



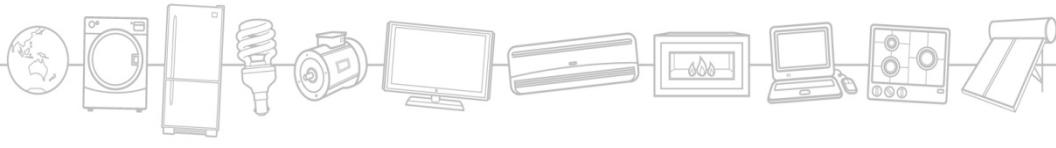
E3

Equipment Energy
Efficiency

E3 Product Profile: Electric Motors

Australia and New Zealand

September 2013



**A joint initiative of Australian, State and Territory
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1. Introduction

Purpose

This consultation document forms part of an investigation into the feasibility of increasing the Minimum Energy Performance Standards (MEPS) for electric motors and expanding the scope of motors covered under the *Greenhouse and Energy Minimum Standards Act 2012* in Australia and the *Energy Efficiency (Energy Using Products) Regulations (2002)* in New Zealand. The document serves two purposes:

1. To provide an update on the state of electric motor technologies, their capacity for improved energy efficiency and the current and projected markets for sales of motors in Australia and New Zealand. This information has been collected for the benefit of policy makers, however, stakeholder feedback is sought in verifying the report's findings.
2. To signal to stakeholders the options that will likely form the basis of initial stakeholder consultation. Final policy options would be subject to detailed investigation through a Regulation Impact Statement (RIS). In New Zealand, approval of Ministers is required for any proposed regulatory option that might be modelled by a RIS.

Context

Energy efficiency is widely accepted as a low cost approach to reducing greenhouse gas emissions. Modelling by the International Energy Agency (IEA) shows that as much as half the savings in greenhouse gas emissions required by 2050 can be achieved by adopting energy efficiency measures. Improvements to energy efficiency can also help to reduce demand on electricity supply systems (such as during peak periods) with consequent savings in capacity requirements.

The following benefits arise from use of more energy efficient technology:

- Enhanced economic growth through increased productivity
- Improved energy security by reducing energy demand
- Improved energy affordability by reducing consumer energy costs
- Deferred need for more expensive energy supply by making better use of existing energy resources
- Reduced greenhouse gas emissions from energy consumption

Available energy efficiency measures include the use of new technologies and processes to reduce energy use in residential, business, industry and manufacturing applications. Use of high efficiency electric motors would reduce greenhouse gas emissions and therefore the cost of carbon abatement. In the Australian 2020 carbon abatement cost curve, which explores a range of energy efficiency measures, improvements to motor systems have the largest negative abatement cost (Lewis and Gomer 2008). A key mechanism to drive performance improvements in motors is to use minimum energy performance standards (MEPS) on products manufactured in or imported into Australia or New Zealand.

MEPS are one of the tools used by the broader Equipment Energy Efficiency (E3) Program, which aims to deliver cost-effective increases in the energy efficiency of appliances and equipment used in residential, commercial and manufacturing sectors in Australia and New Zealand. MEPS for electric motors help reduce energy use by ensuring inefficient motors are not available on the market.

Three phase electric motors from 0.73 to <185 kW manufactured in or imported into Australia or New Zealand have been subject to MEPS since 2001 in Australia and 2002 in New Zealand. MEPS levels were increased in 2006 in both countries. An intention to further raise MEPS levels sometime after 2012 was signalled to stakeholders in industry consultation in 2003. Voluntary High Efficiency Performance Standards (HEPS) in the standard AS/NZS 1359.5-2004 are broadly equivalent to the IE3 levels in the international IEC performance standard.

Where to from here

Consultation on this Product Profile

Readers are asked for feedback on the information and proposed policy options in this document, and to assist by providing robust data where possible.

Feedback from industry stakeholders will be important in formulating the most appropriate policy approach, and responses to the Key Questions below would be of particular assistance.

Comments should be sent via e-mail, and should be received by 20 October, 2013.

Comments should be clearly titled and sent to:

Australia Subject: Electric Motors Product Profile energyrating@ret.gov.au	New Zealand Subject: Electric Motors Product Profile regs@eeca.govt.nz
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After consultation on this Product Profile

The material in this Product Profile will be reviewed and supplemented in light of any written submissions made by stakeholders and/or issues raised at stakeholder meetings. Decisions will then be made on whether to proceed with proposals to improve the energy efficiency and performance of electric motors.

If the preferred options involve regulation (e.g. MEPS) a Regulation Impact Statement (RIS) will be prepared to analyse the costs, benefits, and other impacts of the proposals. Consultation will be undertaken with stakeholders prior to any final decisions being made. Final decisions on policy will be made by the Select Council on Climate Change in Australia and by the New Zealand Cabinet.

Electric Motors Product Profile – Key Questions

Readers are invited to comment on any aspect of this Product Profile. Key items are listed in the box below, and also at the end of each section throughout the paper. Responses to these would be of particular assistance. Where the specific data asked for is not available, any indication of the relative split between identified categories would be very useful.

The Problem

- To what extent do the market barriers 'principal-agent problem' and 'split incentives' exist?
- Can you explain why more efficient electric motors do not make up a larger proportion of AU and NZ markets?
- Can you provide robust supporting data?

The importance of electric motors

- Can you comment on the electricity use and greenhouse gas emissions of electric motors reported in Figures 1-4, and provide robust supporting data where possible?

Product description

- Can you comment on the key motor types in terms of technologies that may have an impact in the future?

Market profile

- Can you provide improvements to the sales and stock estimates for three-phase and single-phase motors on page 15? There is some uncertainty around the figures, so robust information and supporting evidence would be appreciated to facilitate better informed policy decisions. Useful data would be broken down by size and motor type, for motors currently scope (0.73 – 185 kW), and those considered for regulation, ie. line start permanent magnet motors and three-phase motors 185 – 1,000 kW and single- and three-phase motors <0.75 kW.

Performance and testing standards

- Can you comment on the international standards which would be applicable to Australia and New Zealand?

Technological advances

- Stakeholder views are sought regarding technological advances that will need to be considered when exploring possible extensions to MEPS for motors.
- Can you comment on the current and likely future availability of motors which would meet the proposed regulatory levels?

Policy options

- Can you comment on the policy options proposed in Section 7? Do you think they could feasibly address The Problem outlined in Section 2, in terms of market failures inhibiting improved energy efficiency of electric motors?
- What additional costs do you think these options would place on industry compared to the current situation?
- What do you think would be the best way for governments to facilitate an increase in the average energy efficiency of electric motors sold?
- Can you suggest how regulation could be viably extended to small motors?
- Can you provide any data to support in-depth cost-benefit analyses of these policy options?

2. The Problem

Scope

Alternating current (AC) three-phase electric induction motors from 0.73 to <185 kW manufactured in, or imported into, Australia or New Zealand are subject to MEPS. Policy options under consideration could extend the scope to include:

- All technical constructions of AC electric motors rated for on-line operation in the range 185 to 1,000 kW, including line-start permanent magnet motors and three-phase induction motors
- All technical constructions of AC electric motors rated for on-line operation in the range 0.12 to 0.73 kW, including line-start permanent magnet motors, and single- and three-phase induction motors

Objective

The objective is to improve the energy efficiency of electric motors supplied in the Australian and New Zealand markets by addressing market failures such as information failure and principal-agent problems.

The Australian Government has made commitments under the United Nations Framework Convention on Climate Change to adopt national policies and measures to mitigate climate change, limit Australia's anthropogenic emissions of greenhouse gases, and to promote the development and application of technologies and practices that minimises these emissions of greenhouse gases.

The E3 Program has been in place for 21 years. In 2012 it transitioned from state-based legislation to the national GEMS legislation (*Greenhouse and Energy Minimum Standards Act 2012*). GEMS is supported by the states and territories through an intergovernmental agreement and is an action under the National Strategy on Energy Efficiency (NSEE).

The policy options presented in this Product Profile would complement the carbon pricing mechanism or an emissions trading scheme by helping to offset the cost impacts on businesses of the carbon pricing mechanism and rising network costs. Complementary measures have been recognised as necessary by the Stern review (2006).

The Problem

The problem is that businesses are paying unnecessarily high electricity costs to power motors that are not as efficient as they could be. This may be because motors are either installed by third parties who choose lower cost inefficient motors over lower lifetime cost, more efficient motors, or because there is insufficient information available for businesses to quickly make purchase decisions based on motor efficiency and running costs.

While technological advancements mean higher efficiency models are available, and higher performance standards are mandated in key trading partners, the local electric motors market is biased toward MEPS-compliant models as lifetime costs are not being considered in purchasing decisions.

Market failures including principal-agent problems and information failures are inhibiting the uptake of more efficient electric motors. These barriers are not adequately addressed by the current MEPS or by the carbon pricing mechanism and further government intervention may be justified.

The principal-agent problem arises when an agent does not act in the best interests of the principal due to 'split incentives'. For example, consultants may use out-dated specifications on a new plant to avoid risk and the time needed to convince a client that it is worthwhile investing in more expensive and efficient equipment; replacement motors may be chosen based on replacing 'like' with 'like' to minimise the contractor's time and risk or the plant spares may just keep standard products; and package vendors may select cheaper and less efficient motors to minimise the package capital cost.

Information failure can be a problem when buyers are not able to compare the lifetime costs of electric motors and therefore make sub-optimal purchase decisions. For example, commercial refrigeration operators may lack sufficient knowledge of new fan motor technologies and their costs and benefits, to select optimal equipment.

If more efficient motors were installed, businesses would improve their energy productivity, reduce their costs and reduce associated greenhouse gas emissions.

Questions for stakeholders:

To what extent do these market barriers exist? Is the problem accurately defined, in terms of market failures?

Can you explain why more efficient electric motors do not make up a larger proportion of the Australian and New Zealand markets?

Can you provide robust supporting data?

The importance of electric motors

Electric motors are found in the industrial, commercial, residential, agricultural and transportation sectors. They use a significant portion of Australia and New Zealand's electricity. Figures 1 and 2 below show the amount of electricity consumed by electric motors in Australia and in New Zealand. The figures show that 59% of Australia's electricity and 42% of New Zealand's electricity is consumed by motors. Between 10% and 20% of electricity consumed by motors is used by small single-phase motors. Around one third of the power used by motors is used by the three-phase motors that are currently covered by MEPS. The remainder is used by three-phase motors not covered by MEPS. In the case of Australia, this is 60% of the electricity used by motors and may point to an area where an extension of MEPS could be contemplated. Of all the different motor types, three-phase induction motors use almost 80% of the electricity used by all motors.

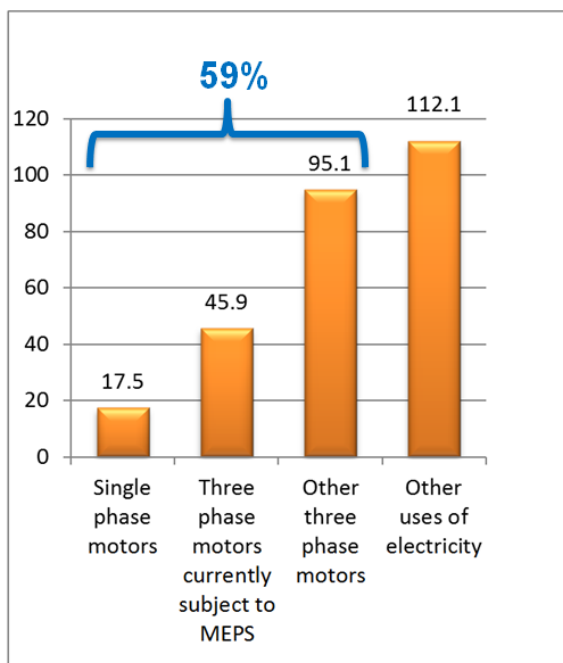


Figure 1: Electricity used by motors in Australia in TWh/yr (2006/07)
Source: Energetics

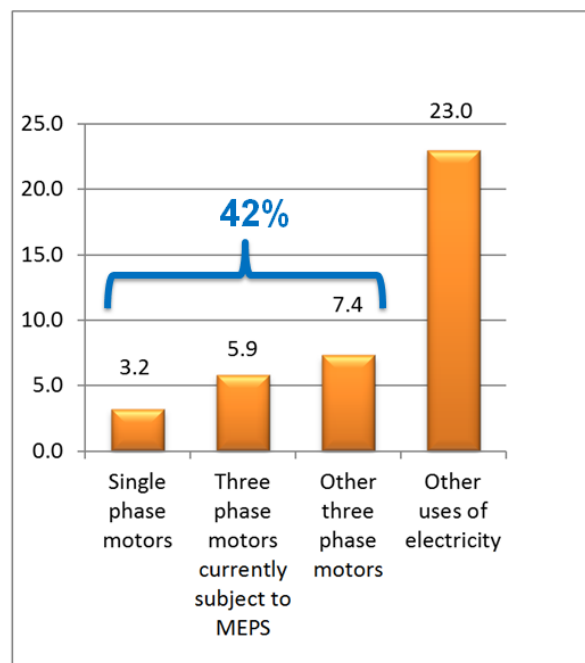


Figure 2: Electricity used by motors in New Zealand in TWh/yr (2006/07)
Source: Energetics

Figures 3 and 4 show the contribution of electric motors to the nation's greenhouse gas emissions.

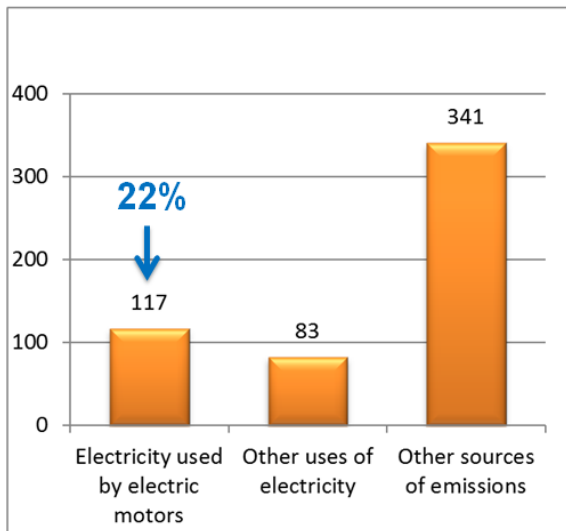


Figure 3: Greenhouse emissions due to electric motors in Australia in MT CO₂-e (2006/07)

Source: Energetics

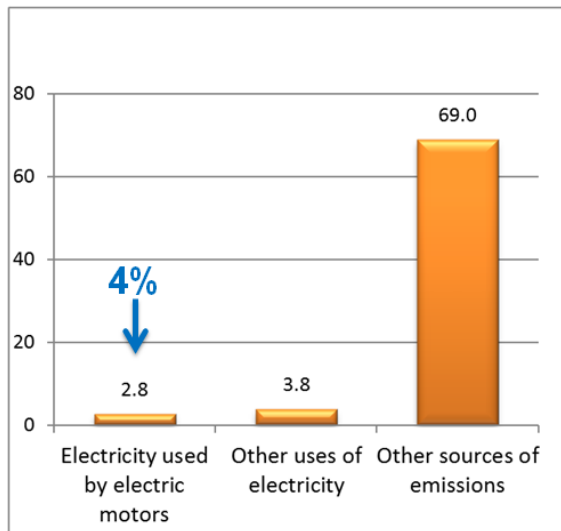


Figure 4: Greenhouse emissions due to electric motors in New Zealand in MT CO₂-e (2006/07)

Source: Energetics

The impact of improvements in motor efficiency will have a much greater impact on emissions in Australia compared with New Zealand due to the greater emissions intensity of electricity in Australia.

Stakeholders are asked to comment on the figures for electricity use and greenhouse gas emissions of electric motors reported above, and to provide robust supporting data where possible.

3. Product Description

Electric motors turn electrical energy into mechanical energy through the manipulation of magnetic fields. There are many ways of implementing this fundamental principle, and this gives rise to many different types of electric motor technologies. The primary classification of motors is whether the motor is powered by direct current (DC) or alternating current (AC). The different types of motors have different attributes, making them more or less suited to particular applications. Figure 1 below provides a graphical representation the different types of electric motors. MEPS currently apply to three-phase induction motors, as highlighted in the figure.

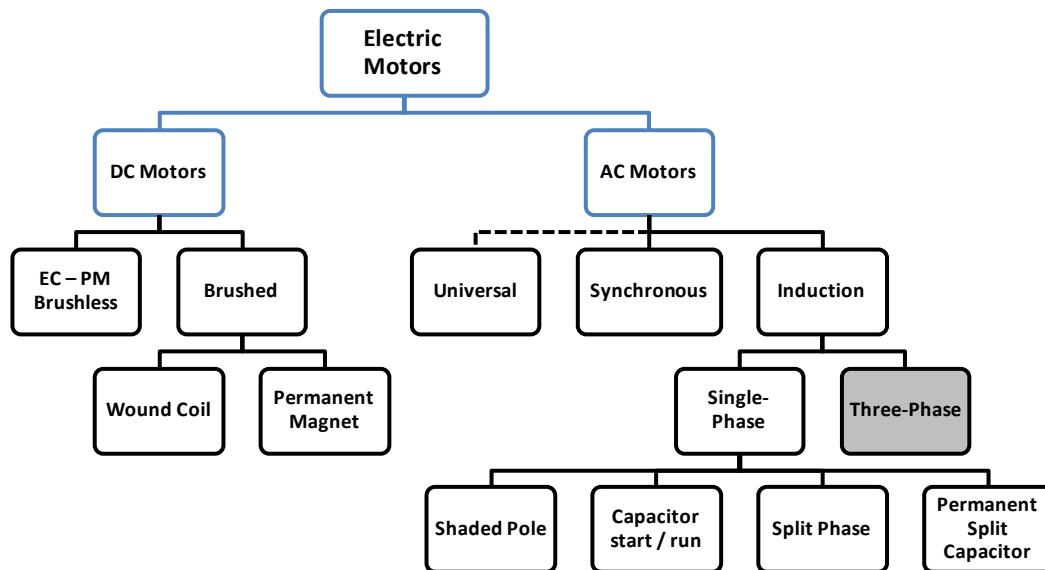


Figure 1: Family tree of electric motors

Based on Waide and Brunner, IEA, 2011

Electric motors rely on the interaction of magnets in a stator and a rotor to cause the rotor to move i.e. rotate. Figure 6 illustrates an exploded view of a motor showing the stator and rotor. It is necessary for at least one of the magnets to fluctuate (i.e. reverse its north and south poles at regular intervals) to keep the rotor moving.

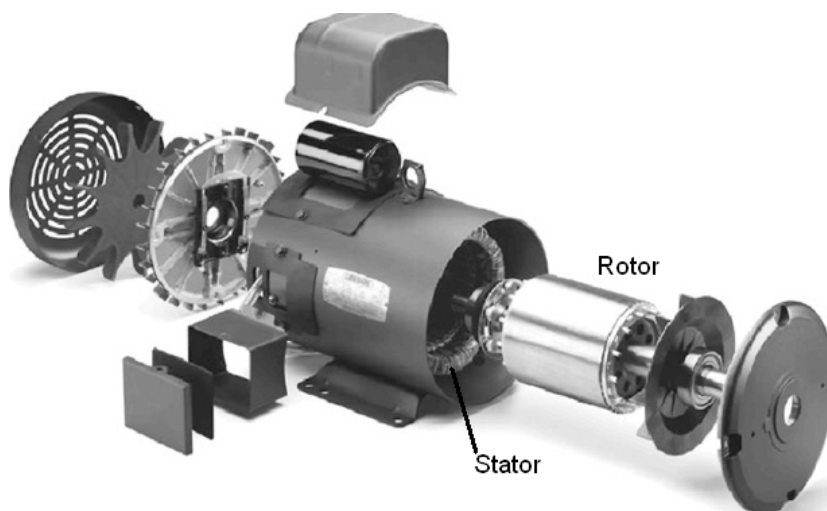


Figure 2: Exploded view of a typical squirrel-cage induction motor

Source: Leeson Electric Corp

Important types of motors

AC induction motors are the most common type of motors. As with most motors, they have electromagnets in the stator that when connected to the power supply, generate a rotating magnetic field. This magnetic field interacts with metal coils in the rotor to induce electric currents, which in turn induce a magnetic field in the rotor. The interaction of the two magnetic fields causes the rotation. The speed of rotation is linked to the frequency of the AC power and the design of the stator – the number of poles¹ in the motor. AC induction motors are simple, low cost and robust.

Within the broad class of AC induction motors, it is possible to further categorise them based on the type of AC power source, that is, whether it is single-phase or three-phase power. Small motors such as the ones found in home or office appliances, can be successfully driven by single-phase power but all large motors require three-phase power. The most important type of motor and the type that uses the most electricity is the **three-phase induction motor**.

Three-phase induction motors do not require any special configuration to start rotating when the stator is first energised. This, however, is not the case with single-phase induction motors, which must use one of a variety of devices to start. Without a starting mechanism, a single-phase induction motor will vibrate but not rotate when the stator is energised. The simplest mechanism to start a single-phase motor is to provide a small 'starting-coil' in addition to the main electromagnet coil in the stator. The starting coil is energised to start the motor turning and then switched off once the motor is running. This is the basis of the **permanent switched capacitor motor**, which is a very common type of single-phase motor.

Shaded pole motors are another common type of motor, particularly for applications that need small, low cost, robust motors. They use an additional coil to shade part of the main coil causing an interaction of magnetic fields that cause the motor to start rotating. However, the shading decreases the efficiency of shaded pole motors. Another cause of efficiency loss is electrical resistance loss in the rotor that affects the current induced in the rotor. Other important types of motors dispense with the coils in the rotor and eliminate this source of losses. The causes of losses in motors are described below, after a brief description of **permanent magnet motors** and **switched reluctance motors**.

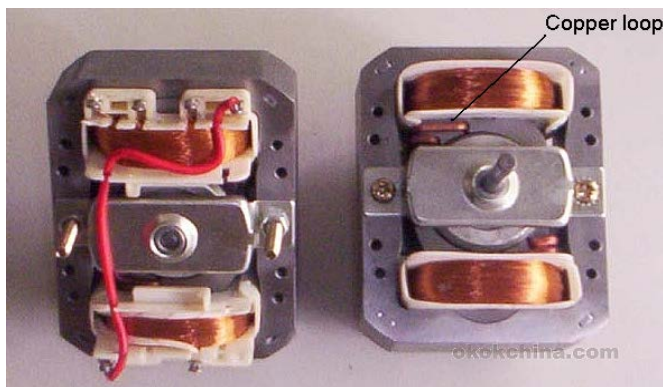


Figure 3: Shaded pole motor

Source: www.okokchina.com

Permanent magnet (PM) motors use permanent magnets rather than electromagnets in the rotor. There are both AC and DC permanent magnet motors. The **electronically commutated (EC) motor** is one example of a PM motor. These use electronic controllers to convert DC into AC power, which is used to power the electromagnets in the stator and drive the motor. The advantage of EC motors, besides eliminating a source of inefficiency, is that their speed can be precisely controlled using an electronic controller.

The emergence of precise electronic controllers also opened the way for **switched reluctance motors**. Rotation occurs through the magnetic attraction of a steel rotor to electromagnets in the stator. The rotor's position relative to the stator is detected using internal sensors or by electronic 'sensorless' means, and the controller then energises

¹ Poles are the number of sets of electromagnetic windings the motor has. The more poles a motor has, the slower it will rotate. In a 50 Hertz system, a 4-pole motor with two sets of electromagnetic windings will rotate at 1500 rpm, and a 6-pole motor will rotate at 1000 rpm.

each stator winding only when it can produce useful torque. SR motors are representative of the motor technologies that offer levels of efficiency that cannot be achieved by the more generally used induction motors.



Figure 4: Switched reluctance motor
Source: www.srdrives.com

The efficiency of some types of motors

The following table lists indicative efficiencies for some classes of motors over a range of sizes.

Table 1: Typical motor efficiencies

Output Power	Shaded Pole	Permanent Split Capacitor	Permanent Magnet	Three-phase
0.5 – 25 W	8 – 25%		40 – 60%	
26 – 100 W	25 – 35%	25 -40%	40 – 60%	
101 – 250 W		40 – 60%	60 – 85%	
251 – 750 W		70 – 80%	75 – 90%	75 – 80%
751 – 2200 W		75 – 85%	80 +%	80 – 83%
2.201 – 5.5 kW			90 +%	80 – 85%
5.5 – 20 kW			90 +%	85 – 90%
20 kW +			90 +%	90 +%

Table Key:

Domestic Motors

Industrial Motors

Industrial motors that are currently covered by MEPS

Source: Stakeholder consultation, Melbourne 3 May, 2011

In general, the efficiency of all motors increases with size, permanent magnet motors are more efficient than induction motors and shaded pole motors have very low efficiencies, and are limited in their capacity. Permanent split capacitor motors also have low efficiency compared to three-phase induction motors, and are unsuited to most industrial and commercial applications due to their low efficiency and small size.

Stakeholders are asked to comment on the key motor types in terms of technologies that may have an impact in the future.

4. Market Profile

This section of the Product Profile looks at the market for electric motors, in terms of the applications for motors and the size of the market.

Uses of electric motors

This next figure gives an overview of the market for motors. The figure illustrates that small, usually single-phase, motors dominate in terms of the number of motors sold and installed. However, the mid-sized three-phase induction motors dominate in terms of the amount of electricity consumed.

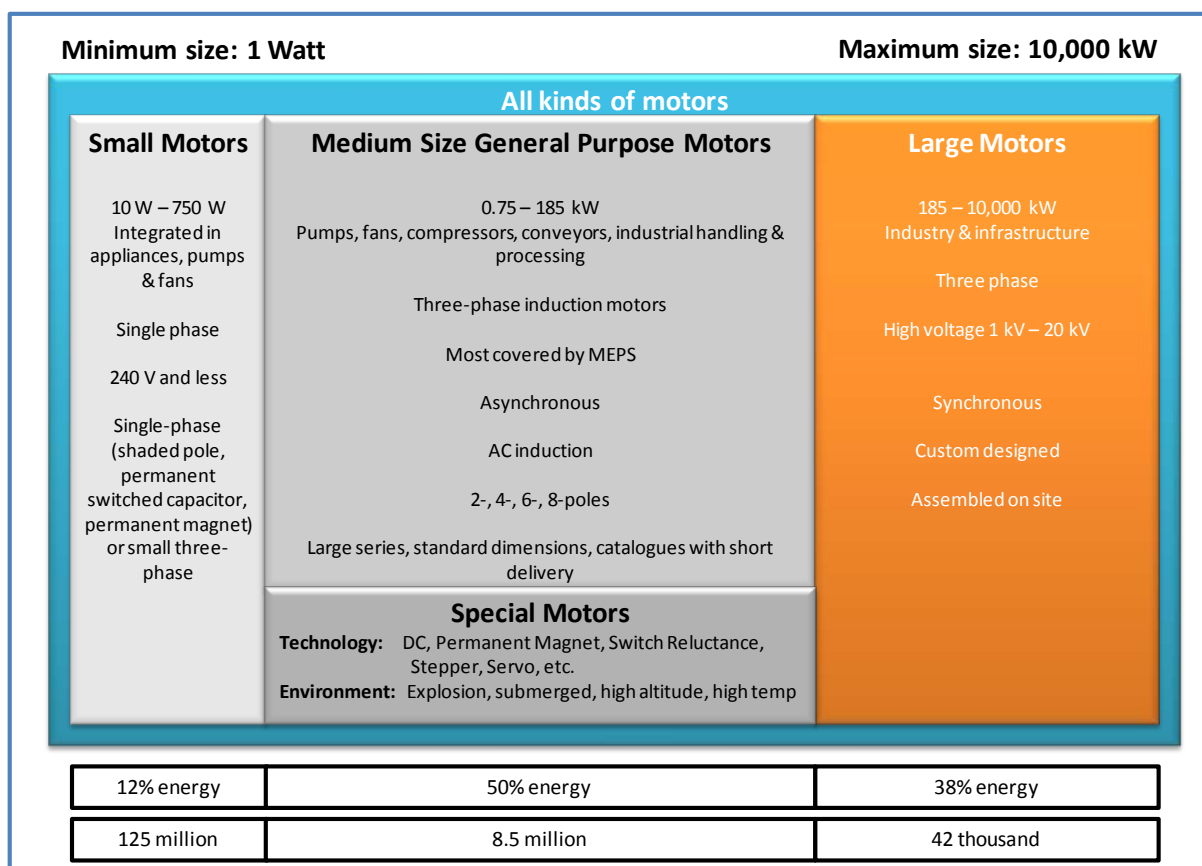


Figure 5: Main types of electric motors as a function of power and associated characteristics, values are for Australia and New Zealand combined

Source: Based on Waide and Brunner, IEA, 2011

The various types of electric motors are used across all sectors of the economy, although certain trends appear:

- Small single-phase AC motors dominate the residential sector, and appear in most domestic appliances. Sizes range from the tiny motors that power the fans and disk drives found in electronic equipment through to mid-sized large motors found in air conditioners, refrigerators and washing machines. The vast majority of these single-phase motors are sold as an integral part of the appliance.

- Three-phase induction motors are used heavily in industry. They can appear as an integral part of another piece of equipment such as an air compressor or a fan, but are very often sold as a separate item.

It is noteworthy that more than 80% of industrial motors are destined for pumps, compressors and fans. Where there is a variable load, these are classic applications for variable speed drives, and improving the energy efficiency of these driven systems is often a matter of installing a variable frequency drive.

Electric motors can be considered a 'commodity' like product, with a large number of suppliers producing a basically similar product. A large number of motors, particularly smaller motors are sold in large quantities to original equipment manufacturers who incorporate them in the final consumer products such as domestic appliances, IT hardware and industrial equipment.

The stock and sales of electric motors

Tables 2 and 3 show estimated annual sales and installed stock of electric motors (three-phase and three types of single-phase) in Australia and New Zealand. Estimated figures for 2010 plus projected figures for 2020 are shown.

Table 2: Sales and stock of motors in Australia

Motor type	Sales		Stock	
	2010	2020	2010	2020
Three-phase	277,400	369,300	7,267,000	10,547,000
Permanent switched capacitor	5,288,000	6,483,000	55,340,000	68,760,000
Shaded pole	4,255,000	5,245,000	40,691,000	49,352,000
Permanent magnet	1,238,000	1,695,000	8,683,000	13,502,000

Table 3: Sales and stock of motors in New Zealand

Motor type	Sales		Stock	
	2010	2020	2010	2020
Three-phase	21,100	34,300	1,366,000	1,665,000
Permanent switched capacitor	886,800	999,400	11,310,000	13,380,000
Shaded pole	664,000	776,000	7,883,000	9,157,000
Permanent magnet	104,180	132,600	1,647,000	2,491,000

Stakeholders are asked to provide improvements to the sales and stock estimates for three-phase and single-phase motors. There is some uncertainty around the above figures, so robust information and supporting evidence would be appreciated to facilitate better informed policy decisions.

Useful data would be broken down by size and motor type, for motors currently scope (0.73 – 185 kW), and those considered for regulation, ie. line start permanent magnet motors and three-phase motors 185 – 1,000 kW and single- and three-phase motors <0.75 kW.

5. Performance and testing standards

Standards are fundamental in the context of MEPS. Specifically, a performance standard is required to define the level of performance that the piece of equipment must deliver, and a standard for testing must define the methods and procedures to be employed to measure the performance of the equipment.

The proposed changes to MEPS presented in Section 7 are readily supported by existing standards. The adoption of these standards fits with the E3 Program commitment to align with international standards.

The two standards currently used for electric motors MEPS are AS/NZS 1359.5-2004 which is the performance standard, and AS/NZS 1359 Parts 101, 102.1 and 102.3 which is the test standard.

AS/NZS 1359.5-2004 defines a set of minimum performance standards that three-phase electric motors from 0.73 to <185 kW manufactured in or imported into Australia or New Zealand must comply with. There are also a set of non-mandatory performance targets (HEPS) that a 'high efficiency' motor must meet.

AS/NZS 1359 offers two methods for assessing stray losses. One is based on IEC 60034-2 and this approach assumes the stray losses to be a fixed percentage. The second method is based on IEEE 112 Method B which includes a method for calculating stray losses.

The most important international standard that defines test methods for three-phase motors is the International Electrotechnical Commission (IEC) 60034-2-1. IEC 60034-2-1 sought to harmonise methods for determining efficiencies of rotating electrical machines and also methods for obtaining the specific losses. A revision of this standard is expected to be published in the first half of 2014.

The IEC performance standard is IEC 60034-30-1. This standard defines three commercial levels of energy efficiency, ranging from IE1, which is the lowest standard through to IE3. Further, the standard recommends IE4 (Super Premium Efficiency) as a future level above IE3. Nations have their own performance standards that are largely aligned with the IEC levels. For instance, all motors covered by MEPS in the EU must achieve a minimum standard of IE2.

A revised IEC 60034-30-1 is expected to be published in the first half of 2014. It significantly expands the product range covered, from 0.12 to 1,000 kW. All technical constructions of electric motors will be covered as long as they are rated for on-line operation and not just three-phase, cage-induction motors as in the first edition.

The basic alignment across international standards is shown in Table 4. Australia and New Zealand have obligations to align with international standards such as those of the IEC, based on World Trade Organisation commitments on barriers to trade.

Table 4: Global Efficiency Classes, Testing Standards and MEPS for Electric Motors

Efficiency Levels	Efficiency Classes	Testing Standard	Performance Standard
3-phase induction motors	IEC 60034-30-1	IEC 60034-2-1	Mandatory MEPS ****
	Global classes IE-Code 2008; rev. 2013 *	incl. stray load losses 2007; rev. 2013 **	National Policy Goal
Super Premium Efficiency	IE4	Preferred Method	
Premium Efficiency	IE3	Summation of losses with load test: P_{LL} determined from residual loss	Canada
			Mexico
			USA
			South Korea 2015
			Switzerland 2015
			EU*** 2015 / 2017
High Efficiency	IE2		Australia
			Brazil
			China
			Europe
		South Korea	
		New Zealand	
		Switzerland	
		Turkey	
Standard Efficiency	IE1		Costa Rica
			Israel
			Taiwan

22 May 2013, CUB
A+B International
EMSA/MEPS table May 2013

*) Output power: 0.12 kW - 1000 kW,
50 and 60 Hz, line operated
2-, 4-, 6- and 8-poles

**) for 3-phase machines,
rated output power < 1000 kW
****) Minimum Energy Performance Standard

bold means in effect
****) European Union (2015: below 7.5 kW),
2017: IE3 or IE2 + Variable Speed Drive

The United States Department of Energy (DOE) has adopted energy conservation standards for small electric motors, which commenced in February 2010 (DOE 2009). Motors covered under the new regulations range from 0.2 to 2.2 kW and include single- and poly- phase general purpose motors. New regulations will take effect in 2015.

Stakeholders are asked to comment on the international standards which would be applicable to Australia and New Zealand.

6. Technological advances

The technological advances that are discussed here are focused on improving the efficiency of electric motors, which means eliminating or reducing the sources of losses. Losses in an electric motor come from several sources. These are losses due to electrical resistance, magnetic losses due to magnetic eddies in the magnetic cores, and mechanical losses. Mechanical losses are due to bearing friction, and losses associated with the cooling fan. Figure 6 shows how the losses compare to the mechanical output of a typical motor.

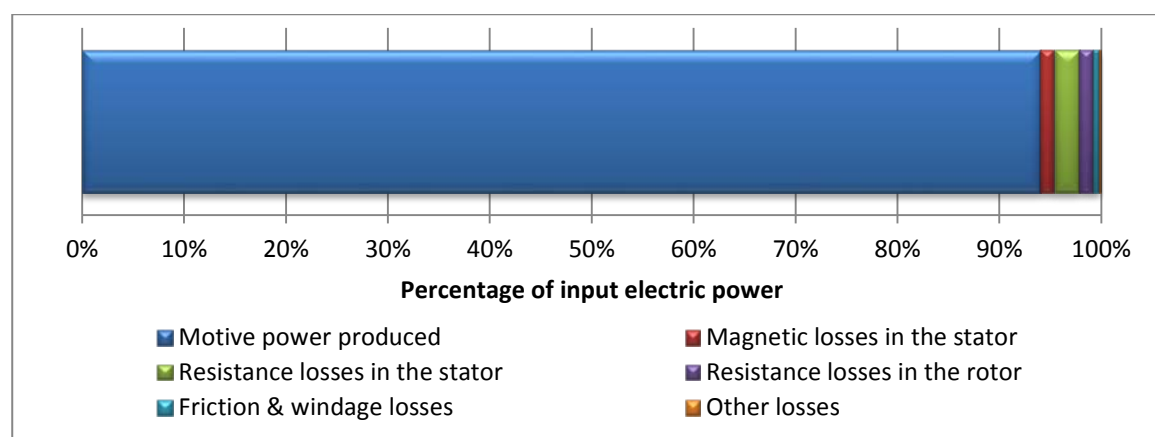


Figure 6: Magnitude of losses and motive power in a typical three-phase electric motor

Source: Waide and Brunner, IEA, 2011

These losses appear in all motor types to a varying degree, and the approaches used to tackle these sources of loss apply to most types of motors (and especially all AC induction motors). Losses in electric motors are being reduced in the following ways.

- Electrical losses can be tackled by lowering the resistance of the coils i.e. using thicker wires or by removing the rotor coils (permanent magnet and switched reluctance motors).
- Magnetic losses can be reduced through better construction of the motors e.g. thinner laminations, magnetic steel with better magnetic properties in the laminations.
- Mechanical losses can be reduced through better construction of the motors e.g. tighter tolerances.

It is understood that motor technologies sufficient to meet some of the proposed MEPS levels (e.g. IE3 three-phase induction motors) are already available in the Australian and New Zealand markets. The key issues appear to be availability and relative cost of these technologies, and also the likely availability and relative cost at the point that more stringent regulations would commence.

Stakeholder views are sought regarding technological advances that will need to be considered when exploring possible extensions to MEPS for motors.

Stakeholders are asked to comment on the current and likely future availability of motors which would meet the proposed regulatory levels.

7. Policy options

Possible policy directions for the electric motor program are outlined below. More than one option could be implemented at the same time. Policy options investigated in a Regulation Impact Statement (RIS) would be subject to further consultation in both countries, and to Ministerial approval in New Zealand.

Option 1: No action (business as usual);

Option 2: Increase MEPS stringency to mandate IE3 performance levels;

Option 3: Extend the scope of MEPS upward to include all electric motors rated for on-line operation in the range 0.73 – 1,000 kW;

Option 4: Extend the scope of MEPS downward to include all electric motors rated for on-line operation in the range 0.12 – 185 kW;

Option 5: Mandatory testing, registration & public disclosure of energy efficiency and key performance information for all AC electric motors rated for on-line operation in the range 0.12 to 1,000 kW; and/or

Option 6: Voluntary efficiency standards and certification for selected electric motors that are not covered by MEPS.

Option 1: No action

This scenario assumes no changes to policy. The electric motor market would continue to operate as it does now, with those motors in scope required to meet MEPS set at lower levels than international markets, risking that Australian and New Zealand markets receive less efficient products. Motors outside of scope are not required to meet energy efficiency performance standards nor provide information to enable consumers to compare products.

Option 2: Increase MEPS stringency to mandate IE3 performance levels

The IE3 levels in IEC 60034-30-1 are approximately equivalent to those in the High Efficiency Performance Standard (HEPS) in AS/NZS 1359.5-2004. This option would broadly align with leading international motor efficiency regulations. In the US, electric motors in the range 1 – 150 kW have been required to achieve NEMA Premium Efficiency (equivalent to IE3) since 2010. In the EU, IE3 levels will apply from 2015 for motors 7.5 – 375 kW, and from 2017 for motors 0.75 – 375 kW. Canada and Mexico also regulate to IE3 levels, and more countries are following.

Australia and New Zealand have the option to follow the EU in allowing a lower performance (IE2) motor coupled with a variable speed drive (VSD) as a substitute for a higher performance (IE3) motor. If regulatory amendments to MEPS are agreed, they would not come into force before 1 April 2015 in Australia and New Zealand.

Option 3: Expand MEPS to include all AC motors rated for on-line operation, 0.73 - 1,000 kW

Imposing MEPS on all kinds of electric motors that are rated for on-line operation in the range 0.73 to 1,000 kW (including all single- and three-phase induction motors, and line-start permanent magnet motors) would align with the upper-end of the size range within scope in the revised IEC performance standard 60034-30-1. This standard is likely to be published in the first half of 2014 and will likely be adopted by regulators in the EU and other jurisdictions.

Current regulations in the EU, USA, Canada, Mexico, Switzerland and others impose MEPS on three-phase induction motors 185 to < 375 kW, at the IE2 level in IEC 60034-30-1.

This option would address information failures by mandating public disclosure of motor energy efficiency and key performance information for motors within scope, on the Energy Rating website. If regulatory amendments to MEPS are agreed, they would not come into force before 1 April 2015 in Australia and New Zealand.

Option 4: Expand MEPS to include all AC motors rated for on-line operation, 0.12 - 185 kW

Imposing MEPS on all kinds of electric motors that are rated for on-line operation in the range 0.12 - 185 kW (including all single- and three-phase induction motors, and line-start permanent magnet motors) would align with the smaller-end of the size range within scope in the revised IEC performance standard 60034-30-1. This standard is likely to be published in the first half of 2014 and will likely be adopted by regulators in the EU and other jurisdictions. Fan motors in commercial refrigeration are particularly worth considering because of the relatively large amount of power consumed by fans.

US regulations introducing energy efficiency standards for certain classes of small motors will take effect in 2015 (DOE 2010). The US regulations will not cover the common split-phase, permanent switched capacitor, and shaded-pole motors. Small motors that are components of products already covered by energy efficiency regulation, e.g. refrigerators and freezers, clothes washers and dryers, are also excluded.

This option would address information failures by mandating public disclosure of motor energy efficiency and key performance information for motors within scope, on the Energy Rating website. If regulatory amendments to MEPS are agreed, they would not come into force before 1 April 2015 in Australia and New Zealand.

Option 5: Mandatory testing, registration & public disclosure of energy performance information

This option proposes that a selection of electric motors which are not covered by MEPS (e.g. AC electric motors rated for on-line operation in the range 0.12 – 0.73 kW and 185 – 1,000 kW) be required to provide information to facilitate informed motor purchasing decisions.

In Australia, the *Greenhouse and Energy Minimum Standards Act 2012 (GEMS 2012)* would require models within scope to be registered with the GEMS Regulator as a condition of lawful supply.² In New Zealand, registrations would also be required by regulation.

Publication of energy performance and other data on the Energy Rating website (www.energyrating.gov.au) would significantly improve the reliability and comparability of the energy efficiency information available in the market for electric motors which are currently out of scope.

Option 6: Voluntary efficiency standards for selected motors outside of MEPS

The feasibility of a voluntary certification scheme for electric motors which are not covered by MEPS could be explored. It would rely on encouraging motor suppliers to meet minimum energy efficiency levels voluntarily.

Cost-Benefit Analysis

Preliminary cost-benefit analysis was previously undertaken for **Option 2**. Tables 5 and 6 show the projected savings. This is existing material from the Department's preliminary investigations into regulatory options, and is provided for illustrative purposes only. All policy options for further consideration would be subject to thorough analysis of costs and benefits in a consultation RIS.

Table 5: Savings from increasing MEPS on three-phase motors in Australia

Option	Electricity savings (GWh)		Greenhouse abatement (kt CO ₂ -e)		Net present value of Societal Cost
	Annual in 2012	Cumulative to 2020	Annual in 2012	Cumulative to 2020	
Option 2: Increasing the stringency of current MEPS as applied to three-phase induction motors from IE2 to IE3	61.5	3,025.2	59.3	2,587.5	\$AU 1,437.9 million

² S14 of the GEMS Act states that 'A supply of a GEMS product includes a supply of the product by way of sale, exchange, gift, lease, loan, hire or hire-purchase.'

Table 6: Savings from increasing MEPS on three-phase motors in New Zealand

Option	Energy savings (GWh)		Greenhouse abatement (kt CO ₂ -e)		Net present value of Societal Cost
	Annual in 2012	Cumulative to 2020	Annual in 2012	Cumulative to 2020	
Option 2: Increasing the stringency of current MEPS as applied to three-phase induction motors from IE2 to IE3	5.8	285.5	0.7	36.8	\$NZ 62.7 million

Stakeholders are asked to comment on these possible policy directions.

Do you think that these policy options could feasibly address the Problem outlined in Section 2, in terms of market failures inhibiting improved energy efficiency of electric motors?

What additional costs do you think these options would place on industry compared to the current situation?

What do you think would be the best way for governments to facilitate an increase in the average energy efficiency of electric motors sold?

Can you suggest how regulation could be viably extended to small motors?

Stakeholders are asked to provide data to support in-depth cost-benefit analyses of these policy options.

8. Additional activities

Several additional activities underway in the area of electric motors regulation are outlined below.

Mandate a test procedure to explicitly include totally enclosed air over (TEAO) motors in MEPS

TEAO motors are frame surface cooled machines, the exterior of which is cooled by a ventilating means external to the machine, for example a fan. These would be applied in situations which require significant ventilation such as poultry farms, large buildings, tunnels, and mining operations.

Such machines are not equipped with their own external cooling fans, and they rely on the air-stream in which they are mounted to transfer heat away from the external surface of the motor. Because such a motor is reliant on its driven load for cooling, the usual methods for determining motor efficiency are not applicable.

The current draft of the IEC efficiency classification standard IEC 60034-30-1 includes these types of motors. While the Australian/New Zealand standard AS/NZS 1359.5-2004 does not explicitly exclude these types of motors, the test method specified in regulation is not appropriate for testing them.

An efficiency measurement procedure for TEAO motors will be developed to explicitly include these products in MEPS requirements for electric motors. The test procedure would then be recommended for inclusion in the IEC test method standard for electric motors IEC 60034-2-1.

Adopt IEC standards for test method and performance levels

The latest revisions of IEC standards, *IEC 60034-2-1: Rotating electrical machines* and *IEC 60034-30-1: Motor efficiency classes* are likely to be published in the first half of 2014. Australian and New Zealand MEPS requirements are planned to reference this test method for electric motor registrations.

The revised test method standard is greatly improved and contributes greatly to international harmonisation of methods for determining efficiencies and obtaining the specific losses of electric motors. The IEC performance standard defines 4 levels of energy efficiency plus proposes a higher 'future' level of efficiency. Australia and New Zealand would join other nations in regulating to the performance levels that they select from the IEC classifications.

9. Reference List

2006, 'The Stern Review on the Economic Effects of Climate Change', *Population and Development Review*, 32: 793-798.

DOE 2010, *Energy Conservation Program: Energy Conservation Standards for Small Electric Motors*, United States of America Office of Energy Efficiency and Renewable Energy, Department of Energy, Washington

Lewis, A. and Gomer, S. 2008, *An Australian Cost Curve for Greenhouse Gas Reduction*, McKinsey & Company

Waide, P. and Brunner, C. 2011, *Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems*, International Energy Agency



E3 Product Profile: Electric Motors

www.energyrating.gov.au

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