Market Transformation Program for Electric Motor Systems - Global progress report and outlook

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Abstract

The market transformation towards highly efficient, integrated electric motor systems is making slow progress. The basic development of market transparency with agreed harmonized international efficiency measurement standards and efficiency classes has made progress for fixed speed electric motors. The expansion of the scope of engineering practice to also include new motor technologies run on variable speed and towards more complex systems applications of motors with pumps, fans, compressors and mechanical movement machines is recognized but so far almost non-existent in the market place.

The introduction of mandatory minimum requirements for the sale of fixed speed electric motors that started in 1997 will reach a first plateau in 2015 for the USA, Canada, Mexico, Australia and New Zealand. The European Union, Switzerland and China have also adopted mandatory minimum requirements, though they are not yet fully aligned with the premium efficiency level IE3 defined in IEC 60034-30. Today 69% of motor electricity is used in countries with Minimum Energy Performance Standards (MEPS) for motors. Most of these countries have not yet implemented the necessary compliance measures. A global energy efficiency certification system to give industrial buyers the confidence of a superior product was launched at the end of 2012 by the IEC System for Conformity testing and Certification of Electrotechnical Equipment and Components (IECEE).

Very few MEPS for motor systems exist, among them are the new European Ecodesign requirements for small integrated circulators and larger non-integrated pumps and ventilation fans. The complexity of these MEPS for motor-plus-application has led to additional efforts in persuading the European Commission and extra time to secure industry's acceptance. Also similar requirements for pumps and fans are started in Australia, China, Mexico, Vietnam and other countries

A report on international activities of the International Energy Agency's Implementing Agreement 4E Electric Motor Systems Annex (EMSA) is presented here. The goal of EMSA is to improve energy efficiency of electric motor systems through information dissemination, capacity building, training, experience exchange and other activities.

1. Facts and figures of the global motor market

Based on the energy data base of the IEA [1], the global annual electricity production in 2009 was 20 100 PWh and the respective final consumption was 16 800 PWh. According to A+B International's recent update of the Global Motor Energy Data Base [2] the rolling stock of electric motor systems of all types and sizes account for 45% of the electricity consumption in rotating machines totaling 7 600 PWh[1]. With 60% of the total, industry applications of motors are still by far the largest share (see Figure 1). Thus they are responsible for some 5 100 Gt of CO_2 emission from fossil power plants. Motors in the six largest electricity consuming countries/regions (USA, China, EU-27, Japan, India and Russia) already account for 70% of the global electricity demand and 75% of global CO_2 emissions. China, South Africa and Russia have an especially high share of industry use of electricity and therefore have an overall larger share of motor electricity than the global average. China alone is responsible for 22% of motor electricity and 30% of motor CO_2 emissions. Some of these large countries have extremely high CO_2 emission factors because the electricity is generated almost exclusively from coal, oil and gas: South Africa, Australia, Saudi Arabia, China, India and Indonesia are in the highest consuming group. The annual electricity cost at 0.1 € per kWh for motors amount to some 760 billion € per year.

[1] Physicists emphasize that an electric motor does not "use" electricity, but it drives a machine and thus delivers work. The motor itself is responsible for some 10% losses, plus the additional losses in the VFD, the gear, the transmission and the driven equipment. Systems efficiency values are often below 50%.

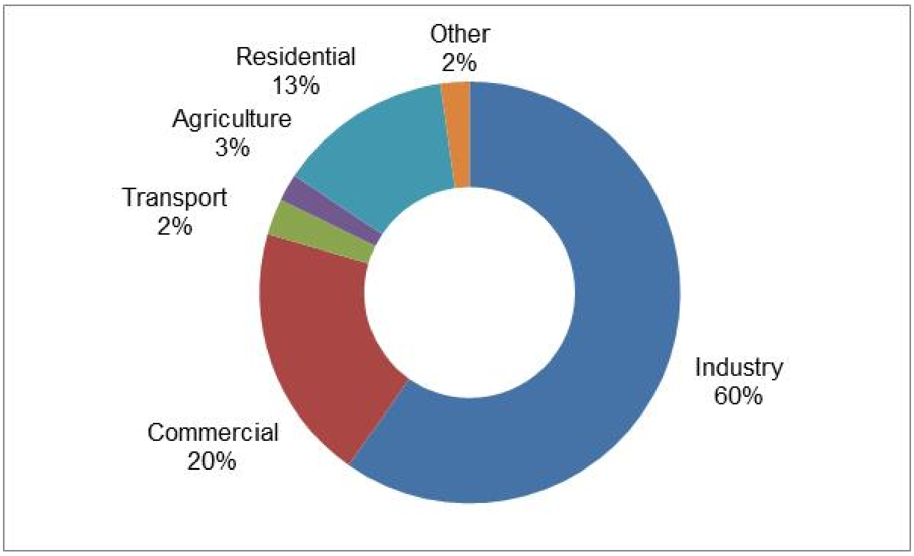


Figure 1 **Global electricity demand for electric motor systems: Share of sectors (Source: A+B International: Global Motor Data Model, 2013, based on IEA energy statistics 2009)**

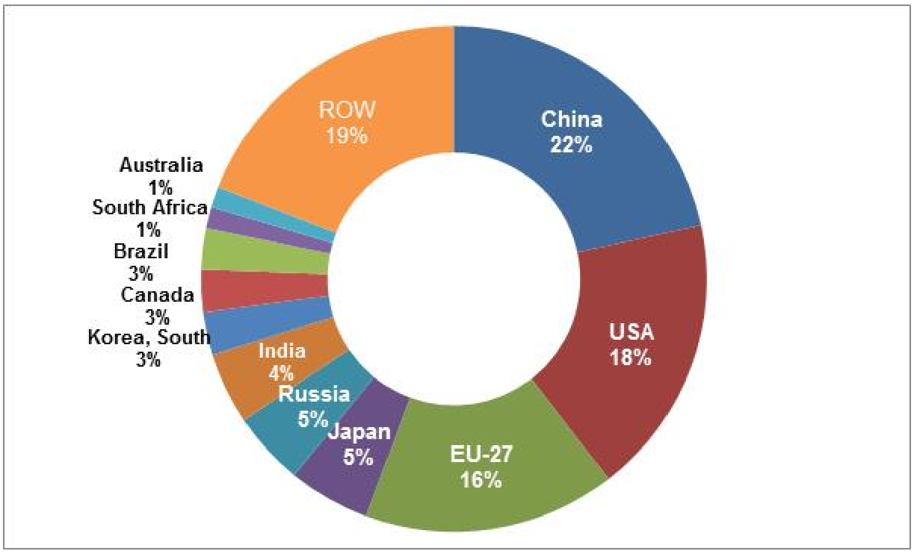


Figure 2 **Global electricity demand for electric motor systems: Share of countries (Source: A+B International: Global Motor Data Model, 2013, based on IEA energy statistics 2009), ROW: rest of the world**

The total electricity demand for motors systems has a tendency to increase substantially due to economic expansion, especially in the five large BRICS[2] countries (see Figure 2). The energy savings potential for electric motor systems presented in [3] has still not been challenged by a more comprehensive and updated global study. A policy path towards sustainable development can within 20 years indeed deliver 20% electricity and cost savings compared to Business-as-Usual - a period within which all motors need be replaced anyhow at the end of their technical lifetime. This would at least keep the electricity consumption almost constant after 2015: the efficiency gain can compensate the additional demand of BRICS countries.

2. Market transformation: wish and reality

The global motor and drive systems market is expanding especially in the five rapidly growing BRICS countries. Based on 2006 data from [3], the global increase of electricity demand for motor systems between 2006 and 2030 in a "Business-as-Usual" (Baud) scenario reaches 2.5% p.a. The estimated

[2] BRICS: Brazil, Russia, India, China, and South Africa

annual sales volume of 30 million medium size motor published in [4] is outdated by today's data. More recent and more comprehensive market research by Chausovsky from IMS [5] published at the Motor Summit in Zurich in 2012 has added specifics to the data on global market development. The development from traditional "electro-mechanical" motor manufacturers to new "integrated automation" producers with electronic controls (variable frequency drives (VFD), and factory automation systems) has changed the industry. Fewer and bigger global players are in the process of leading the market with international take-overs of complimentary products and smaller manufacturers. This development towards big conglomerates has changed both the regional market access of big players and their portfolio of different types of systems and components they deliver. In 2011, according to market research by IMS [5], 49 million low voltage motors with a revenue value of 15.0 billion USD and 21 million VFDs with a value of 12.6 billion USD were globally shipped (sold to end-users). The respective average product value is thus 305 USD per motor and 601 USD per VFD. This means that the total sales volume in USD of VFDs is rapidly catching up with that of motors, and the average VFD product price is almost double the price of a motor. This is certainly enough reason to restructure the manufacturing industry.

Nevertheless, the transition towards more energy efficient electric motor systems is slow; the large potential energy savings are not yet being harvested. IMS [5] estimates the share of the revenue from motor sales for IE3 and higher efficiencies to go from some meager 4% in 2010 to a proud 25% in 2015. This will in turn move the entire rolling stock of motors in 2015 according to [4] slowly only to some 11% market share for IE3. The development is on one hand driven by countries with MEPS for new installations and on the other hand it is slowed down by the lack of investment in the renewal of old inefficient equipment and the lack of knowledge for regular inspection and systematic systems integration.

The first indicator of inefficient motor systems in the rolling stock is motor age. The running stock of electrical motors is aged (see Figure 3) and lacking regular renewal and technical enhancement. The recent analysis in 17 industrial parks in Switzerland with 3 979 electric motor systems listed in the context of the Easy financial incentive program [7] and [8] shows that 58.4% of the motors are already older than the operating life expectancy (10 to 20 years depending on size) and these motors are on average 99.3% too old. The assumption is, that - if in a highly developed economy the motors in use are way too old - in a global perspective the problem could potentially be much more severe. Industry is losing money with old, inefficient and frequently oversized motors, and manufacturers are not marketing their products sufficiently to convince industry to buy their modern highly efficient new equipment and systems.

The second indicator of inefficient motor systems is oversizing. Motors too large for their required duty run on low efficiencies in partial load. Often 100% or 200% oversized machines can be seen in operation. The past fears of overheating or of not being able to deliver the necessary starting torque are in many cases unfounded. So, when a motor needs to be changed, its required output size needs to be thoroughly reassessed. An easy measurement of the input electricity during start and normal operation can provide the answer. A smaller motor as the replacement is generally much cheaper and most of the time more efficient. The introduction of variable frequency drives is, in this context, a dangerous measure. Only when the new motor requires a VFD based on its variable load profile and is then correctly sized the introduction of a variable frequency drive can help to improve the efficiency under variable load. A VFD should not be used as a means to keep a system oversized because they have low efficiencies in partial load.

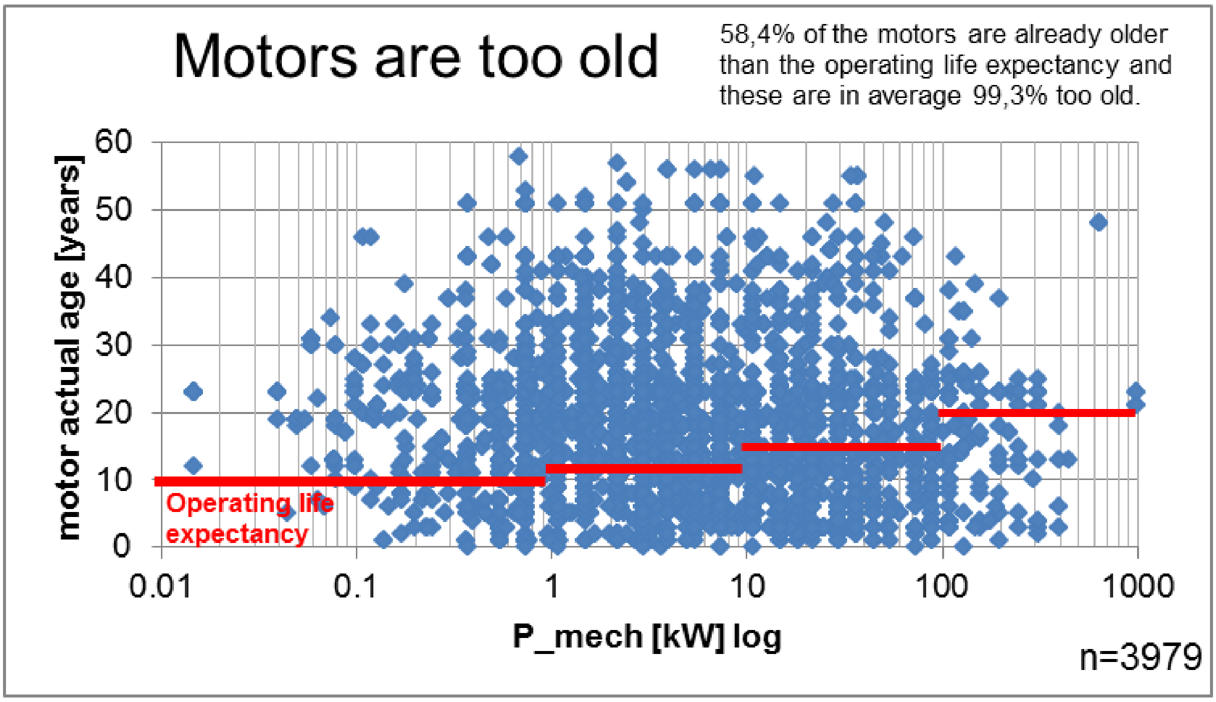


Figure 3 Motor age compared to nominal operating life expectancy in industrial plants in Switzerland (Source: Easy 2013)

3. Economic downturn slows development

The economic downturn in 2007 has reduced industry output and this reduces in turn electricity consumption, but it also diminishes the investment capacity of industrial plants to renew and improve their old equipment. The downturn and later stagnation is concentrated in the industrial and developed economies (USA, Europe), and not in the developing economies (China, India, Brazil, etc.) where steep growth is still visible (see Figure 4).

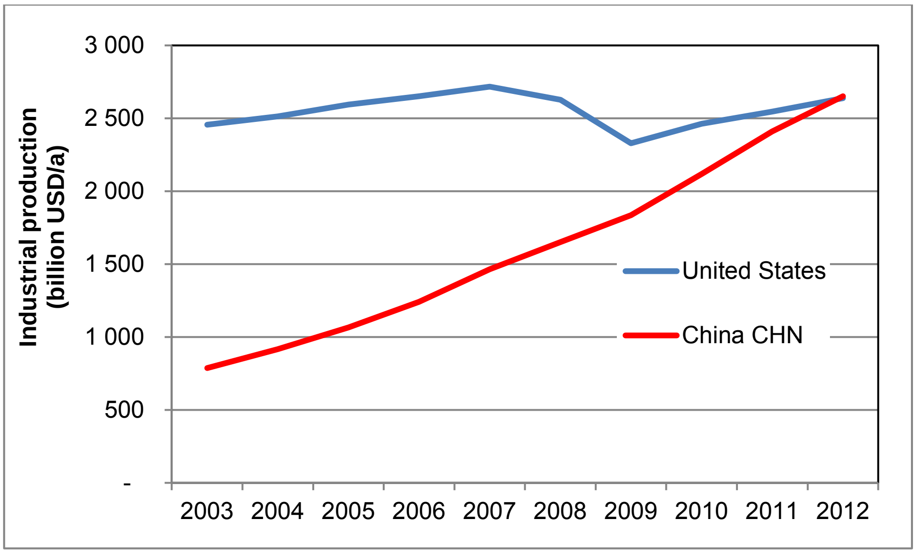


Figure 4 Industrial production in constant USD, seasonally adjusted (Source: Worldbank Global Economic Monitor, 2013)

The development of energy efficient electric motor systems depends on a number of key parameters:

- Industrial demand. If demand is expanding (see Figure 4) it creates increasing volumes of motor sales for new installations and replacement; this increases competition and can lower product prices.

- Energy and electricity price (see Figure 5). Rising energy prices create higher demand for reduced operating costs with savings from energy efficiency; thus it can stimulate investment in energy efficiency improvement and replacement of old running stock.
- Price of base materials for motors, namely copper, aluminum (see Figures 6 and 7), electric steel and rare earth materials. If prices of a specific material are rising, tendency grows to avoid or reduce the use of the specific materials. Within certain limits the substitution of several materials and respective technologies is possible. This can endanger certain technologies that heavily depend on one material: copper rotor, permanent magnet motors, etc.
- Price of labor: The share of work cost is not high in electric motors. Still the gross hourly wage and the number of hours needed per piece on average are a substantial element of optimization of product cost.
- Lately energy efficiency measures are under competition from lower renewable energy prices. When wind and solar energy (see Figures 8 and 9) can more often produce large quantities of electricity at specific times at grid parity (cost equal to conventional electricity production) then efficiency measures need to become also more cost effective.
- The competition for electro-mechanical equipment (motors and generators) especially in small sizes is intense. Only clear efficiency certificates can remove cheap, inefficient and low quality products from the market.
- For manufacturers the VFD is the more profitable piece of equipment with a higher margin of profit and more rapid return on investment in new product lines. Few motor manufacturers are also strong VFD manufacturers.
- Many specialists in combined products (motor plus VFD plus pump or fan or compressor) are increasingly becoming independent of motor manufacturers and start to design, measure, build and market tailor-made motors for their packaged and well integrated application.

The economic downturn in 2007 has reduced industry output and this reduces in turn electricity consumption and price, but it also diminishes the investment capacity of industrial plants to renew and improve their old equipment. Electricity prices for industry are increasing only slowly, still either cross-subsidized from high household tariffs or by artificially low fuel prices. And - of course - no external costs both from fossil and nuclear production are reflected in the end-user prices. In Europe electricity prices for industrial consumers have stagnated since 2008 (see Figure 5).

The electricity prices in Europe have more recently been lower due to the growing share of wind and solar power production (see Figures 8 and 9). Presently, the production from solar (daytime, good weather) plus wind (bad weather, 24 hours) is delivering more stable and more predictable capacities. The renewable electric energy production cuts the required peak production from conventional fuels every day between 9 and 17 hours and reduces the conventional production to a constant band load. The result is lower sales price for conventional power production. No external costs both from fossil and nuclear production are reflected in the end-user prices. This considerable change in the production park has caused severe headaches in the power industry which has benefited for decades from trading and pumping low to peak power. Power control has become more difficult: user side power management with factory automation has become more advantageous and is already in part reflected in good pricing schemes.

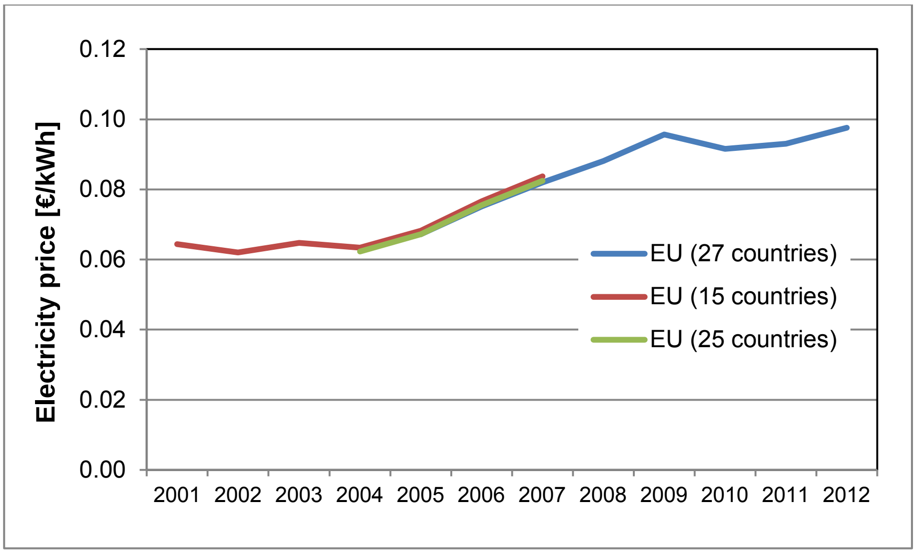


Figure 5 **Development of average nominal electricity price for industrial consumers in Europe (Source: Eurostat database, 2013)**

The price of copper has two well-known tendencies: First the price is highly volatile and depending on world (and regional) copper demand which in turn depends on industry development. Second, it has on the long run rising price levels because all known reserves have the tendency to only be able to deliver high quality copper at increasing cost. The variation reaches a factor of 4 between maximum and minimum prices paid in the last 5 years.

Also, aluminum prices are highly volatile and follow overall industry development. However, there was only a variation of a factor of 2 between maximum and minimum prices paid in the last 5 years, much lower than in copper.

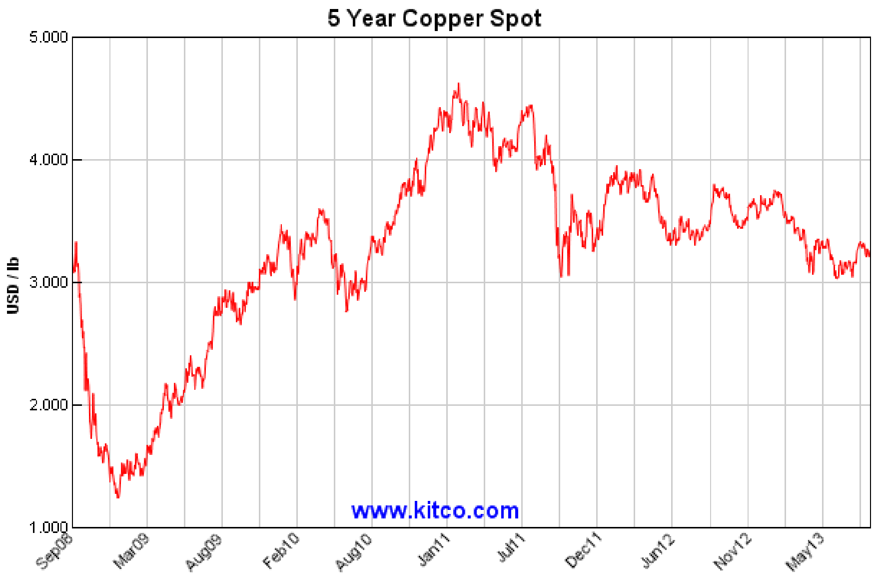


Figure 6 **Copper price 2008 - 2013 (Source: London Metal Exchange, Kitco)**

Figure 7 **Aluminum price 2008 - 2013 (Source: London Metal Exchange, Kitco)**

Solar and wind energy production in Germany and Austria has reached a level where renewable production capacity cuts the daily peak from 8 am to 6 pm to an entirely flat level (see Figures 8 and 9). This has large impact on the power pricing during the daytime and during sunny and/or windy situations. Many conventional power suppliers with large and continuous band production profiles (fossil or large hydro and especially nuclear) suffer heavily from the decay of their revenue. This can in turn reduce total electricity prices for large industrial users and disturbs and can stall investment in energy efficiency measures.

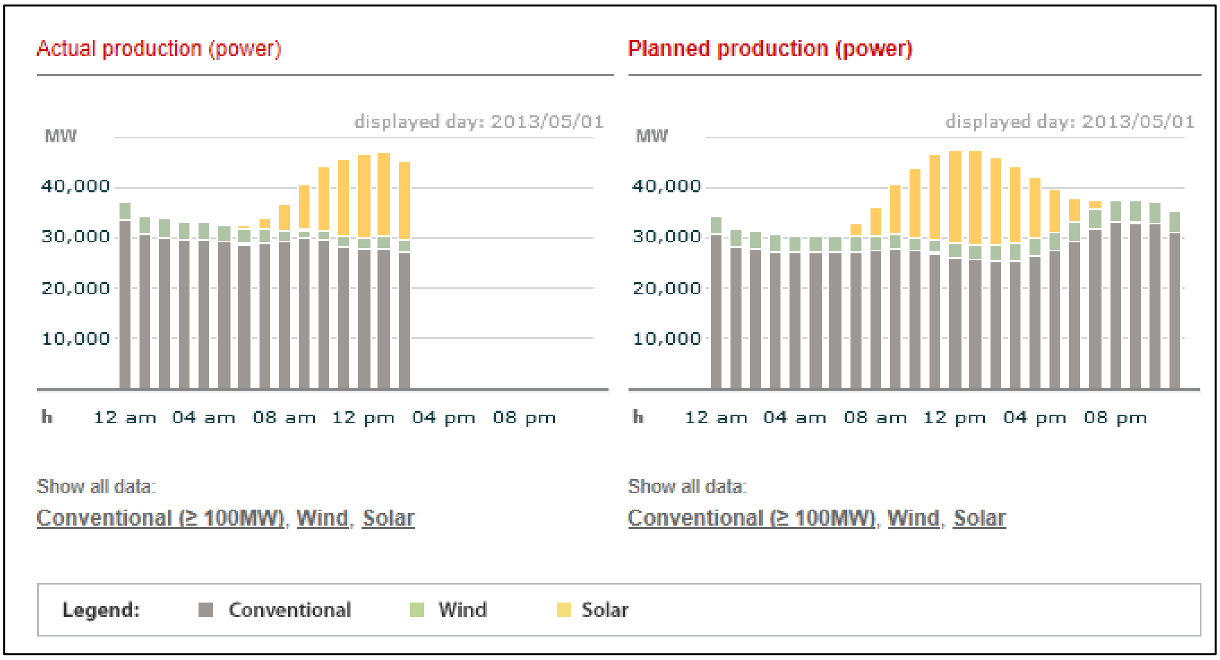


Figure 8 **Conventional, solar and wind production Germany/Austria, actual and planned, peak demand 47 000 MW, sunny day on 1 May 2013 (Source: Transparency Platform EEX, 1 May 2013, www.transparency.eex.com/en/)**

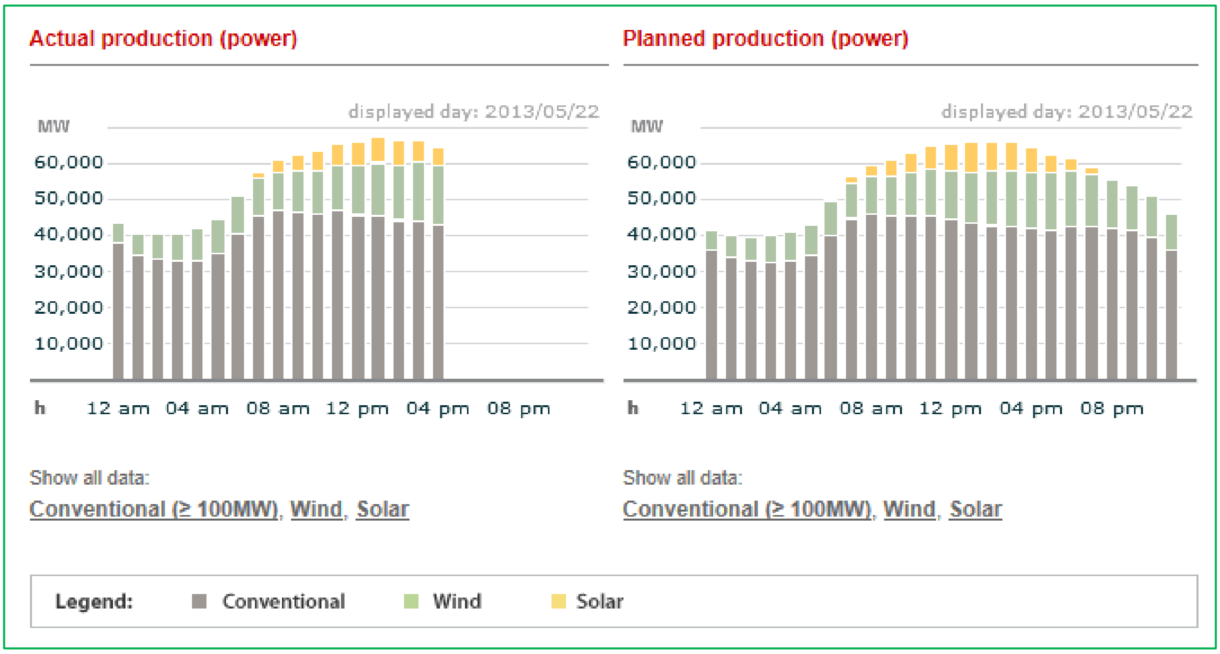


Figure 9 Conventional, solar and wind production Germany/Austria, actual and planned, peak demand 65 000 MW, 8 000 MW solar and 16 000 MW wind power on rainy day on 22 May 2013
(Source: Transparency Platform EEX, 22 May 2013, www.transparency.eex.com/en/)

4. Standards for efficiency measurement and efficiency classification

Accurate efficiency measurement is still the first step

Global standards are slowly making a dent in the wilderness of nationally controlled motor markets with diverging frequencies, voltage, frame sizes, and efficiency definitions and standards. Imports are subject to high certification barriers, renewed testing and tariffs. Harmonization is still far away, more developed by now in fixed speed standard induction motors than in all other components. Neither VFDs, nor pumps, fans, compressors or transmissions and gears have any kind of standardized international method to measure energy performance.

The International Electrotechnical Commission (IEC) has developed in the past decade a comprehensive set of industry standards for electric motors that are slowly replacing older national standards with agreed measurement standards that allow verification at the manufacturing plant, in the government check-testing lab or on the users' site. Thus the accuracy and repeatability can be secured. So lower quality and inefficient products can be identified and with nationally issued legal measures kept from the market. The product definition for electric motors, scope, general performance, environmental conditions, tolerance and rating plate requirements are laid out in IEC 60034-1:2010 which defines basic use conditions and states the required information on the rating plate (see Figure 10). Proposals are ready to introduce a chip for radio frequency identification (RFID) onto the rating plate to make the motor data and their rating much easier to be identified and checked by both the user and the compliance authorities, especially if the motor is embedded into a machine.

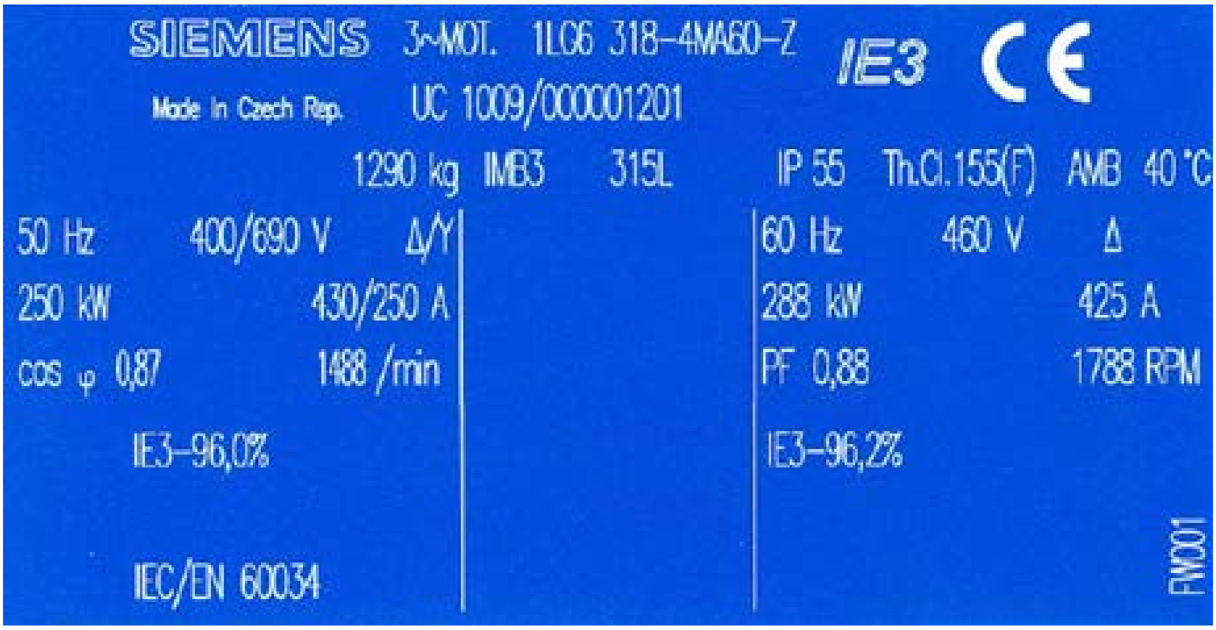


Figure 10 **Rating plate according to IEC 60034-1 for 3-phase 4-pole IE3 motor: at 50 Hz with 250 kW and 96.0% efficiency (1488 rpm), cos φ 0.87;400 V, 430 A; at 60 Hz with 288 kW and 96.2% efficiency (1788 rpm). power factor 0.88 460 V, 425 A; (Source: Siemens online catalogue 2013)**

The next important element is the efficiency measurement now defined in IEC 60034-2-1:2007 for general induction motors with continuous updates available in 2014. Now the efficiency measurement is also defined with two additional standards: IEC 60034-2-2:2010 for special motors and coming up in IEC TS 60034-2-3:2014 for converter fed motors.

The new frontier for industrial users is on electric motors that accommodate variable loads by controlling rotating speed and torque according to the momentary needs. These motors are driven by VFDs together with conventional asynchronous induction technology or use state of the art technology with permanent magnet, switched reluctance or synchronous reluctance. Because of harmonics from the VFD the performance of the motor is changed and its efficiency lowered. The respective standards for efficiency measurement (IEC/TS 60034-2-3:2014) and efficiency classes (IEC 60034-30-2:2015) for VFD fed motors are available in draft status and will be published shortly.

A number of research projects with round robin tests and other in-house measurement series have been made to improve the accuracy and repeatability of motor efficiency measurements. The available findings from Australia, Canada and Europe are now included in the revised IEC 60034-2-1 and include a more precise definition of the necessary sequence of the measurements, the required instrumentation uncertainty, ambient and product temperature control and measurement during the test, etc. The efficiency measurement methods for induction motors fed by converters are now well established (see Figures 10 to 12) and routinely available at a number of independent and industry laboratories around the world for small and larger motor sizes. These findings are integrated into the new IEC/TS 60034-2-3 for converter-fed motors.

Figure 11 Measurement set-up for measurement of motors with variable frequency drives at the Hydro Quebec motor testing laboratory, near Montreal, motor under test is to the right, the torque and speed meter in the middle (under yellow cover), the load machine is to the left, the VFD is placed outside the picture (Source: Pierre Angers 2013)

Figure 12 Yokogawa WT 3000 Precision Power Analyzer in a variable frequency efficiency measurement of the set-up in Figure 11 at the motor testing laboratory of Hydro Quebec near Montreal (Source: Pierre Angers 2013)

New data acquisition systems have been developed in several testing laboratories. Their advantage is that the entire measurement program can be programmed and driven by remote control; the data acquisition is done automatically (see Figure 13). Many earlier human errors (including wrong copying, rounding, etc.) are eliminated.

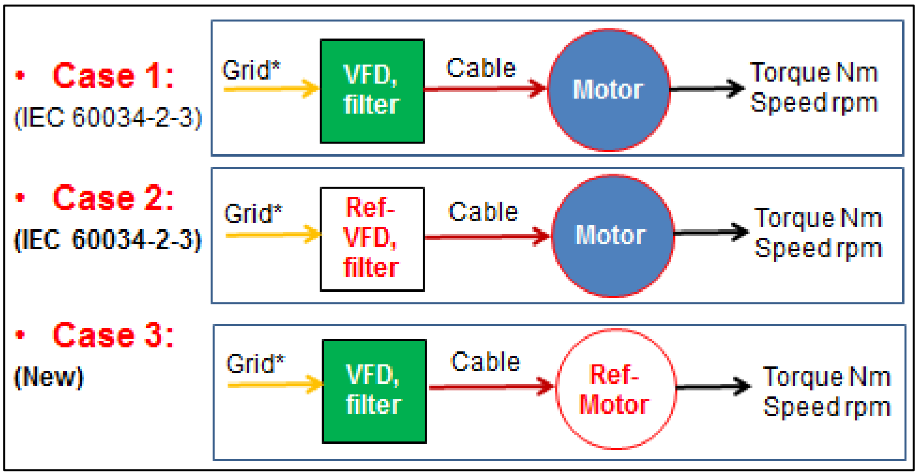
Figure 13 **Programmed testing sequence and automatic data acquisition. Measurement of 315 kW 4-pole IE2 motor with variable torque. (Source: Gamak Motors, Istanbul, 2013)**

Efficiency classification is the second step

The next crucial element is the standard for efficiency classification based on these internationally harmonized IEC measurement standards. IEC 60034-30:2008 has caused a big market jump in 2008 by presenting a common language for IE1-Standard Efficiency, IE2-High Efficiency and IE3-Premium Efficiency motors. The scope was only for 2-, 4- and 6-poles, with a frequency of 50 and/or 60 Hz, and with output sizes from 0.75 and 375 kW. The now completed revision in IEC 60034-30-1:2014 is expanding the scope also to 8 pole motors and the output size from 0.12 kW up to 1000 kW. The introduction of IE4-Superpremium Efficiency is the logical consequence of the ongoing rapid technology development plus the fact that the USA, Canada and Mexico already have a Minimum Energy Performance Standard (MEPS) on IE3 in place since 2012.

Systems efficiency measurements are step number three

The evidence shows in all energy efficiency programs for motors that large savings can only be achieved through system optimization. This includes the electrical side (transformer, uninterruptable power supply, power factor correction, variable frequency drive and motor) as well as the mechanical side (transmission, gear, brake, clutch, the driven equipment) and its operation condition (no idle time, no standby, no operation without use, no unnecessary high loads, high speeds and pressures in ducts and pipes). In order to avoid a mismatch between two or more components new kinds of software tools are necessary. The Motor Systems Tool MST [6], developed in the context of EMSA by S.B. Nielsen (Denmark), is an excellent example for that.



In Case 1 a VFD and a motor is available and they can be tested together.

In Case 2 only the motor is available, the VFD has to be replaced by a reference converter.

In Case 3 only the VFD is available, the motor has to be replaced by a reference load machine.

Figure 14 **IEC 61800-9 Efficiency classes and efficiency measurement of motor plus VFD (Source: SC22G AG15, 2013)**

The next step is towards systems optimization. This takes into account the combined efficiency from an electric motor and a variable frequency drive. A series of measurements have been made in 2012 by Canadian, Australian and European laboratories to secure the methodology of measurement of additional harmonic losses. Now the standard for the efficiency measurement and efficiency classification of the combined operation of a VFD and a motor IEC 61800-9 will be developed and shall be published by 2016. It will account for the three different situations, shown in Figure 14. This schematic is based on the fact that often motors and VFDs are manufactured separately by different manufacturers. The two products meet for the first time in a factory, ready to be mounted into a large machine. If a motor with its VFD has to be measured the procedure is clear and simple. A combined efficiency can be established with only output and input measurements, thus avoiding the complex measurements of the harmonics in the feeder of the motor. To secure the measurement of a motor alone in IEC 60034-2-3 a reference converter is used (case 2). The most challenging situation for measurement is the given VFD without a motor (case 3). A reference load has to be designed in order to have the VFD measured and the results are reproducible in other test labs.

The efficiency measurement set-up is complex because also the electrical power (voltage and current, power factor, and harmonics) between VFD and motor in point needs to be measured accurately. These measurements require advanced instrumentation technology to return accurate results for the harmonic content.

5. Certification

The recently launched project by IECEE[3] together with NEMA wants to go one step further. It will introduce a globally harmonized certification and label system for motors that is secured by the international IECEE logo. This will then include transparent and accurate efficiency ratings, coming from measurement results by qualified (i.e. regularly calibrated instruments, trained staff), independent and government accredited testing laboratories. They will need trained personnel to perform measurements according to precise efficiency measurement standards and procedures. This kind of network with accredited complex of motor testing laboratories exists so far only on a limited scale (NIST NVLAB[4]), mainly in the USA. Also national governments need to acknowledge this certification and product registration in their legal framework.

6. Policy trendsetters for MEPS

National policies have made large inroads for market transformation by setting MEPS. Notably Europe has reached the same level of advancement as the US, Australia and Canada who have been world leaders for a many years. The Ecodesign Framework Directive from 2005 [9] has sparked a number of

[3] IECEE: Worldwide System for Conformity Testing and Certification of Electrotechnical Equipment and Components, www.iecee.org
[4] NIST: National Institute of Standards and Technology; NVLAB: National Voluntary Laboratory Accreditation Program, www.nist.gov/nvlap/

systematic technology assessments, ecological research on fabrication, use and decommissioning of product technologies, economic studies, and market impact analysis based on a common method. The Ecodesign technical analysis under Lot 11, led by Anibal de Almeida, has covered motors as well as circulators, pumps and fans [10]. Subsequently all these products have received European mandatory requirements with MEPS; motor MEPS are in force since 2011 and will be gradually upgraded to IE3 (see Figure 15).

Lately, Turkey joined the ranks of MEPS countries implementing IE2. Preparatory work is under way to bring also Japan into the rank of MEPS countries while India remains on a voluntary national scheme only. Many countries are planning to move their MEPS level to IE3 in 2015. 69% of global electricity consumption of motors is by 2013 used in countries implementing MEPS on motors.

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

bold means in effect

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

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

**) for 3-phase machines, rated output power < 1000 kW

****) Minimum Energy Performance Standard

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

Figure 15 MEPS and IEC standards, status May 2013, Turkey and South Korea joined in 2012 (Source: A+B International, 2013)

In 2013 the European Commission mandated Anibal de Almeida to update the 2008 technical preparatory study and to recommend MEPS for a larger scope of electric motors from 0.12 kW up to 1000 kW, including 8-poles, in line with the revised efficiency classification in IEC 60034-30-1. The goal of the European Commission is to secure the next step in legislation beyond IE3 once the technology is mature and the respective global standards are available. At the same time studies are well under way to also include new motor technologies (permanent magnet motors, switched reluctance motors, etc.) into the scope of the new MEPS.

The US policy discussion between industry and NGOs on the renewal of the current DOE requirement for IE3 Premium Efficiency motors is going into a different direction. In order to avoid the logical next efficiency step to move the current MEPS to a more costly IE4 Superpremium Efficiency level, the wide expansion of the current motor scope for mandatory requirements of IE3 is developed in order to include a number of motor types that were not included before because of their more complex design features.

7. The 4E EMSA program

The IEA implementing Agreement "Efficient Electrical End-Use Equipment (4E) focuses on several important products like solid state lighting, standby, and motors (www.iea-4E.org). The "Electric Motor Systems Annex" (EMSA) concentrates on the market transformation towards more energy efficient electric motor systems in industry, infrastructure and large buildings (www.motorsystems.org). EMSA exists since 2008 and is now a cooperation of Australia, Austria, Denmark, the Netherlands, Switzerland and the USA.

The main goal of EMSA is to speed up the global market transformation towards efficient motor systems through bringing relevant technical and management know-how to the policy leaders as well as to the technical officers in factories and thus help to make better use of the knowledge on how to save energy. EMSA has recognized that for a successful global market transformation it needs to work on different levels, targeting different groups of stakeholders (see Figure 16):

Figure 16 EMSA works on different levels

- On the global level, with international standards development organizations to help develop global standards,
- On the national level with policy makers, to help governments develop and implement policies ranging from MEPS through information & education programs to financial incentives,
- On the company level with industrial users, thus factories to support them in the implementation of energy management,
- On the personal level with individuals, to provide them with necessary information and tools to apply the energy efficiency knowledge for motor systems.

In particular, EMSA provides the following services:

Testing centers	Network of testing engineers to learn how to choose and operate equipment and measurement instrumentation, train staff on calibration procedures and run efficiency measurements.
Motor Systems Tool	Motor Systems Tool for optimization of motor, gears, transmission, variable frequency drive depending on variable load. See EEMODS'13 presentation by Sandie B. Nielsen, Denmark.
International standards	Program to bring national standards in harmony with both IEC standards on motors and systems as well as ISO standards on applications like pumps and fans.
Energy management	Support to the introduction of ISO 50001 and its application to use electrical energy for motor systems in industry efficiently.
Policy Guidelines	Update on best practices for governments interested to launch a comprehensive efficiency policy including industrial motor systems. See EEMODS'13 presentation by Konstantin Kulterer, Austria.
Outreach	Web and periodic newsletter in 5 languages (English, Chinese, Japanese, Russian, German) to over 3 200 interested contacts in 72 countries.

Some other global organizations and initiatives operate in the field of electric motor systems in industry besides EMSA:

Acronym	Institution	Web
IIP	Institute for Industrial Productivity	www.iipnetwork.org
CLASP	The Collaborative Labeling & Appliance Standards Program	www.clasponline.org
SEAD	Super-Efficient Equipment and Appliance Deployment Initiative; SEAD Global Efficiency Medal Competition for Electric Motors	www.superefficient.org
IEA	International Energy Agency energy efficiency department at IEA headquarters in Paris France	www.iea.org/efficiency/index.asp
IEA Industry	Implementing Agreement on Industrial Energy-related Technologies and Systems (IETS).	www.iea-industry.org

Table 1 Global motor systems efficiency programs

In addition, many programs are available as part of national energy efficiency campaigns. EMSA tries to cooperate with the international organizations and initiatives and keep contacts to some of the national activities and report on new events, standards and findings in its newsletter. It has supported the design of the Global Efficiency Medal Competition for Electric Motors with technical advice.

8. The way forward

A number of key barriers have to be overcome for a more rapid market transformation towards energy efficient electric motor systems both in existing and new machines in industry, infrastructure and buildings by the relevant groups of stakeholders:

INDUSTRIAL USERS Slow industrial development, lack of technical and management know-how, shortage of resources and investment capital. *> Initiatives to support efficiency measures for industrial users, better know-how transfer, training and new financing instruments.*
MANUFACTURERS, WHOLESALERS and OEMs Reluctance to upgrade standard products to more efficient ones. *> Training for efficiency know-how, attractive business model for higher quality products.*
POLICY MAKERS (national governments) Incomplete understanding of the impact of legal measures and their economic and ecological benefits. Fragmented efficiency policy with limited means for financial incentives. *> Learning from best practice in a number of frontrunner countries. Support energy management capacity build-up in industry combined with mandatory audits.*
POWER PRODUCTION INDUSTRY Understand potential optimization of production, transmission and transformation capacity with energy efficiency measures and factory automation systems. *> Proactive involvement and industry efficiency subsidy programs.*
ENGINEERING COMMUNITY Work is often fragmented between mechanical and electrical engineers, know how is scarce and not systems oriented. *> Use interdisciplinary approach for systems optimization.*
STANDARD MAKERS IEC (TC2, SC22G) and ISO Coordinated and up-to-date standards for product definition, efficiency measurements and efficiency classes covering all current and recent technology development. *> Rally for regional and national standards to adopt global standards.*
NGOs (environmental protection agencies) Often only fragmented and contradictory arguments are presented for energy efficiency, the focus is mainly on additional power production with renewable energy and environmental protection. *> Concerted efforts to national policy makers and industrial leaders to adopt rapid measures: MEPS, financial incentives, compliance programs with check-testing. Efficiency measures cause no environmental damage.*

Table 2 Barriers and possible actions by stakeholders to overcome the barriers (Source: A+B International, 2013)

The earlier calculated potential energy savings of electric motor systems in [3] are today neither wrong nor outdated, but the envisaged 20% to even 30% savings compared with a Business-as-Usual scenario by 2030 still lay deep-frozen in the industrial refrigerator, waiting to be melted and cooked into concrete action and implementation plans. These actions will lower operating cost for industry, create profitable additional jobs for manufacturers and help the environment.

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