

# **ISSUES PAPER**

## **Energy Efficiency Regulation of Electric Motors**

**January 2020**

## 1. Introduction

To promote the development and adoption of efficient electric motors, Australian and New Zealand Governments have adopted minimum energy performance standards (MEPS) for low-voltage, three-phase cage induction electric motors<sup>1</sup> that are supplied domestically.

Motors with outputs  $\geq 0.73$  kilowatts (kW) to  $<185$  kW manufactured in, or imported into Australia or New Zealand, have been subject to MEPS regulatory requirements since 2001 in Australia and 2002 in New Zealand.<sup>2</sup> In 2006, MEPS levels were tightened in both countries to approximately align with IE2 levels prescribed in the International Electrotechnical Commission's (IEC's) framework. In 2019, minor changes were made to Australia's MEPS levels that aligned them with IE2 levels. As part of this update, Australia's and New Zealand's high efficiency levels were aligned to IE3 (Premium Efficiency) levels. If motors are supplied either as individual items or incorporated into other equipment, they must be registered with either the Australian or New Zealand regulator.

The Australian Department of Industry, Science, Energy and Resources – on behalf of the Equipment Energy Efficiency (E3) Program – is planning to release a motors consultation regulation impact statement (RIS) in 2020 to Australian and New Zealand stakeholders. The consultation RIS will examine the costs and benefits of tightening motors MEPS to IE3 levels. Other issues outlined below will also be examined in the consultation RIS.

The purpose of this Issues Paper is to seek stakeholders' views on what regulatory changes may be appropriate to examine during the RIS process. Stakeholders are encouraged to provide input on the issues below.

## 2. Consultation RIS modelling assumptions

The consultation RIS will include a cost benefit analysis (CBA) that will examine the net benefits of changes that will be proposed to the energy efficiency regulation of electric motors. E3 notes there is no commercial source of Australian sales data for motors that could be used in the CBA. Therefore, E3 has attempted to obtain disaggregated sales data from major Australian suppliers on a voluntary basis. However, because mutually agreeable terms on the supply of the data could not be reached, E3 will now make assumptions on Australian motor sales volumes and prices. New Zealand sales data is available and de-identified, and this aggregated data will be used for the analysis. **Appendix A** details the approach and data sources that will be used to develop the CBA model.

*1) Are there any modelling assumptions listed in Appendix A that you disagree with and if so what assumptions should be used instead?*

## 3. Regulatory Framework for Motors Energy Efficiency

In Australia, the *Greenhouse and Energy Minimum Standards (GEMS) Act 2012* regulates the energy efficiency of certain products and appliances. Motors are regulated under the provisions of the *Greenhouse and Energy Minimum Standards (Three Phase Cage Induction Motors) Determination 2019* (the Determination).<sup>3</sup> The Determination references the IEC 60034-2-1 Ed. 2.0 test standard (Method 2-1-1B) to determine the energy efficiency of

<sup>1</sup> Unless stated otherwise, all references to motors relate to three-phase cage induction electric motors.

<sup>2</sup> See Section 4 for details concerning the scope of the regulation.

<sup>3</sup> <https://www.legislation.gov.au/Details/F2019L00968>

motors. In New Zealand, motors are regulated under the *Energy Efficiency (Energy Using Products) Regulations 2002* (the Regulations). The Regulations generally mirror the Determination's requirements. In this paper, the Determination and the Regulations are collectively referred to as 'efficiency regulations'.

#### 4. Why Government Action is Required

Many developed countries and regions have progressively tightened their MEPS levels to IE3 levels. Consequently, Australia's and New Zealand's MEPS levels which are at IE2 levels, have lagged behind those adopted by many countries as shown in Table 1 below.

**Table 1: Motors MEPS Levels in Countries/Regions**

Country or Region	MEPS
Australia/New Zealand	IE2
EU/Switzerland/Turkey	IE3 <sup>1</sup>
USA, Canada, Mexico	~IE3
South Korea	IE2/IE3 <sup>2</sup>
Japan	IE3
Singapore	IE3
Saudi Arabia	IE3
China	~IE2
Brazil	~IE2
Taiwan	IE2

**Notes**

<sup>1</sup> IE2 for exclusive use with inverter (variable speed drive (VSD)) operation

<sup>2</sup> IE2 (0.75 - 30 kW); IE3 (37 - 375 kW)

While Australia's and New Zealand's MEPS levels were appropriate for the market conditions prevailing in 2006, since then:

- Large markets in the EU, US and elsewhere have tightened MEPS to IE3. China continues to pursue an aggressive campaign to improve motor energy efficiency and meet IE3 levels.
- Consequently, most of the world's motors market is supplied with energy efficient motors that are also available in Australia and New Zealand.
- Australia's electricity prices have increased over the past seven years and this should have provided an incentive for consumers to demand more efficient motors.
- Global market forces have driven down the real price of motors, making higher levels of efficiency more cost effective.

E3 notes the operating costs of most electric industrial motors (including the consumed energy and maintenance costs) dominates the life-cycle cost of motor ownership.<sup>4</sup> Despite the supply of IE3 motors in global markets, product registration data shows that only 39% of motors registered for supply in Australia and New Zealand meet IE3. E3 recognises there are several factors that may influence buyers to purchase IE2, rather than IE3 motors. These include:

- Buyers may not be considering the lifetime costs of their motor ownership;
- Buyers may not be the end users of motors and therefore cheaper IE2 motors are being selected to minimise capital expenditure costs, rather than minimising lifetime ownership costs (i.e. a split incentive market failure may exist); and

<sup>4</sup> For example, see *A Study into the True Life Cycle Costs of Electric Motors*, [https://ceed.wa.edu.au/wp-content/uploads/2017/02/10.Irfan\\_.Ameer\\_.pdf](https://ceed.wa.edu.au/wp-content/uploads/2017/02/10.Irfan_.Ameer_.pdf)

- The costs associated with upgrading from an IE2 motor to an IE3 motor (e.g. possible motor control or supply upgrades) may outweigh the possible energy savings.

IE3 is now considering whether it is appropriate to tighten Australia’s and New Zealand’s MEPS levels to IE3.<sup>5</sup> The RIS process will estimate the costs and benefits of this change.

2) *Are there any issues not identified above that should be considered if MEPS were increased to IE3?*

## 5. Scope of Regulation

Motors with the following characteristics are regulated for energy efficiency in Australia and New Zealand:

- Poles: 2, 4, 6 and 8-pole
- Output: 0.73 kW up to less than 185 kW
- Voltage: up to 1,100 volts alternating current (V)

### 5.1 Output

Table 2 shows that most countries or regions’ energy efficiency regulations for 2, 4 and 6-pole motors generally cover motors with capacities from 0.75 kW to approximately 375 kW. Australia and New Zealand’s scope is considerably narrower with coverage extending from 0.73 kW to less than 185 kW. Several countries also regulate 8-pole motors with upper ranges varying from 185 kW to 370 kW. The US regulates small 2, 4, and 6-pole motors with open (unsealed) enclosures down to 0.18 kW and requires compliance at IE3 levels. The EU has agreed to regulate 8-pole motors and also adopt MEPS at IE2 levels for small motors in the range 0.12 kW to less than 0.75 kW. These new regulations are take effect from 1 July 2021.

**Table 2: Regulatory scope for motors - Output x Poles**

Country or Region	Rated Output (kW)		
	2 & 4 Pole	6 Pole	8 Pole
Australia/New Zealand	0.73 - <185	0.73 - <185	0.73 - <185
EU/Switzerland/Turkey <sup>6</sup>	0.75 - 375	0.75 - 375	n.a.
Singapore	0.75 - 375	0.75 - 375	n.a.
Japan	0.75 - 375	0.75 - 375	n.a.
China	0.75 - 375	0.75 - 375	n.a.
Saudi Arabia	0.75 - 375	0.75 - 375	n.a.
USA	0.75 - 373	0.75 - 261	0.75 - 186
Canada	0.75 - 375	0.75 - 260	0.75 - 185
Mexico	0.746 - 373	0.746 - 261	0.746 - 186
South Korea	0.75 - 375	0.75 - 200	0.75 - 200
Brazil	0.75 - 370	0.75 - 370	0.75 - 370
Taiwan	0.75 - 200	0.75 - 200	0.75 - 200

<sup>5</sup> If MEPS were changed to IE3 levels, it follows that IE4 (Super-Premium Efficiency) levels could be adopted as Australia’s and New Zealand’s voluntary high-efficiency levels.

<sup>6</sup> EU countries have amended their ecodesign requirements to extend the scope of their motors regulation to: include 0.12 kW to less than 0.75 kW motors at the IE2 level, include 8-pole motors; and extend their upper scope to 1,000 kW. Changes will commence on 1 July 2021.

To more closely align Australia’s and New Zealand’s regulatory scope with that generally adopted elsewhere, the consultation RIS will examine the net benefit of changing the regulatory scope as follows:

- Small motors – 0.12 kW to less than 0.75 at IE2 levels; and
- Other motors – 0.75 kW to 375 kW at IE3 levels.

- 3) *What issues need to be considered if efficiency regulation’s lower boundary was extended to 0.12 kW and the upper boundary was extended to 375 kW?*
- 4) *Are there any practical limitations of testing larger motors rated up to 375 kW and smaller motors rated between 0.12 kW and 0.75 kW?*

## 5.2 Voltage

Table 3 below shows the scope of countries’ or regions’ energy efficiency. Australia and New Zealand are the only countries that have an upper threshold greater than 1,000 volts alternating current (VAC).

**Table 3: Coverage of regulation by voltage**

Country/Region	VAC
Australia/New Zealand	≤ 1,100
EU, Switzerland, Turkey	1,000
China	1,000
Japan	1,000
Saudi Arabia	1,000
Singapore	< 1,000
Taiwan	690
South Korea	600
USA, Canada, Mexico	600
Brazil	600

Australian industry considers low-voltage motors to be those that operate on an electrical supply ≤1,000V. This approach is consistent with the IEC’s low-voltage definition. The GEMS registration database has 15 motors registered as rated to operate at 1,100V. However, these motors are also rated to operate at voltages below 1,000V and therefore would still be captured by regulation if the upper threshold was lowered to 1,000V. The RIS process will propose lowering the upper voltage threshold to 1,000V.

- 5) *Are there any reasons why the efficiency regulation’s voltage threshold should not be changed to 1,000V?*

## 5.3 Duty Type

As shown in Table 4 below, of the countries and regions examined, only Australia and New Zealand regulate all duty type motors<sup>7</sup> with the exception of S2<sup>8</sup> (short-time duty)

<sup>7</sup> See Appendix B for a full explanation of the duty types discussed in this paper.

<sup>8</sup> S2 motors are designed to operate briefly in high-load applications for (e.g. hoists, roller doors and cranes).

motors. While all countries regulate S1<sup>9</sup> (continuous duty) motors, many also regulate S3<sup>10</sup> (intermittent periodic duty) motors if they are rated with a cyclic duration factor  $\geq 80\%$ .<sup>11</sup> The EU, Turkey, Switzerland and Singapore also regulate S6<sup>12</sup> (continuous-operation, periodic duty) and S9<sup>13</sup> (non-periodic duty) motors.

**Table 4: Coverage of regulation by duty type**

Country or Region	Duty Types Covered
Australia/New Zealand	All but S2
USA, Canada, Mexico, South Korea, Brazil	S1
Japan, Saudi Arabia, China	S1, S3 [ $\geq 80\%$ ]
EU/Switzerland/Turkey	S1, S3 [ $\geq 80\%$ ], S6, S9
Singapore	S1, S3 [ $\geq 80\%$ ], S6, S9

E3 notes that:

- The overwhelming majority (understood to be >99 per cent) of motors sold in Australia and New Zealand are S1 duty type motors.
- Appropriately specified S1 motors may also be used to perform non-continuous duty type applications (i.e. S2 to S9 applications).
- S2 to S9 duty types describe motor operating modes that are characterised by motor temperatures that never become stable.
  - If temperature stability is not achieved, a motor cannot be assigned a single, efficiency rating. This is because the various components of its losses are all, to varying degrees, temperature-dependent, with stator and rotor winding losses most strongly temperature-dependent.
  - For these reasons, S2 to S9 duty type motors cannot be consistently evaluated with reference to fixed MEPS.
  - E3 notes that given the current IEC testing framework, it is not practicable to test S2-S9 motors to give replicable results.
- The use of high-efficiency motors in non-continuous duty applications, can lead to the consumption of more, rather than less, electrical energy, than would be the case if lower-efficiency motors were employed for that duty.
  - For example, the use of copper rotor ‘windings’ (used in lieu of the more usual die-cast aluminium) lowers rotor resistance and reduces slip, which, in turn, lowers rotor losses and improves efficiency.
  - However, the use of copper windings results in increased rotor inertia and reduced motor starting torque.
  - While neither of these effects is important for motors that run continuously (i.e. S1 motors) in other duty type motors, which are employed in repeated stop-start operations, the use of copper rotors leads to:
    - Longer acceleration period (and associated increased rotor and stator losses), due to reduced starting torque and increased rotor inertia.

<sup>9</sup> S1 motors can deliver rated output for an indefinite period without overheating (e.g. pump applications).

<sup>10</sup> S3 motors are designed to operate in applications involving a sequence of identical duty cycles at constant rated output followed by a period at rest (e.g. computer-controlled production drilling operations).

<sup>11</sup> S3 cyclic duration factor = (Operation time at constant load) / (time of one load cycle).

<sup>12</sup> S6 motors are designed to operate in applications involving sequence of identical duty cycles consisting of a time of operation at constant rated load and a time of operation at no load (e.g. saw mill).

<sup>13</sup> S9 motors are designed to operate in applications where load and speed vary non-periodically. This duty includes frequently applied overloads.

- Increased starting current (and associated increased rotor and stator losses), due to decreased rotor resistance.
- Accordingly, in applications with frequent stop/start cycles (such as S3 applications) IE2 motors with low-inertia rotors may consume less energy than IE3 motors.

6) *Are there any motor duty types that should be excluded from energy efficiency regulation? Why?*

## 6. Family of models

When motors' energy efficiency regulation shifted from a state and territory-based approach to Commonwealth regulation, an interim fee concession was introduced for Australian registrations. Registration of motors in New Zealand is free. This temporary facility was adopted until a family facility could be introduced. Following consultations with suppliers and other stakeholders, the 2018 Motors Determination introduced a family of models facility. The family of models facility provides flexibility to make it easier and cheaper for suppliers to register their electric motors.

### FAMILY OF MODELS

The motors family of models definition allows suppliers to register two or more models, up to a maximum of 10 models, if each model:

- (a) is of the same brand; and
- (b) has the same frame size; and
- (c) has the same characteristics for each of the following:
  - (i) number of poles;
  - (ii) the duty type;
  - (iii) rated output power (in kilowatts); and
- (d) relies on a single test report.

In addition, the product of each family member's rated voltage and its rated current must be the same.

Note: The Determination at <https://www.legislation.gov.au/Details/F2019L00968> provides the complete text of family requirements.

The motors family requirements mean that all family members rely on a single test report and are electrically equivalent. It is likely that there will be relatively few members in each family and many models will not meet the criteria to be in a family. Further, if one model of the family is found to be non-compliant, including failing to meet MEPS requirements, then the registration risks being cancelled which would affect all models covered by the registration, not just the model that failed check testing. Where this occurred, the affected models could potentially be re-registered under a new family if a new test report that demonstrated compliance was provided. This is the case for all GEMS products that employ a family of models arrangement.

Across GEMS products, family registrations have generally been an arrangement to reduce registration costs for products with different model numbers and minor cosmetic differences, but with the same core technical specifications and energy performance.

E3 is now exploring whether the family of models definition is appropriate for motors or if it should be broadened. This would allow more models to be grouped into family registrations and therefore reduce the registration costs for suppliers.

A new family arrangement could be to allow suppliers to register two or more models, up to a maximum of 10 models, if each model:

- (a) is of the same brand; and
- (b) has the same rated output power (in kilowatts); and
- (c) has the same number of poles.

E3 notes that under this proposal:

- All family members would need to have efficiency equal or greater than the efficiency indicated in the test results for the least-efficient family member.
- While there would continue to be a cap on 10 family members, in practice, there could be many more models in a family under this arrangement.
- If one model of the family is found to be non-compliant, then the registration risks being cancelled and this would also apply to all models in the family.
- A suitable transition arrangement that would facilitate moving current registrations into new families would need to be developed.

**7) *Would the family arrangement proposed above be practical for suppliers? What alternative family definitions may be more suitable?***

## **7. Exclusions**

The Determination (for Australia) and Standard (for New Zealand) specify that the following types of motors are not covered by the regulation:<sup>14</sup>

- a) submersible (sealed) motors specifically designed to operate wholly immersed in a liquid;
- b) motors that are integral to, and not separable from, a driven unit;
- c) multi-speed motors;
- d) motors to be used only for short-time duty cycle applications, which have a duty type rating of S2<sup>15</sup>;
- e) rewind motors;
- f) motors that are supplied exclusively to third parties who will incorporate the motors into equipment that will be exported to a country other than Australia or New Zealand; and
- g) high slip motors (torque motors).

Several countries or regions also exclude these types of motors from their energy efficiency regulations. Table 5 lists the most common exclusions that countries have adopted.

**8) *Are any of the above exclusions inappropriate and if so, what would be the rationale for their removal?***

<sup>14</sup> See Section 12 of the Determination for full details concerning all exclusions

<sup>15</sup> See above for discussion concerning exclusions based on duty types



**Table 5: Common exclusions from efficiency regulation - various countries and regions**

	Au/NZ	EU Switzerland Turkey	USA	Mexico	Canada	Japan	S Korea	Singapore	China	Taiwan	Brazil	Saudi Arabia
Completely integrated	Y	Y				Y		Y	Y	Y		Y
Submersible (wholly immersed)	Y	Y	Y	Y	Y		Y	Y		Y		Y
Two speed/Multi-speed/Switchable pole	Y	Y	Y	Y	Y		Y	Y	Y	Y		Y
Rewound	Y											
High-slip/Torque	Y					Y <sup>2</sup>		Y				Y
Supplied exclusively for exported equipment	Y							Y				
Designed for inverter (VSD) operation <sup>1</sup>		Y	Y	Y	Y	Y <sup>3</sup>	Y <sup>4</sup>			Y	Y	Y
Explosive atmospheres/hazardous location		Y				Y		Y			Y	Y
Brake motors (construction/hoist)		Y		Y				Y	Y			Y
Operating temperature > 400°C (smoke extraction)		Y						Y	Y			Y
Traction of electric vehicles		Y										
Ambient < -30°C; < 0°C, water-cooled; > 60°C		Y						Y				
Ambient < -20°C						Y						
Liquid-cooled			Y	Y	Y							Y

Notes:

<sup>1</sup> The rating plate only specifies the torque not the output; not suitable to be connected directly to supply; motors with integrated frequency converters when the motor cannot be tested separately from the converter (IEC 60034-30-1)

<sup>2</sup> 0.75 to < 110 kW: ≥ 5%; >110 kW: ≥ 3%

<sup>3</sup> Only applies to motors using a forced-cooling fan

<sup>4</sup> Not inverter (VSD) motors used in pump, fan or blower applications

E3 will examine the merits of adopting some of the exclusions listed in Table 5, including whether they are appropriate for our markets. Specifically, E3 will consider whether the following types of motors should be covered by regulation:

- i) **Motors designed exclusively for inverter or variable speed drive (VSD)<sup>16</sup> operation:** The efficiency of motors can be greatly improved when using VSDs that control the speed of the motor by varying the frequency of the supply to the motor. This particularly applies in centrifugal load applications, such as pumps and fans. The power that a pump or fan consumes is directly proportional to the cube of its velocity. For example, if a fan is run at 80% of full speed, it theoretically uses approximately 50% of full load power. Because a small reduction in speed can significantly reduce energy consumption, and because many fan and pump systems run below full capacity for much of the time, VSDs can produce significant energy savings. Although these motors may be able to operate and be tested for efficiency at 50 Hz or 60 Hz, their design may have been optimised to be most efficient at higher frequencies (and therefore speeds) that they may be expected to generally operate at.

*9) Should motors designed exclusively for inverter or /variable speed drive operation be excluded from efficiency regulation and if so, what would be the rationale for their exclusion?*

- ii) **Explosive atmosphere motors:** In the past, some suppliers have requested that Australia's and New Zealand's efficiency regulations not cover motors that are designed to operate where gases, vapours, mist or dust mixed with air may form a flammable mixture (e.g. sawmills, where large amounts of sawdust can gather or sewage treatment plants where methane is present). It may not be practicable for these motors to meet IE2/IE3 efficiency levels. E3 understands that several suppliers market a wide range of IE2/IE3 motors designed to operate in a variety of explosive atmospheres.

*10) Are there any reasons why classes of Ex protection type motors (e.g. Ex eb) may be unable to meet IE3 efficiency levels?*

- iii) **Integral brake motors:** IEC 60034-30-1 excludes types of brake motors that use an electro-mechanical brake that is an integral part of the inner motor construction. Their design means that their energy efficiency cannot be tested. This is because the electrical losses incurred to disengage the brake mechanism to enable the motor to operate cannot be separated from other losses that are measured to determine the motor's efficiency. These types of brake motors are distinct from conventional brake motors, in which the braking system is a bolt-on addition.

*11) Are there any reasons why integral brake motors should not be excluded from efficiency regulation?*

- iv) **High operating temperature motors (>400°C):** Motors that have a temperature class above 400°C can be required for smoke extraction units employed in applications such as the ventilation of tunnels, buildings and enclosed car parks. These motors are subject to strict safety rules and regulations to ensure that they will continue to operate under

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<sup>16</sup> A VSD that operates on AC voltage is also referred to as variable frequency drive (VFD)

challenging environmental conditions. This design criteria may mean that some models may be unable to meet energy efficiency requirements. Although some countries have excluded these types of motors from their energy efficiency regulations, E3 understands that several suppliers market a range of IE2/IE3/IE4 high operating temperature motors.

**12) Are there any reasons why high operating temperature motors should be excluded from efficiency regulation?**

- v) **Industrial vibrator motors:** These motors are used in mining and similar sectors and are commonly used to facilitate the flow of material from storage hoppers and to drive sieving equipment. Because of the large vibratory forces produced by the eccentrically mounted weights, the motor is usually fitted with heavy-duty bearings, and the air-gap between the stator and rotor is often larger than that which would be found in a conventional motor. This leads to losses that reduce efficiency and compliance with MEPS requirements may not be achieved.

**13) Are there any reasons why industrial vibrator motors should not be excluded from efficiency regulation?**

- vi) **Motors designed specifically for the traction of electric vehicles:** These motors have been designed to operate with electricity exclusively supplied by batteries. To provide regulatory clarity, these motors should be explicitly excluded from efficiency regulation.

**14) Are there any reasons why electric vehicle motors should be included in efficiency regulation?**

## 8. Motor Identification

Identifying whether a particular motor is within the scope of efficiency regulations and if it has been registered for supply in Australia and New Zealand is an issue that was identified in the *The Independent Review of the GEMS Act 2012 Final Report* published in June 2019.<sup>17</sup>

### 8.1 Rating Plates

The efficiency regulations require that motors be labelled in accordance with the requirements mentioned in clause 10 (Rating plates) of *IEC 60034-1 Rotating electrical machines – Part 1: Rating and performance*. Clause 10 requires that motors shall carry a rating plate that must be marked with numerous items including manufacturer's name or mark, output, rated voltage and efficiency class. However, a unique model number is not one of those marking requirements.

### 8.2 Model Numbers for GEMS Registration

In Australia and New Zealand, products regulated for energy efficiency must be registered using the Energy Rating website's online system and meet a number of legal requirements, before they can be sold or offered for supply.<sup>18</sup> The GEMS Act does not require a supplier to provide a model number for registration purposes. The Act does, however, require a single unique identifier (model identifier). This may be a model number marked on the motor or

<sup>17</sup> *The Independent Review of the GEMS Act 2012 Final Report*, Commonwealth of Australia 2019, pg. 26

<sup>18</sup> The online registration system can be accessed at [www.energyrating.gov.au/suppliers/registration](http://www.energyrating.gov.au/suppliers/registration)

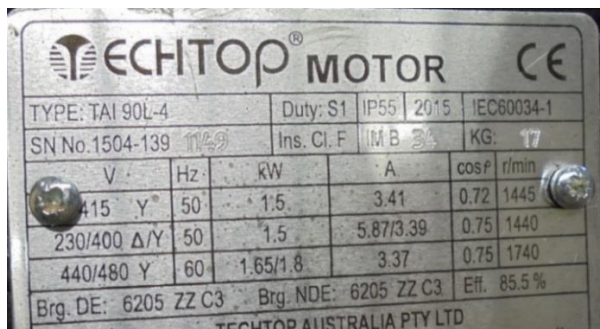
another unique identifier, such as a part number. However, if the model identifier is not marked on the motor, or cannot be determined from other information marked on the motor, compliance officers may be unable to determine if the model of the motor is registered.

For registration purposes, some suppliers use information that is provided on the motor’s rating plate. For example, rating plates commonly include a ‘Type’ field. It is straightforward for a compliance officer to confirm whether a motor is registered if:

- the brand name of the motor can be identified; and
- a brand’s ‘Type’ is unique to a particular type of motor in that brand line; and
- the registrant chooses to use this model identifier for registration purposes; and
- the registrant enters the identifier exactly as it appears on the rating plate.,

Figure 1 is an example of motor’s rating plate that includes the ‘Type’ field and this identifier has also been used for the registration model identifier.

**Figure 1: Rating plate – ‘Type’ field**



Another approach that some suppliers use to create a unique model identifier for registration purposes involves combining some technical features of the product that appear on the rating plate (e.g. output, poles, frame size, model series and IE level). Figure 2 shows an example of a product that has been registered using this scheme to make the model identifier: ‘1.1kW 4P 90S/L W21 E2’. Even though the number of poles is not included on the rating plate, the RPM figure can be used to determine the number of poles.

**Figure 2: Rating plate – adequate details to confirm registration**



However inconsistent approaches are used to construct model identifiers. Figure 3 shows an example of a product that has been registered using the parameters: output, poles, frame size and some characters from the ‘Type’ field. These parameters have been combined to form the following GEMS model identifier: ‘15kW-2 pole-D160M-AEMB/AEMV’.

**Figure 3: Rating plate**



Although it would be preferable that suppliers use a single unique identifier, which appears on the rating plate (or otherwise attached to the motor) to register the motor, any approach that combines motor attributes marked on the rating plate to construct a unique model identifier is acceptable for compliance purposes. However, to simplify identification of registered motors, it would be preferable if constructed model identifiers followed a consistent format. A suitable approach could be that, if a registrant did not provide a unique model identifier that was also marked on the motor at the time of registration, the registration system could use the data entered to automatically generate a unique model identifier. Registrants could also be required to provide an image of the rating plate and possibly an image of the whole motor, so that the details can be verified.

*15) What issues should be considered, if E3 adopts unique model identifiers that are generated automatically by the registration system?*

### **8.3 Motors marked with inadequate information**

E3 notes that some motors have no clearly identifiable model number and may be lacking details such as the manufacturer’s name or mark, or other details that can enable identification. Figure 4 shows a rating label that does not include adequate details to confirm registration. Inadequate marking makes it impossible for compliance officers to connect a physical product or a model offered for sale with a product registration.

**Figure 4: Rating plate from an unidentifiable motor**

INDUCTION MOTOR			
HP	3	KW	2.25
VOLT	415	POLE	2
HZ	50	R.P.M.	2850
AMP	4.2	HEAT	60°C
PHASE	3	DATE	2017.06
CLASS	E	SER NO	OCP 106/1196

When a motor is not marked with adequate information that would provide a clear link to a product registration, compliance officers must take the time to identify the motor and determine whether or not it is registered. This burden diverts resources from other, higher-value activities.

A solution to this problem could be to require the registrant to attach an additional label with durable print to the motor. This label would have to display the model identifier that was used to register the product and would need to be affixed to the product at point of sale.

***16) For motors that are inadequately marked for registration purposes, are there any issues that would make it impractical for suppliers to mark such motors with an additional label with durable print?***

## **9. Motors in Equipment**

As noted above, efficiency regulations require that both individual motors and motors that are incorporated into other equipment are registered and meet MEPS levels. It is understood that most electric motors used in industry are not ordered by the final user, but are purchased by original equipment manufacturers (OEMs), who then install the motors into their machinery.

This can make it difficult for compliance officers to determine whether equipment contains motors that are within the scope of efficiency regulations. This is a problem, when motors are concealed behind covers or are installed deeper inside equipment. In such cases, it may be impossible for compliance officers to even read rating plates if the motors are installed in unfavourable orientations.

E3 notes that clause 10.1 of IEC 60034-1 includes a provision that if a motor is enclosed or incorporated into equipment, such that the motor's rating plate is not easily legible, the manufacturer shall, on request, supply a second rating plate to be mounted on the equipment.

E3 is considering whether to call up this requirement, when the efficiency regulations are revised. This provision could require that, in cases where a motor is installed within a machine and the rating plate is not visible or legible (including cases where motors are installed behind covers) a second rating plate (or a single rating plate with the details for all motors) would need to be attached to the equipment in a location that is visible.

***17) For equipment that contains motors that are installed such that rating plates are not easily legible, are there any issues that would make it impractical for suppliers to attach a second rating plate?***

## 10. Other Issues

Below are some issues that have previously been raised by stakeholders, but which will not be examined in the RIS.

### 10.1 Tolerances

The GEMS Regulator is developing a policy that will provide tolerances to be used when motors are check tested for compliance with GEMS legislation. The proposed tolerances are the same as those contained in IEC 60034-1, which are reproduced below in Table 6.

**Table 6: Check test tolerances**

Quantity	Tolerance
Efficiency $\eta$ (per unit)	
– Motors up to and including 150 kW	–15 % of $(1 - \eta)$
– Motors above 150 kW	–10 % of $(1 - \eta)$

As per the established regime, these tolerances will only be applied when motors are check tested. Efficiencies stated in registrants' test reports are only to be measured efficiencies and are not to include any allowance for a tolerance or measurement uncertainty applied to the measured losses. Further, motors must be at least as efficient as the values specified in the efficiency regulations and no tolerance is applied to those MEPS levels.

This application of the tolerance is identical to how it is applied in the EU, as stated in the European Commission Regulation No 640/2009, Annex III.

### 10.2 Fees

The issue of registration fees in Australia is being examined as part of the GEMS Fees Review.

## 11. Submissions

Written comments on the issues raised in this paper should be provided by e-mail by 28 February 2020 to:

- Australia: [energyrating@environment.gov.au](mailto:energyrating@environment.gov.au)
- New Zealand: [regs@eeca.govt.nz](mailto:regs@eeca.govt.nz)

Submissions should include the subject line 'Electric Motors Consultation'.

## **APPENDIX A: MODELLING ASSUMPTIONS**

The RIS CBA will evaluate the following costs and benefits, over a 15-year period:

### **Costs**

- to the consumer due to the incremental price increases of the more efficient products supplied to the market as a result of the Policy Options, reflecting costs passed on by suppliers. For Australia, these will be based on retail prices and for New Zealand these will be based on wholesale prices;
- to governments for implementing and administering certain Policy Options – in addition to business as usual (BAU) costs; and
- to suppliers for complying with any new requirements of the Policy Options (e.g. administration and training for modified or new product categories).

### **Benefits**

- to consumers for the avoided electricity purchase costs due to the increased average efficiency of the products supplied to the market, improvements which consumers could not otherwise access due to market failures. For Australia marginal retail electricity prices will be used and for New Zealand the long range marginal cost will be used;
- to suppliers for reduced compliance costs (e.g. less testing); and
- to society from the greenhouse gas emission reductions which result from the reduced energy consumption, in order to value the reduction in this negative externality. For New Zealand these will be valued at \$25 per tonne CO<sub>2</sub>-e. For Australia no value will be assigned to the greenhouse emission reductions in the main cost-benefit analysis, but scenarios will test the application of a price (TBA)

### **The Model**

A model will be developed to evaluate the impacts of potential policy options. The model will be a combined stock and energy model of the characteristics and use of motors, by various categories.

The stock model used for the cost-benefit analysis will therefore incorporate data on the equipment characteristics of motors sold in every year for every motor category included in the model, e.g. the average motor size and the efficiency of the units in any given year. These are the equipment characteristics that will be used to calculate average energy consumption for products. The stock model then keeps track of the data needed to calculate these average characteristics for each year, based on the characteristics and number of the new equipment sold in the year, as well as that of all previous years. This stock modelling will be done at the national levels and also at the state/territory levels for Australia.

The model will assume that motors are retired from the stock according to a “survival function” that reflects the lifespan of typical equipment. Hence, a complete stock model of the motors market will be developed by state/region and year, with additional details such as motor type and sector, input power, average efficiency and year of purchase or installation taken into account. The number of motors is multiplied by the average power input under BAU, and the various Policy Options, and corresponding average number of hours of operation for each motor type to obtain the total energy consumption by state/region,



category and input power range. It is worth noting that operating hours can vary according to the sector and motor type.

The key categories proposed are:

- Motor Size (grouped by size ranges)
  - 1: 0.12 to <0.73kW
  - 2: 0.73 to <4kW
  - 3: 4 to <15kW
  - 4: 15 to <40kW
  - 5: 40 to <75kW
  - 6: 75 to <150kW
  - 7: 150 to <185kW
  - 8: 185 to <250kW
  - 9: 250 to <375kW
- Poles
  - 2, 4, 6, 8 pole
- Sector/application
  - Industry application (TBC) (8425 hours, 4000 hours, 2000 hours)

The key inputs for the model will be:

- BAU Sales by category and year (historical and forecast)
- BAU Average efficiency by category and year (historical and forecast)
- Life by size range, based on the *4E Energy efficiency roadmap for electric motors and motor systems (2015)*, 10, 12, 15 and 20 years
- Price change for each change in average efficiency due to the various Policy Options

The proposed Policy Options will be:

- Increased MEPS to Efficiency level IE3
- Increase the scope of coverage of MEPS (below 0.73 kW and above 185 kW)

## Data Sources and Methodology

The methodology to develop the key inputs will depend on the following data sources.

### Average efficiency and sales

Two options are available for the estimation of average efficiency under BAU:

- Option 1: Using historical sales of each motor model and the registered efficiency to calculate sales weighted average efficiency by category. This will require the motor suppliers to provide either:
  - sales by model with registration number (or efficiency); or
  - sales by category/size and IE2/IE3 efficiency
- Option 2: Estimating sales of motors by category based on the motor imports data and estimating the average efficiency.

Option 1 is the preferred method, as this will provide the most accurate basis for determining average efficiency and sales by category. However, unless a significant number of major suppliers agree to provide sales data under the terms of the Commonwealth's *Data Licence Deed*, Option 2 will be used in the CBA.

Option 2 will require a number of assumptions to be made, as follows:

- The import data provides total imports, which may overestimate the actual annual sales, as it will include products being imported but not offer for sale. Also, products may not be correctly categorised on the import declaration. It will be assumed that all imports are treated as sales for that year.
- Share of sales by state will be based on the share of Gross State Product (by industry categories that represent the sectors using motors from ABS 5220.0).
- The import data is segmented by 6 size categories:
  - 0: < 0.75kW
  - 1: > 0.75 < 3.0kW
  - 2: > 3.0 < 7.46kW
  - 3: > 7.46 < 75kW
  - 4: > 75 < 132kW
  - 5: > 132kW

These categories could be used or the output categories proposed earlier could be used (e.g. import category 3: >7.46 < 75kW would cover three separate output categories).

The share of import categories by pole will also need to be assumed, and will be based on New Zealand sales data (by size/poles) collected by the New Zealand Regulator. New Zealand 2019 sales data shows the share of sales by poles was: 2 pole=34%; 4 pole=59%; 6 pole=6%; and 8 pole=1%.

- The average efficiency of motors sold will be based on the average efficiency by category and year from the New Zealand sales data. It will be assumed that the average efficiency of motors sold in Australia is the same as those sold in New Zealand. However, suppliers have noted that the two markets have different characteristics. TABLE A.2 shows the share of IE3 motor sales by pole and size category that will be used, based on analysis of 2018-2019 New Zealand sales data.

**TABLE A.2: ASSUMED SHARE OF IE3 MOTORS OF SALES**

<b>Poles, Size Ranges</b>	<b>Assumed Efficiency Shares</b>	
	<b>Non IE3</b>	<b>IE3</b>
<b>2 Pole</b>		
2: 0.73 to <4kW	57%	43%
3: 4 to <15kW	44%	56%
4: 15 to <40kW	12%	88%
5: 40 to <75kW	19%	81%
6: 75 to <150kW	74%	26%
7: 150 to <185kW	12%	88%
8: 185 to <250kW	12%	88%
<b>4 Pole</b>		
2: 0.73 to <4kW	48%	52%
3: 4 to <15kW	59%	41%
4: 15 to <40kW	43%	57%
5: 40 to <75kW	45%	55%
6: 75 to <150kW	54%	46%
7: 150 to <185kW	57%	43%
8: 185 to <250kW	57%	43%

Notes:

Category 8 (185 to <250kW) efficiencies are assumed to be the same as category 7's

Category 1 (0.12 to <0.73kW) and 9 (250 to <375kW) efficiencies are to be determined

### **Price vs efficiency relationship**

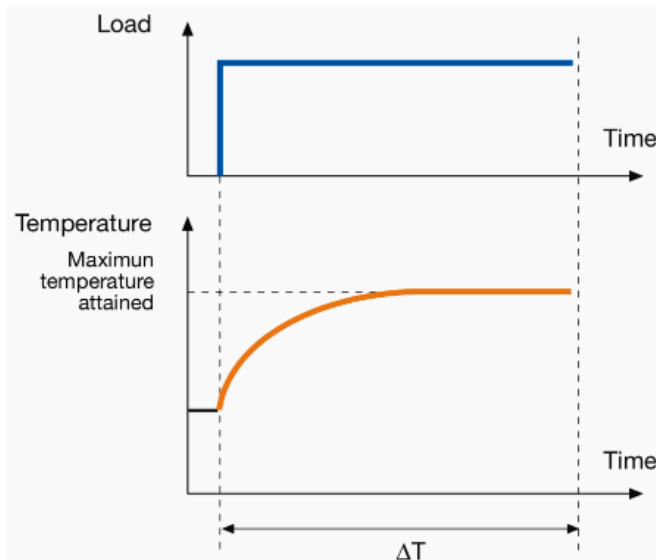
To determine the total costs of the Policy Options, the average incremental price of products that meet the policy will be estimated. This relationship will be used in the model to assess the costs of increased efficiency (due to the policy options) for each category.

Motor suppliers will be consulted to obtain the percentage price difference of an IE3 motor compared to an IE2 for each of the categories. This average price difference will be used (along with the estimated average price of IE2 motors, also to be confirmed with suppliers) to determine the incremental price vs efficiency relationship. Preliminary consultation suggested that the incremental price increase from IE2 to IE3 is 10%. In the first instance, this value will be used as the default, with sensitivities at 5% and 15%.

## APPENDIX B: DUTY TYPES <sup>19, 20</sup>

### S1 – Continuous running duty

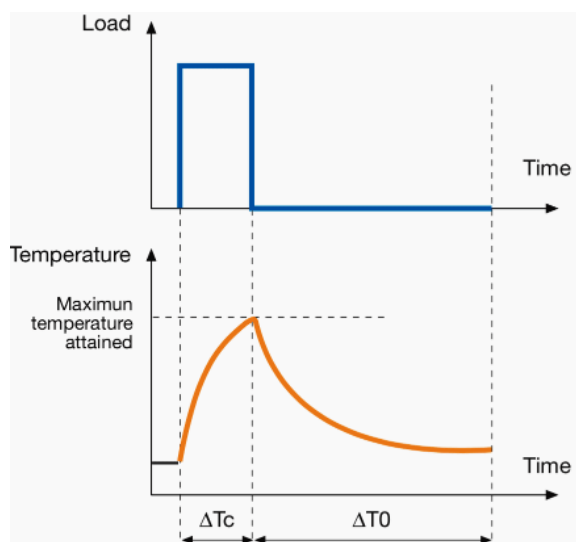
Motors of this duty type can be operated for an unlimited period at the rated output. The S1 duty type can be defined as operation at a constant load maintained for sufficient time to allow the machine to reach thermal equilibrium.



Where  $\Delta T$  = Time sufficient to allow the machine to reach thermal equilibrium.

### S2 – Short-time duty

Motors of this type can be operated at rated output for a specified limited period. The S2 duty type can be defined as operation at constant load for a given time, less than that required to reach thermal equilibrium, followed by a time de-energized and at rest of sufficient duration for it to cool to ambient temperature.



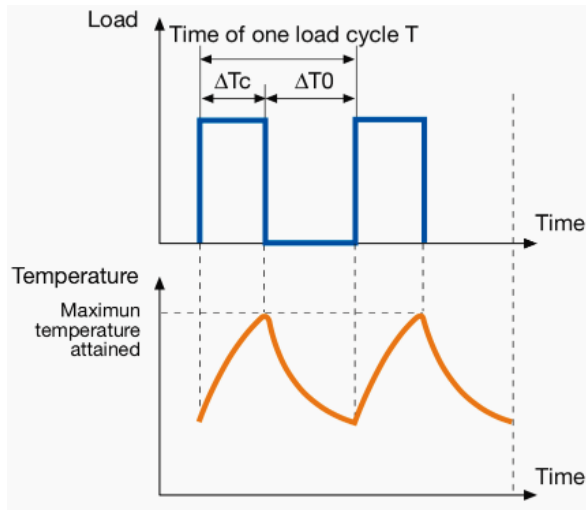
$\Delta T_c$  = Operation time at constant load  
 $\Delta T_0$  = Time de-energized

<sup>19</sup> Source: Electrical Engineering Portal, 10 Different Duty Types (Load Cycle) of Three-Phase Asynchronous Motors, <https://electrical-engineering-portal.com/10-duty-types-three-phase-asynchronous-motors>

<sup>20</sup> See IEC 60034-1 *Rotating electrical machines – Part 1: Rating and performance* for a full description of duty cycles.

### S3 – Intermittent periodic duty

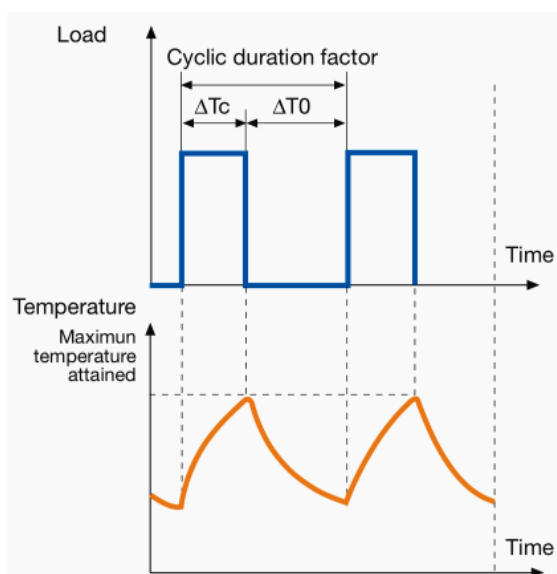
Motors of this type can be defined as designed to perform a sequence of identical duty cycles, each including a time of operation at constant load and **a time de-energized and at rest**. The contribution to the temperature-rise given by the starting phase is negligible. A full designation provides the abbreviation of the duty type followed by the indication of the cyclic duration factor (e.g. S3 80%). Thermal equilibrium is not reached.



$\Delta T_c$  = Operation time at constant load  
 $\Delta T_0$  = Time de-energized and at rest  
Cyclic duration factor =  $\Delta T_c / T$

### S6 – Continuous-operation periodic duty

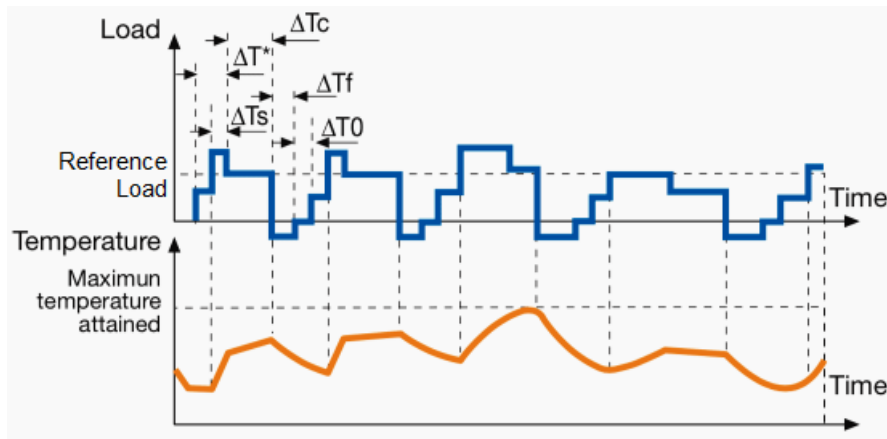
Motors of this type can be defined as designed to perform a sequence of identical duty cycles, each cycle consisting of a time of operation at constant load and **a time of operation at no load**. There is no time de-energized and at rest. Thermal equilibrium is not reached. A full designation provides the abbreviation of the duty type followed by the indication of the cyclic duration factor (S6 30%).



$\Delta T_c$  = Operation time at constant load  
 $\Delta T_0$  = Operation time at no load  
Cyclic duration factor =  $\Delta T_c / \Delta T_0$

### S9 – Non-periodic duty (Duty with non-periodic load and speed variations)

Motors of this type can be operated non-periodically at rated output. Motors of this type can be defined as designed to operate in an application in which load and speed vary non-periodically within the permissible operating range. This duty includes frequently applied overloads which may greatly exceed the reference load. Thermal equilibrium is not reached.



- $\Delta T^*$  = Starting / accelerating time
- $\Delta T_s$  = Time operating overloaded
- $\Delta T_c$  = Operation time at constant load
- $\Delta T_f$  = Time of electric braking
- $\Delta T_0$  = Time de-energized and at rest