Inverter MEPS Discussion Paper

Prepared by EES for E3, 26 March 2007

Background

Single phase non-ducted air conditioners have been subject to mandatory energy labelling since 1987. Three phase and ducted systems may carry the energy label on a voluntary basis. MEPS for three phase units was introduced in 2001 and MEPS for single phase units was introduced in 2004. Single and three phase MEPS are being progressively upgraded through the period 2006 to 2007 for all types.

Over the past 10 years, air conditioners have seen very fast increases in ownership and there are now a large variety of configurations available. There is increasing interest and concern regarding the contribution that air conditioners make to peak demand on electricity supply networks. In response, governments are investigating a range of option including more stringent MEPS levels and load control options for these products. A range of relevant reports on these issues can be found on www.energyrating.gov.au in the electronic library.

One type of air conditioner that has been given special consideration with respect to MEPS levels are units with variable output compressors (predominantly those using variable speed drives or inverters, but other types are also becoming available). Most conventional single speed compressors run at a constant speed and vary their capacity by varying their duty cycle (switching on and off as required); their efficiency stays relatively constant at part load output. Air conditioner units containing a variable output compressor (eg an inverter) allows the compressor output to be reduced to match the steady state cooling or heating output required. The efficiency (COP and EER) of the system theoretically increases as the output of the system decreases because the total refrigeration system becomes more efficient with a smaller compressor output feeding into a constant sized evaporator and condenser. Although some of these systems may appear less efficient at rated output, due to parasitic control system losses, they tend to be very efficient at part load output, which is likely to make up a substantial proportion of their normal operation.

The precise map of EER/COP versus output will vary for each individual model. However, a typical shape for many inverters is a bell shaped curve, with the maximum efficiency typically in the output range of 40% to 80%. The subsequent analysis undertaken for this paper depicts the efficiency trends of variable output models at 2 points only – this is insufficient to determine the precise shape of the efficiency curve. This needs to be considered when considering possible rules for variable output systems.

Issue

When MEPS for three phase systems were originally proposed for three phase systems in the late 1990's, concern was expressed about variable output (inverter) systems which may just fail MEPS at rated output, while under typical use conditions (part load) they would normally exceed MEPS by a substantial margin. A simplistic rule was developed and introduced to allow inverter systems to claim MEPS

compliance at any part load condition (down to 50% output). This rule was developed cooperatively between government and industry although the full implications were not explicitly analysed at the time.

The rule which allows part load compliance for variable output systems where they are unable to meet MEPS at rated output has been in AS/NZS3823.2 since MEPS were first introduced in 2001.

Recently, industry concerns have been raised about this mechanism. Theoretically, an inverter product could have a very low efficiency and may in fact be below the specified MEPS level for most of its operating range and only meet the MEPS level at say 50% output. This would be against the spirit of the allowance for variable output models – the underlying assumption in the development of the part load compliance rule was that the model may just fail MEPS at rated output but would be above MEPS for most of its operating range.

There have been calls from industry, now supported by government, to review the rule for variable output products and, if necessary, revise this rule to make sure these units exceed MEPS over most of their operating range.

Current Wording in AS/NZS3823.2-2005

It is useful to review the wording in the standard that permits part load testing for MEPS compliance of inverter units. Clause 3.4 states:

Appliances with variable output compressors, which do not meet the minimum energy performance standard requirements at rated capacity under CONDITION T1 in AS/NZS 3823.1.1 or AS/NZS 3823.1.2 or AS/NZS 3823.1.3, may be tested at part load operation. Variable output compressors shall be deemed to comply with the minimum EER cooling requirements of this standard if they achieve the minimum required EER when they are operated at not less than 50% of their rated cooling capacity, under CONDITION T1. A separate test report with supporting data is required if compliance with MEPS is not at 100% of rated capacity.

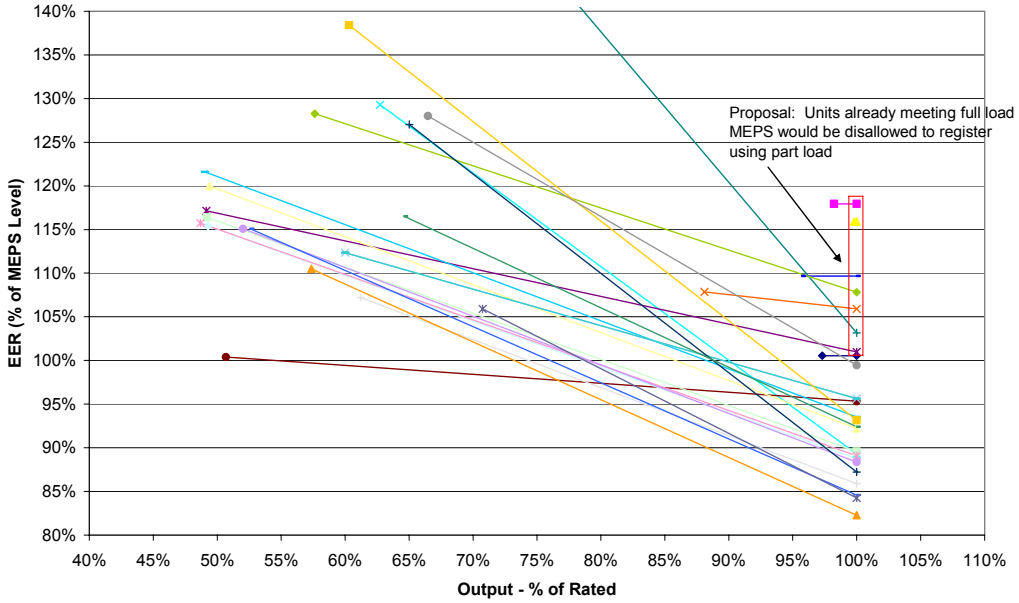
Review of the Part Load Data

Historically, around 10% of air conditioners that have been registered (out of a total of 8,500 air conditioners) are designated as “inverter” models (variable output). However, information on this product attribute has only been recorded in registrations since 2001. The vast majority of variable output models are single phase units (currently 580 approved models), with only 19 registrations being three phase. Of these units, only 26 approved registrations for variable output models have claimed MEPS compliance using part load (although around a third of these models actually meet the MEPS requirements at full load – see discussion below) and all of these are single phase models. 17 of the single phase inverters that require part load to demonstrate MEPS compliance are non ducted split systems; only one model is a ducted split system. All these units are reverse cycle.

A greater breakdown of the registration data can be found in the Appendix.

To date there are 26 approved inverter models claiming part load compliance, although 8 of these actually meet MEPS requirements at full load[1] (these are found in the red box in Figure 1 below). When asked, one supplier indicted that part load was used (even though the model met MEPS using full load) 'just to be sure' that they were able to comply with the MEPS requirements. For unknown reasons, four models were registered using the same figures for both full load and part load and were also found to have a full load EER above the MEPS level. These models have flat EER lines in Figure 1 below.

Figure 1 – Output (as a % of Rated) vs EER (as a % of MEPS Level)

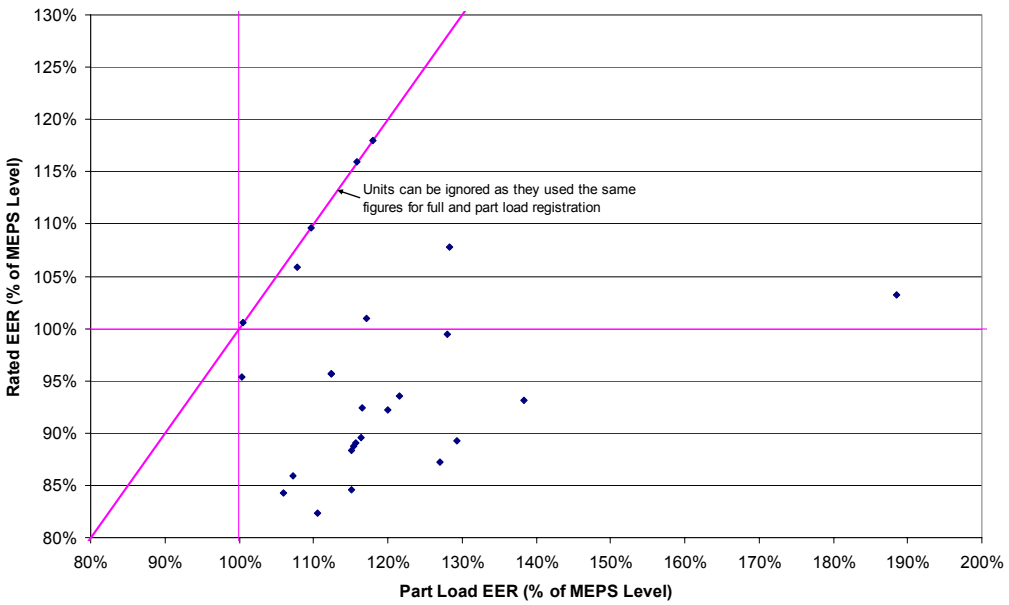


Note: As noted above, EER vs output for variable output systems is typically a bell shaped curve. Data for the two points shown above (and in subsequent figures) provides little information on the actual output-EER shape for individual models.

Figure 2 below shows the models registered for part load in a different way. Models lying on the diagonal pink line are the models that used the same figures for both full and part load. Models below the horizontal pink line fail MEPS at full load, whilst models above this line pass MEPS at full load. Any models that lie close to the vertical pink line (and below the vertical one) or within 10% of this vertical line are of interest.

[1] Changes to the registration system will be made to only allow part load data to be entered when the unit does not comply with MEPS at rated output.

Figure 2 – Part Load EER (% of MEPS Level) vs Rated EER (% of MEPS Level)



Determination of Rated Output – Variable Output Units

For single speed compressors, the rated output is a definitive value that can be easily determined through operation under the maximum output condition with the compressor in operation. For variable output products, the rated output can, to some degree, be selected by the manufacturer. AS/NZ3823 states that the rated output shall not exceed the maximum continuous output of the unit. However, in many cases the rated capacity claimed by some manufacturers is thought to be somewhat less than the maximum continuous output. AS/NZ3823 currently has no rules about how the rated capacity claims for these types of units are determined, where this is less than the maximum continuous output.

This is relevant as the point selected for determination of rated capacity for variable output units effectively sets the EER for determination for MEPS compliance. If a "rated output" was selected by a manufacturer that is perhaps as low as 50% of the maximum continuous output, then the EER at this capacity would in all likelihood look fairly reasonable even on a model with a poor overall efficiency profile. Conversely, the efficiency at outputs beyond the selected "rated capacity" in such cases will be lower than the rated EER. If the unit spends significant periods of time operating in this output range, the principle that the product must exceed MEPS over most of their operating range will not be met.

So a critical element of this discussion on part load MEPS compliance must be to determine rules about how the rated capacity of these types of units is determined to avoid exploitation of the system.

Proposals to Redress this Issue

Of the 580 single phase variable output model currently approved, only 18 require the part load allowance to pass the current MEPS requirements. All of these units are claiming compliance with the more stringent MEPS levels introduced in April 2006 or proposed for October 2007 (depending on product size and type). Of these 18 models, the rated output EER distribution is as follows:

- 4 lie in the range 0.95 to 1.00 of the MEPS EER
- 5 lie in the range 0.90 to 0.95 of the MEPS EER
- 7 lie in the range 0.85 to 0.90 of the MEPS EER
- 2 lie in the range 0.80 to 0.85 of the MEPS EER

While these models are of some concern, it is not considered to be widespread abuse of the current inverter allowance at this stage. However, government is keen to review the issue in consultation with industry with a view to introducing a more technically rigorous approach to this issue.

A range of possible options could be developed to further restrict the use of clause 3.4 with regard to MEPS compliance for variable output models. Possible options include:

1. Removing the allowance for part load compliance altogether (ie all units must comply with MEPS at rated output)
2. Putting some restriction on the EER at rated output – eg cannot be less than MEPS less a fixed EER (say 0.10 or 0.20) or could not be less than say 95% of the MEPS level EER (for example).
3. Ensuring that the part load EER is significantly higher than the rated load EER and that this is well above the MEPS level.
4. A combination of the two previous requirements.
5. Making the part load allowance less generous – for example by ensuring that the MEPS level is exceeded at a part load output that is not less than say 75% rated output (less generous than the current 50% part load requirement).

Most of these proposals are fairly self evident and will be reviewed in consultation with industry. One of these (Option 4 above) has been examined in more detail as the basis for a possible proposal for consideration.

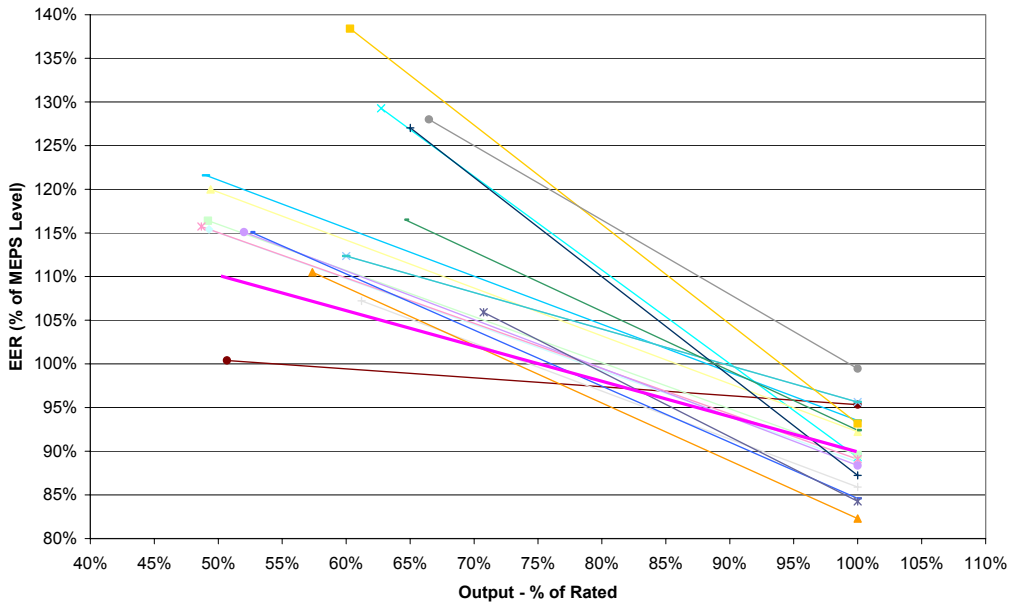
Part Load Options (Option 4)

These options examines the possibility of setting a limit on the EER at rated output in combination with a requirement for an increase in EER at part load that is well above the MEPS level. These are only options to stimulate discussion.

The first example is where the product must exceed 90% of the MEPS EER at rated output together with a requirement to exceed the MEPS EER by at least 10% at 50% output. This can be developed as a conceptual MEPS line so that it could cover all part load conditions between 50% output and 100% output. This is illustrated as the pink line in Figure 3. The primary proposal is that both the rated output and part load output must lie above the line, but a variant could be that only one point need lie above the line. This variant is not favoured as it suffers from the same problem as the

current requirement – under some conditions the EER may be quite poor and this could not be controlled.

Figure 3 – Part Load Option – 90% EER at Rated Output, 110% EER at 50% Load



Conceptually, this purple line can be expressed as an equation as follows:

$y = -0.4x + 1.35$

where y = Measured EER as % MEPS EER, x = % rated output

The pink "inverter MEPS line" in this case would require cooling outputs below 75% to have an EER that exceeds the MEPS level while at outputs greater than 75% rated that the EER could be less than the MEPS level. Some industry analysts argue that many air conditioners spend much of their working hours at higher outputs, so some may regard this as rather too generous.

A similar and slightly more stringent proposal would be to set a limit of 95% of the MEPS EER at rated output together with a requirement to exceed the MEPS EER by at least 15% at 50% output.

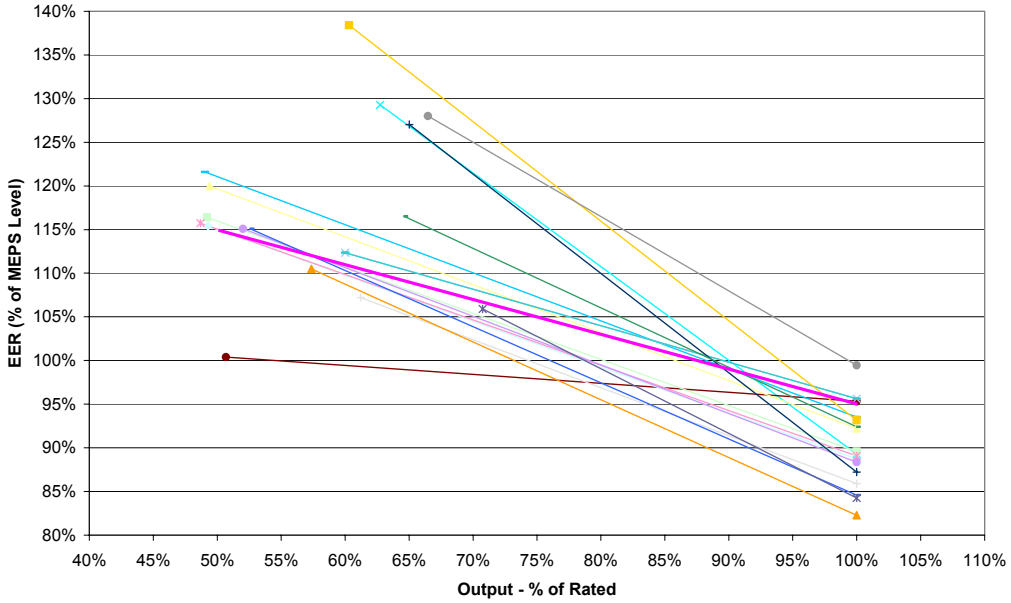
In this case the pink "inverter MEPS line" would require cooling outputs below 87.5% to have an EER that exceeds the MEPS level while at outputs greater than 87.5% rated that the EER could be less than the MEPS level. This could be argued to better meet the goal that the product exceeds the MEPS level over the majority of its operating range.

This more stringent option is illustrated in Figure 4. The equations for this requirement would be:

$y = -0.4x + 1.3$

where y = Measured EER as % MEPS EER, x = % rated output

Figure 4 - Part Load Option – 95% EER at Rated Output, 115% EER at 50% Load



For the part load option 90% MEPS at rated and 110% MEPS at 50% (pro rata), a total of 7 of the current 18 approved models would meet the requirement (assuming products have to meet the requirements under both conditions).

For the part load option 95% MEPS at rated and 115% MEPS at 50% (pro rata), a total of 3 of the current 18 models would meet the requirement.

Next Steps

This discussion paper will be circulated to EL15/16 for consideration together with key industry associations such as AEEMA, CESA, AIRAH and AREEMA. It is hoped that a consensus proposal to address this issue be developed quickly, which a view to amending the standard as soon as possible to bring this requirement into affect. The Australian Greenhouse Office will convene a working group to prepare a detailed proposal for government consideration.

It is proposed that any new requirement contained in an amendment would apply on publication. Discussion with industry would determine what transition arrangements would apply (whether current approved models that do not meet the new requirements would expire at a specified date or whether they would continue into the future until the next regulatory change – for example the new energy label in 2009 or new future MEPS levels).

Appendix – Detailed Data

Total Air Conditioners *	8478	100%
Approved	2942	35%
Grandfathered	2722	32%
Cancelled	2814	33%
Single Phase *	7180	85% (of total ac's)
Approved	1745	24%
Grandfathered	2718	39%
Cancelled	2717	38%
Three Phase *	1297	15% (of total ac's)
Approved	1197	92%
Grandfathered	3	0.2%
Cancelled	97	7%
Inverter *	849	10% (of total ac's)
Approved	599	71%
Grandfathered	226	26%
Cancelled	24	3%
Inverter Single Phase *	830	98% (of total inverters)
Approved	580	70%
Grandfathered	226	27%
Cancelled	24	3%
Inverter Three Phase *	19	2% (of total inverters)
Approved	19	100%
Grandfathered	0	0%
Cancelled	0	0%
Inverter part load MEPS *	44	5% (of total inverters)
Approved	26	59%
Grandfathered	14	32%
Cancelled	4	9%

Note: * Includes all units ever registered for energy labelling and/or MEPS

Note all units in the below table are approved registrations and single split system reverse cycle units.

Approved Models Registered using Part Load to Demonstrate MEPS Compliance

Brand	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
Config1	ND	ND	D	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Rated EER	2.5	3.049	2.379	2.806	2.865	2.938	2.667	2.817	3.51	2.155	2.574	2.667	2.711	2.504	2.556	2.931	2.463	2.674
Rated Input	3.20	0.82	2.90	2.53	1.92	1.94	2.55	2.52	1.80	1.16	1.360	2.55	1.66	1.35	0.99	1.74	2.72	1.87
Rated Output	8	2.5	6.9	7.1	5.5	5.7	6.8	7.1	4.7	2.5	3.5	6.8	4.5	3.38	2.53	5.1	6.7	5
Tested EER	2.456	2.908	2.338	2.707	2.732	2.813	2.63	2.717	2.695	2.62	2.58	2.63	2.562	2.51	2.57	2.735	2.399	2.541
Tested Input	3.214	1.75	2.894	2.585	1.981	2.002	2.481	2.544	1.812	1.160	1.360	2.481	1.678	1.35	0.983	1.79	2.670	1.895
Tested Output	7.889	2.468	6.767	6.998	5.412	5.632	6.529	6.912	4.884	2.5	3.500	6.529	4.322	3.382	2.530	4.895	6.405	4.815
MEPS Year	2007	2007	2007	2007	2007	2007	2006	2007	2007	2006	2006	2006	2006	2006	2006	2006	2006	2006
MEPS Level	2.75	3.05	2.5	3.05	3.05	3.05	2.75	3.05	3.05	3.05	3.05	2.75	2.75	3.05	3.05	2.75	2.75	2.75
Tested EER/MEPS Level (%)	89%	95%	94%	89%	90%	92%	96%	89%	88%	86%	85%	96%	93%	82%	84%	99%	87%	92%
Declared Part Load %	62.7	50	50	50	50	50	60	50	50	50	50	60	50	57	71	70	70	70
Calculated Part Load %	63%	51%	49%	49%	49%	49%	60%	49%	52%	61%	53%	60%	60%	57%	71%	66%	65%	65%
PL Tested EER	3.555	3.062	3.04	3.52	3.55	3.99	3.09	3.53	3.51	3.27	3.51	3.09	3.806	3.37	3.23	3.52	3.493	3.204
PL Tested Input	1.41	0.41	1.11	0.99	0.76	0.77	1.32	0.98	0.70	0.50	0.60	1.32	0.71	0.58	0.55	0.96	1.25	1.01
PL Tested Output	5.02	1.27	3.38	3.50	2.72	2.82	4.08	3.46	2.45	1.53	1.84	4.08	2.72	1.94	1.79	3.39	4.36	3.23
Tested EER PL/MEPS Level (%)	129%	100%	122%	115%	116%	120%	112%	116%	115%	107%	115%	112%	138%	110%	106%	128%	127%	117%

Legend
ND – Non Ducted
D – Ducted