In harmony

Defining global energy-efficiency standards

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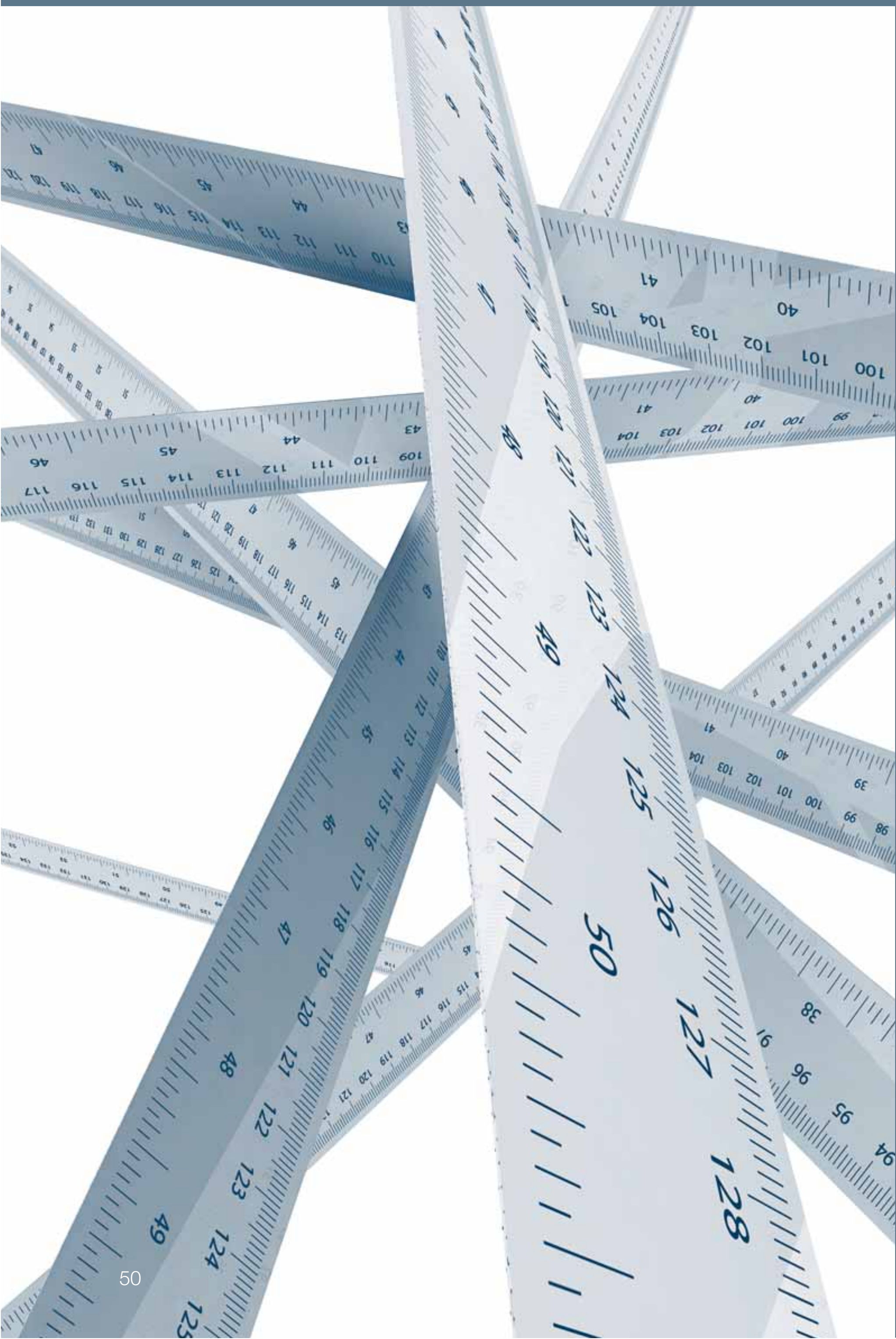

Energy efficiency has become an essential attribute of today's industrial products and systems. But the multitude of different standards in this area makes the direct comparison of energy-efficiency performance indicators enormously difficult, if not impossible. The globalization of markets has resulted in the need to compare the energy efficiency of devices in the same product group, regardless of where a specific device was produced. The harmonization of standards and underlying legislation is a prerequisite for successful proliferation of energy-efficient technologies.

Standardization initiatives have resulted in the harmonization of energy-efficiency requirements, testing methods and certification schemes in a number of areas, including electric motors. Today, all major organizations that develop standards, as well as intergovernmental bodies, are working on defining common frameworks for the comparable qualification of products and systems in terms of their energy use. This is just the beginning of a very important undertaking.

From a technical and legal perspective, the electrotechnical market is very complex. Every electrical device must comply with various requirements connected to its application, safety and compatibility with other devices. Those requirements may be included in national, regional or industrial regulations, procedures or standards. Often there are additional indirect requirements.

Standards may address the energy efficiency of a specific device in different ways. The typical process of determining the efficiency of a device is to measure the value of energy losses in accordance with the rules defined in a standard. The results (energy losses or calculated energy efficiency) are matched against efficiency indexes (normative loss or efficiency values) to determine if the device meets the minimum energy-efficiency performance standards (MEPS) or some other regulations. If the device meets the MEPS requirements of a given country, it can be put on the market. If it meets the voluntary labeling scheme criteria, it can also be labeled and recognized as an energy-efficient product.

Standards define what energy efficiency is, determine the procedure for testing and measuring energy usage, and integrate the requirements of MEPS or voluntary labeling schemes. Problems arise when those standards are not harmonized across countries or industries. A nice example of the successful harmonization of standards can be found in the electrical motor industry.

Harmonization in motors

It is estimated that 40 percent of the world's electricity is used by electric motors in a variety of applications. The improvement of motor efficiency depends on the total reduction of all types of energy losses that exist in motors:

- Stator winding losses (P_s)
- Iron losses (P_{fe})
- Rotor losses (P_r)
- Friction and windage losses (P_{fw})
- Additional load losses (P_{LL})

For many years there were two main standards used around the world to determine these losses:

- IEC 60034-2
- IEEE 112 method B (or IEEE 112-B)

IEC 60034-2 was used mainly in Europe, India and China, and previously in Australia and New Zealand. The method defined in IEEE 112-B was used in North America and countries with a 60 Hz power supply. Around 2000, a method similar to IEEE 112-B was introduced in Australia and New Zealand, but IEC 60034-2 may still be operational in those countries. An equivalent standard (CSA C390) was adopted in Canada.

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IEEE 112-B eliminated the temperature problems existing with IEC 60034-2 for calculating the stator winding and rotor losses at fixed temperatures. Additionally a test procedure was established to determine additional load losses to avoid the fixed allowance existing in IEC 60034-2. Consequently two dominant efficiency determination methods emerged for polyphase electrical motor efficiency: IEC and IEEE 112-B 1.

In the European Union, the determination of efficiency was performed in accordance with the testing method described in IEC 60034-2. The voluntary agreement of the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) defined three possible efficiency classes for motors:

EFF3 Low-efficiency motors
EFF2 Improved-efficiency motors
EFF1 High-efficiency motors

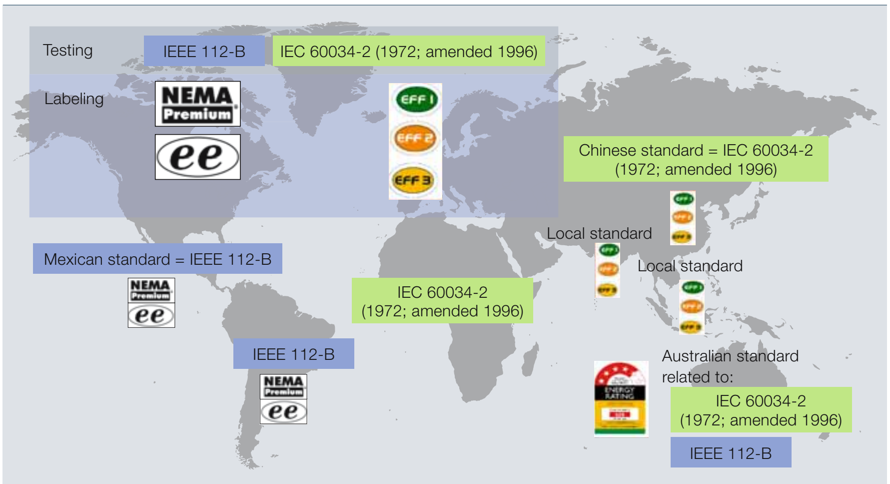
The agreement also stipulated that the manufacturers should mark the efficiency level on the product nameplates and a sample data table to help users select and identify the most suitable motor.

In the United States, the determination of efficiency was based on the IEEE-112 standard. The testing method, IEEE 112-B, required direct measurements of all losses under a network frequency of 50 or 60 Hz. The MEPS for all motors produced or used in the United States were established in the Energy Policy Act (EPAct 1992). Later NEMA proposed a voluntary certification program, NEMA Premium, which was based on IEEE 112-B. For both mandatory and voluntary requirements, the measurement results were later matched against specific efficiency indexes, which were defined in the NEMA MG1 standard.

In addition, the United States uses the industrial standard IEEE 841 in the chemical, petroleum and metallurgy industries for heavy-load motors with long operation times.

The solutions in other countries were thus an adaptation of the EU or US approaches – they were either harmo-

1 Motor efficiency standards and labels: historical status



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nized with or similar to IEC 60034-2 or IEEE 112-B.

Brazil, for example, has a test method based on IEEE 112-B, but the existing MEPS is different from that which is used in the United States. In India, efficiency classes were harmonized with CEMEP, but the test method is based on the local standard rather than on the IEC standard. China adopted the MEPS policy; its minimum energy-efficiency requirements and energy-efficiency grades for small and medium three-phase asynchronous motors are described in China's GB 18613-2006 standard. For testing purposes, however, a local GB/T 1032 standard – equivalent to IEC 60034-2 – is used. Additionally in China there are a few groups of de facto standards (eg, the so-called Y-series motors). These types of motors, although not described in the predominating standards, are widely recognized on the Chinese market and are regarded as the reference.

Different testing methods and labeling schemes led to problems with the comparability of motor efficiency. Additionally, the nomenclature used in various economies was a problem as well. The phrase "high-efficiency motor" might have a different meaning in different markets or countries. What was considered a high-efficiency motor in one country might hardly have met the minimum efficiency levels of a country with more advanced technologies. Together, these elements were blocking the global promotion of energy-efficient motors.

Working toward homogenization

Efforts were thus made to move toward unity and away from the redundancy of the existing standardization practices. Based on a new work item proposal issued by the German national committee DKE K311, a working group (WG 31) was established in 2006 by the IEC TC 2 (the rotating electrical machines technical committee) and was assigned the task to define energy-efficiency classes for three-phase industrial motors.

Another contributor to this harmonization process was the private initiative known as Standards for Energy Efficiency of Electric Motor Systems (SEEEM), created in 2006, whose recommendations were also taken into consideration by WG 31.

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The first meeting of WG 31 took place in October 2006 in Frankfurt, Germany. By the second meeting in May 2007 in Washington, DC, it was clear that the existence of a classification standard alone would not solve all the problems – the methods for energy-efficient operation of electric motors and applications should be described as well. In May 2007 a proposal to create an energy-efficiency guide was presented at the general IEC TC 2 meeting in Milan, Italy, where the project was confirmed and launched under the name IEC TS 60034-31.

Also, IEC TC 2 began revising the IEC 60034-2 standard, which had been around for many decades. The revision was initiated in 1996 when a European Commission mandate (M244) was given to CENELEC (European Committee for Electrotechnical Standardization), who then passed the task of developing a new testing standard to the IEC. The intention was to prepare a new IEC standard similar to IEEE 112-B. At the first WG 2 meeting of IEC SC2G in September 1997 in Frankfurt, the IEEE 112-B test method was presented by a member of IEC working group but this first proposal was not accepted. (Incidentally, working group 2 would later become WG 28 of IEC TC 2.) After many years of discussion, the test method was put into IEC 61972. Later, the method was included in the new edition of IEC 60034-2 2. Consequently, IEC 61972 has been withdrawn.

Further activities undertaken by the IEC technical committee 2, rotating machinery (WG 28 and WG 31), resulted in the following standards:

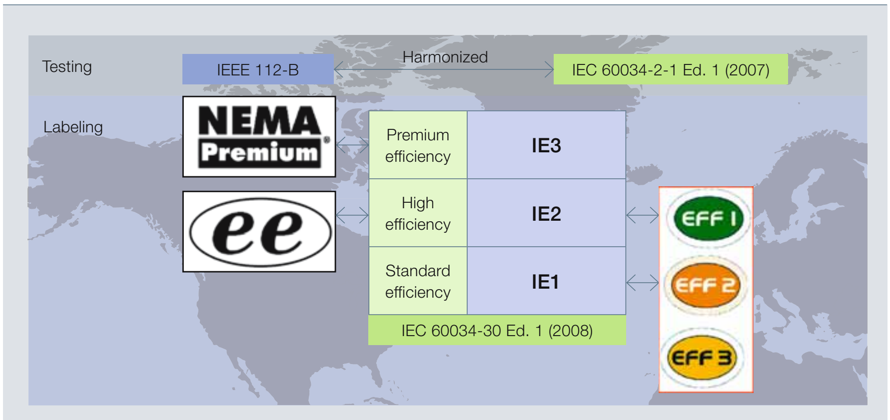
IEC 60034-2-1 (2007) Includes the efficiency testing methods (harmonized with IEEE 112-B; however, small differences still exist).

IEC 60034-30 (2008) Defines new efficiency classes IE1, IE2 and IE3, which are harmonized at 60 Hz with Brazilian regulations (IE1) and are harmonized with current US regulations for enclosed motors (EPAct for IE2 and NEMA Premium for IE3), eg, IP44, IP55, and are based on EU-CEMEP (EFF1, EFF2) for IE2 and IE1. The IE3 class introduced at 50 Hz is derived from IE2 with about 15 percent lower losses. This standard excludes motors that were designed in accordance with IEC 60034-25 (ie, motors specifically designed for converter supply), and motors that are the integral part of appliances (eg, pumps or fans).

In addition, the following standards are currently under development by the IEC:

IEC TS 60034-31 Guide for the selection and application of energy-effi-

2 Efficiency classes around the world (2009)



cient motors, including variable-speed applications (planned publication in April 2010; the second draft became available in April 2009).
IEC 60034-2-3 Testing standard for converter-fed AC machines (planned publication in July 2011).

Meanwhile, the US Department of Energy has mandated that, beginning December 19, 2010, NEMA Premium will become the minimum energy-efficiency performance standard for motors in the United States. In order to obtain the certification, the producer must test its products in an accredited laboratory. The other rules (ie, IEEE 112-B as the testing standard and NEMA MG1 as the efficiency-class standard) remain unchanged.

In the EU countries the situation is different – it is the producer who is held responsible for compliance with standards. The third-party certification is not mandatory; however, government agencies will perform occasional market audits. Should a device not meet the required (and declared) efficiency levels, the producer will be obliged to remove it from the market at his own cost.

The Ecodesign Regulatory Committee, composed of representatives of the Member States of the EU, voted positively for a new regulation, Ecodesign Requirements on Electric Motors, on the basis of a proposal from the European Commission. The new regulation states the energy-efficiency class for asynchronous motors with an output power between 0.75 kW and 375 kW. The IE2 efficiency class defined in EN/IEC 60034-30 will become mandatory starting June 16, 2011, the IE3 class for motors with a nominal power (P_N) output from 7.5 to 375 kW starting in 2015, and for motors with P_N from 0.75 to 375 kW in 2017. An IE2-class motor may be used in place of an IE3 motor if it is supplied through a converter drive. This regulation was adopted by the European Commission on July 22, 2009. The scope of the regulation differs slightly from the IEC 60034-30 standard (eg, motors for converter operations are included). 3 shows the anticipated implementation roadmap of the different IE efficiency levels as defined by IEC 60034-30, as well as the minimum energy-efficiency standards in various countries.

3 Implementation roadmap of the different IE efficiency levels as defined by IEC 60034-30

Efficiency level	Efficiency class IEC 60034-30	Uncertainty as per testing standard IEC 60034-2-1 (2007)	Countries having performance standard regulations
Premium efficiency	IE3	Low uncertainty	USA (2011) Europe (2015/2017*))
High efficiency	IE2	Low uncertainty	USA Canada Mexico Australia New Zealand Brazil (2009) China (2011) Europe (2011*)) Switzerland (expected 2012)
Standard efficiency	IE1	Medium uncertainty	China Brazil Costa Rica Israel Taiwan Switzerland (expected 2010)

No date indicates that specific MEPS regulations are already active. IEC 60034-2-1 includes several test methods associated with different uncertainties. For IE1, test methods associated with low and medium uncertainty are acceptable; for IE2 and IE3, low uncertainty is required.

*) Schedule for efficiency-level implementation in the EU:
- After June 16, 2011 all motors from 0.75 kW to 375 kW must meet the IE2 efficiency class.
- Effective January 1, 2015 motors with a nominal power (P_N) of 7.5 to 375 kW cannot be less efficient than the IE3 efficiency level, or must meet the IE2 class, and must be equipped with a variable-speed drive (VSD).
- As of January 1, 2017 motors with a P_N of 0.75 to 375 kW cannot be less efficient than the IE3 class, or must meet the IE2 requirements and be equipped with a VSD.

Factbox 1 IEC conditions precedent to standardization in the area of energy efficiency

- Distinct, reasonable and coherent definition of “efficiency”
- Definition of test and measuring methods for the evaluation and rating of efficiency
- Definition of efficiency levels (classes) for standard and commodity products
- To start standardization only in those areas where a significant savings potential exists; priority on “high potentials”
- Mandatory limiting values shall be prescribed by the authorities

Source: IEC Workshop, Sao Paulo, Nov. 2008

Working group 31 of the IEC TC 2 is currently developing a new IEC TS 60034-31. A draft document was issued in which the definitions of super premium or IE4 classes were proposed. The IE4 energy-efficiency class is not limited to three-phase cage-induction motors like the IE1, IE2 and IE3 classes of EN/IEC 60034-30. Instead, IE4 is intended for use with all types of electrical motors, particularly with converter-fed machines (both cage-induction and other types, such as permanent-magnet synchronous motors). Currently, there are no motors on the market that fit this energy-efficiency class level. This nicely illustrates the fact that standardization may be determining the direction of technology and product development.

A case for standardization

Standards and labels are present in all areas of energy-efficiency policy support, particularly for specific products (like motors) or applications. Standards:
- Define what efficiency is (IEC 60034-2-1).
- Formulate testing procedures to determine efficiency (IEC 60034-2-1).
- Establish minimum required efficiency indexes and efficiency requirements for various voluntary efficiency labels and certificates (EN/IEC 60034-30, NEMA MG1).
- Define the maintenance conditions that should be met to achieve high efficiency (ANSI/EASA AR100, EASA/AEMT).
- Describe specific industrial or sector rules and requirements (IEEE 841).
- Push the direction of technology and product development toward more energy-efficiency-oriented solutions (IE4, IEC TS 60034-31).

The International Energy Agency (IEA) launched the 4E implementing agreement Efficient Electrical End-Use Equipment in March 2008. A part of

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Factbox 2 Acronyms

AFNOR	Association Française de Normalisation (French national organization for standardization)
CEMEP	Comité Européen de Constructeurs de Machines Electriques et d'Electronique de Puissance (European Committee of Manufacturers of Electrical Machines and Power Electronics)
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CENELEC	Comité Européen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardization)
EMSA	Electric Motor Systems Annex
EPAct	Energy Policy Act
IEA	International Energy Agency
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
MEPS	Minimum energy-efficiency performance standards (also referred to as minimum energy performance standards or minimum efficiency performance standards)
NEMA	National Electrical Manufacturers Association
SEEEM	Standards for Energy Efficiency of Electric Motor Systems

Factbox 3 ABB motors and the new efficiency standards and labels

- ABB ensures that its products fully comply with the new requirements.
- ABB supplies a full range of motors in the IE2 class, as well as premium efficiency motors in the IE3 class.
- Motors' ranges, including flameproof Ex d, dust ignition proof Ex tD and non-sparking Ex nA from 0.75 to 375 kW, are labeled according to IEC/EN 60034-30.
- The efficiency values are determined according to standard EN/IEC 60034-2-1 with the low uncertainty method defined in this standard.

4E, the Electric Motor Systems Annex (EMSA) is focused on motor-systems efficiency. It addresses energy efficiency not only from a product perspective, but also with regards to the motor as a part of a broader system that has its own energy-efficiency potential. EMSA is building a Global Motor Systems Network to provide information on new developments in standards and technology. The system approach, while potentially offering the biggest benefits, is very difficult to standardize, which is why past standardization efforts have mainly dealt with efficiency standards for devices.

Focus on energy efficiency

In recent years, the issue of electrical energy efficiency has been recognized by the International Electrotechnical Commission as one of the key priority areas. The IEC standardization management board (IEC-SMB) has established a strategic group (SG 1) – energy efficiency and renewable resources – that cooperates closely with its sister counterpart in ISO - ISO/TMB/SAG EE 1, strategic advisory group on energy efficiency. The IEC-SMB SG 1 has defined a set of recommendations regarding energy-efficiency-related issues for IEC technical committees Factbox 1. As such, after IEC-SMB approval, these considerations determine the direction of future IEC works in this area.

One of the main requirements identified by SG 1 is to establish common terminology and definitions concerning energy efficiency. Presently there are a number of initiatives and activities in both standards-setting and legislation – eg, ISO/CSC/STRAT, CEN/CENELEC sector forum energy management (SFEM), existing IEC standards and legislation – that refer to basic terms (eg, energy efficiency, energy performance) in different ways. As a result, their interpretation may differ in various contexts and applications. Upon the recommendation of SG 1, ISO has begun developing a new standard that will fix the basic terminology for all organizations dealing with energy efficiency. The French national organization for standardization (AFNOR) will coordinate this development, which is estimated to be completed in about three years.

The SG 1 recommendations extend further to focusing standardization on those products and processes where energy-efficiency gains are expected to be the most significant; that is, products and devices operated in large volumes. This applies to, for example, lamps and lighting, rotating machines, heating and cooling applications, power generation and transmission, power transformers and consumer electronics.

Another priority area distinguished by SG 1 is the development of: standards and best-practice guidelines concerning optimal matching of a given product to actual application; guidelines for systems design with consideration for energy-efficiency criteria, automation of complex systems and plants (eg, power plants, electrical trains); and guidelines for power losses in distribution networks. SG 1 also recommends more focus on the standardization of electrical storage systems, especially in the context of distributed energy generation involving renewable sources.

This approach breaks away from the traditional focus on isolated devices, and rather takes into consideration their operation in the context of the larger system and processes for which they are used. Such system-level energy efficiency ought to be considered already at the design stage, taking into account application context, lifetime maintenance and interaction with other system components.

Electrical energy efficiency has been recognized by the International Electrotechnical Commission as one of the key priority areas.

Like the IEC, the International Organization for Standardization pays significant attention to various aspects of energy efficiency. Apart from the joint development of a basic terminology standard for the energy-efficiency domain, ISO technical committees work on standardizing methods of calculating, comparing and labeling with respect to energy performance, consumption and efficiency of various devices, means of transport and buildings. In this area, development of the standard ISO 13602 (by TC 203, technical energy systems), which includes principles for comparable characterizations of different sources of energy, is ongoing.

Another novel standardization area is energy-management systems. It is addressed notably in the upcoming standard ISO 50001, the final version of which is expected around 2010 (a draft version of the document has already been created). It is anticipated that this standard will have an impact on energy-related issues similar to that of ISO 9001 (on quality management) and ISO 14001 (on environmental management). ISO 50001 does not introduce required efficiency levels, but rather postulates continual improvement of overall energy efficiency of a plant or factory. This new standard may encourage companies to develop comprehensive, system-level approaches to energy-efficiency management, including efficiency measurement, monitoring and process-control optimization, to name but a few. A typical example of such a system is building systems (said to be accountable for about 30 percent of overall energy use). The new ISO standard takes a holistic perspective of intelligent buildings – from design requirements and the use of alternative energy sources to control and management systems. Determining the energy efficiency of the whole system presents substantially different challenges and requires methodologies beyond just benchmarking an isolated motor under laboratory conditions. Standards for assessing system-level energy-efficiency are an important element of enforcing energy-saving policies.

Standardization may be determining the direction of technology and product development.

Facilitating change

In line with the IEA's sentiments regarding energy efficiency, international standards in this area are playing a critical role as a change enabler because they include terminology, test methods, classifications and management practices, thereby building a common implementation framework. Additionally they formalize the state-of-the-art knowledge based on the consensus of experts with a broad range of technological, industrial and economic backgrounds from all over the world.

From the perspective of the World Energy Council and the IEA, standards are one of most important tools for enabling the realization of global strategies in practice. Standards facilitate the international cooperation between governments and industrial players. This is especially important as most solutions (including renewable energies) must be implemented on a mass scale in order to achieve the desired outcomes.

In the case of most electrical devices, the harmonization of local standards with international standards leads to:

- Minimization of testing costs, especially for the organizations that produce electrical devices for global markets
- Easier comparability of efficiency and energy consumption for the same devices in various regions and economic systems
- Facilitation of the production of higher-efficiency devices
- Facilitation and enabling of knowledge transfer, resulting in standards implementation in legislation

Standards do not just define efficiency and provide the methods to assess it. Standards also describe the broader perspective – how to manage the energy in a system and how to monitor, identify and verify the energy savings resulting from specific actions taken. Such an approach is part of a wide-ranging vision of energy-efficient markets where efficiency and energy savings are a service that can be purchased and sold in a same way as electricity or gas.

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Further reading
http://www.iso.org/iso/hot_topics/hot_topics_energy.htm
http://www.standardsinfo.net/info/livelink/fetch/2000/148478/13547330/outcome.html
http://www.iea.org/Textbase/work/2009/standards/Thies.pdf
http://www.iea.org/Textbase/Papers/2008/cd_energy_efficiency_policy/7-Energy%20utilities/7-Standards.pdf
http://www.motorsummit.ch/
http://www.seeem.org/news.php
http://www.nema.org/gov/energy/efficiency/premium/
http://www.motorsystems.org/

OPC Unified Architecture

The future standard for communication and information modeling in automation

Wolfgang Mahnke, Stefan-Helmut Leitner

OPC Unified Architecture (OPC UA) is the new standard specification for interconnectivity in state-of-the-art industrial automation technology, enabling rich information modeling capabilities, replacing existing OPC specifications. OPC UA provides a framework for interoperability to be used over the next 10 years and beyond (published also as IEC 62541).

ABB played a major role in creating OPC UA and has ensured the new standard meets process automation community requirements. After several years of work, a major segment of the specification was released in February 2009, and the first ABB product supporting OPC UA is already on the market.