Minimum Energy Performance Standards for Electric Motors

Regulatory Impact Statement

Draft Report – December 12, 2003

Prepared for

Australian Greenhouse Office

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Contents

Abbreviations

ABARE	Australian Bureau of Agriculture and Resource Economics
AC	alternating current
ACEEE	American Council for an Energy Efficient Economy
AEEMA	Australian Electrical and Electronic Manufacturers Association
AGO	Australian Greenhouse Office
APEC	Asia Pacific Economic Cooperation forum
APEC-ISIS	APEC Energy Standards Information System
AS/NZS	Australian Standard/New Zealand Standard
BAU	business as usual
CPI	consumer price index
CEMEP	European Committee of Manufacturers of Electrical Machines and Power Electronics
E2G2	Working Group for Energy Efficiency and Greenhouse Gas
EU	European Union
GWA	George Wilkenfeld and Associates
IEEE	Institute of Electrical and Electronic Engineers
LBNL	Lawrence Berkeley National Laboratories
MCE	Ministerial Council on Energy
MEPS	minimum energy performance standards
NATA	National Analytical Testing Authority
ODP	open drip proof (motors)
OEM	Original equipment manufacturer
PV	present value
MEPS	Minimum Energy Performance Standards
NAEEEC	National Appliance and Equipment Energy Efficiency Committee
NAEEEP	National Appliance and Equipment Energy Efficiency Program
NGS	National Greenhouse Strategy
NPV	net present value
RIS	regulatory impact statement
rpm	revolutions per minute
TEFC	totally enclosed fan-cooled (motors)

Executive summary

This is a regulatory impact statement for proposed changes to minimum energy performance standards (MEPS) for motors falling within the scope of the joint Australian New Zealand Standard AS/NZS 1359.5. These are three-phase induction motors with output ratings from 0.73 kW up to but not including 185 kWh. They are used in a wide range of applications, including airconditioning and ventilation systems, pumps, mechanical drives and compressors. The new regulation would take effect from 2006.

The problem
The proposal is an element of the National Appliance and Equipment Energy Efficiency Program (NAEEEP), which is jointly managed and funded by the Commonwealth, State and Territory governments. NAEEEP is part of the National Greenhouse Strategy and targets the energy efficiency of consumer appliances, industrial and commercial equipment.

The energy used by motors accounted for about 13% of Australia's greenhouse emissions in 2000. However efficiency measures can only reduce the heat and other energy losses within the motor itself, since the rest of the energy is effectively used by the pumps and other machinery that is driven by motors. Motor losses account for about 1% of greenhouse emissions.

The objective
The proposal would substantially complete NAEEEP's strategy for motors, which includes energy labelling and information activities, alignment with international test procedures, registration and associated product databases, and preliminary MEPS that have applied to three-phase motors since 2001.

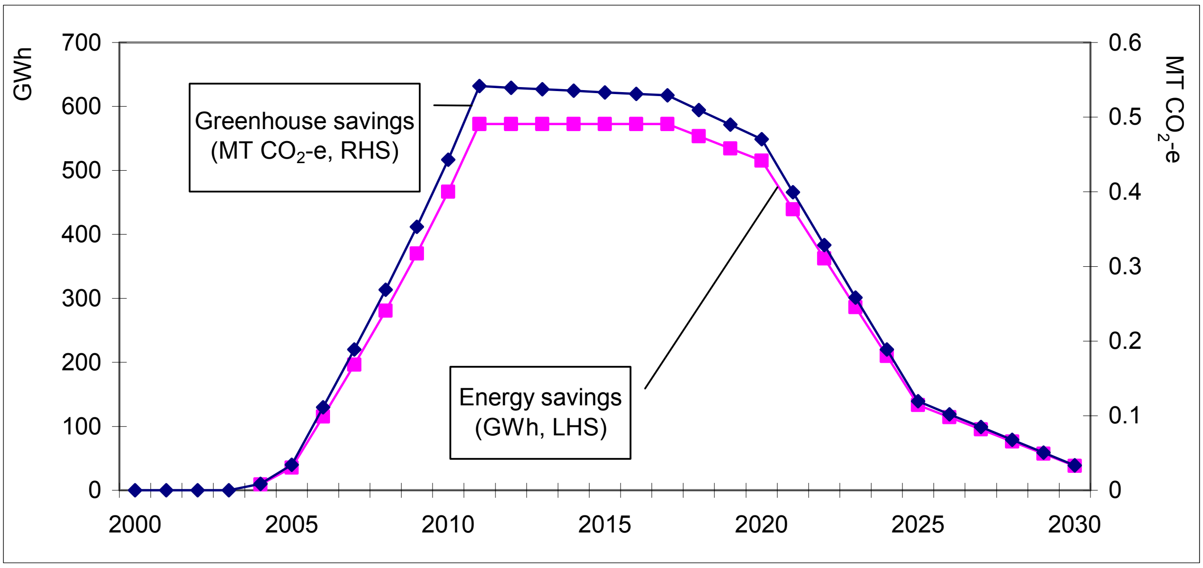
NAEEEP has adopted a policy 'world's best regulatory practice'. This involves setting MEPS at levels broadly comparable with the most demanding MEPS adopted by Australia's trading partners, but following that lead with a lag of several years. Given Australia's status as a large net importer of electrical appliances and equipment, it is considered inappropriate to take the lead or to otherwise adopt standards that put Australia significantly at odds with its trading partners. Canada and the United States provide the lead for motors, having adopted comparable standards in 1997.

However the actual efficiency benchmarks correspond closely to the European Union's 'Efficiency 1' or EFF1 level. This is appropriate since, like Europe and many of Australia's trading partners in Asia, Australia's power system operates on a frequency of 50 Hz, and our traditional suppliers have strong European connections. North America is on 60 Hz. Hence, while the proposal is to follow the North American lead in mandating high efficiency, the actual benchmarks are European.

The proposal
The proposed measures will require about 70% of existing models to be withdrawn from the market. Motor losses will need to be reduced by 10-20% for most motors that are borderline compliant with the existing 2001 MEPS, with larger reductions for some smaller motors.

Figure 1 indicates the expected reductions in energy use and greenhouse emissions through 2008 – 2012, which is the first commitment period under international arrangements to reduce greenhouse emissions. The total savings of electricity and greenhouse gas are about 8,900 GWh and 7.7 $MTCO_2$-e respectively. At their peak in 2012, energy use and greenhouse emissions would be reduced by 0.7% relative to the BAU projections of the total amount of energy used by motors.

Figure 1: Profile of energy savings and greenhouse reductions



It is assumed that requirements beyond 2012 will be subject to a further review of regulatory options. Savings would continue to increase to about 1.5% of the projected levels if the regulation is maintained beyond 2012.

Assessment

Nationally, the proposed regulation is expected to deliver net benefits of $120M in present value terms and a benefit/cost ratio of 2.5. A significant investment is required from users, costed at $70M in present value terms. There will also be once-off costs of adjustment for suppliers, put at $10M. The additional cost to government is virtually zero, since the effect of the regulation is to strengthen a MEPS regime that is already in place.

The balance of benefits and costs to users is variable, depending on the types and size of motors that they use, and the intensity of use. For example, the returns are markedly higher in the industrial sector than in the commercial sector, reflecting the longer hours of operation in the former.

The overall assessment depends critically on the relationship between the percentage reduction in motor losses and the percentage increase in the cost of motors that deliver those reductions. The RIS draws on a number of studies to assess this tradeoff. While suppliers have suggested that the cost effects have been underestimated, the proposal remains cost-effective under their alternative estimates of cost impacts.

Other options

Minimum levels of energy efficiency could be further increased. However Australia 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 Australia. Australia is a small market, heavily reliant on imports, and there is no prospect that new models would be developed to meet specific Australian requirements.

The option of implementing MEPS by voluntary agreement was also considered, given that the European Union has adopted the voluntary approach. However that model is not a viable alternative to the proposed Australian regulation. In particular, the European agreement is much less ambitious compared with the level and scope of the efficiencies that will be required here.

Recommendations (draft)

It is recommended that:

1 States and Territories implement the proposed mandatory minimum energy performance standards.

2 Existing State and Territory regulations governing appliance energy labelling and MEPS be amended to implement the proposed standards.

1 The context for regulation

This regulatory impact statement (RIS) addresses a proposal to increase the minimum energy efficiency requirements of certain electric motors supplied in Australia. The proposal is part of the National Appliance and Equipment Energy Efficiency Program (NAEEEP), which is an element of the National Greenhouse Strategy (NGS). This section explains the policy context.

1.1 National Greenhouse Strategy

The Australian Government's response to concerns about the environmental, economic and social impacts of global warming was enunciated in the Prime Minister's statement of November 20, 1997, *Safeguarding the Future: Australia's Response to Climate Change.* In the statement the Prime Minister announced a package of measures to reduce Australia's greenhouse gas emissions designed to ensure Australia plays its part in the global effort to reduce greenhouse gas emissions while protecting the Australian economy.

The Prime Minister noted that the Government was seeking . . . *realistic, cost-effective reductions in key sectors where emissions are high or growing strongly, while also fairly spreading the burden of action across the economy.* He also stated that the Government is . . . *prepared to ask industry to do more than they would otherwise be prepared to do, that is, go beyond a "no regrets", minimum cost approach where this is sensible in order to achieve effective and meaningful outcomes.*

The NGS was subsequently endorsed by the Commonwealth, States and Territories as a commitment by governments to an effective national greenhouse response.

> *The Strategy maintains a comprehensive approach to tackling greenhouse issues. The range of actions it encompasses reflects the wide-ranging causes of the enhanced greenhouse effect and the pervasive nature of its potential impacts on all aspects of Australian life and the economy. (NGS 1998)*

The NGS is also the mechanism through which Australia will meet its international commitments as a party to the *United Nations Framework Convention on Climate Change*. The Australian government has announced its intention to meet an overall target by 2008-2012 of 108% of its 1990 emissions which is, in effect, a 30% reduction on the projected business-as-usual scenario that would occur in the absence of interventions.

1.2 Nationally Consistent Energy Efficiency Program

The proposed regulation is an element of the National Appliance and Equipment Energy Efficiency Program (NAEEEP). NAEEEP is part of the National Greenhouse Strategy and targets the energy efficiency of consumer appliances, industrial and commercial equipment. The main tools of the Program are mandatory energy efficiency labelling, minimum energy performance standards, and voluntary measures including endorsement labelling, training and support to promote the best available products.

NAEEEP's governance structure is as follows:

- The Program is the direct responsibility of the National Appliance and Equipment Energy Efficiency Committee (NAEEEC), which comprises officials from the Commonwealth, State and Territory government agencies, together with representatives from New Zealand, responsible for implementing product energy efficiency initiatives in those jurisdictions.

- NAEEEC reports through the Working Group for Energy Efficiency and Greenhouse Gas (E2G2) to the Ministerial Council on Energy (MCE), which is made up of the Ministers with portfolio responsibility for implementation of the National Greenhouse Strategy in this field.
- MCE has charged E2G2 to manage the overall policy and budget of the national program.

NAEEEP relies on State and Territory legislation to give legal effect. In turn, this legislation invokes the relevant Australian Standards for the specific product type. In the present case, State and Territory legislation will invoke AS/NZS 1359 series for 'rotating electrical machines', Part 5 in particular[1]. These arrangements are further explained in chapter 7, dealing with implementation of the proposals.

1.3 NAEEEP's policy framework

The broad policy directions of NAEEEP were reviewed in 1998-99 and again in 2000-01, with recommendations brought together in two 'Future Directions' documents (NAEEEC 1999 & 2001). The MCE subsequently endorsed certain changes, with the result that NAEEEP operates with the authority of the MCE with respect to broad policy objectives. These relate to product coverage, communication, and procedures and timetable.

Product coverage
Any type of consumer appliance, industrial or commercial equipment is eligible for inclusion in NAEEEP, 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. The measures adopted by NAEEEP are subject to a community cost benefit analysis and consideration of whether the measures are generally acceptable to the community.

Communication
NAEEEP develops its product strategies 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 by MCE to match the best MEPS level of Australia'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.

Related to that, NAEEEP uses the standards machinery that is familiar to industry. Labelling and standards requirements are implemented in Australian and New Zealand Standards, and developed in consultation with, and using the consultative machinery of, Standards Australia. On this occasion, there has been parallel development of Australian standard tests for motors, harmonising with existing international standards and development in those standards. These are described in further detail in chapter 3.

[1] AS/NZS 1359.5 – *Rotating electrical machines – General requirements. Part 5: Three-phase induction motors – High efficiency and minimum energy performance standards*.

NAEEEP 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.

1.4 Contribution of motors to energy use and greenhouse emissions

The total amount of energy used by three-phase motors, which are the subject of the proposed regulation, cannot be determined with great confidence. An earlier study by Energetics summarised the available estimates of the energy used by such motors as follows:

…

- *about 75% of industrial and agricultural energy use (excluding metal melting & smelting which is approximately 35% of total industrial energy use), ie 48.75% of total industrial energy use;*
- *about 50% of all commercial energy use (excluding small commercial establishments that are on a single phase supply and estimated to account for 50% of all commercial energy use) ie 25% of total commercial energy use;*
- *no residential energy use;*
- *no traction energy use. (Traction motors are usually DC and thus fall outside the scope of the study).*

(Energetics 1997: Book 1, page 13)

Based on these assessments, three-phase motors would account for about 42% of the electricity used by the combined commercial and industrial sectors, and about 30% of total electricity use.

The modelling reported in this RIS indicates that the energy used by three phase motors is somewhat higher, at 48% of the combined commercial and industrial electricity use, or 35% of total electricity use. These ratios are expressed relative to ABARE's historical estimates and projections for electricity consumption by sector (ABARE 1999 & 2003).

On that basis, table 1.1 provides estimates of the energy use and related greenhouse emissions of three-phase motors. The greenhouse emissions are expressed relative to the AGO's historical estimates and projections for greenhouse emissions by sector (AGO 2002). Over the period 1990 to 2010, ABARE estimates that there will be an 83% increase in energy use and a 63% increase in greenhouse emissions. The difference reflects the projected decline in the greenhouse intensity of electricity generation. Overall, there is a substantial increase in the proportion of greenhouse emissions attributable to the energy used by three-phase motors – from 9.4% to almost 14%.

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

	Energy use		*Greenhouse emissions*		
	GWh	*% of 1990 level*	*Mt CO_2-e*	*% of total emissions*	*% of 1990 level*
1990	46,244	100%	49.2	9.4%	100%
2000	72,265	156%	71.2	12.9%	145%
2010	84,686	183%	80.4	13.8%	163%

However it is important to distinguish between the gross energy used by motors and the energy losses that can be attributed to motors. The distinction arises because motors are intermediate devices that convert electrical energy into the mechanical energy required by a wide range of end uses.

For example, consider a 3kW motor that drives a water pump, running at full load, and is 75% efficient. This means that the motor uses 4kW of input power to provide 3kW of output power to the water pump, since efficiency is measured as the ratio of output power to input power (3kW/4kW = 75%). 3kW of power is used to do the work of the pump and 1kW is lost as the motor converts electrical energy into mechanical energy. A large part of the loss is in the form of heat that is generated by electrical resistance within the motor.

Importantly, an improvement in the energy efficiency of this motor can only reduce the amount of energy lost by the motor; it does not reduce the energy required by the pump. For example, a motor that is 80% efficient would deliver the 3kW required by the pump but lose only 0.75kW in the conversion process. (3kW/3.75kW = 80%). It may also be feasible to reduce the energy requirements of the pump but that would require a more efficient pump or some other change in the production process to reduce the demands on the pump. These are separate issues that are not affected by the efficiency of the motor.

Accordingly, it is sensible to focus on motor losses as the energy that is, strictly speaking, used by the population of electric motors - as distinct from the pumps, fans, compressors, conveyor belts, and all manner of other devices that are driven by motors. Table 1.2 presents this alternative perspective, indicating that motor losses account for about 1% of greenhouse emissions. These losses as estimated at about 8.2% of the gross energy that is used by motors, consistent with the modelling that has been undertaken for this report.

TABLE 1.2: MOTOR *LOSSES* AND GREENHOUSE EMISSIONS: 1990-2010

	Energy use		*Greenhouse emissions*		
	GWh	*% of 1990 level*	*Mt CO_2-e*	*% of total emissions*	*% of 1990 level*
1990	3,717	100%	4.0	0.8%	100%
2000	5,140	138%	5.1	0.9%	128%
2010	6,533	176%	6.2	1.1%	157%

1.5 Market failure

For there to be scope for regulations to achieve cost-effective reductions in motor losses, markets must be regarded as having failed to minimise the lifecycle costs of using motors.

Lifecycle costs of electric motors

The purchase price and the energy bills are the only elements of lifecycle cost[2] that are significantly affected by the proposed regulations. They also comprise the bulk of these costs.

Table 1.3 provides useful perspective on lifecycle costs, using the example of 4-pole[3] electric motor used in the industrial (manufacturing & mining) sector. It indicates that lifecycle energy bills are about 3-5 times larger than the purchase price of the motor itself. Energy costs are clearly a significant part of total motor costs. Ideally they would be given a weight in purchasing decisions that reflects their relative importance.

[2] Lifecycle costs also include the costs of monitoring, maintenance and repairs (including periodic rewinding of larger motors) but these are not significantly affected by energy efficiency measures.
[3] The number of poles determines the speed of the motor, with slower motors having more poles. They are commonly made with 2, 4, 6 or 8 poles.

TABLE 1.3 COMPONENTS OF LIFECYCLE* COSTS (4-POLE MOTORS ONLY)

Rated output (kW)	*Components of lifecycle cost ($/kW)*			*Ratio of energy bill to purchase price*
	Purchase price	*Energy bill for motor losses***	*Total*	
0.73 - 2.2	120	350	470	2.9
3 - 7.5	60	250	310	4.2
11 - 37	50	240	290	4.8
45 - 90	40	190	230	4.8
110 - 180	40	170	210	4.3

Notes
* Lifecycle costs are defined here to exclude monitoring, maintenance and repair costs that would not be significantly affected by efficiency measures.
** The lifecycle energy bill is the present value of energy bills discounted at 7% per year.

Motor system purchase and management practice
The US Department of Energy recently published the *Final Report of the United States Industrial Electric Motor System Market Opportunities Assessment* (DOE 2002). This assessment was intended to provide a blue print for the implementation of the Motor Challenge strategy, one of its tasks being develop a profile of motor system purchase and maintenance practices. Key findings[4] of relevance to this RIS are as follows:

- Overall awareness of energy efficient motors was found to be relatively low. Only 1 in 5 respondents to the survey were aware of premium-efficiency motors. A similar proportion indicated that they had purchased efficient motors over the previous 2 year period.
- Only 4% of respondents reported that they were aware of the efficiency ratings associated with the high or premium efficiency designation.
- Manufacturer's catalogues were the most frequently used references for motor selection but only 5% of customers reported using these resources regularly. Only one quarter were aware of any publications or tools whatsoever for guiding motor purchases.
- Only 11% of companies had written specifications for motor purchases, two-thirds of which included efficiency specifications.
- 40% of motors in use operated at less than 40% load, which is the point at which energy efficiency starts to fall away, particularly for smaller motors. This suggests that the practice of oversizing motors is widespread, resulting in both higher capital costs and higher energy bills.

Larger companies, particularly in motor intensive sectors such as petroleum, are more likely to have adopted better management practices. Overall, however the general finding is that ... *few facilities managers have implemented more than one or two elements of good motor systems purchasing and management practices. Many had implemented none*[5].

While no survey of this kind has been conducted in Australia, it is generally accepted by suppliers that these departures from best practice are similarly widespread here. Market failure is strongly suggested by observations such as the following:

- There are large differences between the energy efficiency of the least efficient and the most efficient motors on the Australian market. Motor losses commonly vary by 30-50% of the average loss. Even more efficient motors are available overseas.

[4] See Section 3 of the assessment report.
[5] DoE 2002: page 73

- Marketing sources report that energy efficiency is often not a primary or even a significant consideration in electric motor purchases. The apparent lack of concern is at odds with the fact that energy costs contribute significantly to the lifecycle costs of using a motor.
- The cost effectiveness of regulatory measures to promote energy efficiency has been demonstrated across a range of appliances and equipment in many countries, including electric motors in Australia.

The continued commercial success of inefficient motors can be traced to the fact that motors contribute only a small proportion of all costs of many operations where they are used. As a result, relatively little attention is given to their overall costs.

2 The objective

This section explains the objectives of the regulations, firstly in terms of completing NAEEEC's strategy for motors, and secondly in terms of the formal objectives against which the proposal is assessed in this RIS.

2.1 NAEEEP's motor strategy

Existing measures
The proposed regulations will substantially complete NAEEEP's package of motor measures. The following elements of the strategy have already been implemented through successive amendments to the AS/NZS 1359 series.

- The regulation of performance standards for three-phase motors on a national scale commenced in October 2001. This work was completed under the previous policy strategy, that is, prior to the MCE decision to accelerate the development process by focusing on world's best regulatory practice.
- In addition to the mandatory MEPS that apply to all motors that fall within the scope of the Standard, the national regime also requires motors that are designated as *high efficiency* to comply with specific efficiency requirements that are significantly more demanding than the mandatory MEPS. These will be referred to as 'conditional MEPS' hereafter. The conditional MEPS are a form of energy efficiency labelling, providing information that might not otherwise be readily obtained by users.
- It is recognised that it may not be cost-effective to mandate minimum energy efficiency requirements for certain types of motor. For that and other reasons[6], the following classes of motor are excluded from the MEPS requirements:
    - submersible (sealed) motors specifically designed to operate wholly immersed in a liquid;
    - motors that are integral with, and not separable from, a driven unit (an example is a motor constructed on the same shaft as a compressor for an air-conditioning unit);
    - multi-speed motors;
    - motors that have been granted exemption by the relevant Australia/New Zealand regulatory authority due to their application placing restraints on the motor dimensions or other key design aspects;
    - motors for use only for short-time duty cycle applications (eg. those used for hoists, roller doors and cranes) which have a duty type rating of S2 under the IEC 60034-12;
    - rewound motors, unless claimed to be 'high efficiency'.
- AS/NZS 1359 also requires that rating plates be attached to motors and that ... *The motor efficiency marked on a rating plate, specified in technical literature or otherwise claimed shall not exceed the value obtained by a test undertaken by or for the supplier.* Claims of energy efficiency are liable to be check tested subject to specified tolerances.

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6 The other main exclusions are motors that are imported as part of original equipment. For the purposes of state and territory legislation these are not regarded as *supplied* in Australia. However the regulation applies to all motors that are included in original equipment that is manufactured in Australia, provided the motor is separable from the equipment. This applies regardless of whether the motors are imported directly by the manufacturer or are obtained through an importer, and regardless of whether the equipment is destined for export or for domestic use.

- Finally, the Standard provides for the registration of motors if required by State or Territory regulatory authorities. Where registration is not required it also provides for the regulator's access to the supplier's test data, which is the option adopted by New Zealand. However, registration – and the possibility of deregistration – is a key element in the existing Australian compliance regime
- In 2000, a revised test method for motors was also published (AS/NZS 1359.102.3). The revised method provides equivalent results to the US test method of the Institute of Electrical and Electronic Engineers (IEEE) 112-B, which is recognised as superior to the European method that had previously been used in Australia. Both methods are now accepted under AS/NZS 1359.5.

NAEEEP has been using the only NATA-accredited test facility in Australia to verify electric motor compliance (referred to as *check testing*). However this laboratory is located within the Melbourne premises of a motor supplier, CMG, and there have been complaints from CMG's competitors about these arrangements. NAEEEP is therefore encouraging the establishment of an independent test lab for electric motors, by paying for the NATA accreditation of a laboratory and offering some level of revenue from guaranteeing the check testing of a certain number of motors for NAEEEC. The establishment of an independent NATA lab is a priority for NAEEEP and should be operational in 2004.

Outside the Standards process, NAEEEC also works with stakeholder groups to promote highly efficient equipment, using market transformation programs. NAEEEC (2002b) describes a range of complementary initiatives, as follows:

- Provision of a database and internet search facility to provide product information by size, speed and efficiency.
- Support for the Motor Solutions Online web site and database to assist with motor selection and optimisation of motor systems.
- Codes of practice and conduct for motor suppliers to encourage accurate disclosure of information.
- Provision of training and assistance to industry in the testing and measurement of motors and motor system energy performance.
- Development of best practice programs in conjunction with industry groups to encourage energy efficiency in electric motors and motor systems.

Development of new measures to complete the strategy

The proposed regulation provides for increased stringency of the mandatory MEPS from April 2006 plus commensurate increases in the conditional MEPS that apply to motors designated as 'high efficiency'. Importantly, the high efficiency designation signals NAEEEC's intentions beyond 2006, which it does in two ways. First, NAEEEC has indicated to industry that, after 2006, there would be no further increases in MEPS until 2012. Second, it has indicated to industry that the 2012 MEPS will not exceed the conditional MEPS for high efficiency appliances that are proposed for 2006. It follows that the proposed regulation offers industry a clear view of regulatory developments to 2012 and beyond.

To determine the proposed MEPS, NAEEEC followed the MCE's policy directive to explore levels that are commensurate with MEPS adopted by Australia's trading partners, thereby using international developments as the benchmark for regulatory proposals in Australia. Given Australia's status as a large net importer of electrical appliances and equipment, NAEEEC considers that it would be excessively costly to adopt standards that are significantly at odds with major trading partners. By contrast, the 2001 MEPS were developed over many years using a market regression analysis, the aim of the current MEPS being to retire 40% of the available models, but without explicit reference to international developments.

To implement the strategy of world's best regulatory practice it is first necessary to review the regulatory arrangements of other countries. Much of this information was brought together in a report commissioned by NAEEEC (2002a). The proposed relationship between the regulatory regimes in Australian and its trading partners is as follows:

- Where possible, the proposed 2006 MEPS have been aligned with the most demanding of the three classes of motor efficiency that have been defined by the European Union (EU). This is the so-called 'efficiency 1' or 'eff1' class of motors. This is appropriate, given that there are certain similarities between the electricity supply systems of Europe and Australia (both have a frequency of 50 Hz) and that European companies are major suppliers to the Australian market. The key differences are as follows:
    - EU has entered into voluntary agreements with suppliers rather than impose minimum requirements.
    - The voluntary agreements are to adopt 'eff 2' as the standard motor specification, which corresponds to the MEPS adopted by Australia in 2001. The 'eff 1' standard applies only for labelling purposes.
    - The voluntary agreements relate only to 2 and 4-pole motors, leaving the 6 and 8-pole motors unregulated.
    - The EU regime applies to motors rated up to 90 kW, whereas the Australian regulation extends to motors of 150 kW.
- The proposed 2006 MEPS are comparable with the MEPS introduced by the United States in 1997 and subsequently by Canada, allowing for the fact that the US practice is to regulate the average performance of each design rather than specify a minimum performance as occurs in Australia. The correspondence is particularly close for 2 and 4-pole motors. The main differences are as follows:
    - The Australian requirements for 6-pole motors are somewhat less demanding than in North America. This relaxation recognises the difference in frequency of the power supply, which is 50 Hz in Australia and 60 Hz in North America. The increase in speed means that 6-pole motors are a relatively high volume product in North America and that efficiencies are somewhat easier to achieve.
    - 8-pole motors are unregulated in North America.

  Notwithstanding these differences, NAEEEC's proposal for 2006 is essentially to follow the US and Canadian lead with a lag of 9 years.
- There are similarities between Australia and a number of Australia's trading partners – specifically, China, Taiwan, Thailand, Malaysia and Brazil. They currently have (or will soon have) MEPS that are broadly similar to Australia's 2001 MEPS, and have defined high efficiency standards that are similar to those *currently* applying in Australia. However, they have not taken the further step of converting the current high efficiency standards into a future MEPS. Thailand and Malaysia are possible exceptions, having indicated that the transition will occur in 2008 and 2009 respectively. Details are not available.

Overall, the Australian proposal is to adopt the North American *approach* to regulation but using EU efficiency *benchmarks* where possible. The North American approach is to explicitly regulate for high efficiency, whereas the EU approach is based on voluntary agreements at a lower level of efficiency. However EU has defined high efficiency motors (eff 1) for labelling purposes. That benchmark is familiar to the European manufacturers that are major suppliers in the Australian market and has been adopted for the 2006 MEPS wherever possible.

In addition, the Australian proposal goes beyond overseas practice in one respect, in that MEPS have been extended to 8-pole motors. This is a small market, accounting for about 2% of total sales that fall within scope of the regulation. The loss reductions required of 8-pole motors are much the same as required from the 4 and 6-pole motors and will require the upgrading of a similar proportion of the models that are currently registered.

It needs to be kept in mind that the 2006 MEPS will be fixed at least until 2012, during which time there will be regulatory changes in other countries. All of these countries are on rolling programs of increasing MEPS, but moving to different timetables. Different countries will 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 Australia 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. Specifically, Australia will match the leaders in 2006 but fall back in relative terms as it is matched or leap-frogged by other countries in the years after 2006. Over the long haul the effect will be for Australia to broadly keep pace with its reference group, not with a particular country.

Options considered in the previous RIS
In selecting traditional or 'command and control' regulation to complete the motors strategy, NAEEEC has implicitly rejected a number of alternative approaches, including voluntary arrangements, levies and targeted regulation. These alternatives are explained in the following chapter, and a shortlist of options is subject to detailed consideration in chapter 4.

2.2 Specific objectives of the proposal

The objective of the proposed regulation is to reduce Australia's greenhouse gas emissions from the use of electric motors, subject to the following constraints:

- The measures need to be cost-effective for the broad community of users.
- 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.

It is not envisaged that the measures will be cost-effective for all users, always and everywhere. There will be circumstances where particular electric motors are so lightly used that increases in appliance costs are larger than expected small savings in energy savings. Cost-effectiveness is interpreted in terms of the interests of the broad community of users.

3 Options

NAEEEC's options for finalising the motor strategy are explained here, and a shortlist of options is provided for more detailed consideration in chapter 4. The first two sections deal with options for the stringency of the proposed MEPS, including the option of maintaining the *status quo*. The remaining sections deal with a series of options that depart from the proposal in some other significant respect.

3.1 The proposed regulation

The proposed MEPS are tabulated in appendix 1, differentiated according to the size of the motor and the number of poles. For technical reasons it is easier to achieve high efficiency for more powerful motors and harder to achieve high efficiency for motors with more poles. (Appendix 1 provides a more detailed explanation of these differences.) Accordingly, MEPS are set higher for larger motors. Except for the largest motors (>45 kW), the MEPS are set lower for 6-pole and 8-pole motors than for 2-pole and 4-pole motors.

Figure 3.1 summarises the existing and proposed MEPS regime for 4-pole motors, which account for about 75% of the market. The MEPS are shown against a scatter diagram representing the 876 4-pole motors that have been registered with the Australian Greenhouse Office. Each point in the scatter represents the output power and efficiency ratio of a registered model.

Three MEPS levels are shown, as follows:

- The existing mandatory MEPS were introduced in October 2001 and are shown as '2001 MEPS'.
- It is proposed that the conditional 2001 MEPS applying to high efficiency motors will become the mandatory MEPS from 1 April 2006.
- The highest level of MEPS is the conditional MEPS applying to high efficiency motors from 1 April 2006.

FIGURE 3.1: EFFICIENCY OF REGISTERED MOTORS, COMPARED WITH EXISTING AND PROPOSED MEPS (4-POLE MOTORS ONLY, USING TEST METHOD A)

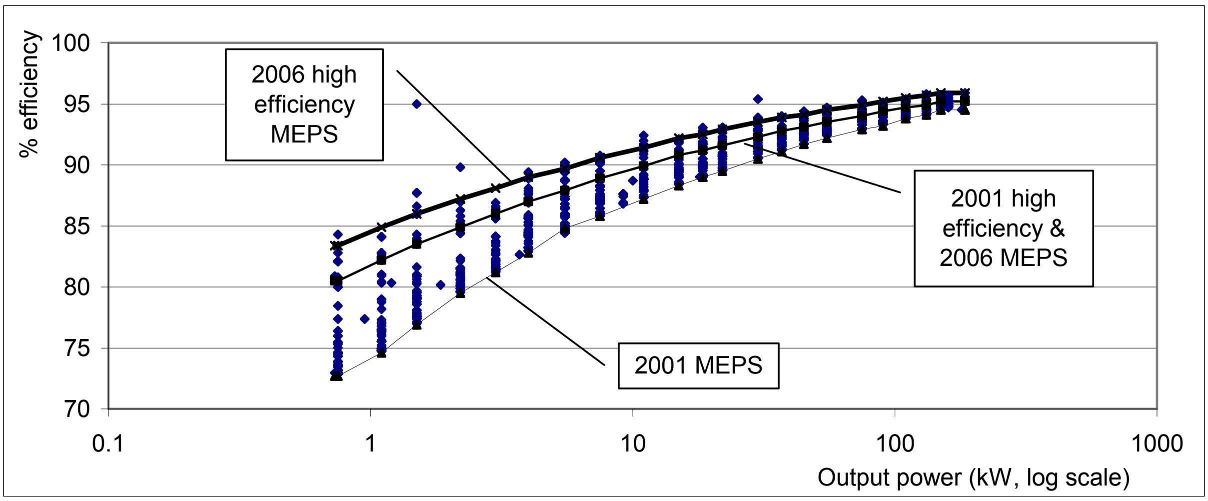
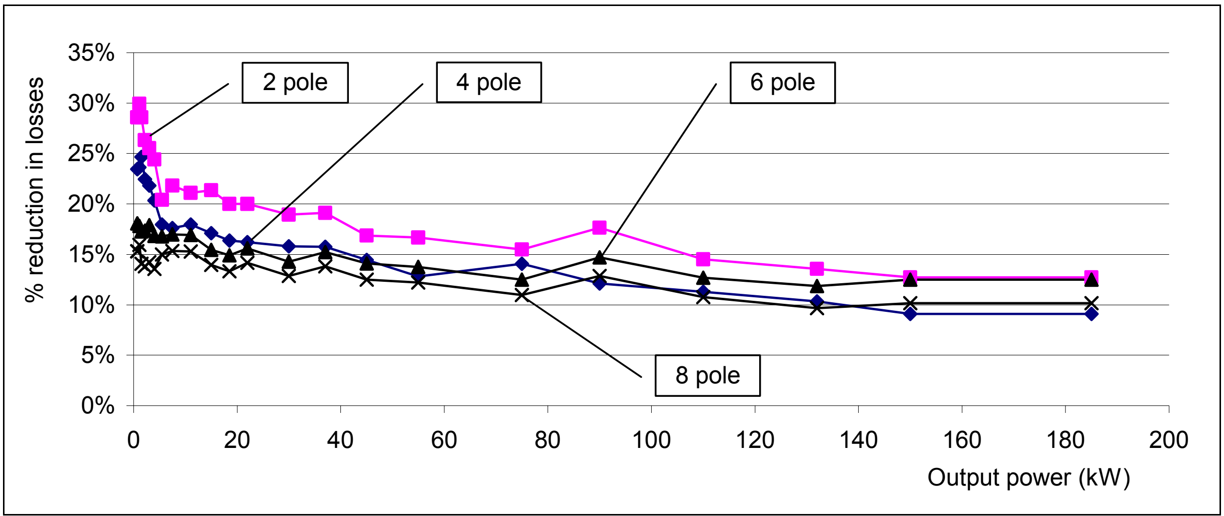


Figure 3.2 reports a comparison of the 2001 and 2006 MEPS in terms of the percentage reduction in motor losses that are required by a 'borderline motor'. Most of the loss reductions are in the range 10-20%, with the exception of the smallest 2-pole and 4-pole motors, where the required loss reduction ranges up to 30%. In general, larger motors are required to achieve smaller loss reductions.

Relative to the mandatory 2006 MEPS, the conditional 2006 MEPS for high efficiency motors would require a further 15% reduction in energy losses.

FIGURE 3.2 REQUIRED REDUCTION IN MOTOR LOSSES – 2006 MEPS COMPARED WITH 2001 MEPS



The adoption of world's best regulatory practice in 2006 will affect about 70% of the models that were registered with the AGO in mid 2003. A breakdown of non-compliance rates by output power and number of poles is provided in figure 3.3 and table 3.1. On average, there are about 22 models in each of the occupied cells. The general pattern is for the non-compliance rate to fall in the range 50-70%. The main exceptions are, first, many of the smaller types of motors have non-compliance rates that range up to 90%, and second, virtually all of the cells with only one registered model return a non-compliance rate of 100%. That is, the single model does not comply.

3.2 Options for higher and lower MEPS

The proposed regulation is effectively defined by figure 3.2, which sets out the required reductions in motor losses. The requirements could be tightened or relaxed in two ways. Either the minimum requirements could be raised or lowered, or the implementation date could be advanced or delayed. Given the large number of potential combinations, it is necessary to identify reasonable combinations for comparison with the proposal.

The business as usual option

It is necessary to compare the proposal with the option of maintaining the existing regulatory position. This is the *status quo* or business as usual (BAU) option. It would preserve the motor strategy that is already in place but the proposed increase in stringency would not occur. Specifically, the efficiency of three-phase motors would continue to be constrained by the 2001 MEPS, with the minimum levels of efficiency increasing with the output power of the motor.

FIGURE 3.3 NON-COMPLIANCE RATES FOR MOTORS, AGAINST 2006 MEPS

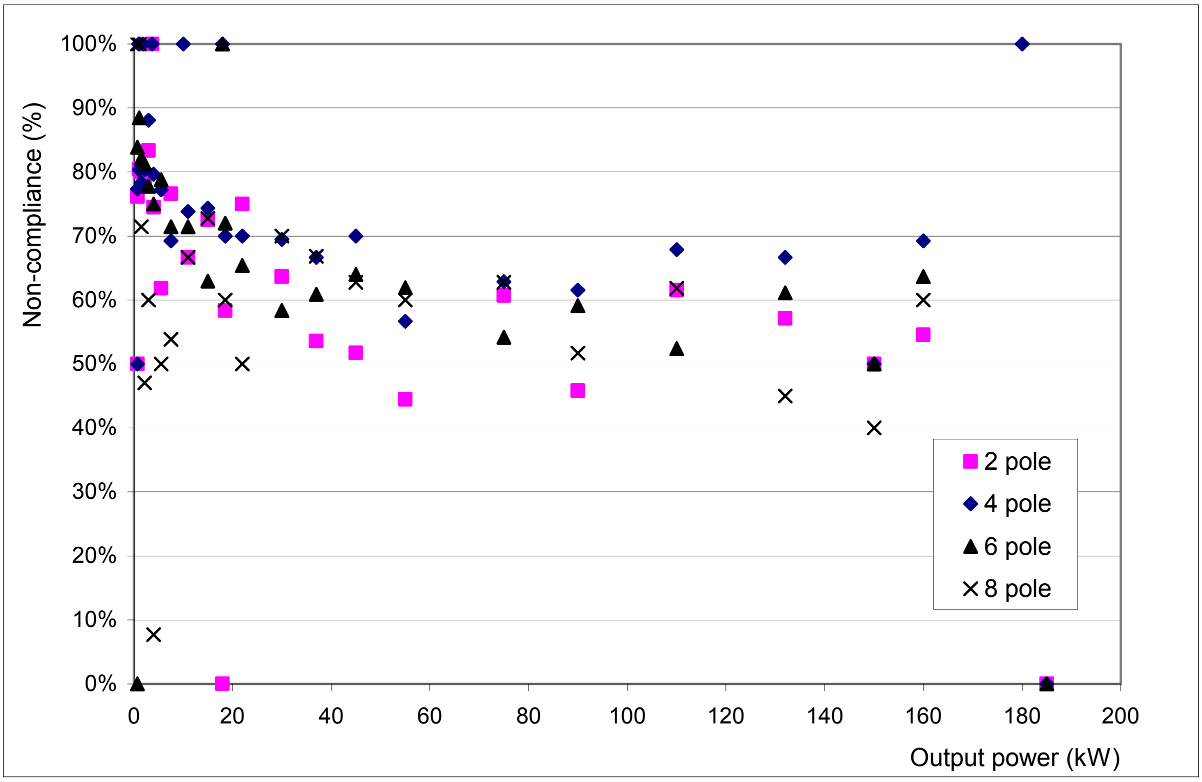


TABLE 3.1 NON-COMPLIANCE RATES FOR MOTORS, AGAINST 2006 MEPS

Output power (kW)	*Number of poles*				*Total*
	2	*4*	*6*	*8*	
0.73 – 4	78%	79%	82%	78%	79%
5.5 – 11	73%	79%	77%	52%	74%
15 – 30	65%	71%	66%	72%	68%
37– 75	51%	63%	60%	72%	59%
90 – 185	57%	64%	56%	44%	57%
Total	68%	73%	70%	65%	70%

The outlook is not one of zero efficiency gain under the BAU option. In the previous RIS (GWA 2000) it was projected that efficiency would increase by 0.05 – 0.15 percentage points per year under BAU conditions, with slower rates of growth for the larger motors. This assumes a continuation of efficiency improvements that have been observed since the issue was first addressed in a report commissioned by the Department of Primary Industries and Energy in the mid 1990s (Energetics 1997). All round improvement at the rate of 0.1 percentage points per year is assumed for the purposes of this RIS.

The leadership option

It is also necessary to consider the alternative of adopting even more stringent requirements than are proposed. Rather than follow world's best regulatory practice, Australia would 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 motors that would qualify as high efficiency units under the proposal. Specifically, the leadership option would be to raise the mandatory 2006 MEPS to the proposed high efficiency level, reducing motor losses by a further 15%. All but a handful of the models that are currently registered would fail to comply with such standards.

Options for delayed implementation

The proposal is for implementation in April 2006. There is no scope to bring this date forward without seriously limiting the adjustment time that is available to both suppliers and users. However, implementation could clearly be delayed further and that option needs to be explicitly considered.

3.3 Options for excluding certain classes of motor

Certain classes of motor are currently excluded from the MEPS requirements, either because it is not feasible or not cost-effective to include them. These are listed in section 2.1. Since the proposal is to make the MEPS more stringent, it is conceivable that certain types of motor should be excluded from the *increase* in MEPS. Any such fresh exclusion would still be subject to the 2001 MEPS. Certain suppliers have raised two issues in this context.

The first is the status of 8-pole motors, since 8-pole motors are not subject to energy performance requirements in either North America or Europe. However the option of excluding 8-pole from the increase in MEPS does not appear separately on the shortlist of options. The issue is addressed as part of the overall assessment of the stringency of the MEPS.

The second issue is the status of motors with certain duty ratings. (The 'duty' of a motor refers to the time and load profiles of operations for which it is designed.) Ten such ratings are defined in the standards and can be summarised as follows:

- *S1 – continuous running duty:* These motors are appropriate for loads that are maintained for periods that are sufficient to allow the machine to reach equilibrium temperature. There is no question that these motors would be excluded.
- *S2 – short time duty:* These motors are used intermittently for short periods and are already excluded.
- *S3, S4 & S5 – intermittent periodic duty, with or without starting and/or braking:* The usual approach to increasing efficiency, which involves making the motor somewhat heavier, can be counterproductive for some of these motors. This is because the additional energy required to start or to stop the motor can exceed the energy savings while operation normally.
- *S6, S7 & S8 – continuous-operation periodic duty, with or without braking and/or load and speed changes:* As in the previous case, the usual gains are offset by the additional energy needed to increase and decrease speeds and loads.
- *S9 – non-periodic load and speed variations:* As in the previous case, the usual gains are offset by the additional energy needed to increase and decrease speeds and loads.
- *S10 – discrete constant loads:* There is no question that these motors would be excluded. While there are load changes, each phase is maintained long enough for the motor to reach thermal equilibrium.

Ideally, some motors with S3- S9 duty ratings would be excluded from the 2006 MEPS. These would be motors on relatively short cycles characterised by a high incidence of starts, stops and other speed changes, with short intervening periods of steady operation. However options of this kind have not been included in the shortlist for detailed consideration in chapter 4, for the following reasons:

- Advice from AGO's technical consultants and steering group is that the candidates for exclusion comprise a small minority of motors within these broad groups and would not justify exclusion of entire classes of motors with particular duty ratings.

- The Standard also allows the regulatory authorities to grant exemptions on a case by case basis … *due to their application placing restraints on the motor dimensions or other key design aspects.*

Overall, the view is that it is better to rely on the discretionary powers of the regulatory authorities to deal with small exemptions rather than further complicate the explicit rules that are built into the proposed regulation.

3.4 Option of a minimalist regulation

The Australian motor standards (AS/NZS 1359 series) contain 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 (MEPS) but to do without one or more of the supporting provisions. The aim would be to adopt a minimalist regulation, unencumbered by the provisions relating to the practicalities of testing, registration and labelling.

In the present case, however, all but one of the supporting provisions are part of the BAU scenario and are left unchanged by the proposed increase in MEPS. (See the list of 'existing measures' in section 2.1.) The one exception is that the proposed regulation will alter the conditional MEPS applying to motors that are designated as 'high efficiency'. However the logic of the high efficiency designation is unchanged. Specifically:

- The high efficiency designation provides consumer information that would not otherwise be available. In the absence of regulation the designation tends to be used indiscriminately to describe motors that offer little or no efficiency premium, to the point where the designation loses all practical meaning.
- No additional costs are imposed on suppliers since they must test for efficiency in any case.
- There is no obligation on suppliers to use the designation even if their motors satisfy the conditional MEPS criteria.

It is common practice for other countries to include a high efficiency category in their MEPS or MEPS-like arrangements. And it was noted in chapter 2 that, given NAEEEC's undertakings to industry, the high efficiency designation provides industry with an indication of the maximum possible increase in MEPS in 2012.

All of these supporting measures were assessed as cost-effective in the earlier RIS (GWA 2000: section 4.3) and are effectively unchanged. Accordingly, they are not further assessed in this RIS.

3.5 Option of reduced government role in regulation

The proposal is that the minimum energy efficiency of motors be subject to explicit government regulation. That is one form of regulation. ORR (1998) 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-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 previous RIS (GWA 2000) under the heading of 'Voluntary MEPS', referring mainly to the option of self-regulation. This needs to be further considered, given the voluntary agreement that has since been adopted by the European Union.

3.6 Option of using alternative instruments

ORR 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 are not given further consideration in this RIS. As discussed in chapter 2, the motors strategy already includes initiatives of this kind, comprising the *Australian Motor System Challenge*. Nevertheless, NAEEEC considers that significant opportunities for cost-effective increases in energy efficiency remain. This basic proposition is assessed in chapter 4.

The previous RIS also briefly considered the options for market based instruments – specifically, levies on the use of energy or on the use of inefficient equipment. However, these are major policy issues for the highest level of governments. They would not be decided by NAEEEC or even necessarily by MCE. Nor would they be decided in relation to specific items of equipment such as motors, since such schemes would apply to inefficient equipment generally or to the use of energy generally. They were rejected in the previous RIS and no longer represent realistic alternatives that could be considered by MCE. Accordingly, these options are not further considered in this RIS.

3.7 Shortlist of alternative options

Based on the above analysis, the proposal needs to be compared with the following alternatives:

- The business as usual option, including maintenance of the existing MEPS and supporting arrangements in respect of testing, registration, labelling and the designation of high efficiency motors.
- The leadership option, requiring Australia to set the pace in terms of motor efficiency.
- The delayed implementation option, providing the industry with additional adjustment time.
- The voluntary agreements option, drawing on the experience of the European Union.

4 Impacts analysis

This chapter is organised in 8 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 four sections, first to bring together the results of the first four sections in a single statement, then to assess various alternatives to the proposed regulation, as follows:

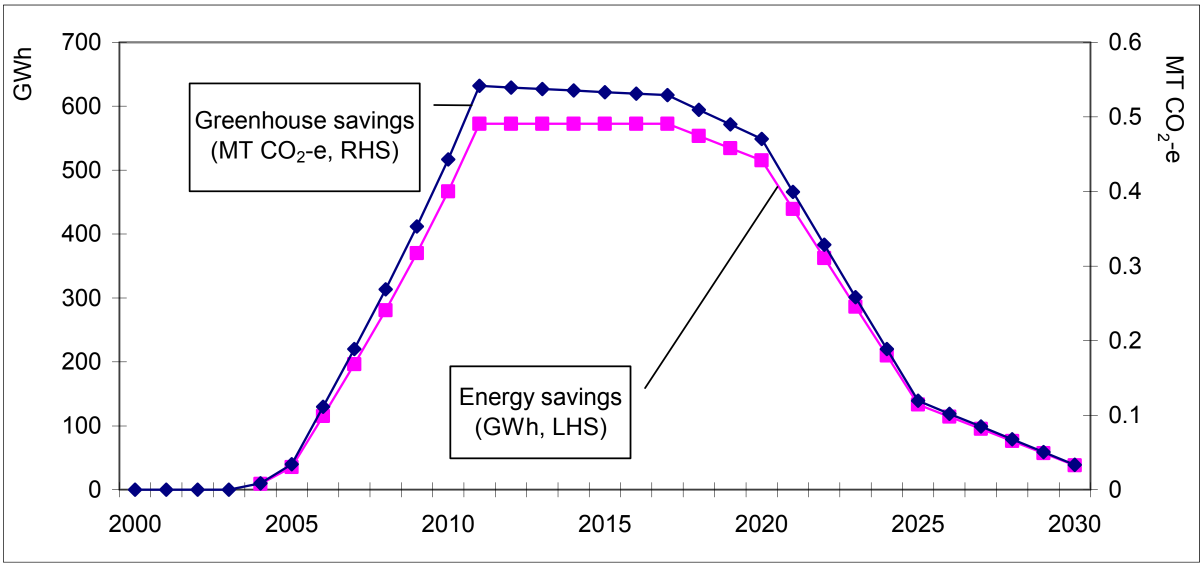
- National costs and benefits – section 4.5
- Assessment of more demanding options – section 4.6
- Assessment of delayed implementation – section 4.7
- Assessment of Voluntary Agreements – section 4.8

4.1 Impact on energy use and greenhouse emissions

Figure 4.1 reports estimates of the expected reductions in energy use and greenhouse emissions. The profile of savings over time reflects the following considerations:

- It is assumed that motor suppliers need to start introducing more efficient motors to the market some time before 2006, which means that the savings start to accumulate from, say, 2004.
- The regulation is assumed to have a life of 6 years and that a fresh regulatory decision will be taken in 2012. It follows that the proposal will only affect motors sold in the period to 2012, hence the sharp increase in annual energy and greenhouse savings to 2012.

FIGURE 4.1: PROFILE OF ENERGY SAVINGS AND GREENHOUSE REDUCTIONS



- Annual savings start to fall away after 2015 as the motors acquired in the period to 2012 are retired and replaced. (The assumptions about average life and retirement patterns are detailed in appendix 2.)
- The greenhouse savings grow somewhat more slowly than the energy savings, and the relative size of the gap between the two increases over time. This reflects the expectation that the greenhouse intensity of electricity generation will decline over time, for example, due to fuel switching from coal to gas.

The total savings of electricity and greenhouse gas are about 8,900 GWh and 7.7 $MTCO_2$-e respectively. At their peak in 2012, energy use and greenhouse emissions would be reduced by 0.7% relative to the BAU projections. However, the transition to more efficient motors would be incomplete at this stage. The savings would continue to increase to about 1.4% of the projected levels if the regulation is maintained beyond 2012. In the longer term, however, it is increasingly difficult to know how the regulation would differ from the normal processes of technological change and efficiency improvement.

Some energy efficiency experts believe that the energy used by motors can be reduced by 20% or more. However, these larger gains require users to make significant changes to the industrial and commercial processes that are motor driven, and also to optimise their motor selection in terms of size and other design characteristics. The impact of the proposed regulation has been assessed on the assumption that these systematic features of motor use are unaffected by the regulation.

4.2 Impact on users

Benefit cost analysis, by market segment

It is clear that the savings in energy costs to users will be offset by some increase in the purchase price of motors. There are few 'free lunches', if any. The critical factors are, firstly, the relative size of the energy bills and the purchase price for the BAU motor, and secondly, the impact of the MEPS on the motor losses relative to its impact on the purchase price. (Note that the 'energy bill' is defined here as the cost of the energy absorbed in *motor losses*, putting aside the energy transformed by the motor into mechanical energy.)

It is convenient to define these factors as two ratios, as follows.

Loss/price ratio =	ratio of the lifecycle energy bills to purchase price, for the BAU motor
∆loss/∆price ratio =	ratio of percentage reduction in losses to percentage increase in price when a motor with higher efficiency is used. (∆, pronounced 'delta', denotes the change in a variable, but is measured here as the percentage change.)

The benefit/cost ratio for the investment in higher efficiency can then be obtained by multiplying the first ratio by the second, expressed as follows:

Benefit/cost ratio = Loss/price ratio X ∆loss/∆price ratio

For example, suppose that *Loss/price ratio* is 5.0, which means that the lifecycle energy bill for the BAU motor is 5 times greater than its purchase price, and the *∆loss/∆price ratio* is 1.0, which means that the percentage reduction in motor losses equals the percentage increase in the purchase price when the higher efficiency motor is adopted. It immediately follows that the benefit/cost ratio for the investment in higher efficiency is 5 to 1. This is because the same proportional change is applied to an amount that is 5 times larger on the benefit side than on the cost side. A reduction in the *∆loss/∆price ratio* (say, to 0.5) would reduce the benefit/cost ratio (to 2.5 in this case).

Estimates of the Loss/price ratio
Table 4.1 reports representative estimates of the *Loss/price ratio* for the industrial and commercial sectors. The assumptions underlying these estimates are detailed in appendix 2. The technical assumptions – relating to years of life, duty hours and loads – are from European sources. The price assumptions – relating to energy tariffs, purchase prices and discount rates – are from Australian sources.

The relative size of energy and purchase costs is highly variable, ranging from approximate equality through to the situation where energy costs are 5 or more times larger than the purchase price. Note that the ratio is systematically higher in the industrial sector. This reflects the higher duty hours of industrial motors. By contrast, commercial motors would average 50-60% of the industrial hours. However, the difference is partly offset by the higher energy tariffs paid in the commercial sector.

TABLE 4.1 ESTIMATES OF THE *LOSS/PRICE RATIO*

Rated output (kW)	*Industrial sector*				*Commercial sector*			
	2-pole	*4-pole*	*6-pole*	*8-pole*	*2-pole*	*4-pole*	*6-pole*	*8-pole*
0.73 - 2.2	5.2	3.9	3.6	3.0	2.8	2.1	1.9	1.6
3 - 7.5	5.1	5.1	3.7	2.6	2.5	2.5	1.8	1.3
11 - 37	5.4	5.4	4.7	3.3	2.5	2.5	2.2	1.5
45 - 90	5.1	5.2	3.5	2.4	2.3	2.3	1.6	1.1
110 - 180	4.5	4.5	3.1	2.8	2.0	2.0	1.4	1.2

Estimates of the *Δloss/Δprice ratio*
Estimates of the *Δloss/Δprice ratio* can be extracted from a number of studies that have assessed the tradeoff between efficiency gains and price increases. These are reviewed in appendix 2. The most relevant of these is a European assessment (Parasiliti et.al. 1999) of the transition from EFF2 motors to EFF1 motors, which corresponds to the transition from Australia's 2001 MEPS to the proposed 2006 MEPS. A conservative interpretation of those estimates would be to set the *Δloss/Δprice ratio* at 1.1. This means that a 10% increase in prices is associated with an 11% reduction in losses.

This is consistent with the other studies that are reviewed in appendix 2. Studies that return higher estimates of the ratio (greater than 2.0) address earlier stages in the transition from less efficient to more efficient motors. Studies that return lower estimates (1.0 or less) address later stages in the transition, taking efficiency beyond that required by the proposed 2006 MEPS. Overall, the pattern is for the *Δloss/Δprice ratio* to decline as losses are progressively reduced, reflecting increases in the marginal cost of reducing motor losses.

Suppliers have put the ratio somewhat lower, in the range of 0.5 to 0.7. Specifically, they suggest that a 15% reduction in motor losses, which is broadly what is required to make the transition from the 2001 MEPS to the 2006 MEPS, would require a 30% increase in purchase price. In the absence of any supporting evidence, the approach taken in this RIS is to put the baseline estimate at 1.1 but to report the effect of lower *Δloss/Δprice ratios* on the benefit/cost ratio.

Benefit/cost ratios for investments in more efficient motors
Table 4.2 presents estimates of the benefit/cost ratio, obtained by multiplying the entries in table 4.1 by various estimates of the *Δloss/Δprice ratio*. The benefit/cost ratio is always greater than 1.0 if European estimates of the *Δloss/Δprice ratio* are adopted – see the first panel. The benefit/cost ratio ranges up to 5.9 in this case – see the first panel of the table. The overall pattern is for the industrial sector to return higher benefit/cost ratios than the commercial sector, and for the 2 and 4-pole motors to return higher ratios than the 6 and 8-pole motors.

The benefit/cost ratios are much smaller if supplier estimates of the *Δloss/Δprice ratio* are adopted. In the extreme case (bottom panel) the benefit/cost ratio becomes marginal or falls below 1.0 in the commercial sector.

The middle panel of table 4.2 represents an intermediate position that gives significant weight to supplier claims about the effect on price. 8-pole motors in the commercial sector remain marginal or fall below 1.0 in this case.

TABLE 4.2 ESTIMATES OF THE BENEFIT/COST RATIO

Rated output (kW)	*Industrial sector*				*Commercial sector*			
	2-pole	*4-pole*	*6-pole*	*8-pole*	*2-pole*	*4-pole*	*6-pole*	*8-pole*
Δloss/Δprice ratio = 1.1								
0.73 - 2.2	5.7	4.2	3.9	3.2	3.0	2.3	2.1	1.7
3 - 7.5	5.6	5.6	4.0	2.8	2.7	2.7	2.0	1.4
11 - 37	5.9	5.9	5.2	3.6	2.7	2.7	2.4	1.7
45 - 90	5.6	5.7	3.8	2.6	2.5	2.6	1.7	1.2
110 - 180	5.0	5.0	3.4	3.0	2.2	2.2	1.5	1.4
Δloss/Δprice ratio = 0.7								
0.73 - 2.2	3.6	2.7	2.5	2.1	1.9	1.4	1.3	1.1
3 - 7.5	3.5	3.5	2.6	1.8	1.7	1.7	1.3	0.9
11 - 37	3.8	3.8	3.3	2.3	1.7	1.7	1.5	1.1
45 - 90	3.6	3.6	2.4	1.7	1.6	1.6	1.1	0.8
110 - 180	3.2	3.2	2.1	1.9	1.4	1.4	1.0	0.9
Δloss/Δprice ratio = 0.5								
0.73 - 2.2	2.6	1.9	1.8	1.5	1.4	1.0	1.0	0.8
3 - 7.5	2.5	2.5	1.8	1.3	1.2	1.2	0.9	0.6
11 - 37	2.7	2.7	2.4	1.6	1.2	1.2	1.1	0.8
45 - 90	2.6	2.6	1.7	1.2	1.2	1.2	0.8	0.5
110 - 180	2.3	2.3	1.5	1.4	1.0	1.0	0.7	0.6

Supply side considerations

The above cost benefit analysis is based on implicit assumptions about the supply of motors to Australian users. Specifically, it is taken for granted that increased Australian demand for more efficient motors will be accommodated at observed market prices and that any supply bottlenecks will be relatively temporary. This is a reasonable assumption given that motors are freely traded internationally and Australia is a very small part of the international market. Changes in the Australian market would not trigger significant constraints on the supply side.

There are a number of other positive indications that market competition will continue to be vigorous, as follows:

- All suppliers who had examined the issue indicated that they will continue to operate in the industry.
- The burden of adjustment is evenly distributed across the market – see table 3.1. With the possible exception of the largest 8-pole motors, there is no market segment without a significant minority of complying product already in existence.
- The market is diverse. Seventeen brands are registered with the AGO, with an average of 145 models each.
- The technology is mature, indicating that there are no significant barriers to entry into the market for more efficient motors.

That said, one issue of concern is that the existing product range, which complies with the 2001 MEPS, may not be replaced on a one-to-one basis with products that comply with the 2006 MEPS. Some gaps will appear in the product range. For example, one supplier has indicated that they will withdraw from some of their small markets for 6 and 8-pole motors. Other suppliers have yet to examine their sourcing options and leave open the possibility that some types of product may not be replaced. All agree that new models will not be designed specifically for the Australian market.

However this does not mean that a user will actually be denied the use of a suitable motor. Gaps can be filled in several ways:

- Gaps in the product range can be filled either by the ‘specials’ industry or by changing the drive arrangements between the motor and the application, for example, by using a gearbox. ‘Specials’ are motors built to specifications when the appropriate product cannot be sourced directly from manufacturer catalogues.
- Original equipment manufacturers (OEMs) have the option of importing non-complying products directly for use in their motor-driven products, since these imports are not regarded as *supplied in Australia*.
- As a last resort, the regulatory authority can grant exemptions where application of the standard places restraints on the motor dimensions or other key design aspects.

These are all more costly options in terms of both purchase price and replacement delays, with the practical effect of increasing the *Δloss/Δprice ratio* and reducing the benefit/cost ratio.

Discussion

Table 4.2 gives a sense of the range of possible outcomes but it cannot do justice to the variety of outcomes that will actually occur. Each cell of the table is still the average across many motors and many users. Within each cell, some motors will return a low benefit/cost ratio because they are used less intensively than the average, or their life is truncated by poor motor management or the closure of production facilities, or because particularly cheap energy is available. Others will return much higher benefit/cost ratios.

The direct impact on individual users depends on the particular mix of motors that they use (viewed as motors from a number of different cells in table 4.2), how intensively they use the motors, and how well the motors are maintained. In addition, however, all users operate in a value chain comprising customers and suppliers who also use motors, and what matters most to individual users is the competitiveness of the entire value chain in which they operate. It is therefore necessary to focus on broad outcomes, averaging the good with the bad across many users. Section 4.5 adopts the broadest possible perspective, dealing with the national costs and benefits.

The main issue that arises from table 4.2, therefore, is whether there are weak links in the chain. The obvious test case is 8-pole motors. Arguably, a smaller increase in efficiency should be required, or possibly no increase at all, for the following reasons:

- Australia’s trading partners have not given a lead on 8-pole motors. They are not subject to energy performance requirements in either North America or Europe.
- All of the empirical evidence on the costs and benefits of more efficiency relates to 2, 4 and 6-pole motors. 8-pole motors are not directly addressed.
- Even accepting that evidence as relevant to 8-pole motors, the case for upgrading 8-pole motors used in the commercial sector is marginal at best, particularly where users find that they have to fill gaps in the product range by commissioning ‘specials’.
- Inspection of figures 3.2 and 3.3 indicates that, in respect of larger motors, the required reduction in motor losses is more demanding for 8-pole motors than for 2, 4 and 6-pole motors. Rates of non-compliance are correspondingly higher.

However the advice from AGO's technical consultants and steering group is that there is nothing especially demanding about MEPS requirements for 8-pole motors, relative to the MEPS for other motors. Specifically, the cost-benefit parameters developed for the other motors would be applicable to 8-pole motors. Their view is that, while there will be some difficulties at the margin, it is appropriate for these to be addressed on a case-by-case basis using the discretionary powers of the regulatory authorities.

Further, it is not feasible to separately exclude motors that are used in a particular sector, such as the commercial sector. The assessment therefore needs to be in terms of the weighted average return across all sectors. And, with 50-60% of motors used in the industrial sector, 8-pole motors return a benefit cost ratio in excess of 1.0 except under the most extreme assumptions for the *Δloss/Δprice ratio*.

4.3 Impact on government

The impact of the proposals on the taxpayer will be minimal. Not only is NAEEEP a relatively inexpensive program 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 the MEPS initiative are of the order of $2M per year at most. This allows for the equivalent of two full-time staff members in each of the regulatory authorities of the larger states, a somewhat smaller resource commitment from the smaller states, and ongoing work by AGO staff at the national level.

On the second point, the ongoing program of registration, monitoring and check testing would be required for the purposes the existing MEPS for three-phase motors. The more demanding nature of the MEPS may justify some increase in the tempo of check-testing, at least for a period. However the additional costs would be less than $100,000 and can be safely ignored for the purposes of the RIS.

4.4 Impact on suppliers

A sample of registered suppliers was surveyed to identify impacts. These impacts fall into three broad groups: demand shifts; concerns about check-testing arrangements; and the up-front costs of adjustment.

Demand shifts
The demand for new mass-produced motors will be adversely affected in several ways:

- Some users will respond to the increased cost of new motors by extending the life of old motors, either through better maintenance or by having motors rewound. The loss of business for suppliers would be offset by increased business for repairers and maintenance workers. Better maintenance enhances the efficiency gains but these are offset by the reduced efficiency of older motors and rewound motors.
- Users will respond to the increased cost of new motors by paying more attention to the appropriate sizing of motors. It is generally agreed that a large proportion of motors are oversized and run at less than optimal efficiency as a result. The side effect of smaller motors on efficiency is therefore positive.
- There will also be increased business for the manufactures of 'specials', filling gaps in the product range that arise if suppliers decide to withdraw from certain niche markets.

There will also be changes in the pattern of demand between suppliers. It is apparent that some suppliers are better positioned than others to comply with the proposed regulation. At one extreme, some say that their product range already complies with the 2006 MEPS or that existing models can be readily replaced with 'off the shelf' products. Others are concerned that they will be disadvantaged by lack of access to complying product or lags in the process of obtaining replacement products. These fears may moderate as more suppliers digest the changes and determine their competitive response. This underlines the need for reasonable lead times to be provided. On that point, there was general acknowledgement that the proposals were clear and unambiguous, and that reasonable lead time had been provided.

Finally, there are opportunities to re-route imports in such a way that the MEPS requirements are avoided. The main opportunity arises from the fact that the regulations do not cover motors imported directly by original equipment manufacturers (OEMs), since these motors are not regarded as *supplied in Australia*[7]. These direct transactions with overseas suppliers would displace transactions that are mediated by domestic agents or subsidiaries of the overseas suppliers.

In the context of the Australian market, it appears that the proposals will have significant commercial consequences and may be somewhat disruptive in the short to medium term. From the perspective of multinational suppliers, however, the Australian market is small and these changes will be viewed as marginal.

Testing and enforcement issues

Suppliers expressed some concern about the adequacy of check-testing arrangements, and even about arrangements for ensuring basic compliance with the registration requirements. On the basis of experience with the 2001 MEPS, it was claimed that less scrupulous suppliers have submitted false test results in the expectation that they are unlikely to be caught. Conceivably, this would put complying suppliers at a considerable disadvantage in the market. A related concern is that there is inadequate monitoring of exemptions for motors that are claimed to be integral to (not separable from) a piece of equipment.

There is a general concern that the only available check-testing laboratory, with the required NATA registration, belongs to one of the suppliers. For other suppliers, one issue is the risk that commercial confidentiality will be breached, despite NATA requirements to the contrary. That particular supplier may also obtain an unfair commercial advantage, based on a market perception that it is a preferred or accredited supplier or has unique capabilities.

NAEEEP has provided certain assurances to industry on both counts. Specifically, it is proposed that a Memorandum of Understanding be agreed between the AGO and AEEMA, to ensure that the testing program is robust. Also, the establishment of an independent NATA lab is a priority for NAEEEP and should be operational in 2004.

Up-front costs of adjustment

It is assumed that any additional ongoing costs of manufacture and supply will be passed on to consumers, and cannot be regarded as an adverse impact on suppliers. This assessment of costs to suppliers is therefore limited to up-front costs of adjustment that may not be readily passed on in a highly competitive market. These may take several forms.

First, there may be costs associated with the design and testing of new models. However, suppliers have indicated that the Australian market is too small to justify any significant investment in redesign.

Second, there will be once-only costs of registering models that have not previously been supplied in Australia. Assuming that two thirds of the non-complying models are replaced on the AGO register, the cost would be of the order of $200,000. The unit cost is assumed to be the $150 registration fee plus a similar cost in paperwork – that is, $300 per model.

Third, there will also be significant costs associated with the alteration of supplier and dealer relationships, including contractual relationships. These would be a concern for the smaller

[7] Buyers of OEM equipment can avoid the regulations by substituting imported OEM products for Australian-made products, since the motors in OEM imports are regarded as integral with that equipment, and not separable from it. However, based on the results of an OEM survey conducted by Energetics (1997), Australian OEMs consider that this is not a serious option for users and it would not have a significant impact on their business.

importers based in Australia. Most of their existing models will need to be replaced. A generous allowance of $5,000 is provided for each model that needs to be replaced, which totals about $8.5M.

Overall, the up-front costs to suppliers have been put at $10M.

4.5 National costs and benefits

Baseline estimates of the national costs and benefits are presented in the top panel of table 4.3. Overall, it is expected that the proposed MEPS will deliver substantial economic benefits over the life of the regulation, which is taken to be the 6-year period after implementation in early 2006. The net benefits and the benefit/cost ratio are assessed at $120M and 2.5 respectively.

The national assessment is based on the best available information about the distribution of motor capacity across the various size ranges and number of poles, and between the industrial and commercial sectors. These assumptions are detailed in appendix 2. However, there is one significant departure from the assumptions underlying table 4.1, relating to the treatment of energy costs.

TABLE 4.3 NATIONAL COSTS AND BENEFITS

	Present values ($M)			*Benefit cost ratio*
	Benefits	*Costs*	*Net present value*	
Baseline scenario (discount rate = 7%, ∆loss/∆price ratio = 1.1)				
Impact on users, valued at the avoidable cost of electricity	201	72	130	2.8
Impact on taxpayers	0	0	0	-
Impact on suppliers	0	10	-10	-
TOTAL	201	82	120	2.5
Sensitivity to variation in discount rate				
Discount rate				
0%	404	100	304	4.1
5%	242	86	156	2.8
7%	201	82	120	2.5
10%	156	76	80	2.1
Sensitivity to variation in ∆loss/∆price ratio				
∆loss/∆price ratio				
0.3	201	273	-71	0.7
0.5	201	168	34	1.2
0.7	201	123	79	1.6
0.9	201	98	104	2.1
1.1	201	82	120	2.5
1.3	201	71	131	2.9

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. From the perspective of the broader community, 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 Board[8] (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. Accordingly, the avoidable cost of electricity has been put at 6.5cents/kWh for the purposes of the national assessment in this RIS, compared with estimates of 8 and 12 cents/kWh for the marginal tariffs paid by the industrial and commercial sectors respectively.

The figure of 6.5 cents/kWh is conservative, making little concession to the increased cost of electricity at peak times.

Discount rate

It is the established practice of NAEEEC to calculate present values at *real pre-tax discount rates* of 0%, 5% and 10%. These are presented as variations in table 4.3, compared with a baseline estimate of 7%. This is a little higher than the discount rate adopted by the ABCB after a detailed investigation of risk factors and market rates of return. While the ABCB expresses the discount rate in nominal post-tax terms, the equivalent in real pre-tax terms is readily calculated[9].

As shown in the second panel of table 4.3, the assessment remains comfortably positive for variations in the discount rate.

Δloss/Δprice ratio

A critical factor is the *Δloss/Δprice ratio*, which is a measure of the trade-off between price increases and reductions in motor losses. As discussed in section 3.1, the preferred estimate is 1.1, indicating that a 10% increase in price is associated with an 11% reduction in losses. This is consistent with a number of published studies.

Suppliers have put the ratio much lower, at 0.5, with a proportional reduction in the benefit cost ratio. As shown in the final panel of table 4.3, the balance between costs and benefits is much closer in this case, although still marginally positive.

Adjustment for coverage and existing above-MEPS efficiencies

The underlying model of national impacts features two simplifying assumptions. Specifically, no allowance was made for the exclusion of various types of motors from the scope of the regulation, and it was assumed that the efficiency of all motors would be raised from borderline compliance with the 2001 MEPS to borderline compliance with the 2006 MEPS. The results of the underlying model were then adjusted at the aggregate level to take account of these two factors.

With respect to the coverage issue, the earlier RIS (GWA 2000: page 22) provides an estimate that about 80% of the motors reaching end users would be covered by the MEPS. The remaining 20% escape the MEPS because they are not regarded as being supplied in Australia or because they are motors that are integral with, and not separable from, a driven unit. The former are directly imported by OEMs.

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

[9] There are two key differences between the approaches. First, the post-tax approach treats the flow of revenue from an energy conservation measure as taxable company income after allowing for depreciation allowances. This provides a direct link with observed market rates of return on assets, since post-tax income is the focus of share market valuations. To cover the tax, pre-tax discount rates are necessarily higher than post-tax discount rates. Second, nominal rates are higher than real rates because they include an inflationary factor.

A further discount was applied to allow for motors that already comply with the 2006 MEPS or fall somewhere between the 2001 MEPS and the 2006 MEPS and require a partial upgrade. Based on consideration of the distribution of efficiencies for the motors that are currently registered, a further discount of 25% has been applied to the simple model. That is, it is assumed that, on average, motors losses are reduced by 75% of the simple difference between the 2001 MEPS and the 2006 MEPS.

The result is that table 4.3 reports 60% of the cost and benefit impacts estimated by the simple model (60% = 80% * 75%).

4.6 Assessment of the leadership option

NAEEEC's policy is to adopt a world's best regulatory practice, which means following the lead country with a lag. The alternative is for Australia to actually set the pace.

It is certainly arguable that further increase may be beneficial. Specifically, the US evidence suggests that the *Δloss/Δprice ratio* would be of the order of 1.0, which is only a small reduction on the preferred estimate for the proposed increase in MEPS. However, the risks are unacceptable, as follows:

- No country with a similar power supply (50 Hz) has even defined levels of efficiency that go beyond the 2006 MEPS. It is reasonable to expect, therefore, that the product range will become increasingly thin and significant gaps will appear. And there is no prospect that motors will be designed especially for the small Australian market.
- There is no doubt that such a move would meet strong supplier resistance.
- While there is reasonable empirical support for the assessments provided in this report, there is no similar empirical basis for assessing further increases. And, as an overwhelming importer of motors, Australia is not well placed to undertake such assessments from scratch.
- It must also be kept in mind that the benefits of increased efficiency are distributed unevenly between users, depending on the type of motor used, the cost of energy and, most importantly, the duty factor. The incidence of losers is likely to increase as efficiency requirements are further increased, particularly in the commercial sector.

4.7 Assessment of the option for delayed implementation

Accepting that it is inappropriate for Australia to lead the world in setting MEPS for motors, the further issue is the adequacy or otherwise of the lead time provided to suppliers. Given the proposed commencement in April 2006, the lead time has been effectively reduced to about 2 years. This may be regarded as the minimum period that should be allowed for suppliers to make the required adjustments. If anything, a longer lead time may be appropriate. This is considered unnecessary, however, in light of the following considerations:

- The MEPS have been at this level in North America since 1997.
- There has been forewarning of the proposed 2006 MEPS in the existing regulation, through the definition for motors that can be designated as high efficiency.
- The timing may actually err on the generous side for some suppliers. Regardless of how long the lead time, their response is still of the 'last minute' variety.
- Based on the industry interviews conducted for this RIS, suppliers are content with the amount of lead time that has been provided.

4.8 Assessment of Voluntary Agreements

A voluntary agreement to increase the market share of energy efficient motors has been concluded between the European Union (EU) and the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP). The aim of the agreement was to first achieve a 30% reduction in the market share of EFF3 motors, by 2001 and 2002 for 4-pole and 2-pole motors respectively, then a 50% reduction for both types by 2003. This agreement was seen as an expeditious alternative to public regulation, but with the clear implication that regulation is the alternative outcome. According to CEMEP's monitoring report for 2002, 36 companies have signed the agreement so far and the results are satisfactory.

However the EU model is not viable in Australia, for several reasons. First, the EU agreement is much less ambitious than the proposed Australian regulation. Consider that the EU agreement:

- targets the equivalent of Australia's 2001 MEPS, and imposes only a labelling standard for the equivalent of Australia's 2006 MEPS;
- is confined to 2 and 4-pole motors, whereas the Australian MEPS extend to 6 and 8-pole motors;
- seems to have a wider range of exclusions, including brake motors and motors for special environments.

It is unlikely that the EU could have concluded a voluntary agreement for the more demanding Australian requirements, the mandatory nature of which takes a lead from the North American approach.

Second, there is no industry organisation in Australia corresponding to Europe's CEMEP. The Australian Electrical and Electronic Manufacturers Association (AEEMA) is a much more diverse grouping without CEMEP's focus on motors and drives. CEMEP predates the greenhouse issue, having started during the oil crisis at the end of the seventies. And it has sufficient internal cohesion and structure to support a number of industry working groups on technical, economic and regulatory issues. By comparison, Australian suppliers are neither strongly motivated nor well structured to take the initiative.

Finally, it is recognised that cheaper non-complying imports are a threat to the agreement. The agreement is currently scheduled for revision in 2004/05 but with the proviso that earlier revision can be considered if there is a significant increase in the market share taken by importers. This threat is possibly more significant in the Australian case, given the almost complete reliance on imports.

5 Consultation

The following provides the history of the consultative process leading up to the introduction of the 2001 MEPS for three phase motors in October 2001.

TABLE 5.1 CHRONOLOGY OF REPORTS & CONSULTATIONS LEADING TO THE 2001 MEPS

April 1994	Motors identified as one of the products potentially suitable for MEPS and/or labelling (Energetics and GWA 1994)
May 1994	Bureau of Industry Economics publishes analysis of energy labelling and standards for motors and drives (BIE 1994)
March 1995	DPIE holds meeting in Sydney to discuss issues related to motors. Attended by representatives of AEEMA, suppliers, electricity utilities, professional and standards associations and governments.
January 1996	Energetics reports to DPIE on changes affecting the motors market since 1994, and on feedback from stakeholders on specific issues.
October 1997	Energetics reports to DPIE on energy efficiency program for motors, including recommended MEPS levels and “High Efficiency” requirements. (Energetics 1997)
April 1999	Consultation Paper on proposed MEPS prepared for AGO by SRCI
April 2000	Standards Australia issues drafts of proposed revised AS/NZS 1359.5 – comment period closed 7 May 2000
May 2000	Before preparing the draft RIS, GWA presents issues paper to a steering group comprising members of AEEMA.
September 2000	Draft regulatory impact statement released (GWA 2000), followed by a period of public comment and feedback.

Subsequently, NAEEEC commenced work on the proposals for increased MEPS for 2006, starting with a series of industry meetings and a survey of the MEPS adopted by Australia’s trading partners (NAEEEC 2002a). This led to the release of an industry consultation document (NAEEEC 2002b), asking for comments to be received by 28 February 2003. There has been further round of phone interviews with a sample of 11 suppliers for the purposes of drafting this RIS, and a roundtable discussion with 6 suppliers at the Melbourne office of Standards Australian on 17 September 2003. A request for further data was agreed at this meeting but there was a poor response, with only 2 firms supplying information.

Proposed consultations

The following further consultations are planned for early 2004.

- The AGO will: write to known interested parties informing them of the opportunity to make comment on the proposed regulation and this Regulatory Impact Statement; advertise this document’s availability; and if there is demand, they will hold public meetings in Sydney and Melbourne.
- Written comments will be received until close of business **27 February 2004.**
- NAEEEC will determine its response to the comments and revise the final RIS as appropriate.

6 Conclusion and recommended option

6.1 Assessment against objectives

Table 6.1 provides a summary statement of the three options considered in this RIS 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 the NGS, 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.

6.2 Recommendations [Draft]

It is recommended that:

1 States and Territories implement the proposed mandatory minimum energy performance standards.

2 Existing State and Territory regulations governing appliance energy labelling and MEPS be amended to implement the proposed standards.

TABLE 6.1 ASSESSMENT SUMMARY

Objective	*BAU option*	*Proposed MEPS*	*Leadership option*	*Delayed implementation*	*Voluntary Agreement*
Reduction in greenhouse emissions	The outlook is for strong growth of emissions, reaching 157% of 1990 levels by 2008-12.	Greenhouse emissions from the targeted motors will be reduced by about 0.7% in 2012, rising to 1.4% over the longer term.	More rapid reduction in greenhouse emissions could be achieved. The savings could be doubled by 2012.	A delay of one year reduces the greenhouse savings by 1.3 $MTCO_2$-e	It would not be feasible to negotiate the introduction of the proposed high efficiency requirements by voluntary agreement. The European model for such agreements is much less demanding in terms of minimum efficiency requirements, and the agreement itself may yet be undermined by unregulated imports of less efficient motors.
Cost effective for users	Most users continue to minimise capital costs, but largely ignore the potential to reduce 'whole of life' costs by improving energy efficiency.	Total benefits exceed total costs by a significant margin. The benefit/cost ratio for most users would be in the range 2.0 – 5.0. There would be some losers amongst those with low energy costs or who use motors less intensively.	There are significant risks associated with further increases in MEPS at this stage. The proportion of losers would increase and the range of complying product would be significantly reduced.	Under baseline assumptions, a delay of 1 year reduces net national benefits by about $30M.	
Minimise adverse effects on manufacturers and suppliers	The business as usual scenario is for continued growth of demand for motors, reflecting the sustained growth of the Australian economy.	Suppliers may not be able to pass certain fixed costs of redesign onto users. These are not significant in total but may fall disproportionately on the smaller Australian importers.	Given Australia's status as a large net importer of motors, there would be significant additional costs if Australia took a leading role in setting MEPS.	Suppliers would probably welcome any delay but the adjustment task would not be significantly altered by a delay of 1 or 2 years.	
Minimise potential for confusion or ambiguity	No confusion or ambiguity	Suppliers are generally aware of the proposals and find them clear and comprehensive. However, some do not plan adequately for changes and are caught up in a last minute rush to adjust.	Adjustment processes would need to be accelerated considerably, imposing a significant extra burden on the management team.	Any further delay would not reduce the management task of with the proposed changes.	

7 Implementation and review

The national legislative scheme for mandatory energy labeling and performance standards is reliant on State and Territory legislation to give it legal effect. This creates some potential for inconsistencies in the operations of the various regulatory agencies to create additional costs and inconvenience to industry. NAEEEC published a set of administrative guidelines to minimize those risks (NAEEEC 2000). The Guidelines are not legally binding but they are intended to guide State and Territory regulatory agencies to facilitate uniform and consistent practice across the individual jurisdictions, delivering consistent outcomes for all affected products irrespective of the product or jurisdiction.

Key elements of the scheme are as follows:

- The technical details of the MEPS are contained in Australian Standards that are incorporated by reference into the State and Territory legislation. The Standards do not vary between States. The format and content of Australian Standards are also familiar to industry, as are the operations of Standards Australia.
- Changes to the technical detail in Standards are subject to transition periods that are negotiated between industry and government.
- To minimize trade barriers, State and Territory regulatory agencies support a policy of adopting international standards wherever appropriate.
- Grandfathering arrangements are adopted, allowing reasonable time for the phase out of non-complying stock.
- All States and Territories accept the registration of an appliance or equipment undertaken in another State.
- State and Territory regulatory agencies have set target time periods within which they aim to process applications.
- Proposed changes in administrative and operating practice are subject to consultation between states.
- Compliance monitoring takes the form of a program of check testing by accredited laboratories.
- Equipment is selected for check testing on the basis of risk factors rather than randomly. The risk factors are as follows:
  - history of success and failure in check tests;
  - age of models, with newer models given greater attention, reflecting the prospect of longer life in the market;
  - high volume sales;
  - claims of high efficiency;
  - complaints from third parties.
- There are several sanctions. There is a shaming option involving publication of failed brands or models in the AGO annual report. The second option is deregistration by the state authorities, subject to show cause procedures. Subsequent sale of deregistered appliances would be a criminal offence. Re-registration of models that are subject to MEPS is subject to new registration tests. The third option involves legal action by the Australian Consumer and Competition Commission but is highly unlikely.
- Standard statistical criteria are applied to deal with normal variation in the performance of equipment selected for check testing. (A sample of only one is selected initially, with a further sample of three selected if the first fails.)

- Laboratories that produce misleading test results may also be denied further registration business.
- In due course the introduction of more stringent MEPS will also be handled nationally. That is likely to be in 2012. Further increases in the stringency level at that time will be subject to the same processes of industry consultation and a RIS.
- NAEEEC holds a consultation forum each year, providing an opportunity for stakeholders to raise concerns about the operation of the Standards or the Guidelines.

The check-testing and sanctions regime is obviously critical. Currently, check-testing expenditure (on all products) is running at about $350,000 per year, and accounts for about 25% of NAEEEC’s budget. The 2002 program included 160 laboratory tests, 126 tests as part of the standards development program and 34 as part of the enforcement program. There were 12 instances where the claimed energy efficiency was not supported by testing conducted at NATA accredited laboratories. State regulators subsequently deregistered six products, and negotiated acceptable outcomes including re-labelling of another four products.

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APPENDIX 1: PROPOSED MINIMUM ENERGY PERFORMANCE REQUIREMENTS

Technical background

The efficiency of motors is measured as the percentage ratio of output power to input power. The ratio is necessarily less than 100% and is usually in the range 75-95%. The output power or capacity (also referred to as rated power) is usually reported in kilowatts (kW). Under the regulation, efficiency must be tested and reported in terms of either Test Method A and Test Method B.

- *Test Method A:* This is the Method of the Institute of Electrical and Electronic Engineers (IEEE) 112-B and is generally used in the USA. This is technically equivalent to IEC 61972 (currently in draft) and to AS 1359.102.3 *Rotating electrical machines – General requirements: Methods of determining losses and efficiency-three-phase cage induction motors.*
- *Test Method B:* This method is defined by AS 1359.102.1 *Rotating electrical machines – General requirements: Methods of determining losses and efficiency-General.* It is technically equivalent to International Electro-technical Commission (IEC) standard 60034-2, which is generally used in Europe.

The Standard distinguishes between motors according to the *number of poles*. The term poles (or magnetic poles) refer to the ends of magnets. Magnetic poles always come in pairs, referred to as north and south poles. In the squirrel cage induction motor covered by the MEPS, the poles relate to a rotating magnetic field created in the stator by AC currents carried in the stator windings. The changing magnetic field in the stator induces current flow in the rotor conductors, and these in turn set up a rotor magnetic field. The magnetic forces in the rotor follow the rotating stator magnetic fields creating the rotary motion.

Depending on how the stator windings are configured, it is possible to have 2, 4, 6, 8 or even more poles. The effect of increasing the number of poles is to make the motor rotate at a lower speed. The nominal speed in revolutions per minute is given by 60 times 50 Hz divided by the number of pole pairs. Thus a 4-pole motor operates at 1500 rpm (60 x 50 divided by 2 pole pairs). In practice, motor speeds are somewhat less than the rpm predicted by this simple formula and the discrepancy is referred to as *slip*.

Motors with more than 8 poles are rare, reflecting the added manufacturing costs. Slower speeds can be obtained by mechanical (using gears) or electronic means.

The RIS sometimes makes a distinction between ‘totally enclosed fan-cooled’ motors (TEFC) and ‘open drip proof’ motors (OPD). In TEFC motors, there is no air exchange between the inside and the outside of the motor. The fan is driven by an extension of the motor shaft through the housing. OPD motors are cooled by an internal fan(s) forcing air through the motor. The ventilation openings are positioned to keep out the majority of liquid or solid particles.

Proposed MEPS

The proposed mandatory and conditional MEPS for 2006 are tabulated in tables A1.1 and A1.2. They apply to motors falling within the scope of AS/NZS 1359.5 *Rotating electrical machines – General requirements Part 5: Three-phase cage induction motors – High efficiency and minimum energy performance standards requirements.*

This Standard applies to three-phase cage induction motors with ratings from 0.73 kW up to but not including 185 kW with rated voltages up to 1,100V AC. Note that the requirements are defined for the discrete capacities at which motors are generally supplied. The largest commonly available capacity covered by the Standard is 160 kW. The MEPS level varies according to the output power of the motor and the number of poles. For technical reasons it is easier to achieve high efficiency for more powerful motors and harder to achieve high efficiency for motors with more poles.

TABLE A1.1 MINIMUM EFFICIENCY FROM 1 APRIL 2006 – ALL MOTORS (%)

Capacity (kW)	Test method A				Test method B			
	2 poles	4 poles	6 poles	8 poles	2 poles	4 poles	6 poles	8 poles
0.73	78.8	80.5	76.0	71.8	80.5	82.2	77.7	73.5
0.75	78.8	80.5	76.0	71.8	80.5	82.2	77.7	73.5
1.1	80.6	82.2	78.3	74.7	82.2	83.8	79.9	76.3
1.5	82.6	83.5	79.9	76.8	84.1	85.0	81.5	78.4
2.2	84.1	84.9	81.9	79.4	85.6	86.4	83.4	80.9
3	85.3	86.0	83.5	81.3	86.7	87.4	84.9	82.7
4	86.3	87.0	84.7	82.8	87.6	88.3	86.1	84.2
5.5	87.2	87.9	86.1	84.5	88.5	89.2	87.4	85.8
7.5	88.3	88.9	87.3	86.0	89.5	90.1	88.5	87.2
11	89.5	89.9	88.7	87.7	90.6	91.0	89.8	88.8
15	90.3	90.8	89.6	88.9	91.3	91.8	90.7	90.0
18.5	90.8	91.2	90.3	89.7	91.8	92.2	91.3	90.7
22	91.2	91.6	90.8	90.2	92.2	92.6	91.8	91.2
30	92.0	92.3	91.6	91.2	92.9	93.2	92.5	92.1
37	92.5	92.8	92.2	91.8	93.3	93.6	93.0	92.7
45	92.9	93.1	92.7	92.4	93.7	93.9	93.5	93.2
55	93.2	93.5	93.1	92.9	94.0	94.2	93.9	93.7
75	93.9	94.0	93.7	93.7	94.6	94.7	94.4	94.4
90	94.2	94.4	94.2	94.1	94.8	95.0	94.8	94.7
110	94.5	94.7	94.5	94.5	95.1	95.3	95.1	95.1
132	94.8	94.9	94.8	94.8	95.4	95.5	95.4	95.4
150	95.0	95.2	95.1	95.2	95.5	95.7	95.6	95.7
185	95.0	95.2	95.1	95.2	95.5	95.7	95.6	95.7

TABLE A1.2 MINIMUM EFFICIENCY FROM 1 APRIL 2006 – HIGH EFFICIENCY MOTORS (%)

Capacity (kW)	Test method A				Test method B			
	2 poles	4 poles	6 poles	8 poles	2 poles	4 poles	6 poles	8 poles
0.73	82.0	83.4	79.6	76.0	83.4	84.9	81.0	77.5
0.75	82.0	83.4	79.6	76.0	83.4	84.9	81.0	77.5
1.1	83.5	84.9	81.6	78.5	84.9	86.2	82.9	79.9
1.5	85.2	86.0	82.9	80.3	86.5	87.3	94.3	81.6
2.2	86.5	87.2	84.6	82.5	87.8	88.4	95.9	83.8
3	87.5	88.1	86.0	84.1	88.7	89.3	87.2	85.3
4	88.4	89.0	87.0	85.4	89.5	90.1	88.2	86.6
5.5	89.1	89.7	88.2	86.8	90.2	90.8	89.3	87.9
7.5	90.1	90.6	89.2	88.1	91.1	91.6	90.2	89.1
11	91.1	91.4	90.4	89.5	92.0	92.4	91.3	90.5
15	91.8	92.2	91.2	90.6	92.6	93.0	92.1	91.5
18.5	92.2	92.5	91.8	91.2	93.0	93.4	92.6	92.1
22	92.5	92.9	92.2	91.7	93.4	93.7	93.0	92.5
30	93.2	93.5	92.9	92.5	94.0	94.2	93.6	93.3
37	93.6	93.9	93.4	93.0	94.3	94.6	94.1	93.8
45	94.0	94.1	93.8	93.5	94.6	94.8	94.5	94.2
55	94.2	94.5	94.1	94.0	94.9	95.1	94.8	94.6
75	94.8	94.9	94.6	94.6	95.4	95.5	95.2	95.2
90	95.1	95.2	95.1	95.0	95.6	95.8	95.6	95.5
110	95.3	95.5	95.3	95.3	95.8	96.0	95.8	95.8
132	95.6	95.7	95.6	95.6	96.1	96.2	96.1	96.1
150	95.8	95.9	95.8	95.9	96.2	96.3	96.3	96.3
185	95.8	95.9	95.8	95.9	96.2	96.3	96.3	96.3

APPENDIX 2: BENEFIT/COST ASSUMPTIONS

Market segments analysis

The market segments analysis refers to a range of feasible investments in energy efficiency, distinguished in terms of the industry sector, the output power of the motor and the number of poles. (These categories are evident from table A2.1.) In each case it is assumed that the BAU motor complies with the 2001 MEPS and is replaced by a motor that would comply with the 2006 MEPS. Compliance is assumed to be borderline in both cases.

As discussed in section 4.2, the benefit cost ratio for investments in motor efficiency can be addressed in terms of two the following two ratios:

- *Loss/price ratio:* This is the ratio of the lifecycle cost of the energy losses to the purchase price of the BAU motor. Other things given, a higher ratio means a higher return to investments in energy efficiency.
- *Δloss/Δprice ratio:* This is the ratio of the percentage reduction in motor losses to the percentage increase in price when a higher efficiency motor is used. Other things given, a higher ratio means a higher return to investments in energy efficiency.

The cost/benefit ratio is the first ratio multiplied by the second ratio.

Estimates of the Loss/price ratio

For a given market segment, the lifecycle amount of motor losses depends on the efficiency of the motor, the life of the motor, the number of duty hours per year, and the load on the motor. With respect to efficiency it is assumed that the motor complies with the 2001 MEPS but is of borderline efficiency. Table A2.1 reports various estimates of the other factors. Note that the operating hours at ‘equivalent full load’ are the product of actual operating hours and the load factor; motors typically run at less than full load.

The estimates in table A2.1 are from three sources. There is one US source (ACEEE 2002), one Australian (Energetics 1997) and one European (Parasiliti et.al.: 1999). The overseas estimates draw on motor surveys, whereas the Australian estimates appear to be judgement estimates, possibly influenced by overseas estimates. Note the following:

- There are considerable differences in the estimates of asset lives. The more conservative European estimates have been adopted in this RIS. An asset life of 20 years has been assumed for the largest capacity range, for which there is no matching European estimate.
- Allowing for differences in coverage, the estimates of annual operating hours and average load are reasonably consistent. The European estimates are used in this RIS, taking advantage of their broader coverage and the distinction between industrial and commercial uses.

Table A2.2 presents the estimates of economic parameters that are used in the market segments analysis. Note that the purchase price is expressed in $ per kW pf power output, which accounts for the reduction in the unit price for larger motors.

The estimates reported in tables A2.1 and A2.2 are brought together to generate the estimates of the *Loss/price ratio* that are reported in table 4.1 of the text. The resulting variation in the ratio reflects underlying variation in duty factors, purchase prices and energy tariffs.

TABLE A2.1 ESTIMATES OF TECHNICAL PARAMETERS

Output power (kW)	*ACEEE (2002), manufacturing sector*	*Energetics (1997)*	*Parasiliti et.al. (1999)*	
			Industry, including mining	*Commercial*
		Asset life (years)		
0.73 - 2.2	18	12	12	12
3 - 7.5	20	15	12	12
11 - 37	22	20	15	15
45 - 90	28	22	15	15
110 - 180	30	25	-	-
		Operating hours		
0.73 - 2.2	3000		4441	1309
3 - 7.5	3500		4527	1309
11 - 37	4000		5454	1568
45 - 90	5250		5719	1755
110 - 180	5500		-	-
		Load factor		
0.73 - 2.2	50%		50%	60%
3 - 7.5	50%		54%	60%
11 - 37	50%		56%	60%
45 - 90	50%		61%	60%
110 - 180	50%		-	-
		Operating hours, equivalent full load		
0.73 - 2.2	1500	1200	2220	790
3 - 7.5	1750	1500	2430	790
11 - 37	2000	2000	3070	940
45 - 90	2625	2300	3490	1050
110 - 180	2750	2500	-	-

TABLE A2.2 ESTIMATES OF FINANCIAL PARAMETERS

Output power (kW)	*Purchase price ($/kW)*				*Electricity tariff (cents/kWh)*		*Discount rate*
	2-pole	*4-pole*	*6-pole*	*8-pole*	*Industry*	*Commerce*	
0.73 - 2.2	90	120	140	200	8	12	7%
3 - 7.5	60	60	90	140			
11 - 37	50	50	60	90			
45 - 90	40	40	60	90			
110 - 180	40	40	60	70			

Estimates of the Δloss/Δprice ratio

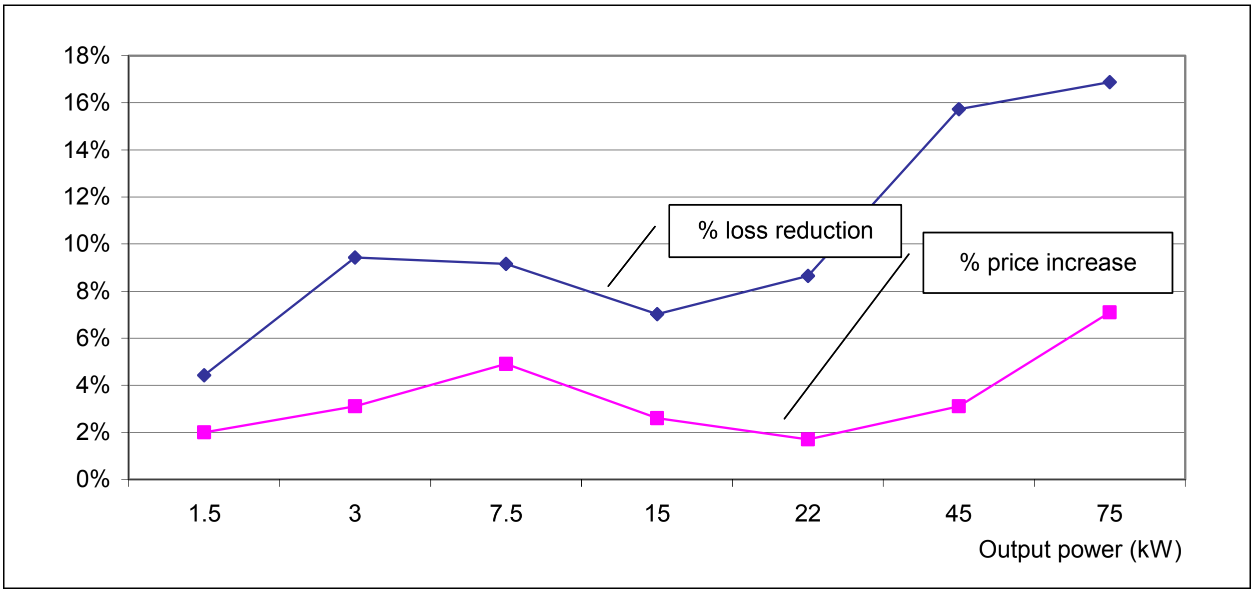
As discussed in section 4.1, the *Δloss/Δprice ratio* for a particular investment in a more efficient motor is the ratio of the percentage increase in purchase price to the percentage reduction in motor losses. This ratio can be extracted from the analysis presented in a number of reports, which are discussed below. Overall, the evidence suggests that the *Δloss/Δprice ratio* is greater than 1; an average estimate of 1.1 is reasonable. That is, a 10% increase in price is associated with an 11% reduction in losses. As discussed in section 4.1, Australian suppliers have put the ratio somewhat lower – at 0.5. Specifically, they suggest that a 15% reduction in motor losses would require a 30% increase in purchase price.

Existing estimates are summarised here under three headings. The first are the easiest steps, increasing efficiency from the lowest levels up to compliance with the 2001 MEPS. The second is the intermediate step of direct relevance to this RIS, delivering compliance with the proposed 2006 MEPS. The final step is an increase beyond compliance with the proposed 2006 MEPS. In terms of the efficiency benchmarks adopted by the European Union, the first step is from EFF3 to EFF2 and the second is from EFF2 to EFF1.

Move 1 - EFF3 to EFF2, delivering compliance with Australia's 2001 MEPS
The first and easiest step has been addressed by several studies. Figure A2.1 presents the findings from a European study (Parasiliti et.al. 1999). The percentage increase in price is clearly less than the percentage reduction in motor losses. The *Δloss/Δprice ratio* averages 2.8. That is, a 1% increase in price is associated with a 2.8% reduction in losses.

The European estimates were obtained by using motor design software to determine the most cost-effective means of redesigning a number of reference motors to achieve compliance with EFF2 requirements.

FIGURE A2.1 EUROPEAN ESTIMATES OF REDUCTIONS IN MOTOR LOSSES AND INCREASES IN PRICE: EFF3 TO EFF2



The efficiency cost relationship has also been investigated in an Australian study (Energetics 1997) commissioned by the (then) Department of Primary Industries and Energy. Regression analysis was applied to estimate a linear relationship between list prices and efficiency, with the prices and efficiency of all motors reduced to a comparable basis by normalising these two variables.

While the analysis is not cast explicitly in terms of the ratio of price increases to loss reductions, the implied relationship is readily derived. Implicitly, Energetics estimates that the *Δloss/Δprice ratio* falls in the range 2.5 to 10. That is, a 1% increase in price is associated with a 2.5-10% reduction in losses.

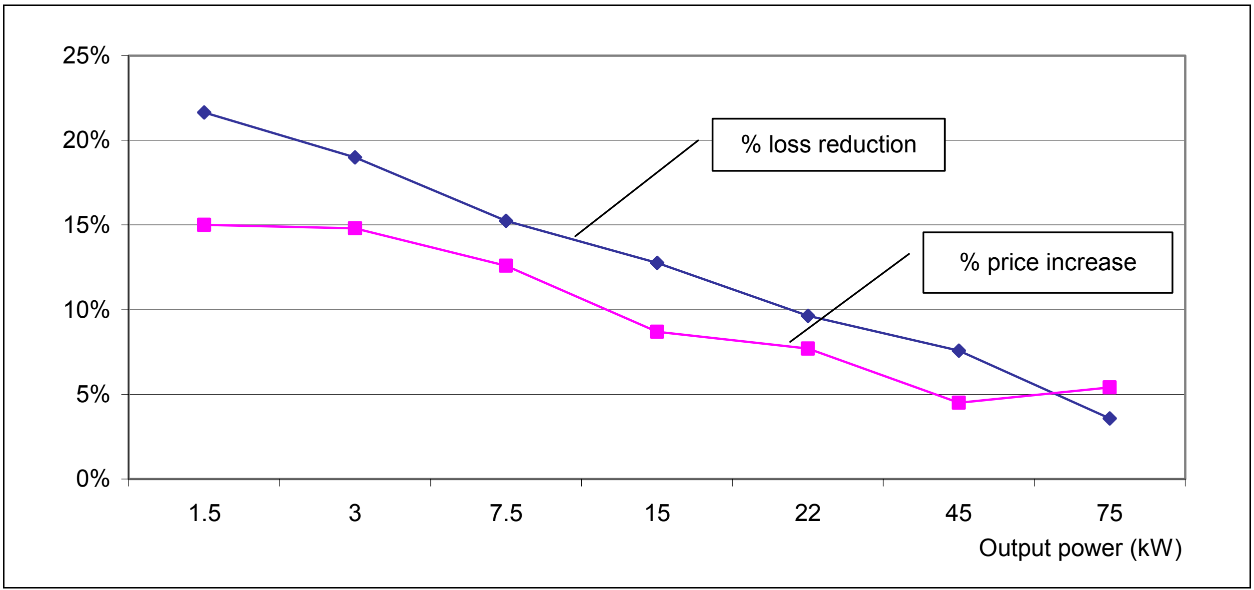
The US Department of Energy has recently published a study (DoE 2003) of energy conservation standards for certain small electric motors with output power up to 2.25 kW. It is based on an engineering analysis of how different design options affect efficiency and cost. Options for reducing losses by up to 33% were considered, with the final target reached in two or three steps that were separately assessed. Two separate pathways were investigated – one using better steel, the other relying on changes in stack design. In general, the former was found to be the more cost effective.

Importantly, the efficiency of these motors is currently unregulated in the US. This suggests that the study provides a look at the early stages of the cost-efficiency curve. Key findings for the purposes of this RIS are as follows:

- There were no ‘free lunches’. That is, all efficiency gains were at the expense of some increase in the cost to users.
- As would be expected, the first step was generally the most cost effective. The observed ratios of percentage reduction in losses to percentage price increase were of the order of 2.0-2.5. This is consistent with the European estimates.
- Subsequent steps returned lower ratios of loss reduction to cost increase – averaging 0.7-0.8 for the second and third steps respectively but showing considerable variation.

Move 2 – EFF2 to EFF1, delivering compliance with Australia’s proposed 2006 MEPS
The intermediate step has been addressed has been explicitly addressed only by Parasiliti’s European study. The key findings are shown in figure A2.2. With one exception the percentage price increase is less that the percentage loss reduction. Overall, the *Δloss/Δprice ratio* is 1.2; a 1% increase in price is associated with a 1.2% reduction in losses.

FIGURE A2.2 EUROPEAN ESTIMATES OF REDUCTIONS IN MOTOR LOSSES AND INCREASES IN PRICE: EFF2 TO EFF1



Move 3 – going beyond compliance with Australia’s proposed 2006 MEPS
Appendix A to the ACEEE handbook (ACEEE 2002) contains estimates of the market prices for standard motors and for premium efficiency motors. The former comply with the existing requirements in the US EP Act (analogous to mandatory MEPS in the Australian context) and are comparable with the proposed Australian 2006 MEPS. The data therefore provide an indication of the price increases that would apply if minimum requirements are set *higher* than is proposed for 2006. The data is summarised in figures A2.3 and A2.4.

FIGURE A2.3 ACEEE COST-EFFICIENCY RELATIONSHIP FOR TEFC MOTORS

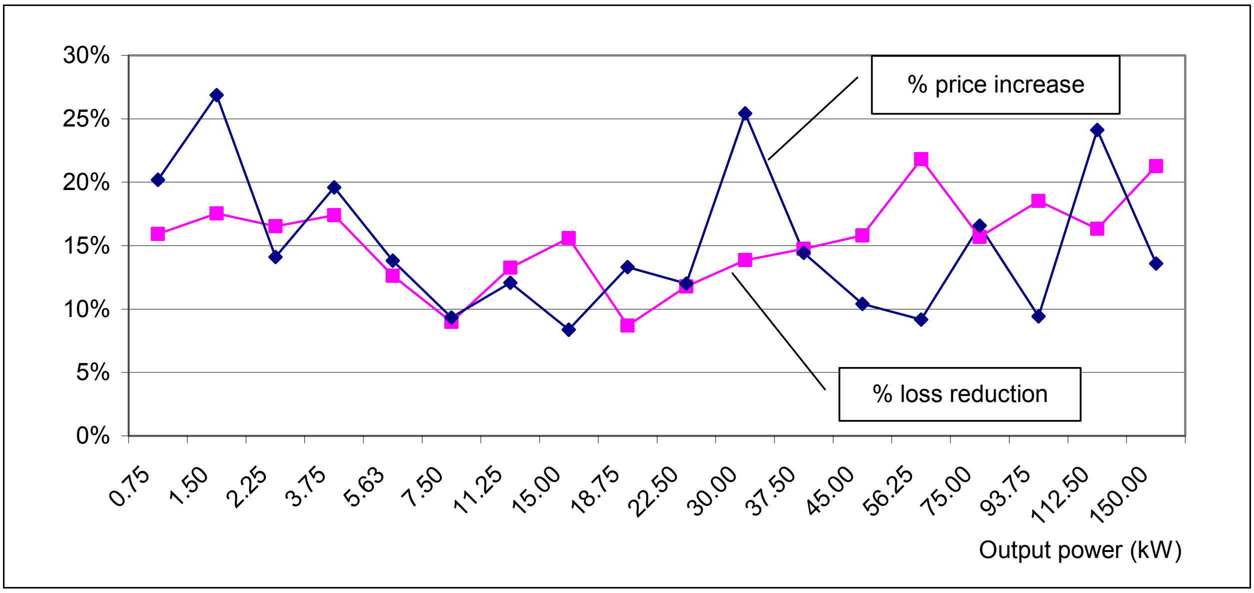
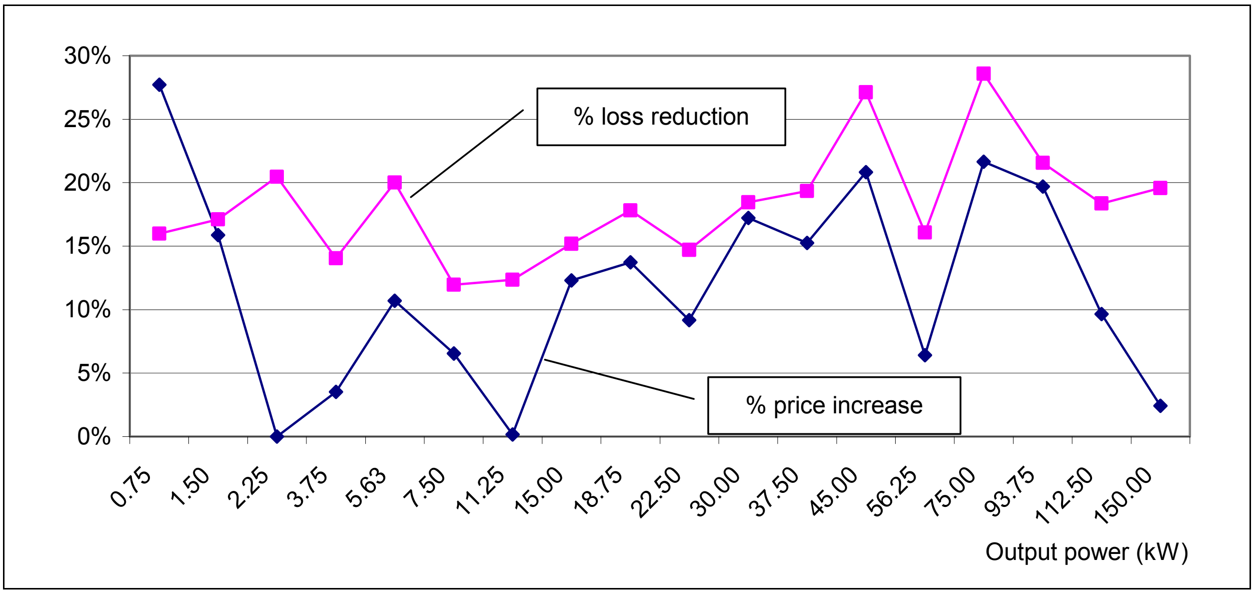


FIGURE A2.4 ACEEE COST-EFFICIENCY RELATIONSHIP FOR ODP MOTORS



Note the following:

- The estimates are provided for a range of sizes, and separately for 'totally enclosed' and 'open drip proof' motors. The former are by far the most important category, accounting for 98% of the registered models.
- The improvement in energy efficiency has been presented as a reduction in the energy losses, with most of the sample falling in the range of 10-20%.
- There is evidence of a weak positive correlation between the loss reductions and the price increases. That is, larger loss reductions tend to be associated with larger price increases.
- The percentage increases in price for TEFC motors are of the same order of magnitude as the percentage reduction in energy losses. This suggests a rule of thumb that a 10% reduction in energy loss is at the cost of a 10% increase in price. Larger TEFC motors

are the main exception, with price increases being somewhat smaller than the loss reductions.

- The percentage increases in price for ODP motors are clearly somewhat less than the percentage reduction in energy losses. The data suggests a rule of thumb that a 10% reduction in energy losses is at the cost of a 6.7% increase in price. However, given the small market share of these motors, this relationship can be ignored for practical purposes.

Conclusion
The various studies tell a consistent story, which is that the *Δloss/Δprice ratio* is very favourable (greater than 2.0) for the initial increases in efficiency, but falls as the efficiency demands are increased. For the intermediate steps that are directly relevant to this RIS, the *Δloss/Δprice ratio* falls in the range 1.0-2.0, but closer to the bottom end of the range according to the European study, which is the most directly relevant.

Based on the available evidence it is reasonable to assume that, in relation to the proposed MEPS, the ratio of percentage loss reduction to percentage price increase is of the order of 1.1.

Aggregate analysis

Aggregation requires estimates of the relative importance of the each segment. The assumed distribution of sales (by type and size of motor) have been adopted from the initial scoping study (Energetics 1997) and the earlier RIS (GWA 2000). These estimates are set out in table A2.3.

TABLE A2.3 COMPOSITION OF SALES

	Average size (kW)	*Unit sales (%)*
	By output power of motor (kW)	
0.75 - 2.2	1.35	47.2%
3 – 7.5	4.9	33.6%
11-37	19.2	13.4%
45 – 90	59.6	4.5%
110 – 180	125.1	1.3%
	By number of poles	
2-pole	-	21%
4-pole	-	72%
6-pole	-	5%
8-pole		2%
	By sector	
Industrial	-	57%
Commercial	-	43%

Sources: Energetics (1997) & GWA (2000)