Appliance Labelling Review Committee
Air Conditioner Algorithm Working Group
Discussion Paper

prepared by EES, July 2005

Background

Energy labelling was first introduced for air conditioners in 1987. During 1998, the Appliance Energy Labelling Review Committee set a revised algorithm for air conditioners. This came into force during 2000, together with a redesigned label for all labelled products, including air conditioners after consultation with stakeholders. This was implemented in AS/NZS 3823.2-2000.

Since the revision of the energy label in 2000, MEPS were introduced for three phase units in October 2001 and for single phase units in October 2004.

A range of new MEPS levels are scheduled to come into force in 2006, 2007 and 2008 for various air conditioner types, sizes and configurations. The details are set out in the revised regulatory impact statement by Syneca Consulting which was released for comment in June 2005 (NAEEEC report 2005/16) and are summarised in Appendix A. This RIS is available for download from www.energyrating.com.au in the electronic library. The introduction of these new MEPS levels will mean that many of the lower star rating bins will be empty for air conditioners in the near future.

The purpose of this paper is to canvass options for a revised air conditioner algorithm for implementation in conjunction with revised MEPS levels for single phase air conditioners from October 2006. The intent is to include these requirements in the revision of AS/NZS 3823.2, which will be published in late 2005 in preparation for revised MEPS levels which come into force in October 2006.

This discussion paper is intended to provide background for a stakeholder meeting which is scheduled to be held in mid August 2005. Inquiries, submissions and expression of interest to be involved in the meeting should be directed to Janine Corcoran of the Australian Greenhouse Office at energy.rating@deh.gov.au prior to 10 August 2005.

Summary and Recommendations for Discussion

With a range of new MEPS levels coming into force over the period 2006 to 2008, a regrading of the star rating system for both cooling and heating modes is warranted for air conditioners. Ideally this should be implemented in conjunction with the MEPS requirements for 2006 to minimise disruption to industry, although precise transition arrangements are still to be discussed and finalised with industry.

Energy labelling is currently only mandatory for single phase non-ducted units. Non-ducted split systems dominate the market. Very few products, where energy labelling

is voluntary (single phase ducted and three phase models), are registered for energy labelling.

This paper makes the following recommendations with regard to regrading of the star rating algorithms for air conditioners:

- For cooling mode, it is recommended that the 1 star line be moved to an EER of 2.5 with a EER step of 0.4 per additional star. This is shown as Option 3C in the body of this paper.
- For heating mode, it is recommended that the 1 star line be moved to a COP of 2.5 with a COP step of 0.4 per additional star. This is shown as Option 1H in the body of this paper.
- These equations should be included in the revision of AS/NZS 3823.2-2005 which is open for public comment as DR05316.
- Transitional arrangements for the introduction of the new energy labelling requirements should be discussed and agreed to in the working group but the target implementation date should be around October 2006.
- Labelling system to continue to show half stars.

Several alternative star rating algorithm options are shown in this paper. However implementation of the recommended algorithms above will ensure that the labelling scheme for air conditioners remains viable for the next 5 years (or more).

Current Energy Labelling Requirements – from 2000

The energy labelling algorithm requirements from 2000 are set out in AS/NZS 2007.2-2000. In summary these requirements are:

SRI cooling = [(Tested EER × 10) – 17] / 3

SRI heating = [(Tested COP × 10) – 20] / 3

Under this algorithm:

SRI cooling is 1 star for an EER of 2.0 with 1 star for each increase in EER of 0.3.

SRI heating is 1 star for a COP of 2.3 with 1 star for each increase in COP of 0.3.

Air Conditioner Algorithm 1987 to 2000

For reference, the energy labelling algorithm requirements up to 2000 are set out in AS/NZS 2007.2-1998. In summary these requirements are:

SRI cooling = (Tested EER × 5) – 8.5

SRI heating = (Tested COP × 5) – 9.5

Under this algorithm:

SRI cooling is 1 star for an EER of 1.9 with 1 star for each increase in EER of 0.2.

SRI heating is 1 star for a COP of 2.1 with 1 star for each increase in COP of 0.2.

Current Status of Labelling and Registrations – July 2005

The scope of energy labelling for air conditioners is as follows:

- Non ducted single phase – mandatory
- Non ducted three phase – voluntary
- Ducted all types - voluntary

The vast majority of products registered for energy labelling are single phase non ducted units. Some single phase ducted and very few three phase units are registered for energy labelling.

There are now a huge number of air conditioners registered for energy labelling and MEPS and the market has grown quickly in recent years. The following table summarises the current registrations as of mid July 2005.

Type and Details	Cooling Only	Reverse Cycle
Total approved records	**809**	**2290**
Single Phase	**651**	**1655**
- Ducted (all)	43	169
- Ducted (with label)	32	118
- Ducted (no label)	11	51
- Non Ducted (all labelled)	608	1486
- Unitary	263	210
- Split	345	1276
Three Phase	**158**	**635**
- Ducted (all)	90	422
- Ducted (with label)	1	2
- Non Ducted (all)	68	213
- Non Ducted (with label)	0	6

The main product of concern with regards to energy labelling is non-ducted single phase products, which is the only category of product for which energy labelling is mandatory. More than 80% of labelled air conditioners currently registered are now single phase non-ducted split systems. This category of product also makes up about two thirds of all registrations for air conditioners (single phase and three phase). Interestingly, more than half the single phase ducted registrations are registered for energy labelling (noting that this is not mandatory) but almost no three phase registrations have elected to register for energy labelling (either ducted or non-ducted types).

So the analysis in this paper will concentrate on the performance of single phase products, and non-ducted products in particular.

Forthcoming MEPS Levels

New MEPS levels are being introduced for single and three phase air conditioners in 2006, 2007 and 2008. The efficiency levels by type and date are set out in Appendix A.

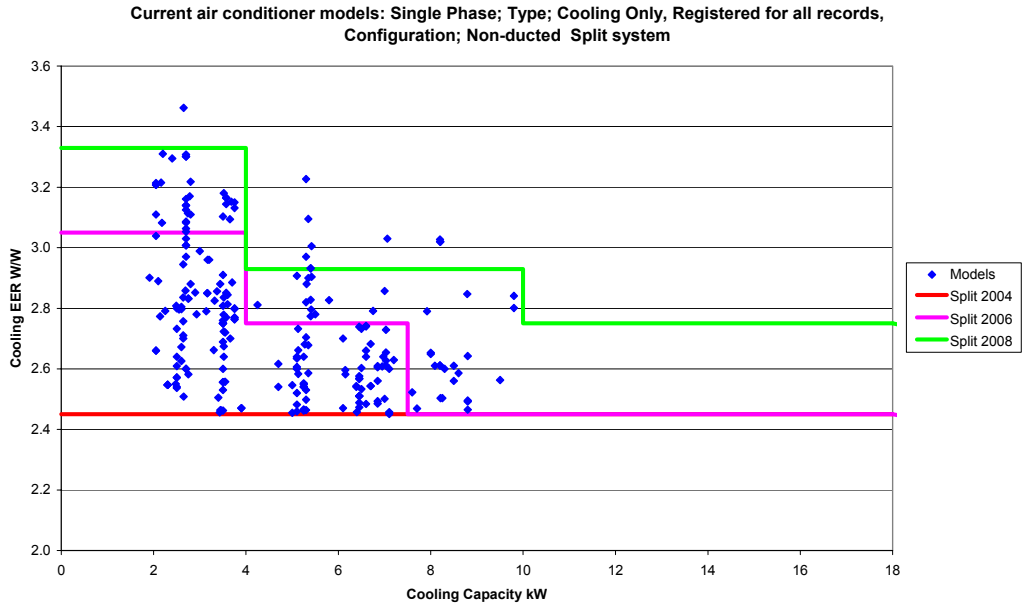
Snapshot of Current Models and Forthcoming MEPS Levels by Type

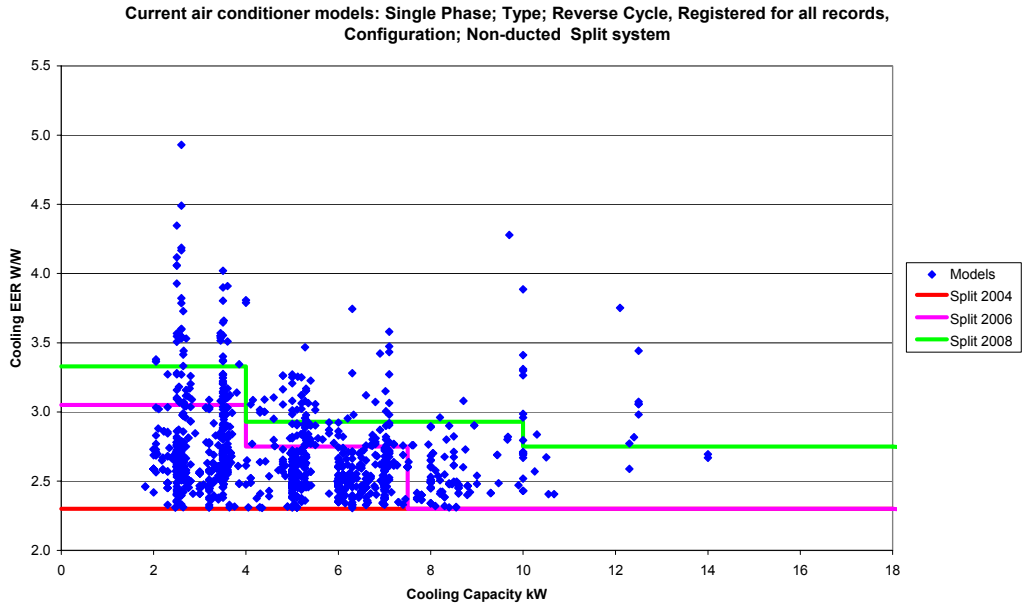
This section depicts a visual representation of models which are currently registered for energy labelling and MEPS for each of the main product types. Only single phase models are covered.

MEPS levels shown are described briefly in the associated text.

Single Phase Non-Ducted Split Systems

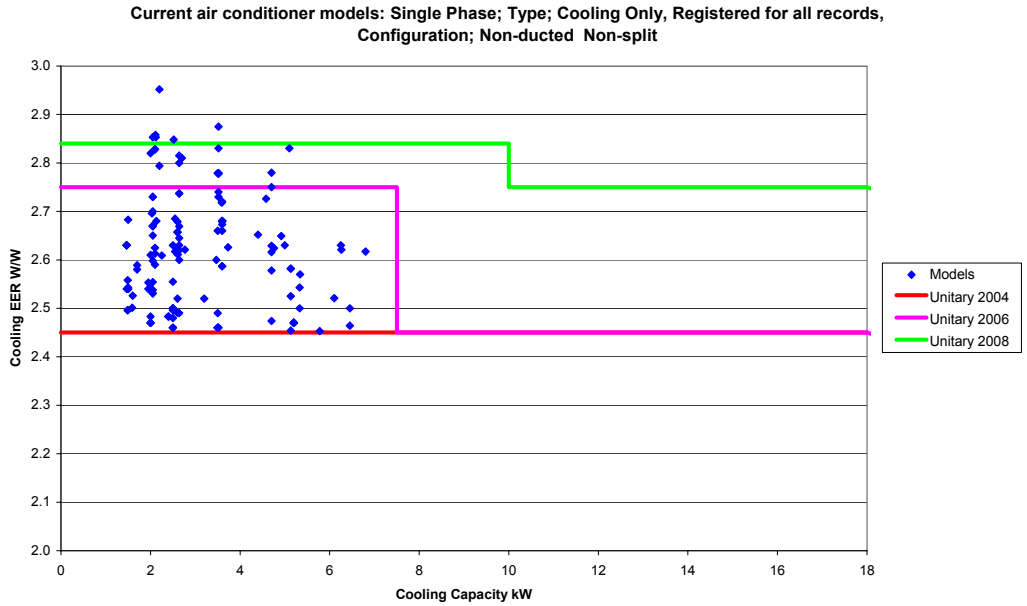
Total current models are 345 cooling only and 1276 reverse cycle. The relevant MEPS levels are 2004 (already in force), 2006 (models less that 7.5kW output have to meet increased MEPS levels), 2007 (models over 7.5kW have to meet an EER of 2.75 – not shown on the figure) and 2008 (increased MEPS levels for all sizes up to 10kW with units over 10kW meeting three phase MEPS levels). Note that there are differences in MEPS levels for cooling only and reverse cycle in 2004, but later MEPS levels apply equally to both types.

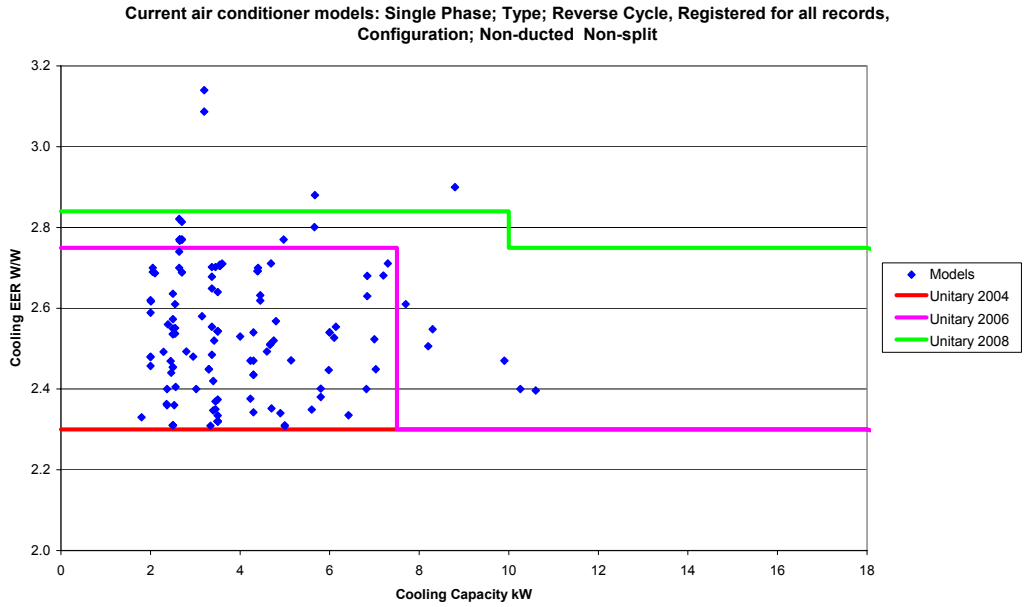




Single Phase Non-Ducted Unitary (Window Wall)

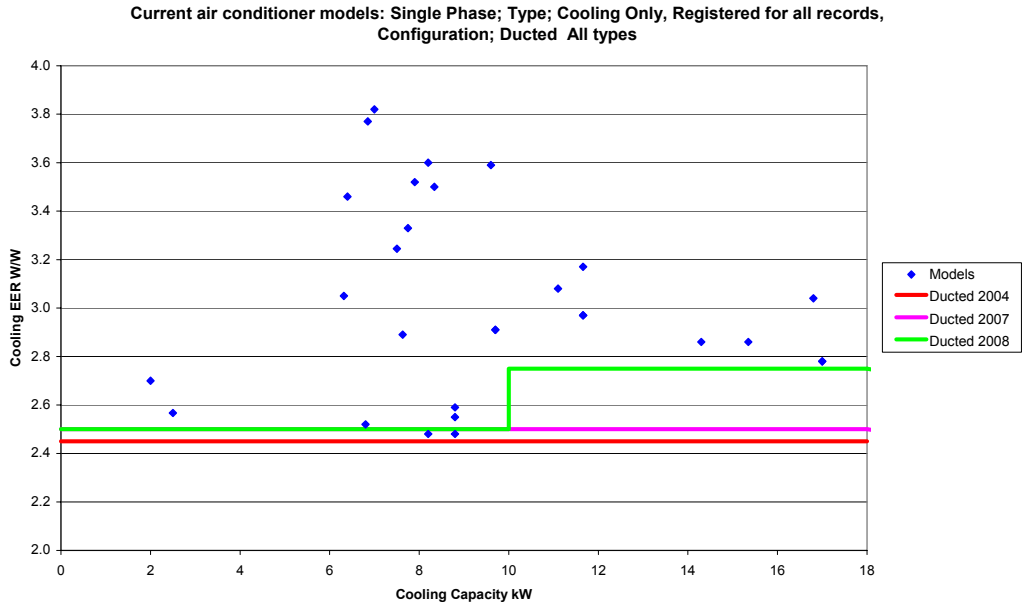
Total current models are 263 cooling only and 210 reverse cycle. The relevant MEPS levels are 2004 (already in force), 2006 (models less that 7.5kW output have to meet increased MEPS levels), 2007 (models over 7.5kW have to meet an EER of 2.75 – not shown on the figure) and 2008 (increased MEPS levels for all sizes up to 10kW with units over 10kW meeting three phase MEPS levels). Note that there are differences in MEPS levels for cooling only and reverse cycle in 2004, but later MEPS levels apply equally to both types.



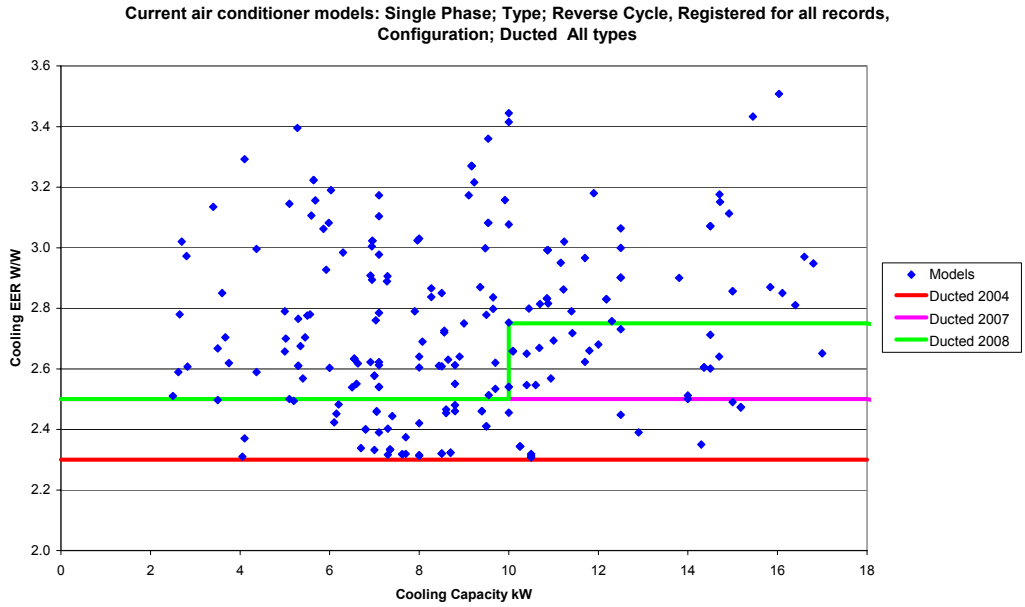


Single Phase Ducted

This configuration includes split and non-split ducted types. Total of current models is 43 cooling only and 169 reverse cycle. The relevant MEPS levels are 2004 (already in force), 2007 (all models have an EER of 2.5) and 2008 (increased MEPS levels for all sizes over 10kW to 2.75 which is the requirement for three phase). Note that there are differences in MEPS levels for cooling only and reverse cycle in 2004, but later MEPS levels apply equally to both types.



Note: That this figure includes some models not registered for energy labelling



Note: That this figure includes some models not registered for energy labelling

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 stars should be set as a difficult but achievable target in the next 5 years;

These points are addressed below.

Geometric Progression

For air conditioners, a "geometric progression" (defined as a fixed percentage reduction in energy per additional star) is not directly relevant for air conditioners as EER is already a measure of efficiency (rather than energy). In effect, even steps of EER used in pervious air conditioner algorithms are a quasi geometric progression and it is recommended that this approach be retained in a revised energy labelling algorithm.

Half Stars

The current star rating system already has half stars: these should be retained.

Elimination of Size Bias where it Exists

The issue of size bias in efficiency is complex for air conditioners. For window wall (unitary) and ducted systems as shown above, there is no obvious size efficiency relationship (although there are some size factors that may affect efficiency). For split systems, it appears that smaller units tend to be more efficient. The reasons for this are complex, but one of the main factors is that larger single phase systems tend to have constraints on the size of the evaporator and condenser, which tend to reduce overall refrigeration system efficiency as compressor size increases. The MEPS levels for small split systems (<4kW) are significantly higher from 2006 compared with other products. Another important factor is that MEPS levels in Japan and Korea in particular are driving the efficiency levels for smaller products, which has some flow on effect in Australia.

The trend towards lower efficiency for larger units in air conditioners is opposite to the efficiency trend for most of the labelled products (size bias is the term used to explain how larger white goods tend to appear more "efficient" compared to smaller models based on energy service per unit of energy consumed).

Given that the EER is a reasonably objective measure of unit efficiency, it is not proposed to have any adjustment of star rating by output capacity for air conditioners as part of this algorithm review.

Worst Products on the Market to be About 1 Star

The "worst" efficiency products on the market will depend on the MEPS applicable for the particular product. The weakest MEPS level will be EER > 2.5 for ducted units, while many non ducted units will have to be > 2.75 in 2006 or 2007 (depending on the size and type). By 2008 almost all non ducted MEPS levels will be 2.75 or higher (small split systems will be as high as 3.33). The issue of the 1 star line is addressed in the star rating algorithm options section below.

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 every 5 to 8 years. The last re-grading for air conditioners was in 2000 and a regrading now will be implemented in 2006, which is a 6 year gap between revisions. Given the reasonably large increases in MEPS levels over the period 2006 to 2008, regrading of the star rating algorithm is now essential.

The key points for consideration on this particular matter are:

- The labelling system went through a significant regrading step in 2000 and given the stringent new MEPS levels, a regrading is warranted in the near future.
- There has been significant improvement in air conditioner efficiency over the past 5 years. A number of products currently on the market (35) rated well over 6 stars (based on the 2000 algorithm, which is equivalent to an EER of more than 3.5);

- Given the objective measure of EER as a measure of unit efficiency, it is important that a common star rating algorithm be adopted across the board for all product types and configurations to allow product comparison on the basis of efficiency.

Star Rating Algorithm Options

A number of possible star rating algorithms are set out below for review and discussion by stakeholders.

The basic design principles used are:

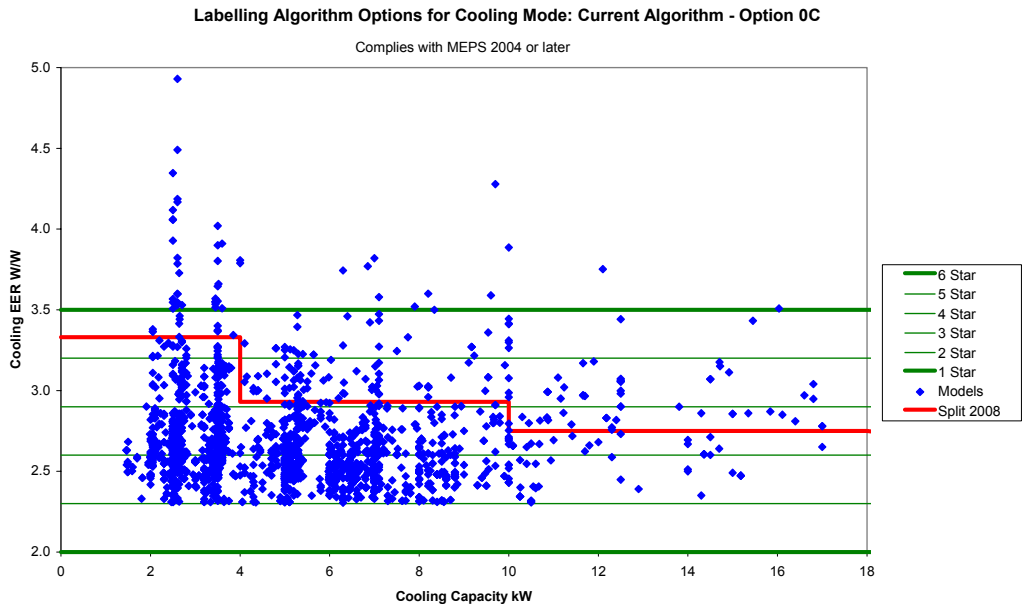
- Horizontal lines for all star rating lines in terms of capacity (constant EER and COP for a range of kW outputs).
- Even step sizes of EER and COP for each additional star.
- Taking into account the MEPS levels coming into force over the coming years (to 2008) to ensure reasonable longevity for the revised algorithm.
- Provision of reasonable differentiation of efficiency with the star rating system.

In this review only data for single phase products has been reviewed.

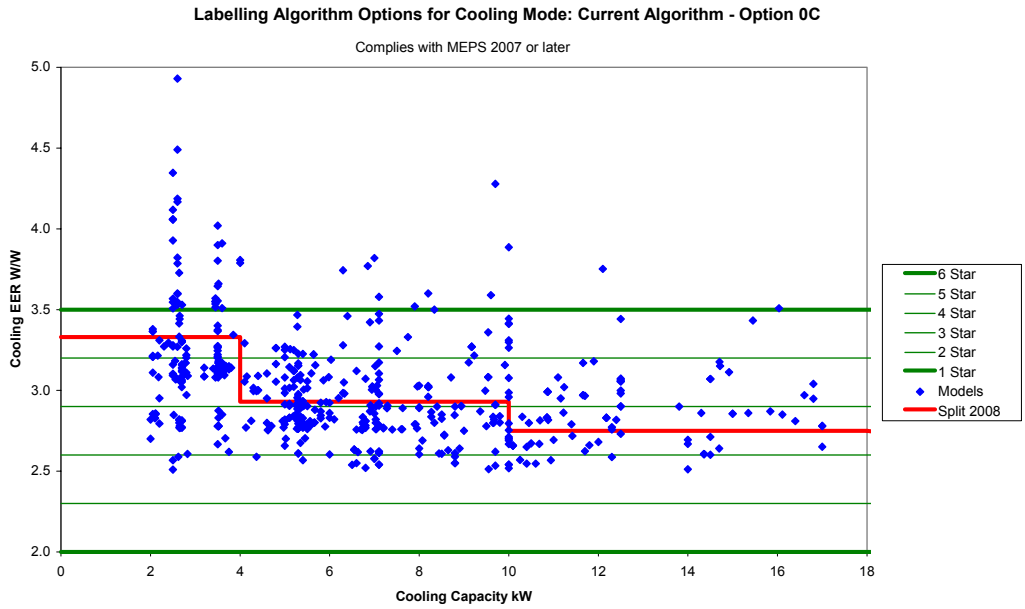
Cooling Star Ratings

Minimum cooling EER levels apply equally to cooling only and reverse cycle models from 2006 onwards. The following figures show the cooling performance (EER) for both cooling only and reverse cycle models together and ducted and non-ducted types altogether.

Consider the current energy labelling algorithm for cooling star rating together with the current market (ie models compliant with MEPS 2004 requirements) which is shown as Option 0C below.



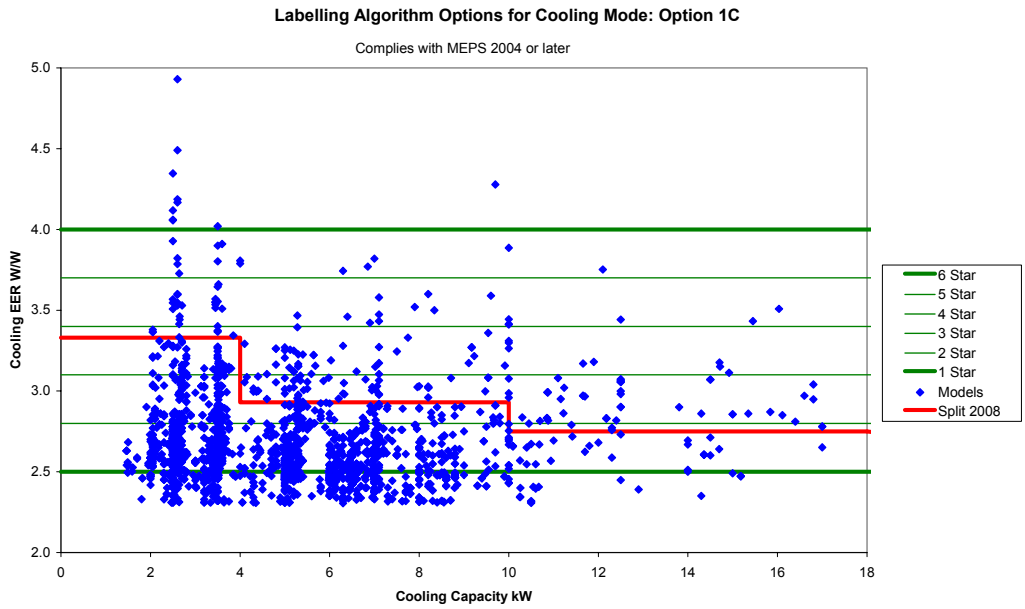
The most important point to note is that the 1 star bin (EER from 2.0 to 2.3) is already empty as the minimum MEPS level is 2.3 for reverse cycle models and 2.45 for cooling models from 1 October 2004. The MEPS level for split systems in 2008 is shown for reference. Of interest is the following figure which shows only models which are currently registered and which comply with the relevant 2007 MEPS level for the particular product.



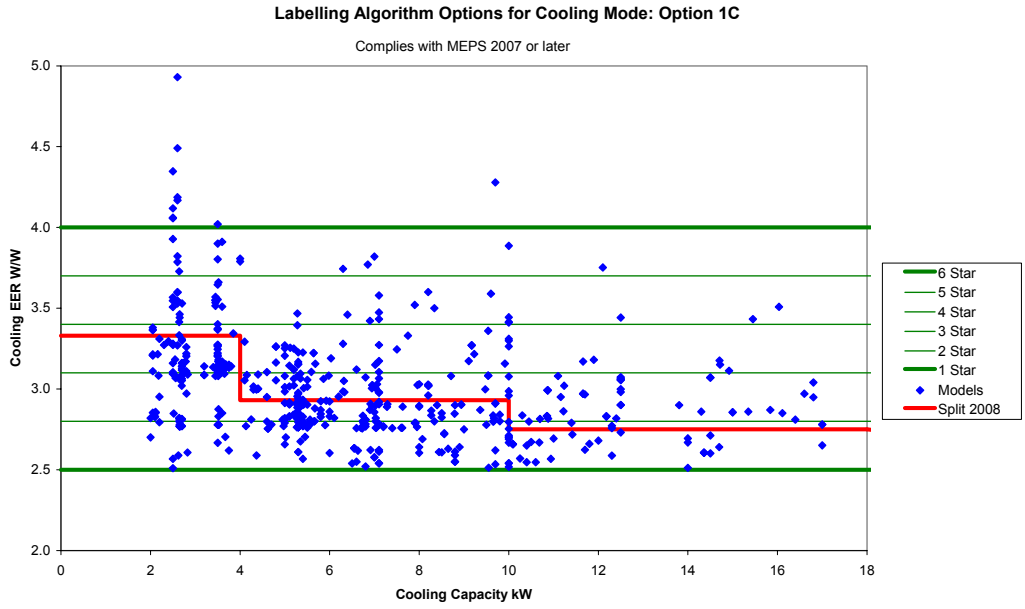
This figure shows that by 2007 almost all products on the market will be at least 3 stars under the current star rating algorithm. By 2008, the only split system models (which are expected to remain the predominant product type) left on the market will be a minimum of 5.5 stars for less than 4kW and a minimum of 4 stars from 4kW to 7.5kW. The only units on the market that lie between an EER of 2.5 and 2.75 are ducted models and only some of these carry an energy label.

Three star rating options have been developed for air conditioner cooling mode. These are illustrated in the following figures. In summary:

- Option 1C is 1 star at an EER of 2.5 and a star step of 0.3
- Option 2C is 1 star at an EER of 2.75 and a star step of 0.3
- Option 3C is 1 star at an EER of 2.5 and a star step of 0.4.

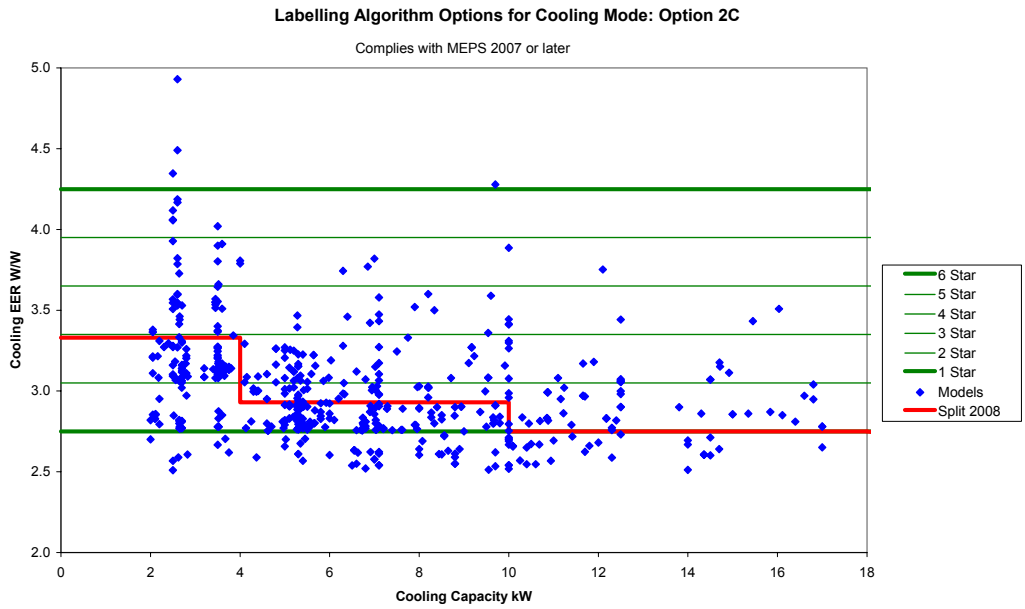


The same figure for Option 1C is shown below with only those models on the market that comply with MEPS 2007 requirements. The following charts are all based on this reduced data set as this provides some clarity on the possible future distribution of model efficiency.

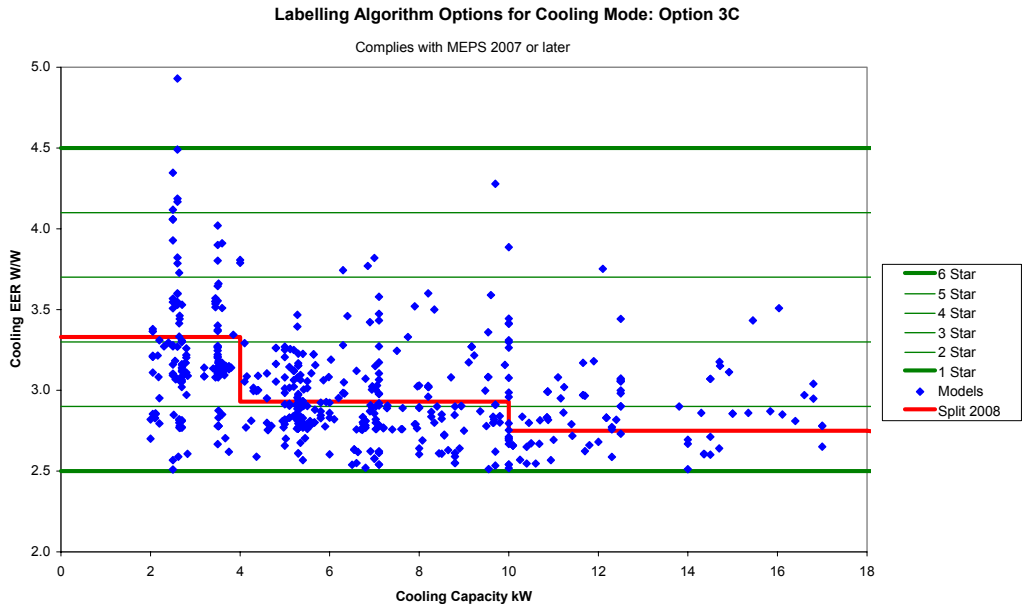


A substantial number of models achieve greater than 5 stars under Option 1C.

Under Option 2C the number of model above 6 stars is reduced, but there are a significant number of ducted models which have a star rating of less than 1 star that still meet MEPS requirements beyond 2008.



Under Option 3C, all the ducted units that pass MEPS all achieve 1 star. For non-ducted split systems, the MEPS levels in 2008 for split systems corresponds to 3 stars for smaller units (<4kW) and 2 stars for medium sized units (4kW to 7.5kW).



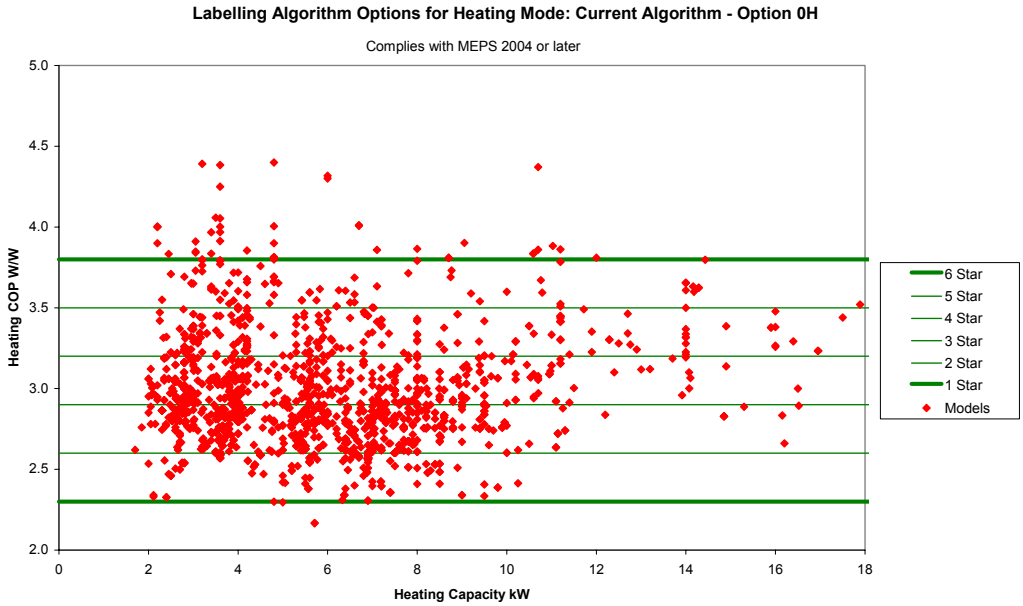
Option 3C is perhaps the most robust option examined as it sets the 1 star line to a MEPS level that will be in force for some time (beyond 2008 for ducted models), and yet provides good differentiation across product types. Some models on the market already exceed 5 and 6 stars, but these are limited in number.

Option 3C is the preferred option for a revised star rating algorithm for cooling mode.

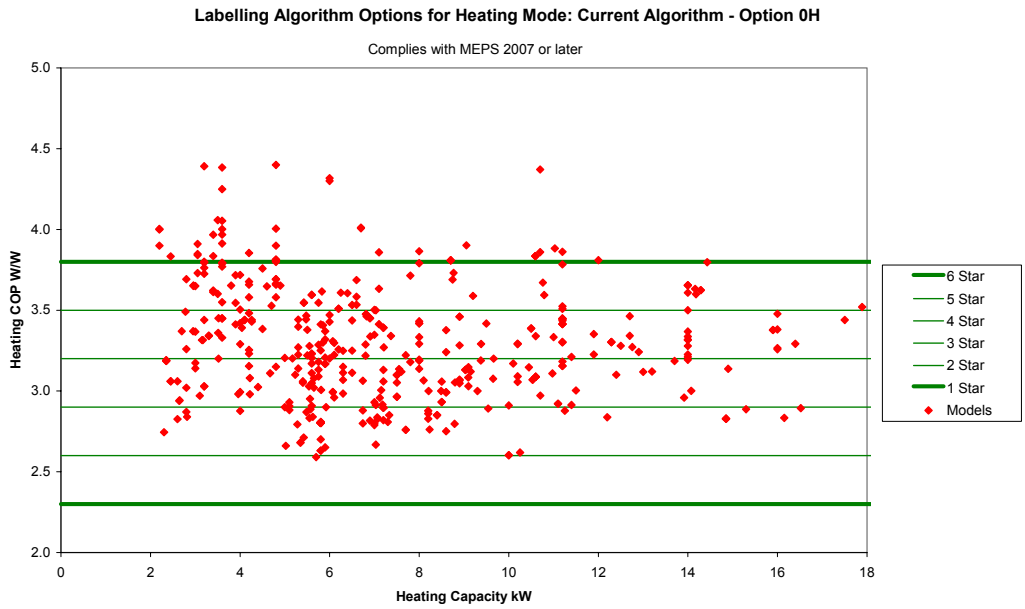
Heating Star Ratings

No MEPS levels have been set for COP in heating mode of reverse cycle models at this stage, although these may be considered in the future. The following figures show the heating performance of reverse cycle models for both ducted and non-ducted types together.

Consider the current energy labelling algorithm for heating star rating together with the current market (ie models compliant with MEPS 2004 requirements).

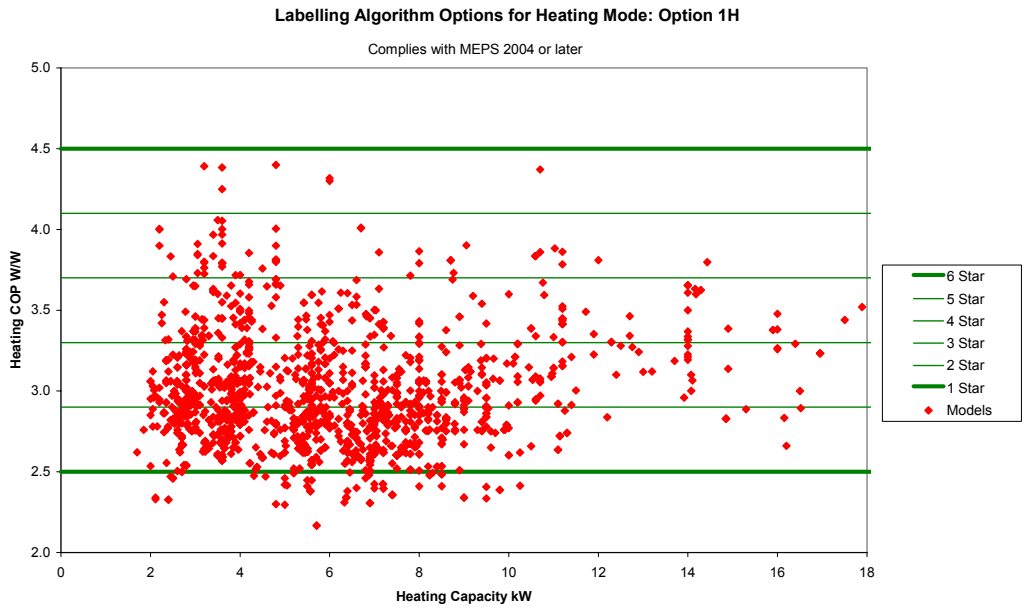


There are still some models in the 1 star range with the majority of models in the 2 and 3 star range. There are a substantial number of models in the 4 and 5 star range and many models with more than 6 stars. Note that this figure has a locked scale to allow direct comparison with the cooling figures and as a consequence the heating COP performance for some models lie off the chart (above a COP of 5.0). Of interest is the following figure which shows only models which currently comply with the relevant 2007 MEPS level (for cooling performance) for the particular product. Based on current registrations, after MEPS for 2007 is implemented, the lowest COP on heating mode left on the market will be about 2.6. The minimum heating COP remains comparable after MEPS 2008 levels are implemented for all products.

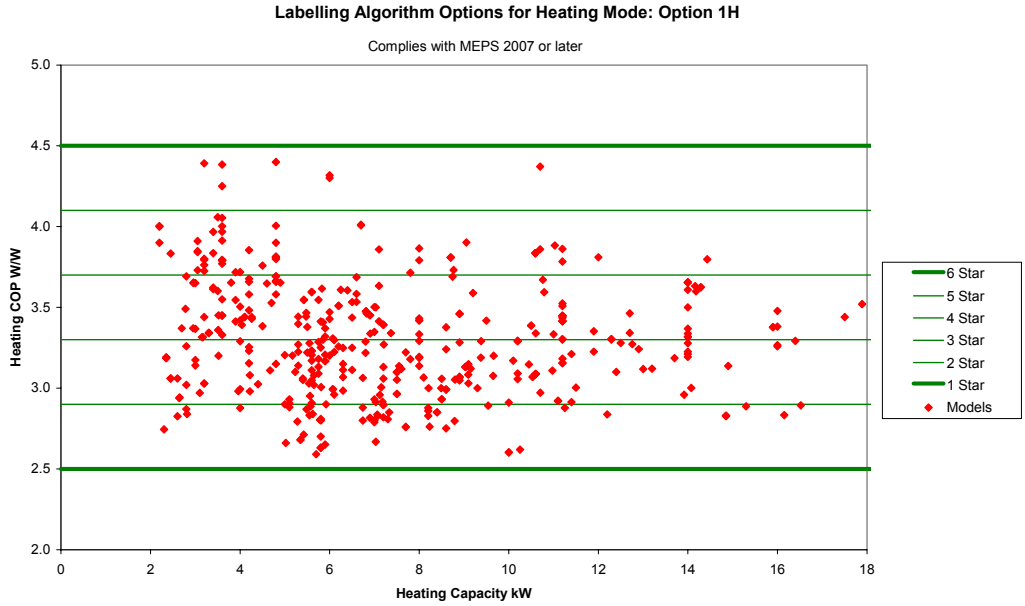


The 1 star base for heating mode is a COP of 2.3, which is significantly higher than the cooling mode 1 star base EER of 2.1 under the current star rating system (2000). Shifting the 1 star COP up to 2.5 will do little to alleviate the significant numbers that have already exceeded 5 and 6 star ratings under the heating performance. However, raising the 1 star level significantly above 2.5 will mean that some products will achieve an SRI of less than 1.0. So it appears that a workable solution for a revised star rating algorithm for heating mode is to increase the size of the steps per additional star while increasing the 1 star base slightly.

Option 1H has been configured to achieve these goals and is shown below. This is a 1 star base of COP 2.5 and a step size of 0.4 COP per additional star. This coincidently is the same equation as Option 3C for cooling and is illustrated below.



Option 1H looks even more robust when only models that comply with MEPS 2007 or later are left as shown below.



Option 1H is the preferred option for a revised star rating algorithm for heating mode.

Appendix A – Forthcoming MEPS levels for Air Conditioners

Phase	Type	Configuration	Configuration Type	Capacity Range kW	1 Oct. 2001	1 Oct. 2004	1 Oct. 2006	1 Oct. 2007	1 Oct. 2008
1	Cooling only	Non-ducted	Split	<4.0	N/A	2.45	3.05 *	3.05	3.33
1	Cooling only	Non-ducted	Split	4.0 to <7.5	N/A	2.45	2.75 *	2.75	2.93
1	Cooling only	Non-ducted	Split	7.5 to <10.0	N/A	2.45	⇐	2.75	2.93
1	Cooling only	Non-ducted	Unitary	<7.5	N/A	2.45	2.75 *	2.75	2.84
1	Cooling only	Non-ducted	Unitary	7.5 to <10.0	N/A	2.45	⇐	2.75	2.84
1	Cooling only	Ducted	All	<10.0	N/A	2.45	⇐	2.50	⇐
1	Cooling only	All	All	≥10.0	N/A	2.45	⇐	2.50	See 3 Phase
1	Reverse cycle	Non-ducted	Split	<4.0	N/A	2.30	3.05 *	3.05	3.33
1	Reverse cycle	Non-ducted	Split	4.0 to <7.5	N/A	2.30	2.75 *	2.75	2.93
1	Reverse cycle	Non-ducted	Split	7.5 to <10.0	N/A	2.30	⇐	2.75	2.93
1	Reverse cycle	Non-ducted	Unitary	<7.5	N/A	2.30	2.75 *	2.75	2.84
1	Reverse cycle	Non-ducted	Unitary	7.5 to <10.0	N/A	2.30	⇐	2.75	2.84
1	Reverse cycle	Ducted	All	<10.0	N/A	2.30	⇐	2.50	⇐
1	Reverse cycle	All	All	≥10.0	N/A	2.30	⇐	2.50	See 3 Phase
3	Both #	Non-ducted	All	<10.0	2.25	⇐	⇐	See 1 Phase	See 1 Phase
3	Both #	Ducted	All	<10.0	2.25	⇐	⇐	2.50	⇐
3	Both #	All	All	≥10.0 to 12.5	2.30	⇐	⇐	2.75	⇐
3	Both #	All	All	>12.5 to 15.5	2.35	⇐	⇐	2.75	⇐
3	Both #	All	All	>15.5 to 18.0	2.40	⇐	⇐	2.75	⇐
3	Both #	All	All	>18.0 to 18.9	2.45	⇐	⇐	2.75	⇐
3	Both #	All	All	>18.9 to 25.0	2.45	⇐	⇐	3.05	⇐
3	Both #	All	All	>25.0 to 30.0	2.50	⇐	⇐	3.05	⇐
3	Both #	All	All	>30.0 to 37.5	2.55	⇐	⇐	3.05	⇐
3	Both #	All	All	>37.5 to 39.0	2.60	⇐	⇐	3.05	⇐
3	Both #	All	All	>39.0 to 45.5	2.60	⇐	⇐	2.75	⇐
3	Both #	All	All	>45.5 to 65.0	2.65	⇐	⇐	2.75	⇐