
Minimum Energy Performance Standards for Air conditioners

Impact Assessment

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Prepared for
Energy Efficiency and Conservation Authority

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Contents

1	The context for regulation	1
1.1	Climate Change Policy	1
1.2	National Energy Efficiency and Conservation Strategy	1
1.3	Policy framework	2
1.4	Contribution of air conditioners to energy use and greenhouse emissions	3
1.5	Market failure	3
2	The objective	5
2.1	EECA’s airconditioner strategy	5
2.2	Objectives against which the proposed regulation is assessed	7
3	Options.....	8
3.1	The proposed regulation	8
3.2	The business as usual option	10
3.3	Option of a minimalist regulation	11
3.4	The leadership option	12
3.5	Less stringent options	13
3.6	Option of reduced government role in regulation	13
3.7	Option of using alternative instruments	14
3.8	Conclusion	14
4	Impacts analysis	15
4.1	Impact on energy use and greenhouse emissions	15
4.2	Impact on users	16
4.3	Impact on government	21
4.4	Impact on suppliers	21
4.5	National costs and benefits	22
4.6	Assessment of more demanding options	23
5	Conclusion and recommended option.....	24
5.1	Assessment against objectives	24
5.2	Recommendations	24
	References	26
	Appendices	
Appendix 1:	Technical background & tabulation of MEP Sproposals.....	28
Appendix 2:	Cost benefit assumptions.....	30
Appendix 3:	US estimates of the efficiency-cost relationship	36

Tables

Table 1.1: Energy use and greenhouse emissions: 1990-2010 3
Table 3.1 ‘On-trend’ sales of air conditioners in 2002 – rates of non-compliance with the 2007 MEPS..... 12
Table 4.1 Benefit-cost analysis of 2007 MEPS on non-complying air conditioners..... 17
Table 5.1 Assessment summary 25

Figures

Figure 3.1 Preliminary MEPS for single-phase and three-phase units 8
Figure 3.2 Minimum EER = 3.05 (Non-ducted, single-phase split units with capacity up to 4 kW, plus three-phase units with capacity 19-39kW) 9
Figure 3.3 Minimum EER = 2.75 (All other air-cooled units except ducted single-phase units) 9
Figure 3.4 Minimum EER = 2.50 (Ducted single-phase units) 9
Figure 4.1: Profile of energy savings and greenhouse reductions 16

Abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
ABCB	Australian Building Codes Board
AGO	Australian Greenhouse Office
AREMA	Australian Refrigeration Equipment Manufacturers Association
AS/NZS	Australian Standard/New Zealand Standard
BAU	business as usual
CCO	Climate Change Office
COP	coefficient of performance
CPI	consumer price index
DoE	(US) Department of Energy
EER	energy efficiency ratio
EES	Energy Efficient Strategies Pty Ltd
E2G2	Working Group for Energy Efficiency and Greenhouse Gas
GWA	George Wilkenfeld and Associates
HVAC	heating, ventilation and air conditioning
LBNL	Lawrence Berkeley National Laboratories
MCE	Ministerial Council on Energy
MED	Ministry for Economic Development
MEPS	minimum energy performance standards
MT CO ₂ -e	Mega tonnes of greenhouse emissions, measured as equivalent units of carbon dioxide
NATA	National Analytical Testing Authority
PV	present value
MEPS	Minimum Energy Performance Standards
MCE	Ministerial Council on Energy
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NPV	net present value
RIS	regulatory impact statement
UNSW	University of New South Wales

Executive summary

This is a regulatory impact statement for proposed changes to minimum energy performance standards (MEPS) for air conditioners falling within the scope of the joint Australian New Zealand Standard AS/NZS 3823. These are air conditioners of the refrigerative type with a cooling capacity of up to 65kW. They may be configured for cooling only or with a reverse cycle capability to provide both cooling and heating services.

The problem

The proposal is an element of the National Energy Efficiency and Conservation Strategy (NEECS). NEECS is part of New Zealand's Climate Change Policy, targeting the energy efficiency of consumer appliances, industrial and commercial equipment.

The air conditioners targeted by the regulation contribute about 0.6% of New Zealand's emissions of greenhouse gases, and are projected to remain at that level under business-as-usual conditions.

The objective

The Energy Efficiency and Conservation Authority (EECA) is responsible for implementing NEECS, coordinating its activities with Australia via the joint Australia/New Zealand National Appliance and Equipment Energy Efficiency Committee (NAEEEC). The proposal would substantially complete EECA's strategy for air conditioners, which includes energy labeling and information activities, alignment with international test procedures, and preliminary MEPS that have applied to three-phase air conditioners since 2001.

NAEEEC has followed a policy of adopting 'world's best regulatory practice'. This involves setting MEPS at levels broadly comparable with the most demanding MEPS adopted by Australia and New Zealand's trading partners, but following that lead with a lag of several years. Given New Zealand's status as a large net importer of electrical appliances and equipment, it is considered inappropriate to take the lead or to otherwise adopt standards that put New Zealand significantly at odds with its trading partners. Taiwan and the US have provided the lead for air conditioners.

The proposal

An interim MEPS for the cooling performance of three phase air conditioners came in to force in July 2002. Initially it is proposed to mandate an interim MEPS level for the cooling performance of single phase air conditioners in October 2004. In 2007 the MEPS levels for the cooling performance of both three phase and single phase units will be raised to the level of world's best regulatory practice defined as discussed above.

Currently sales of air conditioners that would not comply with the 2007 MEPS account for about 76% of total sales, as measured by the total cooling capacity. These will need to be withdrawn from the market. Overall, the replacement models will be about 16% more efficient.

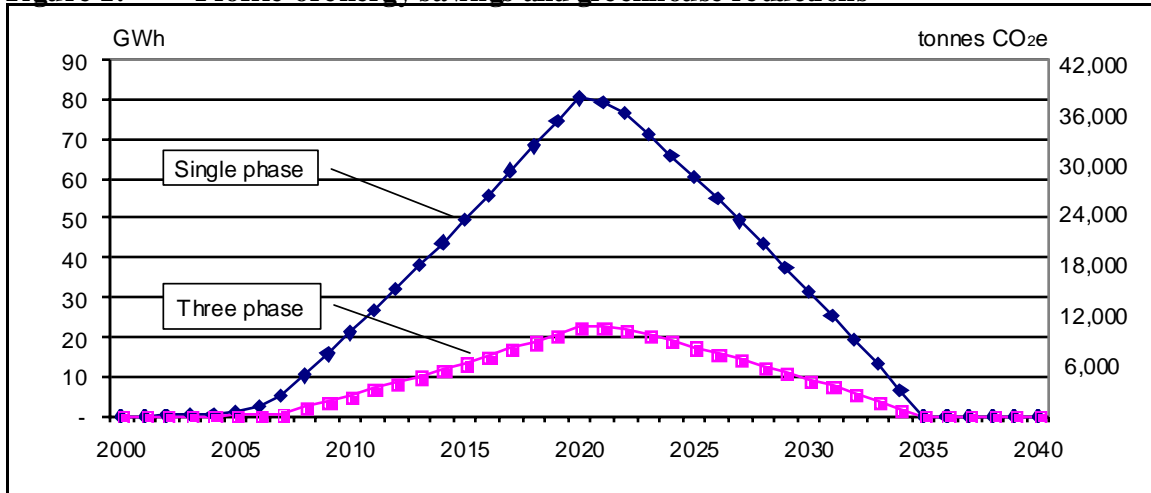
Figure 1 indicates the expected reductions in energy use and greenhouse emissions through to 2035, on the assumption that the regulation does not affect efficiency levels of air conditioners sold after 2020. The energy use and greenhouse emissions of non complying air conditioners would be reduced by 3.2% in 2010 and by 10.4% in 2020. This allows for a steady improvement in energy efficiency under business-as-usual conditions, at 0.4% per year.

Assessment

Nationally, the proposed regulation is conservatively estimated to deliver net benefits of \$29 million in present value terms and a benefit/cost ratio of 2.2. A significant investment is required from users, costed at \$25 million in present value terms. The adjustment costs incurred by suppliers are expected to be minimal, that is, in addition to the costs that will be

incurred to accommodate the same regulations in the Australian market. The additional cost to government is virtually zero, since the effect of the regulation is to strengthen a MEPS and labelling regime that is already in place.

Figure 1: Profile of energy savings and greenhouse reductions



The balance of benefits and costs to users is variable, depending on the types and size of air conditioners that they use, and the intensity of use. For example, the returns are markedly lower in the residential sector than in the commercial sector (but still positive), due mainly to the shorter hours of operation in the former.

The overall assessment depends critically on the relationship between the percentage increase in efficiency and the percentage increase in the cost of air conditioners that deliver those improvements. The report draws on a number of US studies to assess this tradeoff and uses a particularly conservative assessment.

Other options

Minimum levels of energy efficiency could be further increased. However New Zealand would then be setting the pace for the rest of the world and the inherent risks are unacceptable. In particular, the empirical basis for assessing further increases is minimal; there would be strong supplier resistance; and significant gaps would appear in the range of products that are available to New Zealand. New Zealand is a small market, and there is no prospect that new models would be developed to meet specific New Zealand requirements.

Recommendations

It is recommended that New Zealand implement the proposed mandatory minimum energy performance standards for cooling performance of air conditioners.

Heating performance

As noted in 3.9 of AS/NZS3823:2:2003 “Minimum coefficient of performance of heat pumps at low ambient temperatures is under consideration by the regulatory authorities.”

1 The context for regulation

This impact statement addresses a proposal to increase the minimum energy efficiency requirements of certain air conditioners supplied in New Zealand. The proposal is part of the National Energy Efficiency and Conservation Strategy (NEECS). In turn, NEECS is part of the Government's policy package on climate change. This section explains the policy context.

1.1 Climate Change Policy

New Zealand ratified the Kyoto Protocol on 19 December 2002 and will need to limit greenhouse gas emissions to 1990 levels during the first commitment period, which is 2008 to 2012. This is a significant undertaking. The principal growth in greenhouse gas emissions comes from increased CO₂ emissions, primarily from the energy sector, and particularly from electricity generation and transport. Overall emissions from the energy sector have grown by almost 30% relative to its CO₂ emissions in 1990.

In October 2002 the Government confirmed a set of policies for meeting New Zealand's obligations under the Kyoto Protocol. They include a number of policies other than NEECS, as follows:

- *Greenhouse emission charge:* This charge will be applied to fossil fuels and industrial process emissions after 2007.
- *Negotiated Greenhouse Agreements:* These are contractual commitments by the firm or industry to achieve international best practice in managing emissions, in return for exemption from all or part of the emissions charge. They are available to sectors that would otherwise suffer a loss of competitiveness as a result of climate change policies.
- *Projects to Reduce Emissions:* This is an incentives program to reduce emissions relative to business as usual (BAU) outcomes.
- *Voluntary arrangements:* Voluntary arrangements are proposed for local government and to reduce emissions of certain synthetic gasses.
- *Sectoral strategies:* Climate change will be a factor in implementing New Zealand's Transport Strategy and Waste Strategy
- *Research, awareness and international partnerships*

1.2 National Energy Efficiency and Conservation Strategy

NEECS is one of the foundation policies in the Government's climate change package. It was formulated in 2001, following the passage of the Energy Efficiency and Conservation Act in 2000. The Act established the Energy Efficiency and Conservation Authority (EECA) as the principal body responsible for implementing NEECS

NEECS sets the following specific targets for 2012:

- a 20% improvement in energy efficiency
- an increase in the use of renewable energy, from 23% to 42%.

The Strategy contains numerous initiatives targeting five sectors: government, energy supply, industry, buildings and appliances, and transport. These are largely voluntary measures but supported by certain mandatory requirements for the energy efficiency labelling and minimum energy efficiency performance. Currently the regime of minimum energy performance standards (MEPS) covers the following product classes:

- domestic electric storage water heaters

- domestic refrigerators and freezers
- fluorescent lamps
- fluorescent lamp ballasts
- packaged air conditioners
- three-phase cage induction motors

MEPS are implemented by invoking the relevant Australian/New Zealand Standards (AS/NZS) for the specific product type. In the present case, the proposed regulation will invoke AS/NZS3823.2, *Performance of household electrical appliances – air conditioners and heat pumps*.

1.3 Policy framework

New Zealand MEPS are developed in consultation with the National Appliance and Equipment Energy Efficiency Committee (NAEEEC), which comprises officials from Australian and New Zealand agencies with responsibility for implementing product energy efficiency initiatives in the various jurisdictions.

NAEEEC's broad policy directions were reviewed in 1998-99 and again in 2000-01, with recommendations brought together in two 'Future Directions' documents (NAEEEC 1999 & 2001). Certain changes were subsequently endorsed at a ministerial level¹. These relate to product coverage, communication, and procedures and timetable.

Product coverage

Any type of consumer appliance, industrial or commercial equipment is eligible for regulation, provided it is identified as a likely contributor to growth in energy demand or greenhouse gas emissions. The selection criteria include potential for greenhouse or energy savings, environmental impact of the fuel type, opportunity to influence purchase, market barriers, access to testing facilities, and administrative complexity.

Communication

Product strategies are developed through a transparent planning process, including by providing stakeholders with formal opportunities for providing comment and feedback.

Procedures and timetable

In respect of any proposal to implement MEPS, a significant initiative in recent years has been the decision to match the best MEPS level of Australia and New Zealand's trading partners, after taking account of differences in test methods and other relevant differences such as climate or consumer preferences. The explicit adoption of 'world's best regulatory practice' focuses attention on specific options, provides stakeholders with confidence that proposed MEPS are technically feasible, and thereby avoids the long and many-sided debates that have characterised the development process in the past.

All of the regulatory requirements are implemented via the standards machinery that is familiar to industry, including not only the required efficiency benchmarks, but also related labelling, testing and registration requirements. On occasion, this has required the development of a new standard, for example, to harmonise New Zealand testing standards with testing procedures commonly used by trading partners.

NAEEEC has also adopted a legislative timetable, designed to implement any proposed MEPS within 3 to 5 years, giving industry adequate notice of new MEPS and some certainty about the process.

¹ NAEEEC reports through the Working Group for Energy Efficiency and Greenhouse Gas to the Ministerial Council on Energy (MCE), which is made up of the Ministers with portfolio responsibility for implementation of greenhouse strategies in this field. New Zealand has observer status on MCE.

1.4 Contribution of air conditioners to energy use and greenhouse emissions

Table 1.1 provides estimates of the energy use and related greenhouse emissions for air conditioners. Note the following:

- Appendix 2 provides a detailed explanation of how the stock of air conditioners has been estimated, and critical assumptions relating to asset lives and operating characteristics. The uncertainties are such that the estimates provided in table 1.1 must be regarded as indicative.
- The estimate of associated greenhouse emissions assumes that marginal units of electricity generate emissions at the rate of .6 tonnes per MWh. This is the figure recommended to the Climate Change Office (CCO) by Concept Consulting Group (CCG 2003), for the purposes of assessing the emissions reductions achieved by projects that reduce the demand for grid-purchased electricity.

Despite the uncertainties, it is apparent that there will be rapid growth of the greenhouse emissions that can be attributed to air conditioners, to the point where emissions in 2010 will be at least 50% higher than in 1990.

TABLE 1.1: ENERGY USE AND GREENHOUSE EMISSIONS: 1990-2010

	Energy consumption (MWh)	Greenhouse emissions		
		MT CO ₂ e	% of total emissions	% of 1990 level
1990	535,713	321,428	0.5%	100%
2000	672,495	403,497	0.6%	126%
2010	844,200	506,520	0.6%	158%

1.5 Market failure

Evidence of market failure (and the implicit scope for cost-effective reductions in greenhouse emissions) is strongly suggested by market observations such as the following:

- There are large gaps between the energy efficiency of the least efficient and the most efficient appliances on the market. Variations of 20-30% are readily observed in the New Zealand market, even putting aside the extremes of high and low efficiency. Even more energy efficient product is available overseas.
- There is expert evidence that the energy efficiency of many air conditioners could be considerably improved at little or no cost to suppliers and hence consumers.
- Marketing sources report that energy efficiency is often not a primary or even a significant consideration in consumer purchases. The apparent lack of concern is at odds with the fact that energy costs contribute significantly to the 'whole of life' costs of using an appliance. Depending on operating characteristics, energy costs may account for 60% of the 'whole of life' costs.
- The cost effectiveness of regulatory measures to promote energy efficiency has been demonstrated across a range of appliances and equipment in a many countries, including for air conditioners.

The continued commercial success of inefficient appliances can be traced to the fact that reliable information about the value of investments in energy efficiency is unavailable or expensive to obtain. Furthermore, most people have a poor understanding of the contributions of different appliances to their total energy bill. They are therefore not well placed to assess investments in energy efficiency.

Even where the appliance or equipment selection is effectively delegated to experts – for example, to the building designers who specify the HVAC equipment – those experts are not systematically

rewarded for energy efficient designs if the ultimate users (owners and renters) fail to appreciate the value of the investment. The perverse result is that small savings in capital costs may be preferred to large savings in energy costs.

2 The objective

This section explains the objectives of the regulations, firstly in terms of completing EECA's strategy for air conditioners, and secondly in terms of the formal objectives against which the proposal is assessed in this report.

2.1 EECA's airconditioner strategy

The proposed regulations will substantially complete EECA's package of airconditioner measures. The following elements of the strategy have already been implemented through successive amendments to Australian and New Zealand Standard AS/NZS 3823:

- EECA's energy efficiency labelling scheme (the 'star' scheme) is mandatory for residential air conditioners taking single-phase power.
- Suppliers of three-phase units have had the option of labelling since October 2001. However all of the conditions apply if that option is taken, including the requirement for product testing. Marketing laws cover instances where suppliers inadvertently or intentionally label inaccurately.
- The regulation of performance standards for air conditioners commenced in October 2001, starting with the cooling performance of air conditioners taking three-phase supply. This work was completed under the previous policy regime, that is, prior to the MCE decision to accelerate the development process by focusing on world's best regulatory practice.
- AS/NZS3823 also requires:
 - all statements about cooling and heating capacity, energy consumption and energy efficiency to be consistent;
 - the values to be determined under the test conditions specified in Part 1;
 - products to meet requirements of the maximum cooling test in Part 1;
 - products to be registered with a State or Territory energy agency;
 - statements about cooling and heating capacity, energy consumption and energy efficiency to be subject to check testing using the procedure specified in Part 2.
- New Zealand test standards have been aligned with overseas testing procedures – specifically, ISO151:1994 and ISO1325.3:1995. This will avoid the costs of duplicate tests, since many supplier countries also have testing requirements as part of their MEPS arrangements.

Outside the Standards process, EECA also works in partnership with stakeholder groups to introduce programs that encourage market transformation by promoting highly efficient equipment.

Development of new measures to complete the strategy

The proposed new regulation implements the following final elements of an overall strategy that will see the industry through to 2012, again via amendments to AS/NZS 3823:

- It will extend MEPS preliminary coverage to single-phase air conditioners from October 2004.
- It provides for cooling MEPS levels for both single-phase and three-phase air conditioners to be increased to reflect world's best practice for air conditioners from October 2007.
- The new Standard includes the definition of 'high efficiency' (Class A) three phase air conditioners for the first time.
- The registration testing requirements have been reduced, reducing business costs.

To determine the proposed MEPS, NAEEEC has followed the MCE policy directive to explore levels that are commensurate with MEPS adopted by Australia and New Zealand's trading partners. By contrast, the 2001 MEPS were completed using a market regression analysis because

negotiations were well advanced when MCE made the policy change. The aim of the 2001 MEPS was to retire 40% of the models available on the market at a set time. This regulatory proposal moves away from that analysis of the domestic marketplace to use international developments as the driver for regulatory proposals. Given New Zealand's status as a large net importer of electrical appliances and equipment, it would be excessively costly to adopt standards that put New Zealand significantly at odds with major trading partners.

Accordingly, NAEEEC described the development of the proposals as follows.

NAEEEC commissioned consultants to examine international developments. ... The results were tested with key representatives from industry and other stakeholder groups and the outcome of this process is reported in this public profile.

In general, USA MEPS being implemented in 2003/4 were considered the basis for MEPS proposed for Australia for three-phase air conditioners while the Taiwanese MEPS levels implemented in 2001 were considered the basis for MEPS proposed for Australia for single-phase air conditioners. These were chosen after detailed comparison of testing methods and comparison with Australian products showed they were the most stringent currently or proposed by the major trading partners. Although Japan has proposed more stringent levels for certain sizes of single-phase air conditioners, they are based on a sales weighted average efficiency and not directly translatable to Australian conditions. They do, however, establish that more efficient product will be readily available. (NAEEEC 2002)

Given an appropriate lead from a trading partner, the strategy is to match international best practice within a few years of the leading country. Note the meaning of 'best practice' in this context. It is best practice in terms of regulation, eliminating the least efficient models, not best practice in terms of leading the process of technological development. However, in instances where New Zealand matches regulation in some countries like the USA or Japan, it will in effect require MEPS levels that match best available technology because that is the legislative mandate in those countries.

The selection of a leading country for three-phase air conditioners is straightforward, since the USA is the only major trading partner to adopt MEPS for the larger (commercial) air conditioners. In broad terms, NAEEEC's proposal for July 2007 is to adopt MEPS levels that will apply in the USA from October 2003 for smaller commercial units and from October 2004 for larger commercial units. The outcome of adopting the USA levels is that about 75% of models on the market in 2003 would not be able to be reregistered in 2007.

A number of New Zealand's trading partners have adopted MEPS or MEPS-like arrangements for single-phase air conditioners. NAEEEC's consultants (EnergyConsult 2002) provided comparisons for existing MEPS in the USA, Chinese Taipei, Japan, Korea and China. The most stringent of these, Chinese Taipei (Taiwan), provides the lead for the proposed regulation. The outcome of adopting the Chinese Taipei levels is that about 8% of the models on the market in 2003 would not be able to be registered in 2004 and 90% of models on the market in 2003 would not be able to be reregistered in 2007.

A further element of the new regulation is to require three-phase appliances designated as *high efficiency* to comply with specific efficiency requirements that are set higher than the mandatory requirements that apply to all appliances. This is a form of energy labelling, designed to ensure that the designation of *high efficiency* retains a well-defined meaning for users and is not diluted to the point where any unit that is marginally better than the MEPS can be marketed as highly efficient.

The high efficiency category also has a role in signalling NAEEEC's intentions beyond 2007, which it does in two ways:

- First, NAEEEC has indicated to industry that, after 2007, there would be no further increases in MEPS until at least 2012, allowing time to recoup costs.
- Second, NAEEEC commits to industry that any future MEPS commencing not earlier than 2012 would not exceed the standard for high efficiency three phase appliances applicable

from 2007. Industry has a clear view of the regulatory timetable for developments well into the next decade.

In respect of single-phase air conditioners, NAEEEC proposes to reduce the requirement for physical testing of each registration to only one unit. Currently, physical tests need to be carried out on three units for each registration. This system brings single-phase registration more into line with three-phase registrations where suppliers declare the efficiency of units without necessarily supplying any supporting data at the time of registration.

Heating performance

As noted in 3.9 of AS/NZS3823:2:2003 “Minimum coefficient of performance of heat pumps at low ambient temperatures is under consideration by the regulatory authorities.”

2.2 Objectives against which the proposed regulation is assessed

The objective of the proposed regulation is to reduce New Zealand’s greenhouse gas emissions from the use of air conditioners, subject to the following constraints:

- The measures need to be cost-effective for the broad community of users of air conditioners.
- The measures need to be efficiently designed, minimising adverse impacts on manufacturers and suppliers, and minimising adverse impacts on product quality and function.
- The measures need to be clear and comprehensive, minimising potential for confusion or ambiguity for users and suppliers.

Cost-effectiveness is interpreted in terms of the interests of the broad community of users.

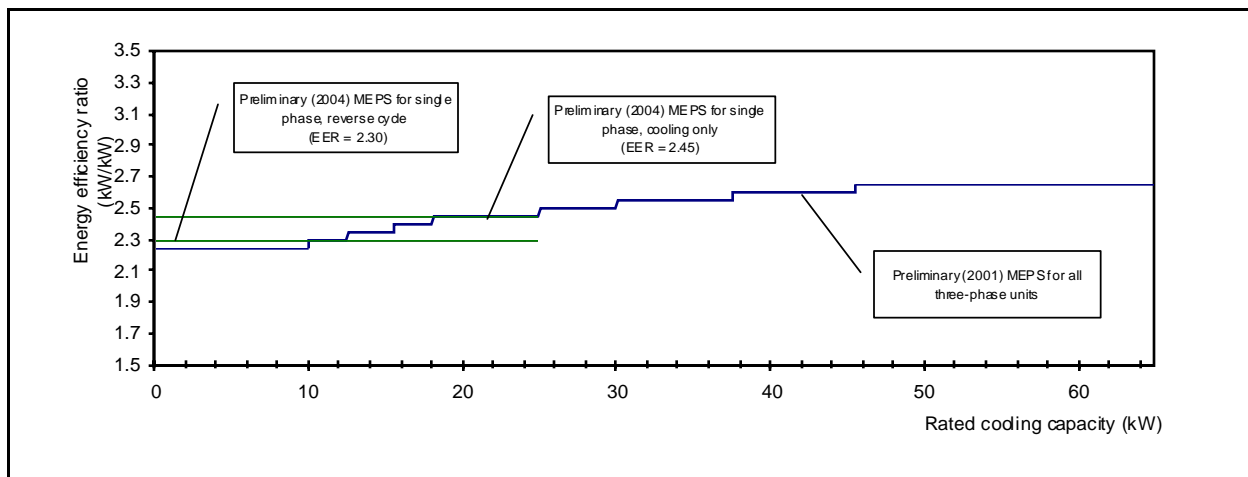
3 Options

EECA's options for finalising the air conditioner strategy are explained here under seven headings. The first two deal with the options of either implementing the proposed regulation or maintaining the existing regulatory position. The remainder deal a series of options that depart from the proposal in some significant respect.

3.1 The proposed regulation

The preliminary MEPS are shown in figure 3.1. Note the stepped nature of the MEPS for three-phase units, imposing higher efficiency requirements on the larger units. Also, the single-phase MEPS are set higher for cooling only models than for reverse cycle models. (It seems more logical to present this information in the order it will be implemented)

FIGURE 3.1 PRELIMINARY MEPS FOR SINGLE-PHASE AND THREE-PHASE UNITS



The minimum EER to be achieved by air conditioners in 2007 depends on certain characteristics of the air conditioning unit. There are four groups, as follows. (See appendix 1 for an explanation of the technical background and related terminology.)

- *Minimum EER = 3.50*: The most demanding requirements are imposed on water-cooled units, reflecting the more efficient transfer of heat to water than to air. However, of the approximately 2,200 models currently registered with the AGO, only 5 are water-cooled. New Zealand suppliers reported no such sales to EECA, although those records are known to be incomplete.
- *Minimum EER = 3.05*: The next most demanding requirement is imposed on two sub-groups. The first comprises smaller (4kW or less) single-phase split units, provided they are non-ducted. The second comprises three-phase units with output capacity in the range 19-39kW. See figure 3.2 for a scatter diagram showing the efficiency characteristics of units reported to EECA.
- *Minimum EER = 2.75*: Subject to a following qualification regarding single-phase ducted units, all of the remaining units must satisfy a general requirement for a minimum EER of 2.75. See figure 3.3 for the matching scatter diagram.
- *Minimum EER = 2.50*: The lower requirement that is imposed on single-phase ducted units is actually equivalent to an EER of 2.75, but adjusted to allow for recent modifications to test procedures that reduce the measured efficiency by about 10%. The modifications have been made to bring New Zealand testing arrangements into line with international testing procedures. See figure 3.2 for the scatter diagram.

FIGURE 3.2 MINIMUM EER = 3.05 (NON-DUCTED, SINGLE-PHASE SPLIT UNITS WITH CAPACITY UP TO 4 kW, PLUS THREE-PHASE UNITS WITH CAPACITY 19-39kW)

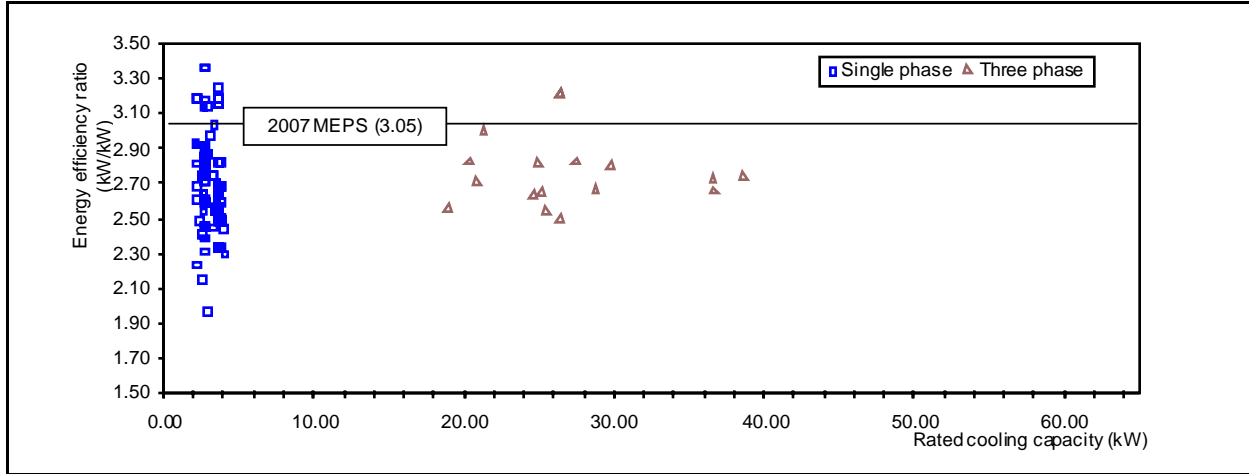


FIGURE 3.3 MINIMUM EER = 2.75 (ALL OTHER AIR-COOLED UNITS EXCEPT DUCTED SINGLE-PHASE UNITS)

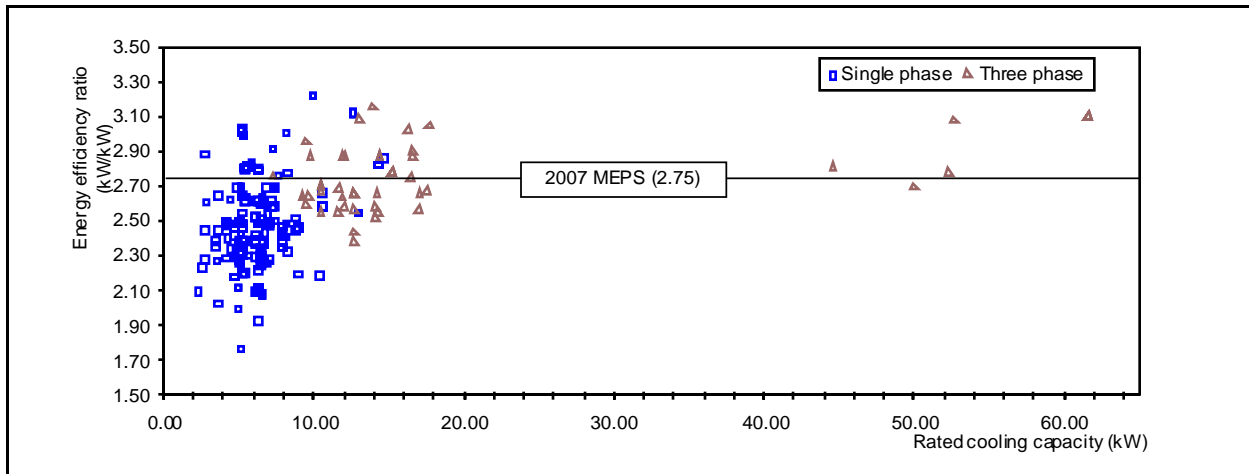
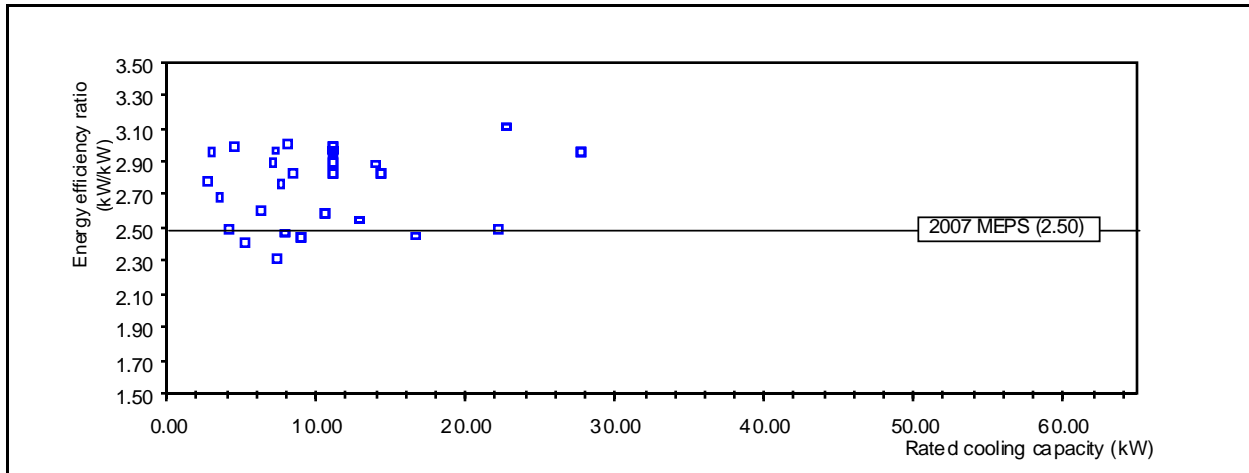


FIGURE 3.4 MINIMUM EER = 2.50 (DUCTED SINGLE-PHASE UNITS)



It is apparent from figures 3.2-3.4 that the single-phase models have a longer tail of low efficiency models relative to the 2007 MEPS, compared with three-phase units. The difference is particularly marked for the larger three-phase units – see figure 3.3. This is because the least efficient three-phase units have already been eliminated by the preliminary MEPS introduced in 2001.

Table 3.1 reports estimates of current rates of non-compliance with the 2007 MEPS, with sales measured in terms of the total cooling capacity of the units sold. The concept of the ‘on-trend’ sales in 2002 is explained in appendix 2. Note the following about table 3.1.

- The table relates to air-cooled models only, since no sales of water-cooled models were reported to EECA. However, all water-cooled models registered with the AGO comply with the 2007 MEPS. The regulation will therefore have little or no impact on Australian sales and similar outcome is expected in New Zealand.
- Three-phase models that would not comply with the preliminary 2001 MEPS have been excluded from table 3.1. The table therefore describes the impact of new regulation, putting aside the impact of the earlier regulation.
- Overall, about three-quarters of the cooling capacity sold would not comply. The figure is slightly higher for single-phase reverse cycle units and somewhat lower for three-phase units. Only the single-phase cooling-only units, which are a small minority, have a significantly higher rate of non-compliance, at about 84%.
- These overall averages hide considerable variation. Ducted units return very low rates of non-compliance, with returns of zero non-compliance for some size ranges. Non-compliance is at or close to 100% for other categories – specifically, all wall/window units and the categories required to achieve the higher EER of 3.05.

The impact will be moderated by the normal processes of efficiency improvement in the period to 2007, including the flow-on from the response of Australian suppliers to the parallel introduction of these MEPS. Several suppliers to the New Zealand market noted that these effects are already apparent from recent changes to the models that are being made available to the New Zealand market.

3.2 The business as usual option

The proposed regulation is effectively defined by figures 3.2-3.4 and table 3.1. However this is only one of the options to be considered. One alternative to that is to maintain the existing regulatory position. This is the *status quo* or business as usual (BAU) option. This option would preserve the elements of the air conditioner strategy that are already in place but the proposals to expand coverage and increase stringency would not occur. Specifically, the efficiency of three-phase air conditioners would continue to be constrained by the 2001 MEPS, with the minimum levels of efficiency increasing with the size of the unit. Most of the smaller air conditioners, being single-phase, would not be required to achieve a minimum level of efficiency.

The outlook is not one of zero efficiency gain under the BAU option. Long term trend increases in the energy efficiency of air conditioners have been documented in US studies (DoE 1997). In an earlier Australian RIS (GWA 2000) it was assumed that the heating and cooling requirements of buildings would decrease at 0.25% per year due to the combined effect of better designed buildings and gains in the energy efficiency of air conditioning equipment. In earlier projections of Australian residential energy demand, EES (EES 1999) put the projected efficiency gains for various types at air conditioners in the range 0.2-0.5% per year. For the purposes of assessing the impact of the proposal relative to the BAU scenario, it has been assumed in this RIS that product energy efficiency improves at 0.4% per year under BAU conditions.

Over time, BAU improvements have implications for the continued impact of EECA’s energy efficiency strategies. Given sufficient time, for example, the star ratings used in energy labelling schemes would no longer reflect the range of available product; they would all be 6-star. And all air conditioners would eventually comply with the proposed MEPS through BAU efficiency gains. It

follows that energy efficiency strategies need periodic adjustment. Otherwise the capacity to drive efficiency gains faster than market delivered improvements is diluted over time.

3.3 Option of a minimalist regulation

The Australian/New Zealand Standard (AS/NZS 3823 series) contains a number of provisions other than the specific MEPS, but which support the MEPS. One option is to preserve the core of the proposed regulation, being the energy efficiency requirements, but to do without one or more of the supporting provisions. The aim would be to adopt a minimalist regulation.

The supporting provisions relate to the practicalities of testing registration and labelling – as follows:

- *Maximum cooling test:* The purpose of the maximum cooling test is to ensure that products are not engineered so as to obtain a high rating on the energy efficiency test at the cost of a reduction in maximum performance, which buyers will not be aware of until after purchase. It is considered that this offers important protection for consumers at a cost that is not excessive.
- *Registration:* The state regulatory authorities have opted to require registration of air conditioners falling within the scope of the AS/NZS 3823 series. The Standard specifies the form of application, including any test data that may be required.
- *Check testing procedure:* NAEDEC funds a check testing program for the purposes of monitoring and enforcement. The Standard specifies the number of units to be tested and the tolerances that will be allowed in test results.
- *Permanent marking:* The compliance plate that is fixed to every unit must include the additional information that the unit complies with the MEPS.
- *Performance simulation option for three-phase units:* Suppliers of three-phase air conditioners have the option of using a simulation test rather than a physical test, in recognition of certain constraints on the availability of suitable laboratory facilities in Australia and New Zealand.
- *Separate requirements for three-phase units designated as high efficiency:* It is proposed that three-phase models designated as *high efficiency* will need to achieve efficiency levels that are clearly higher than the mandatory MEPS. Specifically, three-phase units in the range 19-39 kW must achieve an EER of 3.65 to be designated as high efficiency, which is 0.6 greater than the mandatory requirement of 3.05. All other three-phase high efficiency units must achieve an EER of 3.35, which is 0.6 higher than the general requirement of 2.75.

Most of these are not practical options for the purposes of this RIS. For single-phase air conditioners, the maximum cooling test, registration and check testing procedures² are required for the purposes of the pre-existing labelling requirements and are part of the BAU option. The only new requirement is the need for a statement of MEPS compliance on the compliance plate. This is a negligible cost since the compliance plate itself is required under other regulations.

For three-phase air conditioners, all but the high efficiency measures are also part of the BAU scenario. They were introduced for the purposes of the 2001 MEPS and were assessed in the earlier RIS (GWA 2000). These supports were found to be highly cost efficient, particularly in terms of improving the information base, analytical and monitoring capacities of the regulatory authorities, and addressing the significant risks of non-compliance in the absence of these provisions. With the exception of the high efficiency requirements these options are not considered further in this RIS.

The high efficiency provisions are addressed but in the context of the 'leadership' option that follows.

² As noted in chapter 2, NAEDEC proposes to reduce the requirement for physical testing of each registration to only one unit. Currently, physical tests need to be carried out on three units for each registration of a single-phase model. This change brings single-phase registration more into line with three-phase registrations where suppliers declare the efficiency of units without necessarily supplying any supporting data at the time of registration.

TABLE 3.1 'ON-TREND' SALES OF AIR CONDITIONERS IN 2002 – RATES OF NON-COMPLIANCE WITH THE 2007 MEPS

Type and size (kW)	Sales (kW, cooling capacity)	Sales (% of grand total kW)	Non-complying sales (kW, cooling capacity)	Non-complying sales (% of category)
Single phase- cooling only				
Ducted, 0-4	71	0.05%	0	0.0%
Split, non-ducted, 0-4	216	0.15%	191	88.6%
4-8	364	0.26%	347	95.5%
Window/wall, 0-4	28	0.02%	28	100.0%
<i>Sub-total</i>	680	0.48%	567	83.5%
Single phase- reverse cycle				
Ducted, 0-4	241	0.2%	0	0.0%
4-8	6,150	4.4%	1,304	21.2%
8-12	4,354	3.1%	546	12.5%
12+	931	0.7%	0	0.0%
Split, non-ducted, 0-4	24,150	17.1%	23,233	96.2%
4-8	49,764	35.3%	38,456	77.3%
8-12	4,120	2.9%	3,831	93.0%
12+	1,444	1.0%	1,229	85.1%
Window/wall, 0-4	4,433	3.1%	4,433	100.0%
4-8	3,900	2.8%	3,900	100.0%
<i>Sub-total</i>	99,488	70.60%	76,932	77.3%
Three-phase				
0-19	24,602	17.5%	18,839	76.6%
19-39	7,777	5.5%	7,705	99.1%
39-65	8,375	5.9%	3,683	67.5%
<i>Sub-total</i>	40,753	28.9%	30,226	74.2%
Grand total	140,921	100.0%	107,725	76.4%

3.4 The leadership option

The MCE has adopted a policy of following world's best regulatory practice. An obvious alternative is for New Zealand to take the lead itself and set the pace for the rest of the world. It is convenient to pose this issue in terms of the appropriate status of air conditioners that would qualify as high efficiency units under the proposal. The proposal is not to require suppliers to deliver these levels of efficiency but simply to refrain from describing their products as highly efficient unless they do. The leadership option would be to raise the mandatory 2007 MEPS to the high efficiency level, or at least significantly higher than is proposed currently. While the higher standards have been defined only for three-phase units, similar high standards could be devised for single-phase models and adopted as MEPS. The further percentage increase in efficiency for three-phase air conditioners is about 20%. All but a handful of the air conditioner models that are currently available would fail to comply with such standards.

Weaker variations on this option would involve maintaining the policy of following world's best regulatory practice but to follow more closely. For example, the lag might be reduced by a year or two.

The general effect of either leading or following more closely is to raise the MEPS trajectory relative to what is proposed, affecting the stringency of the regulation. Since stringency is obviously a key dimension of the proposed regulation, this option is specifically addressed in chapter 4.

3.5 Less stringent options

Another alternative is to adopt a less demanding target than world's best regulatory practice. As discussed already, world's best practice was identified by NAEEEC's consultants (Energy Consult 2002), who provided comparisons for existing MEPS in the USA, Chinese Taipei, Japan, Korea and China. Two other countries were also considered but put aside due to differences in testing procedures that prevented direct comparison (Philippines) and lack of coverage (Singapore).

The first point to make about this comparison is that it provides a snapshot of an options menu that is not static. All of these countries are on rolling programs of increasing MEPS, but moving to different timetables. Over the longer term it will be seen that different countries take the lead at different times. Importantly, NAEEEC's strategy is *not* to follow each new leader as it emerges. Rather, NAEEEC plans to revise MEPS at periodic intervals, taking a lead that is appropriate at that time. In that way New Zealand joins the rolling program of increasing MEPS, moving closer to the front when MEPS are revised, but slipping back through the pack during intervening periods. Over the long haul the effect will be for New Zealand to broadly keep pace with its reference group. And it is this *group* that matters in terms of representing New Zealand's suppliers, not the particular country that happens to provide the lead from time to time.

The second point to make is the menu often offers very little choice. Typically, one or two MEPS are clearly outdated and are due for revision. For example, many of the Chinese MEPS were last revised in 1989 and one US MEPS was last revised in 1992. Other MEPS are future industry targets and are not appropriate models for Australia and New Zealand; the Japanese 'Top Runner' scheme takes this form. The result is that the differences between the practical options within the reference group members are not always significant, and certainly not in terms of the data that is available to discriminate between costs and benefits of those options. Generally the difference is less than 7%. At the present time the choice is usually between Korea, Chinese Taipei and the US. While Korea is less demanding just at present, its timetable for revisions may take it ahead of Chinese Taipei within the next year or two.

Overall it is not feasible to identify a less stringent targeting policy that is amenable to meaningful analysis. The options in respect of stringency are adequately addressed in terms of the appropriate lag between the lead country and New Zealand.

3.6 Option of reduced government role in regulation

The proposal is that the minimum energy efficiency of air conditioners be subject to explicit government regulation. That is one form of regulation. The Ministry of Economic Development (MED 1999) identifies a spectrum of regulatory approaches, with explicit government regulation at one end of the spectrum and self-regulation at the other. Intermediate forms of regulation (quasi-regulation and co-regulation) are also identified. The differences can be summarised as follows:

- Self-regulation requires that the industry has a viable industry association with broad coverage and that members are sufficiently 'of like mind' that they will voluntarily adhere to a code of conduct devised by the members. Minimal sanctions such as loss of membership or peer disapproval are all that is required to ensure broad compliance. The government role is reduced to facilitation and advice.
- Self-regulation merges into quasi-regulation, the latter distinguished by a stronger role for government in endorsing industry codes, providing technical guidance, or entering into government-in industry agreements.
- Co-regulation describes the further stage where government provides some form of legislative underpinning for industry codes and standards. This may involve delegating regulatory powers to industry, enforcement of undertakings to comply with codes, or providing a fall-back position of explicit regulation in the event that industry fails to self-regulate.

These options were addressed in the earlier New Zealand RIS and rejected. Accordingly, this RIS gives no further consideration to options for reducing the government role in the regulation of the energy efficiency of air conditioners.

3.7 Option of using alternative instruments

MED also identifies a number of alternative instruments that might be used instead of regulation. These include information and education campaigns; labelling requirements; taxes, subsidies and user charges; and tradable property rights.

The education and information options were assessed as inadequate in the earlier New Zealand RIS, in the following terms:

Public information campaign: This will be undertaken to promote the regulations and the advantages of purchasing energy efficient product. It is not seen as being sufficient alone to address the market failures identified above.

Hence the 'information and education' option is not given further consideration in this RIS.

Nor are options for the use of market based instruments given further consideration. These would include levies on the use of energy or on the use of inefficient equipment. These are broader issues for the highest level of government and would not be separately decided in relation to specific products such as motors. Further, the lack of consideration currently given by purchasers to the lifecycle costs of motor ownership (1.5 Market Failure) suggests that these options would be ineffective.

3.8 Conclusion

Based on the above analysis, three options require detailed consideration. First, there is the BAU option which would leave the air conditioner strategy to continue as present. The second option is the proposed MEPS. The final option is for New Zealand to follow the international lead more closely and possibly to take a leading role itself in setting MEPS.

4 Impacts analysis

This chapter is organised in 6 sections. The first four examine the difference between the proposed regulation and the BAU scenarios from a number of perspectives, as follows:

- Impact on energy use and greenhouse emissions – section 4.1
- Impact on users – section 4.2
- Impact on government – section 4.3
- Impact on suppliers – section 4.4

A national perspective is adopted in the next 2 sections, first to bring together the results of the first 4 sections in a single statement, then to assess various alternatives to the proposed regulation, as follows:

- National costs and benefits – section 4.5
- Assessment of more demanding options – section 4.6

Appendix 2 provides a detailed account of the assumptions that have been adopted for the impact analysis.

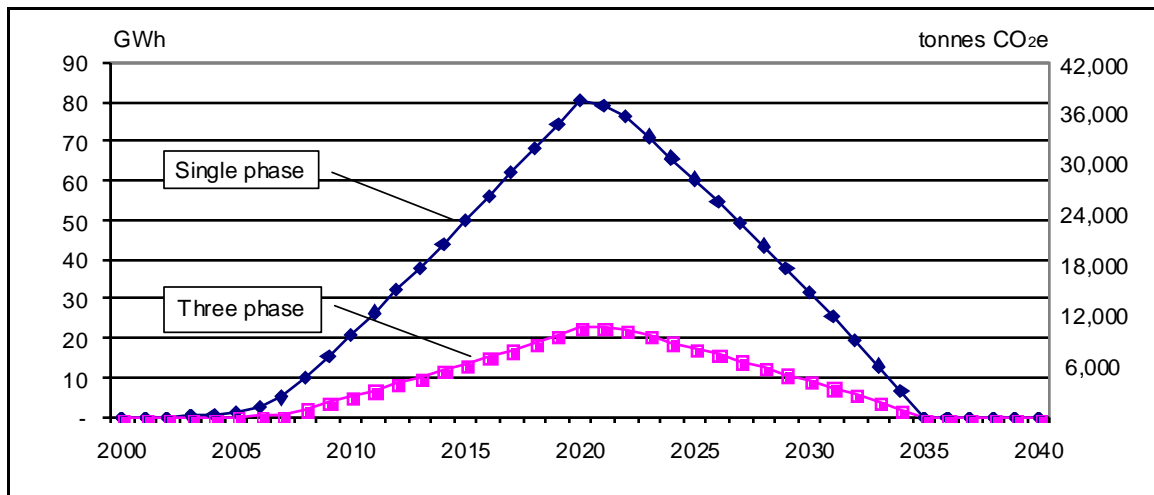
4.1 Impact on energy use and greenhouse emissions

Figure 4.1 reports estimates of the energy savings and reductions in greenhouse emissions generated by the proposed regulation, separately for single-phase and three-phase air conditioners. The time profile of the projections reflects the following assumptions:

- The proposed 2007 MEPS are implemented from October 2007 but assumed to become fully effective from October 2008, since suppliers are given one year to clear stock acquired before October 2007.
- The 2007 MEPS are assumed to terminate at least by 2020, in the sense that there would be a fresh decision about the level of MEPS at least by 2020. Beyond 2020, therefore, it is assumed that there is no addition to the stock of air conditioners that will be affected by decisions taken now.
- The stock of 2007 compliant air conditioners continues to deliver energy savings for the life of the last cohort of units that is installed in 2020. Assuming asset lives of 15 years, energy savings are delivered through to 2035.
- It is also assumed that suppliers anticipate the introduction of MEPS by starting to phase out non-compliant units in the period before the introduction of MEPS. In the case of single-phase air conditioners, the phase out is accelerated by the introduction of preliminary MEPS in 2004.

On these projections, energy use and greenhouse emissions in 2010 are reduced by 26.2 GWh and 15,700 tonnes CO₂-e respectively. The corresponding estimates for 2020 are 89.5 GWh and 53,700 tonnes CO₂-e respectively. In 2010, these savings represent 3.2% of the energy that would otherwise be used by the stock of air conditioners, and 0.12% of the energy used in the domestic and commercial sectors. The corresponding estimates for 2020 are 10.4% and 0.32% respectively.

FIGURE 4.1: PROFILE OF ENERGY SAVINGS AND GREENHOUSE REDUCTIONS



4.2 Impact on users

Table 4.1 presents estimates of costs and benefits to users, based on the following assumptions. Most assumptions are only briefly stated here, since appendix 2 provides a full account. The only exception is the estimates of the percentage cost increases, which are based on US estimates and are discussed in detail later in this section.

- It is assumed that the increase in efficiency, as measured by the EER, will be somewhat greater than that required to achieve borderline compliance with the 2007 MEPS but somewhat less than the average efficiency of units that already comply. The overall increase in efficiency is 16.3%, with most categories falling in the range 10-20%. The main exceptions are the larger non-complying wall/window units which must achieve an average increase of 30%.
- For reverse cycle units, it is assumed that the increases in the energy efficiency of the cooling cycle, which is directly regulated by the MEPS, are accompanied by equivalent improvements in the energy efficiency of the heating cycle. This assumption may not be totally accurate, but the assumption that the hours of use of reverse cycle machines are no longer than for cooling only machines (see below) is very conservative, as winter heating use is likely to increase total usage.
- The percentage cost increases have been put at 25% of the increase in efficiency. That is, a 10% increase in efficiency is at the cost of a 2.5% increase in cost. However, the cost increases relate to installed costs, with manufacturing costs contributing only 40% of the installed cost. That is, a 2.5% increase in installed cost may be equivalent to a 6% increase in manufacturing cost.
- Estimates of the increase in installed cost were obtained by applying the percentage increase to baseline estimates of installed cost. The latter have been extracted from the 18th edition of *Rawlinsons New Zealand Cost Handbook* (Rawlinsons 2003). This is an incomplete record of costs, particularly for larger sized units, and some estimates of unit costs have been obtained by extrapolation.
- Estimates of the reduction in lifetime energy cost have been obtained by applying the increase in efficiency to baseline estimates of lifetime energy costs. The latter were based on the following assumptions:
 - uniform asset life of 15 years;
 - discount rate of 7% in real terms;
 - residential and commercial energy charges of 13 cents/kWh and 10 cents/kWh respectively;

- residential and commercial operating hours of 500 and 1,500 hours per year respectively;
- commercial share of units set at 25% for smaller units, ranging up to 100% for units of 20kW or more cooling capacity;
- 50:50 mix of cooling and heating hours for reverse cycle units.
- On these assumptions, the overall benefit/cost ratio is 2.2, and ranges from low returns of 1.1 and 1.2 for smaller split non-ducted units, through to a high of 5.4 for the largest types of three-phase units. Overall, three-phase units return higher benefit/cost ratios than single-phase units, reflecting longer operating hours and lower baseline estimates of the installed cost per kW of cooling capacity.

TABLE 4.1 BENEFIT-COST ANALYSIS OF 2007 MEPS ON NON-COMPLYING AIR CONDITIONERS

	Percentage changes in...		Change in lifetime costs (\$/kW)		Benefit/cost ratio	Change in lifetime costs of 'on-trend cohort' (\$k)	
	Efficiency	Installed cost	Energy costs	Installed costs		Energy costs	Installed costs
Single phase - cooling only							
Ducted, 0-4	-	-	-	-	-	-	-
Split, non-ducted 0-4	17.0%	4.3%	-46	41	1.1	-9	8
4-8	16.5%	4.1%	-62	27	2.3	-22	9
Wall/window, 0-4	22.3%	5.6%	-68	28	2.4	-2	1
<i>Sub-total</i>	<i>16.9%</i>	<i>4.2%</i>	<i>-57</i>	<i>32</i>	<i>1.8</i>	<i>-32</i>	<i>18</i>
Single phase - reverse cycle							
Ducted, 0-4	-	-	-	-	-	-	-
4-8	14.9%	3.7%	-54	22	2.5	-71	28
8-12	10.0%	2.5%	-37	12	3.1	-20	7
12+	-	-	-	-	-	-	-
Split, non-ducted 0-4	20.2%	5.0%	-54	44	1.2	-1,263	1,024
4-8	18.7%	4.7%	-69	29	2.3	-2,636	1,130
8-12	17.7%	4.4%	-64	22	2.8	-244	86
12+	11.4%	2.9%	-48	13	3.7	-59	16
Wall/window, 0-4	17.7%	4.4%	-52	20	2.6	-229	89
4-8	30.8%	7.7%	-111	27	4.1	-435	105
<i>Sub-total</i>	<i>15.2%</i>	<i>4.8%</i>	<i>-64</i>	<i>32</i>	<i>2.0</i>	<i>-4,955</i>	<i>2,485</i>
Three-phase							
0-19	9.0%	2.2%	-32	13	2.6	-612	240
19-39	13.1%	3.3%	-54	14	4.0	-417	104
39-65	11.0%	2.7%	-52	10	5.4	-193	36
<i>Sub-total</i>	<i>10.5%</i>	<i>2.5%</i>	<i>-40</i>	<i>13</i>	<i>3.2</i>	<i>-1,222</i>	<i>380</i>
Grand total	16.3%	4.3%	-58	27	2.2	-6,209	2,883

Aggregate benefits and costs

The final two columns of table 4.1 show the aggregate outcome that would be expected if the 2007 MEPS were applied to the 'on-trend' cohort of air conditioners that we have used to characterise the market for 2002. This is the same cohort described by table 3.1. As shown by table 4.1, the upgrading of that cohort of air conditioners would have cost about \$2.9 million, but generated lifetime energy savings worth \$6.2 million in present value terms. The net benefit is \$3.3 million. This is, of course, a hypothetical outcome, since the 2007 MEPS did not apply to sales in 2002.

However, this hypothetical calculation provides the basis for calculating the impact of introducing the 2007 MEPS, on the further assumptions that:

- The market continues to take the 'on-trend' mix of product that is described by table 3.1.

- The demand for air conditioning capacity grows at 2.3% per year over the longer term, which is the long-term growth rate of energy demand in the combined residential and commercial sector.
- The BAU rate of efficiency improvement is 0.4% per year.
- The MEPS are fully effective by 2008 and have a partial impact over preceding years as suppliers prepare their product range to comply with the MEPS. In the case of single-phase air conditioners, this is accelerated by the introduction of the preliminary MEPS in 2004.
- The real costs of air conditioners and energy remain unchanged.

Table 4.2 reports the resulting estimates of aggregate costs and benefits over the life of the regulation, which is assumed to be terminated at least by 2020³. The net value to users is \$29 million over the period.

TABLE 4.2 BENEFIT-COST ANALYSIS OF 2007 MEPS APPLIED TO ALL SALES TO 2020

Type	Change in lifecycle costs (\$ million)			Benefit/cost ratio
	Energy costs	Installed cost	Total cost	
Single-phase	-43.6	21.9	-21.7	2.0
Three-phase	-10.6	3.3	-7.3	3.2
Total	-54.1	25.1	-29.0	2.2

Review of cost estimates

More efficient units are generally more costly to manufacture and a number of sources have been consulted to assess these impacts.

Previous Australian studies

In respect of larger split units in the range 15kW to 20KW, staff at the UNSW testing laboratory indicated that substantial energy savings could be achieved by very simple design changes. For example, the outside condenser coil in these units is often kept small for aesthetic reasons and market acceptance. Enlarging the coil would increase costs only to the extent of the additional coil material (since the manufacturing process itself would remain largely unchanged), and the resultant cost increase is estimated to be minimal. However, such modifications may not always be sufficient to achieve the proposed MEPS.

The cost of improving three-phase units to the standard required by the preliminary MEPS was also assessed by Unisearch (1998) and a similar framework was adopted by GWA (2000). Unisearch and GWA put the ongoing costs at \$50/unit and \$100/unit respectively, in Australian dollars, but with those costs expressed relative to the sum of all air conditioner sales, including both complying and non-complying models. Given that about a third of the sales comprised non-complying units, the implied estimates of the increase in costs *per non-complying unit* are \$150 and \$300 respectively. GWA reports that the \$300 estimate is about 6% of the average retail price, which means that Unisearch puts the increase at 3%. The other key difference between the two estimates is that only GWA is referring to additional production costs, that is, the costs of better materials and components. Unisearch refers to the \$50/unit as the costs of administration, labelling and information activities of both industry and government.

US Department of Energy

Engineering studies contained in the following reports from the US Department of Energy (DoE) have also been examined for the current RIS.

DoE (1997), *Technical Support Document for Energy Conservation Standards for Room Air Conditioners*, prepared for DoE by LBNL.

³ The period to 2020 may be regarded as the maximum life of the regulation, and carries no implication about what may happen to air conditioner MEPS in the meantime. Most likely, these MEPS will be subject to further review and a fresh decision well before 2020.

DoE (2002), *Technical Support Document: Energy Efficiency Standards for Consumer Product - Residential Central Air Conditioners and Heat Pumps*, prepared for DoE by staff of Arthur D Little Inc. & LBNL.

DoE (2003), *National Energy Savings Spreadsheet: Commercial Unitary Air Conditioner and Heat Pumps*, downloaded from the following website in June 2003.
www.eere.energy.gov/buildings/appliance_standards/commercial/ac_hp.html

Estimates of the relationship between efficiency and manufacturing costs have been extracted from these studies and are summarised in a series of charts presented in appendix 3. Note that the data have been normalised to present costs as unity (1.0) for equipment with an EER of 2.75. The pattern is that significant improvements in energy efficiency can be achieved at relatively low cost, but that subsequent improvements are achieved at progressively higher marginal cost.

DoE estimates that the increase in manufacturing costs is generally in the range of 3-4%. But there are important exceptions. The figures indicate that manufacturing costs would increase by 15-20% for large (6-10kW) single-phase units. On the other hand, the cost of improving three-phase units in the 20-30kW range is put at about 2%.

It is also important to understand that some of the available estimates have been generated by reverse engineering a sample of low efficiency air conditioners, thereby identifying the most cost-effective design changes that will achieve the desired improvements in energy efficiency. These design changes have two effects. They not only increase energy efficiency, they also increase the output power of the unit⁴. That is, for a given input power, the more efficient unit has a greater cooling capacity. Because the unit is fundamentally changed by reverse engineering and redesign, some adjustments are needed in order to compare like with like.

One adjustment is to allow for the cost savings that could be had by reducing the input power, restoring the cooling capacity of the unit to its original level. For example, a smaller compressor could be used. Alternatively, if the other parts of the design are left unchanged the resulting higher capacity of the unit could be expected to have a higher market value, since consumers are willing to pay more for units with greater capacity. The supplier recoups some of the cost of increased efficiency in both cases, either by reducing the input power of the unit or by marketing the unit in a higher capacity range.

Finally, it is also significant that the US estimates are for manufacturing costs only and that manufacturing costs account for about 40% of the final purchase price. The percentage impact of increased efficiency is therefore reduced by at least half when expressed in terms of the final purchase price.

Supplier responses

In discussions with suppliers, they have indicated that increased efficiency has implications for the size of units and the amount of material used, reflecting the fact that heat transfer is facilitated by increased surface area. When those options have been exhausted, however, further increments in energy efficiency may be more costly.

That said, suppliers have generally indicated that, where they have ready access to complying models to replace non-complying models, the cost implications appear not to be significant. That said, they are responding to the MEPS requirements at a time when there are offsetting favourable impacts on costs. For example, inverters and other new technologies are creating opportunities to drive down costs; there have been favourable exchange rate movements; and manufacturers have steadily reduced their production costs. The general view is that, whatever the impact of MEPS, they will not reverse the steady downward trend in prices.

Conservative estimates adopted in this RIS

⁴ 'Energy' and 'power' are related but different concepts. Energy refers to the total amount of electricity used to complete a particular task such as cooling a given area to a specified temperature. The power of the unit is the rate at which energy can be used.

Given the uncertainties, the cost increases have been very conservatively estimated for the purposes of this RIS. As indicated above, a general rule has been adopted that puts the percentage increase in the installed cost at 25% of the percentage increase in efficiency. Overall, this effect is to increase the *total installed cost* of non-complying units by 4.3%, compared with US estimates that put the increase in *manufacturing costs* at 3-4%. Given that manufacturing costs are no more than 50% of installed costs, the conservative nature of the estimate is apparent.

Other supply side considerations

It is taken for granted that increased New Zealand demand for more efficient air conditioners will be accommodated at observed market prices and that any supply bottlenecks will be relatively temporary. This is a reasonable assumption given that air conditioners are freely traded internationally and New Zealand is a very small part of the international market. Changes in the New Zealand market would not trigger significant constraints on the supply side.

Nor do the proposed MEPS pose a significant threat to the quality of supplier competition in the market for air conditioners. Relevant considerations are as follows:

- There is vigorous supplier competition in the market for air conditioners. Over 105 brands are registered with the Australian Greenhouse Office, with an average of 20 models each.
- The 30 largest brands, accounting for 75% of the registered models, tend to have a high proportion of models that would not comply with the 2007 MEPS. Typically, no more than 20% of these models would already comply with the 2007 MEPS. By contrast, many of the smaller brands have a higher proportion of models that already comply. On the assumption that the large players are best placed to respond to the MEPS requirements, it seems unlikely that there will be any significant reduction in the number of competitive players in the market.
- Industry sources have also indicated directly that the MEPS will not adversely affect the ability of existing suppliers to continue operating in the industry.

An earlier Australian RIS (GWA 2000) also made the point that MEPS may improve the quality of competition, by reducing the scope for misleading efficiency claims and thereby reducing the search and information costs of users.

Sensitivity analysis

Sensitivity analysis indicates that cost benefit analysis is robust, in the sense that the proposals are considered to be financially beneficial under reasonable alternative assumptions.

Increase in purchase costs

Given the deliberately conservative of the estimates of the increase in purchase costs, it is reasonable to look only on the downside. It would be reasonable, for example, to reduce these estimates by 25%, with the following results:

- The estimate of costs is reduced by \$6.2 million and the estimate of net benefits raised by the same amount.
- The overall benefit/cost ratio increases from 2.2 to 2.9.
- The benefit/cost ratio for single-phase units rises from 2.0 to 2.7, and from 3.2 to 4.3 from three-phase units.

Reduction in energy costs

It would be reasonable to test for sensitivity in the range of +/-15% of the estimate for the reduction in energy costs. This is the sort of variation that would be generated by looking at any of the following:

- variation in asset lives from 11.5 to 19 years;
- variation in the discount rate from 5% to 9.5%;
- variation in hours of operation from 425 to 575 hours per year for residential users, and from 1275 to 1725 hours per year for commercial users.

In each of these cases, the overall benefit/cost ratio is in the range 1.8 to 2.9. The corresponding ranges for single-phase and three-phase units are 1.7-2.3 and 2.7-3.7 respectively.

Future energy prices are also an issue. The recently published *New Zealand Energy Outlook to 2025* (MED 2003b) provides various scenarios for the future path of wholesale electricity prices. The reference scenario is for a 14% increase over the period 2005-2020 and a 33% increase over the period 2005-2025. Key drivers are the projected exhaustion of the Maui gas field and the planned introduction of a carbon charge from 2008. These are significant price increases. However, their inclusion adds no more than 2-3% to the estimated value of energy savings, due to the effect of discounting on the present value of energy savings that are significantly deferred.

Finally it should also be kept in mind that total net benefits will be distributed unevenly between users, depending on the type of air conditioner used, the cost of energy and, most importantly, the intensity of use. In particular, the overall returns would tend to be borderline for residential users in particular, where average hours of use are relatively low (at 500 hours per year), and the installed cost per unit of output power (\$/kW) is relatively high. Within the residential sector, the proposals would be of most benefit retired persons and families with young children that use space conditioning equipment for more hours per day. Lack of data on ownership patterns and user behaviour prevent more detailed quantitative assessment of these impacts.

4.3 Impact on government

The impact of the proposals on the taxpayer will be minimal. Not only are MEPS a relatively inexpensive policy instrument from the viewpoint of taxpayers, but the majority of these costs would be incurred under BAU conditions. Once the proposed measures have been developed and implemented, there are no additional costs that can be attributed to the proposal.

On the first point the ongoing costs of administering all the MEPS initiatives are of the order of \$730,000 per year at most. This allows for the equivalent of 2.7 full-time staff members in EECA. On the second point, the ongoing program of monitoring and check testing would be required for the purposes the existing labelling requirements and/or MEPS for air conditioners. The more demanding nature of the MEPS may justify some increase in the check-testing activity, at least for a period. However the additional costs would be less than \$50,000 and can be safely ignored for the purposes of the report.

4.4 Impact on suppliers

Impacts on employment and profitability

It is apparent a number of models will be withdrawn from the market, possibly accompanied by some reduction in the number of smaller or opportunistic suppliers. Overall, however, the proposal is not expected to significantly affect the level of demand, which is expected to continue its strong growth for several more years before stabilising at a higher level. Similarly, there is no expectation that the proposals are any threat to general levels of employment in the supplier industry.

The quality of supplier planning will have a major effect on the relative success of suppliers in adjusting to the new market regime. It is apparent from industry consultations that this is somewhat variable; some are much further advanced than others. However, reasonable advance notice has been provided to all as a result of contact with the industry in regard to the current labelling requirements.

Once-off adjustment costs

Suppliers will incur some once-off costs of adjustment, for example, in negotiating with manufacturers to agree on new product specifications, alterations to marketing materials and technical documents, and costs of redesign. However these costs will be quite low, given that, for most suppliers, these costs will already have been incurred to accommodate the same requirements in the Australian market. The additional, or marginal, costs caused by the New Zealand regulation would be quite low. Conceivably, it would actually be more costly for suppliers to deal with different requirements in the two countries, foregoing the advantages of uniformity.

Ongoing administrative compliance costs

The administrative costs of reporting to EECA will be unchanged, since these are already incurred to comply with existing labelling and MEPS requirements.

4.5 National costs and benefits

Costs and benefits from a national perspective can differ somewhat from costs and benefits from a user perspective, the latter having been reported in table 4.2. Given our assessment that impacts on the government and on supplier will be small, the main potential difference relates to the avoidable cost of electricity.

Avoidable cost of electricity

The cost of electricity consists of the cost of electricity generation (including the energy lost as heat in transmission and distribution), the cost of network services (poles, wires and substations for transmission and distribution of electricity) and the market costs associated with functions such as metering, billing and advertising. These costs are recovered in the tariffs charged to users and users rightly look to the tariff schedules to determine the value of energy savings. However some of these costs are not avoidable. That is, they cannot be reduced by energy saving measures. Market costs are the obvious but relatively minor example, since market costs generally account for less than 5% of average costs.

Less obviously, the large fixed costs of providing network services means that the marginal cost of providing additional network capacity is considerably less than the average costs. Based on a recent report to the Australian Building Codes Board⁵ (ABCB), the marginal network cost of a general increase in energy use might be reasonably put at about 30% of average network costs, although considerable uncertainty attaches to any such estimate. This is a more serious consideration since, in Australia, network costs account for about 70% of the average residential and small to medium commercial tariffs. If 70% of those costs are unavoidable, it follows that about half of the average cost of electricity is unavoidable ($70\% * 70\% = 49\%$).

However a further adjustment is required. Because network capacity is designed to cope with peak loads, the avoided network costs associated with any particular measure depends on the extent to which the measures reduce the peak load on the network. Some measures would have little or no impact on peak loads and would generate no such savings. Air conditioners are at the opposite extreme. In terms of the proportion of its energy that an appliance uses when the network is under peak load, air conditioners have a peak load factor that is 3-4 times greater than the average load profile that networks must accommodate⁶.

It follows that, whereas the network savings associated with proportional reductions in all loads would be equal to about 30% of average costs, the network savings associated with more efficient air conditioners would be in the range 90 – 120% - that is, 3 to 4 times 30%. Note the possibility that reduction in network costs associated with more efficient air conditioners may actually *exceed* the average cost of network services.

Compared with Australia, network costs New Zealand are somewhat less as a proportion of total costs, possibly reflecting the difference in physical scale. However the same reasoning applies. The discount that would otherwise be applied to network costs is negated by the fact that air conditioners contribute disproportionately to peak loads on the network.

Given these particular circumstances arising from the peak load demands of air conditioners, it is reasonable to regard the marginal tariff as a conservative estimate of the avoided cost of electricity. This is particularly so given that generation costs also increase under peak loads, which means that

⁵ Atech (2003), *A Financial Analysis Procedure for Energy Efficiency in Buildings*, Report to the Australian Building Codes Board

⁶ This estimate reflects parameters developed by the Lawrence Berkeley National Laboratories (LBNL) and presented in a report to the US Department of Energy - LBNL (1997). The discussion there is in terms of the Conservation Load Factors of different appliances, and variations in the amount of energy that must be saved to reduce peak loads by 1 kW.

air conditioners incur higher-than-average generation costs as well. The average electricity tariff as has therefore been retained as a reasonable estimate of the avoided costs of supplying the energy used by air conditioners.

Findings

Accordingly, it is considered that table 4.2 provides a reasonable assessment of the national costs and benefits of the proposed regulation.

4.6 Assessment of more demanding options

Minimum levels of energy efficiency could be further increased either by raising the MEPS requirements or by accelerating their introduction. In terms of the EECA's strategy of following the best practice lead of trading partners, acceleration means a reduced gap between introduction overseas and introduction in New Zealand. In the case of three-phase units, for example, the proposed gap for three-phase units is 3 to 4 years. Substantial energy savings are at stake, with a value of the order of \$5 million per year. Taken further, the option of more stringent MEPS entails New Zealand undertaking to lead the process of MEPS setting amongst its trading partners.

Data inadequacies mean that it is not possible to assert confidently that the more stringent options will be cost effective. The main problem is that, while we can be confident that most of the increases in energy efficiency required by the proposal occur along the flat portion of the cost curve, further increases in the MEPS level may take the industry into the region of increasing marginal costs – see appendix 3. The degree of cost increase at the margin cannot be determined with reasonable confidence from the available (mainly US) estimates.

More stringent requirements will also increase the proportion of low-intensity users who are worse off.

For suppliers, the main concerns are access to product in the longer term and the adequacy of adjustment time in the short term. Regarding access to product, New Zealand's status as a large net importer of air conditioners means that we cannot stray far from overseas MEPS without threatening to compromise the range of products that is readily available. Suppliers emphasised that the New Zealand market is not sufficiently large to justify special designs.

A further concern is the adequacy of the lead time provided to suppliers. Certainly, the proposal may err on the generous side for many suppliers. Based on industry discussions, many suppliers tend not to use all of the available time. Regardless of how long the lead time, their response is still of the 'last minute' variety. However the requirements are variable, depending on how closely the supplier is tied to a specific manufacturing operation. At one end of the spectrum, for example, many importers consider that they can readily obtain complying models within a short period and would need no more than one year's notice to adjust their supplier relationships. At the other end of the spectrum, local manufacturers may need to withdraw some models from the market, redesign others, and possibly make significant changes to production facilities.

Between these extremes are suppliers that, while not being manufacturers themselves, cannot quickly change from one manufacturer to another. For example, the MEPS requirement may create gaps in their product line that cannot be readily filled by another manufacturer without disturbing the uniformity of the product line in terms of particular aesthetic and functional characteristics that are not readily replicated.

Based on industry consultation undertaken to date, suppliers generally consider that 2-3 years lead time is the minimum requirement for making the required adjustments, commensurate with the normal product lifecycle. The proposal is to provide 3-4 years for the 2007 MEPS but less than 1 year for the less demanding interim MEPS for single-phase air conditioners. However, the proposal to retire older, less efficient models in 2004 has been discussed with key industry representatives for several years and all suppliers were informed of government intentions in 2002.

5 Conclusion and recommended option

5.1 Assessment against objectives

Table 5.1 provides a summary statement of the three options considered in this report against the objectives of the proposed regulation.

The key issue is the appropriate level of stringency of the performance requirements. Overall, it is considered that, given the broad policy framework provided by New Zealand's Climate Change Policy, the minimum level of energy efficiency cannot be safely increased beyond that contained in the proposal. A more aggressive approach poses significant risks for both suppliers and users, as summarised in the table.

5.2 Recommendations

It is recommended that New Zealand implement the proposed mandatory minimum energy performance standards.

TABLE 5.1 ASSESSMENT SUMMARY

<i>Objective</i>	<i>BAU option</i>	<i>Proposed MEPS</i>	<i>More stringent or accelerated MEPS</i>
Reduction in greenhouse emissions	Improvement dependent on trend improvements in energy efficiency (0.4%/year) plus evolution of more energy efficient building stock, eg, due to energy efficiency measures in the building code.	Greenhouse emissions from the targeted air conditioners will be reduced by about 3.2% in 2010 and 10.4% in 2020.	More rapid reduction in greenhouse emissions could be achieved. The savings could be increased to 5% of BAU emissions by 2010, and 15% by 2020.
Cost effective for users	Most users continue to minimise capital costs, but largely ignoring the potential to reduce life-cycle costs by improving energy efficiency.	Total benefits exceed total costs by a significant margin. But there would be some losers amongst those with low energy costs or who use air conditioners sparingly.	We cannot be confident that further increases in MEPS would be cost efficient at this stage. The proportion of losers would increase and the range of complying product would be reduced.
Minimise adverse effects on manufacturers and suppliers	The business as usual scenario for suppliers is for continued healthy growth of demand for air conditioners	Most of the one-off costs of adjustment would already be incurred in response to the same MEPS introduced in Australia.	Given New Zealand's status as a large net importer of air conditioners, there would be significant additional costs if New Zealand attempted to take the lead in setting MEPS.
Minimise potential for confusion or ambiguity	No confusion or ambiguity	Suppliers are generally aware of the proposals, find them clear and comprehensive, and are preparing to make the appropriate changes.	The redesign and retesting activities would need to be accelerated considerably, imposing a significant extra burden on the management team. More complex design problems would need to be overcome.

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APPENDIX 1: TECHNICAL BACKGROUND & TABULATION OF MEPS PROPOSALS

Technical terms

The *capacity* of an air conditioner is measured as the number of kilowatts (kW) of *output power* in the cooling cycle, which is the rate of cooling achieved in the conditioned space under certain standard conditions. The efficiency of an air conditioner is measured as a ratio of output power to *input power*, which is the rate at which energy is used by the compressor and fans that drive the air conditioner. This ratio is measured in the cooling mode under certain standard conditions and is known as the *energy efficiency ratio* (EER). EERs are typically greater than 2; they can range up to 4.

Many air conditioners are configured as reverse cycle machines, which means that in cold weather they can transfer heat from outside the conditioned space in to the space. When operating in this mode they are often referred to as heat pumps. An air conditioner is generally more efficient in the heating or reverse cycle configuration than in the cooling configuration. The ratio of power output to power input in the heating cycle is referred to as the *coefficient of performance* (COP).

Note that the power output is a multiple of the input power, which means that air conditioners and heat pumps move more energy than they use. This reflects the fact that heat pumps *move* energy in or out of the conditioned space, using a refrigeration cycle; they do not *generate* heat in the same manner as a gas or electric resistance heater.

Table A1.1 shows the existing MEPS introduced in October 2001, the changes proposed for 2004, and the further proposed changes for 2007. The schedule is fairly complex. Note the following:

- The schedule distinguishes between air conditioners taking single-phase and three-phase power. (Smaller units are single-phase and larger units are three-phase, but with a considerable overlap in the intermediate sized units.) The MEPS are being introduced in two stages. The initial MEPS for three-phase units were introduced in 2001, and are proposed for single-phase units in 2004. Further increases are proposed for both single-phase and three-phase units in 2007.
- Regarding the first stage:
 - *Single-phase units*: A distinction is drawn between cooling only and reverse cycle units, with a somewhat more demanding MEPS applying to the former.
 - *Three-phase units*: The MEPS increase with output capacity but there is no distinction in terms of the type of cycle.
- Regarding the second stage, the general rule is for a minimum EER of 2.75, but with the following exceptions that allow for the peculiarities of particular tests or the greater ease or difficulty of achieving increased efficiencies:
 - *Single-phase units*:
 - Air-cooled ducted units - minimum EER = 2.50
 - Air-cooled non-ducted split units with capacity of 4kW or less - minimum EER = 3.05
 - All water-cooled units - minimum EER = 3.50
 - *Three-phase units*:
 - Air-cooled units with capacity in the range 19-39kW - minimum EER = 3.05
 - All water-cooled units - minimum EER = 3.50

TABLE A1.1 AIRCONDITIONER MEPS: 2001, 2004 & 2007

Cycle	Type	Cooling capacity (kW)	MEPS (Minimum cooling EER)			
			October 2001	October 2004	October 2007	
					Air cooled	Water cooled
Single-phase power supply						
Cooling only	Ducted Unitary	All	None	2.45	2.50	3.50
	Split	>4			2.75	
<=4		3.05				
Reverse cycle	Ducted Unitary	All			2.30	
	Split	>4	2.75			
		<=4	3.05			
Three-phase power supply						
All	All	7.6-10.0	No change from October 2001	2.75	3.50	
		10.1-12.5				2.25
		12.6-15.5				2.30
		15.6-18.0				2.35
		18.1-19.0				2.40
		19.1-25.0				2.45
		25.1-30.0				2.50
		30.1-37.5				2.55
		37.6-39.0				2.60
		39.1-45.5				2.65
45.6-65.0	2.75					

APPENDIX 2: COST BENEFIT ASSUMPTIONS

Market size and composition

Table A2.1 shows reports our assumptions about the size and composition of the air conditioner market in New Zealand. This overall picture has been compiled from sales data reported to EECA for the period 1999-2002. There was considerable sales growth over this period that cannot be sustained over the longer term. It has been assumed, therefore, that average annual sales for this period approximate the sales that would be observed in 2002 if 2002 were 'on-trend'. In general, the models employed are not designed to track the fluctuations in sales on a year-to-year basis. Instead it has been assumed that demand follows a smooth growth path.

Note the following about table A2.1.

- One row of data is missing, for three-phase units in the range 18-19 kW. No sales were recorded in this category.
- The size categories for 3-phase units are designed to accommodate the stepped MEPS that were adopted in 2001. Compare these with the schedule of MEPS in table A1.1.

TABLE A2.1 'ON-TREND' MARKET SIZE AND COMPOSITION - 2002

Type and size range (kW)	Av. cooling capacity (kW/unit)	Units sold	Sales of 'cooling capacity' (kW)	Sales of 'cooling capacity' (% of total)	Sales of heating capacity (kW)	Installed cost of AC (\$/kW)	Total expenditure (\$)
Single phase - cooling only							
Ducted, 0-4	3.0	24	71	0.1%	-	898	63,987
Split, non-ducted 0-4	2.6	82	216	0.2%	-	971	209,815
4-8	5.1	71	364	0.3%	-	655	238,260
Wall/window, 0-4	2.4	12	28	0.02%	-	509	14,496
Single phase - reverse cycle							
Ducted, 0-4	3.1	78	241	0.2%	245	874	211,070
4-8	6.4	956	6,150	4.4%	6,377	587	3,609,668
8-12	10.4	419	4,354	3.1%	4,806	485	2,113,388
12+	13.7	68	931	0.7%	982	446	414,933
Split, non-ducted 0-4	3.1	7,809	24,150	17.1%	28,645	875	21,126,490
4-8	5.5	8,989	49,764	35.3%	56,231	629	31,307,336
8-12	9.2	449	4,120	2.9%	4,385	507	2,090,010
12+	12.9	112	1,444	1.0%	1,586	453	654,856
Wall/window, 0-4	3.0	1,498	4,433	3.1%	4,524	452	2,004,408
4-8	5.3	730	3,900	2.8%	3,859	350	1,363,561
Three phase							
0-10	9.2	705	6,478	4.6%	5,399	654	4,235,566
10-12.5	10.8	565	6,123	4.3%	4,269	600	3,673,613
12.5-15.5	13.6	531	7,241	5.1%	7,342	539	3,901,361
15.5-18*	17.0	280	4,760	3.4%	4,984	490	2,334,132
19-25*	21.2	167	3,544	2.5%	3,642	446	1,580,216
25-30	28.0	87	2,438	1.7%	2,607	402	980,776
30-37.5	36.3	41	1,486	1.1%	1,528	385	572,475
37.5-39	38.6	8	309	0.2%	328	290	89,437
39-45.5	44.6	64	2,855	2.0%	3,040	373	1,064,425
45.5-65	55.2	100	5,520	3.9%	5,826	352	1,940,601
Total	-	23,845	140,921	100.0%	150,605		85,794,881

- The sales record is not complete. A rough adjustment for missing data has been made, by adding 12% to all sales.

- Cooling-only units account for only a small fraction of total sales of cooling capacity. (In general, it is more convenient to work in terms of total cooling capacity rather than the number of actual units.)
- Single-phase non-ducted split systems in the range 0-8 kW account for over 50% of total sales of cooling capacity. No other category stands out as having a significant share of sales.
- Total expenditure on air conditioners, including installation costs, approaches \$90 million per year. This estimate of aggregate spending is derived from estimated on costs per kW that we extracted from the 18th edition of *Rawlinsons New Zealand Cost Handbook* (Rawlinsons 2003). This is an incomplete record of costs, particularly for larger sized units, and estimates of unit costs have been obtained by extrapolation.

Stock of air conditioners, energy consumption and greenhouse emissions

Table A2.2 reports estimates of the stock of air conditioners in 2002. These estimates are derived directly from table A2.1, on the assumption that air conditioners have a life of 15 years and the total stock grows at 2.3%/year over the longer term. Under these conditions, the stock is 12.9 times the 'on-trend' annual sales.

Based on various other assumptions, it is estimated that the total cooling/heating capacity of air conditioners in New Zealand is approaching 2,000,000 kW, consuming about 700,000 MWh of electricity per year, at a cost of about \$80 million, and responsible for about 420,000 tonnes of CO₂-equivalent in greenhouse emissions. This is equivalent to about 2.1% of the total electricity (and electricity-related greenhouse emissions) generated in New Zealand, and 4% of the electricity used by the combined household and commercial sectors, where most air conditioners would be located.

This is a convenient point to review the various assumptions underlying table A2.2. Many of these parameters are also critical to the cost-benefit analysis.

Long term growth rate of stocks and sales

It has been assumed that stocks and sales of air conditioners grow at a steady long term rate of 2.3% per year, which is the average annual rate of growth of electricity consumption in the combined household and commercial sectors. While recent sales growth easily exceeds 2.3% per year, suppliers do not regard that as sustainable.

Asset lives

A uniform asset life of 15 years has been assumed for all air conditioners. This is a departure from the assumptions used in the corresponding Australian RIS, which assumed 15 years in commercial applications and 10 years in residential use. A subsequent review found that the US Department of Energy uses an average lifetime of 12.5 years for room air conditioners, 18.4 years for residential central air conditioners, and 15 years for commercial unitary air conditioners. A uniform assumption of 15 years seems reasonable in the context of those estimates, which are based on much more detailed data than is available in New Zealand or Australia.

Average EER and COP

These estimates have been extracted from sales data provided by suppliers to EECA, but from a more limited sample, given that about 20% of the returns did not provide all of the parameters required to estimate efficiency. Importantly, these are weighted average measures of energy efficiency – that is, weighted to reflect differences in sales volume and in cooling and heating capacity.

TABLE A2.2 STOCK OF AIR CONDITIONERS - 2002

Type and size range (kW)	Cooling capacity (kW)	Heating capacity (kW)	Av. EER	Av. COP	Household share (%)	Annual operating hours	Share cooling hours	Energy use (MWh)	Input energy (% of total)	Electricity price (c/kWh)	Annual cost of energy (\$M)	GHG emissions (tonnes CO ₂ e)
Single phase - coding only												
Ducted, 0-4	920		2.7		75%	750	100%	252	0.04 %	12.3	0.0	151
Split, non-ducted, 0-4	2,787		2.7		75%	750	100%	769	0.11 %	12.3	0.1	461
4-8	4,691		2.4		50%	1000	100%	1,950	0.28 %	11.5	0.2	1,170
Wall/window, 0-4	368		2.2		75%	750	100%	61	0.01 %	12.3	0.0	37
Single phase - reverse cycle												
Ducted, 0-4	3,114	3,155	2.8	3.0	75%	750	50%	805	0.1%	12.3	0.1	483
4-8	79,335	82,264	2.8	3.1	50%	1000	50%	27,147	3.9%	11.5	3.1	16,288
8-12	56,161	62,004	2.8	3.2	50%	1000	50%	19,506	2.8%	11.5	2.2	11,703
12+	12,011	12,669	2.7	3.1	25%	1250	50%	5,326	0.8%	10.8	0.6	3,196
Split, non-ducted, 0-4	311,540	369,522	2.6	3.1	75%	750	50%	89,936	12.8%	12.3	11.0	53,962
4-8	641,954	725,385	2.5	2.9	50%	1000	50%	255,608	36.3%	11.5	29.4	153,365
8-12	53,149	56,560	2.4	2.7	50%	1000	50%	21,255	3.0%	11.5	2.4	12,753
12+	18,633	20,458	2.6	3.0	25%	1250	50%	8,689	1.2%	10.8	0.9	5,213
Wall/window, 0-4	57,184	58,357	2.3	2.6	75%	750	50%	17,630	2.5%	12.3	2.2	10,578
4-8	50,312	49,783	2.1	2.3	50%	1000	50%	22,744	3.2%	11.5	2.6	13,646
Three-phase												
0-10	83,564	69,645	2.6	3.2	50%	1000	50%	26,674	3.8%	11.5	3.1	16,004
10-12.5	78,982	55,073	2.7	3.1	25%	1250	50%	29,349	4.2%	10.8	3.2	17,610
12.5-15.5	93,412	94,713	2.6	3.2	25%	1250	50%	41,110	5.8%	10.8	4.4	24,666
15.5-18	61,402	64,299	2.7	3.3	25%	1250	50%	26,468	3.8%	10.8	2.8	15,881
19-25 (18-19 = 0)	45,718	46,987	2.7	3.3	0%	1500	50%	23,163	3.3%	10.0	2.3	13,898
25-30	31,451	33,632	2.7	3.4	0%	1500	50%	16,039	2.3%	10.0	1.6	9,623
30-37.5	19,175	19,709	2.7	3.1	0%	1500	50%	10,158	1.4%	10.0	1.0	6,095
37.5-39	3,984	4,231	2.7	3.2	0%	1500	50%	2,088	0.3%	10.0	0.2	1,253
39-45.5	36,826	39,216	2.8	3.5	0%	1500	50%	18,154	2.6%	10.0	1.8	10,893
45.5-65	71,205	75,150	2.8	2.9	0%	1500	50%	38,843	5.5%	10.0	3.9	23,306
Total	1,817,876	1,942,810						703,724	100.0 %		79.3	422,234

Household share and average annual operating hours

Estimates of operating hours are obvious critical to the benefit cost estimates. The estimates in table A2.2 have been obtained by putting residential and commercial use at 500 hours/year and 1,500 hours/year respectively, and then assigning a household share of 75%, 50%, 25% or 0%. The result is that annual operating hours vary from 750 to 1500.

For commercial use, the assumption of 1,500 hours per year is conservative relative to estimates for US regions that have similar numbers of heating and cooling 'degree-days' as do the major population centres in New Zealand. The US estimates for the Pacific Coast are shown in table A2.3.

For residential use, the estimate of 500 hours/year is also borrowed from the US DoE. It is somewhat higher than the average of 400 hours/year that is implicit in Australian estimates (EES 1999). However it is a considerable discount on the 750 hours/year used by the industry body in the US, ASHRAE.

Regarding the mix of commercial and residential uses, industry contacts say that the residential market is relatively under developed in New Zealand, with the result that 80-90% of some small air conditioners may be purchased for commercial use. We have adopted a conservative assumption that 75% of smallest air conditioners are purchased for residential use, declining to 0% for air conditioners of greater than 20kW output capacity.

TABLE A2.3 COMPARABLE REGIONAL US ESTIMATES OF ANNUAL OPERATING HOURS

<i>Building type</i>	<i>Northern Pacific Coast (Oregon)</i>	<i>Southern Pacific Coast (California)</i>
Small office	1,953	1,860
Large office	2,013	2,140
Small retail	1,348	1,584
Large retail	1,475	1,853
Wholesale		2,279
Sit down restaurant	1,953	1,817
Fast food restaurant	1,177	1,471
Hospital		2,193
School		1,450
Weighted average	1,768	1,830

Source: Extracted from DoE (2003)

Cooling share

The mix of cooling and heating uses affects energy use, since reverse cycle units have different capacity and efficiency characteristics in the two cycles. Generally, somewhat more energy is used in cooling than in heating. In the absence of any better data, the split has been put at 50:50.

Energy use

The above estimates of output capacity, energy efficiency, operating hours and cooling shares are readily brought together to calculate the amount of energy used by air conditioners in New Zealand. These results have been noted already.

Cost of electricity

Electricity charges have been put at 10cents/kWh in the commercial sector and 13cent s/kWh in the residential sector, sourced from the Ministry of Development's *Energy Data File* for January 2003. The average electricity charge then reflects the mix of household and residential use that has been assumed for each type and size of air conditioner.

Discount rate

The discount rate has been set at 6.3% and defined as a *real pre-tax discount rate*. This is the rate adopted by the Australian Building Codes Board for its analysis of energy efficiency measures,

based on a report by Atech Group⁷. This is a relatively low rate, reflecting a judgement that investments in the energy efficiency of buildings will be somewhat insulated from cyclical fluctuations in economic activity, and are therefore relatively low risk.

Emissions factor

A fixed emission factor of 0.6 tonnes CO₂e per MWh has been assumed. This is the figure recommended to the Climate Change Office (CCO) by Concept Consulting Group (CCG 2003), for the purposes of assessing the emissions reductions achieved by projects that reduce the demand for grid-purchased electricity.

Benefit cost analysis of 2007 MEPS applied to the non-complying part of the 'on-trend' cohort

Table A2.3 reports the estimates of the costs and benefits that would result if the final 2007 MEPS were applied to the on-trend cohort of air conditioners that is described by table A2.1. This is a hypothetical exercise in one sense, since the 2002 cohort will be little affected by MEPS that will be introduced in 2007. However, the modelling approach is essentially to 'grow' that cohort at the long term growth rate and to phase in the 2007 MEPS.

Level of non-compliance

The table shows the proportion of total sales (measured as sales of output capacity rather than air conditioning units) that did not comply with the 2007 MEPS. There is considerable variation. For example;

- Three groups of single-phase ducted units were fully compliant – these are the empty rows in table A2.3. These face the lowest MEPS requirement – an EER of 2.50.
- By contrast, all wall/window units were non-compliant.
- Otherwise, non-compliance rates tend to be relatively high, typically greater than 80%.

Overall, 76% of the output capacity of the 'on trend' cohort was non-compliant.

Percentage increase in efficiency

The required increase in efficiency has been calculated with reference to the minimum efficiency requirements of the MEPS and the average efficiency of units that already comply with the MEPS. The former defines the minimum required increase in efficiency whereas the latter may be reasonably be regarded as the upper bound for the improvement that are achieved. The actual increase has been set at the mid-point between these extremes, with the exception of units where there is currently zero compliance. The latter are assumed to achieve borderline compliance.

Percentage increase in purchase cost

The efficiency-cost tradeoff is discussed in the body of the report, including a reasonably detailed discussion of the available evidence, which is mainly US in origin. For present purposes it is sufficient to note that the increase in cost has been put at 25% of the increase in efficiency. That is, a 10% increase in efficiency is at the expense of a 2.5% increase in cost. Importantly, 'costs' include the costs of installing the air conditioning units themselves, although not the cost of ducts, refrigerant pipe work and the like. Since manufacturing costs would usually be about 40% of the installed cost, a 10% increase in efficiency is accompanied by a 6.25% increase in the cost of manufacture.

Benefits and costs

The table also reports estimates of the lifetime benefits and costs, both in aggregate and per unit of capacity. The benefit/cost ratio varies from 1 to 6, with an overall ratio of 2.2. In aggregate terms, application of the 2007 MEPS to the 'on trend' cohort would return benefits of \$6.2M, relative to expenses of \$2.9M. The net benefit is \$3.3M.

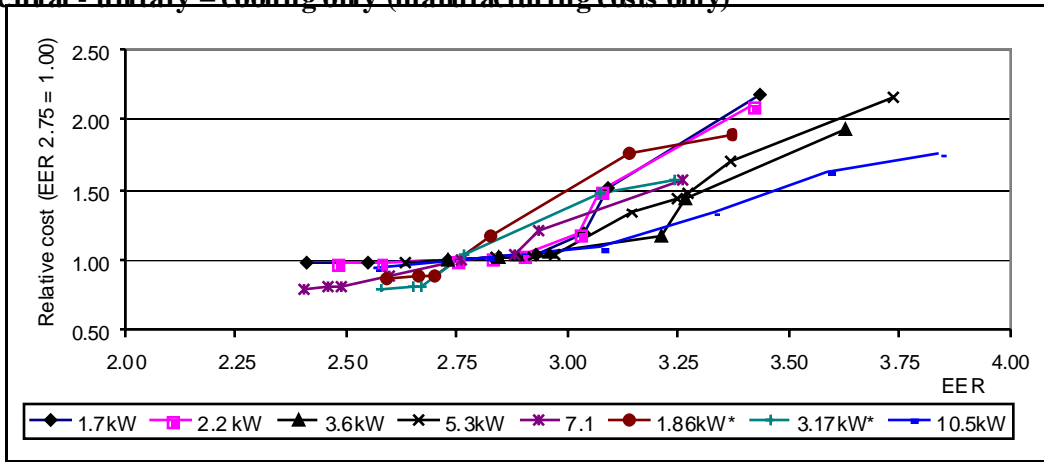
⁷ Atech (2003), *A Financial Analysis Procedure for Energy Efficiency in Buildings*, Report to the Australian Building Codes Board

TABLE A2.3 BENEFIT/COST ANALYSIS OF 2007 MEPS APPLIED TO NON-COMPLYING SALES IN THE 'ON TREND' COHORT

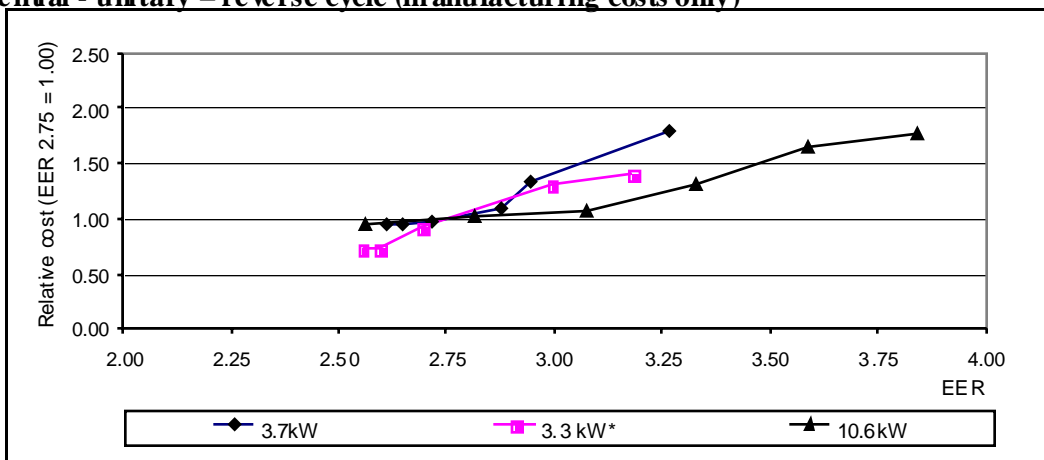
Type and size range (kW)	Non-complying sales (% of output power)	Non-complying sales (kW)	Pre-MEPS EER	Pre-MEPS COP	Percentage changes		Aggregate lifetime benefits & costs		Lifetime benefits & costs per unit of capacity		Benefit/cost ratio
					Efficiency increase (%)	Increase in purchase cost (%)	Reduction in energy costs (\$)	Increase in purchase costs (\$)	Reduction in energy costs (\$/kW)	Increase in purchase costs (\$/kW)	
Single phase - cooling only											
Ducted, 0-4	0.0%	0									
Split, non-ducted, 0-4	88.6%	191	2.67		17.0%	4.3%	8,734	7,913	46	41	1.1
4-8	95.5%	347	2.39		16.5%	4.1%	21,582	9,397	62	27	2.3
Wall/window, 0-4	100.0%	28	2.25		22.3%	5.6%	1,937	810	68	28	2.4
Single phase - reverse cycle											
Ducted, 0-4	0.0%	0									
4-8	21.2%	1,304	2.38	2.75	14.9%	3.7%	70,604	28,477	54	22	2.5
8-12	12.5%	546	2.46	2.94	10.0%	2.5%	20,266	6,596	37	12	3.1
12+	0.0%	0									
Split, non-ducted, 0-4	96.2%	23,233	2.60	3.04	20.2%	5.0%	1,262,686	1,024,219	54	44	1.2
4-8	77.3%	38,456	2.39	2.74	18.7%	4.7%	2,635,717	1,130,335	69	29	2.3
8-12	93.0%	3,831	2.41	2.70	17.7%	4.4%	243,638	85,822	64	22	2.8
12+	85.1%	1,229	2.56	2.96	11.4%	2.9%	58,670	15,896	48	13	3.7
Wall/window, 0-4	100.0%	4,433	2.34	2.59	17.7%	4.4%	229,092	88,598	52	20	2.6
4-8	100.0%	3,900	2.10	2.31	30.8%	7.7%	434,530	104,896	111	27	4.1
Three-phase											
0-10	85.1%	5,514	2.61	3.22	8.1%	2.0%	139,004	72,949	25	13	1.9
10-12.5	65.7%	4,024	2.64	3.02	6.5%	1.6%	91,749	39,319	23	10	2.3
12.5-15.5	75.2%	5,447	2.51	3.17	12.9%	3.2%	273,058	94,361	50	17	2.9
15.5-18	81.0%	3,854	2.65	3.28	7.0%	1.8%	108,061	33,280	28	9	3.2
19-25	100.0%	3,544	2.73	3.32	11.7%	2.9%	170,807	46,072	48	13	3.7
25-30	97.0%	2,366	2.73	3.39	14.9%	3.7%	142,845	35,448	60	15	4.0
30-37.5	100.0%	1,486	2.67	3.09	14.0%	3.5%	88,325	20,101	59	14	4.4
37.5-39	100.0%	309	2.74	3.18	11.3%	2.8%	14,986	2,530	49	8	5.9
39-45.5	1.6%	45	2.58	3.19	7.9%	2.0%	1,631	333	36	7	4.9
45.5-65	65.9%	3,638	2.64	2.67	11.0%	2.8%	191,265	35,239	53	10	5.4
Total	76.3%	107,725					6,209,187	2,882,591			2.2

APPENDIX 3: US ESTIMATES OF THE EFFICIENCY-COST RELATIONSHIP

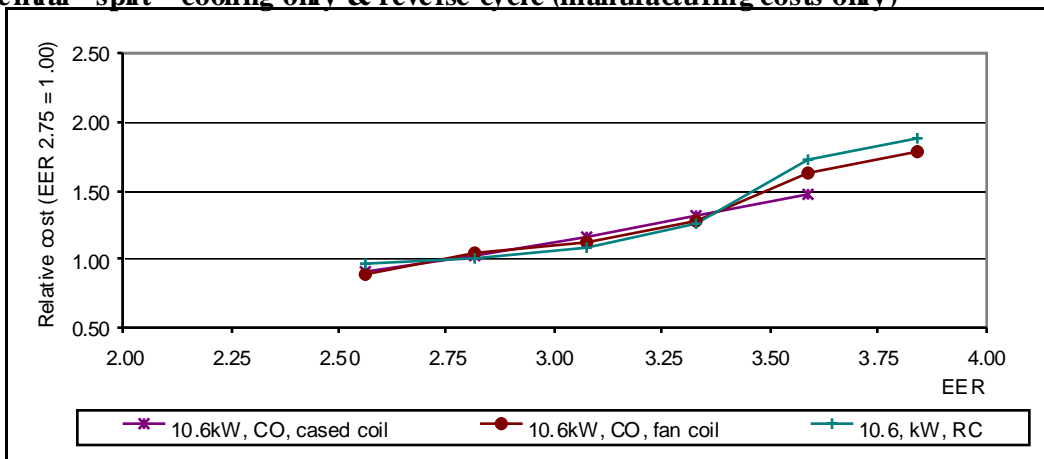
Residential - unitary – cooling only (manufacturing costs only)



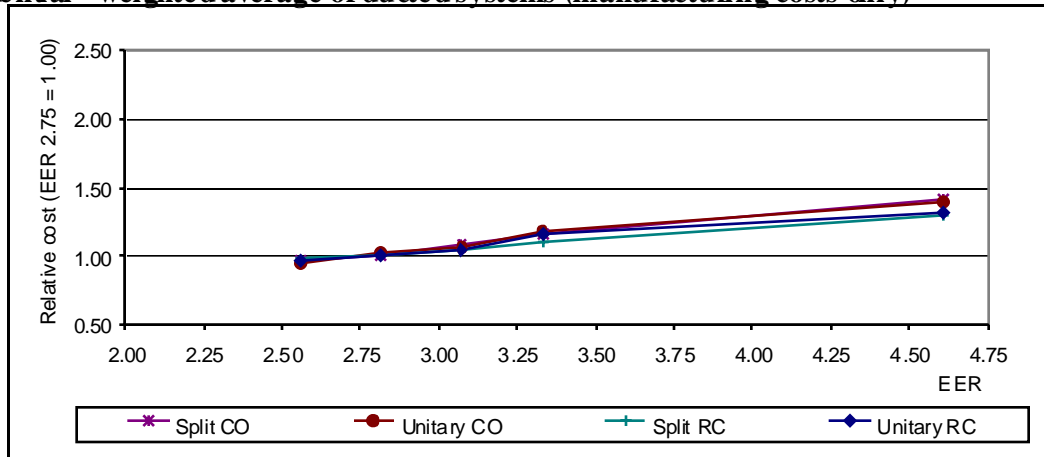
Residential - unitary – reverse cycle (manufacturing costs only)



Residential - split – cooling only & reverse cycle (manufacturing costs only)



Residential - weighted average of ducted systems (manufacturing costs only)



Commercial systems (manufacturing costs only)

