Asia-Pacific
Economic Cooperation

Electric Motors
–Alignment of Standards and
Best Practice Programmes within APEC

Final Report

APEC Energy Working Group

October 2008

EWG 06/2007T

Produced by Mr.Hu Bo
China Standard Certification Centre
Tel: 86-10-58811579 Fax: 86-10-58811580
Email: hubo@cecp.org.cn

For
APEC Secretariat
35 Heng Mui Keng Terrace Singapore 119616
Tel: (65) 68919-600 Fax: (65) 68919-690
Email: info@apec.org Website: www.apec.org

APEC#208-RE-01.12

Content

Table

Figure

Electric motors have broad applications in such areas as industry, business, public service and household electrical appliances, powering a variety of equipment including wind blowers, water pumps, compressors and machine tools. In industrially developed nations and large developing nations, electric motors account for a considerable proportion of total national power consumption. Statistics indicate that electric motors are generally responsible for about 2/3 of industrial power consumption in each nation, or about 40% of overall power consumption, which means that the electric motor system consumes 679 billion kWh of electric power each year. According to estimates, adopting existing well-established energy-conserving technologies and products would result in savings of approximately 11–18%, or 75–122 billion kWh of electric power annually, which would also mean saving US $3.6–5.8 billion in electricity costs. Although the adoption of new equipment would entail certain costs, these would generally be recovered within three years. In addition, the savings in electric power will greatly slow or reduce the need to build or invest in power plants and generating facilities.

1. Overview of motor efficiency improvement in major economies

1.1 United States of America

The US Energy Policy and Conservation Act (EPAct) (published in 1992 and in effect since 1997) was probably the first major step of a leading industrial country towards mandatory electrical energy savings within the industrial market. But the final application rules for industrial motors were not issued by the Department of Energy (DOE) before the end of 1999. In 2001 the National Electrical Manufacturers Association (NEMA), the US motor manufacturer’s association, launched an initiative for even higher efficiency motors (NEMA Premium). And in the end of 2007, the US congress decided on NEMA Premium (IE3) to become MEPS by 2011.

1.1.1 USA Energy Policy Act – EPAct (1992)

It was enforced in October 1997 and requires that motors manufactured or imported for sale in the USA (alone or as a component in another piece of equipment) meet minimum efficiency levels. It is a mandatory agreement. EPAct motors now constitute 54% of the integral horsepower induction motor market share. Other motors include premium efficiency motors and non-general purpose motors.

Table 1: Characteristics of the motors included on EPAct

Motors included in EPACT scheme:
Polyphase squirrel-cage induction motors, NEMA Design A and B
Rated power 1-200 hp
Single-speed
230/400 Volts
60 Hz
Continuous rated
Tested in accordance with IEEE 112- Method B
2, 4 and 6 poles
Type of Enclosure: Totally Enclosed Fan-Cooled (TEFC) and Open Drip-Proof (ODP)

1.1.2 NEMA – Premium (2002)

Because many utilities and industry associations were promoting motors with a higher efficiency than EPAct mandatory levels, the National Electrical Manufacturers Association (NEMA) felt a need to define a classification scheme for premium higher efficiency motors. In 2005 NEMA Premium motors constituted 16% of the market share in USA.

Table 2: Characteristics of the motors included on NEMA Premium

Motors included NEMA Premium scheme
Poly-phase squirrel-cage induction motors, NEMA Design A and B
Rated power 1-500 hp
Single-speed
600 Volts or less
60 Hz
Continuous rated
Tested in accordance with IEEE 112-B
General-purpose motors T frame
2,4 and 6 poles

The following Tables 3 and 4 present a comparison of Efficiency levels for EPAct and NEMA Premium motors for Open Drip-Proof and Totally Enclosed Fan-Cooled (TEFC) motors. Open Drip-Proof and Totally Enclosed Fan-Cooled (TEFC) are different types of motor enclosures. The first is not used in Europe. The two tables are required since there are different efficiency values for the two types of motors. NEMA Premium motors have about 15-20% lower losses than EPAct high-efficiency motors, which typically translate into an efficiency improvement of 1-4%, depending on the motor power level.

Table 3: Efficiency levels for EPACT and NEMA Premium, Open Drip-Proof motors

hp	1200 RPM (6-pole)		1800 RPM (4-pole)		3600 RPM (2-pole)	
	EPAct	NEMA Premium	EPAct	NEMA Premium	EPAct	NEMA Premium
1	80.0	82.5	82.5	85.5	N/A	77.0
1.5	84.0	86.5	84.0	86.5	82.5	84.0
2	85.5	87.5	84.0	86.5	84.0	85.5
3	86.5	88.5	86.5	89.5	84.0	85.5
5	87.5	89.5	87.5	89.5	85.5	86.5
7.5	88.5	90.2	88.5	91.0	87.5	88.5
10	90.2	91.7	89.5	91.7	88.5	89.5
15	90.2	91.7	91.0	93.0	89.5	90.2
20	91.0	92.4	91.0	93.0	90.2	91.0
25	91.7	93.0	91.7	93.6	91.0	91.7
30	92.4	93.6	92.4	94.1	91.0	91.7
40	93.0	94.1	93.0	94.1	91.7	92.4
50	93.0	94.1	93.0	94.5	92.4	93.0
60	93.6	94.5	93.6	95.0	93.0	93.6
75	93.6	94.5	94.1	95.0	93.0	93.6
100	94.1	95.0	94.1	95.4	93.0	93.6
125	94.1	95.0	94.5	95.4	93.6	94.1
150	94.5	95.4	95.0	95.8	93.6	94.1
200	94.5	95.4	95.0	95.8	94.5	95.0
250		95.4		95.8		95.0
300		95.4		95.8		95.4
350		95.4		95.8		95.4
400		95.8		95.8		95.8
450		96.2		96.2		95.8
500		96.2		96.2		95.8

Table 4: Efficiency levels for EPACT and NEMA Premium, Totally Enclosed Fan-Cooled (TEFC) motors

hp	1200 RPM (6-pole)		1800 RPM (4-pole)		3600 RPM (2-pole)	
	EPAct*	NEMA Premium	EPAct*	NEMA Premium	EPAct*	NEMA Premium
1	80.0	82.5	82.5	85.5	75.5	77.0
1.5	85.5	87.5	84.0	86.5	82.5	84.0
2	86.5	88.5	84.0	86.5	84.0	85.5
3	87.5	89.5	87.5	89.5	85.5	86.5
5	87.5	89.5	87.5	89.5	87.5	88.5
7.5	89.5	91.0	89.5	91.7	88.5	89.5
10	89.5	91.0	89.5	91.7	89.5	90.2
15	90.2	91.7	91.0	92.4	90.2	91.0
20	90.2	91.7	91.0	93.0	90.2	91.0
25	91.7	93.0	92.4	93.6	91.0	91.7
30	91.7	93.0	92.4	93.6	91.0	91.7
40	93.0	94.1	93.0	94.1	91.7	92.4
50	93.0	94.1	93.0	94.5	92.4	93.0
60	93.6	94.5	93.6	95.0	93.0	93.6
75	93.6	94.5	94.1	95.4	93.0	93.6
100	94.1	95.0	94.5	95.4	93.6	94.1
125	94.1	95.0	94.5	95.4	94.5	95.0
150	95.0	95.8	95.0	95.8	94.5	95.0
200	95.0	95.8	95.0	96.2	95.0	95.4
250		95.8		96.2		95.8
300		95.8		96.2		95.8
350		95.8		96.2		95.8
400		95.8		96.2		95.8
450		95.8		96.2		95.8
500		95.8		96.2		95.8

1.1.3 Testing standard for motor energy efficiency

1.1.3.1 IEEE 112 (2004)

This standard covers instructions for conducting and reporting the more generally applicable and acceptable tests to determine, not only efficiency but also other performance parameters and characteristics of polyphase induction motors and generators.

1.1.3.2 IEEE 113 (1985)

The IEEE 113 Guide: Test Procedures for Direct-Current Machines (latest edition 1985) included recommendations for conducting and reporting generally acceptable tests to determine the performance characteristics of conventional direct-current machines. However, it was withdrawn some years ago and is no longer endorsed by the IEEE, due to the declining importance of DC machines. No current IEEE standard deals with performance testing of DC machines. Therefore, acceptability of a particular test as proof of DC motor performance is strictly between user and manufacturer.

1.1.3.3 IEEE 114 (2001)

This standard deals with the performance testing of single-phase induction motors.

1.1.3.4 IEEE 115 (1955)

This standard deals with the performance testing of synchronous machines.

1.1.3.5 ANSI/NEMA MG1 – Motors and Generators

This standard assists users in the proper selection and application of motors and generators. Revised periodically, the standard provides for changes in user needs, advances in technology, changing economic trends and practical information concerning performance, safety, test, construction, and manufacture of alternating-current and direct-current motors and generators.

1.1.4 Updated information from US

The American Council for an Energy-Efficient Economy (ACEEE) and the National Electrical Manufacturers Association (NEMA) have agreed to a new set of proposed energy efficiency standards for industrial electric motors that has been submitted to the House Energy and Commerce Committee and the Senate Energy and Natural Resources Committee for their consideration in energy legislation now under development.

The proposal aims not only at setting higher minimum mandatory efficiency levels but also broaden the scope of existing standards, as follows:

Current minimum efficiency standards of general purpose induction motors as defined in the 1992 EPAct and covered by federal legislation should be raised to NEMA Premium levels.

. Seven types of low voltage poly-phase, integral-horsepower induction motors not currently covered under federal law should be subjected to minimum efficiency standards at the levels defined in 1992's EPAct for general purpose induction motors.

- U-Frame Motors

- Design C Motors

- Close-coupled pump motors

- Footless motors

- Vertical solid shaft normal thrust (tested in a horizontal configuration)

- 8-pole motors (~900 rpm)

- All poly-phase motors with voltages up to 600 volts other than 230/460 volts

General purpose induction motors with power ratings between 200 and 500 horsepower should also meet minimum efficiency levels as specified in 1992's EPAct.

And in the end of 2007, the US congress decided to adopt the proposal which means US will take current NEMA Premium level to become MEPS for electric motor energy efficiency by 2011.

1.2 Canada, Mexico and Brazil

1.2.1 Motor energy efficiency standard

In 1991, the Canadian Standards Association (CSA) and Canadian Electric Machinery Association drew up a recommended minimum power efficiency standard for electric motors. British Columbia and Ottawa subsequently passed legislation requiring new electric motors purchased within their jurisdictions to comply with this standard, whose efficiency index is slightly lower than that later mandated under EPACT by the United States. In light of the importance of the energy problem, Canada's Parliament also passed the Energy Efficiency Act (EEACT) in 1992. EEACT, which included minimum energy efficiency standards for electric motors, was to take effect in 1997. Its efficiency index for electric motors was the same as that of EPACT. EEACT differs slightly from EPACT in that it applies both to electrical machinery with a voltage class of 600V or less and to 50/60HZ dual-frequency electric motors in addition to those of 60HZ frequency. As this standard was legally compulsory, high-efficiency electric motors quickly saw widespread use. In 1988, high-efficiency electric motors accounted for less than 4% of Ottawa's electric-motor market; by 1993, this had risen to more than 60%.

Mexico and Brazil have also worked out their own minimum energy efficiency standards for electric motors. The efficiency index of Mexico's 1997 standard (NOM-016-ENER-1997) was the same as under NEMA12-9, the earlier U.S. standard for high-efficiency electric motors. The standard was later amended after Mexico signed a free-trade agreement with the U.S. in 2002. Mexico's current standard is NOM-016-ENER-2002, whose efficiency index is the same as that of EPACT. The Mexican standard has somewhat broader applications than EPACT, covering power between 0.746 and 373 KW (i.e. 1–500 HP) and vertical as well as horizontal installation. This standard took effect in March 2003. See the attached list for standard efficiency indices.

The minimum energy efficiency standard for electric motors in Brazil remains the same as NEMA12-9, which is slightly lower than U.S. EPACT index.

1.2.2 Testing Standards for motor energy efficiency,

1.2.2.1 C390-98 (2005)

This Canadian Standard, very similar to IEEE 112-B specifies the test methods to be used in measuring the energy efficiency of three-phase induction motors. This standard applies to three-phase induction motors rated 0.746 kW at 1800 rpm (or equivalent) and greater. An equivalent motor is a motor with the same torque output but with different kilowatt output and speed.

1.2.2.2 CAN/CSA C22.2 No.100-04 – Motors and Generators

This is the Canadian equivalent to ANSI/NEMA MG1.

1.3 EU

1.3.1 Background

European manufacturers such as Siemens and CEM began to develop and produce high-efficiency electric motors following the first international energy crisis in the 1970s; however, there were no major developments until the 1990s. The situation improved greatly with the founding of the European Union in 1993. In terms of economic integration, the EU is far more powerful than the original European Community, requiring common policies and measures to stimulate economic development and protect the environment. In light of the importance of energy and environmental issues, the EU signed on to the Kyoto Protocol, committing to a significant reduction in greenhouse gas emissions; accordingly, energy conservation is a high priority.

At present, the EU consumes 2 trillion kWh of electric power annually, with consumption growing at a rate of 2% each year. This electric power accounts for 35% of total primary energy consumption and 30% of total CO2 emissions within the EU. For various types of energy-consuming equipment, electric motors are far more energy-efficient than internal combustion engines. However, electric motors are responsible for converting a large amount of electric energy into mechanical energy, and thanks to their widespread use a slight improvement in efficiency is capable of delivering remarkable energy savings.

During the mid-1990s, accordingly, the EU began commissioned research into the energy-saving potential of electric motors and the role of policies and markets. This led to the formulation of an electric motor energy efficiency standard (the EU-CEMEP agreement) on the manufacturing side in 1999. The International Energy Agency (IEA) also funded a competition to design high-efficiency electric motors in 1997. On the application side, the European Database of Efficient Electric Motor Systems (EuroDEEM) was and developed and the European Motor Challenge Programme was implemented. These measures played an important role in promoting the spread and application of high-efficiency motors.

1.3.2 EU—CEMEP

The EU and the European Committee of Manufacturers of Electrical Machines and Power Electrics (CEMEP) reached an agreement in September 1999 to promote the use of high-efficiency electric motors. Under the agreement, the motor industry is required to work proactively on energy-saving performance for motor systems; it also provides for the establishment and implementation of a voluntary agreement on motor energy efficiency as specifically directed by the Directorate-General for Energy and Transport (EU-DGET). The essentials of this agreement, known as the EU-CEMET agreement, are as follows:

1.3.2.1 Purpose of the Agreement

The EU-CEMEP agreement is signed with a view to reorienting the European motor market towards high efficiency and energy conservation. The measures adopted will fully inform clients of the benefits of more efficient motors, lay out clear stipulations for motor efficiency, and reduce production and sale of low-efficiency motors. It will be necessary to thoroughly consider the agreement so that it may be easily implemented and rapidly converted into policy.

1.3.2.2 Rating and Identification of Efficiency

The EU-CEMEP agreement provides for the rating and identification of motor efficiency. Two efficiency indices—high and low—are stipulated for motors of different specifications. Motors with an efficiency value lower than the low index are classified as EFF3; those with an efficiency value between the low and the high index are EFF2; those above the high index are classified as EFF1. Fig.3 shows the efficiency curve for 4-pole electric motors under the agreement. As Fig. 3 shows, the low-grade curve is equivalent to the average efficiency value of motors actually produced in EU countries at present, while the high-grade curve is the upper limit of the distribution of actual motor efficiency. The loss of EFF1 motors is 40% lower than that of EFF2 motors, and they are designed for more than 6000h of annual runtime. The loss of EFF2 motors is 20% lower than that of EFF2 motors, and they are designed for more than 2000h of annual runtime. The efficiency of EFF1 motors, compared with EFF2 motors, has improved 1-5% according to different powers. Efficiency indexes under the EU-CEMEP agreement are given in the attached list. According to CEMEP, replacing the prevailing EFF3 motors with EFF2 motors would save 6 billion kWh of electric power each year, for a savings of €0.6 billion in electricity costs assuming a rate of 0.05€/kWh. EFF3 motors are generally known as low efficiency motors, EFF2 motors as improved efficiency motors, and EFF1 motors as high efficiency motors. The agreement also requires manufacturers to identify efficiency grade on their product nameplates and sample data sheets to facilitate selection and identification for users.

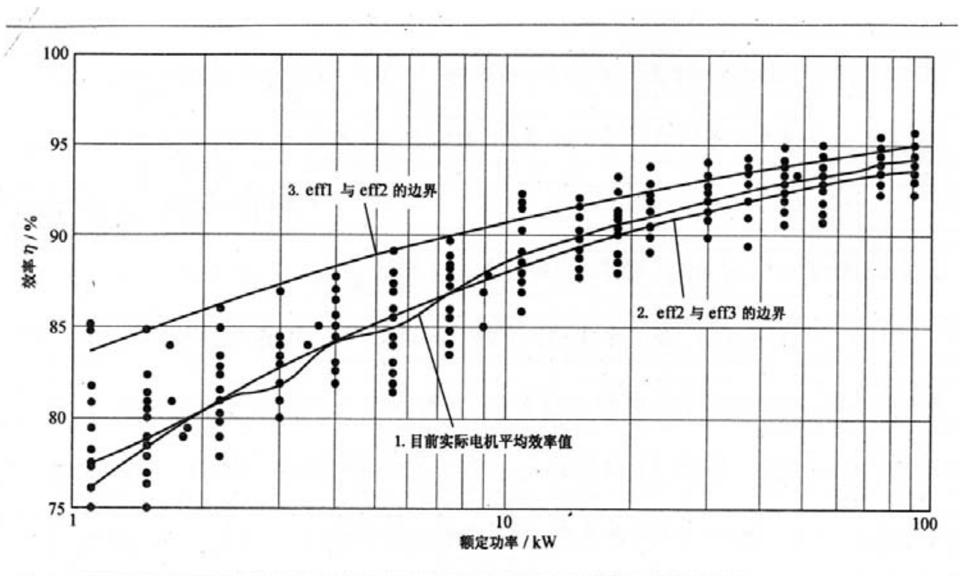

Figure 1: efficiency line of 4-pole motor in EU-CEMEP

EFF1 – High efficiency motors

EFF2 – Standard efficiency motors

EFF3 – Low efficiency motors

Table 5: Characteristics of the motors included on CEMEP/EU agreements

Motors included in CEMEP/EU agreement:
3 phase AC squirrel cage induction motors
Rated power: 1.1 kW to 90 kW
Totally enclosed fan ventilated
Line voltage: 400 V
50 Hz
S1 duty class (continuous mode)
Efficiency tested in accordance with IEC 60034-2 using the "summation of losses" test procedure with P_{LL} from assigned allowance

Table 6: Class Definition for CEMEP/EU agreements

kW	2 - Pole		4 - Pole	
	EFF2	EFF1	EFF2	EFF1
1.1	76.2	82.8	76.2	83.8
1.5	78.5	84.1	78.5	85.0
2.2	81.0	85.6	81.0	86.4
3	82.6	86.7	82.6	87.4
4	84.2	87.6	84.2	88.3
5.5	85.7	88.6	85.7	89.2
7.5	87.0	89.5	87.0	90.1
11	88.4	90.5	88.4	91.0
15	89.4	91.3	89.4	91.8
18.5	90.0	91.8	90.0	92.2
22	90.5	92.2	90.5	92.6
30	91.4	92.9	91.4	93.2
37	92.0	93.3	92.0	93.6
45	92.5	93.7	92.5	93.9
55	93.0	94.0	93.0	94.2
74	93.6	94.6	93.6	94.7
90	93.9	95.0	93.9	95.0

Based on the classification scheme there was a voluntary undertaking by motor manufacturers to reduce the sale of motors with the current standard efficiency (EFF3). The CEMEP/EU agreement was a very important first step to promote motor efficiency classification and labelling, together with a very effective market transformation. Low efficiency motors (EFF3) have essentially been removed from the EU induction motor market which is a positive development. However the penetration rate of EFF1 motors is still very modest in the EU:

1.3.2.3 Scope of Products

The products covered by EU-CEMEP agreement are fully-closed ventilated radiator (IP54 and IP55) motors of three-phase AC cage-type induction, of which the power scope is 1.1–90KW, the pole number is 2-pole and 4-pole and the voltage is 400V, 500HZ and SI duty (i.e. continuous rating), and design is standard (i.e. the starting performance complies with the specifications of N Design in IEC60034-12). However, some specific products are not covered by the agreement, for example, motors and hermetic motors used under special circumstances; motors, brake motors and motors without ventilation radiators sold with frequency converters and applied under shifting circumstances; non-standard air cooling motors; pump motors combining pumps with motors; hollow axle motors; integral gear motors; motors used by woodworkers; motors with sliding bearings; motors with flow bearings other than closed or open type single row bearings; non-integral motors; stator and rotor components; submersible electric machines; refrigerator compressor motors; motors used under explosive conditions; coil type rotor motors; motors placed into sealed containers; and motors used on vessels.
Product testing follows IEC60034-2, currently the prevailing method in Europe. In order to expedite the test, this method assumes one load stray loss of the losses as 0.5% of the input power.

1.3.2.4 Participants, targets and schedule

The EU-CEMEP agreement became effective when signed voluntarily by CEMEP members, and manufactures, importers and retail traders without CEMEP membership are also welcome to participate. At present, 36 manufacturing companies including Siemens, ABB, Brook Crompton and Leroy-Somer have joined the agreement, covering 80% of the European output.

By 2003, the agreement aimed to reduce sales of EFF3 motors to 50% of the level in 1999, when the agreement was signed. Upon implementation of the agreement in 1999, each signing company was required to make periodic sales performance reports to CEMEP on an annual basis, which CEMEP submits to the EU upon tabulation. The agreement is to be amended according to the executing performance in 2004/2005, and an action plan will be proposed to further promote high-efficiency motors.

1.3.2.5 Supporting Measures

The EU-CEMEP agreement plays an important role in reorienting the European motor market towards high-efficiency, and energy-saving motors. However, the agreement mainly relies on the endeavors of manufacturers, and wide application of high-efficiency motors along with other energy-saving measures requires the positive response of users. Therefore the EU has initiated two user-oriented measures, the European Database of Efficient Electric Motor Systems and the European Motor Challenge Programme. Meanwhile, a succession of EU countries has also adopted incentive policies in areas such as taxation in order to promote the application of high-efficiency electric motors and other energy-saving products.

- The European Database of Efficient Electric Motor Systems (EuroDEEM)

EuroDEEM, or the European Database of Efficient Electric Motor Systems, was developed in 1995 by the European Commission – Joint Research Centre. Its main purpose is to provide users with a technical instrument to facilitate the selection of high-efficiency electric motors. The first version of the database, released by EuroDEEM in 1998, included product data for 3000 types of high-efficiency motors on the European market provided by 24 motor manufacturers. Revised in 2000, the database has expanded to cover 29 manufacturers and 5900 models of efficient electric motors. Content has expanded as well, from selection of efficient electric motors to selection of pumps. An upgrade in progress will expand coverage to include wind blowers and compressors.

The database is released on the internet to the public and offers free software for selection. This gives a large population of users a better understanding of efficient electric motors and promotes the development of an efficient electric motor market.

- European Motor Challenge Programme

In light of the fact that motors account for over 30% of total electric power consumption in the EU, EU-DGET created the European Motor Challenge Programme in order to reduce the power consumption of electric motor systems. The program's mission is toimprove the energy efficiency of motor drive systems through a variety of effective measures voluntarily committed to by enterprises in the industrial system. The EU Council will provide support in terms of information, training and technology. The goal is to reduce environmental impacts, particularly CO2 emission, and to strengthen the competitive power of European industry and relieve dependence on imported energy. The program, launched and implemented in February 2003, is one of the important components of Intelligent Energy for Europe carried out by the EU in 2003-2006. Following a statistical analysis, EU-DGET believes that 30-50% of the electric power available for such systems as water pumps, compressors and wind blowers can be saved by improving operation and strengthening maintenance or applying efficient motor systems. The potential is therefore enormous, and a small economic investment may achieve considerable energy-saving effects. In combination with energy-saving incentive policies in individual EU nations, the program creates a sound policy and technological environment for the promotion of efficient electric motors in Europe, facilitating the broader application of efficient electric motors.

1.3.3 Stimulation Measures Adopted by EU Members

EU countries have taken many policy measures to encourage energy saving and CO_2 emissions reduction. In Denmark, for example, motor buyers receive a subsidy from the Danish Energy Authority for every kilowatt a motor exceeds the minimum standard: 100 kroner for purchasing new motors, 250 for replacing outdated ones. The Netherlands grants tax preference in addition to subsidies for purchase. The UK is using reductions and exemptions under the Climate Change Levy, along with the implementation of the Enhanced Capital Allowance Scheme, to reorient the market toward high-efficiency electric motors and other energy-saving products. In addition, the British government has implemented the Market Transformation Programme through the Department for Environment, Food and Rural Affairs (DEFRA), taking the initiative to introduce high-efficiency electric motors and other energy-saving products as well as making information about these products and energy-saving design schemes available over the internet. According to the Market Transformation Programme, there are 10 million electric motors in the UK industrial sector and the installed capacity is 70 million KW. Electric motors account for 2/3 of industrial power utilization and 45% of total consumption in UK, most of which is used by drive pumps (accounting for 32% of total power utilization for electric motors) and fans (accounting for 23% of the total). The electric motor system is therefore the largest industrial power consumer and as such the focus of energy saving in the UK.

The above mentioned ECA is an important measure taken by the UK government to encourage purchase and use of energy-saving products and is jointly performed by DEFRA and UK Inland Revenue. The former Capital Allowance Scheme was intended to encourage corporate and individual investment in scientific research, patent technology and trade business. Under certain conditions, the government offered partial income tax exemptions and reductions, with investment-related taxes deducted from annual income tax for ten years after the completion of the investment. The Enhanced Capital Allowance scheme (ECA) stipulated that any investor in energy-saving products was eligible for the Capital Allowance. The difference is that the ECA can accelerate the refund of the tax. Namely, all taxes can be refunded in the first year instead of waiting 10 years for a refund of only 95%. For instance, if an investor has spent 50,000 pounds on a piece of energy-saving equipment and his/her income tax rate as an investor is 30%, this scheme entitles the investor to a 15,000 pound subsidy within one year after the purchase, saving 15,000 pounds from the profit income tax of the taxation year. The ECA is expected to take effect on April 1, 2001 and covers 8 product types, including AC electric motors, boiler, lighting, betatron, and cold storage facilities. It also includes the UK Energy Technology List; investors are only eligible for preferential tax refunds if the applied products appear on this list and comply with its requirements. The ECA sets out a minimum efficiency index for AC electric motors, offering tax refunds for motors meeting or exceeding this index. Listed motors are cage-sealed fan-cooled motors with voltage between 200 and 750V (50HZ), power between 1.1 and 400KW, and 2, 4, 6, or 8 poles, as well as standard motors, permissible motors and all multiple-speed motors applied to transport fluid substances. The attached table has provided efficiency standard of single-speed motor stipulated in the UK ECA. The efficiency index of single-speed motors under the ECA whose power and poles are identical with that of the EU-CEMEP agreement is in conformity with the efficiency index of the EFF1 rate stipulated in the EU-CEMEP agreement.

1.3.4 Implementation of EU-CEMEP agreement

Since the signing of the agreement in 1999, all motor manufacturers that have signed on to the EU-CEMEP agreement have been able to reduce EFF3 motor production to the greatest extent possible and increase the market share of EFF1 and EFF2 motors. CEMEP disclosed inspection results in August 2003. 36

members have performed EU-CEMEP agreement in accordance with the requirement reaching the standard of reducing the production of EFF3 motor by 50% as stipulated therein. Statistical data is given in Fig. 4. It can be seen that production of the EFF3 motor of 4 poles in 1998 accounts for 68.4% and has declined to 12% in 2002 amounting to 17.5% of that in 1998; the production of the EFF3 motor of 2 poles in 1999 accounts for 43.5% and has decreased to 10.8% in 2002 amounting to 24.8% of that in 1999. The EU and CEMEP members are satisfied with the result. As is seen in the figure, the production of EFF1 efficient electric motors is very small and the production of 2 and 4 poles motor is still within 10%. So the task of market promotion remains tremendous.

Energy saving and environmental protection is an ever-greater priority for the EU, and there are ongoing preparations for the passage of the Directive on Energy Efficiency and Energy Services, which requires EU members to save at least 1% energy per year. Accordingly, the governments of all member nations have enacted many stimulatory policies. Under these conditions, all major motor manufacturers devoted considerable effort to developing and producing high-efficiency electric motors conforming to the requirement of EFF1 efficient electric motors.

For instance:

1LA9 series and 1LG6 Series manufactured by Siemens. The 1LA9 series are electric motors with aluminous shell frame, of which the power is 0.06-30 KW, the frame size is 56M-200L and the pole number is 2, 4 or 6.; while 1LG6 Series are cast iron frame motors, of which the power is 11-200 KW, the frame size is 180M-315L and the pole number is 2, 4, 6 or 8. The protection type of both of the motor series is IP55; when running at the frequency of 50 HZ, both conform to EFF1 index of EU-CEMEP, while running at the frequency of 60HZ, they conform to the American CEMEP index.

Series of WP premium efficiency motors manufactured by the British company Brook Crompton. The power of such series of motors is 0.75-40 KW, the frame size is 80-355L, 50HZ and the pole number is 2, 4, 6 and 8. The protection type of both of the serial motor is IP55; both series of motors conform either to EFF1 index stipulated in the EU-CEMEP agreement, or the lowest efficiency index established by the ECA scheme under the UK government.

M2/M3 Series manufactured by ABB. The power of cast iron frame motors of such series is 0.25-710 KW, and the frame size is 71-400; while the power of the motors with aluminous shell frame is 3-90 KW, and the frame size is 112-280. The protection type of both types of motors is IP55. Those motors whose efficiency index is 11 KW or above conform to the EFF1 index stipulated in the EU-CEMEP Agreement.

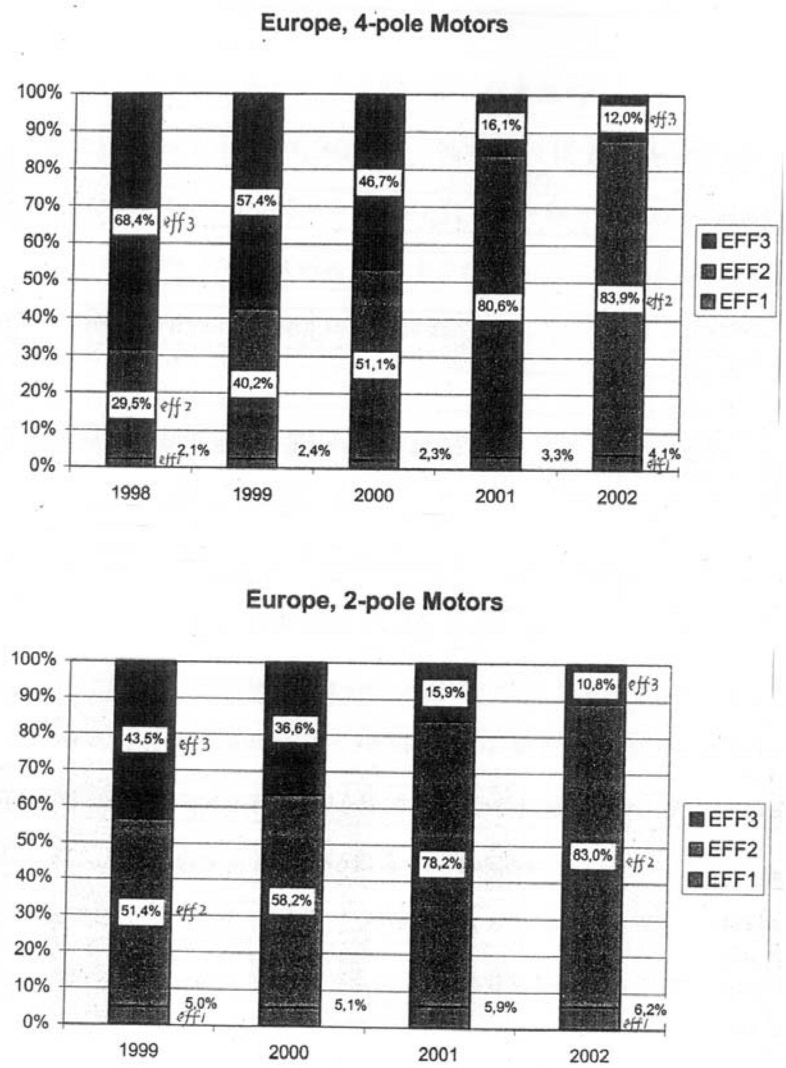

Figure 2: execution results of EU-CEMEP

1.3.5 Testing standards for motor energy efficiency

1.3.5.1 IEC 60034-2 (1996)

This standard establishes methods of determining efficiencies from tests, and also specifies methods of obtaining specific losses.

It applies to DC machines and to AC synchronous and inductions machines of all sizes within the scope of IEC 60034-1.

1.3.5.2 IEC 61972 (2002)

This test standard, developed as a possible replacement of IEC 60034-2 in what concerns three-phase induction motors, allows two methods to determine their efficiency and losses.

- Method 1 - input-output method (similar to IEEE 112-B)

Stray load losses determined from measurements.

- Method 2 - Indirect method (assigned variable allowance)

The main difference is that in the revised method there is an assigned variable allowance for the stray load losses which are estimated using the following equations:

- Method 1 - input-output method (similar to IEEE 112-B)

Stray load losses determined from measurements.

- Method 2 - Indirect method (assigned variable allowance)

The main difference is that in the revised method there is an assigned variable allowance for the stray load losses which are estimated using the following equations:

$$Output\ power \leq 1kW \Rightarrow Stray\ load\ losses = 0.025 \times input\ power$$

$$1 \leq Output\ power \leq 1kW \Rightarrow Stray\ load\ losses = \left[0.025 - 0.005 \times log_{10}\left(\frac{Output\ power}{1kW}\right)\right] \times input\ power$$

$$Output\ power \geq 10\,000kW \Rightarrow Stray\ load\ losses = 0.005 \times input\ power$$

European CENELEC did not adopt this testing standard in Europe due to the additional cost for testing equipment and labor cost (it was claimed to take 10% to 15% more testing time), especially for mid and large size motors. It was thought that small and mid size manufacturers might have difficulties to comply with this standard.

The IEC has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be either: reconfirmed, withdrawn, replaced by a revised edition, or amended.

1.3.5.3 IEC 60034-2-1

This new version of IEC 60034-2 was approved by 23 countries in favor, 5 abstentions and no disapprovals. It introduces the Eh-Star test as a recognized method to determine additional load losses of induction machines.

Eh-Star is an inexpensive method with good accuracy where stray load losses are calculated mathematically. Eh-star is based on an asymmetrical feeding of a three phase induction motor, so this method is based on reverse field component (negative current sequence).

Independent comparative tests carried out by several Universities, between direct test methods and Eh Star method, show a good matching of the test results and comparative accuracy. Because of its relative lower costs to test the large number of motor models already in the market, motor manufacturers see this method as a cost-effective alternative to upgrade the efficiency tests of those motors.

Furthermore it excludes the Calibrated-machine test, the Retardation test and the Calorimetric test, which are only used for large machines where the facility cost for other methods is not economical. However, considering these methods are still in use, they are included in its annex D.

It is difficult to establish specific rules for the determination of efficiency. The choice of test to be made depends on the information required, the accuracy required, the type and size of the machine involved and the available field test equipment (supply, load or driving machine).

This new standard presents three tables with the preferred methods for the determination of efficiency and their levels of uncertainty.

As an example the table regarding Induction motors is presented here.

Table 7: Preferred methods for determining the efficiency of Induction Motors

Method	Clause	Preferred method	Required facilities	Uncertainty
Direct				
Torque measurement	8.1.1	All single phase and polyphase ≤ 1 kW	Torquemeter/dynamometer for full-load	Low
Calibrated machine test	Annex D		Calibrated machine	See Note 4
Dual-supply, back-to-back test	8.1.2		Machine set for full-load Two identical units	Low
Total losses				
Calorimetric method	Annex D		Special thermal enclosure	See Note 4
Single supply back-to-back test	8.2.1		Two identical units (wound rotor)	Low
Summation of losses, with and without load test				
P_{LL} determined from residual loss	8.2.2.5.1	Three phase > 1 kW up to 150 kW	Torquemeter/dynamometer for ≥ 1,25 × full-load	Low
P_{LL} from assigned value	8.2.2.5.3			Medium to high
P_{LL} from removed rotor and reverse rotation test	8.2.2.5.2		Auxiliary motor with rated power ≤ 5 × total losses P_T	High
P_{LL} from Eh-star test	8.2.2.5.4	(see Note 3)	Resistor for 150 % rated phase current	Medium
Summation of losses, without load test				
Currents, powers and slip from the equivalent circuit method P_{LL} from assigned value	8.2.2.4.3		If test equipment for other tests is not available (no possibility of applying rated load, no duplicate machine)	Medium/high

NOTE 1 Due to measurement inaccuracies, the determination of P_{LL} from residual losses is limited to correlation coefficients (see 8.2.2.5.1.2) greater than 0,95 and may have uncertainties of the determined efficiency exceeding ±0,5 %.

NOTE 2 In the "Uncertainty" column, "Low" indicates a procedure determining all loss-components from tests; "Medium" indicates a procedure which is based on a simplified physical model of the machine; "High" indicates a procedure that does not determine all loss-components by tests.

NOTE 3 The method for P_{LL} from Eh-star test is suitable for motors between 1 kW and 150 kW; larger ratings are under consideration. The method requires that the winding can be connected in star.

NOTE 4 Uncertainty to be determined.

1.3.6 Updated information from EU

In EU, the European Commission started discussions with the European manufacturers (CEMEP) around 1996. It was felt necessary to improve the rather inaccurate efficiency test standard IEC 60034-2 and a mandate was given to the European Committee for Electrotechnical Standardization CENELEC (M/244 from 1997). The mandate was passed to working group 2 of SC2G of IEC but an agreement on a new procedure could not be reached until just recently. In the meantime a new standard was created (IEC 61972) with the purpose of improving the accuracy in stray load lost calculation, but never adopted in Europe although used widely in some Asian countries such as China and Korea. In September 2007, IEC approved the new global motor efficiency testing standard IEC 60034-2-1 in which four kinds of testing methods including the new eh-star method have been covered with respective assignment of the level of uncertainty. In addition, IEC is now revising the standard IEC 60034-1for testing tolerance for electric motor and expected to be issued in the end of this year.

1.4 Australia/New Zealand

In October 2001 in Australia and 1 April 2002 in New Zealand, the first stage of the mandatory MEPS program for 3 phase induction motors, MEPS1, was introduced and became mandatory for motor suppliers, manufacturers and importers. In effect, minimum efficiency levels for MEPS1 equated to European EFF2 motor efficiency levels.

The second stage, MEPS2 (also mandatory), was introduced in April 2006 in Australia and June 2006 in New Zealand. MEPS2 motor efficiency levels are similar to European EFF1 efficiency and also redefined the "High Efficiency" levels at a higher level with nominally 15% less loss than the EFF1 levels.

Three-phase motors that fall within the scope of standard AS/NZS 1359.5:2004 must be registered to be offered for sale in Australia, for New Zealand the prescribed forms need to be completed and submitted to EECA before being available for sale. The range and scope of motors affected by this new standard are single speed three phase cage induction motors from 0.73kW up to but not including185 kW, for voltages to 1100V.

1.4.1 Australian Energy Performance Program – MEPS (AS 1359.5:2004)

The new Australian Energy Performance Program – MEPS (AS 1359.5:2004) – has efficiency levels equivalent to EFF1/EPACT. This is a mandatory measure starting in April 2006 applied to motors described in Table 5.

Table 8: Characteristics of the motors included in the Australian MEPS

Motors in Australian/New Zealand scheme
Three phase induction motors
Rated power 0.73-185 hp
Single-speed
Up to 1100 Volts
2, 4, 6 and 8 poles
Continuous rated

Two methods of efficiency measurement, described in AS 1359.102, are allowed:

Method A, identical to method 1 of IEC 61972 and technically equivalent to method B specified in IEEE 112;

Method B based on IEC 60034-2 “summation of losses” test procedure.

Therefore, there are two tables (Table 6 and Table 7) with minimum efficiency levels and high efficiency levels tested according to AS 1359.102.3 (similar to IEEE-112 –Method B) and two tables (Table 8 and Table 9) for minimum efficiency levels and high efficiency levels tested according to AS 1359.102.1 Standard (similar to IEC 60034-2 – PLL from assigned allowance). The four tables below are required since motors tested with different efficiency testing standards have different values.

Table 9: Minimum efficiency levels for Australian MEPS (according with AS 1359.102.3 – Direct method) enforced on April 2006

Rated output kW	Minimum efficiency %			
	2 pole	4 pole	6 pole	8 pole
0.73	78.8	80.5	76.0	71.8
0.75	78.8	80.5	76.0	71.8
1.1	80.6	82.2	78.3	74.7
1.5	82.6	83.5	79.9	76.8
2.2	84.0	84.9	81.9	79.4
3	85.3	86.0	83.5	81.3
4	86.3	87.0	84.7	82.8
5.5	87.2	87.9	86.1	84.5
7.5	88.3	88.9	87.3	86.0
11	89.5	89.9	88.7	87.7
15	90.3	90.8	89.6	88.9
18.5	90.8	91.2	90.3	89.7
22	91.2	91.6	90.8	90.2
30	92.0	92.3	91.6	91.2
37	92.5	92.8	92.2	91.8
45	92.9	93.1	92.7	92.4
55	93.2	93.5	93.1	92.9
75	93.9	94.0	93.7	93.7
90	94.2	94.4	94.2	94.1
110	94.5	94.7	94.5	94.5
132	94.8	94.9	94.8	94.8
150	95.0	95.2	95.1	95.2
<185	95.0	95.2	95.1	95.2

Table 10: Minimum efficiency levels for Australian MEPS (according with AS 1359.102.3 – Direct method)

Rated output kW	Minimum efficiency %			
	2 pole	4 pole	6 pole	8 pole
0.73	81.4	82.9	78.8	75.0
0.75	81.4	82.9	78.8	75.0
1.1	83.0	84.5	80.9	77.6
1.5	84.8	85.6	82.4	79.6
2.2	86.2	86.9	84.2	81.9
3	87.2	87.8	85.6	83.6
4	88.1	88.7	86.7	85.0
5.5	88.9	89.5	87.9	86.5
7.5	89.9	90.4	89.0	87.8
11	90.9	91.3	90.2	89.3
15	91.6	92.1	91.0	90.4
18.5	92.1	92.4	91.6	91.1
22	92.4	92.8	92.1	91.5
30	93.1	93.4	92.8	92.4
37	93.6	93.8	93.3	92.9
45	93.9	94.1	93.7	93.5
55	94.2	94.4	94.1	93.9
75	94.8	94.9	94.6	94.6
90	95.0	95.2	95.0	94.9
110	95.3	95.5	95.3	95.3
132	95.5	95.6	95.5	95.5
150	95.7	95.9	95.8	95.9
<185	95.7	95.9	95.8	95.9

Table 11: Minimum efficiency levels for Australian MEPS (according with AS 1359.102.1 – Indirect method) to be enforced April 2006

Rated output kW	Minimum efficiency			
	2 pole	4 pole	6 pole	8 pole
0.73	80.5	82.2	77.7	73.5
0.75	80.5	82.2	77.7	73.5
1.1	82.2	83.8	79.9	76.3
1.5	84.1	85.0	81.5	78.4
2.2	85.6	86.4	83.4	80.9
3	86.7	87.4	84.9	82.7
4	87.6	88.3	86.1	84.2
5.5	88.5	89.2	87.4	85.8
7.5	89.5	90.1	88.5	87.2
11	90.6	91.0	89.8	88.8
15	91.3	91.8	90.7	90.0
18.5	91.8	92.2	91.3	90.7
22	92.2	92.6	91.8	91.2
30	92.9	93.2	92.5	92.1
37	93.3	93.6	93.0	92.7
45	93.7	93.9	93.5	93.2
55	94.0	94.2	93.9	93.7
75	94.6	94.7	94.4	94.4
90	94.8	95.0	94.8	94.7
110	95.1	95.3	95.1	95.1
132	95.4	95.5	95.4	95.4
150	95.5	95.7	95.6	95.7
<185	95.5	95.7	95.6	95.7

Table 12: High efficiency levels for Australian MEPS (according with AS 1359.102.1 – Indirect method)

Rated output kW	Minimum efficiency %			
	2 pole	4 pole	6 pole	8 pole
0.73	82.9	84.5	80.4	76.5
0.75	82.9	84.5	80.4	76.5
1.1	84.5	85.9	82.4	79.1
1.5	86.2	87.0	83.8	81.0
2.2	87.5	88.2	85.5	83.3
3	88.5	89.1	86.9	84.9
4	89.3	89.9	87.9	86.2
5.5	90.1	90.7	89.1	87.7
7.5	90.9	91.5	90.1	88.9
11	91.9	92.2	91.2	90.3
15	92.5	92.9	92.0	91.4
18.5	92.9	93.3	92.5	92.0
22	93.3	93.6	92.9	92.4
30	93.9	94.2	93.6	93.2
37	94.2	94.5	94.0	93.7
45	94.6	94.8	94.4	94.2
55	94.9	95.0	94.8	94.6
75	95.4	95.5	95.2	95.2
90	95.5	95.7	95.5	95.5
110	95.8	96.0	95.8	95.8
132	96.1	96.1	96.1	96.1
150	96.1	96.3	96.2	96.3
<185	96.1	96.3	96.2	96.3

1.4.2 Testing standards for motor energy efficiency

1.4.2.1 AS 1359.102

This standard establishes methods of determining efficiencies from tests, and also specifies methods of obtaining particular losses when these are required for other purposes. It applies to DC machines and to AC synchronous and induction machines of all sizes within the scope of IEC 60034-1.

It is expected that the Australian Standard will shortly collapse to follow the revised international standard IEC 60034-2.

1.4.3 Updated information from Australia

In February 2008, Australia and New Zealand staff attended the International Energy Agency (IEA) workshop, Meeting Energy Efficiency Goals and as part of that workshop process will share test reports with other governments. E3 product reports have already been referred to the UK government. This workshop should pave the way forward for regulators around the world sharing data about globally traded product.

Australia will be organizing a local testing round robin using Method B between the two NATA accredited motor testing facilities in Australia, Caltest and CMG. Two motors have already been obtained for this testing round robin – a WEG 2.2 kW 2 pole motor and a TECO 0.75 kW 4 pole motor.

SEW Eurodrive in Germany has also generously loaned two motors to Caltest for an international round robin to compare Method A and Method B. Australia is considering whether to include other countries in this round robin, and results from this round robin testing may be shared with the IEC testing round robin occurring later this year.

Equipment Energy Efficiency (E3) periodically reviews current MEPS levels for each product in light of international developments. The US recently announced that they will be moving to mandate NEMA Premium efficiency levels within the next few years for motors (the proposed IE3 level in the current draft IEC standard on efficiency classes for three-phase motors). At the same time, the US is also looking to develop voluntary Super Premium levels (the proposed IE4 level in the draft IEC standard).

Due to these international developments, E3 is planning to start the process of reviewing the current MEPS 2 levels for motors in the near future. Instead of moving to our current 'High Efficiency' levels, E3 is looking to move to the NEMA Premium levels to follow world's best practice. The third round of MEPS might commence in late 2011, if this proposal has industry support.

1.5. China

1.5.1 the 1st EE standard for electric motor (GB18613-2002)

Considering that the energy and environmental issues have become increasingly prominent, China enacted Energy-sawing Law in 1998, and starting in the late 1990s, the minimum energy efficiency value has been imposed upon some important energy-consuming products as a compulsory standard. In addition, in order to encourage the manufacture and application of energy-saving products, a certification system has been implemented for energy-saving products. Electric motors, as major energy-consuming products, were listed on the planning of the above-mentioned certification of energy-saving product; and in January 2002, upon approval of the General Administration of Quality Supervision, Inspection and Quarantine, the standard of Limited Value of Energy Efficiency and Energy-saving Evaluation Value for Small and Medium-sized Three-phase Asynchronous Motors was formally enacted.

This standard prescribed two indices for the efficiency of electric motors: a minimum value, which is the compulsory index, and an energy-saving evaluation value, which is a recommended value. The former value reflects the average level of electric motors currently in use, while the latter value, 2-3% over the former one, reflects the efficiency level of energy-saving motors. The purpose of the standard is to eliminate those inferior energy consuming products threatening market order through implementation of the minimum efficiency limit, and at the same time, promote the manufacture and application of efficient electric motors through such various measures as energy-saving certification, to the extent that the market oriented toward general efficiency motors shall gradually transform to a market characterized by high-efficiency motors.

In China the standard of electric frequency, power and dimensional measurement, power registration of electric motors and the relationship with installation dimension are different from that of Europe; and the basic specifications and testing methods in our country, as stated above, conform to IEC standard as EU does. A significant quantity of electric motors is exported, 3/4 to Europe and Asia and only 1/4 to North America. The former importing countries require motors to conform to IEC standards; accordingly the energy efficiency standard for electric motors in China makes reference to EFF2 of EU-CEMEP as the minimum energy efficiency limit and EFF1 of EU-CEMEP as the energy-saving evaluation value. Any electric motors that reach or surpass such index are named as high residual motors or energy-saving motors. In contrast to EU-CEMEP, the energy efficiency standard for electric motors in China has properly extended the power scope and pole number by referring to Austrian standard and UK ECA standard based on national conditions; the power scope is 0.55-315 KW and the pole number is 2, 4 and 6. In addition, the Chinese standard imposes additional requirements for load stray losses in assessing energy-saving evaluation value. Refer to attached list for the minimum energy efficiency limit and energy-saving evaluation value for electric motors in China. As the above indicates, the energy efficiency index of the several series of electric motors prevalent in China generally meets the minimum limit, but as to energy-saving evaluation value, there is still long way to go.

Table 13: Minimum Efficiency Requirements in GB 18613-2002

Rated output kW	Minimum efficiency		
	2 pole	4 pole	6 pole
0.55	—	71	65
0.75	75	73	69
1.1	76.2	76.2	72
1.5	78.5	78.5	76
2.2	81	81	79
3	82.6	82.6	81
4	84.2	84.2	82
5.5	85.7	85.7	84
7.5	87	87	86
11	88.4	88.4	87.5
15	89.4	89.4	89
18.5	90	90	90
22	90.5	90.5	90
30	91.4	91.4	91.5
37	92	92	92
45	92.5	92.5	92.5
55	93	93	92.8
75	93.6	93.6	93.5
90	93.9	93.9	93.8
110	94	94.5	94
132	94.5	94.8	94.2
160	94.6	94.9	94.5
200	94.8	94.9	94.5
250	95.2	95.2	94.5
315	95.4	95.2	—

Table 14: High-efficiency Motor Requirements in GB 18613-2002

Rated output kW	High-efficiency Motor		
	2 pole	4 pole	6 pole
0.55	-	80.7	75.4
0.75	77.5	82.3	77.7
1.1	82.8	83.8	79.9
1.5	84.1	85	81.5
2.2	85.6	86.4	83.4
3	86.7	87.4	84.9
4	87.6	88.3	86.1
5.5	88.6	89.2	87.4
7.5	89.5	90.1	89
11	90.5	91	90
15	91.3	91.8	91
18.5	91.8	92.2	91.5
22	92.2	92.6	92
30	92.9	93.2	92.5
37	93.3	93.6	93
45	93.7	93.9	93.5
55	94	94.2	93.8
75	94.6	94.7	94.2
90	95	95	94.5
110	95	95.4	95
132	95.4	95.4	95
160	95.4	95.4	95
200	95.4	95.4	95
250	95.8	95.8	95
315	95.8	95.8	-

1.5.2 the revised EE standard for electric motor (GB 18613-2006)

Three factors have contributed to the revision of the energy efficiency standard of electric motor. First, China has faced a severe shortage of energy in recent years. The Chinese government has enacted a series of new energy policies to strengthen the management of energy saving. The implementation of an energy efficiency identification system, in particular, provides a compulsory means to improve energy utilization efficiency of the equipment using energy. In order to apply the energy efficiency identification system in the electric motor field the energy efficiency rate should be added to GB18613. Secondly, energy efficiency of most electric motors made in China has reached the energy efficiency limit. The energy efficiency limit in the original standard has little impetus on the increase of the efficiency of electric motor. Increasing the target energy efficiency limit in the standard and thereby the energy efficiency limit of electric motor is of great importance in promoting energy saving in China.

In addition, at present most economic giants (e.g. US, Australia, EU) in the world have raised their minimum energy efficiency standard. Further increasing the minimum energy efficiency limit of China can help Chinese electric motor entry into the world market

The new Chinese motor Energy Efficiency standard introduced a similar level with the Australian 2006 high efficient level and firstly set three grades for efficiency of electric motors which will pave the way of the introducing of China motor energy labeling. The MEPS of motor set in the 2nd version is not changed and equivalent to the EFF2 level in EU. This is a mandatory measure starting in July 2007 applied to motors described in Table 12.

Table 15: Characteristics of the motors included in the Chinese MEPS

Motors in China scheme
Three phase induction motors, general purpose, N-Design
Rated power 0.55-315 kW
Single-speed
Enclosure type: Totally Enclosed Fan Cooled (TEFC)
Up to 690 Volts
2, 4 and 6 poles
Continuous rated

One methods of efficiency measurement, described in GB 18613-2006, are allowed:

The motor efficiency testing should be in accordance with GB/T 1032 and the stray load loss (PLL) will be calculated as the 0.5% of the input power which is in line with the requirements specified in the old version of IEC 60034-2.

The efficiency requirements set for various grades for electric motors have attached as following Table 13. In where, Grade 3 is the MEPS; Grade 2 is the middle level, equivalent to EFF1/EPAct, which will be replaced as the MEPS after 4 years later from the issuing date of the standard; Grade 1 is the top level with the efficiency requirements similar to the Australian high-efficiency motor efficiency. The tolerance should be in line with GB 755-2000, equivalent to IEC 60034-1.

Table 16: Motor Efficiency Requirements in GB 18613-2006

Rated output kW	Energy Efficiency Requirements								
	Grade 1			Grade 2			Grade 3		
	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole	2 Pole	4 Pole	6 Pole
0.55	—	—	—	—	80.7	75.4	—	71.0	65.0
0.75	—	—	—	77.5	82.3	77.7	75.0	73.0	69.0
1.1	—	—	—	82.8	83.8	79.9	76.2	76.2	72.0
1.5	—	—	—	84.1	85.0	81.5	78.5	78.5	76.0
2.2	—	—	—	85.6	86.4	83.4	81.0	81.0	79.0
3	—	—	86.9	86.7	87.4	84.9	82.6	82.6	81.0
4	89.3	89.9	87.9	87.6	88.3	86.1	84.2	84.2	82.0
5.5	90.1	90.7	89.1	88.6	89.2	87.4	85.7	85.7	84.0
7.5	90.9	91.5	90.6	89.5	90.1	89.0	87.0	87.0	86.0
11	91.9	92.2	91.4	90.5	91.0	90.0	88.4	88.4	87.5
15	92.5	92.9	92.3	91.3	91.8	91.0	89.4	89.4	89.0
18.5	92.9	93.3	92.7	91.8	92.2	91.5	90.0	90.0	90.0
22	93.3	93.6	93.1	92.2	92.6	92.0	90.5	90.5	90.0
30	93.9	94.2	93.6	92.9	93.2	92.5	91.4	91.4	91.5
37	94.2	94.5	94.0	93.3	93.6	93.0	92.0	92.0	92.0
45	94.6	94.8	94.4	93.7	93.9	93.5	92.5	92.5	92.5
55	94.9	95.0	94.7	94.0	94.2	93.8	93.0	93.0	92.8
75	95.4	95.5	95.0	94.6	94.7	94.2	93.6	93.6	93.5
90	95.5	95.7	95.2	95.0	95.0	94.5	93.9	93.9	93.8
110	95.8	96.1	95.7	95.0	95.4	95.0	94.0	94.5	94.0
132	96.1	96.1	95.7	95.4	95.4	95.0	94.5	94.8	94.2
160	96.1	96.1	95.7	95.4	95.4	95.0	94.6	94.9	94.5
200	96.1	96.1	95.7	95.4	95.4	95.0	94.8	94.9	94.5
250	96.1	96.1	95.7	95.8	95.8	95.0	95.2	95.2	94.5
315	96.1	96.1	—	95.8	95.8	—	95.4	95.2	—

1.6 Japan

At present, TC2/WG31 under the International Electro-technical Commission (hereinafter called IEC) is preparing and deliberating on a new standard IEC 60034-30: Rotating electrical machines-Efficiency classes of single-speed three-phase cage induction motors. The target of IEC 60034-30 is to unify the standard values of energy efficiency of three-phase induction motors; however, in Japan there is a related issues as to whether or not the JIS C 4212: Low-voltage three-phase squirrel-cage high-efficiency induction motors, that is the Japanese standard for the standard values of energy efficiency of motors, should be revised in line with IEC 60034-30 when it is established. This paper reports: progress in establishing JIS C 4212, specific issues concerning areas that have a 50 Hz or 60 Hz power supply, energy saving measures for applying inverters and savings measures for applying permanent-magnet-motors.

1.6.1 The course of establishment of JIS C 4212

Oil crises were experienced twice, in 1973 and 1979, and as a result all motor manufacturers strived to develop and design high-efficiency motors. To publicize the approaches and results of the motor manufacturers, the Japan Electrical Manufacturers' Association (JEMA) issued the technical report No.137 "Selection and application of high-efficiency motors" in 1982 and submitted energy efficiency standard values for high-efficiency motors in the Attached Table of that report entitled "Efficiency standard values of energy-saving enclosed-type motors". At that time, no other countries had set such criteria. Thus, Japan's challenge to develop high-efficiency motors had preceded those of other countries.

The Kyoto conference on prevention of global warming was held in December 1997 in the midst of heightened concern for global environmental protection. At this conference, the reduction of emissions of greenhouse gases such as carbon dioxide became an international commitment.

As a result, the “Energy Conservation Law” was revised in 1999, in which “Judgment criteria by business operators concerning rational use of energy in factories” (hereinafter called “Judgment criteria”) was disclosed, and efforts for energy saving in factories and offices were strengthened. It is generally said that electric power consumption by motors in manufacturing factories is around 70% of the total. Thus, it was again noticed that the potential for energy reduction by improving the efficiency of motors was high, and as a result the Japanese technical standard JIS C 4212 “Low-voltage three-phase squirrel-cage high-efficiency induction motors” was established in July 2000. In addition, this standard defines how to measure (IEEE112) and classify motor energy efficiency.

1.6.2 Issues of 50 Hz and 60 Hz power supply areas

There is an issue of different power frequencies of 50 Hz and 60Hz in Japan. This dates back to the Meiji period (1880s) when the 50 Hz alternating generators of German AEG make were adopted in Eastern Japan, while the 60 Hz alternating generators of U.S.A GE make were adopted in the Western Japan. The JIS C 4212, standard for the energy efficiency standard values of motors, therefore, specifies motors for common use for both 50 Hz and 60Hz. It is desirable for the IEC 60034-30 to provide provisions of common use for both 50 Hz and 60Hz. Thus, Japan reported the real state of Japanese power frequencies in the deliberations of IEC/TC/WG31 held in October 2006 and proposed to add provisions for common use for both 50 Hz and 60 Hz, and provisions will be added to the IEC 60034-30. After the IEC 60034-30 is established, JIS C 4212 will be revised.

1.6.3 Energy saving measures when using inverters

Widespread energy saving from the use of inverter-based motor drive systems predates that from the use of highly efficient motors in Japan, and highly efficient motors are not yet widely used. The low rate of use of highly efficient motors seems to be caused by the fact that Japanese industrialists prefer to take energy saving measures when applying motor drive systems whose cost performance is good rather than highly efficient motors because the Energy Conservation Law has strict requirements for energy saving in Japan. In addition, progress in power electronics is remarkable. Table 17 gives specific examples for energy saving measures using inverters.

Table 17: Energy saving measures using inverter technologies

Facilities		Measures for energy saving
Pump Blower Fan	Flow・Wind volume constant	Replacement with high-efficiency motors Suppression of reactive energy loss under light load (Inverters shall apply.)
	Flow・Wind volume Variable	Suppression of throttle loss Valveless or damperless (Inverters shall apply.)
Extruder Conveyer	Speed variable	Replacement with high-efficiency motors (Eddy current joint driver to inverter drive)
	Speed constant	Replacement with high-efficiency motors
Lifts such as crane etc.		Replacement with high-efficiency systems ("Winding-type induction motor+ primary voltage control" to "Cage-type induction motor+ inverter drive") Recovery of regenerative energy when slinging down a load by power regenerative function of inverter
Unwinder		Recovery of regenerative energy of unwinder
Shot-blasting De-scaling pump		Recovery of starting energy

1.6.4 Energy saving measures when using permanent-magnet-type motors

Permanent-magnet-type synchronous motors are those using permanent magnets for magnet poles, and generally have the following characteristics.

① Permanent-magnet-type motors generally have a higher level of energy efficiency than induction motors, exciting-type synchronous motors, etc.

② Maintenance is easy because there are no exciting circuits and slip rings.

③ Protection against temperature rise of magnet poles is unnecessary because there is no temperature rise caused by exciting loss.

④ Exclusive inverters are necessary.

Through the above characteristics, the utilization of permanent-magnet-type synchronous motors has been extended not only in home electrical appliances, but also in industrial equipment such as “freezing machines and products using freezing machines”, “pumps, compressors and blowers”, etc. Accordingly, the Japan Electrical Manufacturers’ Association (JEMA) established a standard called JEM 1487: Low-voltage three-phase permanent-magnet-type synchronous motors in 2005. JEM 1487 specifies low-voltage three-phase permanent-magnet-type synchronous motors. However, permanent-magnet-type synchronous servomotors frequently used for control are excluded from the scope of JEM 1487.

The provisions of JEM 1487 are summarized as follows:

・ Rated voltage 600V or below For standard rated output power, the rated output power used normally in Japan was also specified in addition to the standard output power provided by IEC60076-1: Dimensions and output series for rotating electrical machines - Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080.

・ Temperature control of permanent magnets was specified for items particular to permanent-magnet-type synchronous motors and an induced voltage characteristics test was specified for a specific test. For the load characteristic test, the internationally used brake method or dynamometer method was adopted.

2. Harmonization of motor efficiency improving work

2.1 Summary of relevant regulations

There are no motor efficiency voluntary agreements or minimum efficiency standards regulation regarding motors other than AC induction motors.

Single-phase induction motors are subjected to voluntary labeling schemes in Brazil, India and Mexico.

An overview of the AC three-phase induction motor efficiency voluntary agreements and regulation around the world is presented in Table 1-4. North America (USA, Canada and Mexico) has been the leading region in promoting both high efficiency and premium motors, which now have a market share of over two thirds. Other countries around the world are taking similar initiatives.

Table 18: Motor efficiency voluntary agreements and regulation around the world

Country/Region	Mandatory Agreements (year of implementation)	Voluntary Agreements (year of implementation)	Market Share
U.S.A	EPAct – High Efficiency (1997) NEMA Premium (2011)	NEMA Premium (2001)	NEMA Premium (16%) EPACT (54%)
Canada	EPAct levels– High Efficiency (1997)	NEMA Premium (2001)	NEMA Premium (16%) EPACT (54%)
Mexico	EPAct levels– High Efficiency (1998)	NEMA Premium (2003)	n.a.
EU		Efficiency Classification and market reduction of EFF3 (1998)	EFF1 (12%) EFF2 (85%) for CEMEP members
Australia	High efficiency (2006)	Premium efficiency (2006)	Premium Efficiency (10%) High efficiency (32%) Standard (58%)
New Zealand	High efficiency (2006)	Premium efficiency (2006)	n.a.
Brazil	Standard Efficiency (2002) High Efficiency (2009)	High Efficiency	High Efficiency (15%)
China	Standard Efficiency (2002) High Efficiency (2011)	Premium efficiency (2007)	High Efficiency (10%) Standard Efficiency (90%)
Korea	Standard Efficiency (2008)	Standard Efficiency (1996)	High Efficiency (10%) Standard (90%)

In the above Table 18, four efficiency classes of motors are mentioned:

. Premium efficiency motors (equivalent to IE3, USA NEMA Premium classification)

. High efficiency motors (equivalent to IE2, USA EPACT or EFF1 from

CEMEP/EU)

. Standard efficiency motors (equivalent to IE1, EFF2 from CEMEP/EU agreement)

. Low efficiency motors (equivalent to EFF3 from CEMEP/EU agreement, and below standard efficiency in the rest of the world)

In Canada and the US, the MEPS relating to motors that conform to National Electrical Manufacturers Association (NEMA) requirements are identical, but the Canadian program also covers metric motors. Mexico has recently completed a revision of its MEPS, making the levels equivalent to those in the US and Canada.

2.2 Comparison of MEPS requirements in major economies

In order to compare efficiency requirements, one must be aware that different test methods are used in the assessment of the motor’s efficiency. These test methods can produce significantly different results and therefore efficiency levels are not straightforwardly comparable.

Furthermore, the measurement tolerances varies in the different test methods, and the impact of the supply frequency (50 Hz or 60 Hz) used during the test on the final test results complicates things further. When the torque is not changed, the output power increases by 20%, most motors develop a better efficiency at 60 Hz compared to 50Hz.

NEMA standards apply to motors tested according to IEEE 112 – Method B. It is a direct method where output power is obtained measuring the torque and rotation speed at different load levels.

This method requires accurate measuring instrumentation, including precision dynamometers, for the different power ranges.

The CEMEP/EU agreement, on the other hand, includes motors tested according to IEC60034-2 using the “summation of losses” test procedure.

This test procedure is an indirect method, avoiding the need to measure Mechanical Power and the associated costs. Mechanical Power is calculated by measuring the electrical input power and the losses.

All losses are measured using laboratorial tests except stray load losses which are assumed. The full load stray load losses are arbitrarily assumed to be 0,5% of the full load input power.

$$Efficiency = 1 - \frac{Power\, losses}{Input\ power}$$

Because of the above mentioned assumption, the efficiency measurements between IEEE 112-B and IEC 60034-2 lead to different results. Next figure shows the difference of efficiency tests carried out in the same motors using IEEE 112-B and IEC 34-2 test standards. IEC 34-2 “summation of losses” efficiency test method gives overestimated efficiency values because the value considered for stray load losses (0.5 % of the full load input power) is not realistic. In fact, in the most cases, particularly in the low and medium power motor ranges, stray load losses assume real values well above 0.5%.

Figure 4 presents a comparative assessment of different efficiency levels associated with MEPS and voluntary agreement classification schemes, in which the 60 Hz motor data was converted to 50 Hz (Figure 3) and adjustments were made when needed to take into account typical values for stray-load losses. It is to be noted that for motors using the same amount of active materials, leading to similar torque, the operation at 60 Hz will provide slightly higher efficiency, because although some losses increase with the frequency (e.g. the mechanical losses and magnetic losses) the output power increases more intensively.

If torque remains unchanged, I2R losses remain approximately constant for 50 Hz and 60 Hz operation. Magnetic losses are considered increase with frequency1.5, friction losses are considered to vary linearly with frequency, and ventilation losses increase with the cube of the frequency, if the fan size is not adjusted.

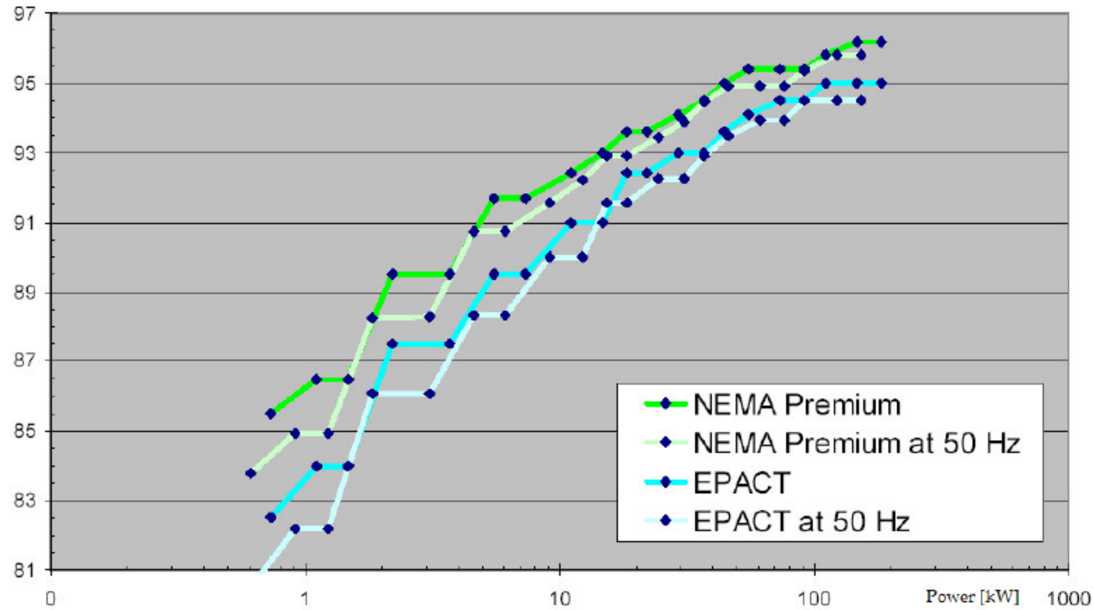

Figure 3: Comparison of 60 Hz efficiency requirements at 50 Hz line frequency (EPACTand NEMA Premium)

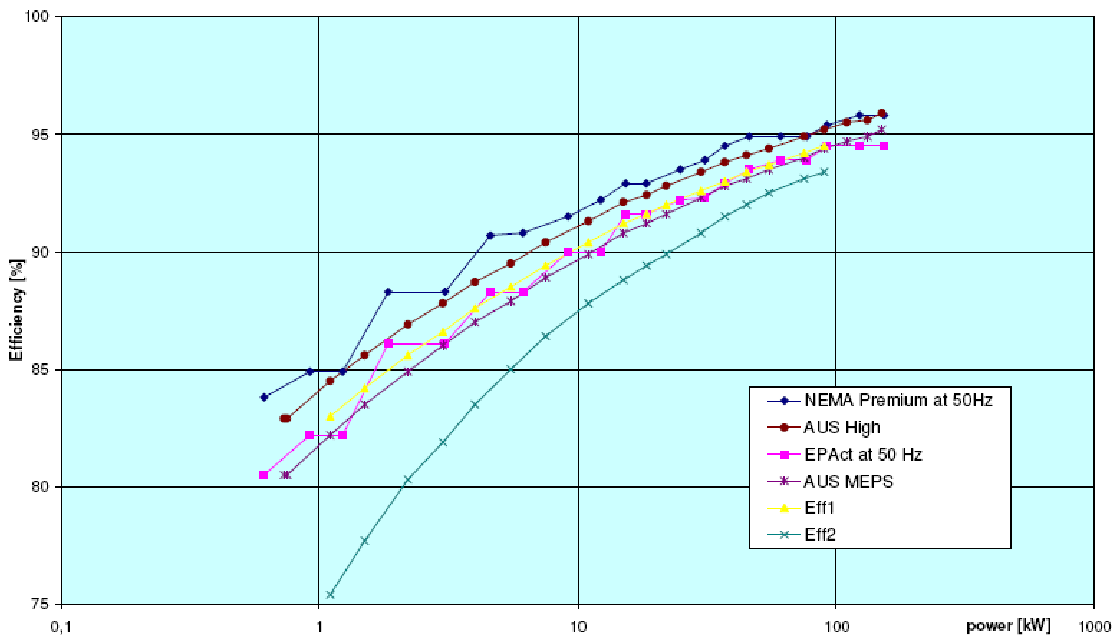

Figure 4: Comparison of Efficiency requirements

As can be seen, current EFF1 motors, under the CEMEP/EU agreement, are roughly on the same efficiency level as EPACT and Aus/NZ MEPS compliant motors. NEMA Premium and Australian/New Zealand High efficiency levels, which have not yet a European correspondent, are slightly higher.

2.3 Harmonization of efficiency classification standards in the World

As it is possible to see from the previous section, several different energy efficiency levels/classes are currently in use around the world, increasing potential confusion and creating market barriers. For the manufacturers this is a big problem because they design motors for a global market. Therefore, IEC developed a classification standard (IEC 60034-30) trying to globally harmonize energy efficiency classes for three-phase induction motors. The second draft of this standard (2/1464/CDV) has been approved by 76% of the voting countries on 1 February 2008. The comments will be discussed by IEC Working Group 31 on 26/27 March 2008. The final edition of the standard is expected to be published before the end of 2008.

The new standard will be called "IEC 60034-30: Efficiency classes of single-speed three phase cage induction motors" covering single-speed three-phase 50 Hz or 60 Hz cage induction motors that:

- have a rated voltage UN up to 1000 V;

NOTE - The standard also applies to motors rated for two or more voltages and/or frequencies

- have a rated output PN between 0,75 kW and 370 kW;
- have either 2, 4 or 6 poles

- are rated on the basis of duty type S1 (continuous duty) or S3 (intermittent periodic duty) with an operation time of 80% or more;
- are intended for direct on-line connection;
- are rated for operating conditions according to IEC 60034-1, clause 6.

Motors with flanges, feet and/or shafts with mechanical dimensions different from IEC 60072-1 are covered by this standard.

Geared motors and brake motors are covered by this standard although special shafts and flanges may be used in such motors.

Excluded are:

- Motors specifically made for converter operation according to IEC 60034-25 with increased insulation.
- Motors completely integrated into a machine (pump, fan, compressor, etc.) which can not be separated from the machine.
- All other non-general-purpose motors (like smoke-extraction motors built for operation in igh ambient temperature environments according to EN12101-3 etc.

Efficiency and losses shall be tested in accordance with IEC 60034-2-1. For IE1, test methods associated with low and medium uncertainty are acceptable. The selected test method shall be stated in the documentation of the motor. For all higher energy efficiency levels only methods associated with low uncertainty shall be acceptable.

Four efficiency classes are defined:

- IE4 – Super Premium (under consideration)
- IE3 – Premium efficiency (equivalent to NEMA Premium)

- IE2 – High efficiency (equivalent to EPAct/EFF1)
- IE1 – Standard efficiency (equivalent to EFF2)
- No designation – below standard efficiency – (equivalent to EFF3)

As there is no sufficient market and technological information available to allow standardization, the IE4 (Super Premium) class efficiency levels are only presented in the form of an informative annex. This new class is expected to be included in the next revision of the standard which will also expand its scope to include new motor technologies.

The rated efficiency and the efficiency class shall be durably marked on the rating plate, for example 89,0 (IE3).

The 50 Hz values of standard (IE1) and high efficiency (IE2) are equivalent to the existing CEMEP/EU agreement EFF2 and EFF1. However the values have been adjusted to take the different test procedures into account (CEMEP/EU: the stray load losses are arbitrarily assumed to be 0,5% of full-load input power; in IEC 60034-30 standard: the stray load losses determined from the test).

The 50 Hz values for premium efficiency (IE3) are newly designed. They were set about 15 to 20% lower losses above the requirements for high (IE2).

The 60 Hz values were derived from the 50 Hz values taking the influence of supply frequency on motor efficiency into account. This approach will enable manufacturers to build motors for dual rating (50/60 Hz).

All efficiency curves are given in mathematical formula in smooth form to allow for various regional and national distinctions for frame dimensions and motor sizes.

The next tables show the proposal efficiency requirements for each class, for 50 Hz and 60 Hz:

Table 19: Nominal values for standard efficiency (IE1) for 50 Hz power supply

Pn kW	Number of Poles		
	2	**4**	**6**
0,75	72,1	72,1	70,0
1,1	75,0	75,0	72,9
1,5	77,2	77,2	75,2
2,2	79,7	79,7	77,7
3	81,5	81,5	79,7
4	83,1	83,1	81,4
5,5	84,7	84,7	83,1
7,5	86,0	86,0	84,7
11	87,6	87,6	86,4
15	88,7	88,7	87,7
18,5	89,3	89,3	88,6
22	89,9	89,9	89,2
30	90,7	90,7	90,2
37	91,2	91,2	90,8
45	91,7	91,7	91,4
55	92,1	92,1	91,9
75	92,7	92,7	92,6
90	93,0	93,0	92,9
110	93,3	93,3	93,3
132	93,5	93,5	93,5
160	93,8	93,8	93,8
200 and above	94,0	94,0	94,0

Table 20: Nominal values for standard efficiency (IE1) for 60 Hz power supply

Pn kW	Number of poles		
	2	**4**	**6**
0,75	77,0	78,0	73,0
1,1	78,5	79,0	75,0
1,5	81,0	81,5	77,0
2,2	81,5	83,0	78,5
3,7	84,5	85,0	83,5
5,5	86,0	87,0	85,0
7,5	87,5	87,5	86,0
11	87,5	88,5	89,0
15	88,5	89,5	89,5
18,5	89,5	90,5	90,2
22	89,5	91,0	91,0
30	90,2	91,7	91,7
37	91,5	92,4	91,7
45	91,7	93,0	91,7
55	92,4	93,0	92,1
75	93,0	93,2	93,0
90	93,0	93,2	93,0
110	93,0	93,5	94,1
150	94,1	94,5	94,1
185 and above	94,1	94,5	94,1

Table 21: Nominal values for high efficiency (IE2) for 50 Hz power supply

Pn kW	Number of poles		
	2	4	6
0,75	77,4	79,6	75,9
1,1	79,6	81,4	78,1
1,5	81,3	82,8	79,8
2,2	83,2	84,3	81,8
3	84,6	85,5	83,3
4	85,8	86,6	84,6
5,5	87,0	87,7	86,0
7,5	88,1	88,7	87,2
11	89,4	89,8	88,7
15	90,3	90,6	89,7
18,5	90,9	91,2	90,4
22	91,3	91,6	90,9
30	92,0	92,3	91,7
37	92,5	92,7	92,2
45	92,9	93,1	92,7
55	93,2	93,5	93,1
75	93,8	94,0	93,7
90	94,1	94,2	94,0
110	94,3	94,5	94,3
132	94,6	94,7	94,6
160	94,8	94,9	94,8
200 and above	95,0	95,1	95,0

Table 22: Nominal values for high efficiency (IE2) for 60 Hz power supply

Pn kW	Number of poles		
	2	4	6
0,75	75,5	82,5	80,0
1,1	82,5	84,0	85,5
1,5	84,0	84,0	86,5
2,2	85,5	87,5	87,5
3,7	87,5	87,5	87,5
5,5	88,5	89,5	89,5
7,5	89,5	89,5	89,5
11	90,2	91,0	90,2
15	90,2	91,0	90,2
18,5	91,0	92,4	91,7
22	91,0	92,4	91,7
30	91,7	93,0	93,0
37	92,4	93,0	93,0
45	93,0	93,6	93,6
55	93,0	94,1	93,6
75	93,6	94,5	94,1
90	94,5	94,5	94,1
110	94,5	95,0	95,0
150	95,0	95,0	95,0
185 and above	95,4	95,0	95,0

Table 23: Nominal values for premium efficiency (IE3) for 50 Hz power supply

Pn kW	Number of poles		
	2	**4**	**6**
0,75	80,7	82,5	78,9
1,1	82,7	84,1	81,0
1,5	84,2	85,3	82,5
2,2	85,9	86,7	84,3
3	87,1	87,7	85,6
4	88,1	88,6	86,8
5,5	89,2	89,6	88,0
7,5	90,1	90,4	89,1
11	91,2	91,4	90,3
15	91,9	92,1	91,2
18,5	92,4	92,6	91,7
22	92,7	93,0	92,2
30	93,3	93,6	92,9
37	93,7	93,9	93,3
45	94,0	94,2	93,7
55	94,3	94,6	94,1
75	94,7	95,0	94,6
90	95,0	95,2	94,9
110	95,2	95,4	95,1
132	95,4	95,6	95,4
160	95,6	95,8	95,6
200 and above	95,8	96,0	95,8

Table 24: Nominal values for premium efficiency (IE3) for 60 Hz power supply

Pn kW	Number of poles		
	2	4	6
0,75	77,0	85,5	82,5
1,1	84,0	86,5	87,5
1,5	85,5	86,5	88,5
2,2	86,5	89,5	89,5
3,7	88,5	89,5	89,5
5,5	89,5	91,7	91,0
7,5	90,2	91,7	91,0
11	91,0	92,4	91,7
15	91,0	93,0	91,7
18,5	91,7	93,6	93,0
22	91,7	93,6	93,0
30	92,4	94,1	94,1
37	93,0	94,5	94,1
45	93,6	95,0	94,5
55	93,6	95,4	94,5
75	94,1	95,4	95,0
90	95,0	95,4	95,0
110	95,0	95,8	95,8
150	95,4	96,2	95,8
185 and above	95,8	96,2	95,8

The approval of the IEC 60034-30 efficiency classification standard, currently under development, that harmonizes the currently different requirements for induction motors efficiency levels around the world, will hopefully end the difficulties manufacturers encounter when producing motors for a global market. Additionally customers will benefit by having access to a more transparent and easier to understand information.

Another important factor is the minimum efficiency levels adopted by each country. Although the CEMEP/EU agreement was an important first step towards the reduction of less efficient motor sales, other countries have achieved better results by the implementation of mandatory agreements which introduced higher minimum efficiency levels. These mandatory agreements have produced more relevant market transformations. As an example, EPAct motors (equivalent to EFF1 in Europe) now constitute 70% of the USA motor market while in Europe EFF1 motors have a modest 12% market share.

3. Recommendations

3.1 Harmonization of energy efficiency standards in major APEC economies

Now that the new IEC energy efficiency grade standard of electric motors IEC60034-30 will be released in the end of this year. However, current energy efficiency standards in major economies are all different on the grades numbering and the efficiency requirements. EU, Australian and China cut the energy efficiency grades into 3 rating in their national standards; US have no grades standards now; and the Japan has no MEPS for their motor efficiency requirements. In order to promote the development of the electric motor industry and eliminate international trade barriers, APEC members should revise the minimum energy efficiency standard for their electric motors as soon as possible in accordance with the standard. One way maybe can solve the problem is that all of APEC economies revised their standard to keep the same efficiency values to the current IEC 60034-30, but various countries can take different numbering to indicate their product efficiency. For example, China can revise the efficiency value to keep alignment with the 50HZ requirement specified in the IEC 60034-30, but also keep the three grades numbering in the national standard because the top level of IE4 requirement is too high for motor manufactures in China base on the current technology and industry development.

3.2 Harmonization of testing methods for energy efficiency of electric motors in major APEC economies

Energy efficiency testing methods are the basis for assessing efficiency level of an electric motor. The new standard IEC60034-2-1 regarding energy efficiency test method for IEC motors includes four methods and each method has got evaluation on the uncertainty level for testing. Different testing methods need various testing equipments with support. Low uncertainty testing methods normally need high cost investment in the testing apparatus. The APEC members should select suitable ones for testing based on the actual condition of their own motor industry and their social development level. One way maybe can solve the problem is that to make a research on the accurate efficiency testing difference between different testing methods for all range of power scope. Therefore, even various economies take different testing methods such as the IEEE-112B and eh-star, we can easily converted into the efficiency under the another testing methods.

3.3 Harmonization of energy efficiency label for electric motors in major APEC economies

Energy efficiency label is the one of the most important ways to implement the energy efficiency standard for electric motors. Label design should be based on the grades setting specified in the standard. However, various countries have different practice in numbering for high and low efficiency products. In China, normally we use grade 1 to stand for the highest grade. But in the new IEC 60034-30, IE1 is the lowest energy efficiency level for motor. Some problem is there for EU-CEMEP grading. It is difficult to fully unify the labels used by different countries on the existing basis. We suggest that different countries should adjust their energy efficiency labels in accordance with IEC energy efficiency rating so as to ensure that the products of the same rate can be mutually recognized in different countries.

3.4 Development and implementation of supporting policies for motors and their energy saving systems

Many developed giants (e.g. EU and US) have a lot of policies associated to the stimulation measures in finance for the purpose of increasing energy efficiency of electric motors. Their policies are different in detail, but identical in purpose and function. We recommend that APEC members, especially developing countries, learn from the experiences of developed countries and develop associated practicable policies based on their conditions to promote energy conservation in the electric motor industry. Here are the most popular methods, tax rebate no matter for customers and producers, government procurement of high efficiency products, additional depreciation rate for the installment of high efficiency equipments, etc., which are used in some countries and have been approved as very good ways to promote the products efficiency improvement and the high energy efficiency market transformation. We suggest the APEC economies try those ways to push the energy conservation work in motor industry.

Reference

1. Qin He，Energy efficiency and effect analysis of electric motor ,small and medium electric motors, 2003 (1)；
2. Qin He, Overview and forecast of small and medium electric motor products, small and medium electric motors, 2000 (3)；
3. Huang Guozhi, High energy efficiency electric motors in United States, small and medium electric motors, 1997 (1), (2), (5)；
4. Steven Nadel ,Michael Shepard etc ,Energy Efficient Motor Systems, ACE3, Washington,DC,1999
5. U.S.Department of Energy ,United states Industrial Electric Motor Systems Market Opportunities Assesment ,Dec.2002;
6. Paul E Scheihing , U.S.Department of Energy'S Motor challenge Program :A National Strategy for Energy Efficient Industrial Motor-Driven System ,Oct.1996;
7. Paul E Scheihing etc, U.S Industrial Motor-Driven System Market Assement: Charting a Roadmap to Energy Savings for Industry ,June.1998;
8. Austin H Bonnett ,An Overview of How AC Induction Motor Performance Has Been Affected by the October 24,1997,Implementation of the Energy Policy Act of 1992;
9. Department of Energy .10 CFR Part 431.Energy Efficiency Program for Certain Commercial and Industrial Equipment : Test Proceduses ,Labeling ,and Certification ,Requirements for Electric Motors ,Final Rule ,Oct.1999;
10. Davids Walters, Energy efficient motors ,Power Engineering Journal ,1999.Feb ,1999.April;
11. H W Falkner, Recent Initiatives to Encourage the Uptake of Higher Efficiency Motors, Ninth International Conference on Electrical Machines and Drives ,1999;
12. J.Haataja etc, Improving 3-phase Induction Motors Efficiency in Europe .The Challenge for Manufactures , International Conference on Electrical Machines and Drives , 1997;
13. D G Waltors etc , The Case for a New Generation of Higher Efficiency Motors–Some Problems and Solutions , International Conference on Electrical Machines and Drives , 1995;
14. R.Hanitsch ,Energy Efficient Electric Motors ,R1002-World Climate &Energy Event , Jana.2002;

15. Paolo Bertoldl ,European Initiatives to Improve Energy Efficiency of Motor Systems ,European Commision JRC .2001;
16. The European Motor Challenge Programme ,http://energy efficiency .jrc.cec.eu.int/motorchanllenge/index.htm;
17. The Euro DEEM database , http://eurodeem_jrc.it
18. European Committee of Manufactures of Electrical Machines and Power Electronics ,Voluntary Agreement of CEMEP,1999;
19. Enhanced Capital Allowance Scheme ,www.eca.gov.vk;
20. Katrin Ostertag ,Re-assessing no-regret potentials –The example of high efficiency electric Motors ,Fraunhofer Institute for Systems and Innovation Research ,2000;
21. Edmar Luiz Fagundes de Almeida ,Energy efficiency and limits of market in France ,Energy Policy ,V.26.NO8.1998;
22. The minimum allowable values and evaluating values of energy efficiency for small and medium three phase asynchronous motors, GB 18613-2006；
23. The Australian Greenhouse Office ,MEPS Requirements for Three Phase Electric Motors from 0.73kw to <185kw , www.energyrating.gov.au ;
24. EuP Lot 11 Motor Final Report, Aníbal T. de Almeida
25. NAEEEC .Minimum Energy Performance Standards , Electric Motors , 2002;
26. Syneca Consulting , Minimum Energy Performance Standards for Electric Motors ,Regulatory Impact Statement ,Dec.2003;
27. Anibal T de Almeida etc ,Comparative Analysis of IEEE112-B and IEC 34-2 Efficiency Testing Standards using Stray Load Losses in Low-Voltage Three-phase ,Cage Induction Motors IEEE Trans on Industry Applications,2002(2);
28. Market Transform Programme ,UK Energy Consumption of Industrial Electric Motor Systems ,Table2: Strategy , www.mtprog.com ;
29. NEMA MG1-1998 Table 12-12 ,Full-load Efficiencies for NEMA Premium™ Efficiency Electric Motors ,2003;
30. IEEE Std 841-2000 ,IEEE Standard for Petroleum and Chemical Industry-Severe Duty Totally Enclosed Fan-Cooled (TEEC) Squirrel Cage Induction Hotors-Up to and Including 500hp;
31. Alan k. Wallace etc, Comparison Testing of IEEE Standard 841 Motors ,0-7803-6745-6/01/2001 IEEE ;