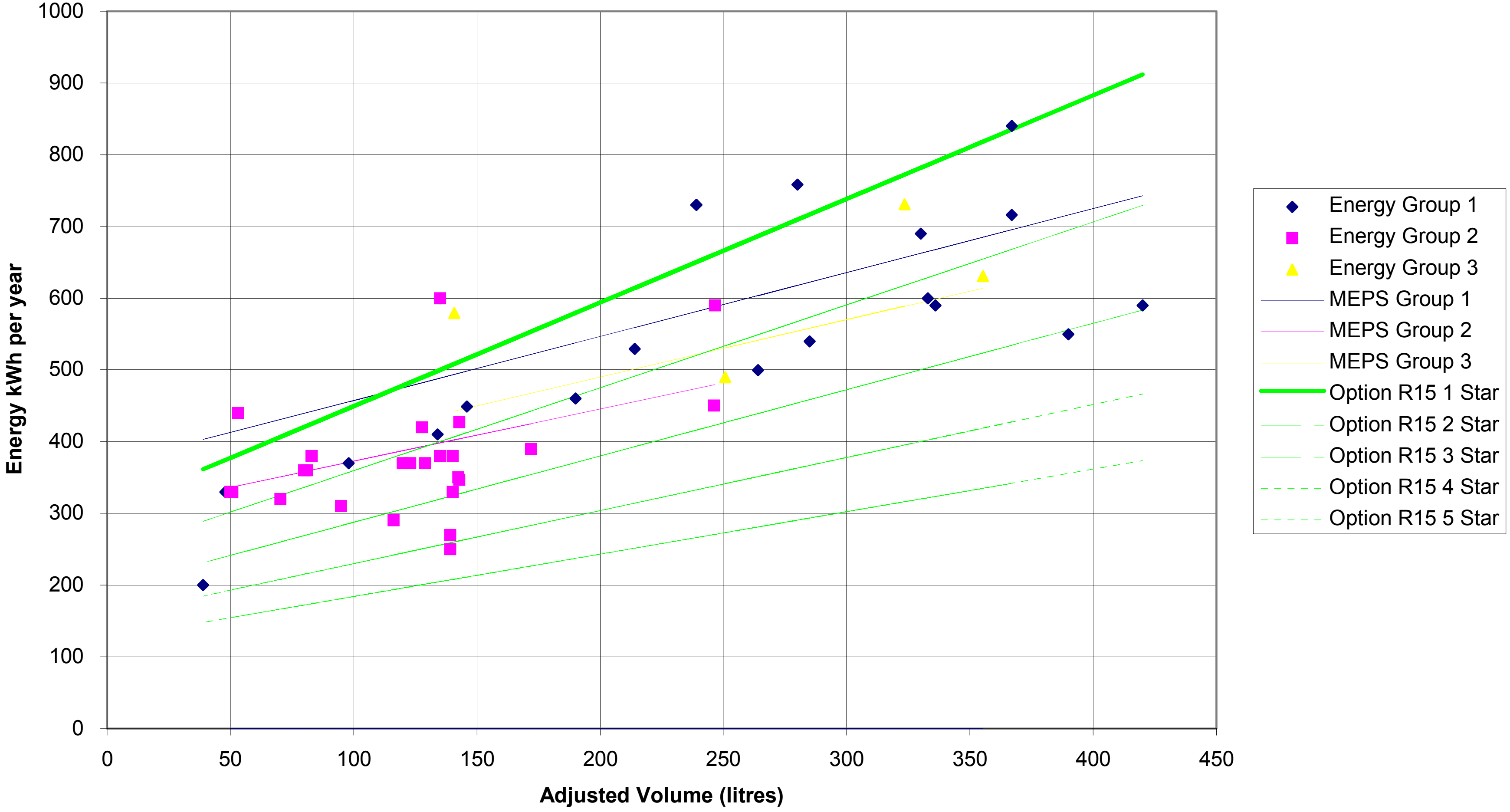

1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S
Energy kWh per year
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 4
Energy Group 5
Energy Group 52
MEPS Group 4
MEPS Group 5
MEPS Group 52
Option B15 1 Star
Option B15 2 Star
Option B15 3 Star
Option B15 4 Star
Option B15 5 Star

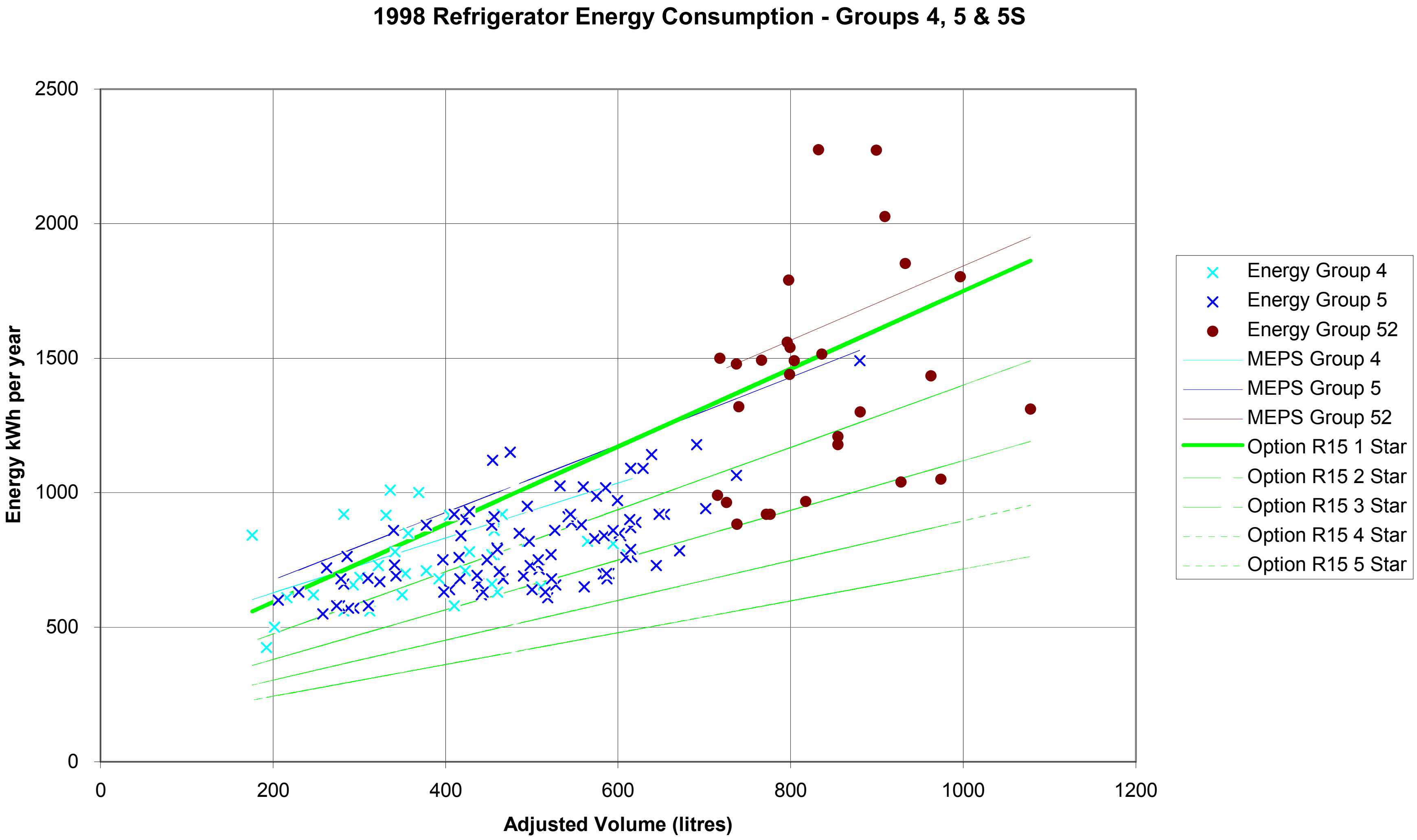

1998 Refrigerator Energy Consumption - Groups 6U, 6C & 7
Energy kWh per year
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Option B67 1 Star
Option B67 2 Star
Option B67 3 Star
Option B67 4 Star
Option B67 5 Star


1998 Refrigerator Energy Consumption - Groups 6U, 6C & 7
Energy kWh per year
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Option Bref-8 1 Star
Option Bref-8 2 Star
Option Bref-8 3 Star
Option Bref-8 4 Star
Option Bref-8 5 Star

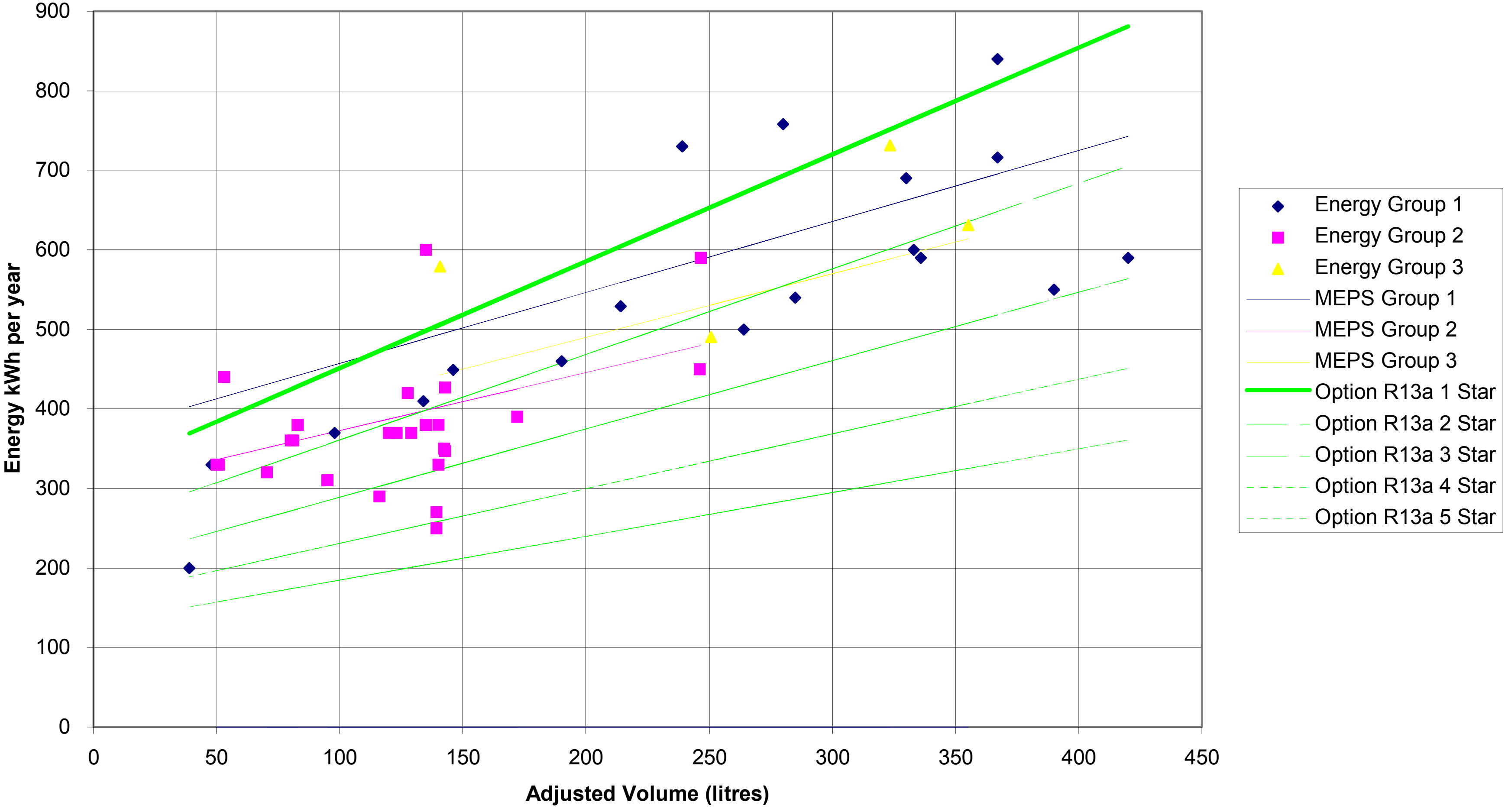

1998 Refrigerator Energy Consumption - Groups 6U, 6C & 7
Energy kWh per year
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Option 6C 1 Star
Option 6C 2 Star
Option 6C 3 Star
Option 6C 4 Star
Option 6C 5 Star

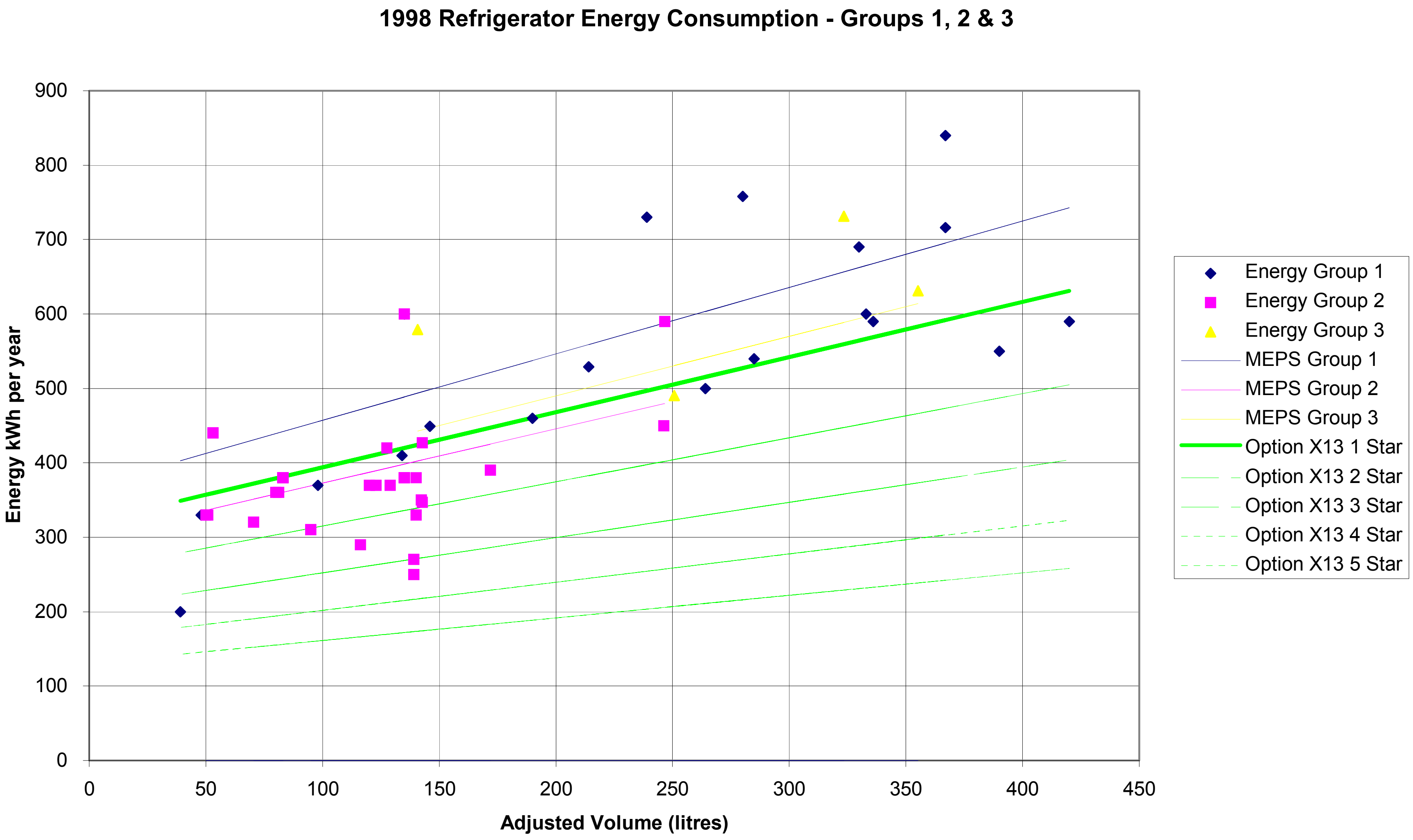
1998 Refrigerator Energy Consumption - Groups 1, 2 & 3



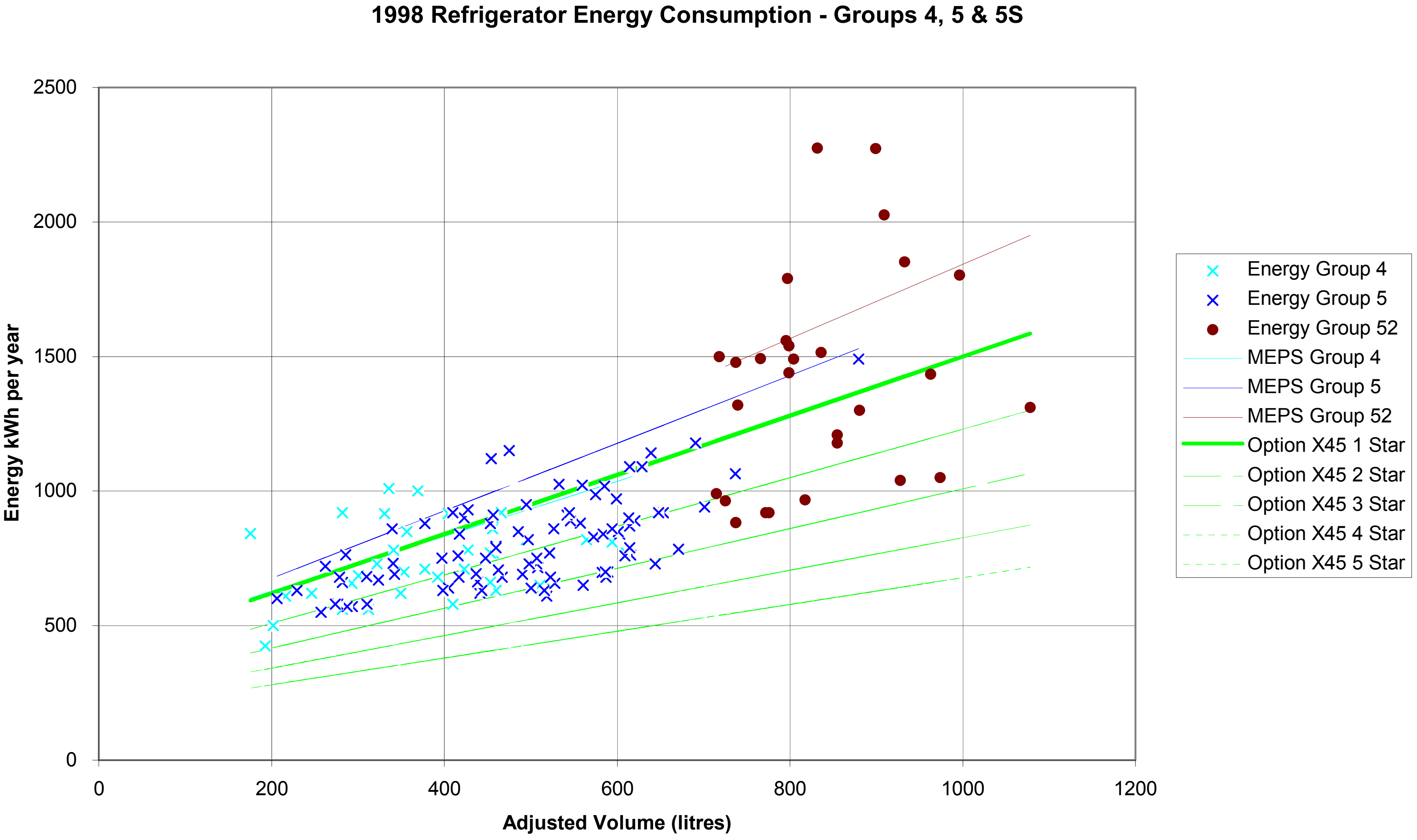

1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S
Energy kWh per year
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 4
Energy Group 5
Energy Group 52
MEPS Group 4
MEPS Group 5
MEPS Group 52
Option R15 1 Star
Option R15 2 Star
Option R15 3 Star
Option R15 4 Star
Option R15 5 Star

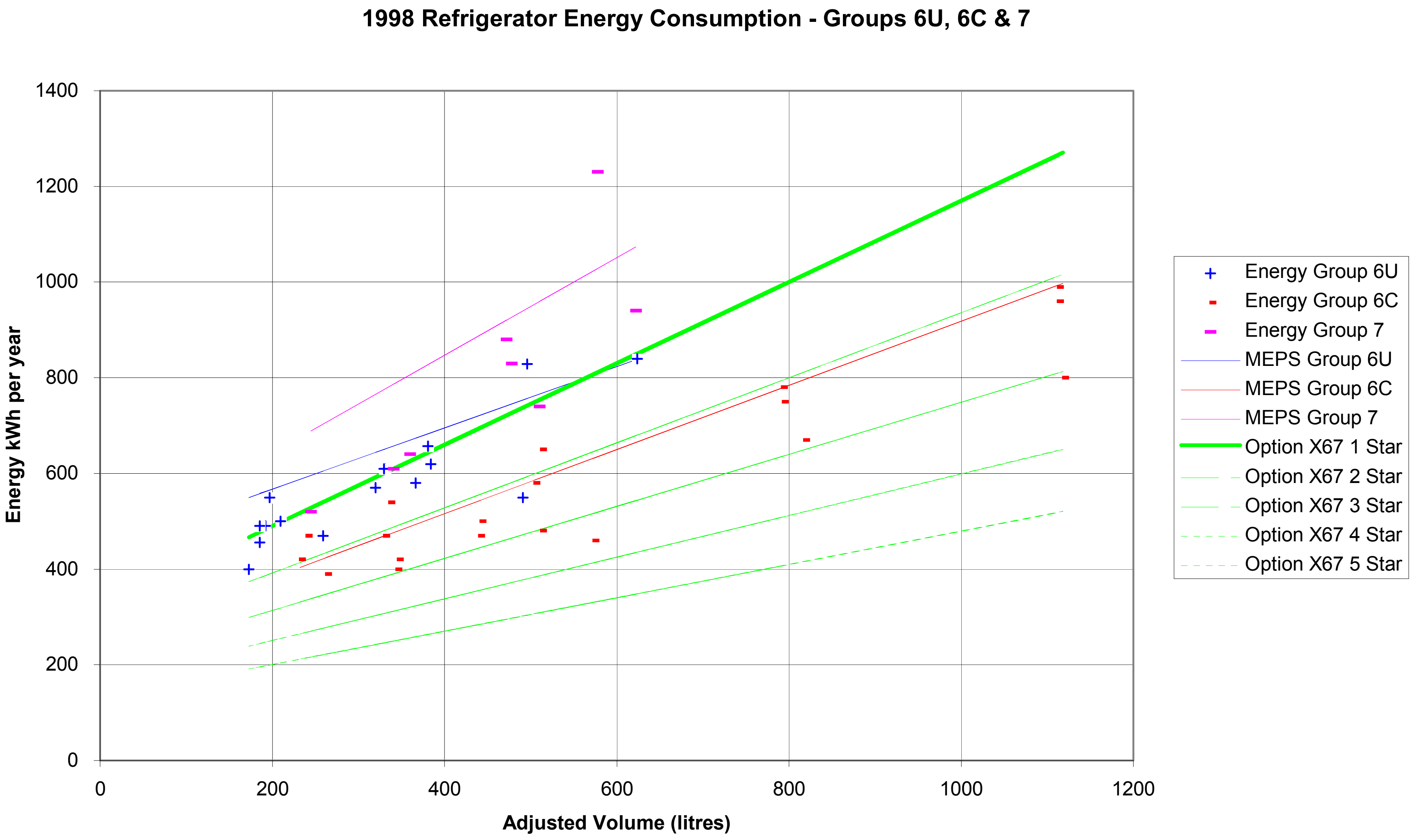
1998 Refrigerator Energy Consumption - Groups 1, 2 & 3





1998 Refrigerator Energy Consumption - Groups 1, 2 & 3
Energy kWh per year
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
450
Adjusted Volume (litres)
Energy Group 1
Energy Group 2
Energy Group 3
MEPS Group 1
MEPS Group 2
MEPS Group 3
Option X13 1 Star
Option X13 2 Star
Option X13 3 Star
Option X13 4 Star
Option X13 5 Star


1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S
Energy kWh per year
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 4
Energy Group 5
Energy Group 52
MEPS Group 4
MEPS Group 5
MEPS Group 52
Option X45 1 Star
Option X45 2 Star
Option X45 3 Star
Option X45 4 Star
Option X45 5 Star


1998 Refrigerator Energy Consumption - Groups 6U, 6C & 7
Energy kWh per year
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Option X67 1 Star
Option X67 2 Star
Option X67 3 Star
Option X67 4 Star
Option X67 5 Star

Appendix A
Extract of Labelling Review Committee Draft Minutes - 2 April 1998

Refrigerators

Refrigerator algorithm working group - Dick Brown, Bruce Buchtmann, Stefan Lofhelm, Lindsay Roke, Lloyd Harrington, DPIE, Terry Foggarty, Colin Doyle/Robert Wooley. Meeting possibly scheduled for Wed 6 May in Sydney.

1.1 Size Bias It was agreed that there is a size bias. There is a need to define the star boundaries before this can be finalised together with some guidelines regarding the approach to be used. Agreed to set up a WG to review and develop algorithm proposals now. WG to liaise with EL15/23. After discussion it was agreed that the WG guidelines were to be as follows:

- 1 star set as the MEPS level
- set as a geometric progression for the star rating system
- set maximum star rating on market at the moment to be around 3.5 stars
- try to ensure that only limited product on the market will achieve 5 stars within the nominal 5 year period (based on estimates of technology progress in this timeframe)
- should there be an allowance for additional doors on the basis that there may be some energy saving in use?
- use Option B from the Brown consultancy paper as the basis for developing proposals
- look at the option of separating Groups 1-3 and 4-5-5S (although Brown has noted that on the basis of his analysis that these are likely to be the same in any case)

1.2 Post MEPS market - This is covered by 1.1

1.3 Ambient test temperature - it was acknowledged that there was a problem but it was agreed to stick with the current standard - partly covered in 1.1.

1.4 Correlation with actual use - covered by 1.1.

1.5 Multi door - Current standard covers this issue and not needed to consider further.

1.6 Door openings - can’t consider under the current test procedure so not considered further.

1.7 Net volume - there was discussion on the pros and cons of using net volume. Agreed that the current round of MEPS should continue to be based on gross volume for the life at that MEPS level. There was discussion regarding harmonisation at the APEC level. The algorithm working group is to look at storage and gross volumes and related issues, including consideration of the levels of harmonisation with ISO and AS/NZS in the determination of storage volume. The issue of changing from gross to net was discussed in depth.

1.8 Show volume on the label - agreed not to consider this until storage (net) volume is used for energy labelling.

Appendix B
Current Refrigerator and Freezer Models - May 1998

Note: Group 52=5S, Group 6 = 6U, Group 61 = 6C

Group	Brand	Model	FF	FZ	Total V	Energy
1	Fisher & paykel	F&PC190	190	0	190	460
1	Westinghouse	RP142	134	0	134	410
1	Kleenmaid	RSB146	146	0	146	449
1	Samsung	SRG118	98	0	98	370
1	Liebherr	KIU1620	135	0	135	600
1	Lg	GR-051SSF	48	0	48	330
1	Coola can	CC3-TR	39	0	39	200
1	Westinghouse	RP42*	420	0	420	590
1	Kelvinator	CS390	390	0	390	550
1	Westinghouse	RP34*	336	0	336	590
1	Kelvinator	CS33*	333	0	333	600
1	Fisher & paykel	F&PC270	264	0	264	500
1	Kleenmaid	RRS285	285	0	285	540
1	Fisher & paykel	F&PC370	367	0	367	716
1	Kelvinator	CS330	330	0	330	690
1	Fisher & paykel	F&PC365H	367	0	367	840
1	Kleenmaid	RRB214	214	0	214	529
1	Liebherr	KIF2820	280	0	280	758
1	Kelvinator	C*25*	239	0	239	730
1	Westinghouse	RP252	239	0	239	730
2	Kelvinator	M142	114	21	135	250
2	Westinghouse	RA14*	102	31	133	270
2	Kelvinator	P17*	136	30	166	390
2	Kelvinator	M14*,P14*	115	21	136	330
2	Frigidaire	FR140M	126	14	140	347
2	Gac	GBC140R	128	12	140	350
2	Fisher & paykel	P120	109	6	115	290
2	Westinghouse	R*14*	103	31	134	380
2	Daewoo	FR-142	135	0	135	380
2	Hoover	DE135SM	135	0	135	380
2	Nec	FR-135	135	0	135	380
2	Daewoo	FSC-135	135	0	135	380
2	Kelvinator	M130C	129	0	129	370
2	Kleenmaid	RFS140	126	14	140	427
2	Lemair	RQ130	105	15	120	370
2	Gac	GW0211R	120	0	120	370
2	Goldstar	GR-131SF	95	0	95	310
2	Lg	GR-131SSF	95	0	95	310
2	Sunair	WB-120	110	15	125	420
2	Liebherr	KIU1423	135	0	135	600

2	Lemair	RQ-85	74	6	80	360
2	Gac	GW0801R	80	0	80	360
2	Sunair	WB-80	62	7	69	320
2	Daewoo	FR-090	83	0	83	380
2	Daewoo	FR-091	83	0	83	380
2	L&m	LM101	83	0	83	380
2	L&m	LM102	83	0	83	380
2	Nec	FR-083	83	0	83	380
2	Daewoo	FSC-083	83	0	83	380
2	Lemair	RQ-55	45	5	50	330
2	Gac	GW0501R	50	0	50	330
2	Daewoo	FR-061	53	0	53	440
2	Nec	FR-053	53	0	53	440
2	Kelvinator	P250	195	43	238	450
2	Westinghouse	RA251	195	43	238	590
3	Kelvinator	P*330**	267	63	330	631
3	Lemair	243PB	213	27	240	490
3	Samsung	SRV33H	203	86	289	731
3	Kleenmaid	RFB134	117	17	134	579
4	Fisher & paykel	C240B	136	110	246	560
4	Fisher & paykel	F&P C250T/C251T	191	57	248	560
4	Kleenmaid	RFD170	135	36	171	425
4	Kleenmaid	RFB264	216	48	264	657
4	Admiral	*T29C**** 2904 SERIES	226	60	286	730
4	Hoover	H*290TC***	226	60	286	730
4	Kleenmaid	RFD260	192	68	260	686
4	Kelvinator	C30*	223	74	297	780
4	Fisher & paykel	F&P C170T	114	55	169	500
4	Kelvinator	C22*	165	51	216	620
4	Westinghouse	RE22*	165	51	216	620
4	Kleenmaid	RFU284	206	78	284	916
4	Kelvinator	C19*	136	50	186	610
4	Westinghouse	RE19*	136	50	186	610
4	Lemair	BF260	170	70	240	920
4	Daewoo	FR-171	115	38	153	842
4	Hoover	DE155TC	115	38	153	842
4	Kelvinator	C400	300	100	400	630
4	Kelvinator	C350	250	100	350	580
4	Westinghouse	RE391	279	109	388	660
4	Admiral	*T37C**** 3704 SERIES	274	93	367	710
4	Hoover	H*370TC***	274	93	367	710
4	Fisher & paykel	F&PC420T	306	94	400	770
4	Fisher & paykel	F&P C380B	263	119	382	770
4	Westinghouse	RE351	266	79	345	680
4	Kelvinator	C30*	228	76	304	620

4	Fisher & paykel	CC390T	277	94	371	780
4	Fisher & paykel	F&PC335T	227	94	321	710
4	Kelvinator	CB380**	245	132	377	860
4	Fisher & paykel	F&PC415H	306	94	400	900
4	Westinghouse	RE311	227	79	306	700
4	Kleenmaid	RFU330	206	124	330	916
4	Kleenmaid	RFD310	232	78	310	850
4	Frigidaire	FRT315 P	248	68	316	850
4	Lemair	300BF	185	115	300	1000
4	Lemair	301TD	240	60	300	1010
4	Westinghouse	RB501	329	180	509	760
4	Westinghouse	RE441	320	120	440	640
4	Westinghouse	RE521	383	142	525	770
4	Westinghouse	RB421	274	148	422	650
4	Fisher & paykel	F&PC520T	402	120	522	810
4	Fisher & paykel	F&PC511B	355	154	509	850
4	Kelvinator	C50*	352	133	485	820
4	Fisher & paykel	F&P C410B/C411B	263	145	408	820
4	Hoover	H*410TC***	309	98	407	920
5	Whirlpool	WRN28NWF6	173	86	259	580
5	Sharp	SJ-25J-WH/GY	172	76	248	570
5	Lg	GR-282MF	174	71	245	570
5	Whirlpool	WRN32NWF6	205	86	291	690
5	Westinghouse	RJ275M	194	81	275	670
5	Daewoo	FR-2701/FR-2702	168	68	236	580
5	Sharp	SJ-24G-WH/GY	154	75	229	580
5	Lg	GR-242MF	144	71	215	550
5	Samsung	SRG-V33	203	86	289	731
5	Samsung	SRG-V29	173	86	259	682
5	Samsung	SRV29H	173	85.8	258.8	682
5	Fisher & paykel	N249T	191	57	248	660
5	Lg	GR-272SSF	173	66	239	680
5	Kelvinator	N30*	223	73	296	860
5	Daewoo	FR-270	180	66	246	762
5	Hoover	DE250TF	180	66	246	762
5	Westinghouse	RJ200M	148	51	199	630
5	Kelvinator	N225C	160	64	224	720
5	Fisher & paykel	N169T	115	57	172	600
5	Whirlpool	WRN38NWF6/A	246	122	368	620
5	Hoover	H*38TF***	282	101	383	630
5	Whirlpool	WRN42NWF6/A	270	123	393	680
5	Admiral	*U36F***	243	122	365	662

5	Hoover	*36UF***	243	122	365	662
5	Panasonic	NR-B39AXA	274	116	390	794
5	Samsung	SRG-V43	268	122	390	707
5	Samsung	SRV43H	268	122	390	707
5	Daewoo	FR-3501/FR-3502	248	98	346	640
5	Admiral	*U32F***	203	122	325	630
5	Hoover	H*325UF***	203	122	325	630
5	Samsung	SRV39H	243	122	365	692
5	Samsung	SRG-V39	243	121	364	692
5	Nec	FR-358	260	98	358	680
5	Daewoo	FR-3801/FR-3802	260	98	358	680
5	Lg	GR-412SF	280	105	385	750
5	Kelvinator	N400	300	100	400	790
5	Westinghouse	RJ360M	259	98	357	760
5	Lg	GR-362SF	221	110	331	750
5	Westinghouse	RJ330M	221	110	331	750
5	Fisher & paykel	F&P N369B	263	119	382	880
5	Fisher & paykel	F&PN405T	306	94	400	910
5	General electric	TBR12ANTRWH	240	111	351	840
5	Lg	GR-392SSF	240	111	351	840
5	Daewoo	FDF-366	271	95	366	900
5	Fisher & paykel	F&PN375T	277	94	371	930
5	Kelvinator	N350**	250	100	350	920
5	Fisher & paykel	F&PN325T	227	94	321	880
5	Kelvinator	NB40*	264	132	396	1150
5	Fisher & paykel	F&PN400H	304	94	398	1120
5	Lg	GR-572SF	327	146	473	650
5	Lg	GR-572TF	327	146	473	650
5	Maytag	GT1527PAC*	309	131	440	610
5	Maytag	GT1727PAC*	346	152	498	700
5	Samsung	SR-57NXA	349	146	495	697
5	Daewoo	FR-430	287	143	430	630
5	Nec	FR-430	287	143	430	630
5	Samsung	SR-52NRA	299	143	442	658
5	Fisher & paykel	E440T	342	99	441	640
5	Fisher & paykel	E442B	307	135	442	680
5	Hoover	H*430TF***	329	101	430	690
5	Admiral	*U42F***	281	142	423	715
5	Hoover	H*423UF***	281	142	423	715
5	Westinghouse	BJ424	262	153	415	730
5	Sharp	SJ-48G-WH/GY	312	163	475	830
5	Westinghouse	RJ422	298	125	423	730
5	Westinghouse	RJ452	322	125	447	770
5	Westinghouse	BJ425S	262	153	415	750

5	Panasonic	NR-B47AXA	335	139	474	881
5	Daewoo	FR-540NT	346	125	471	890
5	Daewoo	FR-510	333	121	454	860
5	Nec	FR-510	333	121	454	860
5	General electric	TBR15ANTRWH	326	107	433	820
5	Daewoo	FR-540N	347	122	469	910
5	Hoover	H*480TF***	361	115	476	920
5	Fisher & paykel	F&PN500BD	355	144	499	1018
5	Kelvinator	N420C	303	114	417	850
5	General electric	TBG 16DA	342	136	478	1022
5	Fisher & paykel	F&P N395B/N394B	263	145	408	950
5	General electric	TBG 14DA	315	136	451	1025
5	Maytag	GT1928PAC*	377	167	544	730
5	Fisher & paykel	E521T	400	117	517	680
5	Samsung	SRL626EV	372	187	559	784
5	Hoover	H*513TF***	390	123	513	700
5	Admiral	*T513F****	390	123	513	700
5	Whirlpool	6ET19DK*****	393	139	532	763
5	Admiral	*U50F***	332	173	505	760
5	Hoover	H*505UF***	332	173	505	760
5	Fisher & paykel	E522B	360	159	519	790
5	Kleenmaid	BRF520T	407	184	591	940
5	Sharp	SJ-51H-WH/GY	342	163	505	840
5	Fisher & paykel	F&PN500B	355	154	509	850
5	Nec	FR-516	352	164	516	870
5	Daewoo	FDF-516W	352	164	516	870
5	Panasonic	NR-B56AXA	399	159	558	919
5	Sharp	SJ-55H-WH/GY	387	163	550	920
5	Westinghouse	RJ532	384	148	532	890
5	Kelvinator	N50*	360	140	500	840
5	Whirlpool	6EB21DK*****	417	200	617	1064
5	Fisher & paykel	F&P N510T/N509T	402	120	522	860
5	Westinghouse	BJ50	316	186	502	900
5	Lg	GR-582WF	340	162	502	970
5	Westinghouse	RS725	443	273	716	1490
5	General electric	TBG 19	390	188	578	1179
5	Fisher & paykel	F&PN510TD	402	108	510	986
5	Amana	TS518S	369	162	531	1090
5	Daewoo	FR-580N	352	164	516	1091
5	Daewoo	FR-580NW	352	164	516	1091
5	Hoover	DE520TF	352	164	516	1091
5	General electric	TBG 18	367	170	537	1142

52	Whirlpool	6ED27DQX****	470	315	785	1050
52	Whirlpool	6ED25DQX****	443	303	746	1040
52	Amana	SSD522T	404	258	662	967.3
52	Whirlpool	6ED22DQX****	416	225	641	920
52	Whirlpool	6ED22PK*****	412	225	637	920
52	Amana	SB520T	355	239	594	883
52	Amana	SR520T	355	239	594	883
52	General electric	TFG30PF	518	350	868	1311
52	Amana	SBT520T	355	232	587	963.6
52	General electric	TPG 24PR	415	275	690	1178
52	Whirlpool	6ED20TK*****	376	212	588	990
52	General electric	TPG24PF/TPG24BF	415	275	690	1208
52	Maytag	GS24B8C3EV	431	281	712	1300
52	Amana	SRDE528T	483	300	783	1434
52	Maytag	GS20B6N3EV	391	218	609	1320
52	Westinghouse	RS652	394	253	647	1440
52	General electric	TFG27	510	304	814	1803
52	General electric	TFG22	452	240	692	1515
52	Jenn-air	GS24B8C	430	234	664	1490
52	Kelvinator	N640	375	265	640	1540
52	General electric	TFG20	395	232	627	1493
52	Maytag	GS22B7C3EV	439	223	662	1560
52	General electric	TFG25PA	453	300	753	1852
52	Jenn-air	GS20B6N	382	222	604	1478
52	Jenn-air	GS22B6C	430	180	610	1500
52	General electric	TFG25PR	453	285	738	2026
52	Kelvinator	N6*0	375	264	639	1790
52	General electric	TFG24	440	287	727	2272
52	General electric	TPG21	400	270	670	2274
6	Fisher & paykel	F&PF160	0	162	162	470
6	Gac	GN8011F	0	108	108	400
6	Kelvinator	F14*	0	131	131	500
6	Kleenmaid	FFB116	0	116	116	456
6	Lg	GF-161SF	0	120	120	490
6	Westinghouse	FR121	0	116	116	490
6	Liebherr	GIU1303	0	123	123	550
6	Fisher & paykel	F&PF310	0	307	307	550
6	Westinghouse	FR393	0	390	390	840
6	Fisher & paykel	F&PF230	0	229	229	580
6	Lemair	240VF	0	240	240	620
6	Kleenmaid	FFS310	0	310	310	829
6	Kleenmaid	FFS235	0	238	238	657
6	Lemair	202VF	0	200	200	570

6	Westinghouse	FR211	0	207	207	610
6	Kelvinator	F21*	0	206	206	610
61	Fisher & paykel	F&PH275	0	275	275	470
61	Fisher & paykel	F&PH280	0	276	276	500
61	Fisher & paykel	F&PH215	0	215	215	400
61	Fisher & paykel	CH220	0	216	216	420
61	Kelvinator	H210	0	206	206	470
61	Westinghouse	FD213	0	206	206	470
61	Fisher & paykel	H160	0	164	164	390
61	Kelvinator	H21*	0	210	210	540
61	Westinghouse	FD21*	0	210	210	540
61	Westinghouse	FD153	0	145	145	420
61	Kelvinator	H150	0	145	145	420
61	Kelvinator	H15*	0	150	150	470
61	Westinghouse	FD15*	0	150	150	470
61	Fisher & paykel	CH701	0	699	699	800
61	Fisher & paykel	F&PH360	0	358	358	460
61	Fisher & paykel	CH510	0	511	511	670
61	Kelvinator	H700	0	695	695	960
61	Westinghouse	FD703	0	695	695	960
61	Kelvinator	H700	0	695	695	990
61	Fisher & paykel	F&PH320	0	320	320	480
61	Kelvinator	H500	0	496	496	750
61	Kelvinator	H500	0	495	495	780
61	Kelvinator	H320	0	315	315	580
61	Westinghouse	FD323	0	315	315	580
61	Kelvinator	H32*	0	320	320	650
7	Fisher & paykel	F&PN308	0	319	319	740
7	Fisher & paykel	N388	0	389	389	940
7	Westinghouse	FJ303	0	299	299	830
7	Liebherr	GI2303	0	225	225	640
7	Fisher & paykel	F&PN210/N210	0	213	213	610
7	Kelvinator	FN291	0	295	295	880
7	Fisher & paykel	F&PN150/N150	0	153	153	520
7	Kelvinator	FN360*	0	361	361	1230

Appendix 8: Refrigerators – algorithm discussion paper 2

Refrigerator Algorithm Discussion Paper 2

Prepared by Energy Efficient Strategies, 22 July 1998

Note that this document is a discussion paper which was supplied to the Working Group that was examining new algorithms for refrigerators in Australia. This document does not contain the final recommendations, but collects a range of relevant data for consideration and includes information which was used in their deliberations.

Background

During 1996 & 1997, RA Brown & Associates was commissioned by DPIE (on behalf of NAEEEC) to undertake a review of energy labelling program in Australia. A final report with a range of recommendations and suggestions was submitted in early 1998 (Brown 1998). Following a series of workshops in late 1997, the Appliance Labelling Review Committee was formed to consider the report by Brown, as well as other material, and to make final recommendations to NAEEEC regarding changes to the energy labelling program. The Review Committee met in early February and early April 1998. The Review Committee formed a refrigerator Algorithm Working Group to specifically consider revision of the star rating system for refrigerators and freezers.

A discussion paper outlining refrigerator algorithm issues and canvassing various proposals (including a review of Brown's proposals) was circulated to the Algorithm Working Group in early May 1998. A meeting of the Working Group was held on 15 May 1998 in Sydney to review the discussion paper and to develop further proposals. Minutes of the meeting were circulated in June 1998.

As this document is an internal working document, much of the background material is omitted for the sake of brevity as working group participants will be familiar with this information. Background information can be obtained from Lloyd Harrington of Energy Efficient Strategies if required.

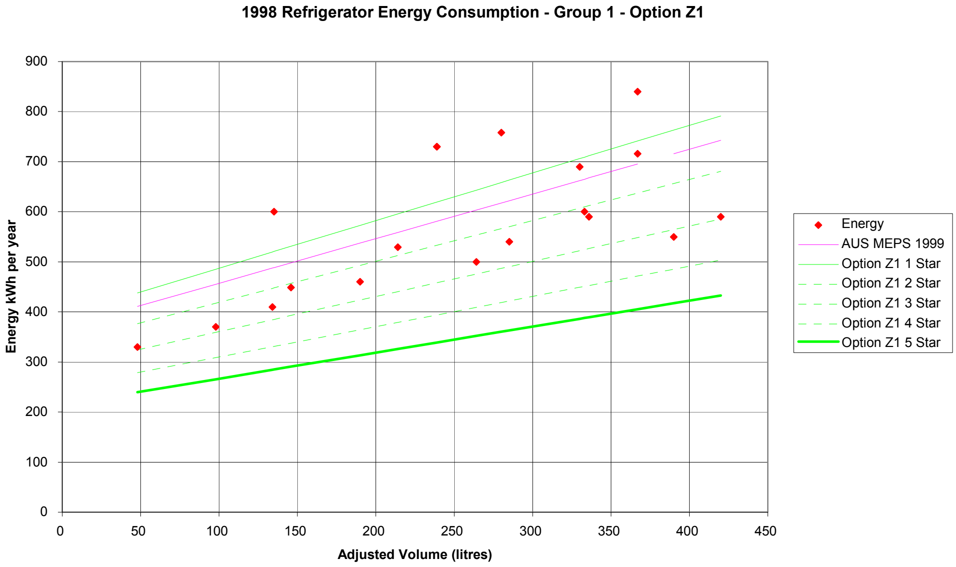
Overview of Options Developed at Working Group Meeting 15 May 1998

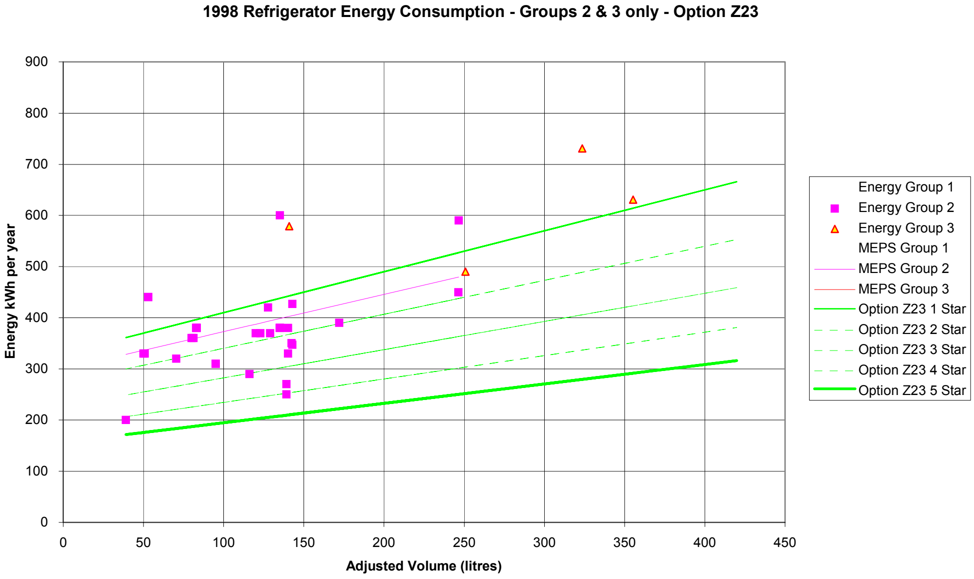
A range of preliminary refrigerator algorithm Options were developed at the Working Group meeting on 15 May 1998. Graphs of these were circulated to the Working Group on 17 May 1998. For the sake of completeness, these Options are included again in this paper. All of these Options had the prefix "Z".

- Working Group Option Z1 - Group 1 models, 1.5 Star at Group 1 MEPS line, 14% reduction per star.
- Working Group Option Z23 - Group 2 and 3 models, 1 Star at Group 3 MEPS line, 17% reduction per star.
- Working Group Option Z45 - Group 4 and Group 5 models, 1 Star at Group 5 MEPS line, 17% reduction per star.
- Working Group Option Z5S - Group 5S (side by side) models, 1 Star at Group 5S MEPS line, 17% reduction per star, no icemaker allowance.

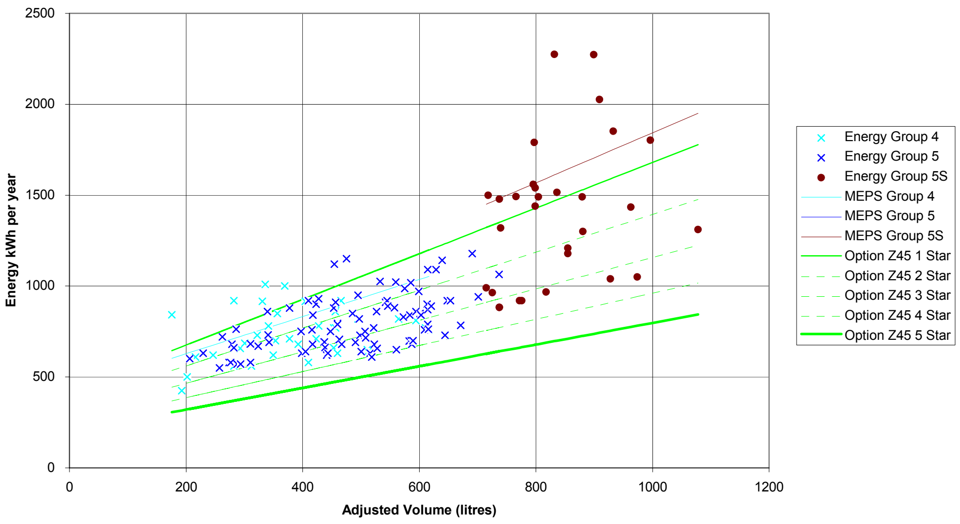
- Working Group Option Z6C - Group 6C (chest freezer) models, 1 Star at Group 6C MEPS line, 14% reduction per star.
- Working Group Option Z6U7 - Groups 6U and Group 7 models - 1 Star at Group 7 MEPS line, 14% reduction per star.

Note that where a MEPS line is shown in the legend but is not visible in the following graphs, it may be lying under the 1 Star line.

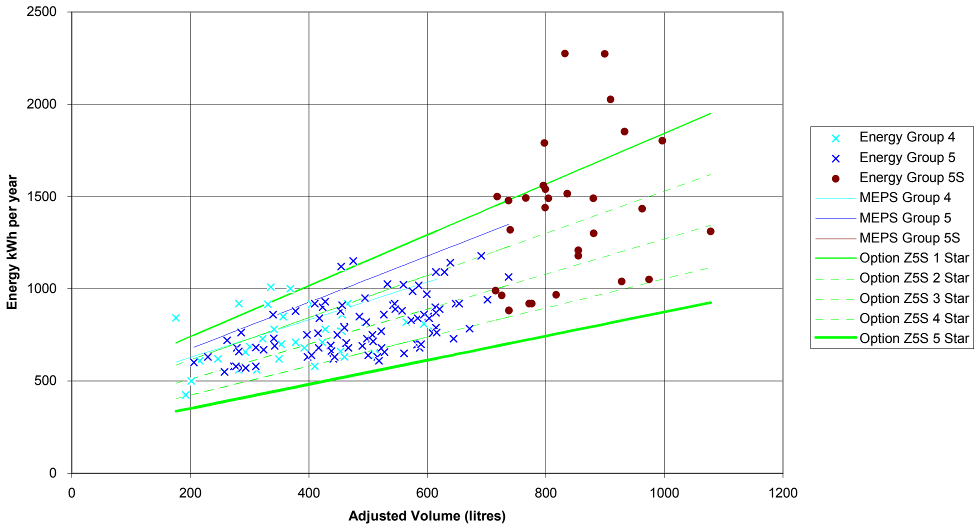




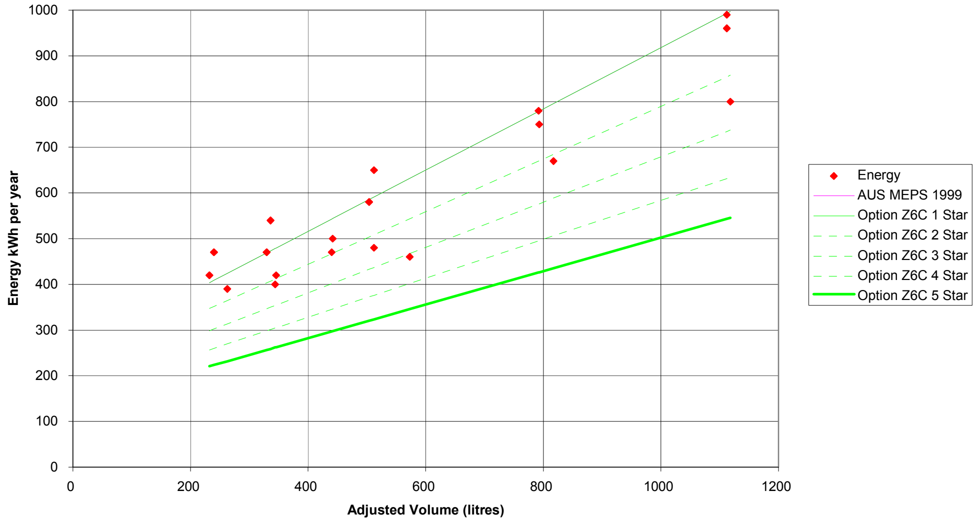
1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S - Option Z45

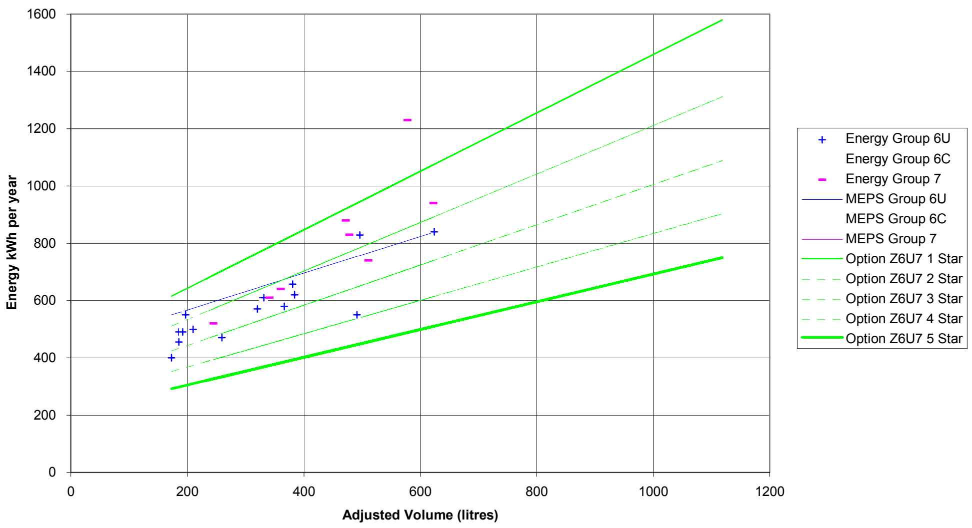


1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S - Option Z5S



1998 Refrigerator Energy Consumption - Group 6C - Option Z6C





1998 Refrigerator Energy Consumption - Groups 6U & 7 only - Option Z6U7

Summary of Recommended Changes

The preliminary algorithms developed at the Working Group meeting in May 1998 have been reviewed taking into account MEPS levels in Europe and the USA and the best models available in Europe and the USA, as well as further Australian data. On this basis, the following recommendations for change are being re-submitted back to the Algorithm Working Group for the consideration. Rationale for the changes is contained in the main body of the report.

Recommendation for Group 1 - Option G1

It is recommended that the 1 Star line for Group 1 be set at the Group 1 MEPS line with the energy reduction per star set at 17%.
1 Star = 368 + 0.892 × $V_{adj.}$

Recommendation for Groups 2 & 3 - Option G23

It is recommended that the 1 Star line for Groups 2 & 3 remain at the Group 3 MEPS line but with the energy reduction per star set at 20%.
1 Star = 330 + 0.800 × $V_{adj.}$

Recommendations for Groups 4, 5 & 5S - Option G45S

It is recommended that the 1 Star line for Groups 4, 5 & 5S be set at the Group 5S MEPS line (without icemaker allowance) with the energy reduction per star set at 23%.
1 Star = 465 + 1.378 × $V_{adj.}$

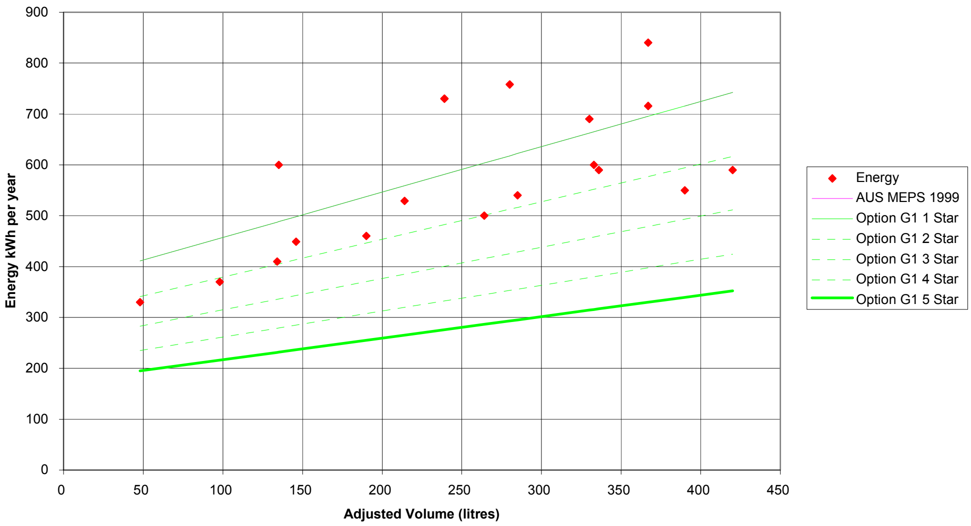
Recommendation for Group 6C - Option G6C

It is recommended that the 1 Star line for Group 6C be set at the Group 6C MEPS line with the energy reduction per star set at 17%.
1 Star = 248 + 0.670 × $V_{adj.}$

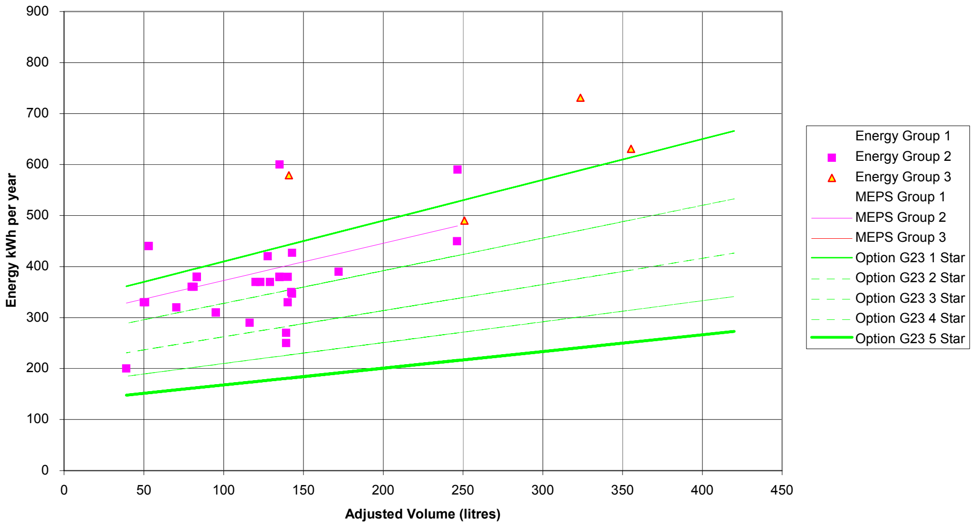
Recommendation for Groups 6U & 7 - Option G6U7

It is recommended that the 1 Star line for Groups 6U & 7 be set at the Group 7 MEPS line with the energy reduction per star set at 20%.
1 Star = 439 + 1.020 × $V_{adj.}$

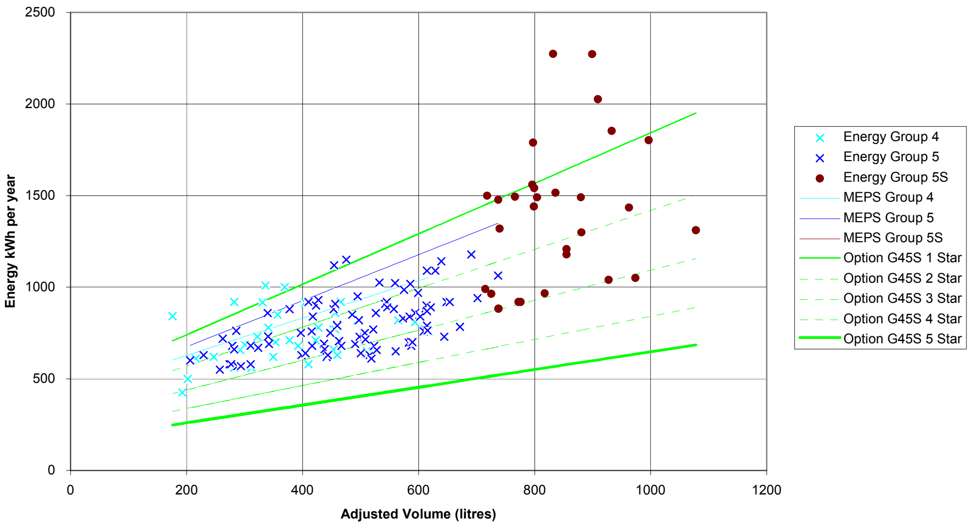
These revised Options (prefixed with letter "G") for each Group (or Group combination) are shown in the following graphs.



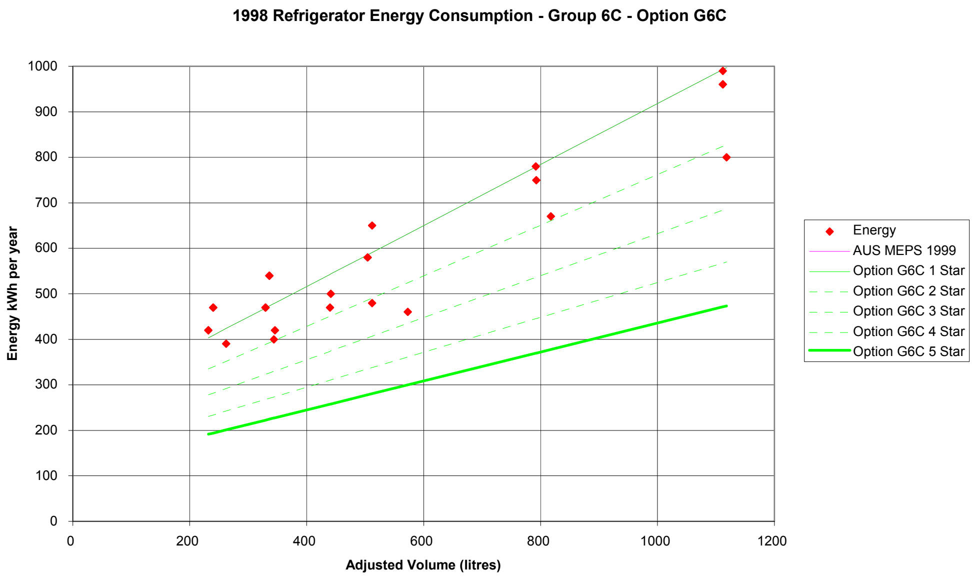
1998 Refrigerator Energy Consumption - Group 1 - Option G1

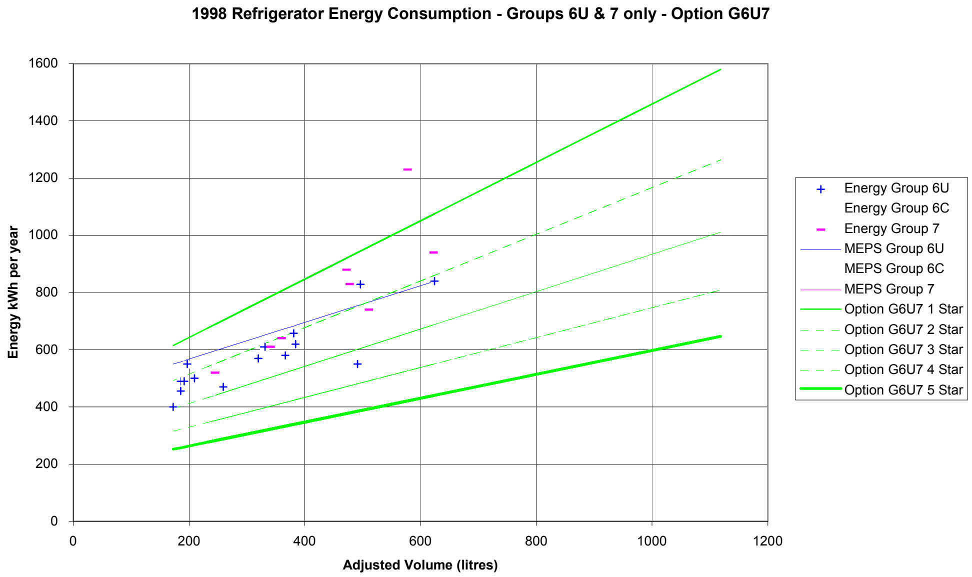


1998 Refrigerator Energy Consumption - Groups 2 & 3 only - Option G23



1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S - Option G45S


1998 Refrigerator Energy Consumption - Group 6C - Option G6C
Energy kWh per year
1000
900
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy
AUS MEPS 1999
Option G6C 1 Star
Option G6C 2 Star
Option G6C 3 Star
Option G6C 4 Star
Option G6C 5 Star


1998 Refrigerator Energy Consumption - Groups 6U & 7 only - Option G6U7
Energy kWh per year
1600
1400
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
Adjusted Volume (litres)
Energy Group 6U
Energy Group 6C
Energy Group 7
MEPS Group 6U
MEPS Group 6C
MEPS Group 7
Option G6U7 1 Star
Option G6U7 2 Star
Option G6U7 3 Star
Option G6U7 4 Star
Option G6U7 5 Star

Detailed Review of Algorithm Options by Group

Discussion for Group 1

Starting Point: Working Group Option Z1 - Group 1 models only, 1.5 Star at Group 1 MEPS line, 14% reduction per star.

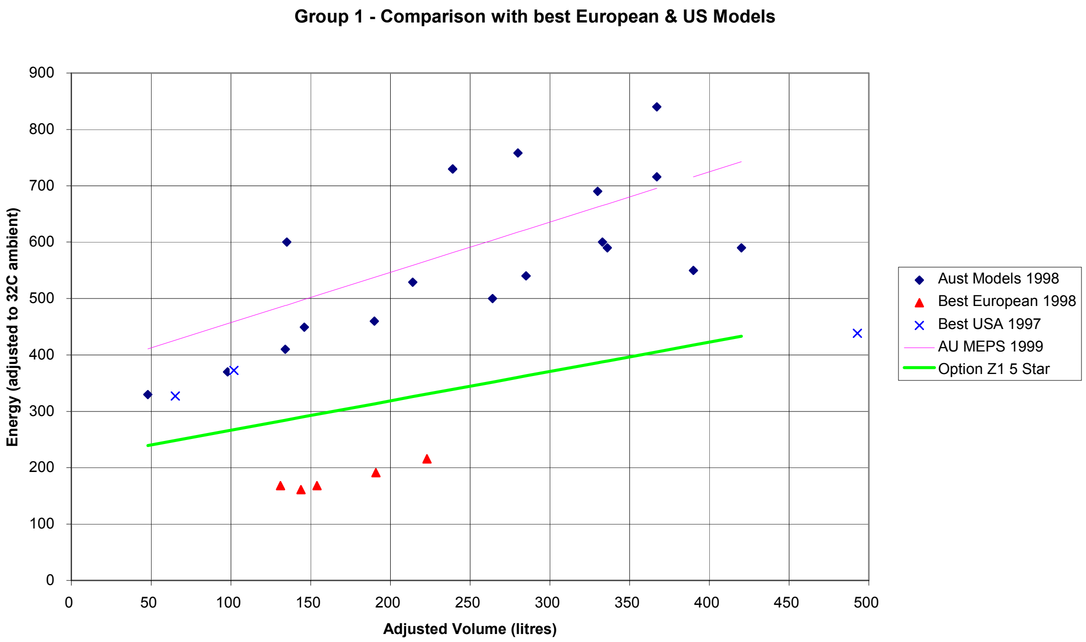
Final Recommendation for Group 1: It is recommended that the 1 Star line for Group 1 be set at the Group 1 MEPS line with the energy reduction per star set at 17%.

This is perhaps the most problematic group of any to be considered. The current range of energy consumption for Group 1 models on the market as of 1998 lies within a rather narrow band. Concern was expressed in the working group that setting the 1 Star line at the Group 1 MEPS level would put most models in the 1 star bracket, with only a few models at 2 stars. There was a concern expressed by some manufacturers that poor star ratings for Group 1 products might inadvertently direct people from Group 1 products to Group 2 or 3. An Option was developed in the working group to artificially overcome the low star ratings where the 1.5 Star line was set at the MEPS line for Group 1 with a rather narrow energy reduction of 14% per band.

Examination of market data for Group 1 suggests that the sales weighted average size is 335 litres (with most big selling units being larger than 250 litres), whereas the sales weighted average size for Group 2 is 106 litres (with most big selling units being well under 200 litres), so there would seem to be very little potential overlap between these Groups. Presumably most Group 1 models are sold as part of a “pigeon pair” (ie with a separate vertical freezer).

It is unclear why the range of energy consumption is so narrow for these models. Certainly, the requirement under AS/NZS4474.1 for Group 1 to be automatic defrost will mean that significant energy reductions will require careful and possibly significant design changes for some models. Group 1 is only a small part of the total market, with somewhat less than 10% of total refrigerator sales, so limited sales volumes have perhaps provided little incentive for manufacturers to undertake significant development work to date.

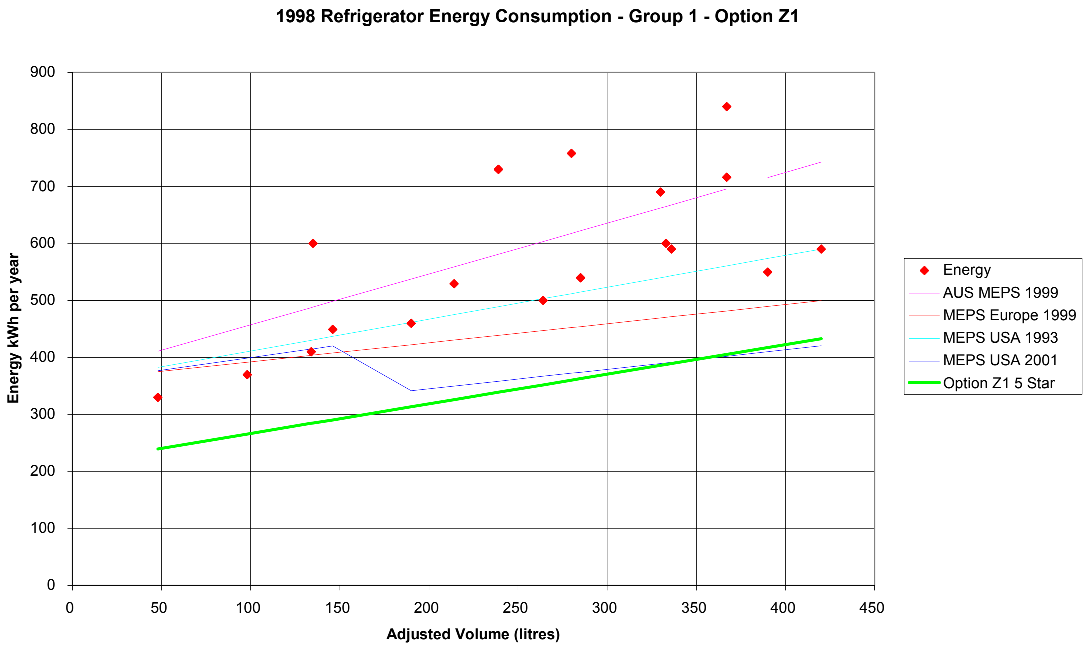
A review of the best Group 1 models currently available in Europe shows that their energy consumption is significantly lower than for equivalent Australian models. Note that European energy has been converted to an “equivalent” energy under the test conditions specified in AS/NZS 4474.1 (given that there is only a single compartment, the theoretical conversion should be reasonable, but still only indicative - see Appendix B). A few US models are also shown.



Only European models which have been clearly identified as automatic defrost have been included. Generally, the best European models consume less than 50% of the same sized better Australian models. The best European models rate about 7 stars (or better). Very few single door all refrigerators with automatic defrost are available in the USA (about 23 models out of about 2,700 refrigerator and freezer models). However, three are shown above - small models are similar to the better Australian models while the large model shown would easily rate better than 5 stars under Option Z1.

More information can be gleaned when the MEPS levels for Australia, Europe and the USA are examined. Only two small Group 1 models on the market at the moment would meet the European 1999 MEPS requirements. About 7 models currently meet the USA 1993 MEPS levels, but only the small models would meet the 2001 USA MEPS requirements. The 5 Star line for Group 1 under Option Z1 is approximately equal to the US 2001 MEPS level for larger models (remembering that the majority of sales are over 240 litres in size).

It is technically difficult to justify setting the MEPS line for Group 1 models at 1.5 Stars, given the broad principle adopted to set the 1 Star line at the MEPS line (where Groups are rated separately, or at one of the MEPS lines where Groups are combined for rating purposes). Also the energy reduction of only 14% per star makes the star bands rather narrow.



Given that the better models in Europe have already attained an energy consumption of about 30% to 40% below the proposed 5 Star energy under Option Z1, and that the few larger products available in the USA also already achieve 5 Stars, there is a strong case for making the Group 1 star ratings more stringent, even if the current products on the market in Australia only achieve one or two stars in the first instance.

A range of new options were examined. If the 1 Star line is set at the Group 1 MEPS line with a 17% reduction in energy per star (Option G1), the best European models still easily achieve 5 stars (although they lie considerably closer to the 5 Star line), while the larger US model achieves about 4 stars. Under this Option, seven Group 1 models rate 1 star (another six fail MEPS), but there are 4 models (50, 100, 260 and 420 litres) that achieve 2 stars and one model (390 litres) almost achieves 2.5 stars. Although this initially appears to be an onerous rating system for this Group, it should provide a robust longer term rating system.

Recommendation for Group 1

It is recommended that the 1 Star line for Group 1 be set at the Group 1 MEPS line with the energy reduction per star set at 17%.

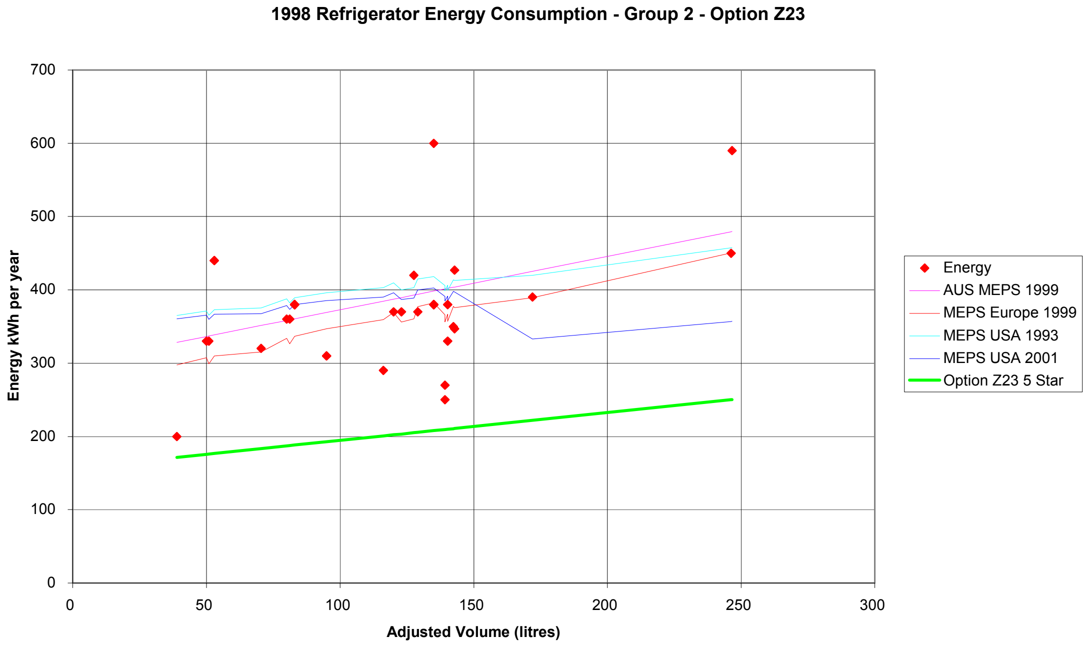
Discussion for Groups 2 & 3

Starting Point: Working Group Option Z23: 1 Star at Group 3 MEPS line, 17% reduction per star.

Final Recommendation for Groups 2 & 3: It is recommended that the 1 Star line for Groups 2 & 3 remain at the Group 3 MEPS line but with the energy reduction per star increased to 20%.

Option Z23 puts a Group 2 product of 40 litres and one of 140 litres on the 4 star line. Because the 1 Star Line is set at MEPS for Group 3, the lowest possible star rating for Group 2 models is about 1.5 stars after MEPS comes into force. There are only four Group 3 models on the market in 1998 and it appears that their market share is continuing to decline (less than 2% of refrigerator sales). Most Group 2 models are at the smaller end of the market (less than 150 litres). In Australia, Group 2 represents about 12% of total refrigerator sales and the share is stable (or declining slightly) and is equivalent to about 7% of total energy for new models sold.

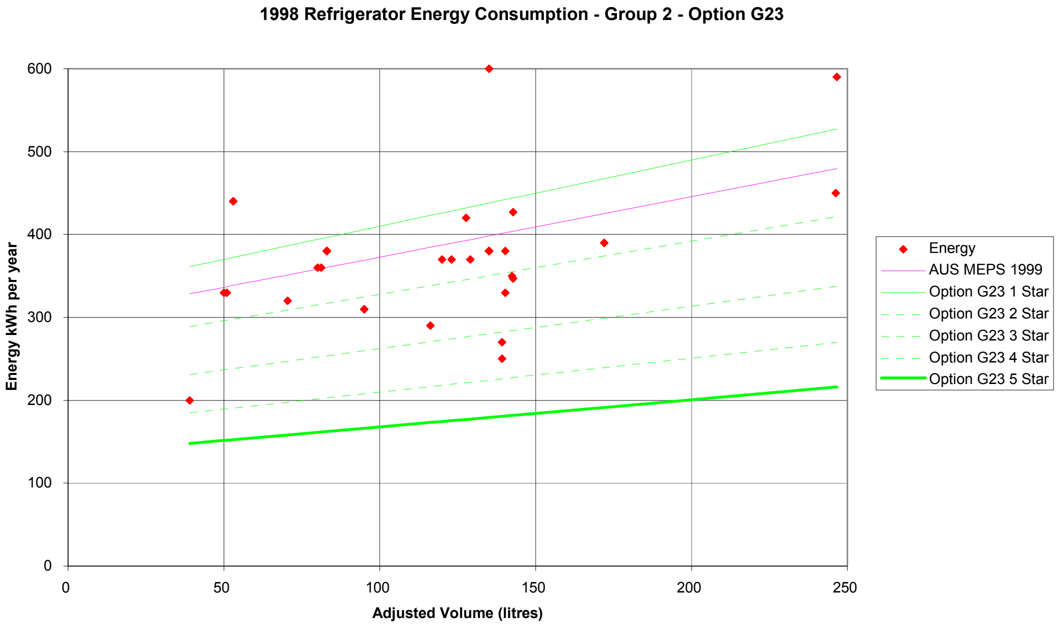
Considering the MEPS levels in Europe and the USA, the proposed Option Z23 5 star line is considerably lower than either, giving scope for future improvements. A significant number of Australian products available in 1998 already meet the European and all USA MEPS requirements for Group 2. However, it should be noted that the MEPS levels for this Group in the USA is not particularly stringent it only constitutes a very small market segment. Note also that US MEPS requirements for Group 2 and Group 3 products are the same.



There is concern that two products already achieve 4 stars under Option Z23. An obvious refinement would be to increase the energy step per star from the 17% to around 20% per star (shown as Option G23 - see below). This would put the best 2 models currently on the market in Australia at just over 3.5 stars (Kelvinator M142, Coola Can), with one other model at 3 stars and about 6 models with 2 or 2.5 stars, with star ratings which are largely unaffected under the revised option.

Recommendation for Groups 2 & 3

It is recommended that the 1 Star line for Groups 2 & 3 remain at the Group 3 MEPS line but with the energy reduction per star increased to 20% (as shown in Option G23 below for Group 2).



Discussion for Groups 4, 5 and 5S

Groups 4 & 5

Starting Point: Working Group Option Z45 - Group 4 and Group 5 models only, 1 Star at Group 5 MEPS line, 17% reduction per star.

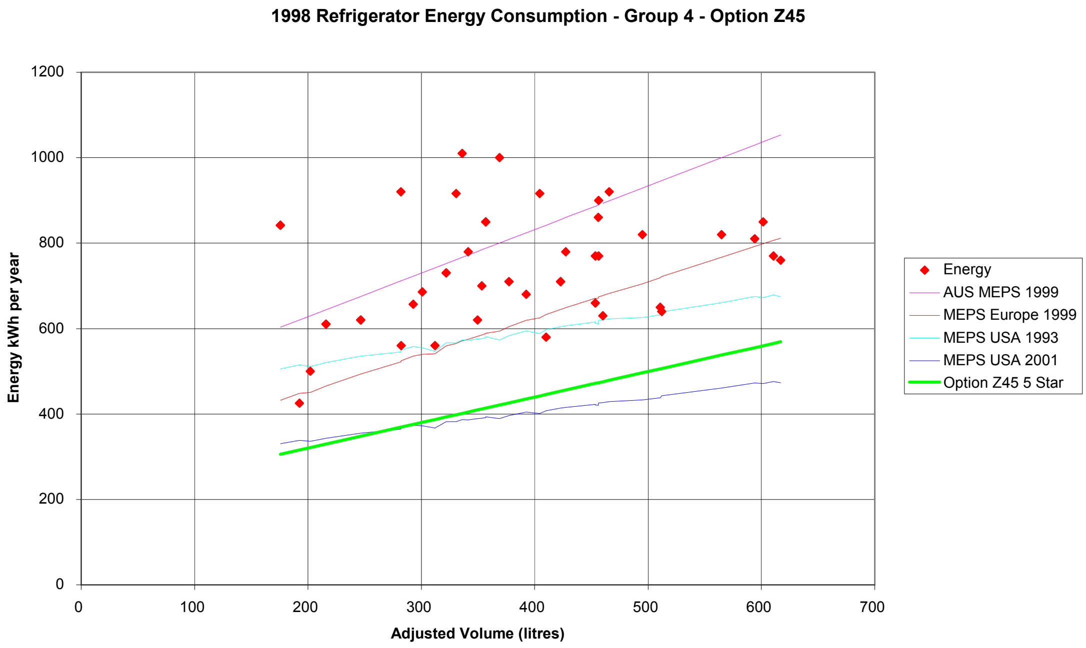
Starting Point: Working Group Option Z5S - Group 5S (side by side) models only, 1 Star at Group 5S MEPS line, 17% reduction per star, no icemaker allowance for the star rating (MEPS allowance for an icemaker remains).

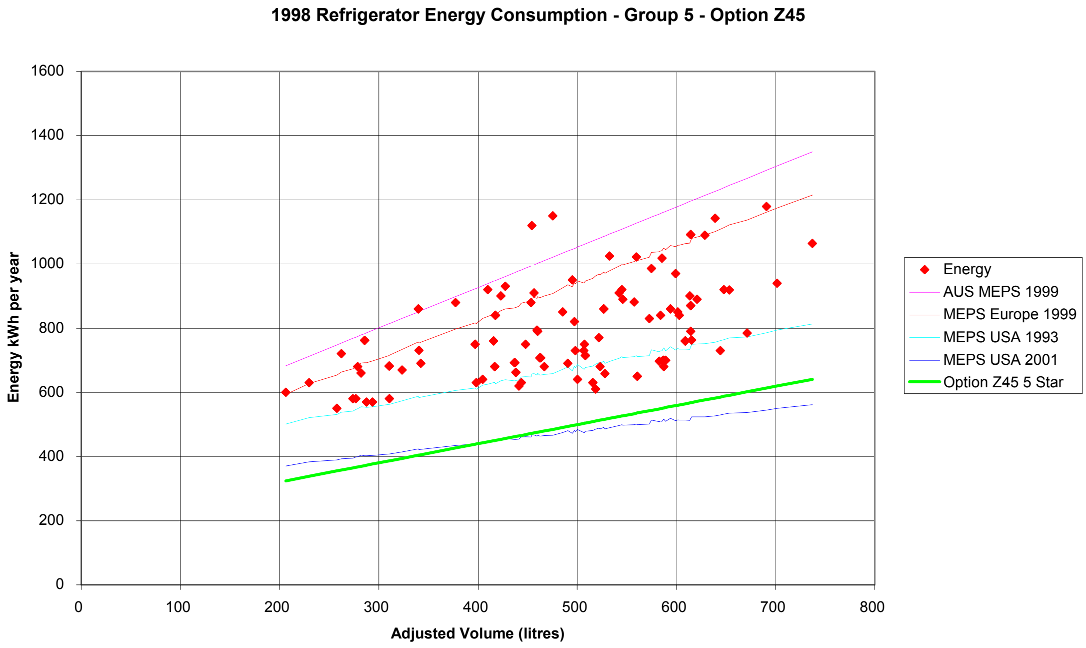
Final Recommendation for Groups 4, 5 & 5S: It is recommended that the 1 Star line for Groups 4, 5 & 5S be set at the Group 5S MEPS line (without icemaker allowance) with the energy per star set at 23% (as shown in Option G45S above for Groups 4, 5 & 5S).

This option sets the 1 star line for Groups 4 and 5 at the Group 5 MEPS line, therefore the lowest possible star rating for Group 4 models is about 1.7 stars after MEPS comes into force. Most Group 4 products are between 200 and 400 litres (sales weighted average of 316 litres), while most Group 5 products are between 200 and 550 litres (sales weighted average of 414 litres). Group 4 is currently about 20% of total refrigerator sales and declining slowly, while Group 5 is 45% of total sales and increasing. Together, these Groups cover nearly two thirds of all refrigerators sold, but are equivalent to nearly 80% of energy and value of new sales and are therefore the most important Groups to consider during the revision of the labelling algorithms.

Under Option Z45 five 5 Group 4 models have 3.5 stars, but none reach 4 stars. Also there are about ten Group 5 models with 3.5 stars and one with 4 stars.

Considering the MEPS levels in Europe and the USA, the proposed Option Z45 5 star line approximately equal to the 2001 US MEPS levels for both Group 4 & 5. A handful of Australian Group 4 products available in 1998 meet the European 1999 & USA 1993 MEPS requirements. None would currently meet the USA 2001 MEPS requirements. Most Group 5 products in Australia in 1998 meet the 1999 European requirements, but these requirements are relatively weak due to the additional 1.2 volume adjustment factor for compartments using forced air. Australian MEPS levels for Group 4 & 5 are weak in comparison to equivalent USA 1993 MEPS levels (20% to 40% lower energy). A handful of Group 5 products in Australia in 1998 meet the USA 1993 MEPS requirements, and while none currently meet the 2001 requirements, some are reasonably close.

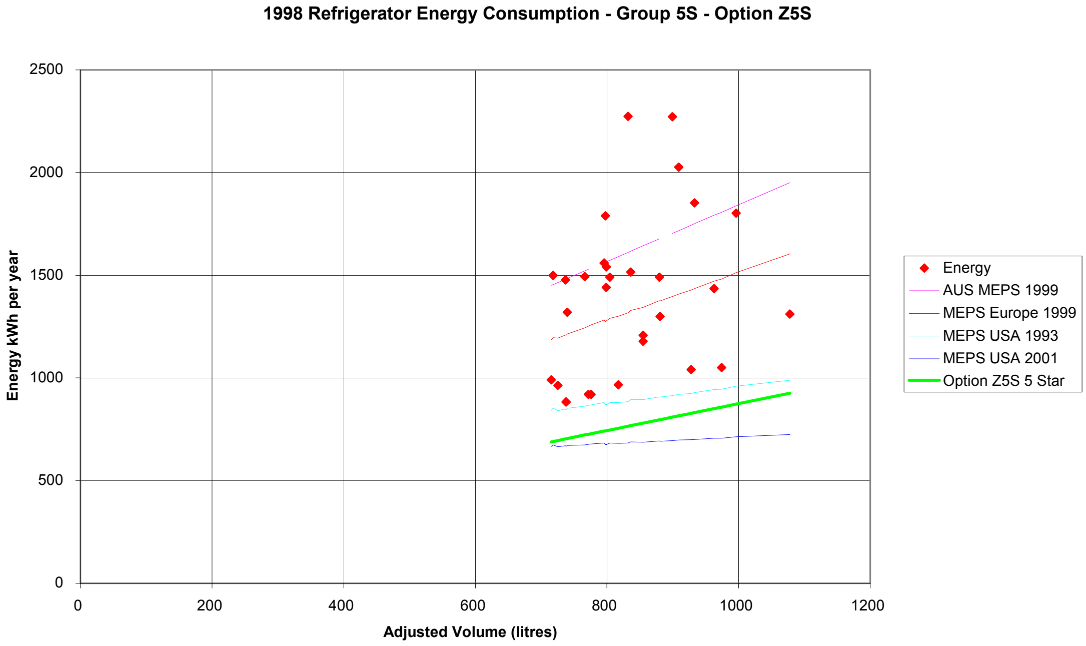




Group 5S

Starting Point: Working Group Option Z5S - Group 5S (side by side) models only, 1 Star at Group 5S MEPS line, 17% reduction per star, no icemaker allowance for the star rating (MEPS allowance for an icemaker remains).

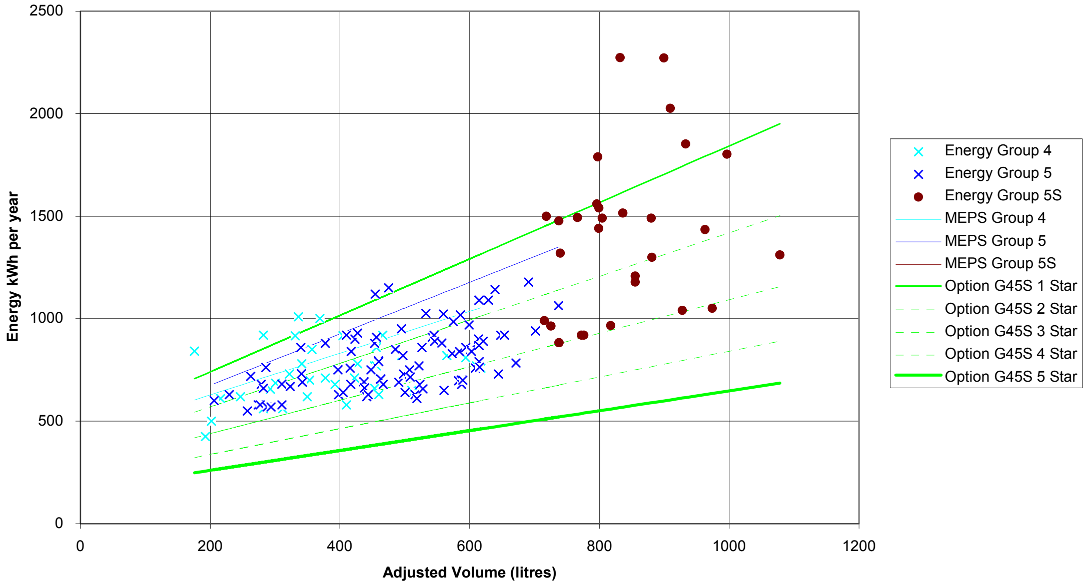
Under Option Z5S a range of Group 5S products are just under the 4 star cusp. The 5 star line under this Option generally lies between the USA 1993 & 2001 MEPS lines.



There is some concern at having so many products close to the 4 star cusp under both Options Z45 and Z5S - this means that only a 17% reduction in energy is required for the better products in these Groups to achieve a 5 star rating (about 100 kWh in 600). This may give the rating system a shorter life than is desirable.

One possible option is to increase the step of the star rating scale for Groups 4, 5 & 5S to around 20%. Another option, which simplifies the requirements somewhat, is to combine Groups 4, 5 & 5S with the 1 star line set at the Group 5S MEPS line with a star reduction of 23% per star (Option G45S). This sets the best the Group 5 products to be about 3.5 stars, with the best Group 4 & 5S products at about 3 stars. This has the advantage of a single rating specification for all nominal “2 door” refrigerator-freezers. This system puts the 3 star line about equal to the US 1993 MEPS level and the 5 star line just below the USA 2001 MEPS line for all three Groups, which should ensure a reasonable life span. Under this system, Group 5 MEPS is set at about 1.3 Stars, while the Group 4 MEPS is set at about 1.8 Stars.

1998 Refrigerator Energy Consumption - Groups 4, 5 & 5S - Option G45S

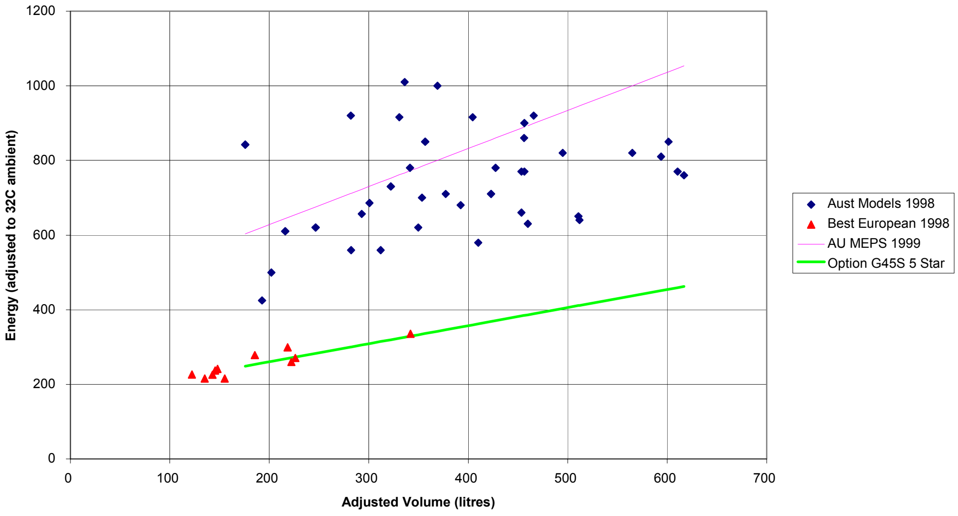


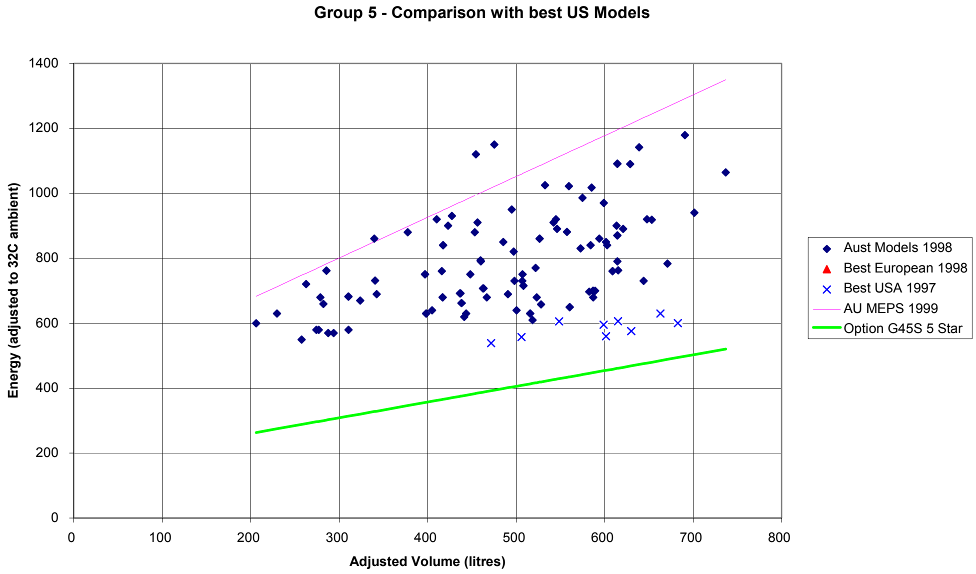
Further confirmation of the robustness of this system can obtained by comparing the proposed system with overseas data for refrigerator-freezers. The Option G45S 5 Star line is equal to about the best Group 4 models currently available in Europe in 1998 (all 4 star freezer, 2 door models with automatic defrost in the fresh food compartment). The best Group 5 models (top mounted freezer) in the US in 1997 obtain just over 4 Stars under the Option G45S while the best side by side models in 1998 (Group 5S) in the US obtain about 4.5 stars. Note that these Group 5S models have through the door ice dispensers.

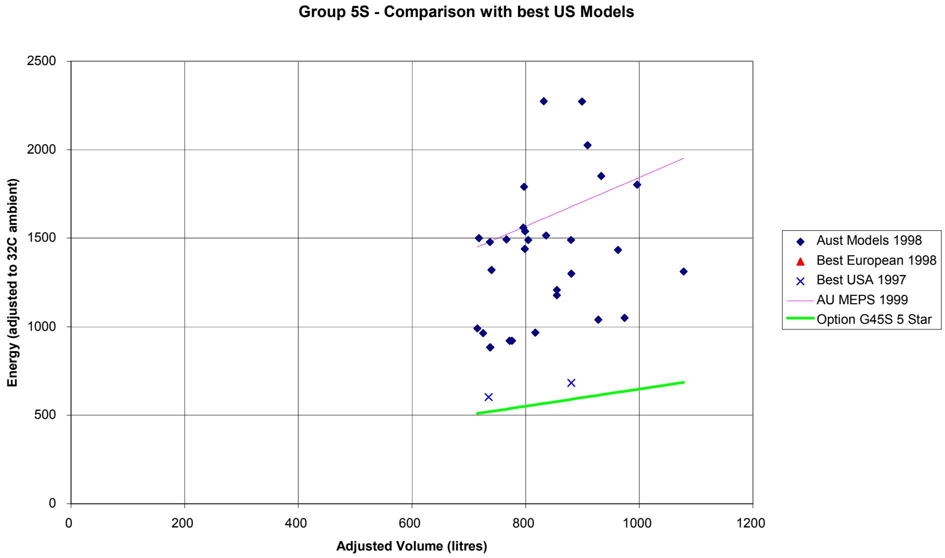
Recommendation for Groups 4, 5 & 5S

It is recommended that the 1 Star line for Groups 4, 5 & 5S be set at the Group 5S MEPS line (without icemaker allowance) with the energy per star set at 23% (as shown in Option G45S above for Groups 4, 5 & 5S).

Group 4 - Comparison with best European Models







Discussion for Groups 6U, 6C & 7

Starting Point: Working Group Option Z6C - Group 6C (chest freezer) models only, 1 Star at Group 6C MEPS line, 14% reduction per star.

Starting Point: Working Group Option Z6U7 - Groups 6U and Group 7 - 1 Star at Group 7 MEPS line, 14% reduction per star. Group.

Final Recommendation for Group 6C: It is recommended that the 1 Star line for Group 6C be set at the Group 6C MEPS line with the energy reduction per star set at 17%.

Final Recommendation for Groups 6U & 7: It is recommended that the 1 Star line for Groups 6U & 7 be set at the Group 7 MEPS line with the energy reduction per star set at 20%.

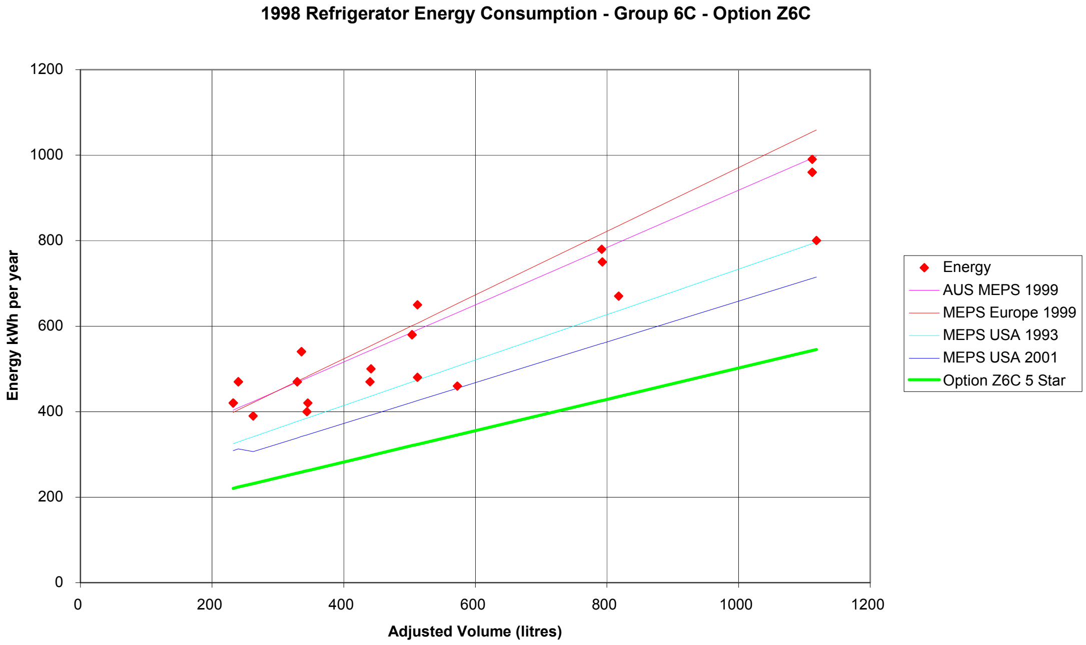
The Working Group concluded that chest freezers and vertical freezers are quite different products and that consumers are unlikely to choose between them as alternatives under normal circumstances (top access versus front access means that they are not usually interchangeable within a particular space). This seems to be reasonable approach for labelling of freezers. Also given the radically different energy characteristics of chest freezers (much lower energy per unit of volume), a combined rating system tends to rate the technology rather than differentiate between models of a particular configuration (see Discussion Paper 1, May 1998).

The attributes of the freezer market in Australia in 1996 are shown below. Although the sales share of Group 7 products is low, the high average price of these products makes the total sales value similar for each of the three product Groups. The sales of Group 7 freezers are increasing while both Group 6U and 6C are declining slowly.

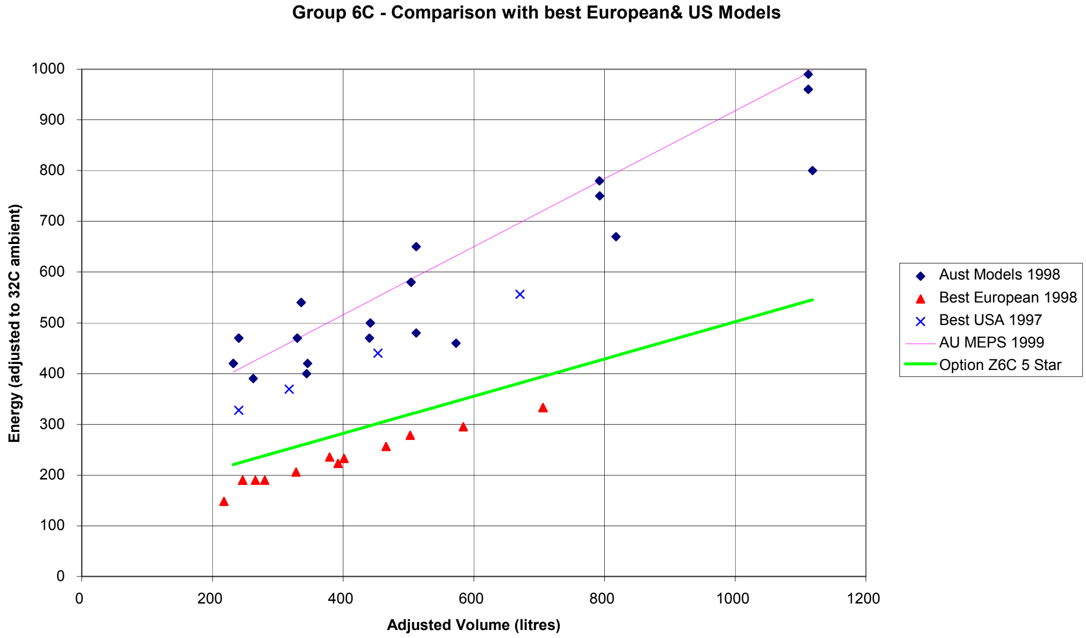
Attribute	Class 6U Vert Fz	Class 6C Chest Fz	Class 7 FF Vrt Fz
Sales	41%	37%	22%
Volume (L)	179	217	319
Energy kWh/yr	566	442	884
Average Price	$543	$533	$1,086
Energy Share	38.8%	27.6%	33.5%

Group 6C

The Option Z6C rates chests freezers separately and sets the 1 star line at the MEPS line. Under this system the best chest freezer just obtains a 3 star rating. The 5 Star line is significantly lower than USA 2001 MEPS line. The USA 1993 MEPS level is approximately equal to 2.5 stars under this system. The European 1999 MEPS level is approximately equal to Australian 1999 MEPS level. The best Australian model currently almost meets the USA 2001 MEPS requirements.



In the USA at the moment, there is currently very little differentiation in the freezer market, as most models just meet the USA 1993 MEPS requirements - these tend to be at the better end of the Australian market. However, it is useful to consider the best models available in Europe in 1998. Most of these easily attain 5 stars as shown below.

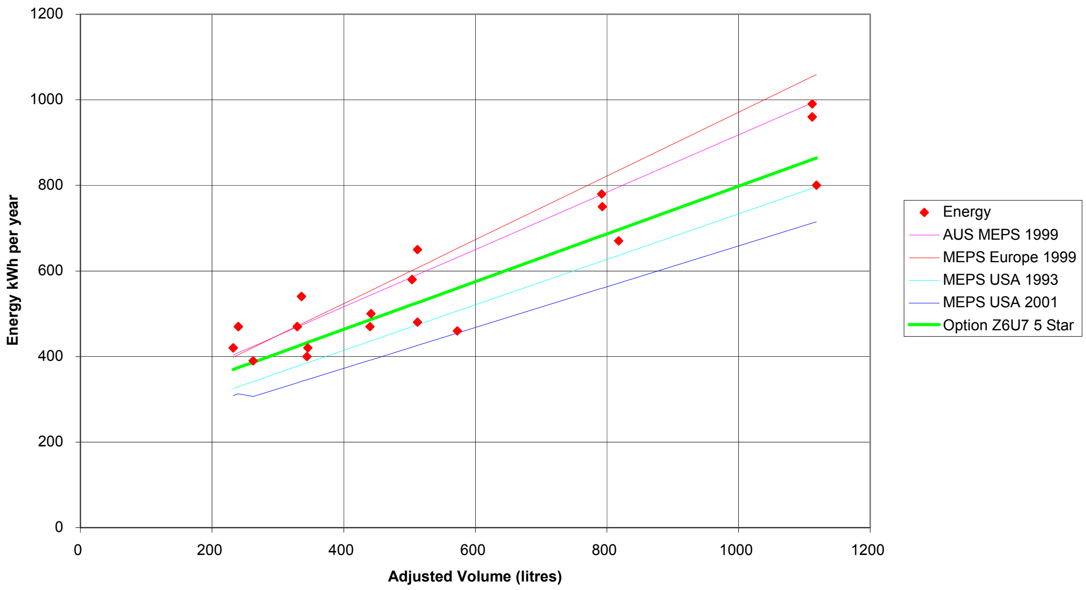


If the energy per star was increased to 17%, then the 5 Star line would be approximately equal to the best models currently available in Europe. This would set most chest freezers at 1 star, with two models at just over 2 stars and one model at 2.5 stars. This also partly overcomes the problems with narrow energy bands per star.

Groups 6U & 7

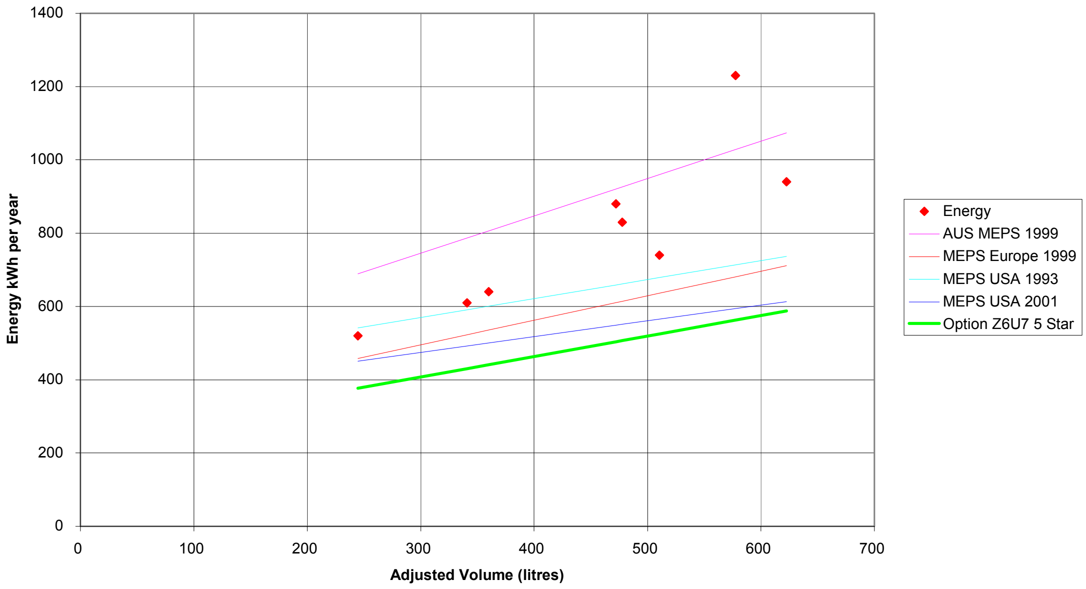
The Option Z6U7 rates vertical freezers together and sets the 1 star line at the Group 7 MEPS line. Under this system the best Group 6U freezer nearly obtains a 4 star rating, while two other models rate over 3 stars. The Group 6U 5 Star line is about equal to the USA 2001 MEPS line. The USA 1993 MEPS level is approximately equal to 4 to 4.5 stars under this system (note that there is very little decrease in energy between USA 1993 MEPS and 2001 MEPS). The European 1999 MEPS is midway between the USA 1993 MEPS and the Australian 1999 MEPS level. No models currently on the market meet the USA 1993 MEPS levels.

1998 Refrigerator Energy Consumption - Group 6C - Option Z6U7

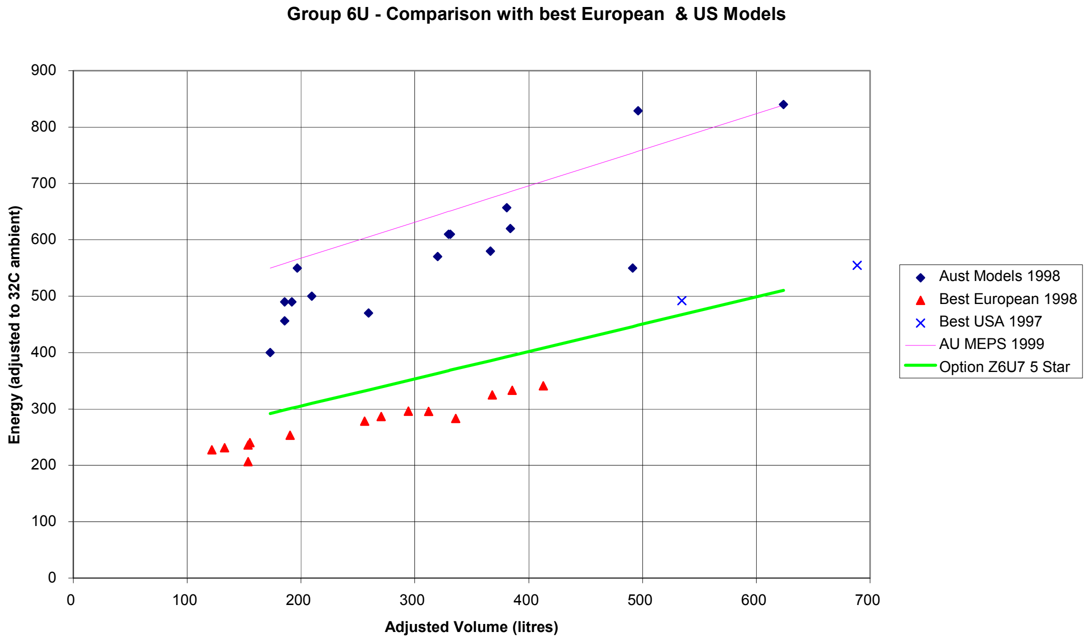


Under Option Z6U7 the best Group 7 freezer obtains nearly 2.5 stars, while three others obtain 2 stars, with three models at 1 Star (1 model fails MEPS). The 5 Star line is below the USA 2001 MEPS line for Group 7. The USA 1993 MEPS level is approximately equal to 2.5 stars under this system (note that there is only a small decrease in energy between USA 1993 MEPS and 2001 MEPS). The European 1999 MEPS is midway between USA 1993 & 2001 MEPS. One model currently on the market meets the USA 1993 MEPS levels.

1998 Refrigerator Energy Consumption - Group 7 - Option Z6U7



In the USA at the moment, there is currently very little differentiation in the freezer market, as most models just meet the USA 1993 MEPS requirements. However, it is useful to consider the best models available in Europe in 1998 (noting that there are virtually no frost free freezers in Europe at this stage). US models available in 1997 would rate about 4.5 stars, while the best models in Europe would rate well over 5 stars.



If the energy per star was increased to 20%, then the 5 Star line would be approximately equal to the best Group 6U models currently available in Europe. US freezers would generally rate between 3 and 4 stars. This would set most Australian Group 6U freezers at 2 stars, with one model at 3 stars and one at 3.5 stars. This would also set three Group 7 freezers at 1 stars, with four models at 2 stars (much the same as the previous Option Z6U7).

Recommendation for Group 6C

It is recommended that the 1 Star line for Group 6C be set at the Group 6C MEPS line with the energy reduction per star set at 17%.

Recommendation for Groups 6U & 7

It is recommended that the 1 Star line for Groups 6U & 7 be set at the Group 7 MEPS line with the energy reduction per star set at 20%.

Next Steps

These Options will be further considered and refined by the refrigerator Algorithm Working Group meeting before recommendations are presented to NAEEEC.

Further information can be obtained from:

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Appendix A
Calculating EER for Each Model

Under the geometric progression used, the EER for a model is calculated as follows:

Firstly calculate ratio of CEC to 1 Star Energy line for the model:

$E_{ratio} = \text{CEC} \div (1 \text{ Star Energy})$

Where:
CEC is the Comparative Energy Consumption shown on the energy label kWh/year
1 Star Energy is V_{adj} * Slope + Intercept as defined for the Group(s)
V_{adj} is the adjusted volume of the model in litres (as per AS/NZS4474.2)
Slope is the slope of the 1 Star line (kWh/year/adjusted litre)
Intercept is the Y intercept of the 1 Star line (kWh/year at zero litres)

The EER (Star rating) of a model can be calculated as follows:

$\text{EER} = 1 + (\ln (E_{ratio}) \div \ln (1 - \text{Reduction}))$

Where:
- ln is the base e log of the number in brackets (base 10 can be used if desired)
- Reduction in CEC (Energy) is per star rating (eg 17% per star)

Alternatively, the star rating can be looked up in the table below.

Similarly, E_{ratio} from the 1 Star line can be calculated for any EER as follows:

$E_{ratio} = \exp ((\text{EER} - 1) \times \ln (1 - \text{Reduction}))$

Example E_{ratio} values for various star ratings are shown below.

Reduction	17%	20%	23%
Stars	E_{ratio}	E_{ratio}	E_{ratio}
1	1	1	1
1.5	0.911	0.894	0.877
2	0.830	0.800	0.770
2.5	0.756	0.716	0.676
3	0.689	0.640	0.593
3.5	0.628	0.572	0.520
4	0.572	0.512	0.457
4.5	0.521	0.458	0.401
5	0.475	0.410	0.352

E_{ratio} is the ratio of the measured energy to the 1 Star Energy for that model.
Reduction is energy reduction per additional star.

For example, a model with a CEC of 493 kWh where the 1 Star Energy consumption is 656 kWh would have an energy ratio of 0.7515. This would equate to 3 stars under 17% reduction per star and 2.5 stars under 20% and 23% reduction.

Appendix B: Notes Regarding Comparison with European and USA MEPS

European MEPS for refrigerators come into force in October 1999. The requirements are set out in Directive 96/57/EC dated 3 September 1996. The USA first had MEPS for refrigerators in 1990 (notified in 1987). These were upgraded in 1993 (notified in 1990). On 28 April 1997, the DOE issued new MEPS levels for refrigerators to come into force on 1 July 2001. The requirements for 1993 and 2001 are set out in the Federal Register, Volume 62, Number 81, pages 23102-23116. Copies are available on request.

The proposed 5 Star rating lines are compared with MEPS levels due to come into force in Europe in 1999 and the various US MEPS levels. It should be noted that the European levels are measured under the ISO test procedure (ambient temperature of 25^{o}C), so the energy consumption has been converted to an equivalent energy that would be theoretically obtained under the Australian standard (using heat gain estimates for each compartment temperature and expected changes in compressor COP). These values should be treated as indicative rather than absolute. In the case of the USA, the ambient test condition is 32^{o}C (the same as the Australian standard) so the “conversion” factors are generally small (except for the fixed adjustment factors used for freezer energy: 0.85 for vertical freezers and 0.7 for chest freezers). Again, the energy values should be treated as indicative rather than absolute.

Both USA and Europe use net volume to define their MEPS levels. Estimated net volumes have been used where the actual values are not known by model. The MEPS levels for Europe and the USA have been plotted against Gross volume, so there are some small discontinuities in the European/USA MEPS lines, especially for small models where there are some significant differences between net and gross (these would disappear if models were plotted against net volume, but the Australian MEPS lines would then show some discontinuities).

In the 1997 rule for 2001, the DOE identified a group of products known as “compact” models. These are defined as having a volume of less than 7.75 cu ft (219.4 litres) AND a height of less than 36” (914 mm). The DOE estimates that compact models use less than 2.5% of all energy consumed by refrigerator products in the USA. They also concluded that the design options for these smaller models were more limited and therefore in 2001 the MEPS levels have been held at the 1993 level for compact products. In 2001, compact products are subject to a reduction in energy, but their MEPS levels remain significantly less stringent cf non-compact products.

Generally speaking, most models in Australia that fall into the compact category are less than 150 litres. Most chest freezers are on the height boundary, but they have generally been treated as non-compact for the purposes of this analysis.

Summary of US Refrigerator MEPS Levels - non HCFC products

Equiv	Equiv	Non HCFC products	US 1993	US 1993	US 2001	US 2001
AUS Class	US Class	US Product Description	Fixed kWh	Slope metric	Fixed kWh	Slope metric
1	3	All Refrigerator A/D	355	0.57	355	0.45
2	1	Manual Defrost Ref. & Refr-Freezer	299	0.48	248.4	0.31
3	1	Manual Defrost Ref. & Refr-Freezer	299	0.48	248.4	0.31
4	2	Refr-Freezer & Partial Auto-Defrost Refr-Freezer	398	0.37	248.4	0.31
5	3	Top-Mount A-D Refr-Freezer	355	0.57	276	0.35
6U	8	Upright Manual Defrost Freezer	264	0.36	258.3	0.27
7	9	Upright A-D Freezer	391	0.53	326.1	0.44
10 *	13	Compact All refrigerator	355	0.57	355	0.45
20 *	11	Compact Manual Defrost Refr-Freezer	299	0.48	299	0.38
40 *	12	Compact Partial Defrost Refr-Freezer	398	0.37	398	0.25
50 *	13	Compact Top-Mount A-D Refr-Freezer	355	0.57	355	0.45
51 &	5	Bottom-Mount A-D Refr-Freezer	367	0.58	459	0.16
5S	4	Side-Mount A-D Refr-Freezer	501	0.42	507.5	0.17
5S **	7	Side-Mount A-D with TTD Features	527	0.58	406	0.36
60	16	Compact Upright Manual Defrost Freezer	264	0.36	250.8	0.35
6C	10	Chest Freezers	160	0.39	143.7	0.35
70 *	17	Compact Upright A-D Freezer	391	0.53	391	0.40
510 *&	15	Compact Bottom-Mount A-D Refr-Freezer	367	0.58	367	0.46
520 *	14	Compact Side-Mount A-D Refr-Freezer	501	0.42	501	0.27
610 *	18	Compact Chest Freezer Manual Defrost	160	0.39	152	0.37
999 #	6	Top-Mount A-D with TTD Features	391	0.62	356	0.36

Notes: A-D = automatic defrost, Slope is kWh per adjusted litre, FAF for Freezers is 1.63 (1.73 sep fz)

TTD Through the door ice/water dispenser.
* compact products are identified separately for analysis purposes only
** TTD features in Australia get 120 kWh MEPS allowance, US specify slopes separately
# top mounted freezer refrigerator-freezer products with TTD are not yet available in Australia
& MEPS for bottom mounted freezer products in Group 5 have not been separately identified

Source: US Department of Energy Code of Federal Regulations, Federal Register, Volume 62, Number 81, page 23116, 28 April 1997.

Appendix 9: Refrigerators – algorithm recommendations

Refrigerator Algorithm Working Group

Summary Report and Recommendations to the Energy Labelling Review Committee

Prepared by Energy Efficient Strategies, 14 August 1998

Background

During 1996 & 1997, RA Brown & Associates was commissioned by DPIE (on behalf of NAEEEC) to undertake a review of energy labelling program in Australia. A final report with a range of recommendations and suggestions was submitted in early 1998 (Brown 1998). Following a series of workshops in late 1997, the Energy Labelling Review Committee was formed to consider the report by Brown, as well as other material, and to make final recommendations to NAEEEC regarding changes to the energy labelling program. The Review Committee met in February and April 1998. The Review Committee formed the refrigerator Algorithm Working Group to specifically consider revision of the star rating system for refrigerators and freezers.

The Refrigerator Algorithm Working Group consisted of:

- Terry Fogarty - Whirlpool (CESA)
- Robert Wooley - Sharp (CESA)
- Dick Brown - Email (AEEMA)
- Ian Lincoln - Email (AEEMA)
- Bruce Buchtmann - Email (AEEMA)
- Vince Moses - Email (AEEMA)
- Stefan Lofhelm - Southcorp (AEEMA)
- Lindsey Roke - Fisher & Paykel (AEEMA)
- Lloyd Harrington - EES (NAEEEC)
- David Cogan - EECA (NAEEEC)
- Jill McCarthy - AGO (NAEEEC) (Chair)
- Megan Smith - AGO (NAEEEC)
- Tony Marker - AGO (NAEEEC)

Two discussion papers were prepared by EES and circulated to the working group:

- Discussion Paper 1 - 11 May 1998
- Discussion Paper 2 - 22 July 1998

The Algorithm Working Group met in Sydney at Standards Australia on:

- 15 May 1998
- 7 August 1998

Note that not all members attend both working group meetings. Copies of the minutes of the meetings and the discussion papers are available from AGO on request.

In the development of its conclusions, the working group considered a wide range of data including information on current models on the Australian market, the MEPS levels in Australia for 1999 and the degree of technological development within each Group. Data on refrigerator MEPS levels in the USA in 1993 and 2001, MEPS in Europe in 1999 and selected data on the best models currently available in Europe and USA were also considered, but industry representatives questioned the use and validity of the conversion factors in this comparison. It was also noted that some overseas models may not meet the performance requirements specified in the Australian Standard and so the energy consumption is not directly comparable.

Formal Working Group Recommendations

1. The proposals for revised algorithms outlined in this paper be accepted by the Energy Labelling Review Committee, noting that the issue of whether to introduce the new label to all product groups in series or in parallel is still to be determined.
2. If approved, these recommendations be forwarded to NAEEEC for their consideration and approval.
3. The Refrigerator Algorithm Working Group be authorised to prepare a draft version of AS/NZS 4474.2 containing these new rating algorithms, also for consideration by NAEEEC.
4. If approved by NAEEEC, that the draft version of AS/NZS 4474.2 be considered by a meeting of Standards Committee EL15/23 and issued as a public comment draft as soon as possible.

General Working Group Findings & Recommendations

It was agreed that the Australian 1999 MEPS lines would define the 1 star line for each refrigerator Group. The exception was that where a number of Groups were rated on the same basis because they are interchangeable from a consumer perspective, then the highest (least stringent) MEPS line would define the 1 star line for these Group combinations. Therefore as a general rule, no products would have an EER of less than 1.0 (although there are isolated cases where this may occur due to MEPS feature allowances).

It was agreed that each additional star should be earned on the basis of a fixed percentage reduction in the energy used (ie a geometric progression) rather than the current system which requires a fixed kWh reduction per star (linear progression).

Based on the results of preliminary tests undertaken by Email, it was agreed that there is no technical basis for an additional volume adjustment factor of 1.2 for frost free compartments as proposed by Brown in his January 1998 report.

It was agreed that, where a feature could be shown to save “in-use” energy, but that this energy saving was not reflected in the tested energy consumption under the Australian Standard, that the standard’s committee would formally consider the matter and where appropriate incorporate such “savings” either into the rating algorithm or the tested energy consumption, as appropriate. However, until such a feature has been shown to save energy (or incur an energy penalty), such factors will not be included.

It was noted that feature allowances under MEPS (eg additional door allowance, icemaker allowance) are government concessions which allow some products to remain on the market (which otherwise would have failed MEPS), on the basis that the presence of the particular feature is reasonable and that additional energy consumption under the test procedure is normally associated with the presence of the feature.   The feature allowance in these cases may bear no relation to the energy saving that a consumer may or may not achieve as a result of the presence of the feature.

Specific Algorithm Recommendations by Group

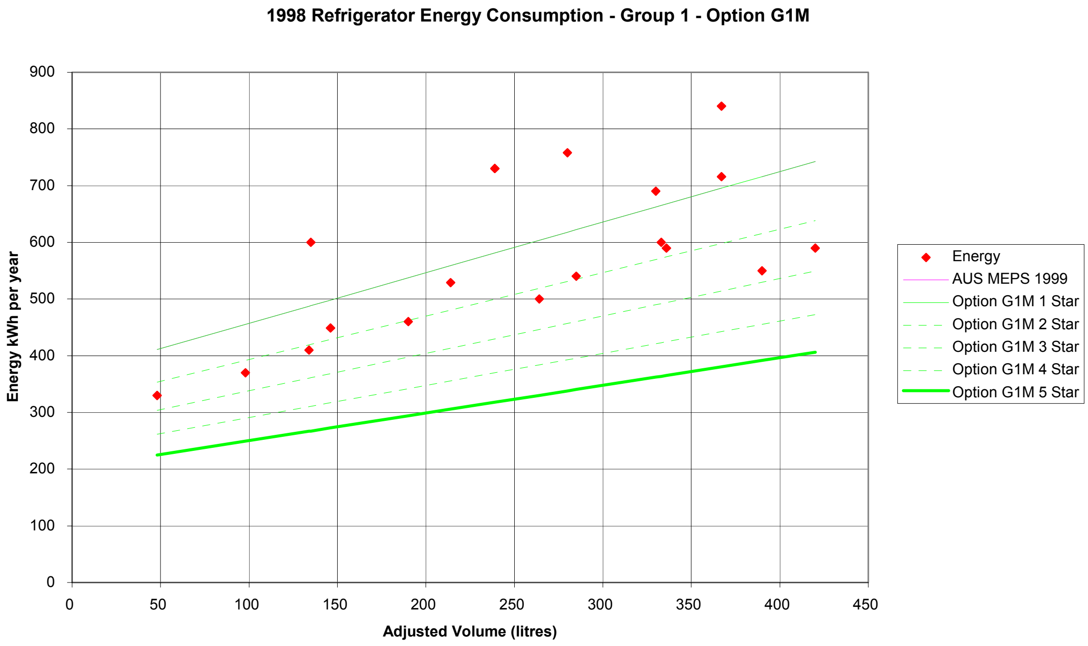
In the following recommendations, 1 Star lines are defined as a fixed kWh allowance plus an energy slope in kWh per adjusted litre. The adjusted volume of the model being rated is defined in AS/NZS 4474.2. An additional star is achieved once the CEC is reduced by the specified amount (%) below the previous star. Energy values for half stars can also be accurately defined under this method (see Appendix A).

Graphs of each recommendation show models on the market in 1998 and rating lines from 1 star (top) to 5 star (bottom).

Recommendation for Group 1 - Option G1M

It is recommended that the 1 Star line for Group 1 be set at the Group 1 MEPS line with the energy reduction per star set at 14%.

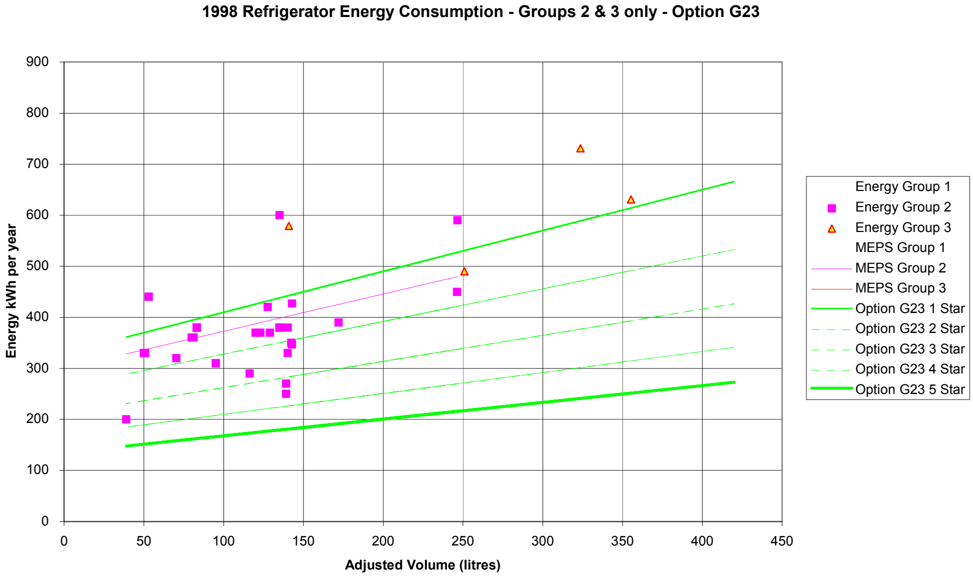
$1\ \text{Star} = 368 + 0.892 \times V_{adj.}$



Recommendation for Groups 2 & 3 - Option G23

For star rating purposes, Groups 2 and 3 are to be combined. It is recommended that the 1 Star line for Groups 2 & 3 be set at the Group 3 MEPS line with the energy reduction per star set at 20%.

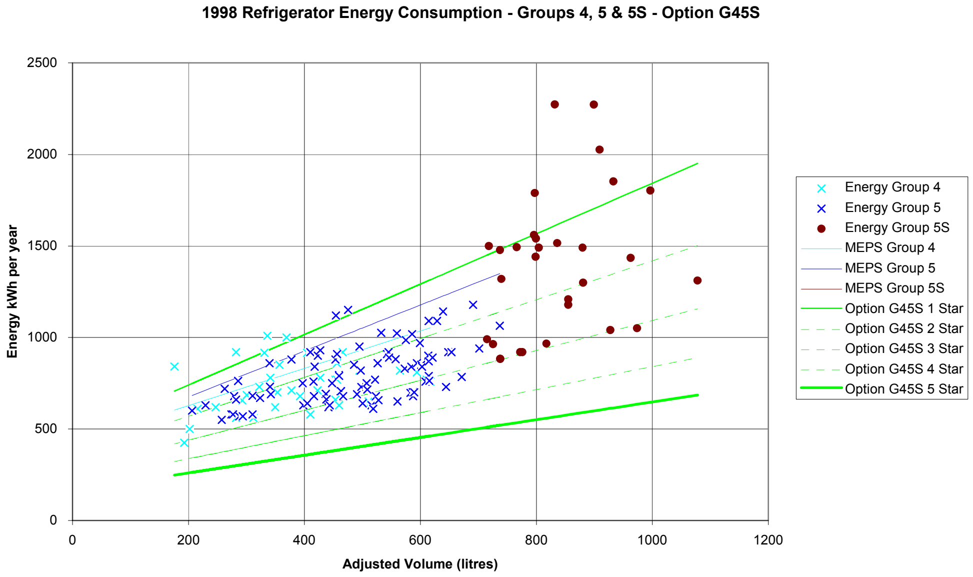
1 Star = 330 + 0.800 × $V_{adj.}$



Recommendations for Groups 4, 5 & 5S - Option G45S

For star rating purposes, Groups 4, 5 and 5S are to be combined. It is recommended that the 1 Star line for Groups 4, 5 & 5S be set at the Group 5S MEPS line (without icemaker allowance) with the energy reduction per star set at 23%.

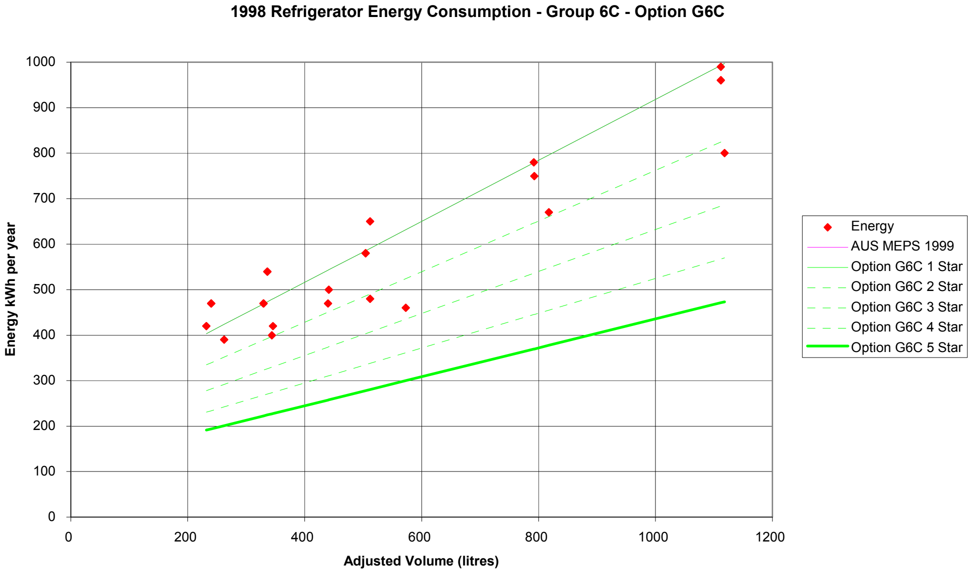
1 Star = 465 + 1.378 × $V_{adj.}$



Recommendation for Group 6C - Option G6C

It is recommended that the 1 Star line for Group 6C be set at the Group 6C MEPS line with the energy reduction per star set at 17%.

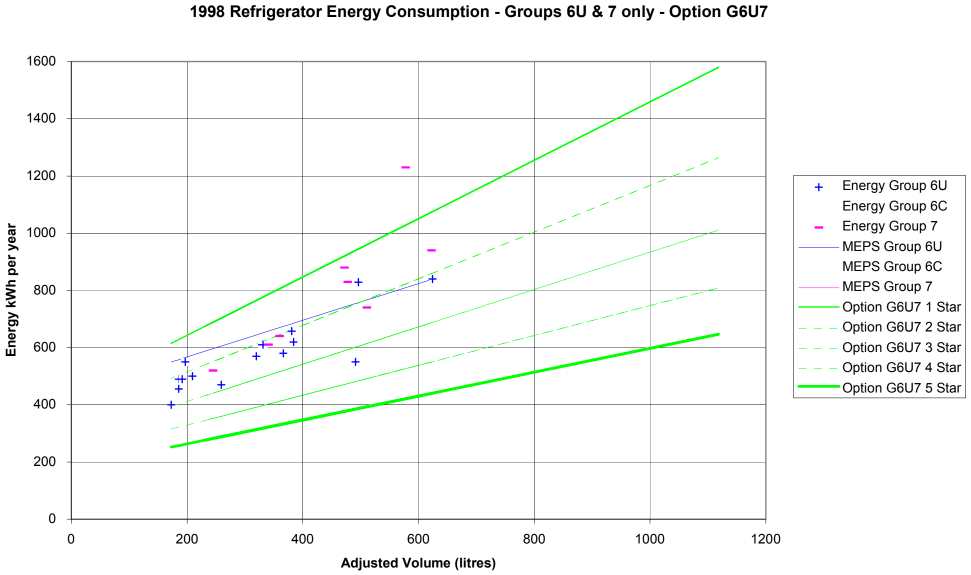
$$1 \text{ Star} = 248 + 0.670 \times V_{adj.}$$



Recommendation for Groups 6U & 7 - Option G6U7

For star rating purposes, Groups 6U and 7 are to be combined. It is recommended that the 1 Star line for Groups 6U & 7 be set at the Group 7 MEPS line with the energy reduction per star set at 20%.

$$1 \text{ Star} = 439 + 1.020 \times V_{adj.}$$



Appendix A - Calculating EER for Each Model

Under the geometric progression used, the EER for a model is calculated as follows:

Firstly calculate ratio of CEC to 1 Star Energy line for the model:

$$E_{ratio} = CEC \div (1 \text{ Star Energy})$$

Where:
CEC is the Comparative Energy Consumption shown on the energy label kWh/year
1 Star Energy is V_{adj} * Slope + Intercept as defined for the Group(s)
V_{adj} is the adjusted volume of the model in litres (as per AS/NZS4474.2)
Slope is the slope of the 1 Star line (kWh/year/adjusted litre)
Intercept is the Y intercept of the 1 Star line (kWh/year at zero litres)

The EER (Star rating) of a model can be calculated as follows:

$$EER = 1 + (\ln (E_{ratio}) \div \ln (1 - \text{Reduction}))$$

Where:

- ln is the base e log of the number in brackets (base 10 can be used if desired)
- Reduction in CEC (Energy) is per star rating (eg 17% per star)

Alternatively, the star rating can be looked up in the table below.

Similarly, E_{ratio} from the 1 Star line can be calculated for any EER as follows:

$$E_{ratio} = \exp ((EER - 1) \times \ln (1 - \text{Reduction}))$$

Example E_{ratio} values for various star ratings are shown below.

Reduction	14%		17%		20%		23%	
Stars	E ratio between		E ratio between		E ratio between		E ratio between	
1	1.000	0.927	1.000	0.911	1.000	0.894	1.000	0.877
1.5	0.927	0.860	0.911	0.830	0.894	0.800	0.877	0.770
2	0.860	0.798	0.830	0.756	0.800	0.716	0.770	0.676
2.5	0.798	0.740	0.756	0.689	0.716	0.640	0.676	0.593
3	0.740	0.686	0.689	0.628	0.640	0.572	0.593	0.520
3.5	0.686	0.636	0.628	0.572	0.572	0.512	0.520	0.457
4	0.636	0.590	0.572	0.521	0.512	0.458	0.457	0.401
4.5	0.590	0.547	0.521	0.475	0.458	0.410	0.401	0.352
5	0.547	0.000	0.475	0.000	0.410	0.000	0.352	0.000

E_{ratio} is the ratio of the measured energy to the 1 Star Energy for that model.
Reduction is energy reduction per additional star.

For example, a model with a CEC of 493 kWh where the 1 Star Energy consumption is 656 kWh would have an energy ratio of 0.7515. This would equate to 2.5 stars under 17% reduction per star and 2.0 stars under 20% reduction.

Appendix 10: Wet products – overview of algorithm issues

Appliance Labelling Review Committee
Wet Products Algorithm Working Group
Background Paper

prepared by EES, 13 October 1998

Background to the Project

During 1996 & 1997, RA Brown & Associates was commissioned by DPIE (on behalf of NAEEEC) to undertake a review of energy labelling program in Australia. A final report with a range of recommendations and suggestions was submitted in early 1998 (Brown 1998). Following a series of workshops in late 1997, the Appliance Labelling Review Committee was formed to consider the report by Brown, as well as other material, and to make final recommendations to NAEEEC regarding changes to the energy labelling program in Australia. The Review Committee met in February, April and August 1998. The committee has considered a wide range of issues with respect to the energy labelling program and good progress has been made to date, including a revised design for the energy label and revision of the algorithms for refrigerators.

A working group of industry and government representatives has been formed by the Energy Labelling Review Committee to undertake a review of the energy labelling algorithms for clothes washers, clothes dryers and dishwashers (the so called "wet products"). This background paper seeks to provide members of the working group with a briefing on their task and a copy of relevant information to assist in their deliberations. The first meeting of the algorithm working group is scheduled for 22 October 1998 at Melbourne Airport.

Objectives

The objective of the wet products algorithm working group is to:

- undertake a review of the existing energy labelling algorithms for wet products
- consider the issues raised under the Energy Labelling Review Committee, bearing in mind the decisions already made by the Committee
- develop algorithm options that redress identified problems
- refine these options into technically feasible algorithm proposals
- make detailed technical recommendations regarding revision of wet product algorithms to the Energy Labelling Review Committee for their consideration, including an implementation strategy and schedule.

Once approved by the Energy Labelling Review Committee, recommendations will be considered by the National Appliance & Equipment Energy Efficiency Committee (NAEEEC) prior to its implementation through the Standards process.

Broad guidelines for the development of new algorithms were provided by the Energy Labelling Review Committee at their April 1998 meeting as follows:

- 1 star set as the MEPS level (where relevant - eg clothes dryers)
- use a geometric progression for the star rating system (eg fixed % reduction in energy per additional star - note that the current system is linear as it has a fixed kWh reduction per additional star)
- set maximum star rating on market at the moment to be around 3.5 stars
- try to ensure that only limited products on the market will achieve 5 stars within the nominal 5 year period (based on estimates of technology progress in this timeframe)
- consider options in the Brown consultancy paper as the basis for developing new proposals for algorithms

Data Sources

Attached to this paper is an excerpt from a document prepared by EES which reviews the major issues identified by the Energy Labelling Review Committee for each of the currently labelled products **[this documentation can be found in the report titled Appliance Energy Labelling Review Committee Support Documentation which is available in the references EES, March 1998]**. Key data sources are also identified. EES will compile those additional sources identified (where available) and distribute these at the first working group meeting. The paper also includes the decisions of the Energy Labelling Review Committee meeting of April 1998.

The other key data sources are Brown's paper (Energy Labelling Review: Options for Improvement of Labels, R.A. Brown & Associates, January 1998) and a paper by Neill Patterson (Energy Labelling Consumer Research - Final Report, by Neill Patterson, January 1998). If you do not already have a copy of these two papers, you should immediately contact Megan Smith of the Australian Greenhouse Office, as these are essential references.

A summary report from the focus groups held in July and August 1998 are also attached as background information. A copy of the proposed new refrigerator label is also attached for information.

Major Issues

Major issues that will need to be considered by the working will include (but will not necessarily be limited to) the following:

Clothes Dryers

- CEC (uses per year) - based on current data, assumed label frequency of use appears to overestimate actual *average* use by a factor of 3 to 5. How is CEC to be shown so as to make it broadly (conceptually) consistent with other products? Main outstanding data source will be Pacific Power data, which should be available shortly.

- Bunching of stars - this is a fundamental issue for the working group, but care needs to be taken to ensure that artificial differences are not created between products of similar technical efficiency. New heat pump dryers achieve very high star ratings.
- Size bias - this is also a fundamental issue for the working group.
- Use patterns - how do we deal with the apparently wide distribution of frequency of use for clothes dryers?
- Field use factor - should this continue? If so, should the factor be adjusted?

Clothes Washers

- Washes per year - data on frequency of use. Main outstanding data source will be Pacific Power data which should be available shortly.
- Cold water washing - this is the major issue to be addressed for clothes washers. Issues such as performance requirements for cold water (if any), what data is to be shown of the label (star rating only for warm or warm and cold, cold and warm energy?) and so on.
- Spin credit in star rating - is it set at a reasonable level, or should it be increased or decreased or eliminated?
- Spread of star ratings - does the algorithm need to be re-graded? (is there bunching?)
- Size bias - is there any significant size bias to consider?

Dishwashers

- Washes per year - data on frequency of use. Main outstanding data source will be Pacific Power data which should be available shortly.
- Spread of star ratings - there is significant star bunching at the top end of dishwashers - the algorithm needs to be re-graded.
- Size bias - is there any significant size bias to consider?
- Performance and energy at half loads - this may need to be considered in the light of F&Ps new drawer dishwasher.

Contacts

Any questions or comments on the wet products algorithm working group meeting should be directed to:

Megan Smith
Australian Greenhouse Office
Telephone: 02 6274 1523

or

Lloyd Harrington
Energy Efficient Strategies
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Appendix 11: Clothes Dryers – algorithm discussion paper

Appliance Labelling Review Committee
Wet Products Algorithm Working Group
Discussion Paper 1 - Clothes Dryers

prepared by EES, March 1999

Background

During 1998, the Appliance Energy Labelling Review Committee considered a wide range of issues associated with the possible revision of the appliance energy labelling program. A number of issues relating to specific products were referred to algorithm working groups. In October 1998, the wet products algorithm working group met to consider the issues associated with the energy labelling of dishwashers, clothes washers and clothes dryers, including the possible regrading of star rating algorithms. An excerpt from the minutes of this meeting which are relevant to clothes dryers has been included as Appendix B. An extract from the Appliance Energy Labelling Review Committee support document for clothes dryers is attached as Appendix C.

This paper reviews the issues associated with clothes dryers. Only issues that require additional discussion have been included (ie topics are not included where a final decision has already been agreed). Where necessary, additional data has been analysed and the results summarised. Some preliminary recommendations are presented for further consideration by the working group.

The opinions offered within this document are those of EES and are not intended to bind the committee to any particular course of action.

Key Issues for Considered in this Paper

- **Uses per year for the CEC**
- **Bunching of star ratings and size bias**
- **Field use factor**
- **Program time in the brochure**
- **Standby power consumption**

It is still to be decided whether retesting will be mandatory for the introduction of the new energy label and algorithms, or whether current models can be re-registered with the new label without further tests.

Summary of Recommendations

Uses per year for the CEC

It is recommended that the Pacific Power data analysis proceed as quickly as possible to assist in finalising the CEC value on the label. However, it is noted that the CEC has no bearing on the relative energy efficiency of the product (ie star rating).

Bunching of star ratings and size bias

At this stage, it is recommended that Option C or Option D (developed by EES) be given further consideration by the wet products algorithm working group for adoption as the new star rating algorithm for clothes dryers. These alternatives can be discussed and refined at the next working group meeting as required.

Option C

Equation: 1 Star = 137 + 141 × RC, reduction per star = 15%

Pros - appears to reasonably account for size bias, top end of current market around 3 stars.

Cons - unclear if and when technology developments will fill the 3 to 5 star ratings, although overseas models are now available at > 5 stars.

Option D

Equation: 1 Star = 50 + 160 × RC, reduction per star = 15%

Pros & Cons - similar to Option C in net effect.

Field use factor

It is recommended that the current 10% timer penalty be retained for the time being. The working group may wish to commission some further monitoring to more accurately quantify the differences between timer and autosensing dryers.

Program time in the brochure

As for verification of other declared variables, program time should be subject to a verification regime during check test. The same regime as for water consumption is recommended for program time, viz:

a) republished program times be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

It is also recommended that the Part 1 test procedure be modified to measure the actual cool down time, which should also be reported in the test report, so that total program time can be determined (for comparison with the declared value).

Standby Power Consumption

It is recommended that standby power consumption be incorporated into the energy consumption shown on the energy label. Actions required to achieve this are:

- defining the possible power consumption states;
- defining the instrument accuracy requirements;

- finalisation of the frequency of use to be shown on the energy label;
- deciding on the composition of the standby power states when the appliance is not in use.

For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle with standby power consumption for non-use periods to give the CEC. Standby power consumption should eventually be shown in brochures and the Internet. It is recommended that the work and proposals of IEC TC74 working group 9 be followed and incorporated into the wet product test procedures as appropriate.

Detailed Discussion

Uses per year for the CEC

The uses per year affects the magnitude of the comparative energy consumption shown on the energy label, but has no bearing on the relative energy efficiency of the product (ie star rating). While it is desirable to get the CEC as close as possible to the actual average energy consumption from a consumer perspective, this is not absolutely critical. There needs to be a balance between policy objectives (favouring overstating energy to encourage efficiency) and accuracy of information for consumers.

Currently available data sources suggest that the average uses per year are of the order of 50 times. It should be possible to improve this estimate (in terms of both the average and the frequency distribution) once the Pacific Power data has been analysed. Initial results should be available by the middle of 1999.

In October 1998 the wet products algorithm working group suggested that energy consumption should be shown in kWh per year and that uses should be shown as uses per week. This would suggest that uses per year should be 52 or 104 (corresponding to 1 & 2 times per week), depending on the findings of the Pacific Power Data. It is recommended that this data analysis proceed as quickly as possible to assist in finalising the CEC value.

Bunching of star ratings and size bias

While bunching of star ratings for clothes dryers is a problem, this is mainly due to the relatively uniform nature of the technology used for clothes dryers in Australia. In fact, much of the difference in current models is due to the Field Use Factor, which penalises timer dryers by 10% in comparison with autosensing dryers. This issue is discussed in the next section. For the purposes of this analysis, it is assumed that the Field Use Factor of 10% remains in place (although it could easily be eliminated or increased as necessary).

The current star rating system is linear in nature. The current formula to determine EER is as follows:

EER = $12 - [(8 \times \text{CEC}) \div (150 \times m_r)]$ (AS2442.2:1996)

Where:
CEC = comparative energy consumption on the label (kWh/150 uses)
150 = assumed uses per year
m_r = average mass of moisture removed during the drying cycle
12 and 8 are empirical factors

Note that the CEC includes the field use factor (1.0 for autosensing dryers, 1.1 for timer dryers). The EER is set such that an Es[1] of 1.37 gives a star rating of 1, while an Es of 0.75 gives a star rating of 6 stars. Most dryers on the market have an Es in the range of 0.95 to 1.1. The current formula provides an extra star for each 16.3 kWh of energy reduction per kg rated capacity (reduction in Es of 0.124 per star).

It is important to understand that the moisture removed and the rated capacity are all interlinked. The rated capacity is the maximum load of *dry* clothes (under ambient conditions) that can be put into the dryer. All masses in the standard are defined in terms of the bone dry mass of clothes. The following relationships are defined in the standard:

Rated Capacity = 1.08 × bone dry mass of clothes.

Wet Mass = 1.90 × bone dry mass (ie 90% initial moisture content)

Final moisture = 1.06 × bone dry mass

Moisture removed = 1.90 - 1.06 bone dry mass

= 0.84 bone dry mass

Note that in the energy labelling regulations still in force today, the initial moisture content of the load is 2.00 × bone dry mass (100% initial moisture content). Of the 65 current registrations, 61 are tested to the old standard with 100% initial moisture content. Only 4 registrations have been tested with the new 90% initial moisture.

It was therefore necessary to "correct" the energy results back to some standardised moisture content level before investigating new algorithms. 100% initial moisture content was selected as most of the registrations have been tested under these conditions. Naturally, the results and formulae in this paper will need to be corrected back to 90% initial moisture (value in the current standard). Note that the initial moisture content has virtually no impact on the EER result, but it will impact on energy (CEC).

The current models on the market together with the current star rating system is shown in the following figure. Most dryers are clustered around 2 and 3 stars, with a few 4 star models and one 6 star model (registered in late 1998). Note that the current

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[1] Es refers to specific energy consumption (a measure of efficiency) in kWh per kg moisture removed from the load.

star bands all pass through the origin. For any specified capacity, the energy reduction per star is constant (which makes extra stars increasingly difficult to achieve).

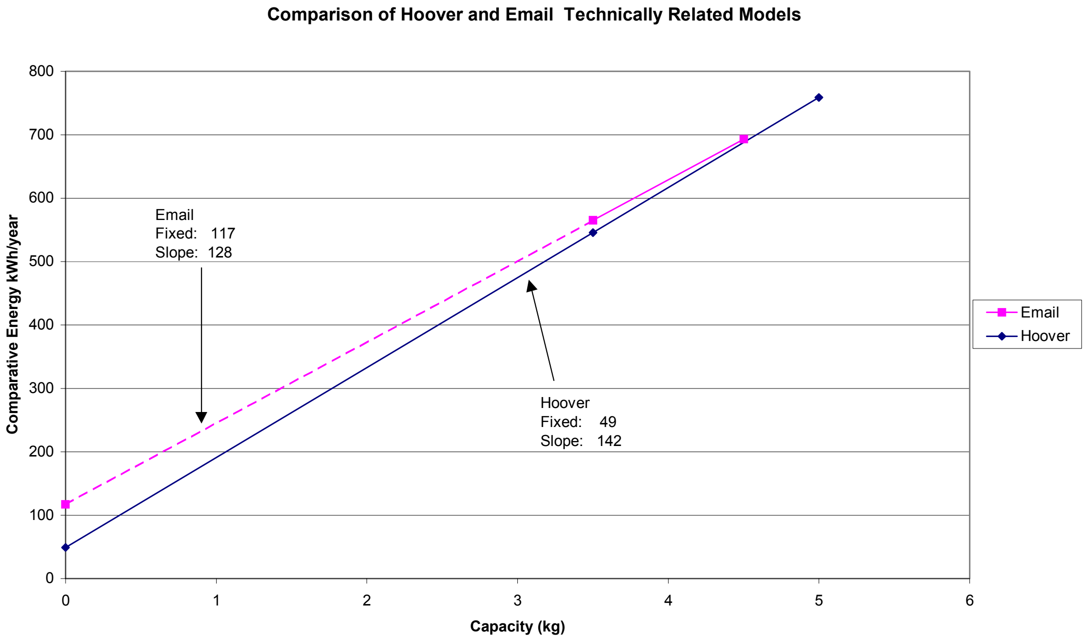
In reviewing the star rating algorithm for products, the Energy Labelling Review Committee provided working groups with some general guidelines:

- new star ratings should be a geometric progression
- best products currently on the market should not generally exceed 4 stars
- 5 star should be set as difficult but achievable in the next 5 years
- worst products on the market (or MEPS level where applicable) should generally be around 1 star
- star rating to be shown in half stars on the new label
- elimination of size bias where this is significant

In his review of the energy labelling program during 1997, Brown (1998) analysed the size energy relationship for dryers. He suggested that the following equation was representative of dryers on the market at that time:

$$CEC = 117 + 120 \times \text{Rated load} \quad \text{- trend line}$$

At the Wet Products Algorithm Working Group meeting in October 1998, Hoover and Email agreed to nominate technically similar "pairs" of dryers of different capacities, which they have done. Both manufacturers only had timer dryers that were technically similar but of different capacities. The results are shown in the following figure. This shows that the "trend" line proposed by Brown (1998) above has been based on Email models, although the Hoover results are not so very different within the general scheme of things (remembering that most models are in the 3.5 kg to 5 kg range). Both sets of data suggest that there is some size related bias, although this is not massive.

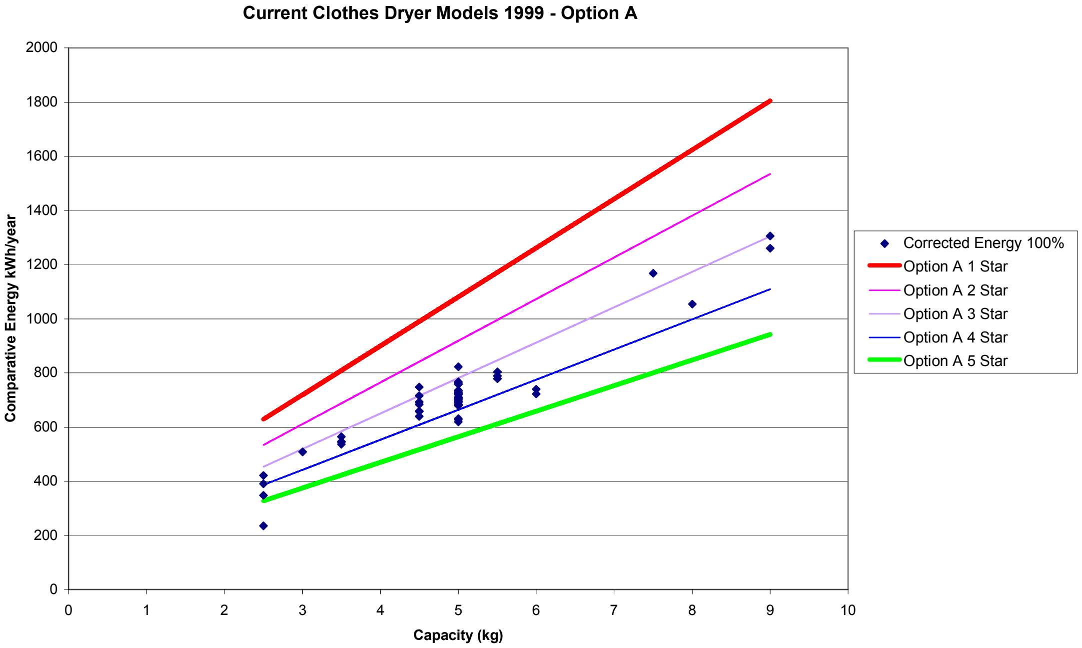


Brown (1998) also presented two options for new energy labelling algorithms for clothes dryers. Brown (1998) defines the 1 star line as fixed kWh offset with a variable kWh per kg rated capacity. The first (Option A) is as follows:

1 Star = 176 + 181 × RC

where:
176 = fixed energy offset
181 = slope of the 1 star line (in kWh per kg rated capacity)
RC = rated capacity in kg

Each additional star is defined as a 15% reduction in energy from the previous star (ie as a geometric progression). Option A is shown in the following figure:



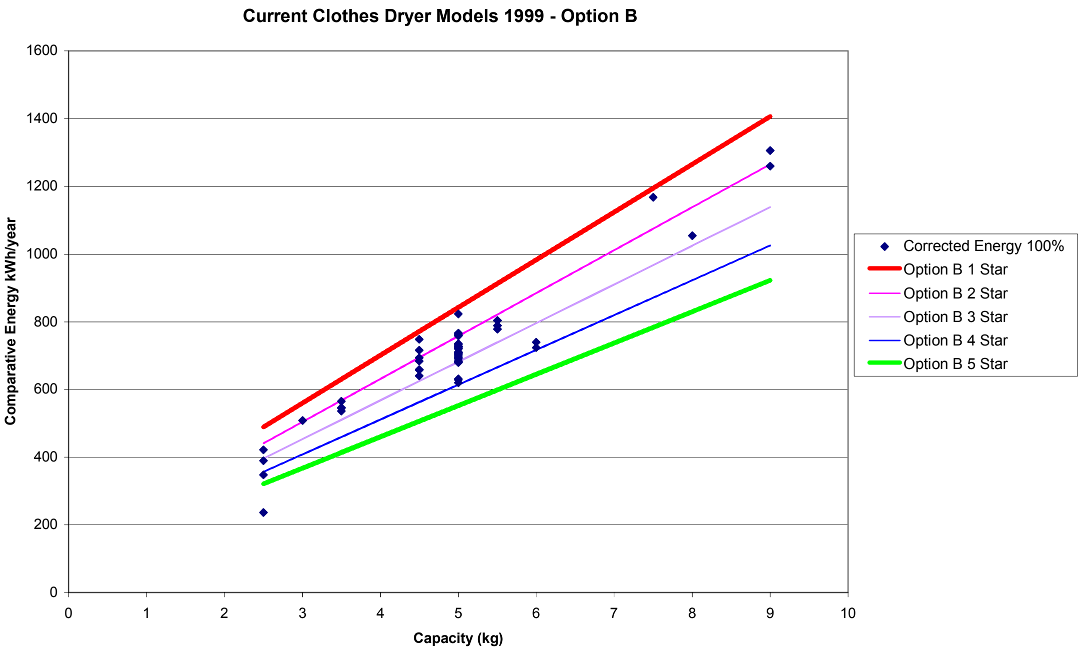
This option is not considered to be very helpful as most models rate 3 stars, with a significant number still at 4 stars. The most efficient model (2.5 kg Miele WT945 combination washer/dryer) still rates 6 stars.

The second Option proposed by Brown (Option B) is of a similar form as follows:

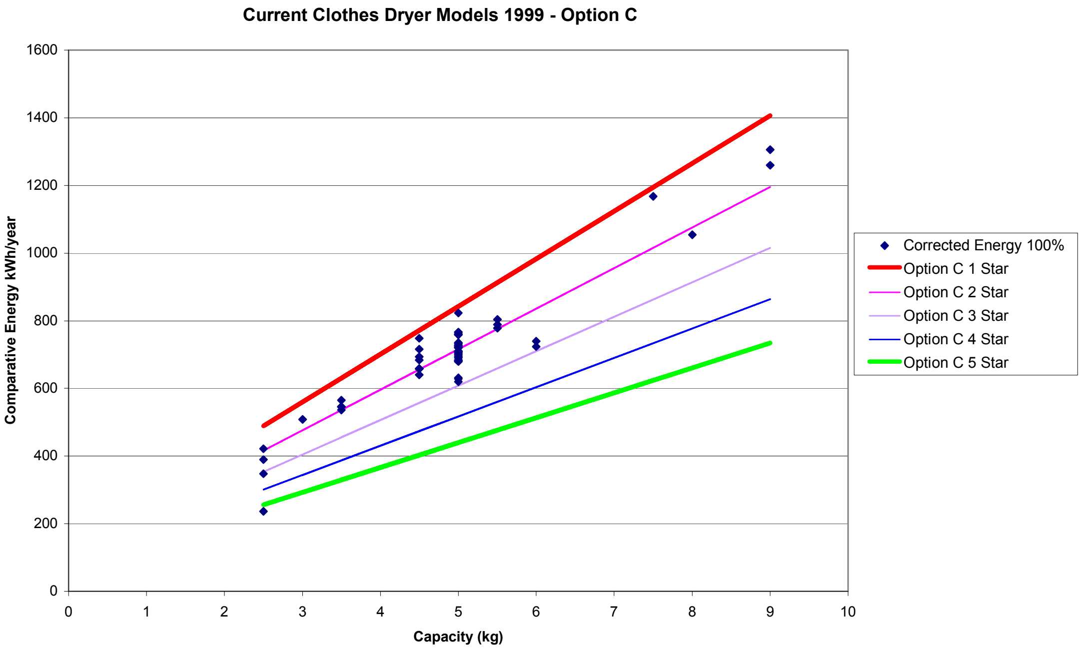
1 Star = 137 + 141 × RC

where:
137 = fixed energy offset
141 = slope of the 1 star line (in kWh per kg rated capacity)
RC = rated capacity
Energy reduction per star of 10%

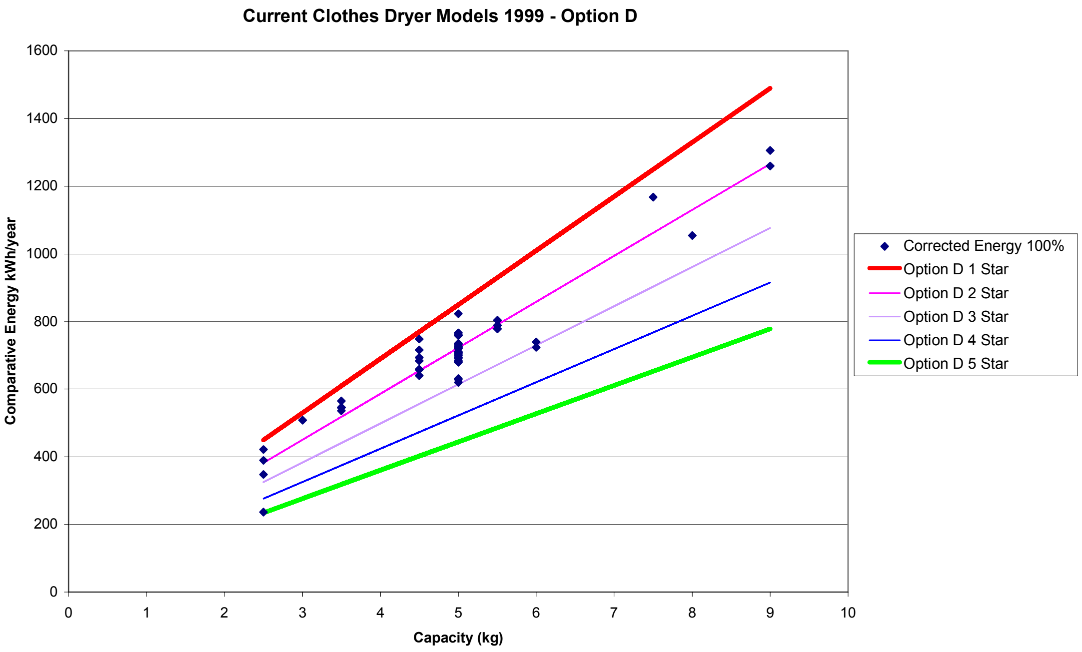
Option B is shown in the following figure. Option B is more interesting as the 1 star line appears to pick up reasonably well the size bias trend at both the less efficient and more efficient end of the current market. However, the best models are generally creeping over the 4 star line, with the Miele unit rating somewhere around 7.9 stars!



An alternative would be to use the 1 star equation of Option B but increase the star steps out to a 15% reduction in energy per star. This is shown as Option C in the following figure. This has the advantage of setting most models in the 1 and 2 star range, with a few models close to or just over 3 stars. The Miele unit still scores 5.5 stars under this scheme.



Another alternative (Option D) is to reduce the fixed component and increase the slope as shown in the following figure to align more with the Hoover data. Option D is similar in net effect to Option C for typical dryer rated capacities.



In summary, each of the Options prepared for this paper are considered:

Option A (Brown 1998)
Equation: 1 Star = 176 + 181 × RC, reduction per star = 15%
Pros - moves some dryers away from a star cusp, few other advantages.
Cons - many high ratings after regarding, several 4 star models, no 1 star, few 2 star.

Option B (Brown 1998)
Equation: 1 Star = 137 + 141 × RC, reduction per star = 10%
Pros - appears to reasonably account for size bias.
Cons - some ratings still a little high, very narrow star bands.

Option C
Equation: 1 Star = 137 + 141 × RC, reduction per star = 15%
Pros - appears to reasonably account for size bias, top end of market around 3 stars.
Cons - unclear if and when technology developments will fill the 3 to 5 star ratings, although overseas models are now available.

Option D
Equation: 1 Star = 50 + 160 × RC, reduction per star = 15%
Pros & Cons - similar to Option C in effect.

International Issues

Clothes dryers are energy labelled in Europe and Canada and MEPS levels have been set in USA and Canada.

North America

Energy Label - relative energy is shown with a standard EnerGuide label (no rating system like stars); no performance requirements. Introduced in 1976 in Canada (various redesigns have occurred since introduction).

MEPS - US DOE set MEPS levels for clothes dryers 3.01 lbs per kWh for units with a capacity of over 4.4 ft^3 (125 litres) or 3.13 lbs per kWh for those with a capacity of less than 4.4 ft^3 capacity (compact). Introduced in May 1994 in USA and 1 May 1995 in Canada (requirements only for larger units in Canada). Interestingly, compact dryers have more stringent requirements than standard dryers (despite the size bias making this more difficult).

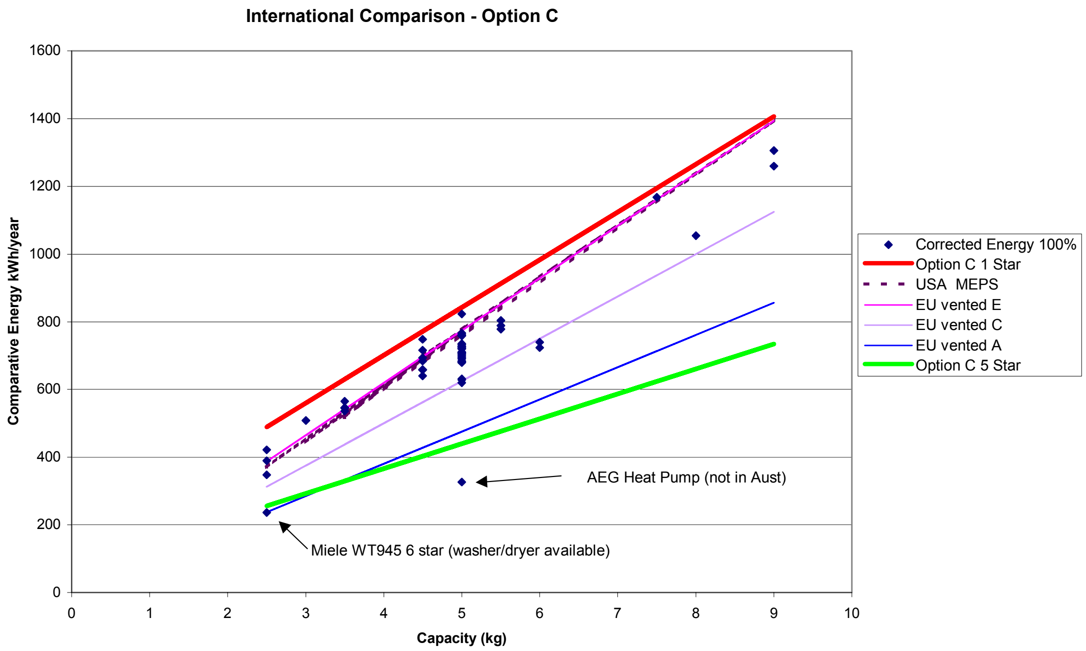
The US test procedure sets the initial moisture content at about 70% of bone dry mass. The final moisture content is between 2% and 5% of bone dry mass. Moisture removed is corrected back to 66% of bone dry mass (linear correction). Amazingly the test load is always 7lbs (3.18 kg) of bone dry mass for a standard sized dryer, irrespective of its volume (3lbs for a compact dryer). This MEPS level translates back to about 1.1 kWh per kg moisture removed under the Australian Standard (1.05 for compact dryers). Rated capacity in lbs or kg is not used in North America.

The North American MEPS levels are comparable to average to low efficiency models on the Australian market in 1999 (see following figure).

Europe

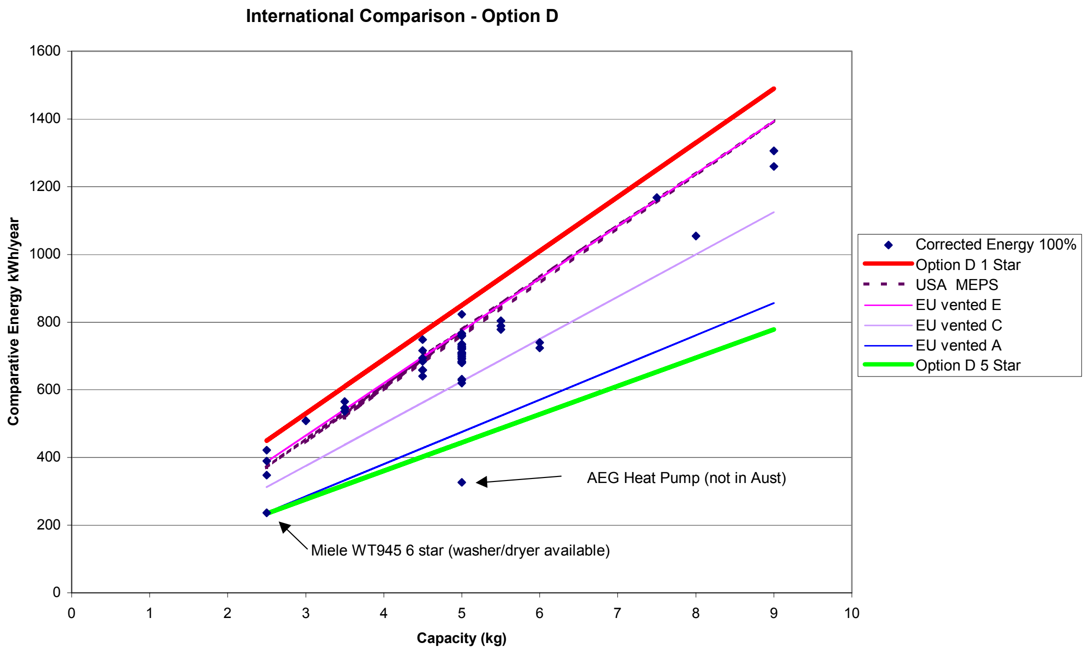
Europe introduced energy labelling for clothes dryers in 1995. As for other European labels, the label itself contains an energy rating (A to G) as well an energy consumption per load and the rated capacity but is generally less cluttered than the other European wet product labels. The best model on the market in Europe is a heat pump dryer rated at 5kg and manufactured by AEG which uses 1.75 kWh per load (per IEC61121). This easily achieves an A rating. This model uses about 50% of the energy of a standard technology dryer but is not available in Australia at this stage. The Miele machine on the Australian market also just about achieves an A rating. It should be noted that the European (EN61121) and IEC standards (IEC61121) use an initial moisture content of about 70% of the normalised load mass (= rated capacity) and a final moisture content of 0% normalised (8% bone dry), which equates to a moisture removal of about 76% of bone dry mass.

An A energy rating for Europe (corrected back to 100% initial moisture under the Australian standard) is shown in the following figure. This is similar to the 5 star level under Option C for smaller capacities but level A is somewhat weaker for larger capacities. The 1 star level under Option C is roughly equal to an energy rating of about F in Europe. Note that the European rating system passes through the origin (ie there is no correction for size bias). Also note that the Europeans have a different rating system for condenser dryers, which is not shown in this report (generally about 7% to 9% more energy allowed for the same rating).



Interestingly, the USA and Canadian MEPS levels are equal to European E rating and are slightly more stringent than 1 star under Option C. The US and Canadian MEPS levels would effect a number of models on the Australian market, some of which are condenser dryers.

Option D (shown in the following figure) has a slope which is more similar to the European and US systems, which may be of some value.



At this stage, it is recommended that Option C or Option D be given further consideration by the wet products algorithm working group for adoption as the new star rating algorithm for clothes dryers. Note that all equations in this report are expressed in terms of 100% initial moisture content and would require adjustment before publication in the Part 2 standard (back to 90% initial moisture content).

Further consideration should be given whether to make all registration holders should be retested to 90% initial moisture content for the introduction of the new label. If not, equations for both 90% and 100% initial moisture content will be required in the standard[2]. These alternatives can be discussed and refined at the next working group meeting as required.

Field use factor

Lloyd Harrington obtained some more data from the USA on the difference between timer and autosensing dryers as discussed at the last working group meeting. However, after extensive investigations and inquiries, it has not been possible to find the original documents regarding the monitoring at Oklahoma Gas & Electric (60 households during the 1970's) which was cited extensively in GWA (1991). We have obtained the engineering analysis document for clothes dryers (US DOE 1982) and another document which summaries a wide range of data collected on clothes dryer use through the 1970's and 1980's (UPA 1990).

The difference between the different control systems is now enshrined in the US regulations for energy labelling of clothes dryers. This was introduced in the amendment to the regulations in 1980 (Federal Register 1980). However, it should be remembered that this was mainly based on data collected during the 1970's. An extract from the relevant section of regulation 10CFR430 is reproduced below:

APPENDIX D TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CLOTHES DRYERS

1.10 "Moisture content" means the ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent.

1.11 "Automatic termination control" means a dryer control system with a sensor which monitors either the dryer load temperature or its moisture content and with a controller which automatically terminates the drying process. A mark or detent which indicates a preferred automatic termination control setting must be present if the dryer is to be classified as having an "automatic termination control." A mark is a visible single control setting on one or more dryer controls.

1.12 "Temperature sensing control" means a system which monitors dryer exhaust air temperature and automatically terminates the dryer cycle.

1.13 "Moisture sensing control" means a system which utilizes a moisture sensing element within the dryer drum that monitors the amount of moisture in the clothes and automatically terminates the dryer cycle. rating as could be obtained from measurements with a standard continuous flow calorimeter as described in 2.4.6.

4. CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS

4.1 Total per-cycle electric dryer energy consumption. Calculate the total electric dryer energy consumption per cycle, Ece expressed in kilowatt-hours per cycle and defined as:

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[2] Note that under the current algorithm, the initial moisture content has little effect on the EER. However, under the proposed system of defining the 1 star energy line, it is important to specify the initial moisture content, as the star rating depends on the ratio of the tested CEC to the 1 star energy (these need to be determined on a consistent basis).

Ece=[66/Ww´Wd)] × Et × FU

Et=the energy recorded in 3.4.5.
66=an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.
FU=Field use factor.
=1.18 for time termination control systems.
=1.04 for automatic control systems
which meet the requirements of the definitions for automatic termination controls in 1.11.1, 1.12 and 1.13.
Ww=the moisture content of the wet test load as recorded in 3.4.2.

Thus the difference between timer and autosensing dryers in the USA is set at about 13%, or slightly higher than the value current set in Australia (10%).

Fisher & Paykel undertook some limited trials on 5 consumers in their laboratory in Auckland. Consumers were given a loads at 0.33 rated capacity and 0.66 rated capacity and asked to use either timer and autosensing dryers. Energy consumption was measured in each case. While the sample is small and may not represent typical household use, it tends to suggest that a timer penalty is warranted, at least at the current 10% level, if not more.

The brief report from F&P is attached at Appendix A.

It is recommended that the current timer dryer penalty of 10% remain in place. The working group may wish to initiate some more detailed monitoring to see whether a larger penalty for timer dryers is warranted, although such a study may be expensive and it may be difficult to get final results before the new label comes into place.

Program time in the brochure

The working group agreed that the time on the brochure should include cool down time (ie not be based on test time alone which excludes cool down). As for the declaration of water consumption for clothes washers and dishwashers (and clothes dryers too, where applicable) the value shown on the energy label or in the brochures/Internet for program time should be on the basis of the declared value. Legal problems would be avoided if the declared value in product literature for program time is the same as brochures.

As for verification of other declared variables such as water consumption, the program time should be subject to a verification regime during check test. The same regime as for water consumption is recommended for program time:

a) republished program times be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

It is also recommended that the Part 1 test procedure be modified to measure actual the cool down time, which should also be reported in the test report, so that total time can be determined (for comparison with the declared value).

Standby power consumption

A large number of appliance models now on the market have electronic controls and switches and many of these require a small but constant power consumption, even when the unit is nominally “off”. This energy consumption can be significant (of the order of 20 to 100 kWh per year) and is of the same order of magnitude as the energy consumption of the motor and pump systems in a typical top loading clothes washer (where hot water is imported). The wet products working group agreed in principle to incorporate standby power consumption into the test procedure for wet products as soon as is practicable.

In practical terms this means:

- defining the possible power consumption states whilst the unit is not in operation (these could include: “off”, on or standby (before a program is commenced), delay start power consumption, other intermediate states such as powering down to off);
- defining the instrument accuracy requirements for the measurement of energy consumption in these states (noting that power consumption may be less than 1 Watt in many cases and that the current waveforms may be very non-sinusoidal - high speed electronic power integration methods would be required to accurately measure power and energy in these cases);
- measurement of the program time for the program used for energy labelling (already undertaken in the current test procedure);
- finalisation of the frequency of use to be shown on the energy label (being considered by this working group);
- the composition of the standby power states which would be typical when the appliance is not in use.

The last point would most probably be considered by the wet products algorithm working group once standby measurements had been undertaken on a range of machines on the market and once the frequency of use aspects had been finalised (in the light of Pacific Power data analysis). For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby power consumption (if any) for non-use periods - these will total to give the CEC. Standby power consumption is likely to be eventually be shown in brochures and the Internet.

In terms of procedures and instrumentation required for the measurement of standby power consumption, there is a range of work being undertaken on the measurement of standby power consumption of office equipment by IEC TC74 working group 9. They will specifically consider measurements for low power states with poor harmonics. It is recommended that the work and proposals of this group be followed and incorporated into the wet product test procedures as appropriate.

References

10CFR430, *US Code of Federal Regulations - Energy Conservation Programs for Consumer Products*, US Department of Energy, 1 January 1998.

16CFR305, *US Code of Federal Regulations - Energy Labelling Requirements for Consumer Products*, US Federal Trade Commission, 1 January 1998.

AS2442.2 1996, *Performance of household electrical appliances - Rotary clothes dryers, Part 2: Energy labelling requirements*, Standards Australia.

Brown 1998, *Energy Labelling Review - Options for Improvement of Labels*, R.A Brown & Associates, Torrens Park, January 1998.

EU 1995, *Implementing Directive on the Energy Labelling of Household Electric Tumble Dryers*, European Commission, Brussels, Directive 95/13/EC, 23 May 1995.

Federal Register 1990, 45 FR 46762, July 10, 1980, US Federal Code of Regulations.

GWA 1991, *Review of Residential Appliance Labelling*, George Wilkenfeld & Associates (with Artcraft and Test Research), for the SECV, September 1991. Dryers are covered pp 138-142 of the main report, Section A4 of the Appendix pp71-87.

NRC 1996, *Guide to Canada's Energy Efficiency Regulations*, Natural Resources Canada.

UPA, UPA Appliance Report, details unclear (obtained from LBL), circa 1990.

US DOE 1982, *Consumer Products Efficiency Standards Engineering Analysis Document*, US Department of Energy, Washington, March 1982.

Appendix A: Results of Auto vs Timer Dryer Tests at F&P

From: Richard Bollard, Fisher & Paykel

Dryer – Manual v's Sensing Comparisons.

Background.
With the review of the Energy Labelling algorithms it was necessary to assess the validity of the 10% penalty applied to all manually-set, timer dryers.

Aim: To quantify the savings, if any, achieved when using an Auto sensing dryer rather than a manually set timer dryer.

Method.
To do this we compared the energy used to dry the same load, first in a sensing dryer and then in a manually-set, timer dryer. 5 different people set the length of the timer dryer's cycle. The tests used similar dryers rated at 4.5kg. The only difference is the control system. The dryers were tested at 1/3rd and 2/3^{rds} the rated capacity of the dryer. The sensing dryer was run 3 times and the power consumption averaged. The result of each individual's power consumption was measured and then compared to this average.

Results.
The detailed results are on an accompanying separate sheet but as summarized below.

Load	Sensing Power Consumption kWh	'Timer' Power Consumption kWh	% Increase Power Consumption
1.5kg	1.25	1.47	+18%
3.0kg.	2.17	2.41	+11%

Conclusion.
As can be seen with either an 18% or 11% increase in consumption when the timer is manually set compared to the sensing system, the 10% penalty in fact understates the energy wasted and there is actually a case for increasing the penalty.

Appendix B: Extract of Minutes - Wet Products Algorithm Working Group - Clothes Dryers

Melbourne, 22 October 1998

Uses per year for the CEC – principles agreed for dishwashers will apply to clothes dryer CEC (consider Pacific Power data when available).

Bunching of star ratings and size bias – Dick Brown suggested that there was a clear size trend line for clothes dryers. Email and Hoover are to nominate pairs of 3.5kg and a 5kg models in their ranges which are the same basic technology so that a size related energy function can be determined for dryers. Options for removing size bias will be considered. Best technology on the market overseas will also be considered when devising a regraded algorithm. New geometric system to be used as for other products.

Star rating removed – The decision of the Energy Labelling Review Committee was noted and accepted (label for dryers is to remain).

Frequency distribution of use – This is to be considered under Section 1.1 (get Pacific Power data and consider further).

Field use factor – Richard Bollard to write up results of consumer experiments recently undertaken. Lloyd to try to get data from Okalahoma in the USA (this data formed the basis of similar field use factors in the USA labelling regulations). Preliminary indications are that the current field use factor should remain.

Program time on the brochure – The decision of the Energy Labelling Review Committee was noted and accepted (program time is to be included on brochures/internet). The working group agreed that time on the brochure should include cool down time (ie not be based on test time alone). Any false claims are an issue for trade practices. The test procedure needs to be modified to measure the cool down time, which should also be reported, so that total time can be determined.

Highlighting capacity on the label – it was agreed that Energy Labelling Review Committee has the issue in hand. It was noted that there needs to be enough space to put data on model and capacity and program on the label.

Standby Losses – it was agreed that standby losses will be incorporated into the test procedure in due course for all labelled products (except for refrigerators and freezers). The standard will need to define various “states” of energy consumption (standby, delayed start, off mode etc) in the Part 1 standard. For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby losses (if any) for non-use periods - these will total to give the CEC. Standby losses (power) are likely to be eventually be shown in brochures and the internet.

Appendix C - Support Documentation - Clothes Dryers

As circulated to Wet Products Algorithm Working Group, October 1998

Clothes Dryers

Determination of Clothes Dryer CEC

Issue: The current algorithm assumes some 150 uses of a clothes dryer per year. Preliminary data from an end use metering project suggests that this is too high by a factor of 5.

Discussion on the Issue: Sales weighted average CEC for clothes dryers sold in 1996 was 643 kWh (EES 1997). Data from Pacific Power (1996) shows that metered in-use energy consumption of some 135 clothes dryers over a one year period was 123 kWh. This suggests that actual frequency of use is of the order of 30 to 50 times per year compared with 150 times assumed in the energy labelling algorithm. Raw data collected by Pacific Power will provide statistics on frequency and duration of use, particularly the spread of use across households. Although the average use across all households is low, there are likely to be some households with high levels of use (where there is no clothes line eg flats). These should be considered when making changes to the energy label.

Data Sources: Brown (1998) discusses the issue in Section 8.1 (page 48). Pacific Power (1996) provides directly metered energy consumption for 135 clothes dryers for one year in 1993/94. It is expected that frequency of operation by household will be available from the raw data if this is obtained, but it is unclear whether data on each appliance monitored will be available as well. Note that the Pacific Power data is for NSW households only.

Data collected in Queensland (Report 2, Table 32, QEC 1993) suggests that average use is about 3.5 times per month (around 40 times per year) which corroborates data collected by Pacific Power.

ABS 8218.0 (1988) collected diary data from 19,331 households over the period from 17 June 1995 until July 1996. A new group of about 750 households collected one week's diary data commencing at the start of each fortnight, so that usage patterns for the whole year were covered. A summary of the data is shown Table 1 to Table 3. Table 2 clearly shows the seasonal pattern of use by state, with peak use in winter and minimum use in summer, as expected. Annual use by state in 1985/86 was derived from ABS8218.0 (1988) and is shown in Table 3. The indicative frequency distribution of use was also derived from ABS8218.0 and is shown in Figure 1. Note that only days that the appliance was used over a one week period were used to derive this figure, so that the number of cycles shown in this distribution does not include those cases were the appliance was used more than once per day (underestimates total use).

Table 1: Clothes Dryer Penetration by State - 1985/86

State	Households '000	Own CD '000	Penetration
NSW	1744.5	850.2	48.7%
Victoria	1300.2	667.6	51.3%
Queensland	811.1	362.1	44.6%
SA	475.1	221.2	46.6%
WA	462.6	154.7	33.4%
Tasmania	145.1	83.3	57.4%
NT	26.7	8.4	31.5%
ACT	78.8	42.4	53.8%
Australia	**5044.1**	**2389.9**	**47.4%**

Source: ABS8218.0-1988, see also EES (1998) for more recent data and ownership estimates.

Table 2: Proportion of all clothes dyers used on at least one day in seven

State	Winter	Spring	Summer	Autumn
NSW	62.4%	61.9%	43.1%	48.5%
Victoria	76.5%	60.7%	43.6%	59.3%
Queensland	52.9%	47.0%	42.1%	48.1%
SA	73.7%	45.9%	37.1%	54.3%
WA	78.3%	47.8%	24.1%	57.3%
Tasmania	67.0%	48.4%	45.7%	55.2%
NT	61.1%	17.4%	57.1%	35.9%
ACT	75.2%	63.2%	24.5%	64.1%
Australia	**67.6%**	**56.3%**	**41.1%**	**52.9%**

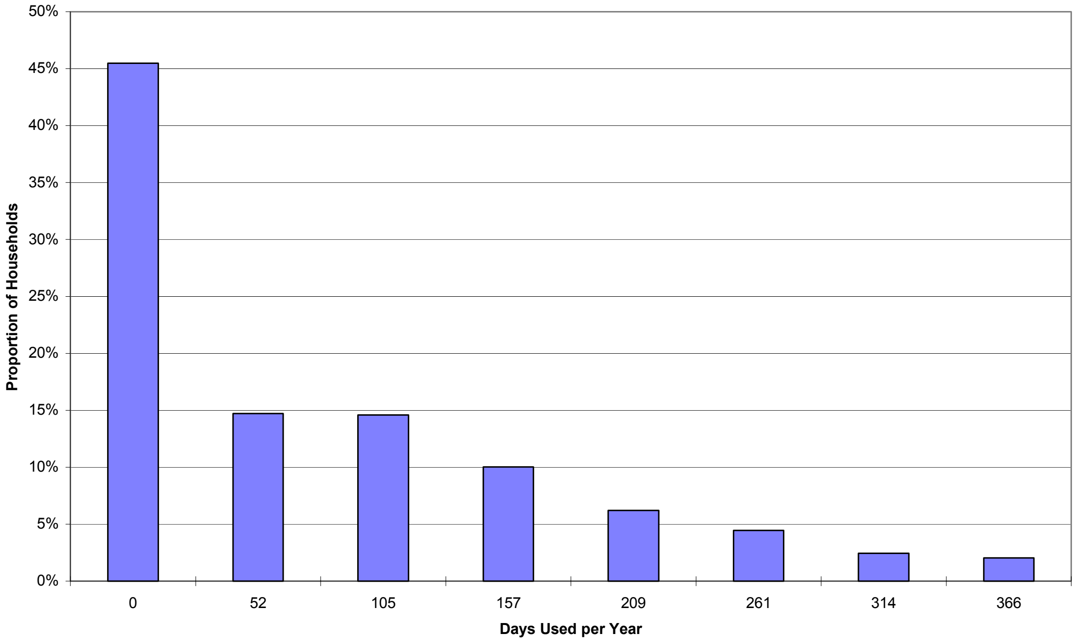
Source: Table 15, ABS8218.0-1988.

Table 3: Annual clothes dryer use by state during 1985/86

State	Annual Average Use (Hours)	Cycles per Year
NSW	86	37
Victoria	123	54
Queensland	70	30
SA	91	39
WA	98	43
Tasmania	109	47
NT **	37	16
ACT	84	37
Australia	**96**	**42**

Source: Table 15, ABS8218.0-1988, Assumes 13 weeks per season.
Cycles per year based on cycle time of 2.3 hours from EES (1997).
Note**: Values for NT are estimates only due to small sample size.

Figure 1: Frequency Distribution of Dryer Use, 1995/96



Source: Table 15, ABS8218.0-1988. Likely to be >1 use per day in some cases.

In Europe, dryer use is much higher than in Australia, which is to be expected given the climate and housing types. Sidler (1997) indicates that average use is 5.2 times per week based on end use metering results. The diary data for the same households that were monitored showed that consumers underestimated their actual use by about 25%, so care needs to be taken when using consumer diary or recall data. Interestingly, diary data for dishwashers overestimated the actual use by about 30% (Sidler 1997). The author warns of the danger of relying on consumer reports of appliance use.

Energy Labelling Review Committee Decision: CEC - loads per year average about 40 but the range varies up to >365 times per year. Agreed to trial energy per use on the label. If this fails we could consider 1 load per week (52 per year) as this is easy to conceptualise for consumers. Agreed that there could be additional support data based on various levels of use and lifestyles in brochures and on the web.

Bunching of Star Ratings

Issue: Star rating for clothes dryers are bunched around 2 and 3 stars, with only a few models at 4 stars.

Discussion on the Issue: Most clothes dryers sold in Australia at the moment are low cost units which are all based on similar technology. The reason for bunching is that the technical efficiency is similar for most models within a size range. The best models on the market at the moment (generally European designs, which tend to be expensive) can just achieve 4 stars.

In 1997 AEG and Miele in Germany released clothes dryers which are based on heat pumps (AEG 1997). The purchase costs are still high, but the efficiency is dramatically increased (claimed 50% energy reduction in comparison with a conventional dryer). While this type of unit is unlikely to have a large market impact in Australia (given the high cost and low average use here), it shows that technically advanced units are possible. These are the first models to achieve an “A” energy efficiency rating under the European energy labelling program. These units would achieve a rating of about 7 stars under the current Australian system (assuming about 0.6 kWh per kg moisture removed, precise specifications are not available as yet).

The USA has been undertaking some research into microwave clothes dryers with a view to reducing energy consumption (EPRI 1992), but there have been some technical problems (eg microwave action on metal items).

Data Sources: Brown (1998) discusses the issue in Section 8.2 (page 48). The main data source is the energy and capacity characteristics on the market at present, which is available from the energy labelling register. These are shown in the energy labelling brochures (copy attached). An electronic copy is available for further analysis. AEG (1997) and EPRI (1992) also provide additional information.

Energy Labelling Review Committee Decision: Bunching of Algorithms - it was acknowledged that there is bunching in the clothes dryer market, but that the technology used is similar for most products so there is no point in creating artificial differences (accentuating small differences in real efficiency). The existing algorithm already does this to some degree. Brown has proposed that the algorithm be realigned to remove size bias, to remove the current bunch from the star cusp and to introduce a geometric progression into the rating system. There is a need to have a view of where the market will be in the next 5 years. There was a general view that there will be only small incremental changes in the Australian market over that period. The heat pump product may appear here soon, but this is likely to only achieve a very small market share.

Size Bias in Algorithm

Issue: The current star rating system is based on kWh per kg of moisture removed. There is currently a slight size bias in this rating system which makes small units appear less efficient.

Discussion on the Issue: Most clothes dryers sold in Australia at the moment are low cost units which are all based on similar technology. Currently most 3.5 kg models rate only 2 stars while most 5 kg models rate 3 stars. Consideration should be given to removing this size bias if and when the labelling algorithm is revised.

Data Sources: Brown (1998) discusses the issue in Section 8.2 (page 48). The main data source is the energy and capacity characteristics on the market at present, which is available from the energy labelling register. These are shown in the energy labelling brochures (copy attached). An electronic copy is available for further analysis.

Energy Labelling Review Committee Decision: Size bias - covered in 1.2. Working group should examine the magnitude of the size bias in the dryer algorithm and make some assessment as to whether this should remain or not and the associated pros and cons (size bias encourages the purchase of larger dryers).

Star Rating for Clothes Dryers Should be Removed

Issue: Clothes dryers are only used infrequently so the total energy consumption is small. In addition, most units sold are low cost units which are based on similar technology, so there is very little difference in efficiency.

Discussion on the Issue: This issue was raised by Patterson, who suggests that labelling for clothes dryers is unnecessary, given the low frequency of use and narrow efficiency range of current models (ie choice of model will not significantly influence energy consumption).

The issues that need to be considered are as follows:
- the technical range is now large, with energy consumption varying by a factor of 2 with the advent of heat pump units in Europe - however these are unlikely to achieve much penetration in Australia, at least in the short term
- average consumers appear to only use dryers infrequently, but there is likely to be a core of higher frequency users - should labelling be retained to target these consumers?

Data Sources: Patterson (1998) mentions the issue in Section 5.4 but has little supporting documentation (page 16). It may be necessary to carry out a cost benefit evaluation of the elimination of labelling for clothes dryers. Data on the distribution of use patterns is essential.

Energy Labelling Review Committee Decision: Removal of the energy label for dryers - there was discussion regarding the pros and cons of deleting the label. It was noted that there are some high level users and that these may be increasing due to high proportion of high density dwellings which will tend to have higher use. Politically there would also a potential problem with removing an energy label from a product. Agreed not to delete the label for dryers. The issue of the basis for energy labelling for all products (overall cost benefit analysis and context by product) will be examined later.

Frequency Distribution of Use for Clothes Dryers

Issue: Use of clothes dryers is likely to be bi-modal with most households having low use but with some households having high use.

Discussion on the Issue: This issue is covered under Section 0, Determination of Clothes Dryer CEC). See also Figure 1 for an indicative frequency distribution of dryer use.

Energy Labelling Review Committee Decision: Frequency distribution of dryer use - covered in 1.1.

Field Use Factor (Timer Penalty) in Current Algorithm

Issue: The current algorithm for clothes dryers allocates a penalty (field use factor) of 10% energy for timer controlled dryers, with no penalty for auto-sensing dryers.

Discussion on the Issue: The field use factor is based on the assumption that an auto sensing dryer will consume the same energy in the field as is shown on the energy label (assuming same initial moisture content), as the program will terminate on each occasion when the clothes are at the same level of dryness. For a timer dryer, it is assumed that consumers will, on average, tend to over dry clothes, hence the 10% energy penalty, which applies to the CEC and subsequent calculations of EER.

It is unclear where the 10% figure originated. Once source associated with the preparation of the Victorian regulations suggested that ACA were commissioned to undertake some comparative research into consumer use of auto-sensing versus timer dryers in about 1989 and this was used as the basis for estimating the factor. Another unconfirmed rumour was that the figure was based on some sort of research in Tennessee in the 1970's, but no data has even been sighted.

Data Sources: It may be possible to find the original ACA research (if it exists), but this is likely to be fairly irrelevant now given the market and technology has changed somewhat. Manufacturers have indicated that they may be able to provide the results of some in house research on this topic.

Energy Labelling Review Committee Decision: Field use factor (timer penalty) - obtain US data from George (Okalahoma report if available), Alan Sharp to inquire whether ACA did any trials (circa 1989). Undertake a literature search as to whether any data exists regarding the difference between timer and autosensing dryers. Richard Bollard will try to undertake some qualitative trials (only a small number of consumers). Harrington to try links and contacts in Europe and USA to see what work has been done. Manufacturers to try sister company contacts overseas. It was noted that SEDA is undertaking a scoping project on this issue and SEDA offered the results of this for consideration by the Review Committee after it is completed.

Inclusion of Program Time on the Brochure

Issue: Clothes dryer program time is currently included on the energy labelling brochure, as this is a variable of interest to consumers. However, the program time determined from the test does not include the cool down period.

Discussion on the Issue: Information included in energy labelling brochures should be accurate as far as is possible. Program time is a variable that is of interest to consumers but there is currently no standardised way of reporting this in product literature. Values in current brochure are taken from the test report which does not include the cool down period. Values should be based on manufacturer rated values as far as possible. Approaches to this issue should be discussed by the committee.

Data Sources: There are no specific data sources for this issue.

Energy Labelling Review Committee Decision: Time on the brochure - it was agreed to continue to use data from the test report. Noted that the 230V/240V issue will have a significant impact in this respect.

Highlighting Capacity on the Energy Label

Issue: Clothes dryer capacity is a key variable of concern to consumers. Although the capacity is currently shown on the label, it is in small print.

Discussion on the Issue: Consideration should be given to highlighting capacity on the energy label. If recommended, this should be tested on consumers.

Data Sources: The international review of energy labelling provides examples of clothes dryer labels for consideration.

Energy Labelling Review Committee Decision: Capacity - look at options for formatting this data in focus groups.

Appendix 12: Clothes Washers – algorithm discussion paper

Appliance Labelling Review Committee
Wet Products Algorithm Working Group
Discussion Paper - Clothes Washers

prepared by EES, March 1999

Background

During 1998, the Appliance Energy Labelling Review Committee considered a wide range of issues associated with the possible revision of the appliance energy labelling program. A number of issues relating to specific products were referred to algorithm working groups. In October 1998, the wet products algorithm working group met to consider the issues associated with the energy labelling of dishwashers, clothes washers and clothes dryers, including the possible regrading of star rating algorithms. An excerpt from the minutes of this meeting which are relevant to clothes washers has been included as Appendix A. An extract from the Appliance Energy Labelling Review Committee support document for clothes washers is attached as Appendix B.

This paper reviews the issues associated with clothes washers. Only issues that require additional discussion have been included (ie topics are not included where a final decision has already been agreed). Where necessary, additional data has been analysed and the results summarised. Some preliminary recommendations are presented for further consideration by the working group.

The opinions offered within this document are those of EES and are not intended to bind the committee to any particular course of action.

Key Issues for Considered in this Paper

- **Washes per year for the CEC**
- **Cold water washing**
- **Spin credit in star rating and regrading of algorithms**
- **Declaration of spin performance on the label**
- **Declaration of water on the label**
- **Standby Power Consumption**

It is still to be decided whether retesting will be mandatory for the introduction of the new energy label and algorithms, or whether current models can be re-registered with the new label without further tests.

Summary of Recommendations

Uses per year for the CEC

It is recommended that the Pacific Power data analysis proceed as quickly as possible to assist in finalising the CEC value on the label. However, it is noted that the CEC has no bearing on the relative energy efficiency of the product (ie star rating).

Cold water washing
It is recommended that the following proposal for cold water washing be adopted:

- star rating continues to be based on warm water washing - only a warm water star rating (red band) is to be shown on the label
- energy for both cold and warm washing be shown on the energy label
- no star rating on a cold water only label, only cold energy to be shown

Spin credit in star rating and regrading of algorithms
A wide range of algorithm options are presented in this report. However, the issues are complex and it is recommended that further discussions and investigations be undertaken by the working group before a final star rating algorithm is developed.

Declaration of spin performance on the label
A range of data is presented in the report so that the working group can further consider this issue of whether the spin performance should be declared on the energy label. However, the spin index in its current form may not be suitable for inclusion on the energy label. Further detailed consumer testing and careful design is strongly recommended before spin performance is included on the energy label to ensure that it does not detract from the label's main message.

Declaration of water on the label
The recommendations for water consumption on the label are that:

a) water consumption on the energy label be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

Standby Power Consumption
It is recommended that standby power consumption be incorporated into the energy consumption shown on the energy label. Actions required to achieve this are:

- defining the possible power consumption states;
- defining the instrument accuracy requirements;
- finalisation of the frequency of use to be shown on the energy label;
- deciding on the composition of the standby power states when the appliance is not in use.

For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle with standby power consumption for non-use periods to give the CEC. Standby power consumption should eventually be shown in brochures and the Internet. It is recommended that the work and proposals of IEC TC74 working group 9 be followed and incorporated into the wet product test procedures as appropriate.

Detailed Discussion

Washes per year for the CEC

The uses per year affects the magnitude of the comparative energy consumption shown on the energy label, but has no bearing on the relative energy efficiency of the product (ie star rating). While it is desirable to get the CEC as close as possible to the actual average energy consumption from a consumer perspective, this is not absolutely critical. There needs to be a balance between policy objectives (favouring overstating energy to encourage efficiency) and accuracy of information for consumers.

Currently available data sources suggest that the average uses per year are of the order of 300 to 450 times. It should be possible to improve this estimate (in terms of both the average and the frequency distribution) once the Pacific Power data has been analysed. Initial results should be available by the middle of 1999.

In October 1998 the wet products algorithm working group suggested that energy consumption should be shown in kWh per year and that uses should be shown as uses per week. This would suggest that uses per year should be 314, 365 or 418 (corresponding to 6, 7 & 8 times per week), depending on the findings of the Pacific Power Data. It is recommended that this data analysis proceed as quickly as possible to assist in finalising the CEC value.

Cold water washing

The working group made the following proposal regarding cold water washing options:
- SRI (star rating index) continues to be based on warm water washing - only a warm water star rating (red band) is to be shown
- CEC for both cold and warm washing be shown on the energy label
- Cold CEC can be calculated from test report where there is no internal heating
- Cold CEC must be determined from a separate test if any internal water heating occurs on a warm wash (on the coldest wash program available)
- No star rating on a cold water only label, only cold CEC to be shown
- There is a need to add a general caveat (possibly on the energy label and/or in brochures) that performance and capacity has not been measured (nor is guaranteed) for cold water washing.

It is recommended that this proposal be adopted for clothes washers as part of the new label introduction.

Spin credit in star rating and regrading of algorithms

As for clothes dryers, there is some bunching of star ratings within clothes washers. However, the energy consumption and star rating of a clothes washer tends to be more of a function of the technology type than any other factor. The main technology types are front loading (drum) machines and top loading (impeller or agitator machines). Front loading machines are generally more energy efficient, mainly because of reduced water consumption per kg of rated capacity. The vast majority of the energy for clothes washers is related to water heating. While the star rating index continues to use a warm wash to determine energy consumption, efficiency will remain strongly linked to water consumption for clothes washers.

The current star rating system is linear in nature. It is rather complex as it is a function of the energy, the rated capacity and the water extraction index (commonly called spin index). The current formula to determine EER is two stage process as follows:

$Em = (F \times WEI_{av} \times RC) / 1.08$ Equation ①

$EER = 6.9 - [(6.9 \times 1.08 / RC) \times (CEC / 365 + Em)]$ Eqn ② (AS2040.2:1998)

Where:
RC = Rated capacity in kg
WEI_{av} = average water extraction index (usually in the range 0.6 to 1.1)
Em = equivalent energy of residual moisture (if using a clothes dryer)
F = 0.21 and is an empirical factor to account for typical dryer use[1]
CEC = comparative energy consumption on the label (kWh/365 uses)
365 = assumed uses per year
1.08 is assumed moisture content of dry load under normal conditions
6.9 is an empirical factor

It is not possible to plot a simple graph of rated capacity versus energy consumption for various star ratings because of the influence of the spin index on the star rating. The spin credit proportion of the total equivalent energy used in the star rating varies from a minimum of 27% to a maximum of 63% for the 170 models on the market in early 1999 (average 44% for all 170 models). A simple plot of capacity versus energy is shown in the following figure. For each capacity, the star rating cusp can vary considerably, depending on the spin performance of the particular model (hence the jagged line). This plot is not particularly useful as the star rating for any particular model is ambiguous (a three dimensional plot is necessary). Note that to achieve 6 stars under the current algorithm (with the current dryer use factor F), that most clothes washers would have to generate electricity!

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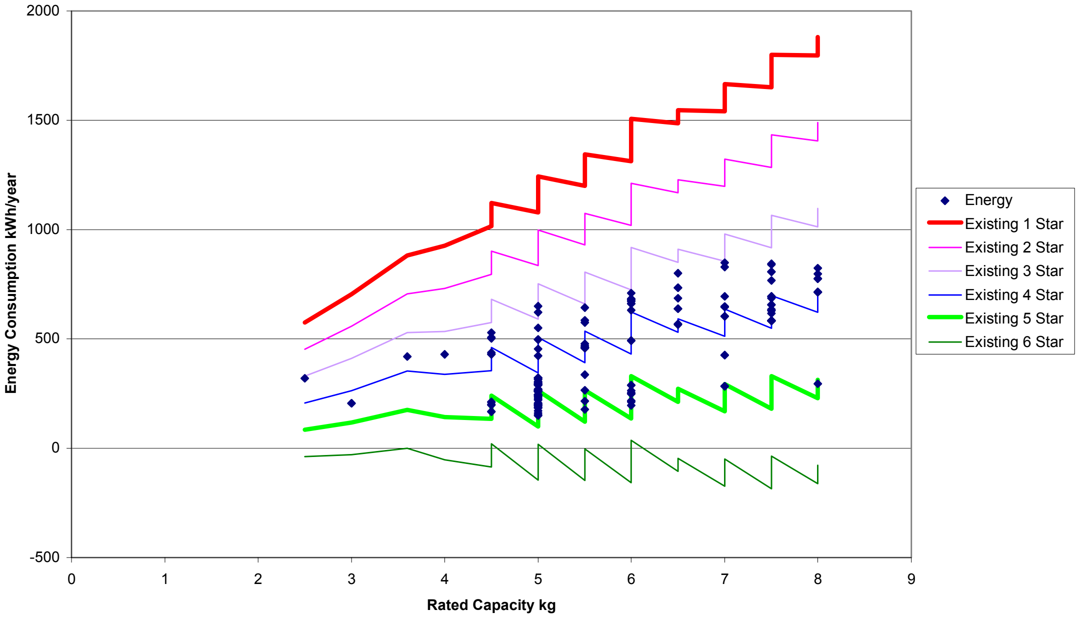
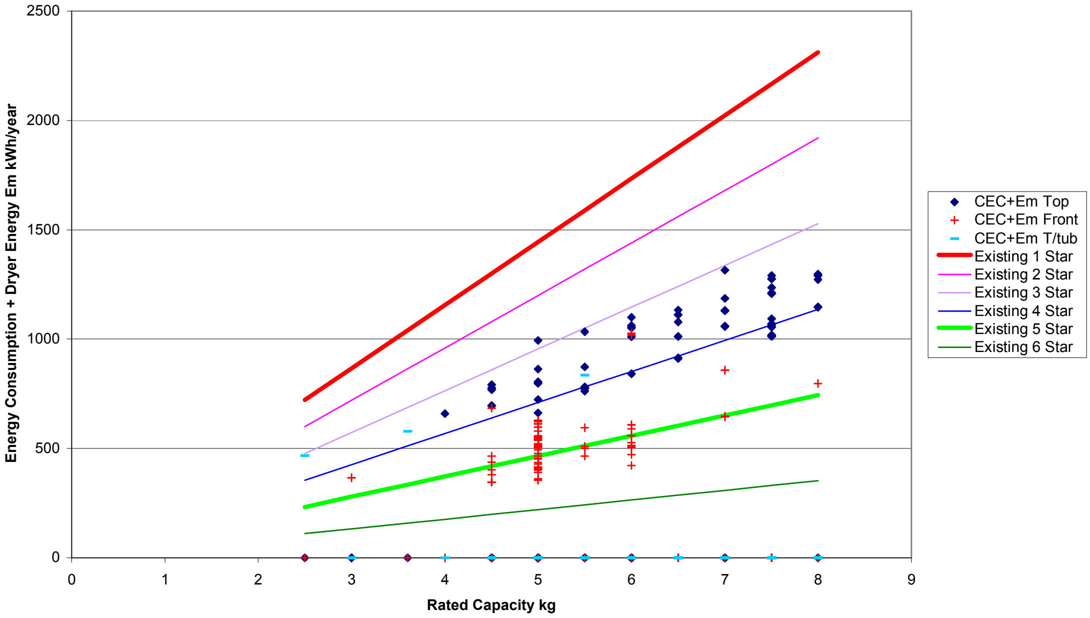
[1] Factor 0.21 comes from assumed use of dryers of 150 times per year (0.41 times per clothes load of 365 times per year) plus an assumed ownership of about 50% plus an average efficiency of just over 1 kWh per kg of moisture removed.

Current Clothes Washer Models 1999 - Existing CEC only



An alternative way of representing the data is to plot the combined CEC plus the equivalent dryer energy Em as a single value for each model. Under this scenario, the star rating bands are straight lines and the current star rating is accurately shown for each model. Note that the values of CEC + Em are on average 45% higher than CEC values alone (but this varies considerably by model). The Em (equivalent dryer use) in equation ① for the current system is determined using a value for F of 0.21.

Current Clothes Washer Models 1999 - Existing CEC+Em (F=0.21)



As can be seen, most of the models in the 4.5 to 5 star range are front loading machines (one or two rate three stars). Top loaders generally rate 3 stars with some models with good spin performance just making 4 stars.

In reviewing the star rating algorithm for products, the Energy Labelling Review Committee provided working groups with some general guidelines:

- new star ratings should be a geometric progression
- best products currently on the market should not generally exceed 4 stars
- 5 star should be set as difficult but achievable in the next 5 years
- worst products on the market (or MEPS level where applicable) should generally be around 1 star
- star rating to be shown in half stars on the new label
- elimination of size bias where this is significant

In his review of the energy labelling program during 1997, Brown (1998) analysed a range of issues related to clothes washers. His key suggestions related to algorithms are as follows:

- spin performance should be estimated and reported in some form (it has already been agreed to report spin index in brochures and on the Internet site);
- spin equivalent (Em) be included in both CEC *and* Star Rating Index (currently only included in the star rating);
- the spin equivalent (Em) be scaled back to a level that reflects actual average dryer use (around 123 kWh per year for those households with dryers (based on Pacific Power (1996) data) which has to be further adjusted down to account for ownership of dryers - currently at 53% nationally weighted by households).

The issue of whether to include the spin equivalent energy Em into the CEC figure shown on the energy label is an interesting one. Brown argues that the inclusion of the Em value within the CEC will influence those buyers which look at CEC rather than the star rating. The arguments against inclusion of spin index within the CEC are that not all clothes washer owners own a dryer (for those without a dryer, the dryer component on the washer label is misleading) and that any dryer energy will have already been accounted within the dryer energy label. A consumer which is buying a washer and a dryer at the same time would be misled as the part (but not all) of the dryer energy included on the dryer label CEC would also be shown on the washer CEC; thus the labels would over estimate the total energy consumed by the two products. However, from a policy perspective, overstatement of energy consumption is not necessarily a bad thing.

As noted above, Brown suggests that the equivalent dryer energy Em be reduced to about 70kWh for a 5 kg top loader, 90 kWh for a 7kg top loader and 60 kWh for a 5 kg front loader (page 56, Brown 1998). While this proposal is a little imprecise, we estimate that this equates to a spin equivalent factor F of about 0.05 (cf the current value of 0.21). With this factor the spin equivalent Em for various types on the market in early 1999 are as follows:

5 kg top loaders - 57 to 82 kWh/year
7 kg top loaders - 85 to 115 kWh/year
5 kg front loaders - 48 to 87 kWh/year

Brown then proposes a number of possible algorithm rating Options. These are defined with the 1 star line as fixed kWh offset with a variable kWh per kg rated capacity. The first two options A & B are a separate rating system for top loaders and front loaders. The third (Option C) is a combined system of rating top and front loaders together (and as noted by Brown, this has large star bands). Note that the existing star rating system uniformly rates all types of clothes washers under a single rating system.

The problem with the rating Options as proposed by Brown is that a reference spin equivalent component of Em is not defined within the star rating equations value as given. Without this, the value of CEC + Em for each machine will appear relative high against the reference 1 star consumption proposed by Brown (which currently has no Em component). Plotting CEC versus capacity while the value of F is greater than zero will result in a jagged graph.

To remedy this, a reference spin component is proposed. This could be either based on the current market average spin index is 0.78 for clothes washers, or the worst spin index on the market. Mathematically, the worst currently on the market works bests as this value is used to define the 1 star line, which should equate to the lowest rating models (worst spin index is currently 1.03). If we had 4 star rating bands (from 1 to 5 stars) with a reduction of 20% per star, this would effectively reduce the reference spin component to around under 0.5 at 5 stars, which is roughly equal to the current technological limit. Hence the reference Em value is also reduced by the same proportion as CEC under this proposal.

Hence, to each of Brown's Options, the following Em component is proposed:

$$Em = (F \times WEI_{ref} \times RC \times 365) / 1.08 \qquad \text{Equation ③}$$

Where:
F = spin weighting factor to be examined
(F is currently 0.21, about 0.05 proposed by Brown as per above)
WEI_{ref} = reference spin index (proposed worst value = 1.03)
RC = Rated capacity in kg
1.08 is assumed moisture content of dry load under normal conditions

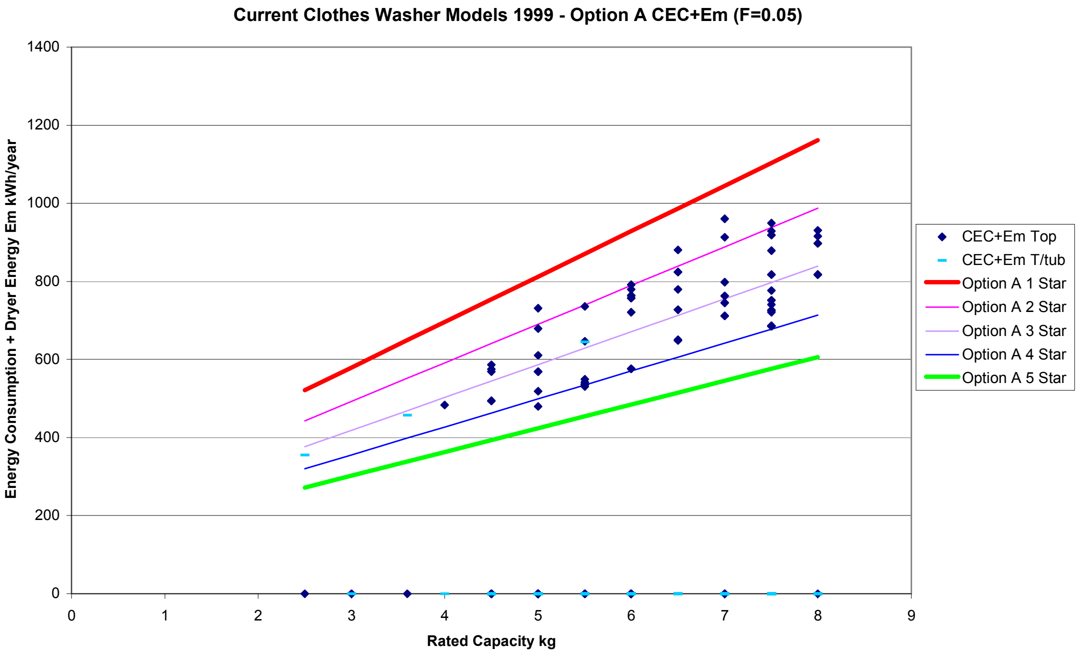
Investigating these options is rather complex as we can essentially vary four variables: fixed kWh component, capacity related kWh component, energy reduction per star and the magnitude of the value of F (spin component). First, the Options proposed by Brown are examined.

The first proposal by Brown (Option A) is for ***top loading machines*** only:

1 Star = 230 + 99 × RC

where:
230 = fixed energy offset
99 = slope of the 1 star line (in kWh per kg rated capacity)
RC = rated capacity in kg
F = 0.05
$Em = (0.05 \times 1.03 \times RC \times 365) / 1.08$
Note that other options below are in the same general format.

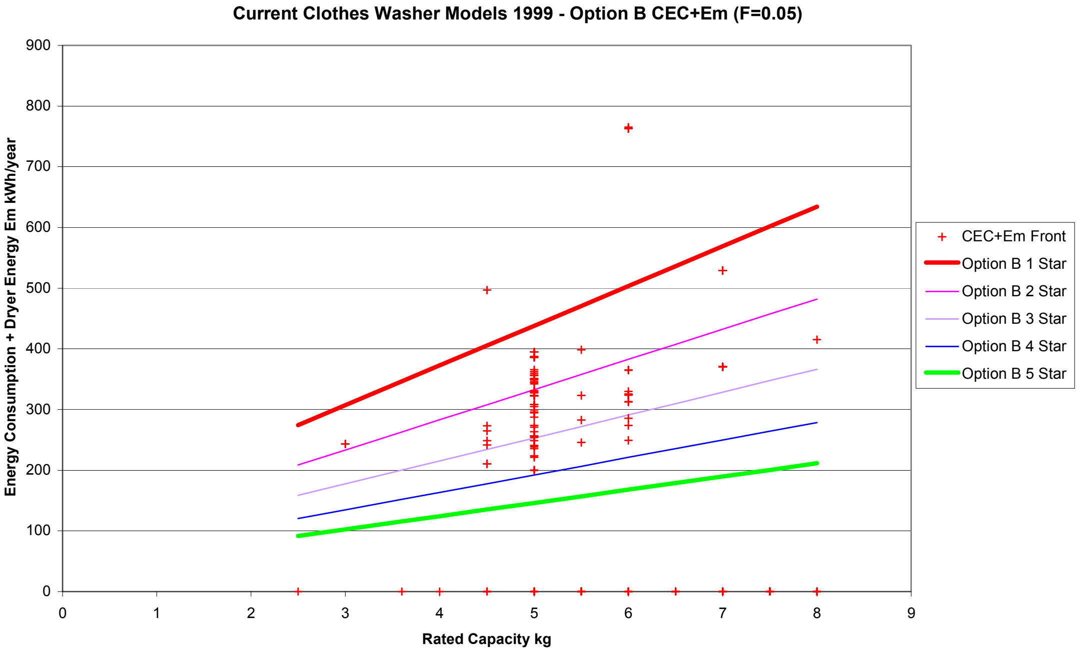
Under Option A each additional star is defined as a 15% reduction in energy from the previous star (ie as a geometric progression). Option A (top loading only) is shown in the following figure (it is assumed that this includes twin tubs):



The second proposal by Brown (Option B) is for ***front loading machines*** only:

1 Star = 111 + 48 × RC
F = 0.05

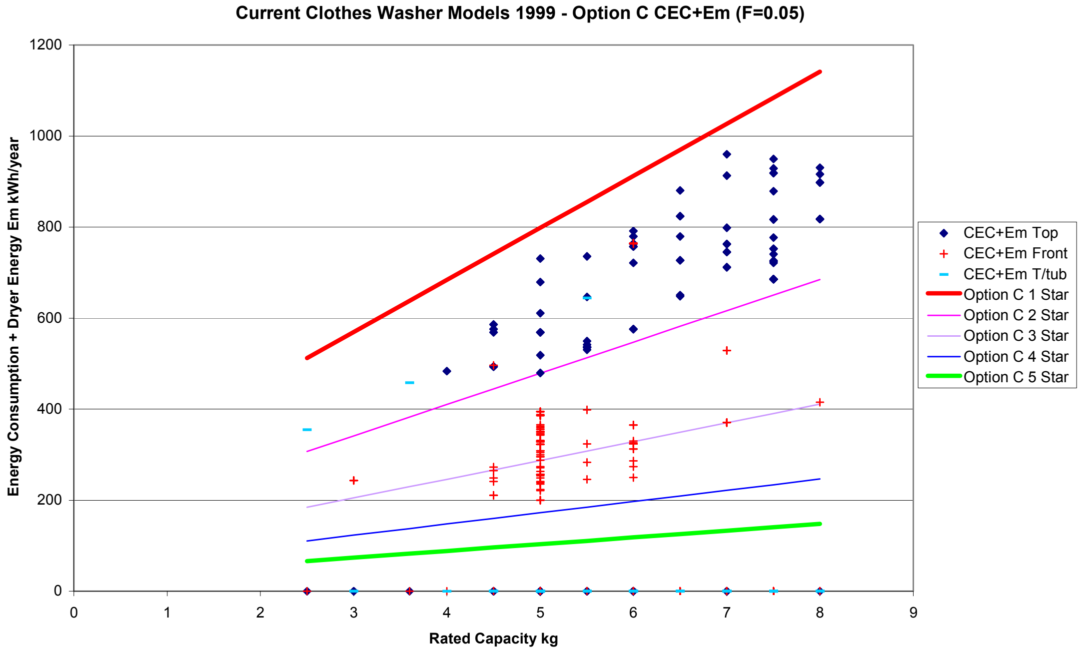
Under Option B each additional star is defined as a 24% reduction in energy from the previous star (ie as a geometric progression). Option B (front loading only) is shown in the following figure (note that 2 models are well below 1 star):



The third proposal by Brown (Option C) is for ***both top and front loading machines***:

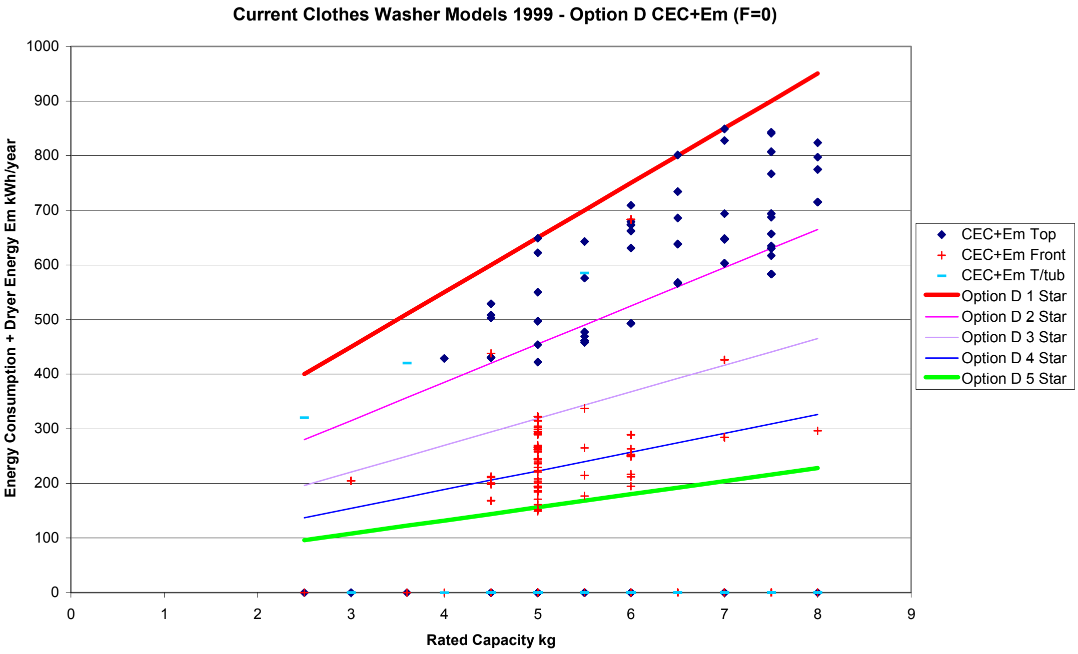
1 Star = 226 + 97 × RC
F = 0.05

Under Option C each additional star is defined as a 40% reduction in energy from the previous star (ie as a geometric progression). Option C is shown in the following figure. Top loaders rate only 1 star while front loaders rate 1 or 2 stars.



Some further options have been developed for consideration. These are combined scenarios which rate front and top loaders on the same basis. The main purpose is to investigate the impact of the spin credit component F on the rating systems as suggested by the working group.

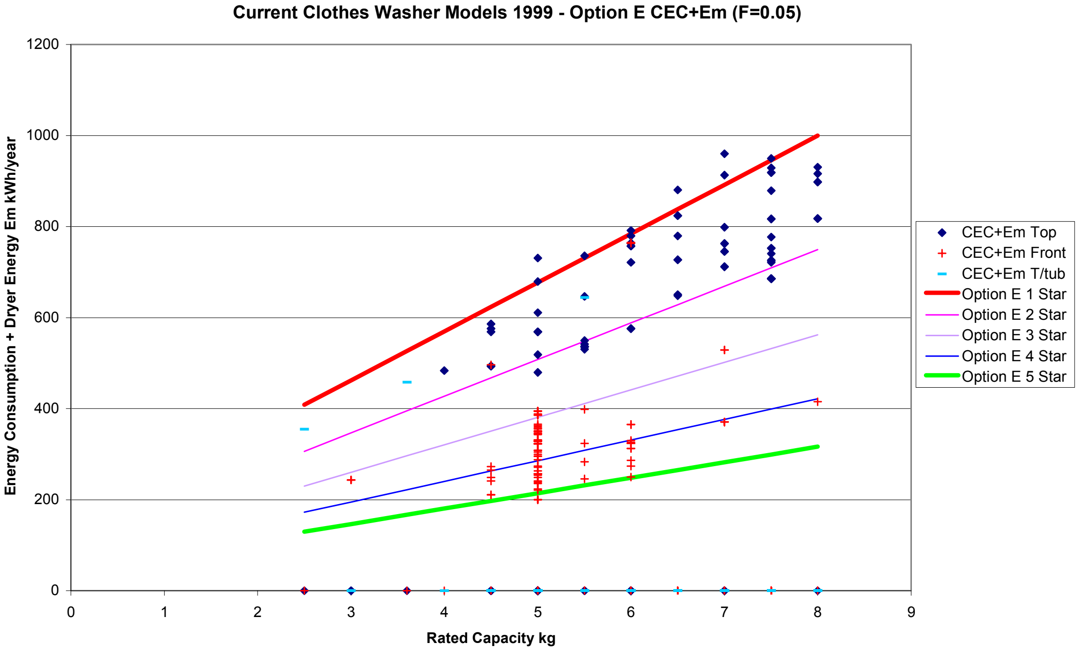
Option D
1 Star = 150 + 100 × RC
F = 0.0, Energy reduction per star of 30%



Option E

1 Star = 140 + 90 × RC

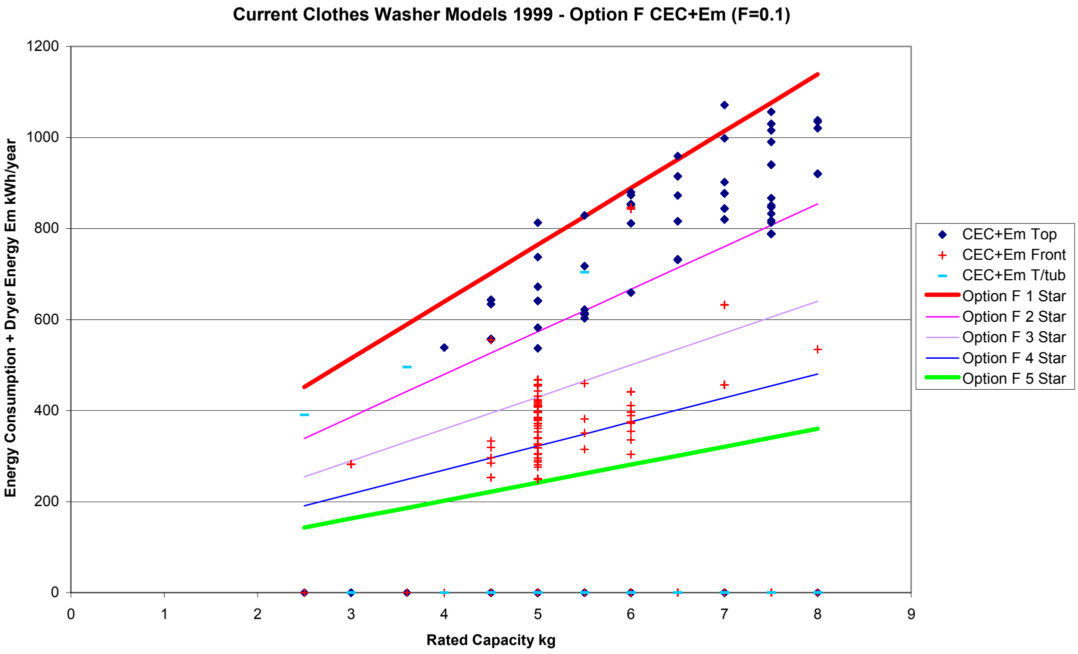
F = 0.05, Energy reduction per star of 25%



Option F

1 Star = 140 + 90 × RC

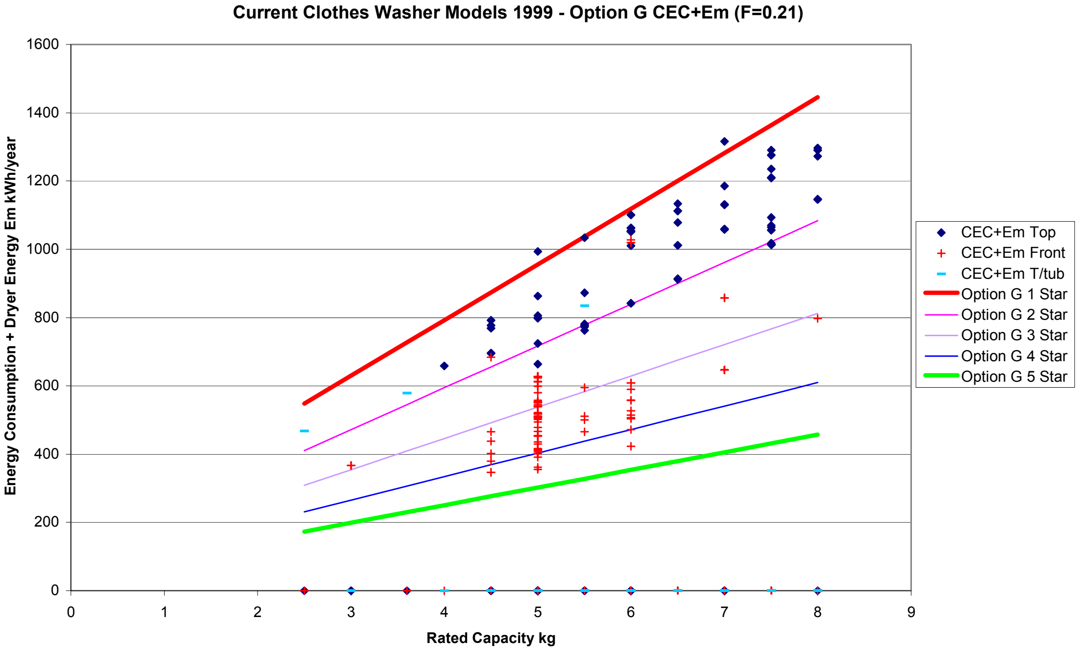
F = 0.1, Energy reduction per star of 25%



Option G

1 Star = 140 + 90 × RC

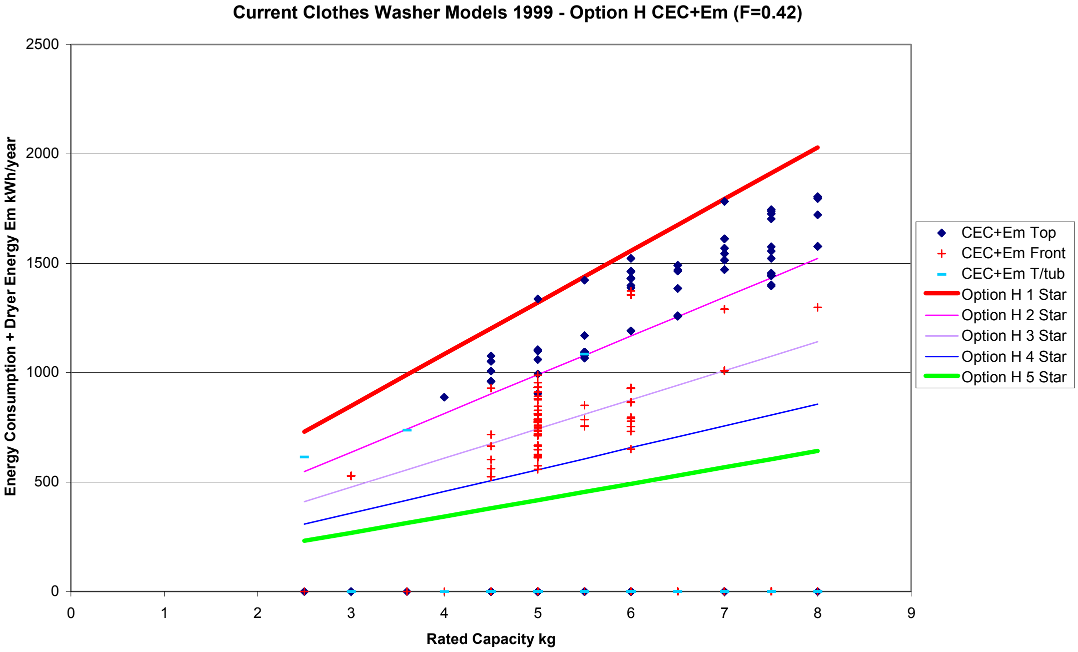
F = 0.21 (current value), Energy reduction per star of 25%



Option H

1 Star = 140 + 90 × RC

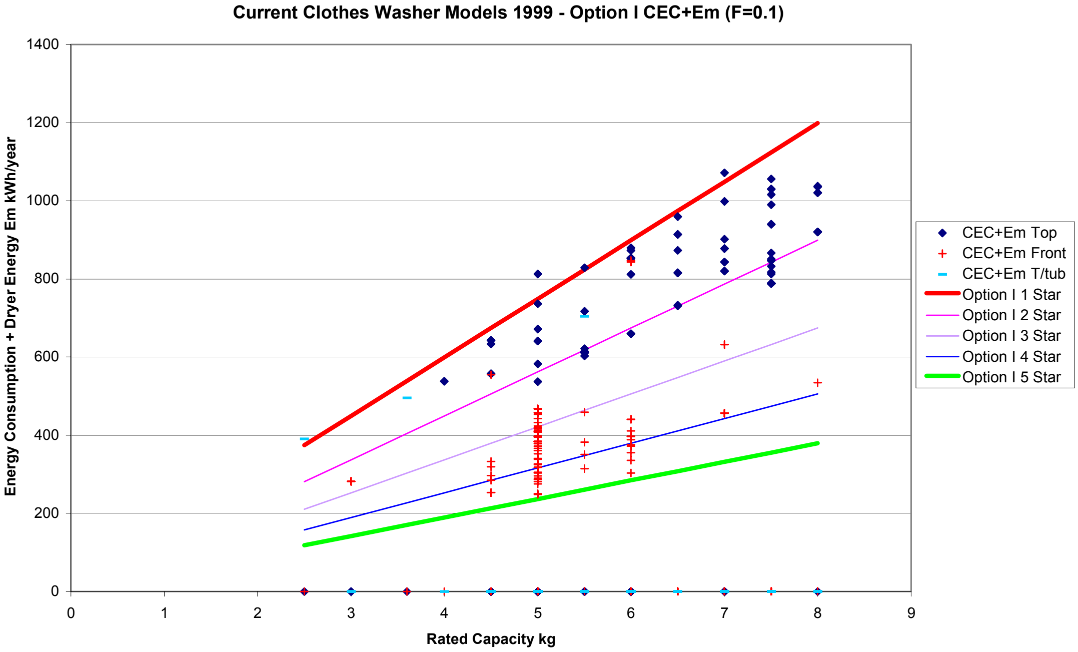
F = 0.42 (double the current value), Energy reduction per star of 25%



Interestingly, increasing the value of F pulls top loaders and front loaders closer together, although the relative star ratings change little. The higher value of F certainly helps differentiate within a clothes washer type, but not really between types. There are still two distinct technology bands. However, a value of 0.42 (as shown in Option H) is very high and this puts Em higher than the warm wash total energy for most clothes washers. This option is unlikely to be adopted, as it presumes that dryer use is of the order of 10 times higher than actual known use.

As requested by the working group, an option with no zero load offset has been developed (Option I). This option looks reasonably attractive as a number of top loaders get 2 stars (some even approach 2.5 stars), while top loaders are generally 3 and 4 stars (some are close to 5 stars). This tends to suggest that the size bias for clothes washers (although evident) is not particularly strong.

Option I
1 Star = 0 + 115 × RC
F = 0.1, Energy reduction per star of 25%



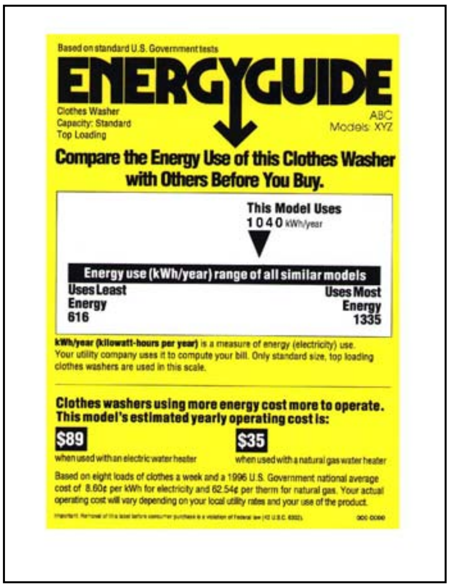
It would appear that a spin factor F of between 0 to 0.1 would be the most desirable option to be adopted (in line with the general recommendation by Brown), as this is broadly reflective of current user patterns of dryers.

As noted by Brown, it is difficult to develop an algorithm that rates top loaders and front loaders on the same basis. In Option E, for example, most top loaders rate 1 star (a few rate 2 stars, while most front loaders rate 3 and 4 stars - some even reach 5 stars). This is a function of the clothes washer types rather than the rating system. The big unanswered question is whether top loaders and front loaders should be rated together or separately. The argument for rating separately is that it allows differentiation within each type of washer. The argument against rating separately is that products which essentially provide the same energy service and use the same energy will receive different star ratings. Some consumers will find this upsetting and misleading and this may undermine the credibility of the labelling scheme.

It is recommended that further discussions and investigations be undertaken by the working group before a final algorithm is developed. Some of these can be undertaken at the next meeting in March 1999.

International Issues

Clothes washers are energy labelled in Europe and North America. MEPS levels have been set in USA and Canada. A range of other countries in south east Asia are considering energy labels for clothes washers while Hong Kong implemented a voluntary label in December 1997.



Based on standard U.S. Government tests

ENERGYGUIDE

Clothes Washer
Capacity: Standard
Top Loading

ABC
Models: XYZ

Compare the Energy Use of this Clothes Washer with Others Before You Buy.

This Model Uses
1040 kWh/year

Energy use (kWh/year) range of all similar models

Uses Least Energy 616

Uses Most Energy 1335

kWh/year (kilowatt-hours per year) is a measure of energy (electricity) use. Your utility company uses it to compute your bill. Only standard size, top loading clothes washers are used in this scale.

Clothes washers using more energy cost more to operate. This model's estimated yearly operating cost is:

$89 when used with an electric water heater

$35 when used with a natural gas water heater

Based on eight loads of clothes a week and a 1996 U.S. Government national average cost of 8.60¢ per kWh for electricity and 62.54¢ per therm for natural gas. Your actual operating cost will vary depending on your local utility rates and your use of the product.

North America

Energy Label - relative energy is shown with a standard EnergyGuide (USA - see left) or EnerGuide (Canada) label (there is no rating system like stars); no performance requirements. Introduced in 1979 in USA and in 1976 in Canada (various redesigns have occurred since introduction).

MEPS - US DOE and Canada set MEPS levels for clothes washers at 33.41[2] litres per kWh per program for units with a capacity of over 45 litres (1.6 ft^3) or 25.48[3] litres per kWh per program for those with a capacity of less than 45 litres capacity (compact - 45 litres is about 2.25 kg capacity for top loading). Introduced in May 1994 in USA and May 1995 in Canada.

The US test procedure specifies a normal program for cotton load. The rest of test procedure is rather complex. Non compact top loading machines are tested without a load. Other machines are test with either a 3 lb load or a 7 lb load (depending on the situation). The electrical energy and water consumption is tested for hot/warm, hot/cold, warm/warm, warm/cold and cold/cold on both maximum and minimum fill options. A whole range of usage factors are then used to adjust each of these values for known consumer use of wash temperatures and hot water system type. The test procedure is so convoluted that it is not possible to draw any comparisons with energy consumption in Australia.

Europe

Europe introduced energy labelling for clothes washers in 1995. The label itself is complex and contains an energy rating (A to G) as well an energy consumption per load, wash performance, spin performance, spin speed and the rated capacity (an example of the European washer label is shown in the following section). The program for energy labelling is the one recommended for a 60°C wash for a normally soiled cotton load. The best models on the market in Europe are made by AEG and Miele (amongst others) and rate A/A/A for energy, washing and spinning. The European test method is essentially IEC60456. Because of the difference in wash temperatures, it is not possible to make any direct comparisons with energy efficiency of clothes washers in Australia.

Declaration of spin performance on the label

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[2] This equates to about 0.6 kWh/kg per wash, but method of energy measurement is an average of many wash temperatures and fill options so is not comparable to energy under AS/NZS2040.1

[3] This equates to about 0.785 kWh/kg per wash, see footnote 2.

The working group noted the decision of the Energy Labelling Review Committee not to put spin performance on the label but to include it in brochures and on the Internet. However, the working group wanted consider the issue of declaration of spin performance on the label again at the next meeting. Some data on spin performance has been analysed to examine the issue of spin credit in the star rating.

There are not all that many countries around the world that have an energy label for clothes washers. The main ones are Canada, USA and Europe. However, a range of countries, particularly in SE Asia, are considering the adoption of a clothes washer energy label (Hong Kong introduced a voluntary label in December 1997). Of some interest is the fact the Europeans are the only ones to declare spin performance of clothes washers on an energy label.

An example of the European clothes washer label is shown to the left (this example is in German). The European label is rather complex as it shows (from the top) brand, model, energy rating (A to G), energy consumption per program, washing performance (A to G), spin performance (A to G) spin speed, rated capacity and water consumption per program.

The main issue for the committee to consider is whether the declaration of the spin performance is going to enhance overall consumer understanding and product differentiation. While the latter is probably true to some degree, the former may well not be so. It should be noted that spin performance will be included on energy labelling brochures and on the Internet site, so that interested consumers will have options to search out more detailed information if they wish to do so.

If the option of including spin performance on the energy label was to be further pursued, serious consideration would have to be given to some sort of simple “rating system” (like stars or A to G) for spin performance. We believe that the current spin index is too abstract and difficult for consumers to remember for inclusion on the label as it stands. An addition rating could also detract from the impact of the energy star rating. Further detailed consumer testing and careful design is strongly recommended before spin is included on the label.

The spin index performance data for models currently on the market is as follows:
Best: 0.54
Worst: 1.03
Model average: 0.78
Sales weighted average (based on GfK data - EES 1999): 0.70

Declaration of water on the label

There was extensive discussion at the last working group meeting in October 1998 regarding the inclusion of water consumption on the energy label. The potential problem of a mismatch between the energy label and a value declared by the manufacturer was raised. The meeting agreed that the value on the energy label for both water and energy consumption should be on the basis of the declared value (noting that some regulators currently opposed self declaration for energy consumption which are not supported by test results). It was noted that legal problems would be avoided if the declared value in product literature for water consumption were the same as the label value.

If this proposal is accepted, the value for water consumption on the energy label would be as per the manufacturer's declaration. There is a related issue regarding the allowable tolerance on such a declaration. It has been historical practice to allow a 10% variation between the declared water consumption and the measured water consumption (in much the same way as energy is currently evaluated). However, this allowance tolerance is during verification of the claim by a third party and has contained within it some allowance for reproducibility and repeatability error. In the case of energy, the average of the measurements on the units submitted for registration are usually used as the basis for the declaration.

The exception is for air conditioners, where the name plate values are used on the energy label, but test results on each of the three units tested has to support this value. The allowable tolerance in this case is 5% of the declared value (ie the test results for *each* unit cannot be more than 5% *worse* than the nameplate value). This would seem a reasonable basis for the declaration of water consumption on the energy label. Given that water pressure is tightly controlled in the test procedure and that water volume can be accurately measured, a tight tolerance on this initial declaration is warranted.

In summary, it is recommended for water consumption that:
a) water consumption on the energy label be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

Standby Power Consumption

A large number of appliance models now on the market have electronic controls and switches and many of these require a small but constant power consumption, even when the unit is nominally "off". This energy consumption can be significant (of the order of 20 to 100 kWh per year) and is of the same order of magnitude as the energy consumption of the motor and pump systems in a typical top loading clothes washer (where hot water is imported). The wet products working group agreed in principle to incorporate standby power consumption into the test procedure for wet products as soon as is practicable.

In practical terms this means:

- defining the possible power consumption states whilst the unit is not in operation (these could include: "off", on or standby (before a program is commenced), delay start power consumption, other intermediate states such as powering down to off);
- defining the instrument accuracy requirements for the measurement of energy consumption in these states (noting that power consumption may be less than 1 Watt in many cases and that the current waveforms may be very non-sinusoidal - high speed electronic power integration methods would be required to accurately measure power and energy in these cases);
- measurement of the program time for the program used for energy labelling (already undertaken in the current test procedure);
- finalisation of the frequency of use to be shown on the energy label (being considered by this working group);
- the composition of the standby power states which would be typical when the appliance is not in use.

The last point would most probably be considered by the wet products algorithm working group once standby measurements had been undertaken on a range of machines on the market and once the frequency of use aspects had been finalised (in the light of Pacific Power data analysis). For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby power consumption (if any) for non-use periods - these will total to give the CEC. Standby power consumption is likely to be eventually be shown in brochures and the Internet.

In terms of procedures and instrumentation required for the measurement of standby power consumption, there is a range of work being undertaken on the measurement of standby power consumption of office equipment by IEC TC74 working group 9. They will specifically consider measurements for low power states with poor harmonics. It is recommended that the work and proposals of this group be followed and incorporated into the wet product test procedures as appropriate.

References

10CFR430, *US Code of Federal Regulations - Energy Conservation Programs for Consumer Products*, US Department of Energy, 1 January 1998.

16CFR305, *US Code of Federal Regulations - Energy Labelling Requirements for Consumer Products*, US Federal Trade Commission, 1 January 1998.

AS2040.2 1998, *Performance of household electrical appliances - Clothes washing machines, Part 2: Energy labelling requirements*, Standards Australia.

Brown 1998, *Energy Labelling Review - Options for Improvement of Labels*, R.A Brown & Associates, Torrens Park, January 1998.

EES 1999, *Analysis of GfK appliance sales data from 1993 to 1997*, prepared by Energy Efficient Strategies for NAEEEC, final report, February 1999.

EU 1995, *Implementing Directive on the Energy Labelling of Household Washing Machines*, European Commission, Brussels, Directive 95/12/EC, 23 May 1995.

GWA 1991, *Review of Residential Appliance Labelling*, George Wilkenfeld & Associates (with Artcraft and Test Research), for the SECV, September 1991.

NRC 1996, *Guide to Canada's Energy Efficiency Regulations*, Natural Resources Canada.

Pacific Power 1996, *The Residential End-Use Study*, A detailed study of how and when electricity is consumed by the residential class in NSW, Pacific Power and NSW Electricity Supply Industry.

Appendix A: Extract of Minutes - Wet Products Algorithm Working Group - Clothes Washers

Melbourne, 22 October 1998

Overstated capacity - The decision of the Energy Labelling Review Committee was noted and accepted (capacity is adequately defined in the standard).

Wear and tear – The decision of the Energy Labelling Review Committee was noted and accepted (limits in the current standard are adequate).

Washes per year for the CEC – principles agreed for dishwashers will apply to clothes washer CEC (consider Pacific Power data when available).

Program nominated for energy labelling – The decision of the Energy Labelling Review Committee was noted and accepted (program specified in the standard is currently adequate).

Cold water washing – It was noted that the main purpose of the energy label is to compare the technical characteristics of different machines at the time of purchase in order to influence the consumer. However, cold/warm water wash program selection is a behavioural aspect of washer use and the label is not ideally placed to have an ongoing influence on consumer behaviour. The issue of performance degradation in cold water washing was noted, but consumers are increasingly using cold water washing despite this consequence.

The issue of how to depict cold water energy on the label was discussed at length. The options seem to be to show cold data on the label (CEC and/or stars) or to keep the rating at warm only with cold water energy information available separately (ie on brochures and Internet). From the discussion it was not clear how to include cold water only machines into the labelling program.

It was proposed that the test procedure in future be altered so that the wash temperature is not specified in the standard and that only a performance measure is specified.

After substantial discussion a proposal was made as follows:

- SRI continues to be based on warm water washing
- CEC shown for both cold and warm washing
- Cold CEC can be calculated from test report where there is no internal heating
- Cold CEC must be determined from a separate test if any internal water heating occurs on a warm wash
- No star rating on a cold water only label, only cold CEC to be shown
- Need to add a caveat (on the label or in brochures?) that performance and capacity has not been measured (nor is guaranteed) for cold water washing.

Spin credit in star rating – It was agreed that a range of star rating index (SRI) options should be developed and that these should include spin credit ranging from 0 up to the existing level (or perhaps more). It was noted that the star rating index will be re-graded according to the existing rules for other products during this process. The issue of size bias was discussed. It was noted that there is a slight size bias for top loaders. For front loaders, as most of the machines are clustered at around 5kg, there is no obvious size bias. It was agreed that the base energy consumption would continue to pass through the origin for clothes washers (ie no correction of size bias). Investigations would look at the options of rating front loading and top loading types together and as separate product categories (with different base indices). It was noted that if they are rated separately that it may be possible for a top and front loader of the same capacity and energy consumption to have a different star rating (in all likelihood the top loader will have a higher star rating in this case).

Inclusion of water consumption on the label – decision is the same as per dishwashers.

Rinse performance – The decision of the Energy Labelling Review Committee was noted and accepted (development of a method and setting a limit is an issue for the standards committee).

Suds saver – The decision of the Energy Labelling Review Committee was noted and accepted (this is a marketing issue for manufacturers).

Declaration of spin performance – the working group noted the decision of the Energy Labelling Review Committee not to put spin performance on the label but to include it in brochures and Internet. However, the working group wanted consider the issue of declaration of spin performance on the label again at the next meeting.

Highlighting capacity on the label – it was agreed that Energy Labelling Review Committee has the issue in hand. It was noted that there needs to be enough space to put data on model and capacity and program on the label.

Standby Losses – it was agreed that standby losses will be incorporated into the test procedure in due course for all labelled products (except for refrigerators and freezers). The standard will need to define various “states” of energy consumption (standby, delayed start, off mode etc) in the Part 1 standard. For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby losses (if any) for non-use periods - these will total to give the CEC. Standby losses (power) are likely to be eventually be shown in brochures and the Internet.

Appendix B - Support Documentation - Clothes Washers

As circulated to Wet Products Algorithm Working Group, October 1998

Clothes Washers

Manufacturers Overstating Rated Capacity

Issue: There has been a distinct increase in claimed capacities for larger top loading clothes washers in recent years, even when the physical dimensions have remained constant.

Discussion on the Issue: Claimed (rated) capacity levels have been pushed to a level where there has been a distinct and noticeable decline in performance of clothes washers. Manufacturers are doing this as a means of increasing their star ratings - they obviously believe that star ratings are valuable. Although there has been some regulatory action to date, this has been partly hampered by the fact that there has been some variation in the washability of various soil batches. These variations make determination of performance failure less certain in some cases.

The new standard for clothes washers is about to be published and this contains a process for swatch normalisation, which should make the performance limits in the standard much more enforceable. This will result in the elimination of overstated capacities.

Data Sources: Brown (1998) discusses the issue in Section 9.1 (page 53). This issue is being considered by EL15/4 and it should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Overstating capacity - ACA's view was that (claimed) rated capacities were currently too high and that standard deviations are large. ACA currently test products at 1 kg less than the rated capacity. Some felt that the issue of overstating capacity is being dealt with in the new standard and therefore it is not an issue for the label review committee but for the standards committee. Email noted that they were not happy with this position and that they would make a formal written submission to the committee regarding this issue.

It was agreed that the issue of how consumers use a clothes washer (in terms of actual capacity versus rated capacity) is not an issue which requires further consideration by the committee.

Wear and Tear Performance (cold washing)

Issue: The current wear and tear limits in AS2040 are moderate. Cold water washing, with increased wash times to meet performance requirements may increase wear and tear on the clothes load to unacceptable levels.

Discussion on the Issue: The current limit for wear and tear is mild (severity of washing index of 0.5 for 3 runs - this is being reduced to 0.35 for a single run in AS/NZS2040-1998). The actual wear and tear on clothes could be increased if performance requirements are included for cold water washing (eg longer wash times). However, such requirements for cold water washing, if any, are unclear at this stage. The issue of wear and tear and the washing performance requirements are an issue for the committee to consider when cold water covered.

Data Sources: Brown (1998) raises the issue in Section 9.1 (page 53) and in section 9.2 (page 55). The committee may need to undertake some analysis or research if necessary.

Energy Labelling Review Committee Decision: Wear and tear - It was noted that a large proportion of total washes are now done in cold water. It was also noted that some manufacturers are increasing wash times in order to meet the soil removal requirements for increased capacity and that this could have an impact on wear and tear. It was agreed that there is no need to change the standard if there is no performance requirement for cold water washing.

Washes per Year for the CEC

Issue: The CEC on the label assumes 365 loads per year, whereas some sources suggest that this is an over-estimate.

Discussion on the Issue: The number of washer per year has a direct impact on the CEC. Clearly there will be a wide distribution of washes per year for different household types and there is some debate whether the mean or median is a more appropriate measure of the frequency of use. A number of data sources are available for consideration.

Data Sources: Brown (1998) raises the issue in Section 9.2 (page 54) and suggests the current number of washes per year is too high. The data he cites is Test Research (1995, Q69 page 41) which suggests an average number of "washing sessions" of about 3.7 per week (although the data was collected in a poor manner). Brown seemed to overlook the fact that this reference also suggests that each session consisted of around 2.34 loads of washing (Q70), giving the total washes per week as 8.7, which means that the current CEC understates the frequency, if anything. QEC 1993 also shows a Queensland average for 1992 at about 3.7 washes per week, but there is some uncertainty as to whether this is "loads" or "sessions".

Some data is available in ABS8218.0 (1988) based on diary records in 1985/86, but this is based on hours of use rather than loads and is difficult to use directly (program times vary considerably between machines).

Another key source may the Pacific Power Residential End-Use Study (Pacific Power 1996). The raw data contains actual in-use information for some 151 clothes washers for a period of about 18 months from early 1993 to mid 1994. However, the raw data is not yet available (DPIE have held a number of discussions with Pacific Power) and it is still unclear whether any energy labelling data for the units measured will be available. The report energy consumption is 55 kWh per year, which is consistent with 365 loads per year at 0.15 kWh per load (almost all units will use external hot water).

Some data on frequency of use may be available from manufacturers, as this data is sometimes recorded within the machines for service purposes.

Energy Labelling Review Committee Decision: The issue of whether to use a time based energy or a per cycle energy was discussed. It was agreed in principle that one load per day should continue to be used, pending the results of the data analysis from the Pacific Power data.

Program Nominated for Energy Labelling

Issue: Program nominated for energy labelling should be the one recommended by the manufacturer for a normally soiled cotton load.

Discussion on the Issue: This requirement is now included in the forthcoming AS/NZS2040 Part 2. The performance requirements in Part 1 also relate specifically to the program recommended for a normally soiled cotton load.

Data Sources: Brown (1998) raises the issue in Section 9.2 (page 54). It should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Program for labelling - it was agreed that this issue was now adequately covered by the standard.

Cold Water Washing

Issue: There is a long term towards increased use of cold water washing in Australia. This trend should be reflected in the energy label to show consumers the energy benefits of cold water washing.

Discussion on the Issue: This is a well documented problem with the current energy labelling system for clothes washers. From a labelling perspective, cold water washing will have the biggest impact where the consumer can compare the energy savings of cold water washing with warm water washing, so it may be desirable to show both on the label. Trends in wash temperatures are as follows:

Wash Temperature Mostly Used	**Cold**	**Warm**	**Hot**
1988	31%	53%	16%
1992	44%	49%	7%
1995 **	54%	41%	4%

Source: Chapter 5, GWA (1993), Test Research (1995)
Note **: 1995 figure was for last wash load, not mostly used, but should be equivalent

The main issues to be addressed are washing performance requirements and capacity for cold water washing: should performance requirements be specified for machines which are labelled for cold water washing and can a machine have a different rated capacity for cold washing and warm washing? This is potentially a very complicated issue.

Obviously, the star rating algorithm will need to be revisited in the light of inclusion of cold water washing into the program. It will probably need revision in any case, even if cold water washing is not included. Revision will also allow the removal of the small size bias from the current algorithm. Note that even with cold water washing (ie very low energy consumption), it is not possible to achieve 6 stars under the current algorithm.

Data Sources: Brown (1998) raises the issues of cold water washing in Section 9.2 (pages 54-55) and revised algorithms in Section 9.3 (page 56) where a number of options are canvassed.

Energy Labelling Review Committee Decision: Cold water washing - the issue was discussed in some detail. Options proposed for consideration were as follows:

- *do we show two CECs? (agreed to test as per AC label variant)*
- *do we have two bands or just one for warm wash? (agreed two bands)*
- *do we have same algorithm for cold and hot? (not clear - see below)*
- *are there performance requirements for cold washing? (only for warm washing)*

It was agreed that there is no need to differentiate between cold water energy results (in terms of star ratings) if they occur in a narrow range (ie no need to accentuate real small differences). Agreed to test options for a cold water label in the focus groups. Test blue/red label as per AC design.

It was agreed that if there is internal heating for warm washing, the unit must be retested to get the energy consumption on the coldest wash (may or may not be internal heating for a "cold wash") for the blue band. While the rating algorithm for cold and warm washing cold be done on a common basis (for consistency across cold, luke warm and warm washes), there may be an argument for looking at separate algorithms for cold and warm.

It was proposed that a ratio of wash performance for cold wash versus warm wash be included in brochures, but this was considered and rejected by the committee. The issue could be considered again in the future when the wash performance on warm wash is fully reproducible and the proportion of cold washes is higher. This will enable consumer to chose a machine that washes well in cold water.

Spin Credit in Star Rating

Issue: The spin performance of a clothes washer is partly reflected in the clothes washer star rating on the basis that some consumers will place the load directly into a clothes dryer. However, the influence of spin performance on star rating should be reviewed based on the latest data.

Discussion on the Issue: The impact on spin index should be reviewed if the energy labelling algorithm is revised on the basis of average clothes dryer characteristics, data on frequency of use and ownership of clothes dryers in Australia. It has been suggested that the spin performance should also be partly included in the CEC, but this would be double counting the energy, as all dryer energy is shown on the dryer label.

Data Sources: Brown (1998) raises the issue in Section 9.2 (pages 55-56). Data on frequency of use of clothes dryers will be covered under Section **Error! Reference source not found.**, **Error! Reference source not found.**). Data on trends in ownership are available by state and nationally in EES (1998). Information on average characteristics of new clothes washers and clothes dryers are available in EES (1997).

Energy Labelling Review Committee Decision: Spin credit - Agreed not to consider adding spin credit into the CEC. The working group is to look at rescaling spin credit back to level based on known current clothes dryer use levels. Two options which should be developed for the committee include one with spin credit and one with no spin credit.

Inclusion of Water Consumption on the Energy Label

Issue: There is a case for inclusion of water consumption on the energy label.

Discussion on the Issue: Information on water consumption is already included in energy labelling brochures. Should this also be included on energy labels? There is the question of jurisdiction - whether there is power to require water consumption to be supplied and whether false claims can be addressed under the current heads of power. Values in current brochures are taken from the test report. However, values should be based on manufacturer rated values as far as possible. Approaches to this issue should be discussed by the committee.

Data Sources: There are no specific data sources in addition to energy labelling brochures for this issue. See also results of recent focus groups.

Energy Labelling Review Committee Decision: Water consumption - show on label as per other wet appliances.

Inclusion of a Rinse Performance Requirement

Issue: The current and proposed clothes washer standards do not include a minimum rinse performance requirement. With the declaration of water performance and water efficiency labelling, there is pressure to reduce water consumption through reduced rinsing, hence a minimum performance requirement is needed.

Discussion on the Issue: Standards committee EL15/4 is highly conscious that this performance requirement is missing from the clothes washer standard. The fundamental problem is that there have been difficulties developing a repeatable and reproducible test procedure. Without a test procedure, it is not possible to specify a minimum performance requirement. Further development work on the IEC procedure is proposed by EL15/4 in 1998.

Data Sources: There are no specific data sources for this issue. It should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Rinse performance - leave it to the standards committee to develop a test procedure and a performance requirement.

Suds Saver

Issue: Should the suds saver feature get some sort of credit under the energy labelling program?

Discussion on the Issue: Suds saver is a water conservation issue and is not related to energy consumption (it is equivalent to a cold water wash). It is recommended that this feature be not shown on the label. The committee should consider whether it is possible or worthwhile to show the feature on energy labelling brochures.

Data Sources: There are no specific data sources for this issue.

Energy Labelling Review Committee Decision: Suds saver - not to be included on label or in the brochures. Responsibility for marketing this feature lies with the manufacturers.

Declaration of Spin Performance

Issue: Should spin performance be shown on the label or in the energy labelling brochures?

Discussion on the Issue: It has been agreed with industry that spin performance is a public performance variable as it is required to calculate the EER. Spin performance is also of interest to consumers. While spin performance is probably not suitable for inclusion on the energy label, the data could be shown in the energy labelling brochures.

Data Sources: There are no specific data sources in addition to energy labelling registers which have data on spin performance.

Energy Labelling Review Committee Decision: Spin performance - not to be put onto the label. Agreed to place it on the web site and in the brochure.

Highlighting Capacity on the Energy Label

Issue: Clothes washer capacity is a key variable of concern to consumers. Although the capacity is currently shown on the label, it is in small print.

Discussion on the Issue: Consideration should be given to highlighting capacity on the energy label. If recommended, this should be tested on consumers.

Data Sources: The international review of energy labelling provides examples of clothes washer labels for consideration.

Energy Labelling Review Committee Decision: Capacity on the label - look at reformatting option.

Appendix 13: Dishwashers – algorithm discussion paper

Appliance Labelling Review Committee
Wet Products Algorithm Working Group
Discussion Paper - Dishwashers

prepared by EES, March 1999

Background

During 1998, the Appliance Energy Labelling Review Committee considered a wide range of issues associated with the possible revision of the appliance energy labelling program. A number of issues relating to specific products were referred to algorithm working groups. In October 1998, the wet products algorithm working group met to consider the issues associated with the energy labelling of dishwashers, clothes washers and clothes dryers, including the possible regrading of star rating algorithms. An excerpt from the minutes of this meeting which are relevant to dishwashers has been included as Appendix A. An extract from the Appliance Energy Labelling Review Committee support document for dishwashers is attached as Appendix B.

This paper reviews the issues associated with dishwashers. Only issues that require additional discussion have been included (ie topics are not included where a final decision has already been agreed). Where necessary, additional data has been analysed and the results summarised. Some preliminary recommendations are presented for further consideration by the working group.

The opinions offered within this document are those of EES and are not intended to bind the committee to any particular course of action.

Key Issues for Considered in this Paper

- Uses per year for the CEC
- Program nominated for energy labelling
- Bunching of star ratings and size bias (algorithm revision)
- Declaration of water on the label
- Water connection mode
- Standby energy consumption

It is still to be decided whether retesting will be mandatory for the introduction of the new energy label and algorithms, or whether current models can be re-registered with the new label without further tests (this is an issue with respect to the algorithm revision).

Summary of Recommendations

Uses per year for the CEC

It is recommended that the Pacific Power data analysis proceed as quickly as possible to assist in finalising the CEC value on the label. However, it is noted that the CEC has no bearing on the relative energy efficiency of the product (ie star rating).

Program nominated for energy labelling

The program specified for energy labelling in future should be the "program that is recommended by the manufacturer for everyday use". No action with respect to the minimum wash performance requirements is recommended until the EL15/4 working group considering this issue makes a recommendation.

Bunching of star ratings and size bias (algorithm revision)

At this stage, it is recommended that Option B1 be given further consideration by the wet products algorithm working group for adoption as the new star rating algorithm for dishwashers if dishwashers are not required to be re-registered. However, if all models are to be changed over to a normal program in a short period (ie during the introduction of the label, which would require retesting and new submissions by manufacturers), Brown's original Option A or Option B1 may be suitable. These alternatives can be discussed and refined at the next working group meeting as required.

Option B1

Equation: 1 Star = 159 + 36 × PS, reduction per star = 30%

Pros - appears to correct for size bias; 1 star line is close to the lower end of the market for various sizes, best models on the market just under 4 stars. Suitable if Normal program not implemented retrospectively.

Cons - none of significance.

Option Brown (Option A)

Equation: 1 Star = 159 + 36 × PS, reduction per star = 25%

Pros - appears to correct for size bias; 1 star line is close to the lower end of the market for various sizes.

Cons - highest rating products currently close to 4.5 stars (too high) - this would be dragged back somewhat if all models had to be re-registered under a Normal program.

Declaration of water on the label

The recommendations for water consumption on the label are that:

a) water consumption on the energy label be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

Water connection mode

With respect to water connection mode for dishwashers, it is recommended that:

a) primary water connection mode be based on cold water (single) connection in all cases;
b) supplementary water connection mode be hot for models with a single water inlet or dual for models with two water inlets;
c) only in the case of a model with a single water inlet where the manufacturer specifically recommends against hot connection, that no supplementary water connection mode be required.

Standby Power Consumption
It is recommended that standby power consumption be incorporated into the energy consumption shown on the energy label. Actions required to achieve this are:

- defining the possible power consumption states;
- defining the instrument accuracy requirements;
- finalisation of the frequency of use to be shown on the energy label;
- deciding on the composition of the standby power states when the appliance is not in use.

For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle with standby power consumption for non-use periods to give the CEC. Standby power consumption should eventually be shown in brochures and the Internet. It is recommended that the work and proposals of IEC TC74 working group 9 be followed and incorporated into the wet product test procedures as appropriate.

Detailed Discussion

Uses per year for the CEC

The uses per year affects the magnitude of the comparative energy consumption shown on the energy label, but has no bearing on the relative energy efficiency of the product (ie star rating). While it is desirable to get the CEC as close as possible to the actual average energy consumption from a consumer perspective, this is not absolutely critical. There needs to be a balance between policy objectives (favouring overstating energy to encourage efficiency) and accuracy of information for consumers.

Currently available data sources suggest that the average uses per year are of the order of 200 to 350 times. It should be possible to improve this estimate (in terms of both the average and the frequency distribution) once the Pacific Power data has been analysed. Initial results should be available by the middle of 1999. Note that it is not possible to show a frequency distribution on the current energy label.

In October 1998 the wet products algorithm working group suggested that energy consumption should be shown in kWh per year and that uses should be shown as uses per week. This would suggest that uses per year should be 209, 261, 314 or 365 (corresponding to 4, 5, 6 & 7 times per week), depending on the findings of the Pacific Power Data. It is recommended that this data analysis proceed as quickly as possible to assist in finalising the CEC value.

Program nominated for energy labelling

The October 1998 the wet products algorithm working group noted that the dishwasher standard currently allows manufacturers to specify any program for energy labelling - this may not be recommended for normal use by the consumer (and in fact may be difficult to select in some cases). It was further agreed at the meeting that in future that data on the energy label should be determined for “the program we expect will most often be used in practice by the consumer” – this may be the "program that is recommended by the manufacturer for everyday use". There needs to be a much stronger link between the manufacturer's recommendations regarding programs and the program specified on the label.

The working group requested that data on programs selected by consumers be compiled for consideration.

The only significant data source on the program selected by dishwasher users was collected by Test Research in 1995. This was a self completed survey questionnaire of about 2,900 consumers. About 40% of the respondents were from NSW. The results of Question 54 (page 34) are summarised in the following table.

Table 1: Uses per Week - Various Dishwasher Programs

Program => Uses per week	**Fast**	**Economy**	**Normal**	**Gentle**	**Pot Scrub**	**Rinse & hold**
0	60%	25%	13%	91%	77%	61%
1	12%	16%	17%	4%	11%	12%
2	28%	13%	13%	5%	12%	7%
3		10%	12%			10%
4		9%	10%			10%
5		10%	6%			
6		7%	6%			
7		10%	19%			
8			4%			
Average uses per week	**0.7**	**2.7**	**3.5**	**0.1**	**0.4**	**1.0**
Proportion of all uses	**8.2%**	**32.4%**	**42.0%**	**1.7%**	**4.2%**	**11.5%**

Source: Test Research 1995, Question 54.

Clearly, a wide of wash programs are selected by consumers. It is also likely that, on average, each consumer selects a number of different programs, depending on the situation. In addition, rinse and hold would be followed by a full washing program of some description, so this can be discounted in terms of energy labelling (rinse is cold water in most cases - except for hot connect).

Average uses per week (excluding rinse and hold) is 7.3, but this needs to be treated with some care as it is based on consumer recall. Nearly half of these are the normal program, while about 40% are "economy" type programs. Fast, pot scrub and gentle programs are relatively uncommon.

Conversely, the programs registered for energy labelling are quite different to those actually used by consumers, as shown in Table 2.

Table 2: Dishwasher Programs Used vs Registered

Program =>	Fast	Economy	Normal	Gentle *	Other **
Proportion of all uses ***	9.2%	36.6%	47.5%	1.9%	4.7%
Registered Program	21.8%	34.7%	22.4%	11.6%	9.5%

* For registered programs, includes delicate and gentle
** For registered programs, about half of Other are unknown programs
*** Excludes wash and hold programs
Source: Energy labelling register database

While the proportion of households using economy program is roughly equal to the proportion of models registered with economy programs, the actual use of normal is much higher than the proportion of registrations and fast and gentle are substantially over-represented in registrations. All of this lends support to the recommendation of specifying the "program that is recommended by the manufacturer for everyday use". This may need to be in the form of a load definition or perhaps a program definition. Note that both North America and Europe use a "Normal" program specification for labelling and MEPS.

It was also agreed at the last working group meeting that if the "normal use" program was specified for labelling, that there may be a need to rethink the context of the minimum performance requirement for dishwashers. In 2007.1-1998 the wash performance requirement is now defined in terms of a performance relative to the reference machine (test machine must equal or exceed wash performance on reference machine "Economy 1/2 55°C").

The current level of wash performance in the Australian Standard has been selected as a reasonable minimum acceptable level for consumers. This is to ensure that a minimum level of energy service has been provided before the energy consumption and efficiency are determined on the energy label. It is included as a consumer protection mechanism to make sure that dishwashers actually wash dishes. If the wash performance requirement is not changed but energy labelling has to be undertaken on a "normal" type program in future, there may be a temptation for manufacturers to "de-tune" their normal programs down to a performance level which is close to the required wash performance requirement on the reference machine. However, there should be no problem as long as the minimum wash performance requirement in the standard is truly acceptable to consumers. The issue of minimum wash performance requirement in the standard is currently under review by a working group. No action with respect to the minimum wash performance requirement is recommended until this working group makes a recommendation regarding wash performance.

Bunching of star ratings and size bias (algorithm revision)

Bunching of star ratings for dishwashers has long been recognised as a problem.

The current star rating system is linear in nature and provides an extra star for each

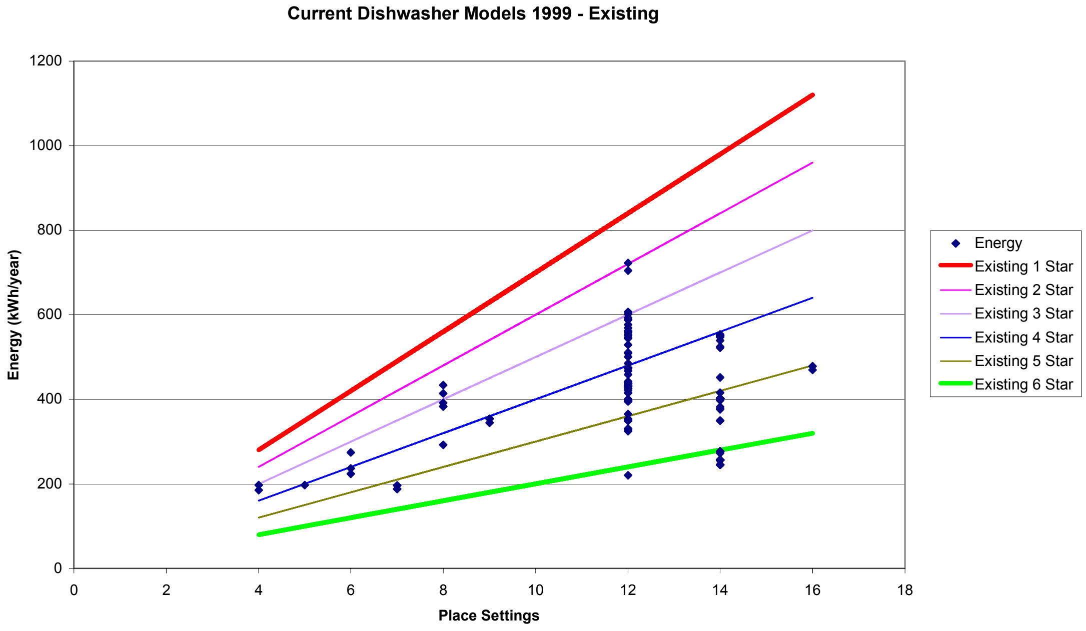
10 kWh reduction of energy consumption per place setting. The current formula to determine EER is as follows:

EER = 8 - [CEC ÷ (10 × PS)]

Where:
CEC = comparative energy consumption on the label (kWh/365 uses)
PS = rated capacity (place settings)

For example, for a 12 place setting dishwasher, 1 star is 840 kWh, 5 stars is 360 kWh and 6 stars is 240 kWh. 360 kWh per year is just under 1.0 kWh per program.

The current star rating lines together with models on the market in early 1999 are shown as "Existing" in the following figure:



As of early 1999, only 1 model has a star rating of less than 2. Of the 147 models current in early 1999, some 66 (45%) had a star rating of 5 or greater. Many of these are the largest selling models on the market.

In reviewing the star rating algorithm for products, the Energy Labelling Review Committee provided working groups with some general guidelines:

- new star ratings should be a geometric progression
- best products currently on the market should not generally exceed 4 stars
- 5 star should be set as difficult but achievable in the next 5 years
- worst products on the market (or MEPS level where applicable) should generally be around 1 star
- star rating to be shown in half stars on the new label
- elimination of size bias where this is significant

Richard Bollard of Fisher & Paykel may table some additional information on the issue of dishwasher size bias at the next working group meeting.

In his review of the energy labelling program during 1997, Brown (1998) made a single recommendation regarding the revision of the dishwasher algorithm (called Option A in Brown 1998, page 65). The option uses the "size trend line" which was determined empirically. Brown states that the trend line is "not as strongly established as the trend line for refrigerators, dryers and top loading washers" and recommends that this should be subjected to "critical review" before the rating formulae are finalised.

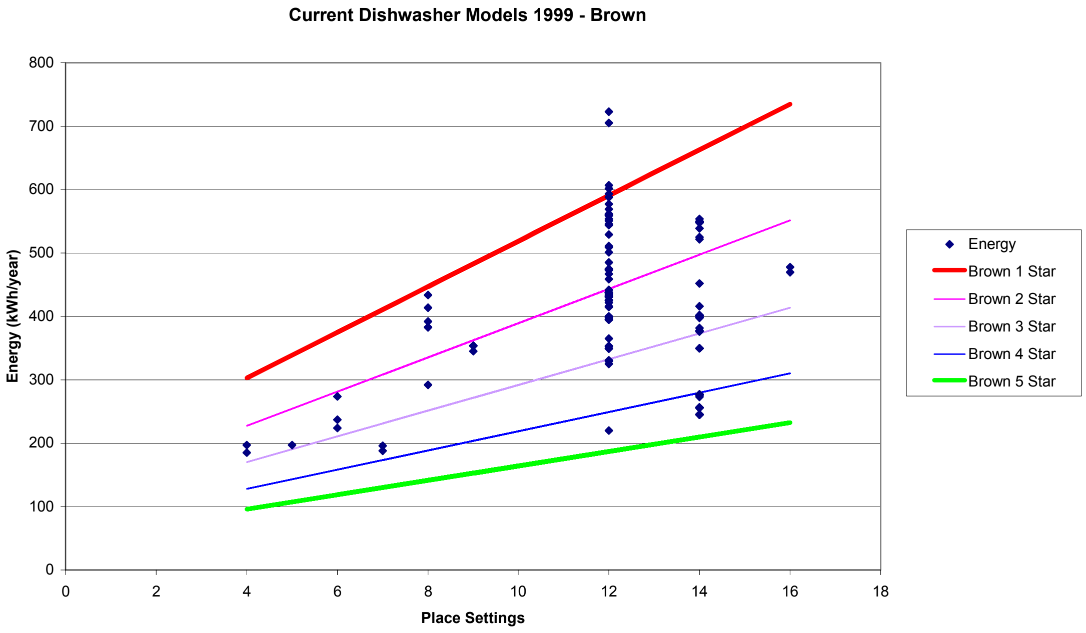
The star rating algorithm proposed in Brown's Option A is a geometric progression (as used for the refrigerator star rating revision) and is generally in line with the broad principles recommended by the Energy Labelling Review Committee.

Brown (1998) defines the 1 star line as fixed kWh offset with a variable kWh per place setting. Each additional star is defined as a 25% reduction in energy from the previous star (ie as a geometric progression). The equation Brown suggests is:

1 Star = 159 + 36 × PS

where:
159 = fixed energy offset
36 = slope of the 1 star line (in kWh per place setting)
PS = rated capacity (place settings)

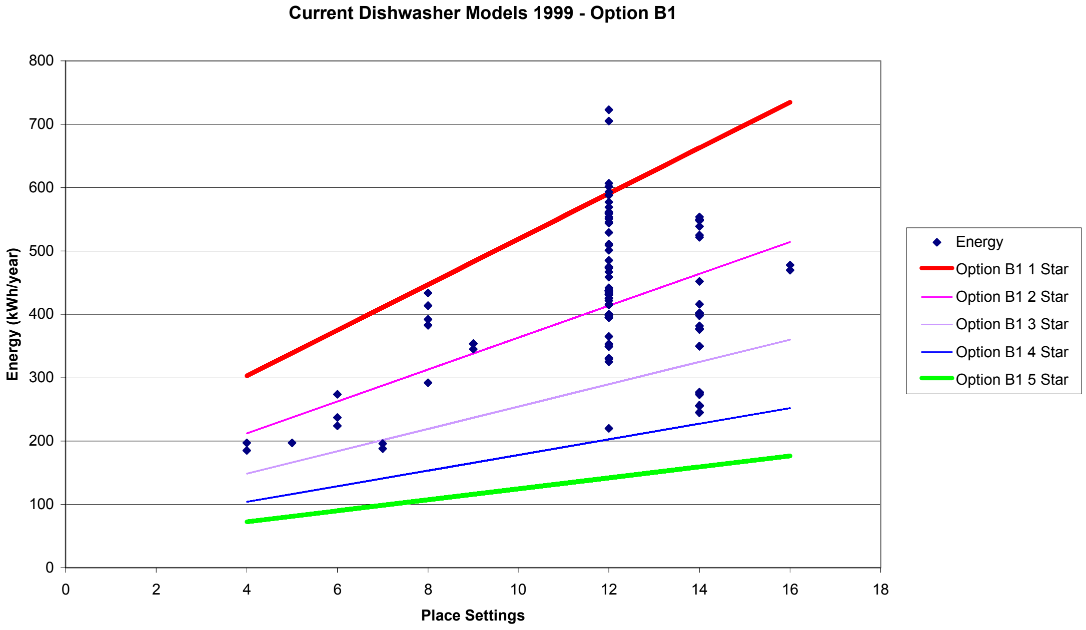
This Option is shown as Brown in the following Figure:



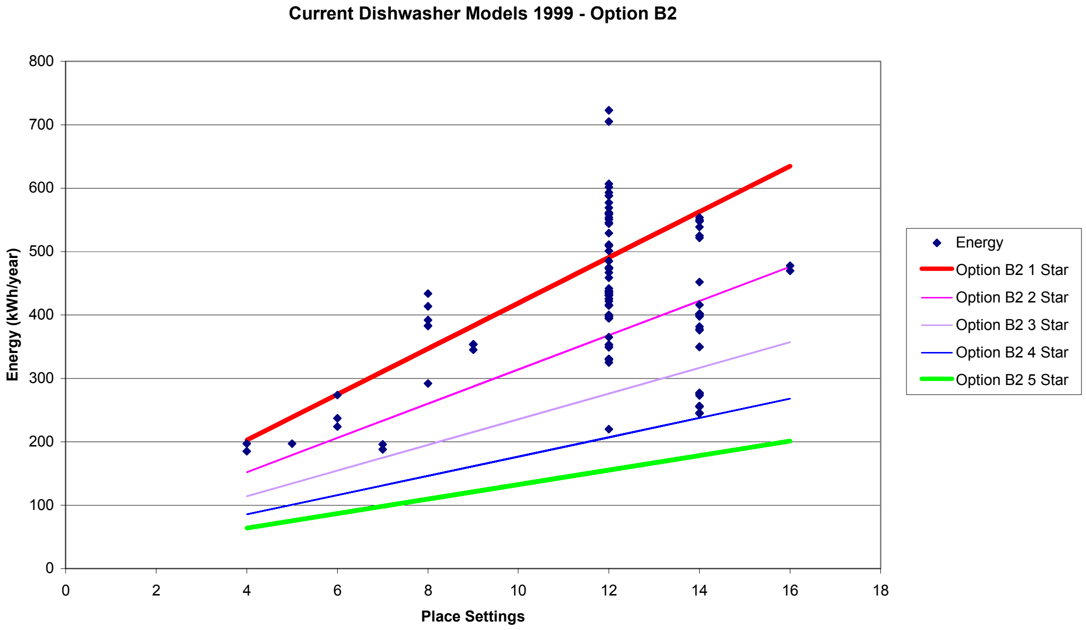
The slope of the line appears to provide reasonable compensation for the reduced energy efficiency for smaller models (based on a visual assessment - technical data is not available to support this proposal). The only problem with this grading is that the best models currently on the market achieve well over 4 stars - in fact the best models achieve nearly 4.5 stars. While it is acknowledged that the best models on the market in Australia are now quite efficient, as a target, the Energy Labelling Review Committee suggested that the best models should achieve just under 4 stars.

The proposed 4 star line could be moved down slightly by either moving down the 1 star line (and keeping the step size constant) or by increasing the step size of the energy consumption decrease per star (while keeping the 1 star line constant).

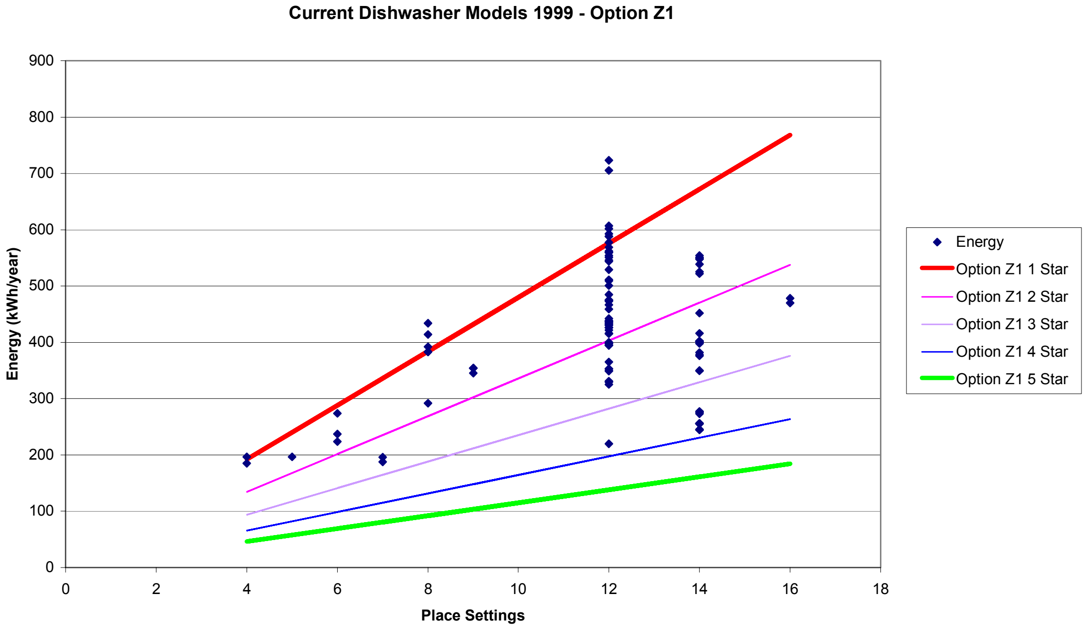
The following Option B1 uses Brown's original 1 star line but with a reduction in energy per additional star of 30%. As can be seen in the following figure, the best models under this Option rate just under 4 stars. The majority of models are 1 and 2 stars, while there are some models in the 3 and 3.5 star range. Under this Option, the 5 star target is set at 142 kWh for a 12 place setting dishwasher - a difficult but achievable target within the next 5 years.



The following Option B2 uses Brown's original 1 star line but with a change in the fixed energy allowance from 159 kWh to 59 kWh - the energy reduction per additional star remains at 25%. As can be seen in the following figure, the best models under this Option also rate just under 4 stars. However, this Option is somewhat problematic as there are many models with an EER (Star Rating Index) of less than 2.5, including a significant number with an EER of less than 1.0, which is generally undesirable. A few models have an EER of greater than 2.5, while a couple of models are in the 3 and 3.5 star range. This option also scores smaller dishwasher relatively more harshly than Option B1.



At the Wet Products Algorithm Working Group meeting in October 1999, the working group "discussed the issue of size bias and agreed that it is not necessary to change the algorithm to eliminate the current size bias (ie star rating curves would still pass through the origin)." Accordingly, an Option with no offset (passing through the origin) has been prepared for consideration. Option Z1 (shown in the following figure) has an energy offset of zero and a slope of 48 kWh per place setting and an energy reduction of 30% per additional star. This option covers the range of CECs currently on the market, but still has a significant size bias.



In summary, each of the Options prepared for this paper are considered:

Option Brown (Option A)
Equation: 1 Star = 159 + 36 × PS, reduction per star = 25%
Pros - appears to correct for size bias; 1 star line is close to the lower end of the market for various sizes.
Cons - highest rating products close to 4.5 stars (too high) - this would be dragged back somewhat if all models had to be re-registered under a Normal program.

Option B1
Equation: 1 Star = 159 + 36 × PS, reduction per star = 30%
Pros - appears to correct for size bias; 1 star line is close to the lower end of the market for various sizes, best models on the market just under 4 stars. Suitable if Normal program not implemented retrospectively.
Cons - none of significance.

Option B2
Equation: 1 Star = 59 + 36 × PS, reduction per star = 25%
Pros - best models on the market just under 4 stars.
Cons - appears to have some size bias, many models worse than the 1 star line, star lines are quite narrow.

Option Z1
Equation: 1 Star = 0 + 48 × PS, reduction per star = 30%
Pros - 1 star line is close to the lower end of the market for various sizes, best models on the market just under 4 stars.
Cons - appears to have significant size bias.

International Issues

Dishwashers are a relatively unusual product in terms of world markets and the only regions which have a significant use of dishwashers are North America, Europe and Australasia. Not surprisingly, North America and Europe also have energy labelling programs for dishwashers as well.

North America

Energy Label - relative energy is shown (no rating system like stars); no washing or drying performance requirements (units are tested with clean loads). Introduced in about 1978 in USA and 1976 in Canada.

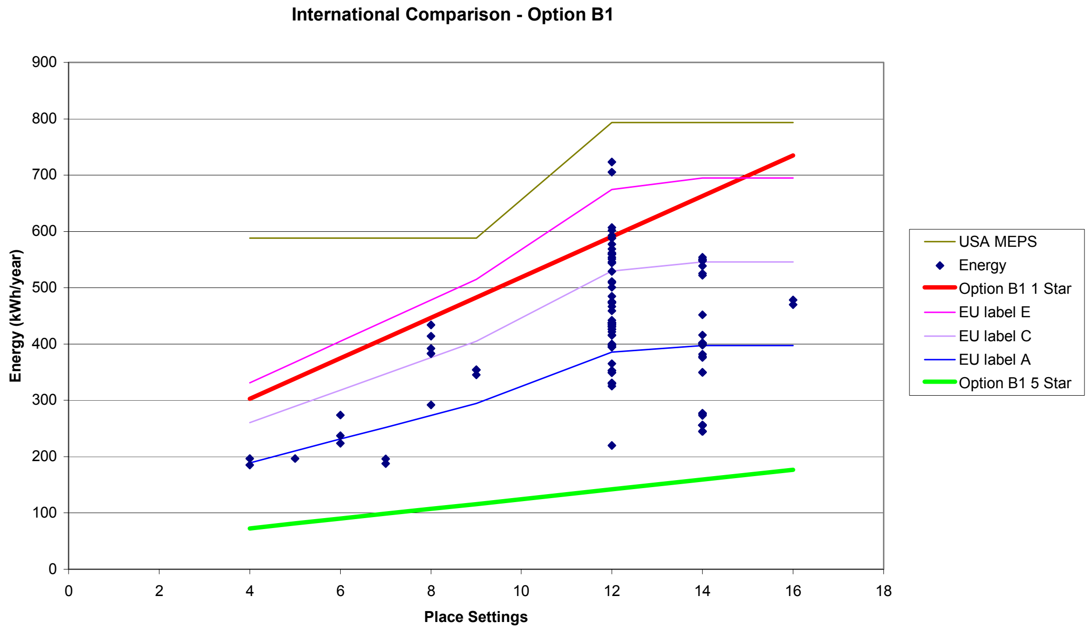
MEPS - US DOE set MEPS levels for dishwashers as 1.612 kWh per program for units with a width of less than 22” (559 mm) and 2.174 kWh per program for 22” and wider. Introduced in May 1994 in USA and 1995 in Canada.

In the USA the program is defined as “Normal” for energy labelling and MEPS which means the “cycle type recommended by the manufacturer for completely washing a full load of normally soiled dishes, including the power dry facility”.

The MEPS levels appear to be weak relative to Australian average energy consumption of dishwashers, but it should be remembered that most machines in the USA are single connected to the hot water supply. Assuming that the plug energy would be around 0.8 kWh electrical for a normal program (which includes power drying) on a 12 place setting machine, this would leave about 1.3 kWh for hot water (this equates to a maximum of 28.5 litres at a supply temperature of 49°C and 22.3 litres at a supply temperature of 60°C - cold water base energy is 10°C), which is not an unreasonable MEPS level. Certainly, there would be many models on the market in Australia that could not meet this requirement. It should also be remembered that many low end dishwashers in the USA sell at well below AU $500 (consumer "not so durables"). Another complication comparing with the USA is that their dishwashers have "random loading" capacity and do not have defined place settings as in Australasia and Europe.

Europe

Europe introduced energy labelling for dishwashers in late 1998. As for other European labels, the label itself is complicated as it contains an energy rating (A to G) as well as a washing rating (A to G) and a drying rating (A to G). Energy labelling in Europe is undertaken on the Normal or Universal program. This, together with the typically higher wash performances, makes direct comparisons with Australia a bit difficult. The best models on the market in Europe are rated currently A/A/B (energy/washing/drying - high end Bosch, Miele and AEG machines). An A energy rating for Europe is shown in the following figure and is somewhat weaker than the 5 star level proposed under Option B1. It should be noted that the A wash performance is about 10% ***higher*** than the Universal Program on the Miele G590 reference machine. By contrast, the minimum wash performance in Australia is currently set at 100% of the Economy 1/2 55 program (typically 15% to 20% weaker than the Universal program on this machine). The other complication is that Europe uses a cold water energy base of 15°C (Australia uses 20°C), which makes Australian energy values appear lower (of the order of 10% to 15%).



See section on USA MEPS levels (hot connect), EU and USA use Normal Program. No temp adjust

The figure above suggests that dishwashers in Australia are getting much better energy ratings by providing somewhat reduced wash performance.

If the requirement for a Normal Program is implemented quickly (and retrospectively), the energy rating in Australia may fall back to around the EU A level shown above, or about the 3 star level. If this were the case, the original Option proposed by Brown (1998) may be more suitable than Option B1. However, it is unlikely that the wash performance requirements in the Australian standard will be close to the Universal Program on the reference machine, at least in the short term, so Option B1 may still be suitable.

At this stage, it is recommended that Option B1 be given further consideration by the wet products algorithm working group for adoption as the new star rating algorithm for dishwashers if dishwashers are not required to be re-registered. However, if all models are to be changed over to a normal program in a short period (ie during the introduction of the label, which would require retesting and new submissions by manufacturers), Brown's original Option A or Option B1 may be suitable. These alternatives can be discussed and refined at the next working group meeting as required.

Declaration of water on the label

There was extensive discussion at the last working group meeting in October 1998 regarding the inclusion of water consumption on the energy label. The potential problem of a mismatch between the energy label and a value declared by the manufacturer was raised. The meeting agreed that the value on the energy label for both water and energy consumption should be on the basis of the declared value (noting that some regulators currently opposed self declaration for energy consumption which are not supported by test results). It was noted that legal problems would be avoided if the declared value in product literature for water consumption were the same as the label value.

If this proposal is accepted, the value for water consumption on the energy label would be as per the manufacturer's declaration. There is a related issue regarding the allowable tolerance on such a declaration. It has been historical practice to allow a 10% variation between the declared water consumption and the measured water consumption (in much the same way as energy is currently evaluated). However, this allowance tolerance is during verification of the claim by a third party and has contained within it some allowance for reproducibility and repeatability error. In the case of energy, the average of the measurements on the units submitted for registration are usually used as the basis for the declaration.

The exception is for air conditioners, where the name plate values are used on the energy label, but test results on each of the three units tested has to support this value. The allowable tolerance in this case is 5% of the declared value (ie the test results for *each* unit cannot be more than 5% *worse* than the nameplate value). This would seem a reasonable basis for the declaration of water consumption on the energy label. Given that water pressure is tightly controlled in the test procedure and that water volume can be accurately measured, a tight tolerance on this initial declaration is warranted.

In summary, it is recommended for water consumption that:

a) water consumption on the energy label be based on the manufacturer's published or declared values;
b) test results for *each* of the three units submitted for an energy labelling registration application should be no more than 5% *worse* than this declaration;
c) for check testing purposes, the measured value should be no more than 10% *worse* than this declaration.

Minimum wash performance

This is now being considered as part of the review of the program specification.

Performance and energy for half loads

Fisher & Paykel were to consider this issue further and make some proposals for the working group to consider.

Water connection mode

The working group made the following recommendations regarding water connection mode (augmented and clarified for this paper):

a) primary water connection mode be based on *cold* water (single) connection in all cases[1];
b) supplementary water connection mode be *hot* for models with a single water inlet or *dual* for models with two water inlets;
c) only in the case of a model with a single water inlet where the manufacturer specifically recommends against hot connection, that no supplementary water connection mode be required.

Standby Power Consumption

A large number of appliance models now on the market have electronic controls and switches and many of these require a small but constant power consumption, even when the unit is nominally "off". This energy consumption can be significant (of the order of 20 to 100 kWh per year) and is of the same order of magnitude as the energy consumption of the motor and pump systems in a typical top loading clothes washer (where hot water is imported). The wet products working group agreed in principle to incorporate standby power consumption into the test procedure for wet products as soon as is practicable.

In practical terms this means:

- defining the possible power consumption states whilst the unit is not in operation (these could include: "off", on or standby (before a program is commenced), delay

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[1] One possible problem case is where a dishwasher does not have an internal heater, however, as far as we are aware, no such product exists in the world.

start power consumption, other intermediate states such as powering down to off);
- defining the instrument accuracy requirements for the measurement of energy consumption in these states (noting that power consumption may be less than 1 Watt in many cases and that the current waveforms may be very non-sinusoidal - high speed electronic power integration methods would be required to accurately measure power and energy in these cases);
- measurement of the program time for the program used for energy labelling (already undertaken in the current test procedure);
- finalisation of the frequency of use to be shown on the energy label (being considered by this working group);
- the composition of the standby power states which would be typical when the appliance is not in use.

The last point would most probably be considered by the wet products algorithm working group once standby measurements had been undertaken on a range of machines on the market and once the frequency of use aspects had been finalised (in the light of Pacific Power data analysis). For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby power consumption (if any) for non-use periods - these will total to give the CEC. Standby power consumption is likely to be eventually be shown in brochures and the Internet.

In terms of procedures and instrumentation required for the measurement of standby power consumption, there is a range of work being undertaken on the measurement of standby power consumption of office equipment by IEC TC74 working group 9. They will specifically consider measurements for low power states with poor harmonics. It is recommended that the work and proposals of this group be followed and incorporated into the wet product test procedures as appropriate.

References

10CFR430, *US Code of Federal Regulations - Energy Conservation Programs for Consumer Products*, US Department of Energy, 1 January 1998.

16CFR305, *US Code of Federal Regulations - Energy Labelling Requirements for Consumer Products*, US Federal Trade Commission, 1 January 1998.

EU 1997, *Directive on the Energy Labelling of Household Dishwashers*, European Commission, Brussels.

NRC 1996, *Guide to Canada's Energy Efficiency Regulations*, Natural Resources Canada.

Test Research 1995, *Appliance Use Survey*, prepared by Test Research for NAEEEC, February 1995.

Appendix A: Extract of Minutes - Wet Products Algorithm Working Group - Dishwashers

Melbourne, 22 October 1998

Definition of capacity: The decision of the Energy Labelling Review Committee was noted and accepted (capacity is adequately defined in the standard).

Uses per year for the CEC: there was quite a discussion on the frequency of use. It was noted that the average use is likely to be about 250 to 300 times per year. The Pacific Power data will provide accurate data for about 60 dishwashers. It was noted that it may be desirable to have a whole number of uses per week on the label if possible (to allow consumers to mentally calculate their own relative use). There is a balance between policy objectives (favouring overstating energy to encourage efficiency) and accuracy of information. It was generally favoured by the working group that the CEC be in kWh per year and that uses be shown “per week” on the label. The precise details will be worked out when the frequency distribution of use is know from the Pacific Power data.

Program nominated for energy labelling: Some background to the issue of the specification of the program was presented. It was noted that there is probably some data on program use but that this was not considered by the Energy Labelling Review Committee. Currently the DW standard allows manufacturers to specify any program for labelling - this may not be recommended for normal use by the consumer (and in fact may be difficult to select). It was agreed that there needs to be a stronger link between the manufacturer’s recommendations regarding programs and the program specified on the label (as per clothes washers). After some discussion it was proposed by Dick Brown, and agreed by the working group, that we should nominate the program on the label as “the program we expect will most often be used in practice by the consumer” – this may be the “program that is recommended by the manufacturer for everyday use” (or possibly a normally soiled load). It was also agreed that if the “normal use” program was specified for labelling that there is a need to rethink the context of the minimum performance requirement for DW (as a consumer protection mechanism). Data on programs selected by consumers to be collected and put into a discussion paper. [Note that Energy Labelling Review Committee did not propose that the current program specification in the standard be altered.]

Bunching of star ratings and size bias. Data in Brown 1998 was considered. Dick stated that size bias in dishwashers was apparent but that it was difficult to determine the exact trend as there was no engineering data to support the data. He made some estimates of the impact of size on energy consumption in his report. Dick felt that there was some justification for not correcting the size bias in the star rating for dishwashers. It was argued that small dishwashers are a niche product and currently have only a small market share. The committee discussed the issue of size bias and agreed that it is not necessary to change the algorithm to eliminate the current size bias (ie star rating curves would still pass through the origin).

Dick outlined the geometric progression used for refrigerators which has been set as a basic principle for all labelled products. The Energy Efficiency Rating is now defined as Star Rating Index (SRI) - decimal version of the star rating. Star ratings are now shown in half star steps. Base Energy Consumption defines the energy for a 1 star rating line for all capacities. It was noted that the Base Energy Consumption line could in fact be a curve or could be a line several slopes (eg which is flat to say 9 place settings and has a different slope above this value).

Dick and Lloyd to prepare various algorithm options for consideration by the WG. Richard Bollard to liaise regarding issue of size bias with respect to small machines.

Highlighting capacity on the label – it was agreed that Energy Labelling Review Committee has the issue in hand. It was noted that there needs to be enough space to put data on model and capacity and program on the label.

Declaration of water on the label – The decision to put water consumption on the energy label by the Energy Labelling Review Committee was noted. It was agreed (in the first instance) that the water consumption figure on the label should be the average of the three values submitted for energy labelling. The legal issue was discussed where the value declared in this case may be different to the label (noting that this is generally an offence under state regulations). It was noted that legal problems would be avoided if the declared value in product literature for water consumption were the same as the label value.

The working group agreed that NAEEEC should be approached to formally allow manufacturers to declare a higher energy consumption or water consumption than the tested values should they wish to do so.

A number of options developed by the working group were summarised by Dick Brown:
6̃ No water on label
7̃ Include water on basis of the test report (average of 3 values)
8̃ Include water on basis of the declared value, but this cannot be less than test value
9̃ Include water and energy on basis of the declared value, but this cannot be less than test value
10̃ Manufacturer declares energy and water without submitting test reports.

After some discussion, the working group agreed that NAEEEC should be approached about implementing Option 4 as part of the energy labelling program.

Claimed capacity versus actual use – The decision of the Energy Labelling Review Committee was noted and accepted. It was agreed to not consider this issue further.

Minimum wash performance – this is now being considered as part of the review of the program specification (section 3.3 above).

Performance and energy for half loads – Fisher & Paykel will consider this issue further and make some proposals for the working group to consider. One option raised would be to have the product rated as both a 6 place setting and 12 place setting dishwasher.

Additional dishwasher issue not included in the discussion paper – water connection mode. It was agreed that the current requirements in the standard, while clear, are rather messy in practice. After discussion the working group agreed that the primary water connection mode in the standard be specified as cold connect. Supplementary water connection mode should be specified as hot connect for single connect machines and dual connect for dual machines.

Standby Losses – it was agreed that standby losses will be incorporated into the test procedure in due course for all labelled products (except for refrigerators and freezers). The standard will need to define various "states" of energy consumption (standby, delayed start, off mode etc) in the Part 1 standard. For wet products, the Part 2 standard can then sum data on assumed uses per year and energy per cycle (as is currently specified) with standby losses (if any) for non-use periods - these will total to give the CEC. Standby losses (power) are likely to be eventually be shown in brochures and the internet.

Appendix B - Support Documentation - Dishwashers

As circulated to Wet Products Algorithm Working Group, October 1998

Dishwashers

Definition of Capacity

Issue: Historically, there appeared to be excessive capacity claims for dishwashers.

Discussion on the Issue: Claimed capacity levels for dishwashers were high in the early 1990's, but capacity definitions have been carefully revised and included in the new version of AS/NZS2007-1998. Claimed capacities have also been dropping in recent years (EES 1997) in the expectation of the new standard. The use of a reference machine in the new standard will also mean that minimum performance requirements are more enforceable. This issue is unlikely to be a problem in the future.

Data Sources: Brown (1998) discusses the issue in Section 10.1 (page 64). It should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Capacity - It was agreed that this issue is adequately covered by the new standard and capacities definition.

Washes per Year for the CEC

Issue: The CEC on the label assumes 365 loads per year, whereas some sources suggest that this is an over-estimate.

Discussion on the Issue: The number of washer per year has a direct impact on the CEC. Clearly there will be some distribution of washes per year for different household types and there is some debate whether the mean or median is a more appropriate measure of the frequency of use. A number of data sources are available for consideration.

Data Sources: Brown (1998) raises the issue in Section 10.2 (page 64) and suggests the current number of washer per year is too high. The data he cites is Test Research (1995, Q48 page 32) which suggests an average number of uses of about 4.0 per week (210 times per year) (although the data was collected in a poor manner). QEC 1993 did not collect data on the use of dishwashers.

Some data is available in ABS8218.0 (1988) based on diary records in 1985/86, but this is based on hours of use rather than loads and is difficult to use directly (program times vary considerably between machines).

Another key source may the Pacific Power Residential End-Use Study (Pacific Power 1996). The raw data contains actual in-use information for some 65 dishwashers for a period of about 18 months from early 1993 to mid 1994. However, the raw data is not yet available (DPIE have held a number of discussions with Pacific Power) and it is still unclear whether any energy labelling data for the units measured will be available.

In Europe, dishwasher use is likely to be similar to Australia. Sidler (1997) indicates that average use is 3.6 times per week based on end use metering results. The diary data for the same households that were monitored showed that consumers overestimated their actual use by about 30%, so care needs to be taken when using consumer diary or recall data (Sidler 1997). The author warns of the danger of relying on consumer reports of appliance use.

Some data on frequency of use may be available from manufacturers, as this data is sometimes recorded within the machines for service purposes.

Energy Labelling Review Committee Decision: it was noted that the current data suggests that the current average usage is somewhere about 250 per year (there is some uncertainty regarding the precise figure). Pacific Power data will provide good data on connection mode and frequency of use. ABS diary is difficult to use for dishwashers. Options that were discussed included per cycle usage and total uses per years. It was argued that overstating the uses per year may make it mentally easy to use for consumers (7 times per week) and has energy policy benefits (overstates energy) but the point was made that the label should be reflective of actual average consumer use where possible. Per cycle use or uses per year should be decided on the basis of frequency distribution of use and acceptance by consumers.

Program Nominated for Energy Labelling

Issue: Program nominated for energy labelling should be the one recommended by the manufacturer for a normally soiled dishware.

Discussion on the Issue: The requirement in AS/NZS2007-1998 is a little ambiguous as it possibly allows the manufacturer to specify a program for energy labelling purposes that is different to the one recommended for normally soiled dishware. In addition, the dishwasher must meet the minimum washing and drying performance requirements on the program nominated for energy labelling.

The only serious issue for consideration is where a manufacturer recommends an obscure for energy labelling purposes and a different program for normal use. There should be much stronger links between manufacturer recommendations, product literature and the program used for labelling. Recommendations by the committee should be implemented through the standard.

Data Sources: Brown (1998) raises the issue in Section 10.2 (page 64-65).

Energy Labelling Review Committee Decision: Program - now adequately covered by the standard.

Bunching of Star Ratings

Issue: Star ratings for dishwashers are bunched around 4 and 5 stars, with only a few models at 3 stars or lower.

Discussion on the Issue: There is a case for the downward revision of the clothes washer algorithm, as there is bunching at 4 and 5 stars and there are a number of models at 6 stars. However, many of the models on the market are based on similar technology, so care is needed to ensure that artificial differences are not created during re-grading.

Data Sources: Brown (1998) discusses the issue in Section 10.3 (page 65). The main data source is the energy and capacity characteristics on the market at present, which is available from the energy labelling register. These are shown in the energy labelling brochures (copy attached). An electronic copy is available for further analysis.

Energy Labelling Review Committee Decision: Bunching of star ratings - It was noted that it will always be necessary (in the foreseeable future) to wash in warm water for a dishwasher. The working group is to look at new algorithm options as proposed by Brown - one of which includes existing size bias and one which eliminates it.

Size Bias in Algorithm

Issue: The current star rating system is based on kWh per place setting. There is currently a size bias in this rating system which makes small units appear less efficient.

Discussion on the Issue: Most dishwashers sold in Australia at the moment standard sized 600mm wide. Small dishwashers are only have a very small market share. Small dishwashers are in fact somewhat less efficient than standard sized units, but consideration could be given to removing the size bias if and when the labelling algorithm is revised, but this is not a high priority.

Data Sources: Brown (1998) mentions the issue in Section 10.3 (bottom of page 65). The main data source is the energy and capacity characteristics on the market at present, which is available from the energy labelling register. These are shown in the energy labelling brochures (copy attached). An electronic copy is available for further analysis.

Energy Labelling Review Committee Decision: Size bias - agreed to examine with/without size bias options under 3.4.

Highlighting Capacity on the Energy Label

Issue: Dishwasher capacity is a key variable of concern to consumers. Although the capacity is currently shown on the label, it is in small print.

Discussion on the Issue: Consideration should be given to highlighting capacity on the energy label. If recommended, this should be tested on consumers.

Data Sources: The international review of energy labelling provides examples of dishwasher labels for consideration.

Energy Labelling Review Committee Decision: Capacity - new formatting options to be tested in the focus groups.

Inclusion of Water Consumption on the Energy Label

Issue: There is a case for inclusion of water consumption on the energy label.

Discussion on the Issue: Information on water consumption is already included in energy labelling brochures. Should this also be included on energy labels? There is the question of jurisdiction - whether there is power to require water consumption to be supplied and whether false claims can be addressed under the current heads of power. Values in current brochures are taken from the test report. However, values should be based on manufacturer rated values as far as possible. Approaches to this issue should be discussed by the committee.

Data Sources: There are no specific data sources in addition to energy labelling brochures for this issue. See also results of recent focus groups.

Energy Labelling Review Committee Decision: Water on label - agreed to include water and test this in focus groups.

Claimed Capacity versus Actual Use

Issue: Dishwashers in actual use are likely to be used at a lower capacity than that defined in the standard.

Discussion on the Issue: This issue was raised by Patterson (1998). The definition of capacity in the standard provides a repeatable and reproducible test method for comparison of dishwashers. Every consumer is likely to use a dishwasher in a different way (even vary their use each day in terms of load items and soils), so there is no possibility of developing a test procedure which accurately reflects the range of consumer behaviour. The standard test is rigorous and requires good performance for both cleaning performance (removal of soil) and filtration (redeposition) under heavy soil loads.

Data Sources: AS/NZS2007.1-1998 defines the test procedure for dishwashers. The committee should be aware that there is a new IEC international dishwasher standard under development. It should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Claimed capacity - it was agreed that the current standard adequately covers the issue of claimed capacity. The issue of actual consumer use versus rated capacity was discussed but it was agreed that it was not necessary to consider this further.

Minimum Wash Performance Requirement

Issue: Some have argued that the minimum wash performance requirement in AS/NZS2007 is too stringent and this impacts on energy.

Discussion on the Issue: This issue was raised by Patterson (1998). The minimum wash performance has been modified in the new version of AS/NZS2007-1998 so that the test machine performance is compared against a specified program on the reference machine. The intention was to ensure that the wash performance requirement is broadly equivalent to the old method under AS2007-1988. The degree of equivalence is still being assessed by manufacturers. Historically, the wash performance requirement in AS2007 has been regarded as satisfactory from a consumer perspective. There is no compelling evidence that this needs to either be strengthened or weakened. In any case, this is an issue for Standards Committee EL15/4.

Data Sources: AS/NZS2007.1-1998 defines the performance requirements for dishwashers. It should not be necessary for the Committee to consider this further.

Energy Labelling Review Committee Decision: Minimum wash performance - adequately covered by new standard.

Performance and Energy for Half Loads

Issue: Should consideration be given to a half load test for energy and performance?

Discussion on the Issue: Most dishwashers are designed to operate fully loaded (even though there are usually 2 baskets, there is effectively only a single compartment). A few models have an option to conserve water and energy for part loads through some minor adjustments to water volumes and temperatures, but these tend to be incremental in nature. This issue arose primarily due to the appearance of the new Fisher & Paykel dishwasher which has separate drawers which can be operated separately or together. This feature reduces energy and water consumption for a half load. While the committee may wish to consider this issue, it is unclear if or how such data should be shown on the energy label. It may be more appropriate to show this in brochures. One option would be to request EL15/4 to develop an approach for testing such a dishwasher at half load.

Data Sources: Fisher & Paykel product and performance literature.

Energy Labelling Review Committee Decision: load - It was agreed in principle to label a product on the program and at the load capacity the consumer will normally use. It may be possible to consider putting half load data in brochures/web site later down the track. At this stage it was agreed not to include half load data on the label. This issue will be introduced into the standards committee process when the technology is more mature.

Appendix 14: Wet products – algorithm recommendations

Wet Products Working Group
Draft Summary of Recommendations - March 1999

The following draft recommendations have been prepared by the Wet Products Algorithm Working Group following their meeting on 29 March 1999. Some of these are subject to further detailed consideration by working group members while others require further data collection and analysis before a final decision can be made.

General Recommendations - All Products

Determination of CEC

The working group agreed to hold over a decision on the determination of the number of uses per year for the Comparative Energy Consumption for all of the wet products until the results of the Pacific Power data is available. The working group noted that the CEC has no bearing on the relative energy efficiency (ie star rating). The working group recommends that the analysis of the Pacific Power should proceed as quickly as possible.

Declaration of Non Energy Values

For non-energy declarations such as program time and water consumption, it is important (for legal reasons) that the value on the energy label and/or on brochures/Internet be the same as that shown in product literature. Therefore the working group recommends that non-energy values shown on the energy label or in the brochures/Internet (such as program time and water consumption) should be on the basis of the value declared by the manufacturer. The working group notes that declarations for these variables are not always based on test reports prepared for an energy labelling application, therefore a tolerance on this declaration is required.

The working group recommends the following approach for the declaration of *non-energy* variables:

a) any variable shown on the energy label and/or brochure/Internet be based on the manufacturer's published or declared values per load where this is available;
b) the *average* test results for the three units submitted for an energy labelling registration application should be no more than 3% *worse* than this declaration, otherwise the registration should not be accepted;
c) for checktesting purposes, the measured value for any unit should be no more than 10% *worse* than this declaration, but that the verification procedure should be the same as the energy checktesting procedure in the relevant Part 2 standard.

Declaration of Energy Values

The working group acknowledges that the measurement of energy consumption of appliances is probably the single most important aspect of the national energy labelling program in Australia. Accordingly, the working group accepts that the submission of test reports for 3 separate units will remain a key aspect of the program. However, the working group strongly recommends that manufacturers be provided with some discretion under the program to declare an energy consumption that is *worse* than the results of the three units submitted for energy labelling.

It is expected that in most cases the Comparative Energy Consumption shown on the energy label will be equal to the average of the three units submitted for an energy labelling application, as there is commercial pressure to minimise energy and therefore maximise star ratings. However, there may be legitimate reasons for increasing energy (eg where units submitted for energy labelling are pre-production and it may be expected that full production units may give a higher energy consumption). In any case, the Part 1 test procedure for all products provides for higher energy consumption than the minimum possible through discretionary selection of sub-optimum conditions during the tests for the initial energy labelling application (such as colder compartment temperatures and warmer ambient temperatures for refrigerators and freezers, warmer than minimum wash temperatures for clothes washers and dishwashers, dryer final moisture content for clothes dryers etc.)

Accordingly, the working group recommends that:

- There be a continued requirement for three test reports to be submitted with an energy labelling application.
- The applicant will still be required to calculate the value of $PAEC_{av}$ in the test report.
- Where the applicant wishes to declare a higher CEC than the value determined from $PAEC_{av}$ that this be permitted but the applicant be required to make a clear statement of this fact both in the test report and in the energy labelling application.
- Under no circumstances would a CEC value be permitted to be lower than the value of $PAEC_{av.}$
- The value of the Star Rating Index for the model be made on the basis of the higher declared CEC value.

Standby Energy Consumption

The working group recommends that EL15/4 develop options for the measurement of energy consumption in standby and off modes for all major appliances (except for refrigerators and freezers). In particular EL15/4 should:

- define the possible power consumption states whilst the unit is not in operation (these could include: "off", on or standby (before a program is commenced), delay start power consumption, other intermediate states such as powering down to off);
- define the instrument accuracy requirements for the measurement of energy consumption in these states (noting that power consumption may be less than 1 Watt in many cases and that the current waveforms may be very non-sinusoidal - high speed electronic power integration methods would be required to accurately measure power and energy in these cases);

Once these aspect are finalised, the possible use of energy consumption in the standby and off states can be further considered by the Energy Labelling Review Committee. In particular the Comparative Energy Consumption could be composed of:

- the frequency and duration of use shown on the energy label;
- one or more of the pre-defined standby states when the appliance is not in use.

The working group noted that the inclusion of standby energy in the CEC would provide an incentive to reduce this aspect of energy consumption (as CEC is linked to the star rating index). It may be possible to define a threshold level below which measurement of standby energy would not be required.

Recommendations - Dishwashers

Program nominated for energy labelling

The program specified for energy labelling in future should be the "program recommended by the manufacture for washing a normally soiled load". Where an existing test report has been undertaken on this program, then re-registration without retesting will be possible (as long as the program definition remains constant, even though the program name may change). Otherwise for dishwashers only, a new test report with this new program but otherwise as per the 1998 version of the standard will be required. No action with respect to the minimum wash performance requirements is recommended until the EL15/4 working group considering this issue makes a recommendation.

Star Rating - Dishwashers

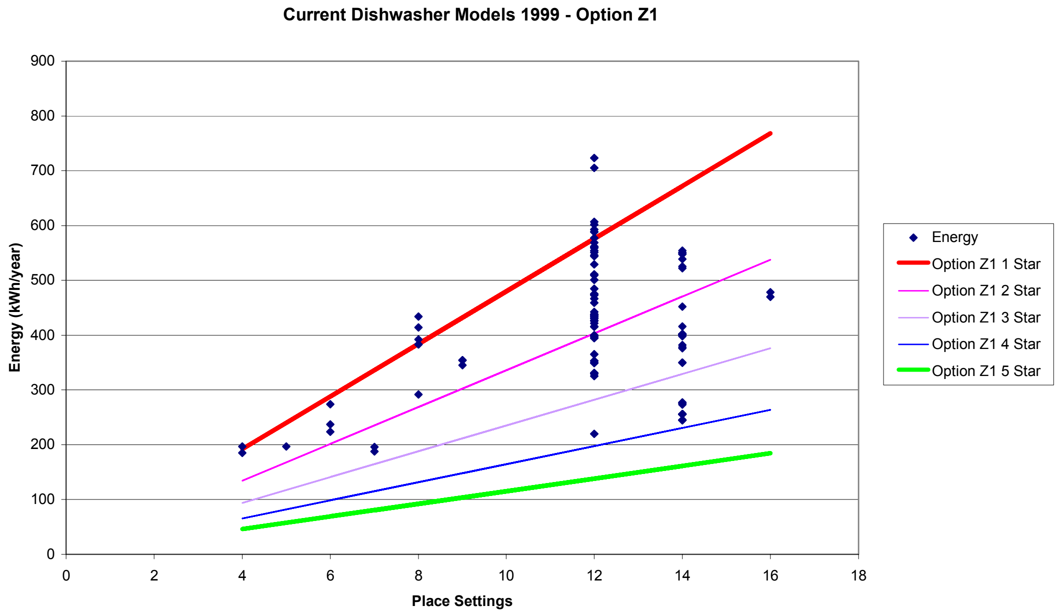
The meeting tentatively agreed to provide for no correction for dishwasher size, on the basis that larger units are inherently more efficient and if consumers only use the dishwasher when full, the use of a smaller unit is generally not justified.

The working group tentatively agreed to Option Z1 as follows:

Option Z1

Equation: 1 Star = $0 + 48 \times PS$, reduction per star = 30%

The 1 star line is close to the lower end of the market for various sizes, best models on the market just under 4 stars.



This Option is subject to further investigation by manufacturers and importers.

Water Connection Mode

Water connection mode for energy labelling purposes as defined in the Part 1 and 2 Standards should be revised as follows:

a) primary water connection mode shall be *cold* water (single) connection in all cases, except where the manufacturer recommends only hot connection, in which case the primary water connection mode shall be single hot;
b) supplementary water connection mode shall be *hot* for models with a single water inlet or *dual* for models with two water inlets;
c) only in the case of a model with a single water inlet where the manufacturer specifically recommends cold water connection only, that no supplementary water connection mode is required.

Recommendations - Clothes Washers

Cold water washing

It is recommended that the following proposal for cold water washing be adopted with the introduction of the new energy label:

- star rating continues to be based on warm water washing - only a warm water star rating (red band) is to be shown on the label
- energy for both cold and warm washing be shown on the energy label
- no star rating on a cold water only label, only cold energy to be shown

It was noted by the working group that Fisher & Paykel strongly disagrees with the wash temperature floor staying at 35°C. The working group agreed that the temperature floor should be removed in the medium term subject to further analysis and investigation of the implications (particularly with respect to the performance of soil swatches and detergent). The working group requests EL15/4 to immediately commence investigations with regard to these aspects of cold water washing.

The working group also agreed that for the introduction of the new energy label that existing test reports can be used as follows:

- Cold CEC can be calculated from test report where there is no internal water heating.
- Cold CEC must be determined from a new separate test if any internal water heating occurs on a warm wash.

The working group considers that a general caveat (possibly on the energy label and/or in brochures) stating that the performance and capacity has not been measured (nor is guaranteed) for cold water washing may be necessary.

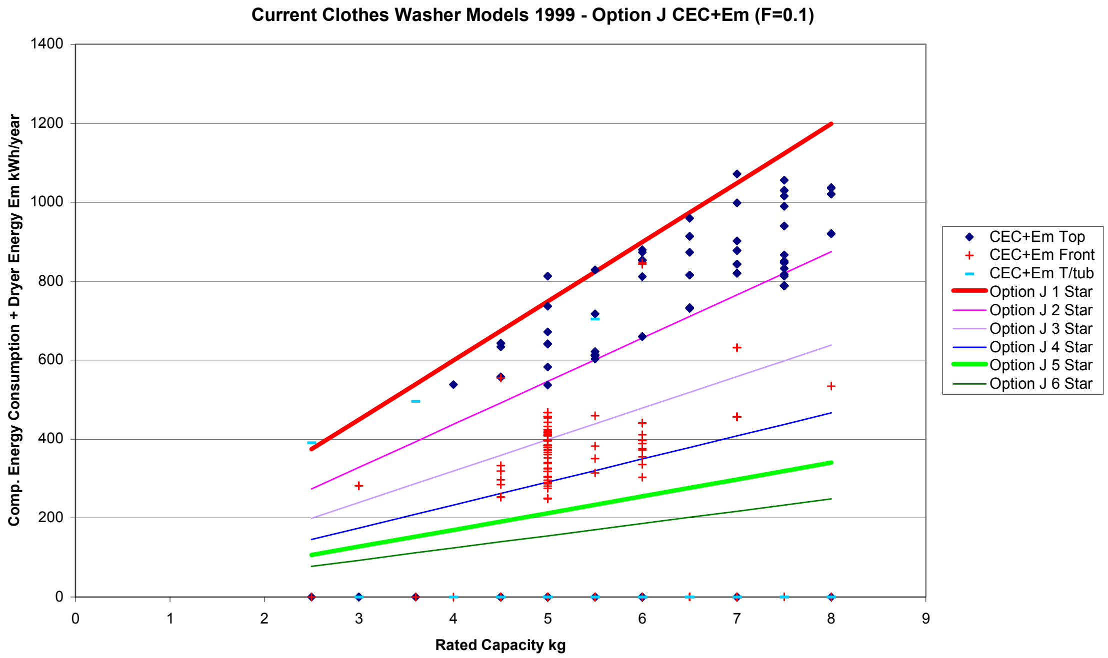
Star Rating - Clothes Washers

The working group recommends that top and front loaders should continue be rated on the same basis to ensure program consistency.

The working group agreed to Option J as follows:

Option J
1 Star = 0 + 115 × RC
F = 0.1
Energy reduction per star of 27%

where:
0 = fixed energy offset
115 = slope of the 1 star line (in kWh per kg rated capacity)
RC = rated capacity in kg
Em = energy equivalent of residual moisture content
F = weighting factor for Em
$WEI_{ref} = 1.03$
$Em = (F \times WEI_{ref} \times RC \times 365) / 1.08$
Total energy for star rating = CEC + Em



Declaration of Spin Performance

It is agreed in principle to show the spin performance on brochures and on the Internet. However, a decision was yet to be made whether to show spin performance on the energy label. It was noted that the raw spin index as measured in the Part 1 standard is not in a form that is suitable for putting in brochures or on the energy label. It was agreed that some sort of simple rating system for spin performance would need to be developed for inclusion on the Internet and in the brochures. The working group is to consider this issue further.

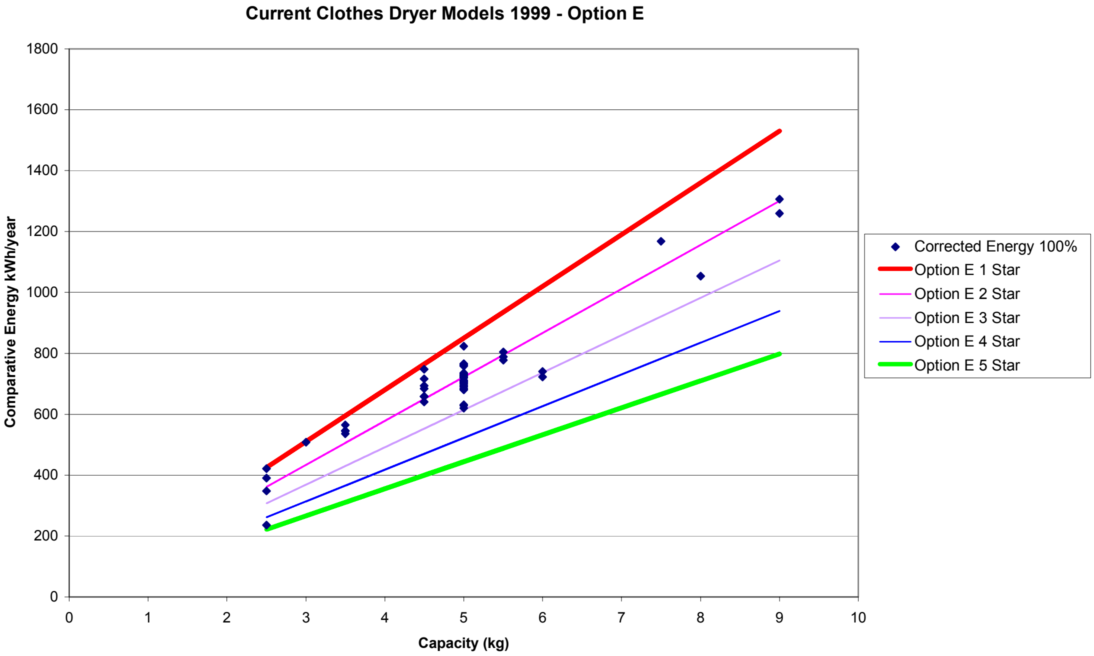
Recommendations - Clothes Dryers

Star Rating - Clothes Dryers

The working group agreed to Option E as follows:
Option E - 100% initial moisture
1 Star = 0 + 170 × RC
Energy reduction per star of 15%
Based on an initial moisture content of 100% but otherwise as to AS2442.1-1996.

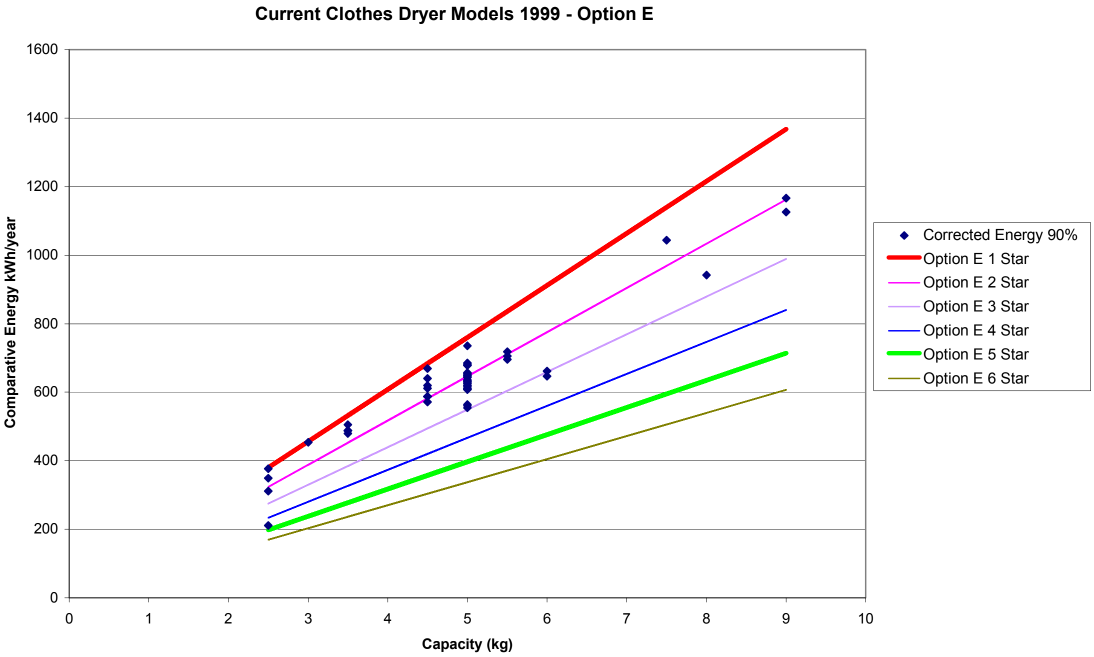
where:
0 = fixed energy offset
170 = slope of the 1 star line (in kWh per kg rated capacity)
RC = rated capacity in kg

Option E for 100% initial moisture content is shown below:



Option E - 90% initial moisture
1 Star = 0 + 152 × RC
Energy reduction per star of 15%
Based on an initial moisture content of 90% as to AS2442.1-1996.

Option E for 90% initial moisture content is shown below:



The working group recommends that re-registration of existing products without retesting be permitted. The primary rating system would be based on 90% initial moisture content and would apply to all new registrations. 100% moisture rating curves would be shown in a separate appendix in the Part 2 standard and these would be used only for re-registrations for the new label.

Field Use Factor
It is recommended that the current field use factor of 1.0 for auto-sensing dryers and 1.1 for timer dryers be retained.

Program Time
It is recommended that the Part 1 test procedure for clothes dryers be modified to measure the actual cool down time, which should also be reported in the test report, so that total time can be determined (for comparison with any value declared by the manufacturer). Further, it is recommended that the issue of a maximum clothes temperature at the end of the cooldown period should also be considered by EL15/4 (to avoid manufacturers unduly shortening their cooldown periods).

Appendix 15: Dishwashers – algorithm discussion paper 2002

Appliance Labelling Review Committee
Dishwasher Algorithm Working Group
Discussion Paper

prepared by EES, July 2002

Background

During 1998, the Appliance Energy Labelling Review Committee and the Wet Products Algorithm Working Group considered a wide range of issues regarding dishwasher energy labelling. The final dishwasher labelling algorithm was agreed and this, together with a revised energy label, was implemented in 2000 through AS/NZS 2007.2-2000.

This standard foreshadowed that the Part 1 standard (test method) was under revision and that eventually (once the revised Part 1 was available) that Part 2 would be changed to require energy labelling to be undertaken on the program recommended for a normally soiled load. No algorithm change was foreshadowed, although this was not ruled out either.

The development of Part 1 through 2001 was slowed by a number of factors including the extensive testing regime and the slow progress within the IEC (the intent was to align much of the revised Part 1 standard with the forthcoming IEC dishwasher standard). Note that the IEC dishwasher committee draft for voting (IEC 59A/108/CDV) has been circulated to EL15/4 for comment – comments close on 1 November 2002. The revised Part 1 has been issued as a public comment draft in late July 2002.

The main changes in the revised Part 1 standard are detailed in the draft, but the following text, which has been taken from the preface, list the main changes.

This Standard includes a number of requirements from the recently revised IEC60436 committee draft for voting which will bring this standard closer to the forthcoming IEC standard. It also incorporates the following significant changes in comparison to AS 2007.1-1998 which it supersedes:

1. *Test methods have generally been made more repeatable and reproducible so as to be suitable for use as part of a compulsory energy labelling scheme. In particular, wash performance test now has a 15 hour soil drying time prior to washing to ensure that the soil is in a uniform state, as per the forthcoming revised IEC Standard.*
2. *An IEC test load (without serving utensils and bowls) is now allowed as an alternative to the Australia test load in this standard.*
3. *There is now a requirement to meet to specified washing and drying performance requirements on the program recommended for a normally soiled load. This program will be mandatory for energy labelling in Part 2.*
4. *Definitions in this standard are now generally aligned with IEC definitions.*
5. *The end of the cycle is now defined as when all activity ceases.*

6. *The reference program on the reference machine is now Gentle 45^{o}C and the reference pass mark for wash performance is now set at 0.90.*
7. *There are improved instructions regarding the use of the reference machine.*
8. *Data has been provided to check the operation and calibration of the reference machine on the Gentle 45^{o}C program (new reference program).*
9. *Specific directions on the use of dishwashers that have a water softener.*
10. *Consideration will be given to the use of new IEC detergent and rinse aid when these become generally available. A limit on the detergent amount for performance tests and a default amount where no quantity is specified is now included.*
11. *Improved specification of measurement accuracy has been included.*

It should also be noted that while the inclusion of standby is noted as "under consideration" in the Part 1 draft, this issue is being given a high priority by NAEEEC over the next few years and in principle, standby will be gradually incorporated in the energy labelling energy consumption for all labelled appliances. A draft IEC test method for the measurement of standby power (IEC 59/297/CD) has been circulated to EL15/4 for comment. Comments on this draft close in October 2002.

Dishwasher Labelling Recommendations for EL15/4 and NAEEEC

The following recommendations are proposed:

- The attached revision of AS/NZS 2007.2-2002 be considered and issued as a public comment draft as soon as possible;
- Transition arrangements for introduction of the new standard be discussed and agreed in the working group;
- The current form of the energy labelling algorithm be retained (BEC = 1 star, x% energy reduction per additional star);
- Labelling system to continue to show half stars;
- Consideration be given to transition issues (identify products tested to the revised Part 1-2002)
- Current labelling algorithm be retained for the 2002 edition (BEC = 48 × RC, 30% reduction per star), subject to discussion and agreement by the working group.

A range of possible alternative algorithm options are shown in Appendix A. However it considered that retention of the current algorithm will ensure that the labelling scheme for dishwashers remains viable for the next 5 years while minimising the disruption that will occur with the change to the normal program.

Current Energy Labelling Requirements

The current energy labelling requirements are set out in AS/NZS 2007.2-2000. In summary:

Base Energy Consumption (BEC) = 48 × RC

Where RC is rated capacity in place settings.

The star rating index is given by:

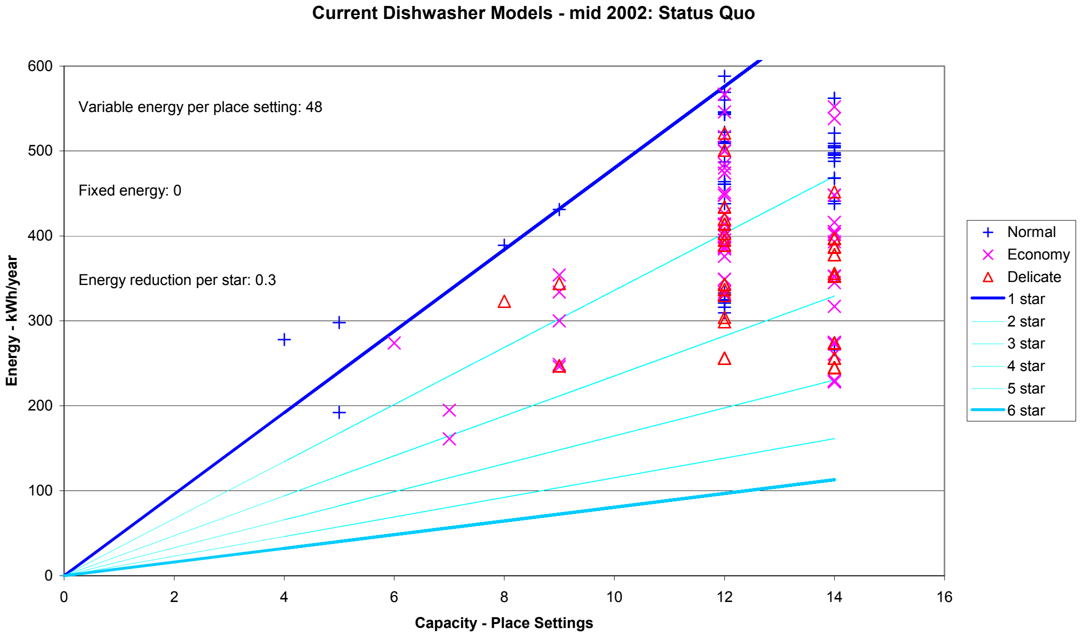
$$SRI \quad = \quad 1 + \left[\frac{log_e\left(\frac{CEC}{BEC}\right)}{log_e(1-0.30)} \right]$$

Where:
CEC is comparative energy consumption
BEC is base energy consumption
0.30 is the energy reduction per additional star

This arrangement sets the BEC as 1 star and an additional star is awarded for each reduction of 30% from the BEC (eg 0.7×BEC would be 2 stars, 0.49×BEC would be 3 stars and so forth). Note that the star rating system is a geometric progression (ie the energy band decreases in size for each increase in star rating – the percentage reduction per star remains fixed).

The star rating status quo with dishwasher models on the market as of July 2002 are shown in Figure 1. This shows registered energy consumption (CEC) versus place settings.

Figure 1: Current dishwashers July 2002 and current star rating system



Current Characteristics of the Market

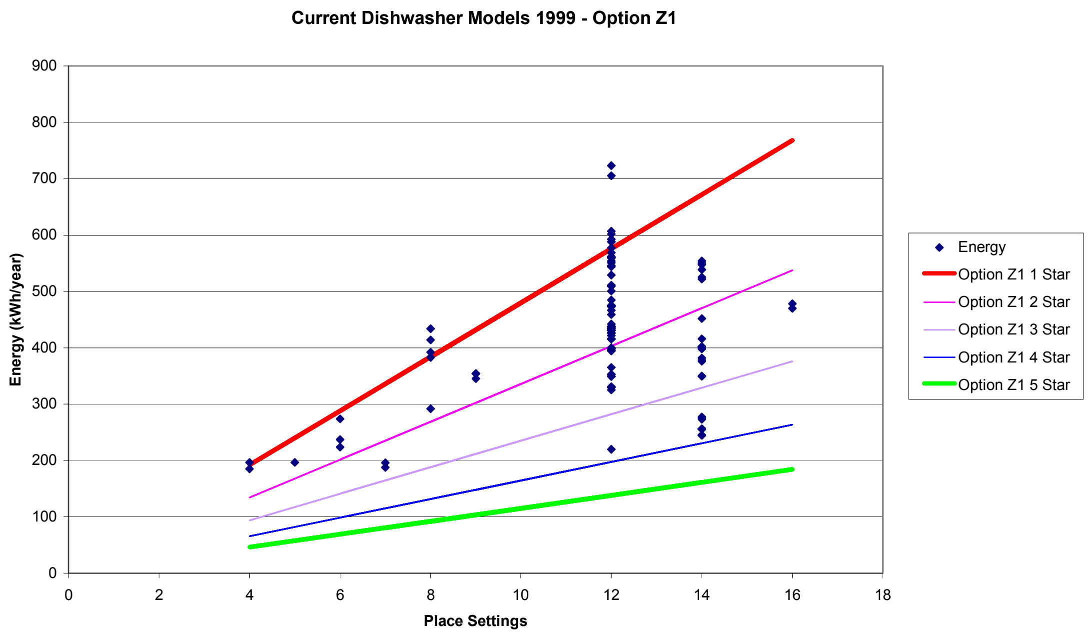
The total number of current dishwasher models on the market in Australia is 173 (noting that not all of these registered models may be available in retailers). Nearly 90% of models registered are standard sized units (nominally 600mm wide) with a capacity of either 12 or 14 place settings, as shown in Table 1.

Table 1: Distribution of capacity for registered models

Capacity	Models	Share
4	1	0.6%
5	2	1.2%
6	1	0.6%
7	2	1.2%
8	2	1.2%
9	11	6.4%
12	84	48.6%
14	70	40.5%
Grand Total	173	100.0%

Figure 1 shows the range of energy consumption for current models – this ranges from around 228 kWh/year for 14 place setting to 588 kWh/year for 12 place settings (a ratio of around 2.6 for standard sized models).

Figure 2: Dishwasher labelling star ratings – current system with 1999 models



Compared to Figure 1, Figure 2 shows the following changes have occurred in the dishwasher market between 1999 and 2002:

- Number of smaller models (8 or less place settings) has decreased;
- There has been an increase in the number of 9 place setting models;

- The best and worst energy performers for 12 place settings have been eliminated (energy range is narrower for this size);
- Energy range for 14 place setting models is about the same, although the number of models in this category has increased;
- 16 place setting models (750mm) are no longer on the market.

Current Programs used for Energy Labelling

AS/NZS 2007.2-2000 allows dishwashers to be labelled on a program recommended by the manufacturer that meets the minimum wash and dry performance requirements specified in Part 1. Figure 1 shows the broad program "type" used for energy labelling registrations.

These programs have been nominally classified on the program name, and in some cases by detailed performance data where the program name was not obvious (primarily maximum temperature and number of fills). These types have been very broadly classified as follows:

- Normal: usually 4 (sometimes 5) fill program with a maximum temperature of 50°C or more: program names include normal, universal, daily, super and normal extra;
- Eco: usually 4 fill program with lower maximum temperature, usually eco options such as no power drying: program names include economy, gentle, normal+eco;
- Delicate: usually 3 fill program (sometimes 4) with lower maximum temperature (often 40°C to 45°C): program names include delicate, rapid, crystal, glassware, quick, light, glass.

Of course, in reality, there is no program definition (in terms of number of fills and bath temperature) for any program name. Whilst most dishwashers have names such as those outlines above, a number of models have generic or non descript names such as "Program 4". In these cases, the user would have to refer to the operation manual for guidance on what program to use in particular circumstances.

There energy consumption by program type and capacity is shown in Table 2.

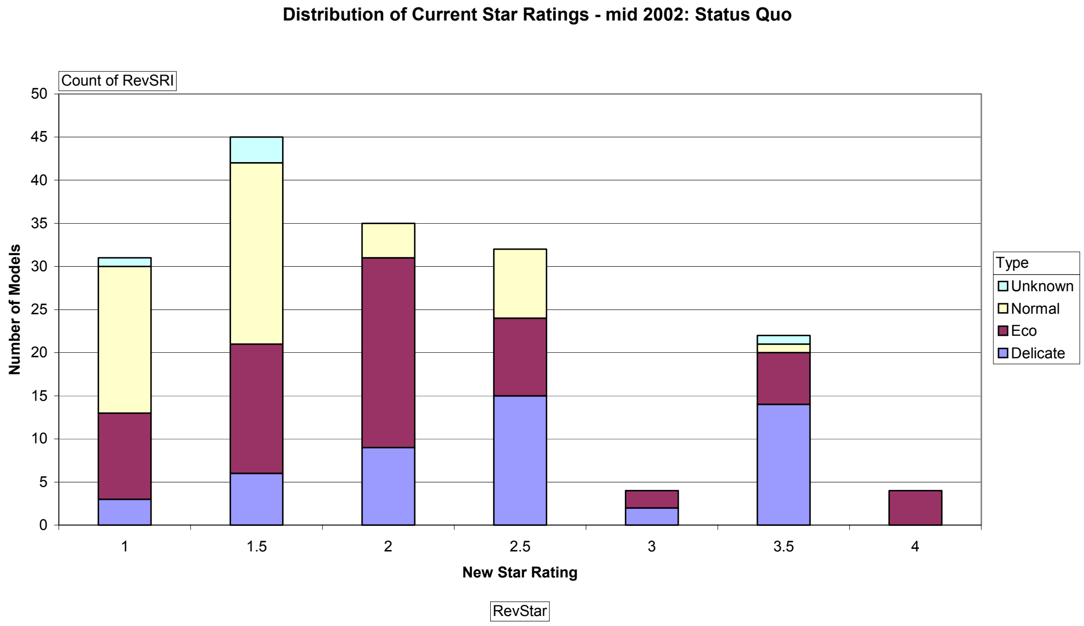
Table 2: Energy consumption of dishwashers

Capacity	Delicate	Eco	Normal	Grand Total
4			278	278
5			245	245
6		274		274
7		178		178
8	323		389	356
9	279	297	431	306
12	377	435	455	430
14	317	348	484	369
Grand Total	337	383	451	390

While the water consumption does vary with program type, the water consumption for Eco and Normal program types are on average fairly similar (around 20 litres – average 4 fills), indicating that the energy saving from Eco type programs is accruing through reduced heating for wash and hot rinse cycles. Delicate programs use around 16 to 17 litres indicating a mix of 3 and 4 fill programs.

The number of models by registered energy labelling program and star rating under the current system is shown in Figure 3. Normal programs are more prevalent in the lower star ratings while delicate are more prevalent in the higher star ratings. Eco type occur across the board.

Figure 3: Dishwasher program name by star rating



What Impact will the Change to Normal Program have on Energy?

As stated above, there is no program definition for the various program names in use on the market today. Even though there is the option to currently label on an "economy" or low energy type program name at the moment, around one third of all dishwashers are registered when tested to a "normal" program. In fact the use of normal, eco and delicate is fairly even for current registrations. The share of normal programs has increased in recent years, presumably partly in response to the impending change in Part 2.

As shown in Figure 1 and Figure 3, normal type programs tend to feature in the lower star ratings at the moment, but a significant number of models already rate 2 and 2.5 stars on the normal program.

It is clear that some of the programs currently named as "normal" are not the most powerful programs available on the dishwasher. Many normal programs appear to have 4 fill operations whereas old style or traditional "normal" would have 5 fills. It is also known that some manufacturers are beginning the re-organise their program definitions so that “normal” is now their high performance low energy configuration.

At the end of the day, the actual program design is of little relevance to consumers or to energy regulators. The main issues are:

- That the program called “normal” meets the minimum wash performance requirement (is greater that 0.9 of the reference machine on the reference program);
- That the program meets the minimum dry performance requirement (is greater that 0.5);
- That consumers are satisfied with the performance of the dishwasher on the “normal” program (given that this is the program recommended for normal use).

The first two points will be objectively assessed to the Australian standard AS/NZS2007.1-2002. The only risk for manufacturers in making the program called “normal” too weak is that they will generate some consumer complaints about poor wash performance.

It is important to note that the minimum wash performance is 0.9 of the reference program (Gentle 45°C) on the reference machine (Miele G590). This is a 4 fill program with a wash temperature at the lower end of the market. The energy consumption for the reference machine is about 450 kWh/year (includes power drying), which is average for current “normal” type programs and this would rate about 1.7 stars under the current system. Note that while the reference machine is a good quality dishwasher, it is based on a design and technology that is now 20+ years old. Note also that the cleaning performance of this reference program is about 10% higher than the minimum required.

It is not possible to accurately predict the impact of the change to normal program. While some models will be able to continue using the same program with a different name, some may require reprogramming to satisfy all requirements (standard and consumers). Some smaller importers may not bother to re-engineer their products at all. The models most likely to be affected are the 14 place setting models that rate 3.5 stars under the current system (although these are primarily 4 fill models, with a couple of 3 fill models and one 5 fill model with a low wash temperature). The engineer response to the change in program will be varied and probably patchy.

Should the Star Rating Algorithm Change?

The general principles and guidelines for the star rating system were set out by the Energy Labelling Review Committee in 1998 as follows:

1. new star ratings should be a geometric progression;
2. star rating to be shown in half stars on the new label;
3. elimination of size bias where this is significant;
4. worst products on the market (or MEPS level where applicable) should generally be around 1 star;
5. best products currently on the market should not generally exceed 4 stars;
6. 5 star should be set as difficult but achievable in the next 5 years;

These points are addressed below.

Geometric Progression

As already noted, the current star rating system is already a geometric progression; this objective was implemented in the 2000 Part 2 edition. The current form of the labelling algorithm should be retained.

Half Stars

The current star rating system already has half stars: these should be retained.

Elimination of Size Bias where it Exists

Figure 1 shows the relationship between energy and size as at 2002. It would appear that there is some size bias in the dishwasher algorithm at present, although smaller units on the market can still achieve a star rating of 3 (majority are 1 and 1.5 stars, although there are 2 and 2.5 star models as well).

However, it is important to note that 90% of dishwasher registered in Australia (and probably a high sales share than 90%) are either 12 or 14 place settings. Interestingly, 14 place setting models generally have lower energy across the board compared to 12 place setting modes (this goes against the trend of capacity versus energy).

Interestingly, the dishwasher algorithm working group "*…discussed the issue of size bias and agreed that it is not necessary to change the algorithm to eliminate the current size bias (ie star rating curves would still pass through the origin)*." in 1998 and recommended the present labelling algorithms, even though it was acknowledged at the time to have some size bias.

The effect of size bias can be reduced by decreasing the size related component of the BEC (currently 48 × RC) and increasing the fixed component of BEC (currently zero). The only models that would benefit significantly from such are change are dishwashers with a capacity of less than 10 place settings. 12 place setting models would see no difference while 14 place setting models may see a slight disadvantage (depending on the exact algorithm adopted).

Worst Products on the Market to be About 1 Star

Figure 1 shows the relationship between energy and size star rating as at 2002. The current system would appear to be reasonable in terms of allocating a 1 star rating for the lowest efficiency products on the market. The only exceptions are two small dishwashers that have an SRI of about 0.5 while the worst 14 place setting model is somewhat better than the current 1 star line (BEC) – the worst is about 1.5 stars.

It may be possible to construct other 1 star line (BEC) scenarios that are also a reasonable approximation of the least efficient models currently on the market. Some of these are shown in Appendix A.

Best Products not to exceed 4 stars, 5 stars difficult but achievable within 5 years

These guidelines provide algorithm design targets during a label algorithm revision. It is arguable that these guidelines should only be applied when a full regrading of the star rating system is required – generally only once ever 5 to 8 years.

The key points for consideration on this particular matter are:

- The labelling system went through a significant regrading step in 2000 (this is illustrated by comparing Figure 2 with Figure 7).
- There has been some increase in energy efficiency over the past 3 years, although the rate of change has slowed in comparison to the mid 1990's;
- A few products (4) have already reached 4 stars and a significant number (22) are already 3.5 stars under the current system. One 7 place setting model has achieved 3 stars under the current system;
- 4 star energy consumption for a 12 place setting model is currently 198 kWh/year, while for a 14 place setting this is 230 kWh/year;
- 5 star energy consumption for a 12 place setting model is currently 138 kWh/year, while for a 14 place setting this is 161 kWh/year;
- There appears to be little need for another full blown regarding of the star rating system at this stage – however a some refinements could be implemented if warranted;

It would seem that the current energy labelling algorithm (BEC = 48 × RC, 30% reduction per star) is still quite valid when applied to the current dishwasher market in 2002. There are a bunch of models in the 3 to 4 star range with only a couple of models at 4 stars. The energy consumption targets for 4 and 5 stars under the current system are quite difficult but probably achievable within the next 3 to 5 years.

The only unknown factor is the impact on energy that the move to the normal program will on have current models. It is probably fair to say that the effect will be negative overall (energy increase) but it will be somewhat erratic on a model by model basis.

There are some advantages to retaining the current labelling algorithm for dishwashers. These are:

- The only significant change in 2002-2003 will be the program (mandatory use of normal) and the test method (which itself should not influence energy consumption to any significant extent) – the labelling star "goal posts" will remain in the current position;
- If the change in program results in a mild increase in energy, then this merely extends the time until the next labelling algorithm revision is required;
- If the change in program results in no significant increase in energy, then the current scheme will remain viable for some time;
- It is unlikely that energy consumption will decrease with the change to normal.

While it is recommended that the current energy labelling algorithm be retained in the 2002 edition of AS/NZS 2007.2, a number of algorithm revision options have been included in Appendix A for consideration by the working group and EL15/4. It may be possible to adopt these in consultation with NAEEEC.

Appendix A – Algorithm Options

Figure 4: Labelling Algorithm Option 1 – removes some size bias

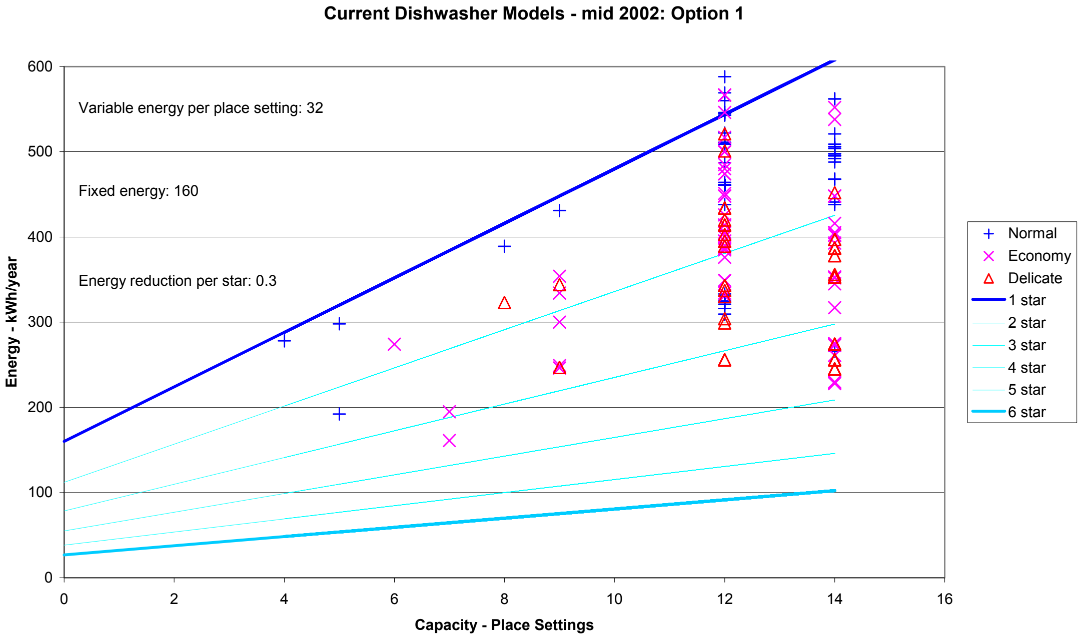


Figure 5: Labelling Algorithm Option 2 – removes some size bias (set to top of 14 place)

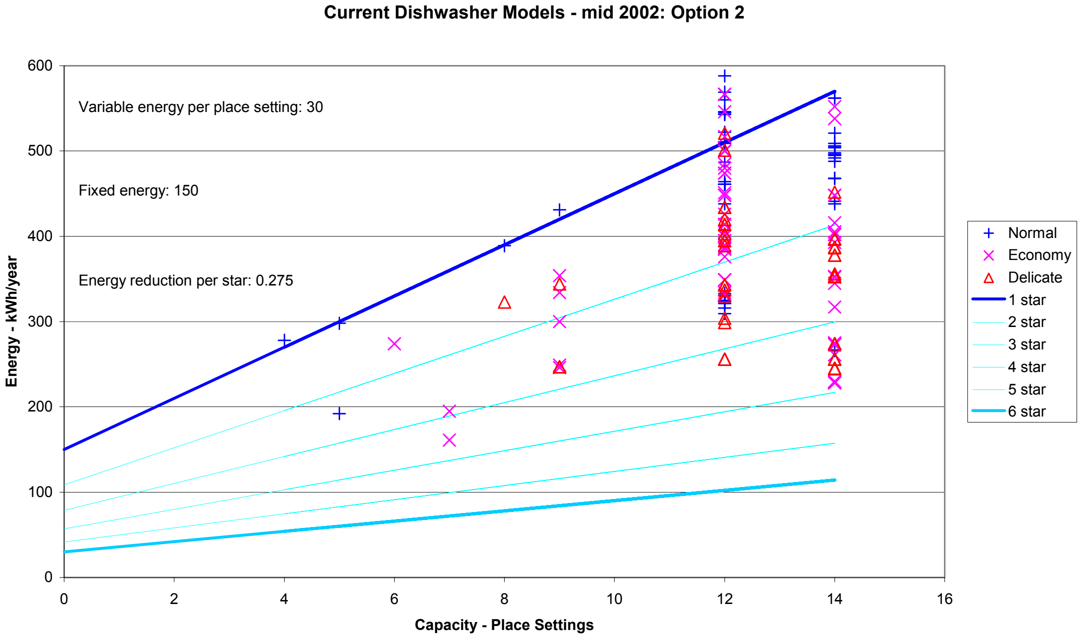


Figure 6: Labelling Algorithm Option 3 – through origin with reduced energy per star

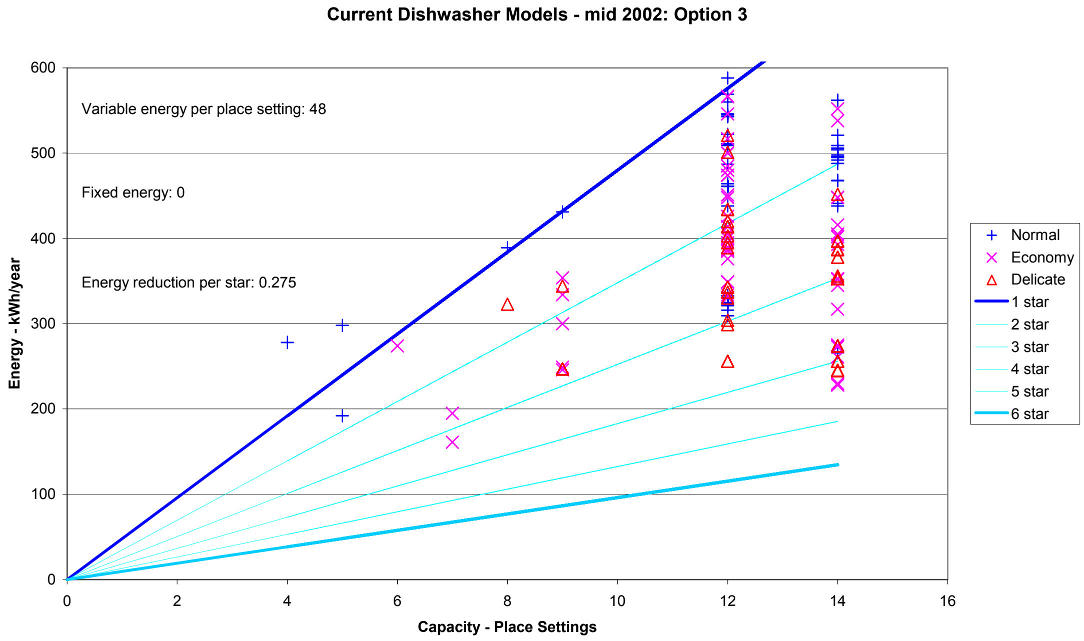


Figure 7: Historical dishwasher labelling star ratings – rating prior to 2000 with 1999 models