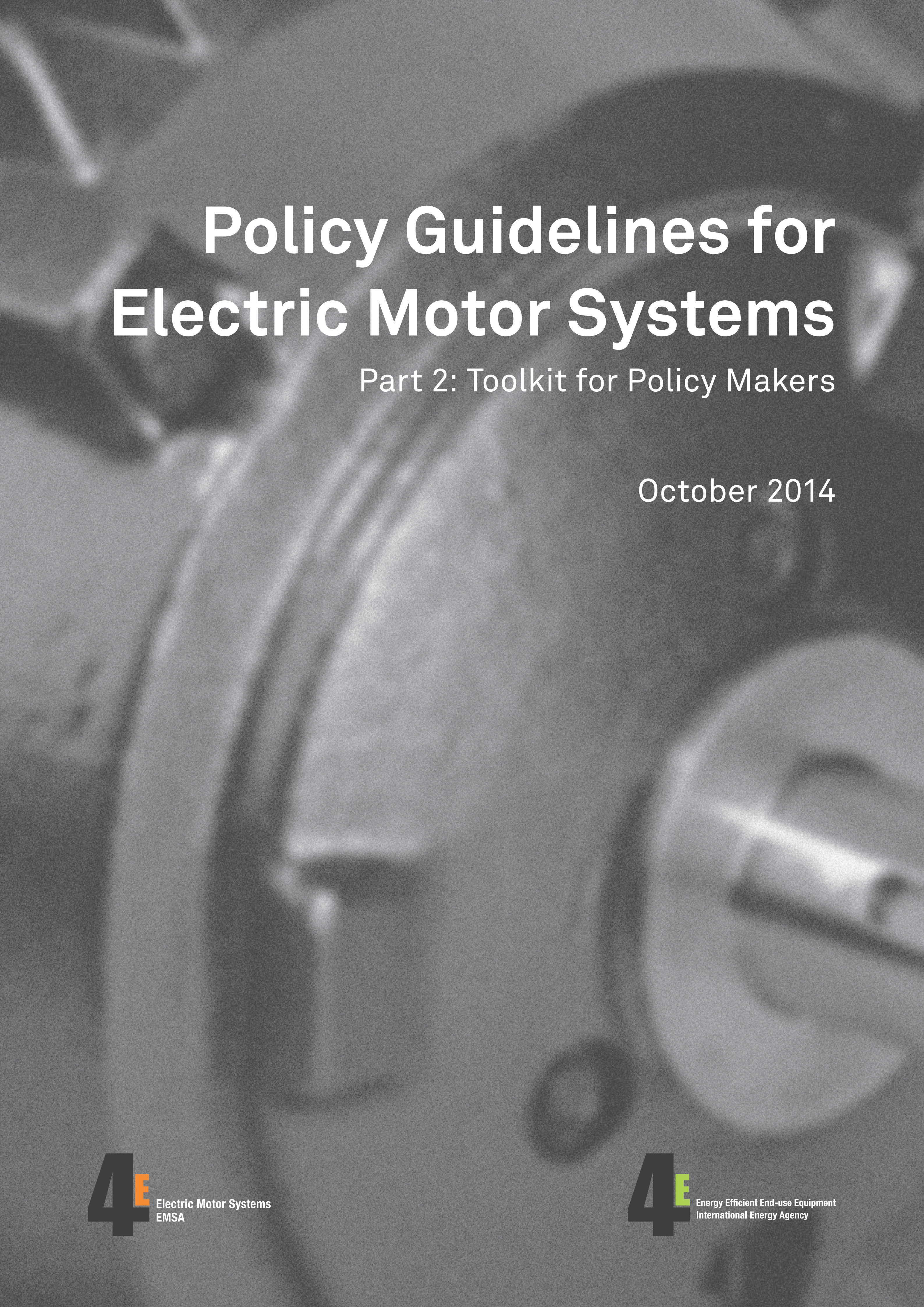

Policy Guidelines for Electric Motor Systems

Part 2: Toolkit for Policy Makers

October 2014

Electric Motor Systems
EMSA

Energy Efficient End-use Equipment
International Energy Agency

Electric Motor Systems Annex (EMSA)

EMSA focuses on improving the efficiency of electric motor systems, including the pumps, fans, compressors and auxiliary components (variable speed drives, gears, transmission belts and brakes) to which they may be attached. Its goal is to help governments develop and implement policies that increase the energy efficiency of motor systems by 20 % to 30 %. As electric motor systems are responsible for over 40 % of global electricity use, this represents a significant savings potential.

EMSA serves as a platform for technical and policy exchange, disseminates best-practice information and aims to support standards and policy development processes to improve the energy performance of new and existing motor systems in both industrialized and developing countries.

Between 2008 and 2014, EMSA has contributed to:

- International standards for electric motors (IEC), including:
  - IEC 60034-30-1: International efficiency classification standard: developing the IE-code (IE1, IE2, IE3, IE4), extending the standard's scope to include motors between 0.12 and 1,000 kW.
  - IEC 60034-2-1: Revision of the test standard with one preferred method for motors up to 1,000 kW.
  - IEC Round-Robin Report: covering 16 laboratories in 11 countries and 75 motors with 194 tests.
  - IEC 60034-2-3: Test method for motors driven by converters.
  - IEC 60034-31: Selection of energy-efficient motors including variable speed applications – Application guide.
  - IEC 61800-9: Testing and efficiency classification of motors and converters.
- The SEAD Global Efficiency Medal Competition for Electric Motors.

Furthermore, EMSA has:

- Expanded the Global Motor Systems Network to almost 4,000 representatives from governments, industry and research in more than 70 countries through systematic outreach: web, newsletter, workshops and international conferences for stakeholder interaction (Motor Summit).
- Established a global network of testing laboratories.
- Developed a Motor Systems Tool for motor system optimization by engineers.
- Published the following guides:
  - Electric Motor MEPS Guide (2009)
  - Motor Policy Guide – Part 1 (2011)
  - Policy Guidelines for Electric Motor Systems – Part 2 (2014)

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4E Electric Motor Systems EMSA

Policy Guidelines for Electric Motor Systems

Part 2: Toolkit for Policy Makers

Table of Contents

1 Summary

These "Policy Guidelines for Electric Motor Systems" aim to provide assistance to policy makers who wish to design and to implement a strategy to encourage the greater energy efficiency of electric motors and motor systems in industry in their jurisdiction.
Electric motor systems are estimated to be responsible for 46 % of global electricity use [1] and are used mainly in industry, infrastructure systems, in building technologies and in the transportation of goods and people. In industry only, they are estimated to account for approximately 70 % of electricity consumption. [1]
This guide builds on previous publications by 4E EMSA and showcases best-practice policy examples that have been implemented in various countries around the globe. These span a wide range of types of policies: both mandatory and voluntary, those that focus on energy management or energy audits, provide financial support, and technical information.
The guide offers a toolkit for policy makers, explaining the different policy instruments that can be applied to transform the market, depending on the individual national context, and provides guidance on the successful implementation of those.
The most effective government policies are those that stimulate action amongst key stakeholders within the motor systems market to achieve long term market transformation. A comprehensive range of policies are therefore required to influence international/national standard makers, industry associations, industrial users and power utilities. Figure 1 illustrates the potential for policy interaction among these groups.

At least five different stakeholders need to interact to transform the market for motor systems:
- **Governments** can set mandatory energy performance standards (MEPS). MEPS based on international standards are already applied in several countries, reducing barriers to trade. For setting MEPS, all relevant motor systems components and their combinations need to be considered, as well as a system for track-

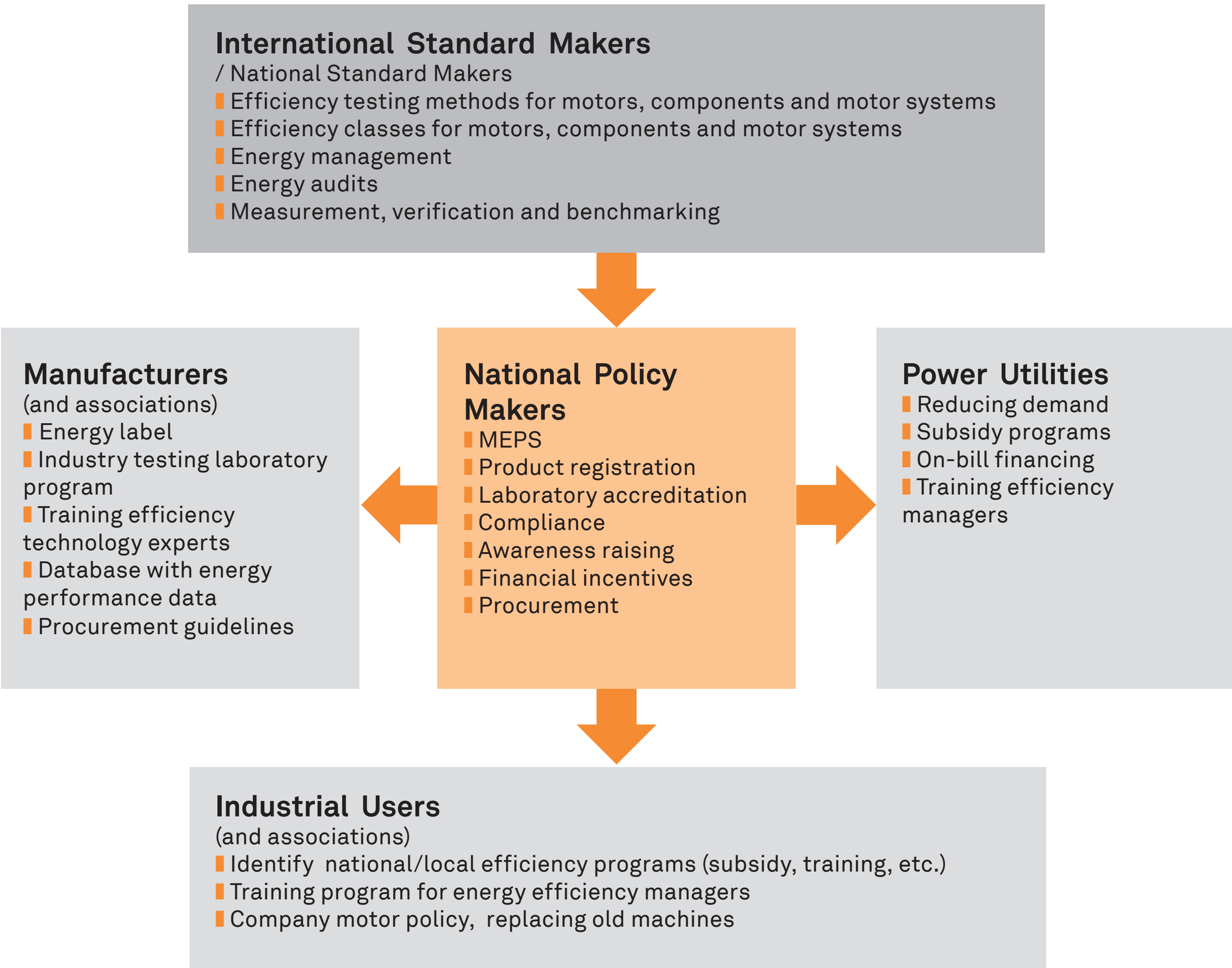

Figure 1: Influence of National Policy Makers (Source: Impact Energy Inc., 2014)

ing which products enter the market (e.g. registration) and for enforcing compliance. Governments can choose to complement MEPS with other policy instruments: defining an energy label, setting energy efficiency targets, entering into voluntary agreements with industry, implementing energy management and energy audit programs, encouraging individual businesses to set up a company motor policy, launching awareness-raising campaigns and giving financial incentives.

- **International standard makers** should focus on developing international standards in all relevant areas from motor system components to certification and labeling programs, energy management and energy audits, measurement, verification and benchmarking.
- **Manufacturers** and industrial associations can develop and/or support energy label programs, establish accredited testing laboratories, initiate and support training programs and define procurement guidelines.
- **Industrial users** are encouraged to set energy saving targets, define responsibilities and train personnel for designing new motor systems and retrofitting old systems.
- **Electric power utilities** can design and run procurement programs and subsidy programs for end-users and use innovative financing instruments to benefit from energy savings.

Policies and especially MEPS are a powerful tool to transform the market on the national and also on the international level (see Figure 3). Therefore, well-designed policies are crucial to convert efficiency potential into real efficiency gains.

Figure 2: Ventilation System in a Chemical Processing Plant (Source: Impact Energy Inc., 2014)

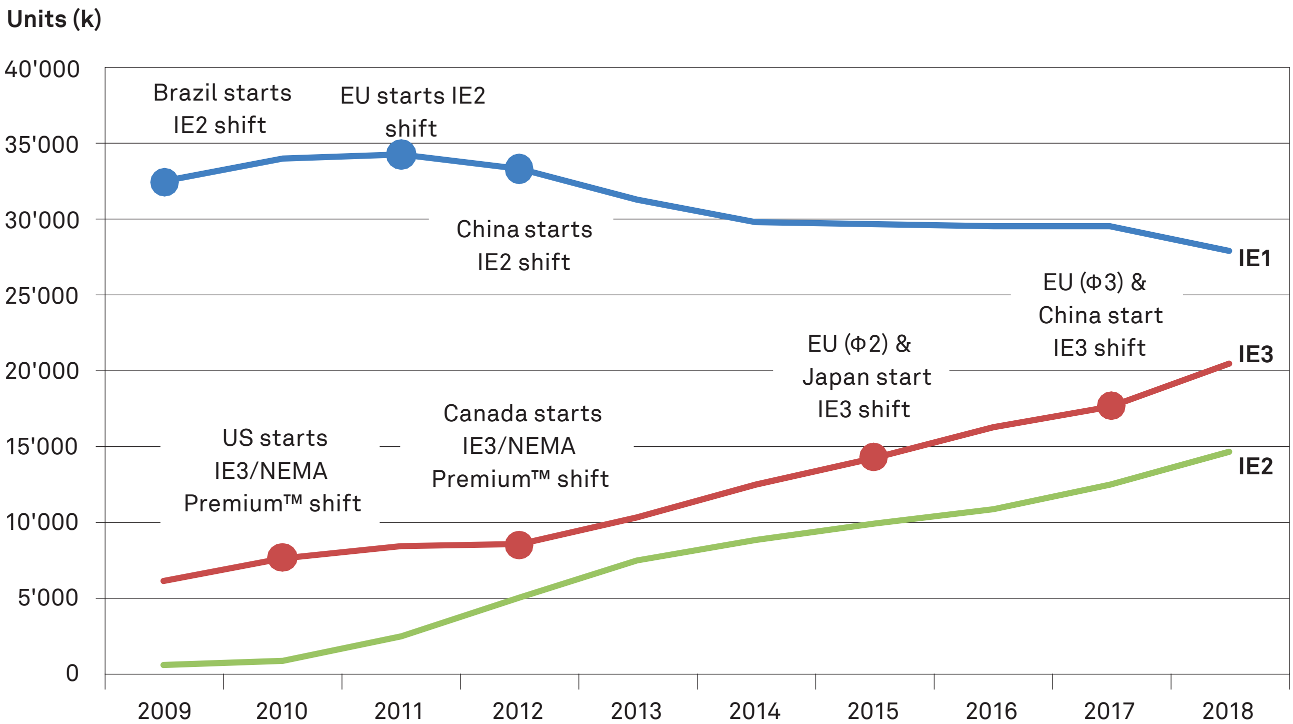

Figure 3: Policy Impact on the Global Sale of More Efficient Electric Motors (Source: IHS, 2014)

2 Transforming the Market for Motor Systems

The presence of significant barriers to energy efficiency in market for motors and motor systems currently prevents the adoption of cost-effective investment in end-use energy efficiency. To transform the market into one where energy efficiency options are fully considered and implemented requires policy intervention by national governments. Since motors and many motor systems are internationally traded commodities, collaboration between governments with similar policy objectives will not only achieve results more quickly, but reduce costs for governments, industry and ultimately end-users.

These opportunities exist in rapidly expanding economies in BRICS countries (Brazil, Russia, India, China, and South Africa), where new and larger factories allow investors to build highly energy efficient new motor systems with best available technology and low life cycle costs. Equally, the highly industrialized and saturated economies in Europe and USA have the chance to achieve major savings through the introduction of new technologies and the upgrade of existing motor systems.

Even within an internationally co-ordinated framework, the particular mix of policies selected by individual governments will always need to reflect national circumstances: existing programs, the legal and administrative infrastructure available, as well as the political and cultural context. Policies may also vary depending on whether a country has a significant domestic manufacturing base or relies primarily on imported products.

The following priority actions for transforming the market for motors and motor systems represent the collective knowledge of participants in 4E EMSA. Further information on how to design and implement policies to achieve each of these outcomes is provided within the body of this guide.

2.1 National Policy Makers

National governments can take the lead in achieving market transformation through the implementation of a range of mandatory and voluntary policy measures. In doing so, governments will need to form partnerships with relevant bodies amongst product suppliers, end-users and utilities.

Best practice for national policy makers:

1. Implement mandatory minimum energy performance standards (MEPS) based on international standards that allow different levels of MEPS according to the individual context in each country. Replacing conflicting regional and national standards makes the harmonization of standards possible on a global level and the trade of globally manufactured goods (motors, machines) much easier.
2. Take an active role in the international standards development process (e.g. through direct participation in the relevant standards committees), to ensure that international standards meet the needs of national policy implementation.
3. MEPS should be introduced sequentially (see Section 6.1):

a. Target all energy relevant components of a motor system first, including motors, variable frequency drives, transmissions, gears and applications (pumps, fans, compressors).

b. Second, focus on integrated systems, including motors plus VFD and an application (pumps, fans, compressors).

c. Third, move to more complex motor systems.

4. Implement a (national) product registration program (see Section 7.2).
5. Establish a government laboratory accreditation program, including initiatives to improve the quality of test laboratories through joint training, calibration and round robin programs. Manufacturers and their associations may also take the lead in these activities.
6. Implement an effective national compliance program for MEPS (see Section 7.3). Implement energy management and/or energy audit programs (see Sections 6.4 and 6.5).
7. Set energy efficiency targets for utilities and/or industrial end-users.
8. Implement a program for the systematic replacement of motor systems 20 years and older.
9. Establish an awareness-raising campaign for industry and benchmarking databases (in cooperation with manufacturer associations) (see Section 6.8).
10. Establish a framework of financial incentives to support energy efficient motor driven systems in industry (see Section 6.7). Implement subsidy programs for industry in cooperation with power utility programs wherein the responsibility for financing and program operation can be shared (see Section 6.7).
11. Implement procurement programs for public institutions and large buyers. If government demonstrates an "exemplary role", this will encourage other market players to follow suit. Procurement programs may be established in cooperation with utilities.

2.2 National and International Standard Makers

Standard makers play a key role in defining test methods, efficiency metrics and in some cases, energy efficiency classification schemes that are universally applicable, based on a sound technical basis and that meet the needs of policy makers.

International standards provide a mechanism to improve global harmonization and reduce trade barriers. Therefore, national standards and policy makers should participate in relevant international fora to ensure that international standards can be adopted for local use.

Best practice for standard makers:

1. Focus work on the development of harmonized international standards, rather than conflicting regional and national standards.
2. Involve policy makers as members in standardization committees. This is to ensure that the concerns of policy makers relating to policy design and successful implementation are understood and taken into account during the standards' development process. The goal is that the final standard serves as a robust basis for implementing national regulations.
3. EMSA recommends to use the following international standards and protocols as a basis for national regulation:

   a. Motors: Precise definition of scope and tolerances of efficiency classes of motors: IEC 60034-1, ed. 13 (2014).
   b. Motors: Efficiency measurement standards, preferred method for motors and inter-acting components: IEC 60034-2-1, ed. 2, (2014), IEC TS 60034-2-3, ed. 1 (2013), IEC 61800-9-3, ed. 1 (planned 2016).
   c. Motors: Efficiency classes for motors and interacting components: IEC 60034-30-1, ed. 1 (2014), IEC 60034-30-2, ed. 1 (2015), IEC 61800-9-2, ed. 1 (planned 2016).
   d. Motors: Guide for the application of IEC standards: IEC 60034-31, ed.1 (2011).
   e. Certification: IECEE Global Motor Labeling Program.
   f. Energy Management: ISO 50001 (2011).
   g. Pumps, fans, compressors: ISO standards.
   h. Energy Audits: ISO 50002 (draft).
   i. Monitoring and Verification: ISO 50015 (draft), International Performance Measurement & Verification Protocol Volume 1, 2012 (IPMVP).

2.3 Manufacturers

Associations of manufacturers for motors and other important components of electric motor systems can take the lead in defining and promoting industry-led labeling, testing, and training programs.

Best practice for manufacturers and their associations:

1. Promote the energy labeling of motors and key components in accordance with IEC 60034-30-1/-2.
2. Provide technical input and support training programs covering energy technology & management in industry (see Section 6.8.7), in collaboration with local tertiary and further education establishments.
3. Define and agree common norms for the presentation of motor energy performance data and establish an industry database with access for end-users. This could be undertaken in partnership with governments.
4. Define standardized specifications for the procurement of energy efficient equipment. These may include: advice on life-cycle cost calculation, efficiency levels, equipment electricity consumption and other relevant information.

2.4 Industrial Users

Through engagement with government motor systems policy, the owners of enterprises and their industrial factories can maximize their opportunity to improve profitability and gain access to support programs. Industry associations can also play a role in forming a link between governments and individual end-users.

Best practice for industrial users:

1. Appointing one or more responsible persons within the factory/enterprise who are responsible for improving energy efficiency.
2. Develop, adopt and implement a company policy for the systematic improvement of motor efficiency throughout the business.
3. Ensure access to information on national and local energy efficiency programs, to take advantage of opportunities for training, financial support and other initiatives.
4. Participate in training programs for energy management and energy efficiency in motor driven systems.
5. Join or establish a program for the recycling of old motors and components.

2.5 Electric Power Utilities

Power utilities can use energy efficiency and demand reduction to expand the range of services offered to larger industrial customers, thereby maintaining customer loyalty and providing cost-effective energy services.

Best practice for power utilities:

1. Identify the potential cost savings from reducing future energy demand and investigate opportunities for encouraging demand reduction by end-users.
2. Identify and implement opportunities to subsidize end-use equipment such as high efficiency motors and systems.
3. Implement programs to provide on-bill financing for implementing energy saving measures.
4. Train energy advisors in energy efficiency and demand side management, for example in accordance with industry training programs for energy technology & management in industry (see Section 6.8.7) or under ISO 50001 (see Section 6.4.4).

3 Introduction

3.1 What Is This Guide

The IEA Implementing Agreement "Energy Efficient End-Use Equipment" (4E) provides a forum for governments throughout the world to share experiences on best practice in the promotion of energy efficiency in appliances and equipment, as well as collaborate in the development of more effective policies.

The 4E "Electric Motor Systems Annex" (EMSA) steers the motor technology world towards the necessary knowledge to reap the fruits of energy savings promised by new technology and better design in an era of higher fuel and electricity prices.

EMSA has been engaged in motor policy since its outset in 2008. A first analysis was published in 2009 as "Motor MEPS Guide" [4] profiting mainly from the US experience in setting mandatory standards. In 2011, a second volume followed: "Motor Policy Guide, Part 1: Assessment of Existing Policies" [5] analyzing motor policy instruments in nine countries/regions.

This "Policy Guidelines for Electric Motor Systems" builds on these previous publications and showcases best-practice policy examples that have been implemented in various countries around the globe. These span a wide range of types of policies: both mandatory and voluntary, those that focus on energy management or energy audits, provide financial support, and technical information.

This publication has been led by an Austrian and a Swiss team, and has drawn on the experience of a number of international experts engaged with motor policy implementation within and outside EMSA. These policy guidelines are intended to provide a framework for policy makers to consider how best to plan and implement a comprehensive energy efficiency strategy for electric motor systems.

3.2 How to Use This Guide

This guide is designed to provide assistance to policy makers who wish to design and implement a strategy to encourage the greater energy efficiency of electric motors and motor systems in industry in their jurisdiction.

It has therefore been structured as follows:

- Section 1 summarizes how to reach a successful market transformation.
- Section 2 contains a summary of best practice for national governments, international/national standard makers, industry associations, industrial users and power utilities.
- Section 3 provides an introduction to this guide.
- Section 4 explains why the development of strategies to stimulate improved efficiency in motors and motor systems is so important.
- Section 5 contains a guide to developing a national policy framework for motor systems.
- Section 6 contains the toolkit of major policies used today by various countries to encourage greater efficiency. Each type of policy is explained and information on its attributes is provided. Furthermore, examples show where and how it is used.
- Section 7 deals with policy implementation and covers topics such as product certification, registration processes, compliance and improvement of the quality of test laboratories.
- Section 8 provides sources of global policy support, including international standards, government-to-government fora, and technical support networks.
- Section 9 gives references used in this guide.
- Section 10 provides a glossary.
- Section 11 lists the abbreviations used in this guide.

4 Why Strategies to Improve the Efficiency of Motor Systems are Important

4.1 Energy Consumption of Motor Systems and Potential Savings

Electric motor systems are estimated to be responsible for 46 % of global electricity use [1] and are used mainly in industry, infrastructure systems, in building technologies and in the transportation of goods and people. In industry only, they are estimated to account for approximately 70 % of electricity consumption. [1] Electric motors between 1 Watt and 100 Megawatt drive pumps, fans, compressors and industrial handling and processing equipment.

Improvements to most older motor driven systems have the potential to save between 10 % and 30 % of energy consumption and running costs [1], thus typically offsetting the investment for high efficient components within three to five years. [2] In addition, more efficient motor systems lead to process and quality improvements, lower cooling demand and reduced noise level. These advantages are due to the improved efficiency of the system components, better dimensioning, improved conditions of operation and easier maintenance, and particularly, due to greater energy efficient control and adaptation to real demand.

In most countries, older motor systems are numerous and provide huge opportunities for electricity savings. For example, an analysis of 4,142 electric motor systems in Switzerland shows [2] that there is a large fraction of very old, inefficient and oversized motor systems in use, many without optimized system performance or electronic controls, and no factory automation and process coordination.

4.2 Definition of Motor Systems

In these Policy Guidelines, the electric motor system is defined as the entire system from the electric input to the mechanical output, as shown in Figure 4.

The motor system, therefore, includes all components within the orange line boundary in Figure 4, including:

- The electrical input from a number of components inside the electric meter (i.e. mains cables, uninterrupted power supply, transformer, power factor correction, soft starter, switch gear, etc.).
- The electric motor including all its auxiliary elements for starting.
- The mechanical components (gears, transmission belts, brakes, clutches, throttles, etc.).
- The end-use application (i.e. pump, fan, compressor, mechanical process, etc.).
- The net operational energy use of the application in all modes of operation (i.e. flow of liquid in a pump or compressor or gaseous matter in a fan, including the energy needed to overcome the resistance and speed in ducts or pipes, heat exchangers, valves, etc.).

Very substantial energy savings are possible through optimizing the interaction of all these components to produce the necessary load or output. Although this means added complexity compared to regulating individual components, the approach of regulating systems is similar to the energy efficiency regulations contained in building codes. For building policies, it is typical to include both minimum performance requirements for individual components (i.e. a window), and requirements for overall energy demand (i.e. the specific final energy demand per m^2 of floor area per year).

In some cases it may be more practical for policy makers to restrict their concerns to the motor driven unit, which includes the variable frequency drive, the electric motor and the application. It may also include the mechanical equipment (gear, belt, clutch, brake, and throttle). While this approach uses typical boundary conditions both on

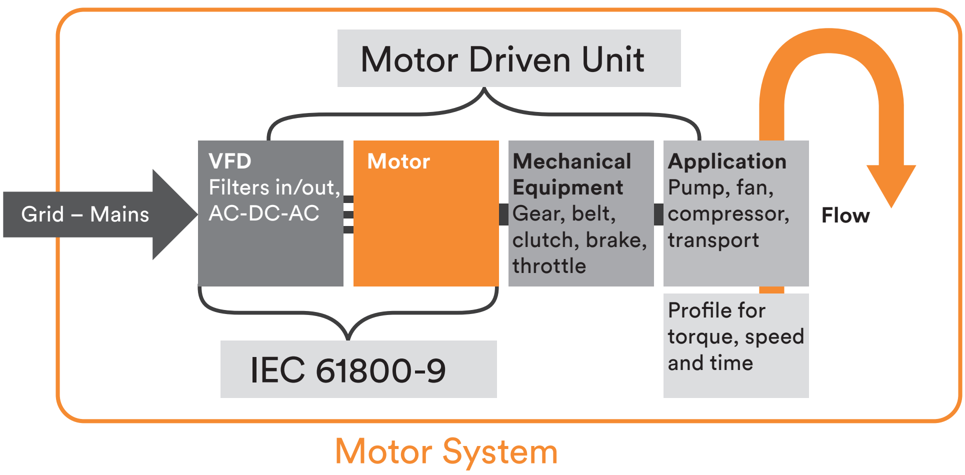

Figure 4: Motor System Definition (Source: Impact Energy Inc., 2014)

the grid side and on the application side, it does not include the losses on both of these boundaries.
The focus of standardization work in IEC and ISO usually concerns only a subset of components and their interaction: for example, Figure 4 also illustrates the scope of IEC 61800-9 to include the interaction of motors with variable frequency drives only. The work for determining efficiency and test methods of smaller integrated systems (e.g. motor plus VFD) has started at the international standardization bodies (IEC 61900-8), making national implementation possible. Indeed, regulations with an extended scope are beginning to emerge, such as the European Ecodesign regulations for motors with integrated circulator pumps and variable frequency drives [7].

4.3 Why Are Policies Needed?

A number of severe barriers between the manufacturer, the Original Equipment Manufacturer (OEM) and the end-user hinder the implementation of optimized electric motor driven systems.
Examples of these barriers include:

- A significant share of motors is built into larger production machines by OEMs. Since many customers demand low purchase prices, OEMS are keen to make their machines cheap and do not consider total cost of ownership or life cycle cost.
- Even if end-users ask for more energy efficient equipment, manufacturers/machine builders are hesitant to meet this demand. This may be related to the cost implications associated with changing the range of products sold.
- Motor manufacturers and machine builders struggle to explain the benefits of more energy efficient equipment.
- The complexity of electric motor systems requires in-depth technical skills and knowledge to design efficient systems, whether this is a retrofit or a complete new system. Many factories lack technical staff qualified to understand the potential for improvement and present a business case for efficiency investments concerning motor systems.
- Any changes to already installed motor systems are hindered by fears of production standstill.
- Motor/machine size is often not matched to the needs of production and tends to be oversized. Running equipment under low load conditions is inefficient and uses excessive energy.
- Considerable resources are needed to analyze existing motor systems on-site before retrofitting takes place in order to ascertain the actual demand from the production process. This represents a major barrier for end-users and leads to an attitude of not changing motor systems as long as they are running, often beyond their expected lifetime.
- Purchasing decisions within a company are typically based on first cost (purchase price) rather than total cost of ownership or life cycle cost. Purchase decisions are typically made by one department within the organization that is different from the department where the need for new equipment is identified. The interest of the purchasing department usually lies in keeping first costs low, which may be in conflict with the interest of the technical department that wants to reap the long-term benefits of higher efficiency.
- The cost of energy represents in general a relatively small share of the total costs of a company. Therefore, energy cost reductions are at risk of not getting too much attention. [1], [2]

5 Developing a National Policy Framework for Motor Systems

5.1 General Principles of Good Policy

Good government policy, including groups of policies, tends to have the following features:

- Are established to achieve well-defined objectives and include mechanisms for measuring the extent to which those objectives have been met.
- Are developed through a process that fully considers the evidence for taking action, as well as the resources required to fully implement the range of policy options.
- Are supported by, and leverage engagement from, relevant stakeholders in the public, private and informal sectors.
- Are transparent, fair and equitable.

5.2 Processes to Develop a National Policy Framework

While the specifics may differ in each country, formulating a national policy framework for motor systems requires the use of processes common to the development of good policies in general. Typically this will comprise the following steps:

1. Establish clear policy objectives.
2. Identify the existing barriers to meeting these objectives.
3. Identify existing policies or activities that may be relevant.
4. Gather relevant information on the market, products, etc., for analysis.
5. Identify policy options.
6. Assess policy options (costs, and other resources required, impacts).
7. Assess risks to achieving the desired policy objectives.
8. Consult with stakeholders.
9. Proposal for approval.
10. Implementation.
11. Evaluation & feedback.

The following section discusses the issues that should be considered when applying these to motor systems.

5.2.1 Policy Objectives

While the overall aim of motor policies may be to maximize energy savings or reduce greenhouse gas emissions, motor policies may be established to achieve a number of objectives. Included amongst such objectives may be the establishment of a sustainable energy efficiency industry, the development of professional expertise and the reduction of industry costs to make them internationally competitive. The setting of clear objectives from the outset will help guide the selection of an appropriate mix of policy measures.

5.2.2 Existing Barriers

It is likely end-users face several barriers that prevent investment in energy efficient motor systems and these may vary by type of industry or size of enterprise. It is very important to identify these barriers for each user-group and gain a good understanding of their relative impact in order to assess which policies are likely to be effective.

As a preliminary step, it may therefore be necessary to conduct surveys, or investigate case studies amongst the target group. In doing so, it may also be helpful to test the likely reaction by end-users to some general policy options, such as different types of information and/or financial assistance.

5.2.3 Identify Existing Policies or Activities That May Be Relevant

Policies to encourage greater efficiency in motor systems may sit within a wider policy portfolio in government. For example, they may be seen as part of a national greenhouse gas mitigation strategy or part of a specific group of policies on energy efficiency. They may also fit with policies to encourage industry development or trade and international competitiveness.

This suggests that a review of existing government policies will need to be wide-ranging in order to identify policies that may already have an influence on the motor systems market.

This review will be helpful in order to identify different departments or ministries within governments that may have an interest in motor policies and which, therefore, are potential partners in delivering policy and should be included in further consultation during the policy development stages.

5.2.4 Gather Relevant Information on the Market and on Products for Analysis

The collection of adequate data is a vital step towards assessing the potential impact of the policy options and their cost-effectiveness and is part of the evidence needed to secure the necessary support for new policies. Many countries will have pre-defined processes for the presentation of proposals for government approval.

Information on the market and on the performance of motor components and systems may be gathered from industry associations, major industry partners, published data, import/export figures or it may be available for purchase from commercial market research companies. It is usual for a number of sources to be used to gain an overall picture, providing an adequate basis to estimate the size of the market and its attributes.

From this data, a "business as usual" scenario (or scenarios) can be forecast, against which the impact of future policies will be measured.

5.2.5 Identify Policy Options

Section 6 of this report provides a thorough guide to the range of policies most commonly used to stimulate motor efficiency and the key attributes of each type of policy. This can be used to select those policies which best meet individual national objectives and address the particular barriers identified above.

It is important to note that, where there are multiple objectives and barriers, it is typical that more than one policy will be needed. [16]

At this stage, it is also important to consider how policies interact and to select those that are complementary. Section 5.3 of this Guide provides useful information on the interaction of different policy types.

5.2.6 Assess Policy Options

Each policy option should be assessed according to its ability to achieve the identified objectives. To do this will require an understanding of how each policy will be implemented and an estimation of the likely impact and cost of each policy measure. Costs and benefits may need to be apportioned to various stakeholders impacted by the policy measure, as well as on a societal basis.

This process typically involves the modelling of the motor and motor system market, based on information gathered in 5.2.4 above, together with a wide range of assumptions. Making these assumptions transparent will help other stakeholders provide input during consultation processes, which is likely to improve the accuracy of the modelling.

At this stage, the aim of modelling is to compare the costs and impacts of different policy options in order to select those that are most cost-effective. Therefore, data on the market and product performance only needs to be adequate to provide such a comparative assessment.

5.2.7 Assess Risks to Achieving the Desired Policy Objectives

An assessment of the risk that a policy, when implemented, may not achieve its objectives is a vital part of the development cycle and a necessary component of most approval processes.

Analysis of the risks for each policy measure typically includes the identification of the key factors that may reduce the effectiveness of that policy, such as through a sensitivity analysis, statements of the magnitude of these potential impacts and lists of responses that can be implemented in order to reduce negative impacts.

5.2.8 Consult With Stakeholders

Consultation with stakeholders is part of the process of seeking further engagement in the policy development process and will help to gain greater commitment to the final result. Often, the early involvement of stakeholders in policy development can identify partners and initiatives that will improve the implementation of a certain policy.

Therefore, while most countries have established procedures that govern the conduct of consultation, particularly where new regulations are under consideration, early consultation is encouraged.

5.2.9 Proposal for Approval

The presentation of final proposals for approval by the relevant authorities will build on the information and analysis undertaken throughout the previous steps. In many cases, such proposals will need to adhere to a prescribed format and therefore, it is wise to consider this at an early stage to ensure that all materials are available.

5.2.10 Implementation

While not part of the policy development process, consideration on how policies will be implemented must be part of the policy design process to ensure that implementation is feasible and in order to understand the costs involved.

Following approval, a detailed implementation strategy should be developed alongside any partners that will assist in program delivery.

5.2.11 Evaluation & Feedback

Processes to monitor progress with implementation of policies are vital to the success of policy measures. The feedback obtained from monitoring enables policy makers to identify any problems at an early stage (e.g. those identified in Section 5.2.7 as "risks") and respond accordingly to improve the overall impact of the program.

Providing evidence that policy measures have met their objectives will be required in order to maintain support for policy intervention in subsequent years.

5.3 Interaction Between Policies

In determining the appropriate mix of policies, consideration should also be given to the interaction between different policy measures. Table 1 highlights some of the ways in which policies complement each other. These are further discussed in Section 6.

Policy Measures	Labels	Voluntary Agreements	Energy Management	Energy Audits	Motor Policy	Financial Incentives	Awareness and Information
MEPS	Highly complementary. Both based on common test methods	All further policy measures may be used to complement MEPS, depending on the individual national legal, political, economic, cultural and environmental situation.					
Labels		Labels can help to specify the procurement criteria for industrial equipment		Labels can help energy auditors to recommend high efficient motors	Label specifications can be used as the basis for selection criteria	Work well together. Specifications for high efficiency components provide the basis for targeting financial measures	Labels require information programs to make end-users understand the information provided by the label
Voluntary Agreements			Voluntary agreements are one mechanism to encourage increased energy management	Energy audits may comprise one action under a voluntary agreement	Motor policy should form a part of a voluntary agreement	Financial incentives can be used to encourage participation in voluntary agreements	Awareness raising, benchmarking and staff training complement voluntary agreements
Energy Management				Energy audits may form one component of a wider policy on energy management	Motor policy should form a part of an overall energy management policy	Financial incentives can be used to focus attention on energy management opportunities	Awareness raising, benchmarking and staff training complement energy management programs
Energy Audits					An energy audit can be the first step towards developing a motor policy	Financial incentives can be used to promote implementation of audit findings	Awareness raising, benchmarking and staff training complement energy audit programs
Motor Policy						Motor policy can take advantage of financial incentives for high efficiency motors	Promotional campaigns can be used to highlight the benefits of motor policy. Training can support implementation of motor policy
Financial incentives							Financial incentives can help to raise awareness of energy efficiency opportunities

Table 1: Summary of Complementary Energy Efficiency Policies

6 Motor Systems Policy Toolkit

This section describes the major policy measures currently used by countries to promote increased efficiency in motors and motor systems. Each measure is explained and a brief description included. The main objective of each policy is outlined, together with other important attributes of the policy. For each policy measure, a number of examples are provided to illustrate how these are implemented by different countries. References to these examples can be followed where a greater degree of detail is required. Finally, a set of recommendations are included, which represent the experience of EMSA members.
Table 2 provides a summary of the information presented in this section.

6.1 Minimum Energy Performance Standards (MEPS)

6.1.1 Description

Minimum Energy Performance Standards (MEPS) are specifications which stipulate the minimum level of energy performance that products must meet. Where MEPS are mandatory, products that do not meet these requirements may not be offered for sale or, in some countries, used for commercial purposes. MEPS are usually implemented through national authority regulations for a defined list of products.

6.1.2 Policy Objectives and Target Audience

The objective of MEPS is to accelerate and focus market transformation towards higher efficiency motors. By specifying a minimum energy performance level, mandatory MEPS prevent inefficient products from entering the marketplace and help to increase the average product efficiency over time. MEPS address the barrier that higher efficiency technology is often, at least in the early stage, more expensive than existing technology by combating the tendency of end-users to base purchasing decisions on initial purchase price rather than life-cycle costing (see Section 6.8.9 for information on life-cycle costing methodologies).
Industry is usually invited to collaborate with the government agency responsible for establishing and implementing MEPS and is involved in the stakeholder consultation through their industry associations and some key manufacturers. In the European process, NGOs are also included in this stakeholder dialogue. A collaborative approach ensures that the target setting process takes into account the different objectives and concerns of the major stakeholders. Broadly speaking:

- **Government** is seeking a balanced approach to MEPS that can be successfully brought into law without conferring privilege on certain industries or "punishing" others with severe burdens, while also maintaining consumer choice. Governments may also want MEPS to have a positive impact on the national employment situation and on international competitiveness of the domestic industry, while still achieving meaningful national energy savings.
- **Industry** supports low interference in free markets and in limiting additional mandatory restrictions for energy efficiency. However, industry is also concerned about low quality and cheap imported products that take market share away from national manufacturers, a concern which can be tackled through MEPS. Where brands have made product energy efficiency part of their business model, these manufacturers may influence the development of MEPS in a positive way.
- **Academics, experts and NGOs** are interested in long-term development, CO_2 mitigation and energy savings. They can coordinate different NGOs and gain technical and policy know-how to influence the decision making process.

The process of setting performance standards depends on the collection of sufficient technical evidence from independent research sources based on national market surveys and recent technical developments. It is important that the methodology for setting targets and deciding on MEPS is transparent with a well-defined timeline (usually several years). This allows the industry to prepare new product lines with higher efficiency products and to abandon older inefficient products from their production. The process is usually iterative with targets being revised over time.

6.1.3 Further Policy Attributes

Mandatory MEPS are one of the strongest instruments that governments can use to achieve energy efficiency improvements. They are often implemented in conjunction with other instruments, such as energy labeling, to maximize their effectiveness.
MEPS for electric motors are generally based on national, or preferably international, energy efficiency performance standards (see Section 8.1). These performance standards are usually designed and published by national, or international[1] standards organizations that try to assemble national and international competence from industry, academia and government and to provide commonly agreed performance criteria. The standards are then quoted in national laws and regulations. This approach separates the detailed specifications from the enabling legislation.
Once established, it is crucial that the implementation of MEPS is complemented by a strong monitoring, verification and enforcement (MVE) regime (see Section 7.3). This checks that only eligible products are present in the marketplace, verifies that the performance claims for these

1 Such as the International Electrotechnical Commission (IEC)

Attributes	MEPS	Labels	Voluntary Agreements	Energy Management	Energy Audit	Motor Policy	Financial Incentives	Awareness and Information
Aim	Remove worst performing components or systems from the market	Provide information on the energy performance of components & systems. Helps to identify best-performing products.	Improve the efficiency of major sectors or companies through non-regulatory mechanisms	Maximize energy savings throughout individual companies	Identify cost-effective energy savings within individual companies	Adopt the most efficient motors that are cost-effective	Either to raise awareness of opportunities amongst end-users, or create long term improvements in the market	Overcome barriers due to a lack of awareness, information or skills
Target Group	Motor and system suppliers	Purchasers of motors & systems	High energy consuming sectors or companies	Individual businesses	Individual businesses	Individual businesses	Purchasers or suppliers of motors and systems	Purchasers and end-users of motors and systems
Speed to Implement	3-5 years before implemented	Voluntary labels (1-2 years) quicker than mandatory labels but take time to achieve brand awareness	Once framework established can be quick to implement, although dependent on voluntary uptake	1-2 years to implement. Requires long-term commitment to maximize impact	Once framework established can be quick to implement	Likely to be quick to implement	Quick to implement, but may not have a long life	Simple awareness and information programs will be quicker to implement than longer-term training and educational programs
Potential to Transform the Market	high	high	medium	medium	medium	medium	medium	low
Market Impact	Needs review and upgrading every 3-5 years to maintain impact	Once the label becomes a valued sales tool, can pull the market. Needs periodic upgrading to continue to provide market incentive	Can help to improve corporate understanding of energy savings and change business culture	Can help to improve corporate understanding of energy savings and change business culture	If programs are sufficiently long-run, these can establish a body of skilled auditors able to sell services to the market	Can help to improve corporate understanding of energy savings and change business culture	Market transformation can occur if measure raises sales to sufficient levels for economies of scale in efficient components to be maintained	Unlikely to achieve transformation on their own but may be part of a larger market transformation program
Financial Implication	Establishment and testing costs for governments Compliance costs for industry	Low cost to implement but needs marketing to educate end-users	Tends to be relatively low cost for governments, depending on the degree of support and incentives provided	Depends on the degree of support and incentives provided	Depends on the degree of support and incentives provided	Aimed at maximizing cost-effective investments by companies	Varied cost depending on the measure, and duration	Varied cost depending on the scale of the program

Table 2: Summary of Key Policy Measures and Attributes

products are correct and provides for a system of penalties for non-compliant products. The verification process involves testing the products against test procedures as established in the enabling legislation.

6.1.4 Recommendations

The general steps of setting standards are described in [6]. It should be noted that many countries have detailed procedures for the development and approval of new regulations, such as mandatory MEPS.

When considering imposing MEPS for electric motors and systems on the national market, it is important to:

- Investigate whether international standards for testing and efficiency classification are already available, which can be used as a basis for setting national MEPS that are also used by other countries. Gather information on draft standards / standards under revision and when such standards will be published.
- For electric motors specifically, consider acknowledging and applying the international test standard IEC 60034-2-1 and the international efficiency classification standard IEC 60034-30-1.
- Aim for applying the same test standards, MEPS levels (based on international standards) and timing for the introduction of the minimum requirements within one geographic/economic region to reduce barriers to trade.
- Learn from the experience of other countries with setting MEPS for single components and especially systems.
- Assess the regulatory impact of the planned MEPS, including end-user, manufacturer, economic and environmental impacts.
- Ensure that all relevant stakeholders are included in the consultation process to facilitate market uptake and technical feasibility of the planned regulation.
- Introduce MEPS sequentially:
  - First, target all energy relevant components of a motor system, including motors, variable frequency drives, transmissions, gears and applications (pumps, fans, compressors).
  - Second, focus on integrated systems, including motors plus VFD and an application (pumps, fans, compressors).
  - Third, move to more complex motor systems.
- Define the update cycles of the regulation (typically two to five years).
- Establish a centrally controlled system (e.g. online registration database) for monitoring which products enter the market.
- Set up a scheme with accredited testing laboratories.
- Check the conformity of products to the relevant regulation.
- Define how to deal with non-compliance (e.g. publishing the name of the manufacturer/brand/model, imposing sanctions/fines, etc.).
- Allocate the necessary resources for the monitoring, verification and enforcement activities.

Figure 5: Pumping System in a Chemical Processing Plant (Source: Impact Energy AG, 2014)

6.1.5 Policy Examples

This section presents examples of MEPS currently in place for motors and motor systems.

Countries with MEPS for Motors

Efficiency Levels	Efficiency Classes	Testing Standard	Performance Standard
3-phase induction motors	**IEC 60034-30-1** **Global classes IE-Code 2014***	**IEC 60034-2-1** **incl. stray load losses; rev. 2014****	**Mandatory MEPS****** **National Policy Requirement**
Super Premium Efficiency	IE4		
Premium Efficiency	IE3		**Canada (< 150 kW)** **Mexico (< 150 kW)** **USA (< 150 kW)** South Korea 2015 Switzerland 2015 Japan 2015 Toprunner EU 28*** 2015 / 2017
High Efficiency	IE2	Preferred Method Summation of losses with load test: P_{LL} determined from residual loss	**Australia** **Brazil** **Canada (> 150 kW)** **China** **European Union (EU 28)** **Mexico (> 150 kW)** **South Korea** **New Zealand** **Switzerland** **Turkey** **USA (> 150 kW)**
Standard Efficiency	IE1		**Costa Rica** **Israel** **Taiwan**

"bold" means in effect

*) Output power: 0.12 kW – 1,000 kW, 50 and 60 Hz, line operated 2-, 4-, 6- and 8-poles

**) for 3-phase machines, rated output power < 1,000 kW

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

****) Minimum Energy Performance Standard

5 September 2014, Impact Energy Inc. © EMSA 2014

Table 3: List of Motor MEPS Worldwide (Source: Impact Energy Inc., 2014)

United States

Example: US MEPS for Motors and Motor Systems

In the US, the National Electrical Manufacturers Association (NEMA) and Motor Coalition[1] approach to setting up mandatory MEPS has shown a successful market transformation overcoming the "initial purchase price decision" barrier. Sovereign regulations can reach the original equipment manufacturer (OEM) segment of the market that is typically not concerned with life-cycle costs. As 75 % or more motors in the US are sold to OEMs, without regulations their purchase decisions would be based on least first cost.

Existing Standards Include:

- Small Electric Motors – Final Rule published on March 9, 2010, 75 FR 10874

Small electric motors include single phase and poly-phase motors built in a two-digit NEMA frame and are rated from ¼ to 3 horsepower. Each small electric motor manufactured alone or as a component of another piece of non-covered equipment and distributed in commerce, as defined by 42 U.S.C. 6291 (16), after March 9, 2015 must have an average full load efficiency specified in the Code of Federal Regulations, 10 CFR 431.446
For more information see: www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/40

- **Medium Electric Motors** – Final Rule published on May 29, 2014, 79 FR 30933

The Energy Policy and Conservation Act (EPCA), as amended by the Energy Independence and Security Act of 2007 (EISA 2007), covers general purpose, definite purpose and special purpose electric motors. These broad categories include a variety of motors including single-speed, continuous-duty polyphase motors with voltages not greater than 600 volts; motors with or without mounting feet; motors built in a T- or U-frame; motors built with synchronous speeds of 3600, 1800, 1200, or 900 rpm (two, four, six, or eight poles, respectively); NEMA Design B motors from 1 to 500 horsepower, NEMA Design A and C motors from 1 to 200 horsepower; and motors that are close-coupled pump or vertical solid-shaft normal thrust motors. (42 U.S.C. 6313(b)(2))
With its most recent final rule, with a compliance date of June 1, 2016, DOE is expanding the regulation and establishes energy conservation standards for a number of different groups of electric motors that DOE has not previously regulated.
Test procedures are specified in 78 FR 75962 (December 13, 2013).
For more information see: www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/50

Current Standard Rulemaking Activities Include:

- **Commercial and Industrial Fans and Blowers:** Framework Document published on February 1, 2013, 78 FR 7306.

For more information see: www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/25

- **Commercial and Industrial Pumps:** Framework document published on February 1, 2013, 78 FR 7304.

For more information see: www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/14

- **Commercial and Industrial Air Compressors:** Framework Document published on February 5, 2014, 79 FR 6839.

For more information see: www1.eere.energy.gov/buildings/appliance_standards/rulemaking.aspx/ruleid/58

1 A coalition of energy efficiency advocates including American Council for Energy Efficient Economy (ACEEE) and the Appliance Awareness Standards Project (ASAP)

European Union

Example: European MEPS for Motors and Motor Systems

Electric Motors

Commission Regulation (EC) No 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors. The MEPS are set in three tiers:

- From 16 June 2011, the minimum efficiency level of motors is IE2.
- From 1 January 2015, for motors with a rated output between 7.5 kW and 375 kW, the minimum efficiency level is IE3 or IE2 equipped with a variable speed drive (VSD).
- From 1 January 2017, for all motors with a rated output between 0.75 kW and 375 kW, the minimum efficiency level is IE3 or IE2 equipped with a VSD.

Integrated Circulator Pumps from 1 W up to 2500 W (hydraulic)

Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products. The MEPS are set in two tiers:

- Tier 1 with an Energy Efficiency Index smaller than 0.27 by 1 January 2013.
- Tier 2 with an Energy Efficiency Index smaller than 0.23 by 1 August 2015.

These products include a motor, a small pump impeller and most often also a variable frequency drive, integrated (and not separable) into one package. They are most commonly used in central water heating and cooling systems and also in heat pumps and solar hot water and heating systems. These integrated products can only be tested as a package, with output (flow of liquid) and input (electric power).

Ventilation Fans

Commission Regulation (EU) No 327/2011 of 30 March 2011 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for fans driven by motors with an electric input power between 125 W and 500 kW. The regulation defines an energy efficiency target for five different types of fans in two tiers:

- Tier 1 from 1 January 2013.
- Tier 2 from 1 January 2015.

The fans consist also of an electric motor, the fan propeller and sometimes an integrated variable frequency drive. Smaller size fans (up to 5 kW) often come as integrated products that cannot be tested otherwise. Larger fans can easily be separated into their man components, i.e. motor, transmission and ventilator, and can also be tested separately.

Water Pumps

Commission Regulation No 547/2012 of 25 June 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water pumps. These pumps are made for “clean water”, which is not sewage water, nor drinking water. They are distinguished in five different types that need to obey a two-tier requirement:

- Tier 1 from 1 January 2013.
- Tier 2 from 1 January 2015.

These pumps, up to approx. 150 kW, are mostly built from two matched components: the electric motor and the pump attached to it. These products can be tested as the integrated circulator pumps or, if necessary, can also be tested separately as motor and as pump.

The European Commission is currently working on a number of other motor systems MEPS such as air conditioners and different types of fans. The full list from 31 January 2014 is available from: http://ec.europa.eu/energy/efficiency/ecodesign/doc/overview_legislation_eco-design.pdf

6.2 Labeling

6.2.1 Description

Energy labeling is the use of a physical label, displayed on the product itself, to indicate the energy performance of that product (usually in terms of its energy efficiency). These may be either comparative or endorsement labels.

- **Comparative labels** relate the performance of the product to a defined performance scale, thereby allowing consumers to compare the energy performance of similar products. Comparative labels may use a continuous scale or discrete categories of performance with minimum criteria for each level. They may also provide the average cost of running the appliance and further information on attributes of the model.
- **Endorsement labels** indicate that a product meets, or exceeds, specified energy performance criteria, thereby allowing consumers to identify the better performing products in the market (but not to compare these "endorsed" products against each other).

The format and specific content of energy labels is highly variable and dependent on the context of their use and cultural issues, and may be either mandatory or voluntary. Information on products may also be provided through a QR code or EAN, as shown in Figure 6. More information on energy labels can be found in [6].

6.2.2 Policy Objectives and Target Audience

The overall objective of energy labeling programs is to move markets for energy-using products toward improved energy efficiency by providing consumers with the information to allow them to include the energy consumption of the product in their purchasing decision. Comparative labels motivate manufacturers to build products that are more efficient than their competitors' products, while endorsement labels provide an incentive (market advantage) for manufacturers to build products that meet the specified criteria.

6.2.3 Further Policy Attributes

Energy labeling is often used in conjunction with other policy instruments, most notably Minimum Energy Performance Standards (MEPS), where it provides a readily identifiable demonstration of compliance with, and in the case of comparative labels, relative performance against the standards.

Energy labels can also facilitate effective procurement and incentive programs providing a "short hand" for utility companies and relevant government agencies when writing specifications for bulk purchase or allowing them to use products differentiated by labels when offering consumers financial incentives, such as rebates, to buy energy efficient products.

Figure 6: QR Code (ISO/IEC 18004:2006)

Whether linked to MEPS or not, energy labels usually relate to a national, or international, testing standard for energy efficiency and national labeling regulations that sets either the thresholds between each label class for comparative labels or the absolute threshold for endorsement labels. National legislation is necessary to set a precise scope for the label for a given product and to define whether the label has to be displayed at the place of sales or on the product itself.

Energy labeling programs should be complemented by a strong monitoring, verification and enforcement (MVE) regime. This ensures that only eligible products are using the label, verifies that the performance claims on the label are correct and provides for a system of penalties for non-compliance.

6.2.4 Recommendations

The process and key issues for the development of labeling programs are very similar to those for MEPS and, because these instruments are frequently implemented together, are often carried out in parallel. The key additional considerations for labeling are:

- The design of the label itself, which must be easy to understand and must accurately reflect the requirements of the labeling scheme, and the rules for how and when it must be displayed.
- The registration/authorization procedure for use of the label.
- Whether labels are printed by the manufacturer based on published guidelines or provided by the regulatory authority.
- Whether labels are mandatory or voluntary: voluntary labels may provide a useful tool for engaging stakeholders as a precursor to the introduction of a mandatory program or MEPS, while a mandatory program will drive a more rapid market transformation.
- The decision making process for the performance scale for comparative labels or the absolute threshold for endorsement labels:
  - For comparative labels, it must be decided whether the scale is continuous or whether it uses discrete categories. The scale must also be sufficiently broad to allow adequate differentiation between products and to avoid "bunching" of products within one category at the top of the scale.
  - For endorsement labels, the threshold for eligibility must be sufficiently high to accurately differentiate the best in the market place from the majority.
- The thresholds for all types of labels should be periodically reviewed and adjusted to reflect advances in technology efficiency.

6.2.5 Policy Examples

Example: Chinese Energy Labels for Motors

Comparative Label: The China Energy Label scheme was implemented in March 2005 and mandatory labels for small and medium motors were included in June 2008. To qualify for the China Energy Label, small and medium motors must meet the requirements specified in the Chinese National Standard GB 18613-2012[1]. The specified testing method is GB/T1032[2], which is identical to IEC 60034-2-1[3], and the grades are in line with the classes in IEC 60034-30[4] (IE2/IE3) and IEC 60034-31[5] (IE4). Motor efficiency must meet the specified level both at 100 % and 75 % load. The program applies to 0.75 kW – 375 kW, 2-6 poles, up to 1000 V 50 Hz, motors (including motors for explosive atmospheres). In addition to energy efficiency requirements, low power motors are subject to the China Compulsory Certificate mark (CCC Mark), which is a compulsory safety mark for many products imported, sold or used in the Chinese market. For more information see: www.energylabel.gov.cn

1 Minimum allowable values of energy efficiency and energy efficiency grades for small and medium three-phase asynchronous motors
2 Test procedures for three-phase induction motors
3 Rotating electrical machines – Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)
4 Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)
5 Rotating electrical machines – Part 31: Selection of energy-efficient motors including variable speed applications – Application guide

Figure 7: Chinese Energy Label for Electric Motors (Source: www.energylabel.gov.cn)

6.3 Voluntary Agreements with Industry

6.3.1 Description

Voluntary agreements are tailor-made negotiated covenants between public authorities and individual firms, or groups of firms, which include targets for actions aimed at improving energy efficiency, or reducing greenhouse gas emissions, and which may define rewards, tax rebates and penalties. [18] Voluntary agreements usually cover the following elements:

- A binding commitment once a party agrees to the voluntary agreement.
- Quantitative targets (such as, energy efficiency improvement, energy or carbon savings) and/or commitments by the signatories to implement energy saving actions with a specific payback period or within a certain timeframe.
- Commitment from the public authorities in supporting actions undertaken by the signatories, such as, the supply of fiscal incentives, practical support in developing energy efficiency plans and actions, and/or cooperative actions on the implementation of enforcement.
- An effective system for monitoring compliance: usually participants report on their implementation and on the energy savings (self-reported data).
- Voluntary agreements may also include:
  - Energy audits or special investigations.
  - Preparation of action plans and implementation of economically reasonable measures.
  - Introduction of energy management systems.
  - Procurement process (purchasing criteria).

The combination of binding commitment, quantitative targets and different instruments to support companies in reaching those targets is crucial for the effectiveness of voluntary agreements.

6.3.2 Policy Objectives and Target Audience

The objective of a voluntary agreement is to engage with companies within a target sector to achieve an improvement in energy efficiency or reduction in energy consumption without recourse to regulation. The main advantages of voluntary agreements are:

- They are extremely flexible and able to deliver tailor-made solutions for each sector or even company.
- With effective reporting and monitoring, they can provide a high degree of certainty that the specified targets will be met.
- They tend to be more acceptable to industry than regulatory approaches.
- They can be used in association with other policy measures such as emission trading schemes or in sectors without existing policy coverage.
- They are particularly applicable for sectors and companies with a high proportion of energy demand from motor systems, e.g. service sector for cooling or pumping for swimming pools in hotels.

Voluntary agreements have historically been focused on industrial process energy consumption, but they can also be used for other sectors and even in the supply chain (such as, service sector, transport, energy utilities), as occurs in Denmark, Finland, and the Netherlands. They may be negotiated on behalf of a whole sector by the sector trade association or directly with individual companies.

6.3.3 Further Policy Attributes

Voluntary agreements depend on the trust and cooperation between public authorities and the sectors involved in the voluntary agreement.

A wide range of motivations are used to encourage industry to join and support voluntary agreements, such as:

- Deferred legislation (e.g. MEPS or taxation) and/or more flexibility in the planning and execution of energy efficiency policy and investments on a company level.
- Less strict enforcement by local and national authorities [20].
- Financial support (subsidies) for energy audits and capital investment in energy efficiency.
- Assistance and training in energy management.
- Energy or carbon tax exemptions.
- Public recognition.

Most voluntary agreements have some form of penalty mechanism or other threat of sanctions to discourage non-compliance with voluntary agreement commitments (such as, having to pay back received subsidies or tax rebates). [27]

The implementation of voluntary agreements should be linked to robust energy auditing for target setting and the planning of energy saving measures (see Section 6.5) and to the implementation of energy management systems and effective monitoring (see Section 6.4).

Although they do not rely on regulation for their effectiveness, voluntary agreements are often a precursor to the introduction of legislation. Some examples of alternative approaches to voluntary agreements for motors are given in Section 6.3.5.

6.3.4 Recommendations

Motor energy consumption is just one component of the total energy requirement of companies in most sectors. Therefore, it is important to specifically identify and include motor system elements into sector voluntary agreements. This can be achieved through the following:

- When setting targets for an agreement, electricity consumption may be explicitly mentioned. Since motor systems are responsible for more than 70 % of industrial electricity consumption [1] [2], this supports the engagement of the participating companies in increasing the efficiency of motor driven systems.
- Motor specific issues, such as purchasing criteria for efficient motor systems, may be included within the specifications of the voluntary agreement.
- Motor systems could be explicitly identified as a target for energy audits and/or energy management systems.
- Voluntary agreements can offer training and capacity building on design, optimisation and maintenance of motor systems.

6.3.5 Policy Examples

Example: European Motor Challenge Programme

The Motor Challenge Programme is a European Commission initiative to help industrial companies improve the energy efficiency of their electric motor driven systems. The Motor Challenge Programme focuses on compressed air, fan and pump systems, for which it has been demonstrated that there exists a large technical and economic potential for energy savings. Any enterprise or organization agreeing to contribute to the Motor Challenge Programme objectives can participate. Through the Motor Challenge, partners will receive:

- Aid in defining and carrying out an Action Plan, to reduce energy related operating expenses, while maintaining or improving reliability and quality of service.
- Public recognition for their contribution to achieving the objectives of the European Union's energy and environmental policies.

In return, the participating company commits to undertaking the specific measures to reduce energy consumption laid out in the Action Plan. For more information see: http://iet.jrc.ec.europa.eu/energyefficiency/motorchallenge and [5]

Example: Motor Efficiency Elements Built Into Netherlands Long Term Agreements

Long Term Agreements (LTA) have become the main policy instrument for industrial energy conservation and CO_2 emission reduction in the Netherlands. By signing an LTA, the industrial sectors (or individual companies) agree to achieve a specified percentage improvement in energy efficiency and every company or institution that takes part in a LTA sets out its energy efficiency targets in an Energy Efficiency Plan. This plan is linked to specific measures and a schedule for the realization of these targets. For every sector, the Dutch Government has developed a specific list of energy efficiency measures. The contents of the Motor Challenge Programme modules are integrated in the new measure list for the LTAs.

For more information see: www.rvo.nl/subsidies-regelingen/meerjarenafspraken-energie-efficiency and [5]

6.4 Energy Management Programs

6.4.1 Description

Energy management is the term used to describe the systematic and structured approach for reviewing the energy needs of a company and for implementing measures to reduce consumption, including putting in place on-going monitoring and reporting systems. Successful implementation of energy management results in:

- Energy cost savings.
- Prioritisation of no- and low-cost energy saving opportunities in day-to-day operations.
- Reduced greenhouse-gas emissions and reduced carbon footprint.
- Reduced exposure to changing energy prices.
- Increased security of supply by reducing dependence on imported fuels.
- Increased energy awareness among staff and greater participation.
- Greater knowledge of energy use and consumption, and opportunities for improvement.
- Informed decision-making processes.
- Reduced uncertainty as future energy use is better understood.

Energy management programs are policies and initiatives that encourage companies to adopt energy management. [35]

6.4.2 Policy Objectives and Target Audience

The objective of energy management programs is to accelerate the uptake of energy management by organizations in order to decrease industrial energy use and reduce greenhouse-gas emissions. If properly designed, they also can help attain other objectives. For example, by supporting industry in using energy more productively they can boost competitiveness and redirect savings to more productive uses and reduce maintenance costs.

Energy management programs are flexible instruments that can be adapted to changing policy needs and changes in industry, thereby ensuring continued effectiveness and relevance. By continuously monitoring implementation and through regular evaluation, policy makers can identify opportunities to include new mechanisms or establish linkages to emerging policies.

In implementing energy management programs, governments can play an important role in establishing a framework to promote the uptake of energy management systems, by developing methodologies and tools and promoting the creation of new business opportunities in the area of energy services. Energy management programs offer the potential to achieve significant and sustainable savings at very low cost in the initial years.

6.4.3 Further Policy Attributes

Energy management programs are most effective when planned and implemented as part of broader energy efficiency agreements with the government. During the planning stage, the purpose of the program should be articulated, including inter-linkages with other policies. Important design steps include establishing what support systems need to be created to boost implementation, how progress will be monitored, and setting up plans for evaluating the results of the program.

The success of the energy management program is clearly correlated with the provision of appropriate resources and supporting mechanisms, including assistance, capacity building and training, and provision of tools and guidance during the implementation stage. [35] Some examples of energy management programs are given in Section 6.4.6.

6.4.4 Tools for Energy Management Programs and Systems

There are various approaches to implementing energy management programs in a country, or a region, depending on the existing policy framework, objectives, industrial composition and other country- or region-specific factors. However, some international tools exist (shown below) that can provide a template for these programs and a framework for companies implementing energy management systems. Some specific tools for the detailed analysis of the energy consumption of motors within an organization can be found in Section 6.8.8.

Policy Pathway Series: Energy Management Programs for Industry [22]

The International Energy Agency (IEA) and Institute for Industrial Productivity (IIP) Policy Pathway Series publication, Energy Management Programs for Industry, offers a structured approach for policy makers to implement an energy management program. The approach is divided into four phases, namely plan, implement, monitor and evaluate, and suggests ten critical steps, as shown in Figure 8.

Global Superior Energy Performance Energy Management Working Group [24]

The Global Superior Energy Performance (GSEP) Energy Management Working Group (EMWG) seeks to accelerate the broad use of energy management systems in industry and commercial buildings worldwide. The EMWG's 11 member governments work together to identify and evaluate energy management systems activities, opportunities, strategies, and best practices, working with industry and others as appropriate. By sharing their knowledge, expertise, and experience, the EMWG members:

- Build the business case: Make the private sector aware of the business case for energy management and its value in maintaining competitiveness.
- Provide support and resources: Provide guidance and resources to support implementation of energy management in GSEP countries.
- Set policy: Establish energy management as a key energy efficiency strategy for the industrial and commercial buildings sectors.

Participating governments include Australia, Canada, Denmark, the European Commission, India, Japan, Korea, Mexico, South Africa, Sweden, and the United States. Some details of the implementation of this program in the US are given in Section 6.4.6.

ISO 50001:2011, Energy management systems

The international standard ISO 50001:2011, Energy Management Systems – Requirements with guidance for use, is based on the management system model of continual improvement that is also used for other well-known standards such as ISO 9001, Quality Management Systems, and ISO 14001, Environmental Management Systems. This makes it easier for organizations to integrate energy management into their overall efforts to improve quality and environmental management. ISO 50001:2011 provides a framework of requirements for organizations to:

- Develop a company policy for more efficient use of energy.
- Fix targets and objectives to meet the policy.
- Use data to better understand and make decisions about energy use.
- Measure the results.
- Review how well the policy works.
- Continually improve the energy management system and energy performance.

UNIDO Guideline and the Toolkit [25], [26]

The remit of United Nations Industrial Development Organization (UNIDO) is to promote and accelerate inclusive and sustainable industrial development in developing countries and economies in transition. Their Cleaner Production Toolkit is a tool that has been developed to "train-the-trainer" to deliver cleaner production training to organizations. Its objective is to train and empower cleaner production experts who are in turn able to assist companies in implementing cleaner production. Chapter 4, Energy Analysis, focuses on energy management systems. The textbook accompanying the chapter describes the work entailed by a corporate energy analysis that will serve as a basis for a company's energy management system. The participants learn how to create and maintain an energy database for a company, based on which a corporate energy management system can be implemented to optimize the overall energy consumption. It covers the key aspects of a company's energy management system under five headings: organization, analysis and planning, monitoring, consulting, and implementation.

6.4.5 Recommendations

When considering the implementation of an energy management program for motors and motor systems, it is important to:

- Clearly define the purpose of the program.
- Identify what materials and/or training are necessary to achieve the desired outcomes.
  - Use established tools (such as ISO 50001 and motor specific calculators described in Section 6.8.8) where they already exist and develop training and new materials where necessary. Bear in mind that training may be required for both the target groups and for energy management consultants and auditors to support them.

PLAN	1 Define the programme role in the policy framework	○
	2 Design the programme	○
	3 Develop the action plan and secure resources	○
IMPLEMENT	4 Provide institutional assistance	○
	5 Promote the programme and recognise achievements	○
MONITOR	6 Establish what to measure and how	○
	7 Assess compliance	○
	8 Communicate results and outcomes	○
EVALUATE	9 Determine what to evaluate and how	○
	10 Revise and adapt the programme	○

Figure 8: Checklist for the Implementation of Energy Management Programs (Source [23])

- Develop guidance on how motor systems efficiency is to be considered within an energy management system, such as:
  - The definition of purchasing criteria, motor inventory list, guideline for replacement, requirement for installation or acceptance tests, requirements for repair.
  - The inclusion of purchasing recommendations (in cooperation with producers, suppliers and industry associations).
  - Design guidelines for the installation of new motor systems.
- To ensure active participation in the program, give careful consideration to how the program will be promoted and to any supporting mechanism for recognizing and communicating achievements. The program should consist of a balanced package of support, incentives and penalties for the target groups involved.
- Build mechanisms for monitoring the progress of participants and evaluating the success of the program into the program design. Decide what to measure and how and what level of reporting is required from participants to achieve this.

6.4.6 Policy Examples

Several countries have already implemented successful energy management programs. Depending on the country specific conditions and needs, different approaches have been taken.

Example: US Implementation of the Global Superior Energy Performance Partnership

In the US, the Energy Management Working Group of the Global Superior Energy Performance Partnership has been implemented under the Superior Energy Performance™ (SEP) program. This certification program provides industrial facilities with a transparent, globally accepted system for verifying energy performance improvements and management practices. It integrates ISO 50001 with the SEP Industrial Measurement and Verification Protocol and provides support to participants to implement ISO 50001, conduct system assessments, or verify conformity to SEP requirements for certification. A recent evaluation of the program[13] states that, "The implementation of ISO 50001 coupled with SEP energy performance targets results in quantifiable and significant energy (0.174 TBtu per year, on average) and energy cost savings (USD 503,000 per year, on average) for the nine facilities."

For more information see:
www.superiorenergyperformance.net

Example: Danish Agreement on Industrial Energy Efficiency

In Denmark, under the voluntary Agreement on Industrial Energy Efficiency program, participants are mandated to implement an energy management system according to ISO 50001 and have it certified by an external accredited certification body. If companies opt into, and comply with, the voluntary agreement, they receive a carbon tax reduction.

For more information see: www.iipnetwork.org

Example: Energy Management in Netherlands' Long Term Agreements

Within the voluntary Long-Term Agreements (LTAs) program in the Netherlands, participants are required to achieve negotiated energy efficiency targets and adopt an energy management system according to energy management systems specifications provided under the agreements. These specifications are not part of a standard (but the requirements are much alike the ISO 50001) and companies are not mandated to seek certification. Companies are also required to implement a broader and more strategic Energy Efficiency Plan and to submit yearly progress reports including details on the implementation of systematic energy management.

For more information see:
www.rvo.nl/subsidies-regelingen/meerjarenafspraken-energie-efficiency and [5]

Example: German Implementation of ISO 50001 for Tax-Re-Imbursement, Germany

From 2014 onwards, industrial companies in Germany must implement ISO 50001 if they want to receive energy tax re-imbursements. Since its announcement two years ago, this regulation has resulted in a high implementation rate of ISO 50001 in the German industry. In May 2014, about 3,500 German companies were certified with ISO 50001. This was about 50 % of the total certified enterprises worldwide.

6.5 Energy Audit Programs

6.5.1 Description

An energy audit is the systematic inspection and analysis of energy use and energy consumption of a system or organization with the objective of identifying energy flows and the potential for energy efficiency improvements.[2] The typical steps in an energy audit are shown diagrammatically in Figure 9.

Audit programs are policies and initiatives that encourage companies to undertake an energy audit. They may be mandatory or voluntary and usually include the provision of support in the form of audit tools and often assistance from professional energy auditors.

6.5.2 Policy Objectives and Target Audience

The objective of audit programs is to encourage and support companies to undertake an energy audit and thereby take the first step towards proactively understanding and managing their energy requirements.

Furthermore, the collation of energy consumption data through an energy audit program provides information that enables policy makers to react to current circumstances or to check the possibilities for the implementation of new methodologies or technologies.

2 From EN 16247: Energy Audits

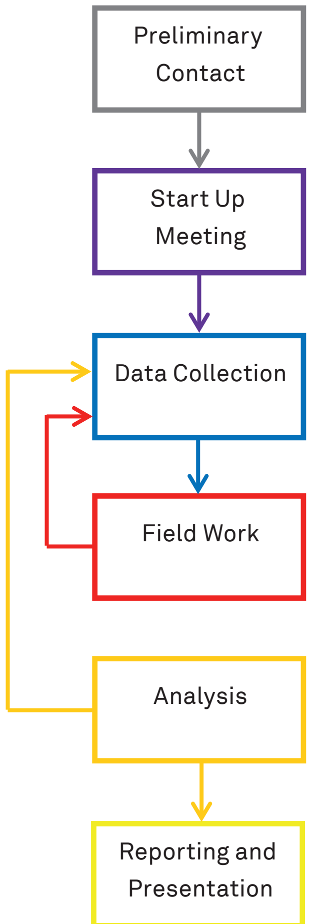

Figure 9: Energy Audit Steps According to EN 16247

6.5.3 Further Policy Attributes

Following an energy audit, which identifies energy saving opportunities, companies should then decide on an implementation and investment strategy. [16]

To encourage implementation of the recommended energy efficiency measures, energy audit programs are usually integrated with other policy instruments, such as an overarching legislative framework, financial incentive schemes (see Section 6.7) and voluntary agreement schemes (see Section 6.3).

Where energy audit programs are mandatory, they may require companies of a certain size, or with an energy consumption level above a certain threshold, to carry out an energy audit. Mandatory programs will usually achieve their objective more rapidly than voluntary programs and have a higher short term impact.

As energy audits only give a spot picture of the energy situation of a company, for maximum effectiveness they should be combined with energy management schemes which lead to continuous improvements in energy efficiency. Energy Audit programs typically include requirements covering:

- Intervals at which energy audits should be conducted.
- The specific auditing methodology to be applied.
- Minimum levels of qualification for energy auditors, e.g. certification.
- Reporting obligations.
- Definition of action plans for implementing the energy saving measures identified.

However, there is the risk that the energy audits conducted under mandatory schemes may be more superficial than under voluntary programs as they may be conducted for forms sake rather than because of true buy-in by the company and because of the higher number of companies that must be visited. [14]

Some examples of energy audit programs and standards for energy auditing are given in Section 6.5.5.

6.5.4 Recommendations

When considering the implementation of an energy audit program for motors and motor systems, it is important to:

- Clearly define the intended goals for an energy audit program, either in terms of the number of audits carried out or the energy savings achieved as a result of the measures identified. These goals will, in large part, determine the design of the program: a smaller volume of more detailed energy audits might bring in better savings than large numbers of a lighter walk-through-type energy audit model.
- Appoint an administrator (very often a government level body) and operating agent (e.g. an energy agency) for the program and, if required, establish a mechanism to authorize auditors to conduct audits on behalf of the program.
- Identify what materials (such as energy audit models, guides and information materials) are necessary to in-

form the target groups and support the energy audits. For example, for motor audits you may require energy audit reporting guidelines for different motor systems, energy consumption calculators for specific systems, and/or saving calculation methods for energy saving measures.

- Define how training and qualification (certification) of energy auditors will be organized, for example, for different kind of motor systems (motors and frequency drives, chillers, compressed air, fans and pumps).
- Define the content and scope of this training (for example, will it cover the checking of basic maintenance requirements during the audits) and, if relevant, the list of equipment which must be possessed by the auditors.
- Develop a definition of motor systems as an area to be considered within energy audits.
- Consider how the program will be promoted and integrated with other instruments (such as energy management programs and voluntary agreements) to ensure that the energy saving opportunities identified are implemented.
- Build mechanisms for monitoring the progress of participants and evaluating the success of the program into the program design – decide what to measure and how and what level of reporting is required from participants to achieve this.

6.5.5 Policy Examples

This section contains examples of mandatory and voluntary energy audit programs and of some of the standards that are in place (or in development) for energy auditing standards for motor systems.

Mandatory Audit Programs

Example: European Energy Efficiency Directive

According to the Article 8 of the Energy Efficiency Directive 2012/27/EU, the Member States of the European Union "shall promote the availability to all final customers of high quality energy audits which are cost-effective and carried out in an independent manner by qualified and/or accredited experts according to qualification criteria; or implemented and supervised by independent authorities under national legislation". In addition, Member States shall encourage small- and medium-sized enterprises to undertake energy audits and implement the recommendations from the audits. Larger enterprises must conduct an energy audit by 5 December 2015 and at least every four years after the previous audit. Enterprises with a certified energy or environmental management system are exempted, if the management system includes an energy audit. For more information, see: http://ec.europa.eu/energy/efficiency/eed/eed_en.htm

Voluntary Audit Programs

Example: Austria klima: active Program

As part of the klima: aktiv program, the Austrian voluntary program "energieeffiziente betriebe/Energy Efficient Companies" for small- and medium-sized enterprises focuses on motor driven systems (pumps, fans, compressed air and cooling systems), since these are technologies used in many different sectors. The first two years (2005-2007) were used to build up the program and discuss details with the Environmental Ministry of Austria (BMLFUW) and the regional programs.

The energy audits are subsidized by national and regional sources. A series of regional program managers are responsible for the authorization of energy auditors based on their professional experience and further training, and for quality assurance of the final audit reports.

Results of energy audits together with saving potentials are reported to the regional program managers. The individual company details, the name of the consultant and recommended actions and associated costs and savings are recorded in a partly public database, together with a list of the planned and implemented measures.

The program is supported by training, the preparation of audit guides and the development of an expert network, and includes a range of awareness-raising activities at a national and regional level.

For more information, see: www.klimaaktiv.at/english/savingenergy/SavingEnergy.html

Example: Swiss Motor-Check Motor Systems Energy Audit Methodology

The Swiss Agency for Efficient Energy Use (S.A.F.E.)[1] has developed the "Motor-Check", a motor systems energy audit methodology as a tool to identify and retrofit existing motor systems with the highest potential savings within an industrial plant. Motor-Check consists of four steps:

- First, the efficiency potential of the whole plant is assessed.
- Second, a list of motors is compiled representing the oldest, the longest running (operation hours per year) and largest (mechanical power) motors.
- Third, motors that appear to offer the greatest savings potential are selected and tested on-site. Where motors have very similar characteristics (e.g. conveyor belt motors), only one motor is tested and the results are applied to all similar motors. After the testing, a list of possible measures, investment costs and savings is created.
- Fourth, the identified measures are implemented.

S.A.F.E. has also developed software tools and guides to enable industrial users to carry out the Motor-Check methodology. These are further explained in Section 6.8.8.

S.A.F.E. applies the Motor-Check methodology coupled with grants for each of the four steps in the Swiss financial incentive program "EASY" ("Effizienz für Antriebssysteme" – efficiency for motor systems, see Section 6.7.5 for more details).

For more information see:
www.topmotors.ch/Motor_Check

1 S.A.F.E. is a non-governmental organization implementing motor market transformation programs on behalf of the Swiss government. For more information see: www.energieeffizienz.ch/home.html

Example: Dutch Green Deal Efficient Electric Motor Systems

The Green Deal Efficient Electric Motor Systems (GDEMS) is one of more than 100 projects within the Dutch Green Deal program[1] [27]. It was initiated at the end of 2012 by a consortium of 28 private companies (manufacturers and industrial service companies of efficient motor systems) and is scheduled to run until mid-2015. Its goal is to establish a standardized, systematic, step-by-step audit method for retrofitting motor systems applying best available technologies and life cycle costing principles, as demonstrated through the real-life application by 35 industrial users. The audit and retrofit programs are implemented in five steps:

1. Identify motor systems with efficiency potential.
2. Compile a list of improvement measures.
3. Measure the motor systems, identifying the savings options.
4. Develop the business case for investment, based on the savings opportunities.
5. Implement measures according to a multi-year investment strategy.

Important elements of GDEMS are:

- The involvement of motor suppliers and service companies. The suppliers carry out the analyses at the industrial sites where motors are used. In doing so, the suppliers learn to apply a new business model based on the promotion of efficient systems and the industrial users save energy and get to know the benefits of efficient motor systems.
- Best practices are made available to raise awareness and build capacity among suppliers, OEMs and industrial end-users. The knowledge transfer and exchange of experience is facilitated through a network of participants.
- Financing options (e.g. through ESCOs and other parties) are also investigated.

By the end of 2013, more than 10 industrial users have joined GDEMS from the dairy, metal, chemical industry and also water treatment plants.

For more information see:
www.greendealaandrijfsystemen.nl

1 initiated by the Dutch Ministry of Economic Affairs in 2011. For more information see: www.government.nl/issues/energy-policy/green-deal

Standards for Energy Audits

International

- **ISO 11011:2013, Compressed Air – Energy Efficiency – Assessment,** contains a framework for the assessment and auditing of compressed air systems.
- **ISO 50002:2014, Energy Audits,** specifies the process requirements for carrying out an energy audit in relation to energy performance. It is applicable to all types of establishments and organizations, and all forms of energy and energy use. It specifies the principles of carrying out energy audits, the requirements for the common processes during energy audits, and the deliverables for energy audits. It builds on the experience of the European standard EN 16247, Energy Audits.

Europe

- **EN 16247-1:2012, Energy Audits – Part 1: General Requirements,** defines the attributes of a good quality energy audit. It states the requirements for energy audits and corresponding obligations within the energy auditing process and seeks to harmonize common aspects of energy auditing in order to bring more clarity and transparency to the market for energy auditing services. The energy audit process is presented as a simple chronological sequence. Part 3 of this standard, **EN 16247-3:2014, Energy Audits – Part 3: Processes,** specifically addresses the energy auditing of processes, while Part 5, **EN 16247-5 Energy Audits – Part 5: Competence of Energy Auditors,** is currently under development.

United States

The ASME (American Society of Mechanical Engineers) [28] has published the following standards:

- **ASME EA-2: 2009, Energy Assessment for Pumping Systems,** covers pumping systems, which are defined as one or more pumps and those interacting or interrelating elements that together accomplish the desired work of moving a fluid. It addresses open and closed loop pumping systems typically used in industry, and is also applicable to other applications. This Standard sets the requirements for conducting and reporting the results of a pumping system assessment that considers the entire pumping system, from energy inputs to the work performed as the result of these inputs. It is designed to be applied primarily at industrial facilities, but many of the concepts can be used in other facilities such as those in the institutional, commercial, and water and wastewater facilities.
- **ASME EA-4: 20109, Assessment for Compressed Air Systems,** covers compressed air systems, which are defined as a group of subsystems comprised of integrated sets of components, including air compressors, treatment equipment, controls, piping, pneumatic tools, pneumatically powered machinery, and process applications utilising compressed air. The objective is consistent, reliable, and efficient delivery of energy to manufacturing equipment and processes. It sets requirements for conducting and reporting the results of a compressed air system energy assessment that considers the entire system, from energy inputs to the work performed as the result of these inputs. It is designed to be applied primarily at industrial facilities, but many of the concepts can be used in other facilities, such as those in the institutional and commercial sectors.

New Zealand

The Energy Management Association of New Zealand [29] works with the Energy Efficiency and Conservation Authority (EECA) and their members to establish technical standards and guidelines for getting the best performance out of industrial processes:

- **Fan Systems Audit Standard** – provides a comprehensive technical methodology and audit template for auditing compressed air systems.
- **Pumping Systems Audit Standard** – provides a comprehensive technical methodology and audit template for auditing pumping systems.
- **Compressed Air Systems Audit Standard** – provides a comprehensive technical methodology and audit template for auditing compressed air systems.

6.6 Company Motor Policy

6.6.1 Description

A motor policy provides a mid- and long-term strategy for the adoption of efficient motor systems throughout a company or plant, for integration within the company's business planning framework. The aim is to achieve the most cost-efficient motor systems justified under economic conditions. A motor policy typically covers the following aspects, discussed in the following section:

- A set of purchasing criteria.
- Establishing an inventory list.
- Requirement for installation or acceptance tests.
- Requirements for repair and maintenance.

6.6.2 Further Policy Attributes

Purchasing Criteria

A motor policy extends traditional purchasing criteria to include consideration of life cycle costs, the energy efficiency of the motor and the expected lifetime:

- Selection should be based on life-cycle costs: see Section 6.8.9. For example, IE3 motors (defined by IEC 60034-30) with an annual running time of 2,000 hours have lower life-cycle costs than IE1 or IE2 Motors. IE4 Motors have even lower losses (see also Section 8.1.3.).
- The actual lifetime of a motor can be 20 to 30 years or even longer (see Swiss analyses in Section 6.6.4.). This means that the benefits of high efficiency motors continue long after their payback time.

In addition, the track record of suppliers should be taken into account.

Purchasing specifications should include:

- Consideration of modern drives for variable loads (especially for pump and fan applications).
- The selection of high efficient drives (direct drives, high efficient belts), avoiding worm gears.
- The provision of technical information, dimensional drawing, installation and user manuals.
- Where relevant, specifications should cover the correct installation of the motor according to best practice and commissioning.

Motor Inventory List

A motor inventory enables companies to minimize equipment failure, reduce downtime and operating costs.

Due to the need to maintain operations, when motors fail they are often replaced by motors already in stock, and these may not be the most efficient models available. For the quick exchange of old motors by high efficient motors the following steps can be taken:

- Establish an inventory of motors in use with the most important parameters (focus on motors with running hours above eight hours a day).
- Draw up an inventory of motors in stock (name plate data and potential application).
- Establish a simple rule to identify when repair or replacement is useful, for example according to size (e.g. up to 30 kW), running hours and costs of repair. For developing this rule, costs of replacing the motor, price of electricity and the efficiency of a high efficient motor and of the old motor after rewind have to be considered.
- Draft a plan for replacing motors, depending on age, size, running time, time for maintenance:
  - Replace motors in use (if low efficiency and high energy demand) during factory downtime.
  - Replace failed standard motors by high-efficient motors.
- Arrange with your retailer to stock high efficient motors (IE3).
- For some critical motors and some motor sizes (e.g. up to 30 kW), carry your own stock of high efficient motors (if this is not done by your retailer).

Requirement for Installation or Acceptance Tests

Failure to pay attention to detail when commissioning electric motors and motor-driven equipment can reduce the efficiency, lead to higher operating costs and an increased risk of early motor or equipment failure.

A thorough commissioning should be done after:

- New equipment is installed.
- Existing equipment has undergone significant repair.
- There has been a significant change in the operating requirements of a machine.

During the commissioning process, the specifications of the supplied equipment should be checked to ensure they follow the process design requirements. It should be verified that the equipment is set up correctly, mechanically and electrically, in accordance with the original manufacturer's specifications, and that the equipment documentation is complete (installation requirements, operation guidelines and maintenance specifications).

Requirements for Repair and Maintenance

Motor rewinding is a common practice in industry, as it can be a cheaper and quicker solution than purchasing a new motor. However, the efficiency of an existing motor can be quite low because of its age and rewinding can reduce efficiency even further. Therefore, the economics of replacing a motor with a new model can compare favorably to those of repairing because of the gains in efficiency and higher operating hours. For small standard motors, rewinding is usually not the best option because the price of a new motor is cheaper than the price for repairing the old motor.

Nevertheless, motor rewinding is often economical for special purpose motors and AC-motors above certain sizes.

When rewinding is the selected path, the contractor should be approved by the motor producer. Specifications for the repairer should ensure that the repaired motor matches the original motor, and this should be verified by the production of test reports.

Relevant information for the selection of motor of the repairer is included in Section 6.6.4.

6.6.3 Recommendations

Policy makers should seek to maximize opportunities to integrate initiatives to support the wider adoption of motor policies within other policy measures, e.g.:

- Purchasing criteria for efficient motor systems should be integrated in energy management programs. Criteria could also be defined by industrial or manufacturer associations.
- National energy audit programs should be required to include motor inventory lists.
- Procedures for replacement, installation, repair and replacement should be integrated into energy management systems.
- Training on these issues should be provided to energy managers, installers, energy auditors and motor sales and distribution personnel.

6.6.4 Policy Examples

Example: Swiss Analysis of Motor Lifetime

An analysis of 4,142 motors in 18 Swiss industrial plants in the framework of the Swiss Topmotors and EASY programs (www.topmotors.ch) shed light on the evident need for implementing a company motor policy in industrial plants. 56 % of motors were already older than their expected lifetime, with one motor found to be 64 years old. The average age of all motors was double their life expectancy, as shown in Figure 10.

Example: Relevant Information for the Selection of Motors by the Repairer

- ISO 9001 certification
- ANSI/EASA Standard AR100-2010, Recommended Practice for the repair of rotating electrical apparatus
- Good Practice Guide To Maintain Motor Efficiency (EASA, AEMT), US 2003

Example: Swedish PFE

Within the Swedish Programme for Improving Energy Efficiency in Energy-Intensive Industries, purchasing criteria for motor systems were clearly defined. Companies within the program had to base their purchasing decisions on either a calculation of total life cycle costs or purchase an IE3 motor. See [5] and [23] for more details on the PFE program.

Further Reading Resources

- Department of Climate Change and Energy Efficiency, Australian Government (DCCEE) Electric Motors Reference Manual: www.climatechange.gov.au/what-you-need-to-know/appliances-and-equipment/electric-motors/reference-manual/commissioning.aspx (April 2013)
- Motor Planning Kit, Strategies, Tools, and Resources for Developing a Comprehensive Motor Management Plan, Version 2.1, www.motorsmatter.org

	0.75 kW to 1.1 kW	1.1 kW to 11 kW	11 kW to 110 kW	110 kW to 370 kW
years	10	12	15	20

Table 4: Average Life Time of an AC Motor Depending on Power (Source: [33])

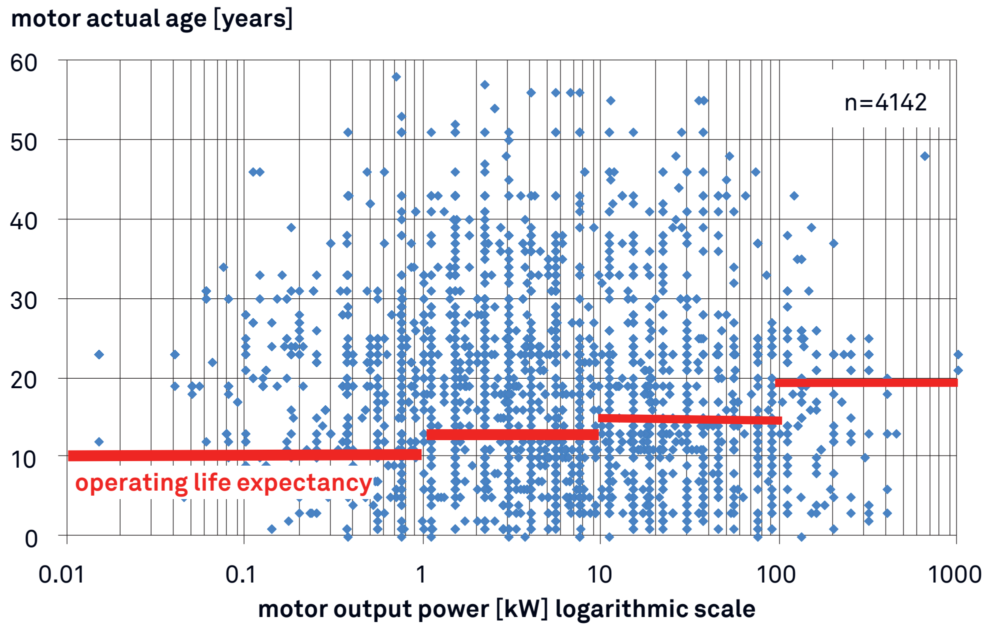

Figure 10: Analysis of Motor Age in 18 Industrial Plants in Switzerland (Source: S.A.F.E., 2014)
56 % of motors are older than their operating life expectancy; these older motors are 99 % too old.

6.7 Financial Incentives

6.7.1 Description

Financial incentives use the provision of a monetary benefit to individuals or organizations to encourage actions that might not occur otherwise. They include a range of tools, such as tax incentives, rebates, grants, loans and alternative financing or procurement (via public-private partnerships, utilities and equipment producers). Public institutions can also support lending institutions in the form of risk sharing. More details on the various financial instruments that may be employed are given in Sections 6.7.4 to 6.7.10, including some examples.

6.7.2 Policy Objectives and Target Audience

In this context, public policy aims to use financial incentives to stimulate demand and catalyze private investment in energy efficiency, with the ultimate objective of increasing the market share of highly efficient motor systems. Financial incentives are particularly useful to promote the latest efficient technologies and activities above the level defined by regulations or "business as usual".

Financial incentive policies achieve these objectives by helping to overcome the barriers to the adoption of more energy efficient technologies. For the industrial end-user, these include:

- High initial costs, including the cost of evaluating potential benefits.
- Access to internal funds for investing in energy efficiency: energy efficiency projects reduce energy costs over time and increase the net profit, but do not increase the gross revenue of enterprises, which is very often the focus of management.
- The very short (three years or less) pay-back periods usually required for investments in "auxiliary" services, which may not be met by energy efficient equipment.
- Potential financial losses as a result of business interruption during implementation of energy efficiency measures.

For financing bodies, these include:

- Lack of experience in financing energy efficiency projects.
- Relatively low value of energy efficiency equipment, which makes them unusable as collateral.
- Mistrust of the estimated benefits from energy efficiency projects.

6.7.3 Further Policy Attributes

When designing policies for a particular country, the selection of the financial instrument (or combination of instruments) depends on local conditions, the specific outcomes required and the particular obstacles to be overcome. It is also important to ensure coherence with other financial instruments applied within that country and to be aware of the strong inter-dependence of financial instruments with other policy instruments.

Public funds, whether from regional, national or international (World Bank, European Investment Bank, EU Structural and Cohesion Funds) sources have a limited size and duration. This should be taken into account as part of the policy design by building in additional tools to ensure the sustainability of the overall policy when the availability of public funding ceases.

The presence of regulatory frameworks, such as energy savings obligations and white certificate schemes, can facilitate the creation of additional cash flows, which improve energy efficiency project economics. [37]

After achieving 30 – 40 % market saturation, financial incentives have minimal effect on the transformation of the market. Therefore, any incentive should only be given for products with a small market share in order to reduce the level of free-riding and should support only products with the highest efficiency levels to provide incentives for further innovation. [34]

The following section describes the main financial instruments that are typically used as part of an overall motor systems policy.

6.7.4 Public-Private Financing Partnerships

Public-private partnerships for energy efficiency finance are mechanisms that use public policies, regulations or financing to leverage private-sector financing for energy efficiency projects. They include dedicated credit lines, risk sharing facilities and energy saving performance contracting. The main elements of public-private partnerships are an agreement between a public entity and a private organization for the allocation of risk between the public and private partners, in order to encourage financing and mobilization of increased project financing, and payments to the private sector for delivering services to the public sector. [35] Public-private partnerships are mainly used at local level. [36]

Dedicated Credit Lines

Dedicated credit lines operate to encourage financial institutions to make funds available for energy efficiency projects. Governments and/or international financial institutions (IFI) provide funds at low-interest to local financial institutions (LFI), which they on-lend at a higher interest rate (but usually at lower-than-market interest rate) to project developers of energy efficiency projects. The credit line also assists in enhancing the technical capacity of the LFI and in establishing new businesses. The agreement between public and private partners stipulates the criteria for eligible projects and the co-finance requirements for the LFIs. Usually, projects funded are required to achieve a certain minimum level of energy savings and GHG emission reductions (e.g. kg CO_2/USD invested). The project financing risk is shared between partners. [35]

Dedicated credit lines work well in situations where there is limited liquidity for energy efficiency financing, limited knowledge and understanding of energy efficiency projects and lack of LFI capacity to evaluate projects and manage risks. For dedicated credit lines to be successful, the LFI partners must be selected according to their number of clients in the targeted market and their management commitment. Supervision by the public partner and implementation support is important. [35]

Risk Sharing Facilities

Risk sharing facilities address the perception of LFIs that energy efficiency projects are more risky than conventional lending. [35] The most common examples of risk-sharing facilities are publicly backed partial risk guarantees or partial credit guarantees. [35]

By sharing the risk, the public partner reduces the risk to the private-sector thereby mobilizing finance and enabling project developers to benefit from lower interest rates. Risk sharing facilities usually include technical assistance and capacity building for the LFIs to increase their knowledge and understanding of energy efficiency projects.

In a typical risk sharing program, a public agency (government or donor agency) signs a Guarantee Facility Agreement (GFA) with the participating LFI to cover a portion of their potential losses from loan defaults [3]. In turn, the LFIs sign agreements with project developers, specifying loan targets and conditions, and are responsible for conducting due diligence and processing the loans. The project developers repay loans to the LFIs. [35] From a consumer perspective, loan guarantee programs make access to funding for energy efficiency projects easier and, because of the lower risk premium, at a lower interest rate.

Energy Saving Performance Contracts

In the case of energy saving performance contracts, the public sector provides no direct financing, but creates the enabling legislative and regulatory frameworks and facilitates the negotiation of performance contracts between public agencies and energy service companies (ESCOs) that lead to financing from the private sector. They are appropriate in a mature commercial financing market, where LFIs have both the liquidity and the understanding and willingness for energy efficiency project financing. [35] The operation of these contracts by ESCOs is discussed in Section 6.7.9.

6.7.5 Grants and Rebates

Grants and rebates are very useful to bring existing high efficiency products or new technologies into the market. They reduce the upfront cost of energy efficiency projects, increase the financial rate of return on investment and improve cash flow, thereby increasing investors' access to debt finance. They can also raise the general awareness and trust in energy efficient technologies, but often have limited duration for budgetary reasons.

Programs may offer grants or rebates directly to the consumer or provide incentives to retailers to encourage them to carry more energy efficient products or to remove inefficient models from their product line.

Alternatively, subsidies may be given directly to manufacturers or retailers/distributors to reduce the wholesale price of energy efficient appliances ("buy down"). This form of program is called an "upstream distributor rebate program".

The advantage of distributor or manufacturer programs is that they leverage investment, reduce administrative costs (as there are a relatively small number of manufacturers and distributors compared to consumers) and increase product availability at the point of sale and therefore accelerate market transformation. [42]

The instrument relies on:

- Defining clear criteria for the efficiency of qualifying product. National MEPS, high efficiency products (HEPS: High Efficiency Performance Standards) or international standards may be used as the foundation for this definition. These efficiency levels should increase with technical progress over the duration of the instrument.
- A transparent definition of the grant or rebate amount, which clearly states any variation in the amount relating to product specification or use e.g. motor size or level of protection against wet environments. Amounts will usually also vary for a product bought for a new application or as a replacement for an old motor. Replacement programs give an incentive for replacing inefficient equipment before the end of their useful lives with significantly more efficient equipment.

Care should be taken to ensure the program is not too complicated and that the timescale for its availability is appropriate. The duration should be long enough for market actors to become informed on the instrument and make a decision, but short enough that the availability of the grant or rebate does not distort the normal pricing of the product (making them more expensive than they would be without the instrument).

For motor systems, these programs should also ensure that the size (power) of the motor being purchased under the scheme is appropriate for the given application. This can be achieved by establishing installation rules and providing training and information workshops for approved or certified installer companies on aspects of appropriate selection and installation of electric motor systems.

3 Typically, the percentage of the loss covered is 50 %.

Example: Swiss EASY Program Using Grants to Encourage Motor Systems Retrofits

In Switzerland, the Motor-Check methodology (see Section 6.5, Energy Audit Programs and Section 6.8.8, System Optimisation Calculators) has been developed to help companies identify and retrofit existing motor systems with the highest potential savings within an industrial plant. The pilot program "EASY" (Effizienz für Antriebssysteme – Efficiency for Motor Systems) was set up in 2011[1] and is working with ten industrial and infrastructure plants to retrofit higher efficiency motor systems. The program uses the provision of grants to help these companies overcome the barrier of undertaking the preliminary analyses required by the Motor-Check methodology by giving a higher grant (in relation to the total cost of each step) for these stages than for the final implementation stage. This is shown graphically in Figure 11. The funds for the program are secured through a surcharge on the electricity tariff. For further information see: www.topmotors.ch/Easy

1 And scheduled to run until 2014.

Sequence	Measures	Subsidy
Step 1	Efficiency potential	100%
Step 2	Motor list	75%*
Step 3	On-site test	50%
Step 4	Implementation	10%

* min. 25 %, max. 75 %.

Figure 11: Grant Scheme of the Swiss Easy Program (Source: S.A.F.E., 2014)

Example: Xcel Energy® Colorado Equipment Efficiency Using Cash Rebates to Encourage the Purchase of Higher Efficiency Motor Products

Xcel Energy Colorado is an electric and gas company that offers cash rebates for its business customers for specified higher efficient motors, drives, constant speed motor controllers, and EC motors (electronically commutated motors) for refrigeration applications. Rebates are available for new motors or for upgrading operating motors (between 1 – 500 horsepower (hp); motors above 500 hp have special conditions). The rebate varies by power, application, and efficiency level. The rebates for 1 hp motors drives are USD 600, increasing to USD 12,000 for drives for 200 hp motors which operate pump or air movement devices (with a maximum rebate of 60 % of the total installed cost). The rebate applicable for drives on non-fan or non-pump motors, or equipment larger than 200 hp, is on an individual basis.

A rebate of USD 15 per hp is available for the constant speed controller for escalators, moving walkways and conveyors or grinders. This also applies to any industrial commercial applications that cannot be shut off or slowed down during normal business operation, and operate at a load factor of less than 20 % more than 65 % of the time (constant speed motor controller rebate application, Xcel Energy®, 2013).

A rebate of USD 40 is available for the replacement of shaded pole motors with electronically commutated motors within low temperature (freezer) or refrigerated display cases. A rebate of USD 70 is available for replacing shaded pole motors within walk-in refrigerators walk-in freezers.

For more information see: www.xcelenergy.com

6.7.6 Loans

Through this instrument, governments and/or international institutions may give a direct subsidy on interest payments or may provide guarantees for loans (as discussed in Section 6.7.4). These programs have the advantage of increasing access to finance for energy efficiency projects and may also help to increase the awareness for energy efficient equipment. However, securities are usually still needed for the company and energy savings often have to be proved in the beginning. Sometimes the limitation of liability is also a relevant aspect. Loans with special conditions are often referred to as "soft loans" and may include:

- Loans with extended payback periods.
- Loans made at low or zero interest rate.
- Loans made with a short-term interest deferral period.
- Loans made with a payback grace period (e.g. no payback in first year).

Example: German Development Bank KfW Providing Low Interest Loans for Environmental Protection and Energy Saving Projects

As of 1 January 2012, the German Development Bank KfW has introduced two programs, the KfW Energy Efficiency Program and KfW-Environment Program. These programs provide very low-interest loans for the financing of environment protection and energy saving investments for private companies and self-employed persons. The interest rates of the loans depend on the project as well as the applicant and start from 1.26 % effective interest rate per year. In the energy efficiency program, the maximum loan amount is EUR 25 million. The financing share can be up to 100 % for small companies. Lenders can receive up to three repayment-free start-up years, depending on the running time of the loan. Topics of the financing can be, for example, motors, pumps, compressed air and other investments. Replacement-investments have to lead to a specific energy saving of at least 20 %, compared to the average energy consumption during the last three years. New investments have to lead to specific energy savings of 15 % compared to the branch average.
For more information see:
www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/Finanzierungsangebote/Energie-effizienzprogramm-%28242-243-244%29/#2

6.7.7 On-Bill Financing

On-bill financing is an alternative financing mechanism where the purchase and installation of efficiency measures are paid either by the utility or one of its financial partners, and a charge is added to the participants' utility bill until all costs are repaid. This helps overcome the financial barrier to energy efficiency investment by improving access to finance and reducing, often substantially, the cost of the investment. It also provides a relatively simple mechanism for facilitating the processing and collection of loan repayments.

This instrument is often used in conjunction with rebates, grants, or tax incentives for energy efficiency products to further reduce the upfront costs. [40] The majority of existing programs rely on a public funding source (grants or loans) and/or ratepayer funds for capital but could also be financed by shareholder funds or on private basis, e.g. by Community Development Financial Institutions, local banks or large commercial banks.

The major barrier to on-bill financing is that utilities may not have the expertise, the human resources, or the desire to become lending institutions. In addition, this system may require an adaptation of a billing system and the program costs may have to be approved by the regulator. [40]

Example: San Diego Gas and Electricity Providing Zero-Percent On-Bill Financing for Energy Efficiency Improvements

San Diego Gas and Electricity (SDG&E) offers eligible customers zero-percent financing for qualifying energy-efficient business improvements with loan repayment through the monthly utility bills. This on-bill financing works in conjunction with SDG&E's rebate and incentive programs.

On-bill financing is available to any commercial or government-funded customer participating in an energy efficiency rebate or incentive program. For commercial customers, loans must have a minimum of USD 5,000 financed and a maximum up to USD 100,000 per electric meter, with a simple payback of no more than three or five years depending on installed equipment. Loan funds must be used for the purchase and installation of qualifying energy efficiency measures. The equipment must meet the requirements listed in the Rebate Application and the Product Catalogue and all equipment must be new. As an example of the product catalogue specification, the variable frequency drives (VFDs) requirements are:

- VFD incentives are for fan applications on HVAC systems.
- The maximum fan size is 100 hp.
- The installation of a VFD on a HVAC fan is eligible for a rebate only if throttling devices, such as inlet vanes, bypass dampers and throttling valves, are removed or permanently disabled.
- A 3 % impedance choke is recommended.
- Rebate is USD 8,000 per unit.

For more information see: www.sdge.com

6.7.8 Tax Incentives

Tax incentives improve the economic parameters of energy efficiency projects through incentive regimes related to capital gain tax, value added tax (VAT), accelerated or free depreciation.

- **Accelerated depreciation** on investments in specified equipment allows companies investing in energy saving technologies to depreciate it at a faster rate, entailing lower corporate tax.
- **Tax credits,** or **tax relief,** offer a reduction in the amount of income tax payable, whereby a percentage of the investment cost of approved technologies can be used to offset corporate profit taxes.
- **Differentiated VAT** may reduce the VAT payable for environmentally friendly products and goods related to energy savings.

Tax incentives have the same effect as a direct grant but have the advantage that they do not require any special grant applications and use the existing tax administrative regime. However, in the same way as grants, they have a burden on public budgets.

Example: UK Government Enhanced Capital Allowance Scheme

The UK Government's Enhanced Capital Allowance (ECA) scheme supports businesses with the possibility to write off the capital costs of the investment in certain energy saving equipment (e.g. boilers and motors) against their taxable profits.

If a business bought a new electric motor for GBP 1,000, claimed the general rate of capital allowance (which is 18 %) and paid 21 % corporation tax, the tax relief would be GBP 37.80 of GBP 210 in the first year, with the possibility to have further tax relief in subsequent years.

If the business bought a motor qualifying for the Enhanced Capital Allowance as it has higher efficiency, then it can claim a 100 % first year capital allowance, giving a one-off 100 % tax relief of GBP 210.

For more information see:
https://etl.decc.gov.uk/etl/site.html and [5]

Example: Energy Investment Allowance in the Netherlands

This tax relief program gives a direct financial advantage to Dutch companies that invest in energy-saving equipment and sustainable energy. 41.5 % of the annual investment costs of such equipment (purchase costs and production costs) are deductible from fiscal profits over the calendar year in which the equipment was procured. The "Energy List" determines which types of equipment qualify for this program. The program includes the costs of obtaining energy advice, provided that the advice results in an investment in energy-saving equipment. The report detailing the action plan for electric motors, following the example of the European Motor Challenge Programme, is also included in this list (see section European Union).

For more information see:
http://english.rvo.nl/subsidies-programmes/energy-investment-allowance-eia – National Office of Entrepreneurial Netherlands

6.7.9 Contracting and ESCOs

Contracting offers a mechanism for companies to share the risk of implementing energy efficiency improvements and, depending on the model used, remove the barrier of accessing financing for up-front costs. Public authorities can create the enabling environment through legislative and regulatory changes that facilitate the implementation of contracting but the use of this model in the public sector is the first step to create the market.

Under an **energy saving performance contract** arrangement, an external organization, usually an energy services company (ESCO), implements a project to deliver energy efficiency and uses the stream of income from the cost savings to repay the costs of the project, including the costs of the investment. The business model is based on delivering savings compared to a predefined baseline. Customers pay for the services from a portion of the actual energy cost savings achieved. [43]

ESCOs can offer complete services, including design, engineering, construction, commissioning, and operation and maintenance of the measures, as well as training of the staff, and measurement and verification of the resulting energy and cost savings. [35]

A limitation of this instrument is the ability to determine the baseline. This is especially true for production companies, where production output, in terms of quality and amount, varies over time and there are changes in process and auxiliary equipment. ISO 50015, The International Performance Measurement and Verification Protocol (IPMVP), which includes mathematical modelling for determining the baseline, can be used to overcome this.

To date, most energy saving performance contracts have been in the building sector, while in the industrial sector the focus has been on lighting refurbishments, where determining the baseline can be simpler. Recently, VSD manufacturers have started to install their equipment using an ESCO delivery model and use the ESCO to provide the audit, arrange the financing and monitor the savings. [44]

In a variation on this concept, the **energy supply contracting** (ESC) model, the ESCO provides a service, such as compressed air, to the industrial user rather than the equipment itself.

For this instrument to be successful, accreditation systems should be put in place to provide a quality assurance framework for energy auditing, contracts and measurement and verification procedures.

Example: NAESCO Accreditation Program

In the US, the National Association of Energy Service Companies (NAESCO) is sponsoring an accreditation program: NAESCO offers three categories of accreditation for companies in the energy service business, namely Energy Service Company (ESCO), Energy Service Provider (ESP) and Energy Efficiency Contractor (EEC).

ESCOs develop and implement turnkey, comprehensive energy efficiency projects. ESCOs offer performance-based contracts (i.e. contracts that tie the compensation of the ESCO to the energy savings generated by the project) as a significant part of their business. To gain accreditation, ESCOs must demonstrate the technical and managerial competence to design and implement projects involving multiple technologies, including: lighting, motors and drives, HVAC systems, control systems, and building envelope improvements.

ESCOs must also demonstrate the ability to provide the full range of services required for a comprehensive energy efficiency project, including: Energy Audits, Design Engineering, Providing or Arranging Project Financing, Construction Management, Commissioning, Operations and Maintenance of Energy Efficiency Technologies, and Verifying Energy Savings.

www.naesco.org/accreditation-categories

6.7.10 Leasing

Leasing of equipment addresses the main arguments against energy efficiency investments: limited budgets and long pay-back times. A lease is a contractual arrangement calling for the lessee (user) to pay the lessor (owner) for use of an asset. The duration of the contract has to be between 40% and 90% of the legal depreciation period. Companies tend to use the longer duration because of lower monthly payments. A shorter time period would confer similar advantages as an enhanced allowance. At the end of the leasing period, the industrial company can usually purchase the equipment at the residual value or return the equipment to the lessee. Until this time, ownership stays with the lessor, which guarantees liquidity protection and balance-sheet neutrality. No collateral security is needed and there are no initial costs. The lease rentals for energy efficiency investments can be paid from the energy savings and are fully tax deductible (for loans only the interest rates are tax deductible).

Example: Atlas Copco Leasing of Compressed Air Systems

Atlas Copco offers an operational lease where against monthly payments a new compressor and/or dryer can be used for three years. After this time period, the compressor can be purchased or be returned. A quarterly maintenance checklist must be completed by customer, or contracted to complete. Genuine manufacturer OEM parts and oil must be used and maintained in equipment.

For more information see: www.jhf.com/home/services/compressed-air/rental-leasing

6.7.11 Recommendations

Financial incentive programs are used increasingly by government and utilities across the world to complement other energy efficiency policies, such as labeling programs. They work best with well-designed and carefully prepared program setup, namely with clear and comprehensive rules and procedures, the right allocation of funds and consistent information for potential applicants to ensure a high uptake of funds. [36]

When considering the development of a financial incentive program, it is important to:

- Ensure that there is a clear understanding of the barriers that are sought to be overcome and clearly define the specific outcomes of the financial incentive program.
- Select the appropriate instrument, or combination of instruments, to achieve this goal and, when using a best-practice model from another country, ensure that it is tailored to local circumstances.
- Review the instruments selected in the light of existing financial instruments and other policy instruments to ensure coherence and added value.
- Seek active engagement from stakeholders, such as trade associations and manufacturers, both when developing the policy and at implementation.
- Carefully consider the expected duration of the program: it should be long enough to have an impact but short enough to avoid distorting normal market pricing and to minimize free-riders.
- Ensure that the program design is transparent and as simple as possible and that the products to be supported are commercially available and ready for adoption.
- Consider the sustainability of the overall policy when the availability of public funding ceases.
- Build in an evaluation mechanism to monitor the progress of the program and its impact.

6.7.12 Policy Sources

This section signposts some general sources of information on financial incentives.

> **Example: Overview on Financial Incentives, DSIRE**
>
> DSIRE is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States. Established in 1995, DSIRE is currently operated by the N.C. Solar Center at N.C. State University, with support from the Interstate Renewable Energy Council, Inc. DSIRE is funded by the U.S. Department of Energy.
> For more information see: www.dsireusa.org

> **Example: CEE 2012 Summary of Member Programs for Motors & Motor Systems**
>
> The Motors & Motor Systems (M&MS) Committee of the Consortium for Energy Efficiency (CEE) recently developed and published the 2012 CEE Motors & Motor Systems Program Summary. This searchable spreadsheet identifies programs offered by CEE members that target efficiency opportunities in motor-driven systems and equipment.
> For more information see:
> http://library.cee1.org/content/cee-2012-summary-member-programs-motors-motor-systems

6.8 Raising Awareness and Information Provision

6.8.1 Description

In the context of this guide, information provision refers to the development of materials for end-users to equip them with information and tools to help them to understand the general benefits of installing more efficient motor systems and to assess the level of savings that they could achieve in their own situation. This includes:

- General awareness-raising material and activities, such as best-practice case studies and energy efficiency awards.
- Technical assistance materials, such as guides and training.
- Self-assessment materials, such as energy saving/system optimization calculators, life-cycle costing methodologies and benchmarking tools.

This section presents specific examples of information provision activities and materials and signposts some general information sources.

6.8.2 Policy Objectives and Target Audience

Lack of information is often one of the main reasons why companies do not consider energy efficiency measures, with decision makers either unaware of the energy saving technologies available or of how they might be implemented within their own organization. The objective of an information provision policy is to overcome this barrier by targeting key personnel and decision makers within companies to fill this information gap.

Many personnel within an organization are responsible for decision-making. It is therefore important when planning an activity that the information materials target each of these personnel with information appropriate to their needs. For example, the:

- Financial director will be interested in a thorough financial analysis of energy saving projects.
- Technical Manager/Operations Manager/Chief Technology Officer will be interested in the impact on the production and maintenance processes.
- Marketing Director is responsible for the reputation of the company and will therefore be interested in the environmental benefits and the overall profitability of the project.
- Regulatory Affairs Officer is responsible for ensuring that the company complies with laws and other legal requirements and will be interested in these aspects of an energy efficiency project.

6.8.3 Further Policy Attributes

Information materials are only of benefit if they reach the target audience. It is therefore important that the materials are integrated into a coherent awareness-raising or communications campaign, where they will often complement and reinforce other policy tools. When targeting industrial consumers, traditional public relations channels such as radio and television advertising are usually not cost effective. Communications campaigns in this context will therefore tend to focus on trade press and shows, industry trade associations and cooperation with large multiplier market partners such as wholesalers.

A full discussion of awareness-raising and communications campaigns is outside the scope of this guide. However, the following section describes a range of information provision activities and materials that can be used as part of an overall motor systems policy.

Example: Austrian "klima:aktiv" Climate Protection Program Using Large Multiplier Market Partners to Communicate With Target Audience

The Austrian climate protection program "klima:aktiv" uses market-partners, in particular, large multipliers (e.g. wholesalers) for specific technologies, to answer the need of companies for very detailed and professional support. Information on these advanced technologies is spread via newsletters and conferences and technical specialists of the market partners are invited as trainers for workshops for energy managers and energy auditors. In return, the promotion partners are allowed to use the klima:aktiv logo that is already well known in Austria and gives a "green ID" to the companies.

6.8.4 Best Practice Case Studies

The use of case studies to highlight examples of best practice is an extremely useful awareness-raising tool. By sharing actual examples with the target audience, it allows them to better identify with the technology and its potential benefits for them. Once developed, case studies are very versatile and can be used in many ways as part of a communications campaign, for example, for publication on websites, in presentations, in articles in trade press or online, in fact sheets and brochures, or as the basis for interviews.

To maximize their effect, case studies should:

- Be tailored to the sector and audience being targeted.
- Be concise and clearly formatted, following a standard structure.
- Include contact details for further information or action.
- Use a combination of text, graphs and diagrams and photographs to make the key messages as accessible as possible.
- Clearly describe the main characteristics of the motor driven system before and after implementation of the energy saving measures.
- Quantify the energy consumption and energy costs before and after optimization and clearly identify the savings achieved.
- Clearly present the investment costs and pay-back time.
- Take care to avoid publicizing confidential or sensitive information about the featured company.

They may also use testimonials or quotes from the company involved to give added authority and objectivity.

Companies for case studies may be recruited through technology providers or planning companies, via subsidized energy audits or awards programs.

Example: Australian Energy Efficiency Exchange Website Sharing Best Practice Information

The Australian Energy Efficiency Exchange website supports the implementation of energy efficiency practices within medium and high energy-using companies. It shares best-practice information on energy efficiency, case studies and resource materials from Australia and overseas.

For more information see: http://eex.gov.au

Example: US Department of Energy Using Industrial Assessments to Provide Case Study Examples

The US Department of Energy offers a limited number of no-cost, one-day assessments for small- and medium-sized industrial plants, focusing on savings through improved energy efficiency and productivity and reduced waste and pollution. The assessments are carried out by university students from one of the 24 Industrial Assessment Centers at 32 participating universities across the country. The assessments, and the subsequent recommendations including cost and savings calculations, are publicly available in the Industrial Assessment Centers Database (http://iac.rutgers.edu/database), thereby providing examples for other companies.

The program has been running since 1976. In February 2014, there were more than 16,000 assessments and 122,000 recommendations listed in the database, which can be searched by assessments and recommendations and filtered by different criteria. Selected success stories are also available as formal case studies (http://iac.rutgers.edu/case_studies).

If the plants implement the recommendations and achieve total energy savings of more than 7.5 % (Save Energy Now Energy Saver Awards) or 15 % (Save Energy Now Energy Champions), they will be awarded and publicly recognized. See http://iac.rutgers.edu/energy_awards.php for more details.

6.8.5 Energy Efficiency Awards

High profile awards programs offer a useful tool for raising the profile of energy efficient technology and their benefits and may form part of a wider communications campaign. They reward companies for their progressive approach (usually through recognition and endorsement, but sometimes through financial means) and also provide a very good instrument for collecting best-practice case studies.

Awards should be organized by a credible institution (e.g. the relevant ministry). The recognition of the award ceremony can be raised through the presence of a prominent person (such as the minister) who can hand over the awards. The categories (e.g. pumping systems, compressed air in industrial companies) and criteria should be transparent and clear and an expert jury should evaluate the projects. Criteria can be the transparent calculation of energy savings, including metering, innovation character or possibility to multiply the measure, amount of energy saved, and others.

In addition, partnerships with the media (e.g. newspapers, websites, television, or radio) may increase public awareness.

Example: Austrian Energy Agency Uses Energy Efficiency Awards to Collect Case Study Examples

The Austrian Energy Agency invites companies, consultants and technical service companies to report on their successfully implemented energy efficiency projects on an annual basis. The best examples are selected and are awarded by the Minister of Environment. In conjunction with this ceremony, the Austrian Energy Agency organizes an annual conference for energy efficiency in production companies. From 2008 – 2013, companies reported best practice case studies amounting to total energy savings of 430 GWh/a electricity and heat, corresponding to 138,109 tonnes of CO_2. The contact and cooperation between the program and the companies were intensified by this procedure. All projects are summarized in a fact sheet and published online.

For more information see: www.klimaaktiv.at/energiesparen/betriebe_prozesse/vorzeigebetriebe.html

Example: SEAD Uses Energy Efficiency Competition to Promote Energy Efficient Electric Motors

The Super-Efficient Equipment and Appliance Deployment (SEAD) initiative of the Clean Energy Ministerial has launched a Global Efficiency Medal competition for Electric Motors. The goal of the competition is to recognize the world's most energy efficient electric motors. This shall help in finding the most efficient products and encourage technological innovation by showing the levels of efficiency that can be achieved with commercially available and emerging technologies.

There are four geographic regions, two induction motor award categories, and two new technology motor categories in which motor manufacturers could nominate their most efficient products (see Table 5):

- Australia, Europe, India, North America
- Induction motors
  - NEMA design at 5 HP and 15 HP
  - IEC design at 4 kW and 11 kW
- New technology motors (<75 kW and <100 HP)

Applicants may only nominate their products if they meet the minimum shipment criteria (number of motor units shipped for sale) in the respective region.

The global winners will be determined by selecting the most energy-efficient product in each category from among the regional winners. Winning products will be marketed using the SEAD Global Efficiency Medal. This enables end-users to easily find and procure super-efficient motors on the market.

Nominations were received until 31 January 2014. Winners are expected to be announced at the Motor Summit 2014 in Switzerland (see Section 8.3.4).

Further details and official rules:
www.superefficient.org/motorawards

Figure 12: SEAD Global Efficiency Medal
(Source: www.superefficient.org)

6.8.6 Guides

Technical literature on motor driven systems usually does not have a focus on energy efficiency and lacks examples for practitioners. Furthermore, it is often dedicated to specialists or academic students or may be issued in the form of standards, such as for energy auditing. An information provision policy may therefore address this information lack by providing guidance for end-users that focuses on the energy efficiency aspects of the technology. Such guides can provide a very useful communications tool and complement existing technical material. Guides should usually target energy managers in an organization, or energy consultants in the target sectors, and address specific motor systems, such as pumps, fans, cooling equipment, and compressed air systems. This equips these individuals with the information to make an assessment of the opportunities for, and benefits of, energy efficiency in their own situation.

Guides and connected tools should include the following content:

- Basic information on the technology, with a focus on energy efficiency.
- A systematic approach to optimizing the system, including:
  - Data sheets for the technology components.
  - Procedures for measuring or methods for calculating the energy demand and other costs of the system.
  - Information on possibilities to save energy within the system, including approaches to calculate the energy savings and costs of those measures.
- Information on maintenance and potential energy savings.
- They can include tips for the implementation of the saving measures within the organization.
- Information on the benefits of purchasing energy efficient components, including specific purchasing recommendations.

Once developed, guides provide a tool to help the target audience take the next step from awareness to action.

6.8.7 Training

Training of key personnel (energy managers, energy technicians and energy auditors, electricians) is crucial when installing new equipment, especially when adding a component to existing motor driven systems. Through the provision of training programs that include a focus on optimizing the energy efficiency aspects of new equipment, policy makers can increase the understanding of energy efficiency in motor driven systems, explain the importance of maintenance and increase the quality of energy audits or saving calculations. This will in the long run lead to more efficient motor systems. The operation of training programs will also help to build better engagement with the different target groups.

The training topics will vary depending on the target group, the planned duration of the training, the pre-qualification of the trained personnel and other aspects, but may cover:

- General introduction of the technological field.
- Use of the audit guidelines or software calculation programs.
- Monitoring and/or data collection and metering of the systems.
- Specific energy efficiency topics, such as leakages for compressed air systems, effects of the installation of frequency drives.

In all cases, the technical content of the training should be appropriate for the target audience and trainers should be experts with extensive experience in this field.

Training may also be provided for energy auditors, and may be a mandatory requirement for certification. The inclusion of pilot audits and/or tests for each motor system covered should be used as indication of competence, and it is good practice to introduce mandatory follow-up training or exams. Details of qualified auditors or experts passing the tests can be published on relevant websites.

Example: Indian Institute of Social Welfare and Business Management Providing Training for Energy Managers and Auditors

The Indian Institute of Social Welfare and Business Management offers a "Short-Term Certificate Course on Energy Management and Audit" to help prepare candidates for the Bureau of Energy Efficiency (BEE) examinations for certified energy managers and certified energy auditors, under the Energy Conservation Act 2001. The courses include an element on motor systems in industrial appliances.

For more information see:
www.energymanagertraining.com/new_energy_course.php

Regional Awards	IEC Induction Motor			NEMA Induction Motor		New Technology Motor	
	3.7 kW	4 kW	11 kW	5 HP	15 HP	< 75 kW	< 100 HP
Australia		•	•			•	
Europe		•	•			•	
India	•		•			•	
North America	•		•	•	•	•	•
Global Awards		•	•			•	

Table 5: SEAD Motor Award Regions and Categories (Source: www.superefficient.org/motorawards)

Example: Swiss Training Program for Energy Technology and Management in Industry (ET&M)

In Switzerland, a new training program is being developed, combining energy technology with a focus on electric motor systems efficiency and energy management (based on ISO 50001, Energy Management). The goal is to enable personnel with the necessary technical and managerial skills to implement energy efficiency projects in industry. This requires:

- Being able to convince top management to invest in motor systems retrofit projects (a package of projects can easily add up to several hundred thousand EUR making the total investment a management decision).
- Being able to work with people across different departments, e.g. convince the purchase department for buying a more efficient (and more expensive) motor system, applying life cycle costing over the payback period approach.
- Being able to negotiate with motor and machine suppliers and service providers, e.g. insisting on a more efficient solution while not being intimated by threats of ceasing warranties on either the machine or the service.

For more information see: www.topmotors.ch

Example: Publication of Lists of Qualified Auditors or Experts

US Department of Energy, Energy Efficiency and Renewable Energy: www1.eere.energy.gov/manufacturing/tech_assistance/qualified_specialists.html
Austrian "klima:aktiv" Climate Protection Program: www.klimaaktiv.at/energiesparen/betriebe_prozesse/beratung_foerderung/kompetenzpartner.html

Example: US Compressed Air Challenge Providing Training for Compressed Air System Specialists

The US Department of Energy and the Compressed Air Challenge (CAC)® offer a 2.5 day training program for compressed air system specialists that includes classroom instruction, a written exam and a practical exam testing hands-on measurement. Participants who pass the exam are recognized on the website of the program as a Qualified AIRMaster+ Specialist.
For more information see:
www.compressedairchallenge.org/training/specialists.aspx

6.8.8 Energy Saving/System Optimization Calculators

The term energy saving/system optimization calculators is used here for applications that are intended to facilitate the estimation of energy saving possibilities or quantification of energy consumption in motor driven systems. These may be web-based or stand-alone and use Excel or other software application for their operation. The use of recommended calculation tools can help to standardize energy audit processes and enables energy efficiency program managers to promote a uniform product.
Motor system tools are usually designed for very specific purposes and are tailored to the group being targeted. Training should be provided for more complex calculators. Examples of specific functions are:

- Calculation of energy savings when replacing an AC-motor with a higher efficient one (these tools may sometimes have a database with new motors behind them).
- Estimating the benefits of installing a variable frequency drive on a pump or fan application.
- Estimating heat recovery by a heat recovery system for an air compressor.

Simple, Excel-based calculators are also used to estimate the energy demand of electric motor systems and to identify the most relevant motors. These are designed to be used without training and usually do not require metering of specific motors, but base their calculations on estimates of running time and nameplate data of the motors installed within a company. These calculators offer companies a straightforward, easy to use tool to help further investigate the possible benefits of energy efficiency technologies in their organization. A list of such tools is shown in Table 6.

6.8.9 Life-Cycle Costing Methodologies

For electric motors, running costs usually comprise over 90 % of the total lifetime costs, as shown in the example in Figure 13. Therefore, the choice of motor systems with the lowest energy consumption is usually the cheapest option over the lifetime, even if the original purchase price is higher.
By developing life-cycle costing methodologies, energy efficiency programs can provide a tool to help energy auditors and energy managers calculate these lifetime costs according to uniform procedures. These methodologies should take account of the:

- Purchase price of equipment and costs of installation (planning costs, costs of variable frequency drives, etc.).
- Electricity costs during lifetime, based on:
  - Actual power, maximal load or maximal torque (most motors are overdimensioned), and power factor.
  - Estimated load profile (expected load depending on production or ambient temperature) and annual running hours.
  - Range of efficiency for most important load points;
  - Calculation of reactive energy for the lifetime.

Example: Currently Available Energy Saving/System Optimization Calculators	
Name	**Description and Link**
Motor Systems Tool	Developed by the International Energy Agency Energy Efficient End-Use Equipment (IEA 4E) Electric Motor Systems Annex, the Motor Systems Tool calculates the efficiency of a complete motor system (motor plus VFD, gear and transmission). It is intended to assist engineers, machine builders, machine component suppliers, energy consultants and others working on optimizing machine systems to benefit from reduced electricity consumption. More information on the Motor System Tool is included in Appendix C. **Link: www.motorsystems.org/motor-systems-tool**
AIRMaster+	AIRMaster+ is a free online software tool that helps users analyze energy use and savings opportunities in industrial compressed air systems. It can be used to benchmark existing and model future system operations improvements, and evaluate energy and dollar savings from many energy efficiency measures. AIRMaster+ provides a systematic approach to assessing compressed air systems, analyzing collected data, and reporting results. **Link: www1.eere.energy.gov/manufacturing/tech_assistance/software_airmaster.html**
Pumping System Assessment Tool (PSAT)	PSAT, distributed by the US Department of Energy, helps users assess energy savings opportunities in existing pumping systems. It relies on field measurements of flow rate, head, and motor power or current to perform the assessment. Using algorithms from the Hydraulic Institute and standards and motor performance characteristics from the US DOE Motormaster database, PSAT estimates existing pump and motor efficiency and calculates the potential energy/cost savings for a system optimized to work at peak efficiency. **Link: www1.eere.energy.gov/manufacturing/tech_assistance/software_psat.html**
Fan System Assessment Tool (FSAT)	FSAT is a free online software tool that helps industrial users quantify energy use and savings opportunities in industrial fan systems. It can be used to calculate the amount of energy used by a fan system, determine system efficiency, and quantify the savings potential of an upgraded system. The tool also provides a pre-screening filter to identify fan systems that are likely to offer optimization opportunities based on the system's control, production and maintenance and effect. FSAT estimates the work done by the fan system and compares that to the system's estimated energy input. Using typical performance characteristics for fans and motors, indications of potential savings (in energy and dollars) are developed. **Link: www1.eere.energy.gov/manufacturing/tech_assistance/software_fsat.html**
VSD Calculator for Pumps/VSD Calculator for Fans	These tools calculate the estimated energy and cost savings that would result from installing a VSD on a pump/fan system. Required inputs include nameplate horsepower, efficiency, motor load, annual operating hours, pump/fan type, and cost of electricity. Using these inputs and the duty cycle, the tool calculates the current energy use, potential energy use with a VSD, potential energy savings, and potential cost savings. **Links: https://ecenter.ee.doe.gov/EM/tools/Pages/VSDCalcPumps.aspx** **https://ecenter.ee.doe.gov/EM/tools/Pages/VSDCalcFans.aspx**
Motor Decisions Matter Tools	The Motor Decisions Matter (MDM) campaign has developed a variety of credible, third-party tools to help demonstrate the benefits of motor efficiency, planning, and system analysis. The MDM tools and resources are publically available, to assist decision makers interested in energy efficiency and process reliability improvement in properly designed, maintained and operated motor systems. **Link: www.motorsmatter.org/tools/index.asp**
S.A.F.E. Software Tools	Excel-based software tools developed by the Swiss Topmotors program of S.A.F.E. help industrial users to assess the savings potential of their existing motor systems: ▮ SOTEA (software tool to estimate potential energy savings) is used to assess the efficiency potential of motor systems in one plant. The goal is to give the industrial user a rough number of possible savings which largely depends on the age of the installed motor stock. ▮ ILI+ (intelligent motor list) is used to compile a list of motors, from which motors with the highest savings potential can be chosen for retrofit. The Decision Maker of the tool helps users identify a relatively small number of motors representing a relatively large share of total possible savings. ▮ The STR (Standard Test Report) is a standardized template for a motor systems analysis protocol and helps to summarize motor test results and proposed motor systems efficiency measures together with the expected costs and savings. These tools are directly linked to and applied as part of the Motor-Check (a motor systems energy audit methodology which is described further in Section 6.5) **Link: www.topmotors.ch/Tools**

Table 6: Motor System Optimization / Energy Saving Calculators

- Electricity prices (active and reactive energy), usually corrected by the interest rate.

- Maintenance costs, repair costs, costs of lubricants.
- Disposal costs.

Life-cycle costing methodologies are also a useful selling tool for manufacturers and distribution associations and may therefore provide a good mechanism for energy efficiency programs to engage with these stakeholders and involve them in the communications strategy for the target group.

> **Example**: SwissEnergy Software Tool for Life Cycle Cost Evaluation
>
> The SwissEnergy developed software tool LCC-Mot-Eval calculates the life cycle costs (LCC) of electric motors. The tool allows a comparison of the life cycle costs of several different electric motors, including the purchase price, costs for installation, energy in use, operations, maintenance, and repair and disposal at the end of the lifetime.
>
> Download (only in German): www.bfe.admin.ch/php/modules/publikationen/stream.php?extlang=de&name=de_708305420.xls

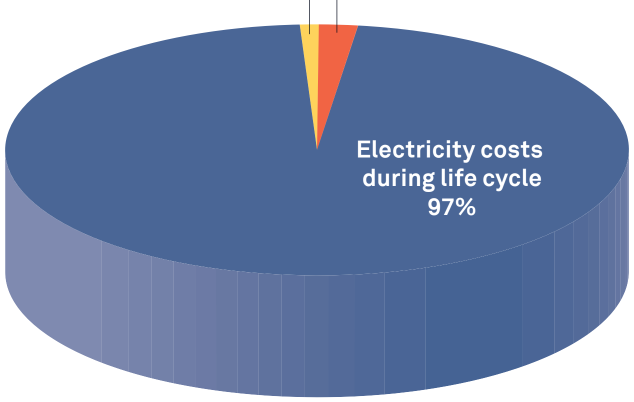

Figure 13: Life Cycle Cost of an Electric Motor: IE3 Motor, 11 kW, 4,000 h, 15 years (Source: [32])

6.8.10 Benchmarking

Energy efficiency benchmarking is the comparison of an individual enterprise's energy consumption with a reference value (such as an industry average) in order to determine the saving potentials. By provision of typical benchmarks for specific sectors and processes, policy makers can help companies compare their existing situation with best practice and provide them with targets for improvement.

When developing benchmarking programs, consideration must be given to the procedures required to establish the benchmark and to the methodology for recruiting participants. Typical energy benchmarks include:

- The average value for the specific energy consumption of similar companies in a sector.
- The value of the best performing company(/ies) within the target group of a benchmarking study.
- A value calculated by applying the best available technologies in a company or a process.

The degree of accuracy required for benchmarking depends on the objective of the benchmarking exercise. For raising awareness, relatively simple benchmarking systems can be established, and made available online, which rely on limited data supplied by users. Where more robust and realistic benchmarks are required[1], a more detailed benchmark study is required, usually based on metering data.

Benchmarks can apply to a facility, an activity, a process, a product, a service or an organization. Most available benchmarks are **sector-specific benchmarks** (e.g. total energy consumption of a whole plant per tons of product, per tons raw material, per conditioned area or per employee). These benchmarks work best if the participating companies are comparable in their size (e.g. annual production) and in their product mix. However, it is common for benchmarks to be established for different sizes of companies and "adaptation factors" to be applied to account for different product mixes. Other performance aspects like technologies and operating practices may be taken into account and regression analysis used to help to identify the energy drivers.

Sector-specific benchmarking has many uses:

- As an awareness-raising tool to give companies an indication of the energy efficiency potential they may have in their company.
- As a means of identifying, and learning from, the best performing companies in the sector.
- As a means of identifying companies that require the most support to improve their potential.
- As a tool for identifying the saving potential of the whole sector (through the use of benchmark curves).

Technology-specific benchmarking is the comparison of energy consumption of a particular technology, process or system. For this type of benchmarking, monitoring sys-

1 For example, as a foundation for mandatory energy saving targets.

tems and measurements are required. Technology-specific benchmarking is of particular relevance in the context of motor driven systems and benchmark indexes are available for some technologies, such as specific fan power for fan systems in building applications, energy efficiency indexes for cooling appliances, or pumping systems in water supply companies. Some of these performance indicators are already used in legal frameworks.

While benchmarking is normally undertaken through direct measurement, values may sometimes be derived through modelling in circumstances where no metered data is available or where deriving absolute benchmarks on-site is difficult because of the complexity of the influences on the energy consumption[2] . Calculated benchmarks (such as, electricity consumption for compressed air per tonne of product) are often used in an individual plant or company level for internal monitoring.

Benchmarking is an important component of **monitoring and targeting (M&T)** systems whereby benchmarking is used to set a target for improvement and on-going monitoring of the energy consumption assesses progress against this target. Monitoring also helps to build a picture of what drives the energy consumption of individual processes and how savings can be achieved by better understanding the energy performance of industrial processes.

There are already some international initiatives that offer a systematic approach for the implementation of M&T, including:

- The work of the International Organization for Standardization (ISO) committees for the future ISO 50006, Baselines and Energy Performance Indicators, the future ISO 50003, Conformity Assessment Requirements and Auditor Competency, and the future ISO 50015, Measurement and Verification.
- The International Performance Measurement & Verification Protocol (IPMVP).
- The M&T approach published by the Carbon Trust.

All these initiatives intend to identify untapped saving opportunities in the production system caused by unknown drivers, to improve the energy performance and to verify the savings.

2 For example, for cooling houses or appliances, the heat capacity of cooled products, time of door opened, cooling degree days on specific location, etc.

Example: UNIDO Working Paper on Energy Efficiency Benchmarking

The 2010 UNIDO working paper on energy efficiency benchmarking, Global Industrial Energy Efficiency Benchmarking, provides international benchmarks of energy intensive manufacturing industry and approaches to establish benchmark curves and saving potentials of countries, branches and sectors.

For more information see: www.unido.org

Example: European Standard on Energy Efficiency Benchmarking (EN 16231)

In October 2012, the European Standard on Energy Efficiency Benchmarking (EN 16231), was published. The overall aim of the standard is to provide organizations with a methodology for collecting and analyzing energy data in order to establish and compare energy efficiency between, or within, entities. The standard addresses the general aspects of benchmarking, but does not include the definition and establishment of sector specific benchmarks.

For more information, see the standards institution for your country, for example: http://shop.bsigroup.com

Example: EU ETS Using Benchmarking to Set Targets for Emissions

Within the framework of the Emissions Trading System (EU ETS), the manufacturing industry received 80 % of its CO_2 allowances for free in 2013, a proportion that will decrease in linear fashion each year to 30 % in 2020. Installations that meet the benchmarks, and are thus among the most efficient in the EU, will in principle receive all the allowances they need. Those that do not reach the benchmarks will receive fewer allowances than they need. These installations will therefore have to reduce their emissions, or buy additional allowances or credits to cover their emissions, or combine these two options. Generally speaking, a product benchmark is based on a value reflecting the average greenhouse gas emission performance of the 10 % best performing installations in the EU producing that product. For more information see:
http://ec.europa.eu/clima/policies/ets/index_en.htm

Example: Austrian Awareness Raising Benchmarking Tool

As part of the klima: aktiv program, the Austrian Energy Agency has developed an online benchmarking tool, Simply Benchmarking, as an awareness-raising tool. It is used by energy auditors in different sectors to show companies how efficient they are in comparison to other companies in their sector.

For more information see: www.energymanagement.at/Simple-Benchmarking.92.0.html

6.8.11 Recommendations

When considering the implementation of an information provision policy, it is important to:

- Undertake preliminary investigations to understand the information gaps that need to be addressed.
- Consider what action you wish the target audience to undertake and which tools, or combination of tools, offer the most effective mechanism for fulfilling these requirements.
- Consider how the materials used will be delivered to the target audience.
- Tailor the materials to the groups being targeted, ensuring that the style of presentation and level of technical detail is appropriate.
- Engage stakeholders, such as trade associations, equipment manufacturers and distributors, professional associations, in the development and delivery of the materials.
- Ensure that the materials developed are accurate, reliable, consistent and as easy to use as possible.
- Ensure that the cost of developing the material and implementing any associated program is commensurate with the savings achievable.

7 Policy Implementation

To achieve their objectives, policies not only need to be well designed, but they also need to be implemented effectively. Consideration of supporting activities and mechanisms required to implement policies therefore should be integrated within the policy development process and be included in cost estimates.

For most policy measures, ensuring that products perform as they claim, is vital to achieving expected energy savings. As such, product certification, registration schemes and effective verification regimes provide the necessary conditions to underpin successful policy implementation. Access to high quality laboratories to test motors is also a prerequisite to quality assurance.

This section provides an explanation of the role played by these aspects of implementation and highlights relevant issues for consideration by policy makers.

7.1 Certification

Product certification is used as a declaration of conformity by a product supplier or to signify that a product has been found to perform as declared by a third party. Certification usually forms part of the monitoring, verification and enforcement procedures associated with national energy efficiency programs.

The process of certification requires definition through laws, regulations or administrative rules that specify:

- Product performance requirements.
- The relevant method for testing products and where tests may be conducted.
- Who may grant the certificate and the procedure for doing so.
- The design and format of the certificate, and where it must be displayed.
- Sanctions for non-compliance.
- Any additional requirements, such as provision of information, maintenance of records, etc.

It should be noted that certification is usually not intended to be a means to provide information to end-users, and is therefore different from energy labels (see Section 6.2).

Example: European CE Marking

The CE marking is a mandatory conformity marking for products placed on the market in the European Economic Area (European Union, Norway, Iceland and Liechtenstein) [8] (Council Directive 93/68/EEC and Council Decision 93/465/EEC).

In the context of ecodesign of energy-related products that includes electric motors, by placing the CE marking on a product, the manufacturer declares that the product conforms with the essential requirements of the applicable directives of the European Union.

Example: USA NEMA Premium Program [9], [10]

The Motors and Generators section of the US National Electrical Manufacturers Association (NEMA) set up the NEMA Premium® energy efficiency motors program in 2001. Manufacturers who wish to participate in the program sign a license agreement with NEMA and can use the NEMA Premium mark (see Figure 14), a registered trademark, on products that meet the NEMA Premium efficiency level (corresponding to the IE3 level), as specified in NEMA MG-1 Table 12-12. By using the NEMA Premium mark, manufacturers demonstrate that their products meet the quality requirements of the program. As of February 2014, participating manufacturers of the NEMA Premium program covered around 90 % of the US market.

In 2007, the Energy Independence and Security Act (EISA) raised the MEPS level for power ratings between 1 and 200 HP to the NEMA Premium efficiency level (corresponding to the IE3 level). In 2010, NEMA included annual verification testing in the program (see Section 7.4 for further details).

Figure 14: NEMA Premium Mark (Source: NEMA, 2014)

Example: IECEE Worldwide System for Conformity Testing and Certification

The IECEE is part of the IEC that operates the Certification Bodies' scheme, which oversees the international certification of electrical and electronic products so that a single certification allows worldwide market access.

In 2012, the IECEE and NEMA launched an initiative that aims to establish an international framework for the assessment of conformity to energy efficiency standards for motors. This would be based on IEC test standards and an IEC Global Motor Label (GMLP) that reflects the efficiency classes defined by IEC.

It is intended that testing laboratories and certification bodies will be registered under the strict control of the IECEE Peer Assessment Programme, ensuring compliance with ISO/IEC 17025: General Requirements for the Competence of Testing and Calibration Laboratories, and ISO/IEC 17065: Conformity Assessment – Requirements for Bodies Certifying Products, Processes and Services, as well as with all IEC Product Standards in terms of energy efficiency/performance and safety aspects. The IECEE GMLP will be operated in accordance with ISO/IEC System 5 that includes testing, factory surveillance, certification, re-testing and market surveillance. [53]

7.2 Product Registration

Several countries require suppliers of regulated products to "register" all models (or sometimes families of models) with a government agency as a condition for placing these models on the market. This process enables governments to:

- Record and track the characteristics of models entering the market, thereby providing the opportunity to measure the impact of policies and follow trends which may help to improve subsequent regulations.
- Record the declared performance of each model made by the supplier, against which the actual performance of models can be compared.
- Link models to their suppliers so that in the event that questions may arise in relation to individual models, the responsible entity can be quickly located.

Examples from the United States, Australia and China are provided below.

Example: China Energy Label Program

The China Energy Label Program (www.energylabel.gov.cn) covers 29 products as of October 2013, including small and medium three-phase asynchronous motors.[1] These products have to be registered with the China Energy Label Management. The energy label regulation includes the label design, test report template, and registration form.

Test reports from the list of qualified testing labs (that includes independent and manufacturers' laboratories) are accepted by the Energy Label Management for registration. The manufacturers or suppliers submit the test report online via www.energylabel.gov.cn and the reports are checked and approved by the Energy Label Management online. [52]

1 GB 18613

Example: US Compliance Certification Number

In order to be able to sell their electric motors affected by regulation on the US market, manufacturers have to request a Compliance Certification (CC) number from the Department of Energy (DOE). They must provide DOE with information relating to each basic model of motor within the scope of regulations, prior to being placed on the market. This information is provided via the DOE's online certification tool, the Compliance Certification Management System, and DOE's preformatted, standardized, product-specific, Excel templates.

In addition to information on the supplier, and the characteristics of the basic models, this process requires the supplier to certify that the models meet the relevant performance requirements, when tested according to the specified test method.

DOE will provide:

- A single unique CC number to the manufacturer which is applicable to all electric motors distributed by that manufacturer, or
- Two or more CC numbers. In this case, DOE will provide a unique CC number to the manufacturer and unique CC numbers for each brand name, trademark or other label name that the manufacturer requested. The CC number for such a particular name will be applicable to all electric motors distributed by the manufacturer under that name.

The CC number must appear on the nameplate of all motors covered by regulation to allow traceability of products back to the point of manufacture. [54], [55]

Example: Mandatory Registration in Australia

Mandatory registration is the first stage in the monitoring, verification and enforcement of Australia's Equipment Energy Efficiency (E3) Program. Each model of electric motor that is regulated for energy efficiency in Australia must be registered and meet a number of legal requirements before it can be supplied, offered for supply, or used for commercial purposes.

On 1 October 2012, a national legislation, the Greenhouse and Energy Minimum Standards (GEMS) Act 2012, replaced a patchwork of state and territory legislation. The Australian GEMS Regulator is responsible for administering the legislation, which provides national consistency and a strong administrative and compliance framework for the regulation of products that use energy, or affect the energy used by another product.

The specific requirements for each regulated product are set in a legislative instrument called a GEMS determination. The determination for electric motors sets out specific requirements, including Minimum Energy Performance Standards (MEPS) and testing requirements, by referring to the applicable clauses in the relevant Australian/New Zealand standards.

Applications for the registration of electric motors are submitted to the Australian GEMS Regulator via an online registration system. Applications must be accompanied by a summary of a full laboratory test report which demonstrates that the electric motor meets the MEPS. No specific accreditation is required for laboratories undertaking the testing for registration purposes. Currently, the fee to register an electric motor is AUD 670[1].

Details of the products, once their application is approved, are placed on the GEMS Register, which the GEMS Regulator may publish. In addition to the Register, registrants may choose to make some of the product detail available publicly on a comparison tool available on the Energy Rating website at www.energyrating.gov.au. A range of information about each model, including energy efficiency and running costs, is available on the website to allow consumers to compare different models. There are currently over 6,000 approved motor registrations in the GEMS register.

To assist motors suppliers manage the cost of registering their range of products, the GEMS Regulator has provided a temporary fee concession option for electric motors. Registrants may include up to 10 electric motors in an application for a single fee provided they are of the same brand name and frame code. This fee concession will remain in place while consideration is given to allowing "family of models" registrations for electric motors. In the future, a "family of models" registration could mean that several electric motor models that have the same energy performance characteristics can be covered by a single registration. For compliance purposes, if one model in a family of models was found to be non-compliant, all models within the family would be considered to have failed. This could result in sanctions being applied in relation to all models in the family.

Sales and Other Data Requirement

Approximately 277,000 three-phase motors were sold in Australia in 2010. The GEMS legislation includes the option for the Australian GEMS Regulator to require that registrants submit data relating to the manufacture, import, supply or export of a registered model, on a one-off or periodic basis. This data will facilitate the establishment of revised MEPS levels and labeling algorithms and will improve the evaluation of the E3 Program. Safeguards will be in place to ensure the confidentiality of this information.

1 One Australian dollar equals USD 0.95 (exchange rate in October 2013).

7.3 Compliance (Monitoring, Verification & Enforcement)

For policy makers, it is important to understand the link between the on-going impact of standards and labeling (S&L) programs and compliance processes and activities, in order to make sure that programs are designed to maximize compliance and resources are effectively allocated. [56]

Establishing an effective compliance regime is one key method of improving the impact of programs, while also realizing numerous co-benefits.

Achieving high rates of compliance has overall benefits for all stakeholders in the S&L process, as well as for the environment. Industry participants operate in a fair market that encourages investment and technological innovation, while end-users benefit from reduced energy costs and governments achieve key environmental and economic policy objectives.

Specifically, addressing compliance is important because:

- Improving compliance rates is likely to improve key outcomes from S&L programs – more energy savings and reduced emissions of greenhouse gases, all of which will have been defined in existing S&L programs but can only be truly verified through compliance activities.
- High compliance rates safeguard the investment made by governments by building up the credibility of their voluntary and mandatory energy labels.
- There is a corresponding risk that a failure to address issues of non-compliance can lead to serious long-term consequences through the erosion of end-user confidence. Instances of non-compliance, which can mean that end-users pay for performance that they do

not receive, can seriously erode credibility. Once credibility is damaged, it will require a considerable effort to re-establish.

- High compliance rates also safeguard the investment made by compliant industry participants in order to manufacture and supply energy efficient products.
- Without adequate enforcement, the compliant industry participant is penalized through a loss of economic returns and competitive advantage, leading to a disincentive to invest in innovation.
- Understanding rates of compliance is a prerequisite to accurately measuring the outcomes of S&L programs (energy savings and reduced greenhouse gas emissions).

Senior policy makers can access the benefits of improved compliance rates, and simultaneously manage the risks associated with low compliance rates, simply through greater attention to planning and implementing comprehensive compliance regimes.

Planning an effective compliance regime can occur at the time of initial program design, or at any point during the life of a program; and can be implemented immediately or progressively depending on the availability of resources and other constraints.

The objective of any compliance regime should be to ensure that industry participants perceive that the risks associated with non-compliance outweigh the benefits.

Each S&L program needs to develop a compliance regime that is appropriate for its circumstances, taking into account its objectives, resources, legal framework, technical capacity, industry views and other factors that may be program or country specific. In considering options for compliance regimes, the exchange of information with national programs in other countries regarding different approaches and experiences can help to better understand the associated advantages and disadvantages.

All compliance regimes should comprise of the following interrelated elements:

- A well designed legal and administrative framework.
- Processes to facilitate compliance, including a communication plan to educate stakeholders about their obligations.
- A plan for monitoring and market surveillance.
- Verification processes to ensure products perform as claimed.
- Practical enforcement procedures that can respond rapidly to identified transgressions and include a range of appropriate sanctions.
- A plan for communicating information and the results of compliance activities to stakeholders in order to build a culture of compliance and highlight the risks of non-compliance.
- Evaluation processes so that policy makers can assess program outcomes, facilitating accountability of all participating parties, and guide improvements in program design.
- A budget for compliance activities consistent with the declared ambition of the S&L program.

Further details of best practice in monitoring, verification and enforcement for appliance standards and labeling programs can be obtained from [56]. Examples of different approaches to verification testing from Australia and the United States are provided below.

Example: Australian Check-Testing Program

The Australian check testing program enables the GEMS Regulator to verify through laboratory testing, whether the performance of an electric motor model meets the requirements of the legislative instruments, including the Greenhouse and Energy Minimum Standard (GEMS) Act 2012, and the claims of manufacturers and suppliers. Check testing encourages compliance with the GEMS Act and helps to uphold the integrity of the Equipment Energy Efficiency (E3) Program, and is conducted according to the GEMS E3 Program Check Testing Policy. [58]

Check testing of electric motors has been on-going since 2002. While it is currently the main compliance activity for electric motors, other activities in future may include education and awareness raising and registration surveys. Currently, approximately 30 electric motors undergo check testing each year to monitor compliance with the MEPS. The E3 Program spends approximately AUD 150,000[1] per year on the motors check-testing program. This amount includes the purchase and testing of motors.

Models are selected for check testing according to a range of risk-based criteria and a procedure described in the Verification Testing Selection Criteria Report. [59] Factors taken into account may include:

- Reports of possible non-compliance from competitors, consumer groups, individuals and overseas testing programs.
- Models with a high market share.
- Product types with the highest greenhouse gas emissions.
- Brands or models with a history of non-compliance or with no check test history.
- High efficiency claims.

Electric motors selected for check testing are, where possible, purchased anonymously from the market. After acquiring units of the selected models for testing, Stage One check tests are conducted according to the requirements set out in the relevant test standard. Wherever possible, check testing is only undertaken by those laboratories accredited with the National Association of Testing Authorities (NATA), Australia, or

1 One Australian dollar equals 0.95 USD (exchange rate in October 2013).

an accreditation body having mutual recognition with the NATA, Australia. A tolerance is applied to efficiency values which are obtained as a result of check testing.
If the Stage One test indicates the model complies with GEMS requirements, the registrant is informed and no further action is taken.
If the Stage One test indicates the model fails to meet the performance or marking requirements, the Regulator will notify the registrant of the results of the failed check test. The registrant then has the option of cancelling the model's registration or proceeding to Stage Two testing, which involves testing of additional two or three units of the model. The registrant must supply the Regulator with a list of serial numbers of all units held in stock from which the Regulator chooses the further models to be tested. The registrant organizes and pays for Stage Two testing.
If Stage Two testing indicates the model complies with relevant requirements, the registrant is informed of the pass result and no further action is taken. If the model fails the Stage Two check test, the Regulator may then undertake appropriate enforcement action as specified in the GEMS Compliance Policy [60], which may include cancellation of the model's registration and other penalties.

Example: United States – NEMA Voluntary Verification [9], [15]

In 2010, NEMA launched an annual verification testing program under which manufacturers participating in the NEMA Premium® program submit a motor for verification testing at an independent third-party laboratory.
Every year each manufacturer ships one sample of a motor rating chosen randomly by NEMA (e.g. 5 HP, 2-pole motor) to the testing laboratory from the distribution channel (or from the manufacturer's inventory, in case supply is not available from the distribution channel). If the motor fails to comply, 5 motors of the same motor rating will be tested. In total, up to three tests of each 5 motors at different ratings, chosen by NEMA, are possible. If all tests fail, the manufacturer's license will be revoked for a minimum of 12 months. As of February 2014, all motors have passed the tests.
In parallel to the verification testing, NEMA also launched the challenge program offering participating manufacturers the opportunity to challenge whether a specific product of another participating manufacturer meets the NEMA Premium efficiency level. The cost of the testing will be borne by the challenged manufacturer if any of the tested motors does not meet the minimum efficiency requirement and by the challenger if all motors meet the requirement. In case the identified motor rating is successfully challenged three times (three tests of each five samples tested at an independent third-party laboratory), the challenged manufacturer's license will be revoked for a minimum period of 12 months.

7.4 Improving Testing Capacity and Quality

The build-up of a larger community of testing laboratories is part of the EMSA Task Testing Centres [61]. So far some 40 international testing labs have joined this effort. The goal is to provide guidance to the use of testing standards and to conduct round robin testing campaigns.
In order to base government performance requirements and customer product selection on precise efficiency values, motors have to be measured in different countries in different laboratories and reach the same (i.e. within specified tolerance limits) results. The respective testing laboratories need to have the necessary capacity and competence to deliver accurate and repeatable efficiency testing results of electric motors. Manufacturers and wholesalers need to know that their specified efficiency values can be check tested by national authorities. This will stimulate manufacturers to improve the efficiency values of their products and reduce their margin of variation. It will also make them more cautious in overstating performance.
Few national and international programs exist for laboratory certification (based on general standards: ISO/IEC 17025 Conformity Assessment — General Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies and ISO/IEC 17011 General Requirements for the Competence of Testing and Calibration Laboratories), for instrumentation calibration and for regular audit of staff training and full compliance to testing standards.
A round robin (inter-laboratory comparison) testing campaign is one of the most effective means to improve the accuracy and repeatability of laboratory measurements. The effort for a controlled Round Robin test with electric motors is considerable. It usually needs international participation and a strong project management to assure confidentiality between testing laboratories.

Example: USA – The National Institute of Standards and Technology (NIST)

NIST [62] is an agency of the U.S. Department of Commerce that operates the National Voluntary Laboratory Accreditation Program (NVLAP). Accreditation requirements are established in accordance with the U.S. Code of Federal Regulations (CFR, Title 15, Part 285), NVLAP Procedures and General Requirements, and encompass the requirements of ISO/IEC 17025.

NVLAP operates an accreditation system that is compliant with ISO/IEC 17011, which requires that the competence of applicant laboratories be assessed by the accreditation body against all of the requirements of ISO/IEC 17025.

NVLAP accreditation means that a laboratory has demonstrated that it operates in accordance with NVLAP management and technical requirements pertaining to:

- quality systems
- personnel
- accommodation and environment
- test and calibration methods
- equipment
- measurement traceability
- sampling
- and handling of test and calibration items as well as test and calibration reports.

NVLAP coordinated the development of the Efficiency of Electric Motors (EEM) program with the National Electrical Manufacturers Association (NEMA) and the Department of Energy (DOE) to assist the motor industry to comply with MEPS.

The purpose of the EEM program is to accredit testing laboratories to assure that standard test procedures for efficiency are followed in testing electric motors. Specifically, the EEM program addresses testing the efficiency of electric motors according to the scope and procedures given in Method B of the Institute of Electrical and Electronics Engineers (IEEE) Standard 112, "Test Procedure for Polyphase Induction Motors and Generators" and Method 1 of Canadian Standards Association (CSA) Standard C390, "Energy Efficient Test Methods for Three-Phase Induction Motors".

A list of accredited NVLAP laboratories is included in Appendix A.

Further information on the EEM program is available from the NIST Handbook [63].

Example: IEC Round Robin

The IEC Round Robin was conducted between 2008 and 2011 in order to find the differences between two motor testing methods:

- Summation of losses with load test: additional-load losses determined from residual-loss (IEC 60034-2-1: 8.2.2.5.1)
- Summation of losses without load test: additional-load losses from Eh-star test (IEC 60034-2-1: 8.2.2.5.4).

The Round Robin consisted of three parts:

- Part 1: A series of tests in the same laboratory on a single motor. These test reports were meant to assist in determining operator errors and the accuracy of the test procedure. Each test was to be performed using the two different methods for determining additional-load losses.
- Part 2: A series of tests in the same laboratory on motors of the same design, from different manufacturing cycles, using the same test method.
- Part 3: A series of tests by different laboratories on the same motor usually referred to as a "round-robin" test.

To cover efficiency variations due to motor size, motors covering four motor output-power ranges and including 50 Hz and 60 Hz models were selected for testing, as follows:

- 1 – 10 kW 8 motors
- 11 – 50 kW 23 motors
- 51 – 200 kW 17 motors
- > 200 kW 2 motors

Sixteen laboratories from 11 countries submitted a total of 194 individual test sets, covering 75 different motors. The list of participating laboratories is included in Appendix B.

The results led IEC TC2 WG28, responsible for IEC 60034-2-1, to focus on the accuracy of the test and its instrumentation, the correct sequence of the procedure, and to refine a number of other issues. As a result of the Round Robin, the second test method, together with earlier methods without full torque meter tests and assigned values for stray load losses, is no longer used.

In a separate study it was shown that there are also problems between the results of measurements and the final calculation of efficiency. The Round Robin highlighted the critical importance of the quality of the laboratory, its equipment and the training of the staff to obtaining accurate results.

8 Global Policy & Technical Support

National policy makers can benefit greatly from the experience and expertise from other countries and international experts through engagement in the many policy and technical exchanges available.

The sharing of information and approaches not only allows policy makers to better understand the options available, but enables them to learn the lessons from previous policy implementation, thereby reducing implementation risks, and costs.

Engagement with other countries and initiatives also increases the opportunity for policy alignment where appropriate, and ensures that the needs of all participating countries are taken into account.

8.1 International Standardization

Electric motors are manufactured and traded globally, and many applications are designed around standard products. To facilitate this, the geometrical dimensions (frame size, shaft height and diameter, bore holes of the foot plate), the output sizes between 0.12 kW and 1,000 kW and the rotations per minute are standardized. This requires internationally accepted technical standards.

8.1.1 The Role of the World Trade Organization

The increased use of international standards is one aim of the World Trade Organization (WTO). [64] Under the "Technical Barriers to Trade" (TBT) agreement, participating countries accept a range of international rules and standards to facilitate trade in products (including electric motors) and services, in order to reduce costs for manufactures, importers and users.

Under the TBT, the WTO monitors the use of national regulations, tariffs, financial instruments and other policy measures to determine whether they create unnecessary obstacles to international trade. However, members maintain the right to implement measures to achieve legitimate policy objectives, such as the protection of human health and safety, or the environment.

In practice, countries wishing to implement national policies (e.g. regulations for motors) that diverge from internationally accepted norms may be required to provide justification, adding to the administrative burden and delaying implementation.

8.1.2 International Standardization Bodies

International standards for rotating machines (motors) are developed by the International Electrotechnical Commission (IEC). [65]

The IEC is a non-governmental organization based in Geneva, Switzerland, with a membership of 82 countries and another 82 affiliate countries.

Each member country is represented at the IEC by its National Body (NB), usually the authorized standards making organization within that country. Within the IEC system, National IEC Committees (NCs), formed from volunteers from industry, government, universities, research laboratories and NGOs, work on the development of standards. All proposed new and amended standards go through a rigorous system of international scrutiny and are finally decided by voting by the NCs.

An IEC member country signs a contract with IEC when becoming a member which obligates it to adopt international standards "to the greatest extent possible" in its country. There is no rule that says that national standards have to be abandoned once an international standard on the same subject is published.

In order to facilitate a consensus-finding process between European and international standards development activities and avoid duplication of effort in the electrical sector, CENELEC [66] and IEC formalized the framework of their cooperation under the Dresden Agreement.

Under the Dresden Agreement, new electrical standards projects are now jointly planned between CENELEC and IEC, and if possible, most are carried out at the international level. This means that CENELEC will first offer a New Work Item (NWI) to its international counterpart. If accepted, CENELEC will cease working on the NWI. If IEC refuses, CENELEC will work on the standards development and its content, keeping IEC closely informed and giving IEC the opportunity to comment at the public enquiry stage.

The key IEC Technical Committees related to the energy efficiency in motor systems are:

- TC2 and its Working Groups 12, 28 and 31, which deal with low and high voltage induction machines, synchronous machines, synchronous generators, permanent magnet synchronous machines, DC and AC commutator machines.
- Special Committee 22 (SC22) Joint Working Group 18 (JWG 18) deals with electric motors driven by variable speed drives.

Thirty countries participate in TC2, while another 15 countries have observer status. All committees are responsible for new work items and the regular update (after five years) of existing standards.

The International Organization for Standardization (ISO) [67] is responsible for the following standards related to industrial energy efficiency under Technical Committee 242 (ISO/TC 242) [68]:

- ISO 50001:2011: Energy Management Systems – Requirements With Guidance for Use
- ISO 50002:2014: Energy Audits – Requirements With Guidance for Use
- ISO/DIS 50003: Energy Management Systems – Requirements for Bodies Providing Audit and Certification of Energy Management Systems

- ISO/DIS 50004: Energy Management Systems – Guidance for the Implementation, Maintenance and Improvement of an Energy Management System
- ISO/DIS 50006: Energy Management Systems – Measuring Energy Performance Using Energy Baselines (EnB) and Energy Performance Indicators (EnPI) – General Principles and Guidance
- ISO/FDIS 50015: Energy Management Systems – Measurement and Verification of Energy Performance of Organizations – General Principles and Guidance

8.1.3 Standards for Energy Efficiency in Motors and Motor Systems

IEC standards provide the foundation for improved international harmonization for electric motors by defining:

- Uniform testing methods to deliver accurate and repeatable test results for energy losses and efficiency.
- A system of classification for motors based on their efficiency, for reference by national energy efficiency schemes in setting minimum performance standards and energy labels.

The relevant IEC standards are shown in Table 7.

Test Methods for Motor Systems

The precise testing of various types and sizes of motors requires highly trained staff in well-equipped testing laboratories that are able to follow the described procedures meticulously.

The three crucial elements of motor testing are:

- The use of a single preferred testing method for each type and size of motors (see Table 8).
- The strictly followed sequence of tests (see Figure 15).
- The use of a standardised protocol for the correct calculation of efficiency values from the test results.

The efficiency test can be made under several circumstances:

- In the factory at the end of the production line: for regular quality control only samples are usually tested, not all motors.
- In the factory testing laboratory: to set rating values a number of motors are usually tested to get average efficiencies, required in some countries.
- In an independent laboratory: to give independent guarantees for the manufacturer for setting the rated efficiency and/or for national requirements for registration of products.
- In a research laboratory: tests are made to analyze performance and to advise manufacturers on improvement possibilities.
- At the site of motor use: to check if the delivered product lives up to the promised efficiency. Usually this is difficult because on-site conditions vary from standard conditions.
- In a national check-test: to check compliance with national legal requirements.

The variations found in testing of electric motors for energy efficiency have several sources:

- The variation in production quality.
- The addition of secondary components (external or internal) like brakes, couplings, and slip rings that can reduce the standard efficiency.

IEC Number	Status	Title	Major Content
IEC 60034-1	published 2010	Rating and performance	Environmental conditions and on/off cycles for use, content of rating plate, tolerances
IEC 60034-2-1	publication edition 2 in 2014	Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)	Preferred testing methods, standard procedures and sequences, accuracy of instruments
IEC 60034-2-3	Technical Specification publication 2013	Specific test methods for determining losses and efficiency of converter-fed AC motors.	Extra losses from harmonics when induction motors are operated with frequency converters
IEC 60034-30-1	publication in 2014	Efficiency classes of single-speed, three-phase, cage-induction motors (IE-code)	Definition of efficiency classes IE1, IE2, IE3 and IE4 for 0.12 kW to 1,000 kW, 50 and 60 Hz, 2-, 4-, 6- and 8-poles
IEC 60034-31	Technical Specification 2010	Selection of energy-efficient motors including variable speed applications – application guide	Systems integration, operating hours, economic analysis
IEC 61800-9	New work item 2014, planned publication in 2016	Energy efficiency of adjustable speed electric power drive systems	Efficiency rating and testing of combined systems with motors and variable frequency drives

Table 7: Important IEC Standards for Electric Motors and Systems

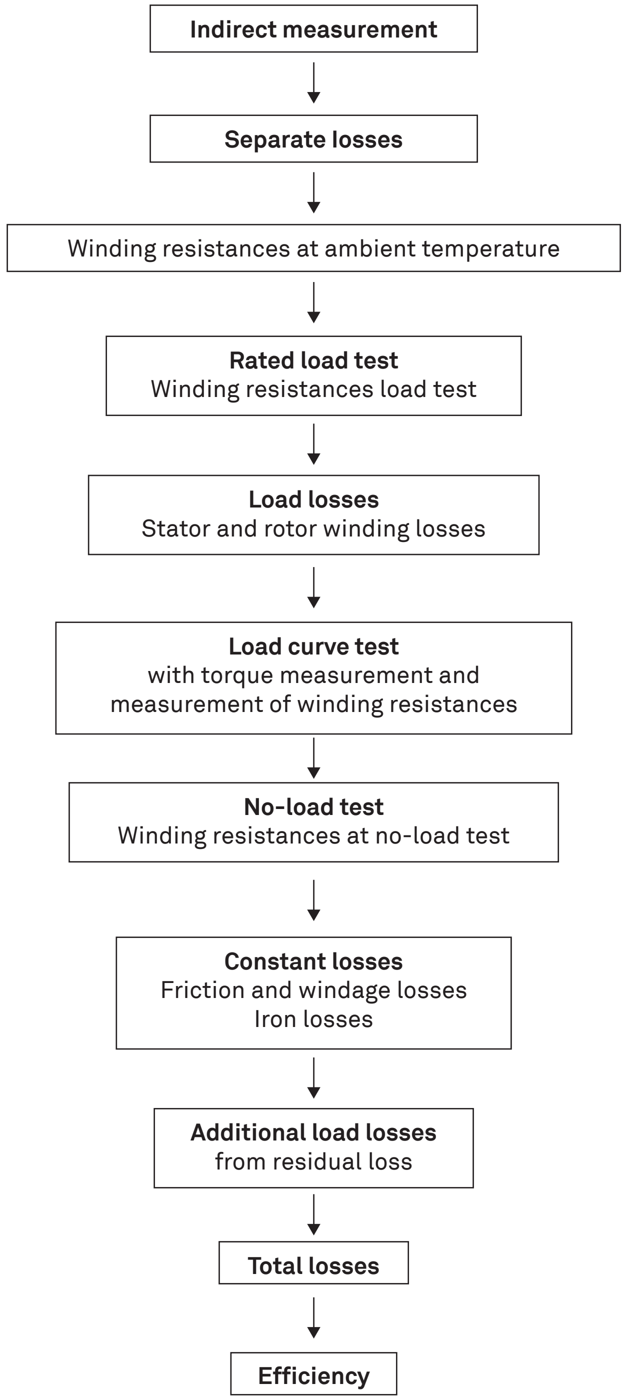

Figure 15: Efficiency Determination According to Method 2-1-1B (Source: IEC 60034-2-1, 2014)

- The hours of operation prior to the initial efficiency test: a new motor can have higher losses due to mechanical friction of slip rings that are not fully worn-in.
- The supply of the precise rated electric current, voltage and frequency without harmonic distortion from the mains.
- The quality of the testing laboratory, its instrumentation and climate control.
- The training and the reliability of the laboratory staff, their knowledge of the standard and its required procedures.
- The standard algorithms used to calculate the efficiency once the test results are available.
- The standard IEC 60034-1 requires a maximum tolerance of the losses of 15 %, or 10 % for motors above 150 kW (see Table 9). This requires strict adherence to the specifications for input voltage, frequency and current as well as following the instrumentation requirements and precision stated in IEC 60034-2-1.

Efficiency Classes for Motors

IEC 60034-30-1 identifies four efficiency classes for motors with output powers between 0.12 kW and 1,000 kW and capable to be run without converters, as shown in Figure 16. This figure shows the high influence of the size of the motor, with efficiencies for smaller motors ranging between 50 % and 70 %; while the efficiency of 1,000 kW motors range between 94 % and 97 %.
The figure also shows the three parts of the curve: the group of small motors (between 0.12 kW and 0.75 kW) has a downgraded steeper curve than the middle size motors (between 0.75 kW and 200 kW). The curves above 200 kW until 1,000 kW are kept constant. The standard defines

Item	Quantity	Tolerance
1	Efficiency η	
	– machines up to and including 150 kW (or kVA)	−15 % of (1 – η)
	– machines above 150 kW (or kVA)	−10 % of (1 – η)
2	Total losses (applicable to machines with ratings >150 kW or kVA)	+10 % of the total losses

Table 9: Schedule of Tolerances on Values of Quantities (Source: IEC 60034-1)

Ref	Method	Description	Clause	Application	Required facility
2-1-1A	Direct measurement: Input – output	Torque measurement	6.1.2	All single phase machines	Dynamometer for full-load
2-1-1B	Summation of losses: Residual losses	P_{LL} determined from residual loss	6.1.3	Three phase machines with rated output power up to 2 MW	Dynamometer for 1.25 x full-load, or load machine for 1.25 x full-load with torque meter
2-1-1C	Summation of losses: Assigned value	P_{LL} from assigned value	6.1.4	Three phase machines with rated output power greater 2 MW	

Table 8: Induction Machines: Preferred Testing Methods (Source: IEC 60034-2-1, 2014)

efficiency classes for the other four different motor pole numbers (2-, 4-, 6- and 8-poles) as well as for the two frequencies used all over the world (50 Hz and 60Hz).
While the 50 Hz were given in smooth curves, the 60 Hz curves – based on prior NEMA and US Department of Energy (DOE) decisions – are stepped curves that follow the steps of the frame sizes.

8.1.4 General Performance Criteria for Motors

Basic characteristics and performance of electric motors are standardized in the following IEC standards:

- Motor Dimensions IEC 60072-1, Edition 6, 1991: Dimensions and Output Series for Rotating Electrical Machines – Part 1: Frame Numbers 56 to 400 and Flange Numbers 55 to 1080
- Motor Mounting IEC 60034-7, Edition 2.1, 2001: Rotating Electrical Machines – Part 7: Classification of Types of Construction, Mounting Arrangements and Terminal Box Position (IM Code)
- Enclosure Protection IEC 60034-5, Edition 4.1, 2006: Rotating Electrical Machines – Part 5: Degrees of Protection Provided by the Integral Design of Rotating Electrical Machines (IP Code) – Classification
- Motor Vibration IEC 60034-14 (Grade N), Edition 3.1, 2007: Rotating Electrical Machines – Part 14: Mechanical Vibration of Certain Machines With Shaft Heights 56 mm and Higher – Measurement, Evaluation and Limits of Vibration Severity
- Motor Noise IEC 60034-9, Edition 4, 2003: Rotating Electrical Machines – Part 9: Noise Limits

8.2 Government to Government Information Exchange

The following international initiatives provide opportunities for government to share experience and expertise, as well as enter into collaborative projects concerning the efficiency of electric motor systems.

8.2.1 Electric Motor Systems Annex (EMSA)

The International Energy Agency's Implementing Agreement for Energy Efficient End-Use Equipment (4E) supports its 12 member countries to develop policies to promote greater efficiency in appliances and equipment. The Electric Motor Systems Annex (EMSA) deals with motor systems efficiency.
EMSA aims to raise worldwide awareness of the savings potential offered by efficient electric motor systems, develops guidelines for motor policy, guides for testing and tools for motor systems optimization. EMSA is represented in relevant standards development working groups and offers an international platform for experience exchange among countries. Currently, Australia, Austria, Denmark, Netherlands, Switzerland and the USA participate actively in EMSA.
On www.motorsystems.org, EMSA presents the latest information on motor systems efficiency in a well-structured and user-friendly way. EMSA engages technical experts, standards developers, policy makers, motor manufacturers, machine builders and motor system users in a dialogue.
EMSA collaborates closely with the Super-Efficient Equipment and Appliance Deployment initiative and provides technical support in the SEAD Global Efficiency Medal Competition for electric motors (see Section 6.8.5).

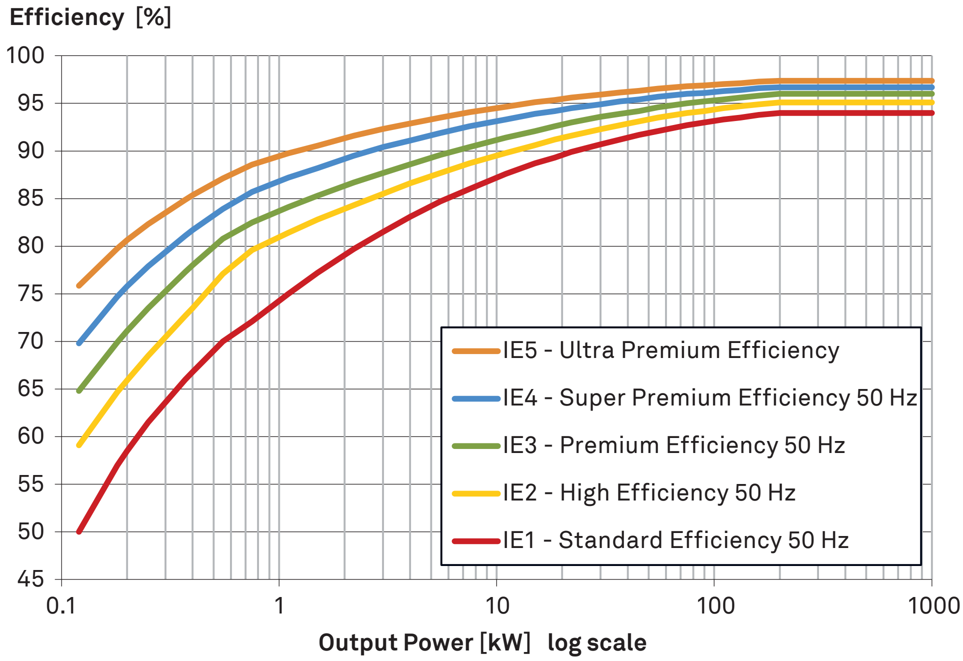

Figure 16: Efficiency Levels for Electric Motors (Source: IEC 60034-30-1, 2014)

8.2.2 Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative

The Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative [69] is an initiative of the Clean Energy Ministerial and a task within the International Partnership for Energy Efficiency Cooperation (IPEEC). SEAD engages governments and the private sector to accelerate the pace of market transformation to efficient equipment and appliances.

As of February 2014, governments participating in SEAD are: Australia, Brazil, Canada, the European Union, France, Germany, India, Japan, Korea, Mexico, Russia, South Africa, Sweden, United Arab Emirates, United Kingdom and United States of America.

SEAD has five working groups focusing on specific topics: Standards & Labels, Awards, Incentives, Procurement and Technical Analysis. Within the Standards & Labels working group, there is an informal collaboration of policy makers focused on topics and issues related to electric motor efficiency.

SEAD also organizes an annual Global Efficiency Medal Competition, an activity of the Awards working group, recognizing super-efficient products in selected markets around the world. The first product categories in the competition were televisions, followed by displays (desktop computer monitors) and electric motors (see Section 6.8.5 for more details).

The Operating Agent for SEAD is the Collaborative Labeling and Appliance Standards Program (CLASP).

8.3 Technical Information Exchange

8.3.1 Institute for Industrial Productivity (IIP)

The Institute for Industrial Productivity (IIP) is an independent, not-for-profit organization, established in 2010. IIP promotes the efficient use of energy by providing advice and best-practice information to industry and government on technology, policy and financing of energy efficiency in industry. IIP focuses on the energy-intensive industrial sectors cement, iron and steel and its country focus is on China, India and the USA. IIP is funded by the ClimateWorks Foundation.

IIP resources made available through the IIP website [70] include the following databases:

- Industrial Efficiency Financing Database, a catalogue of financial programs, products and mechanisms for industrial energy efficiency
- Industrial Efficiency Policy Database with information on industrial energy efficiency policies from different countries
- Industrial Efficiency Programs Database with information about energy management and utility programs
- Supply Chain Initiatives Database with innovative ways for industry to reduce their energy consumption and increase environmental performance in their supply chain
- Industrial Efficiency Technology Database with information on the cement, iron and steel and pulp and paper industrial sectors and on electric motor systems [45].

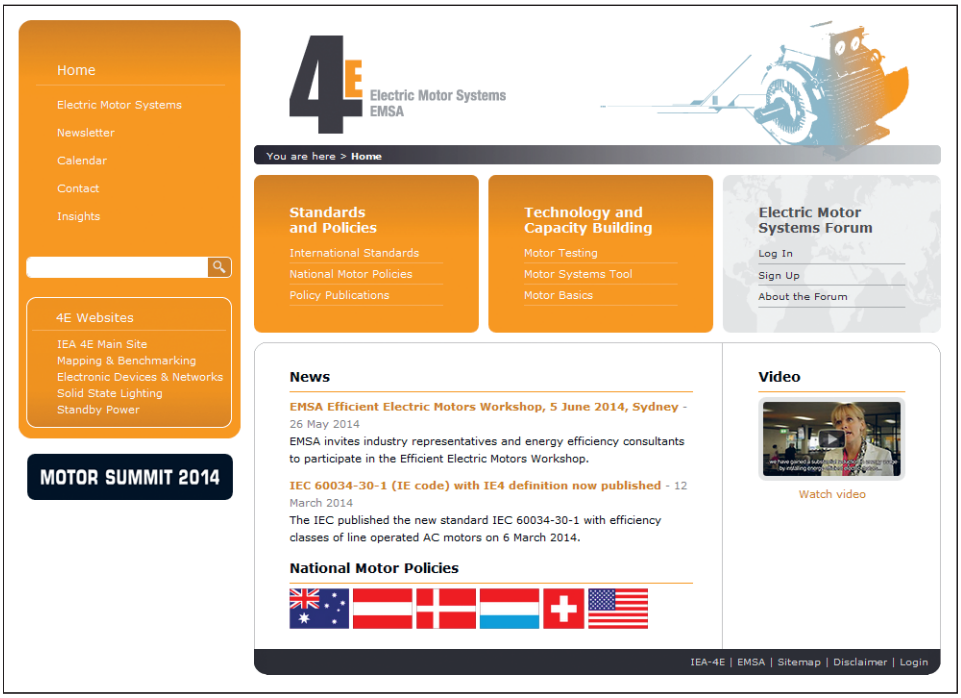

Figure 17: EMSA Webpage, www.motorsystems.org

8.3.2 Collaborative Labeling and Appliance Standards Program (CLASP)

Founded in 1999 and based in Washington, D.C., CLASP [71] promotes technical best practices and international collaboration for standards and labeling for appliances, equipment, and lighting. CLASP provides governments, standards and labeling policy experts, and other stakeholders (e.g. advocates and industry) with the resources essential to understanding these policies. CLASP has worked in over 50 countries and collaborated with the world's foremost standards and labeling experts. Its activities range from local to regional to global, helping decision makers determine and implement the most appropriate and cost-effective appliance energy efficiency solutions. CLASP is the Operating Agent for the Super-Efficient Equipment and Appliance Deployment (SEAD) Initiative.

8.3.3 Further Organizations

A comprehensive list of international, regional and national organizations with a direct link to motor systems efficiency can be found here:
http://iipnetwork.org/sites/iipnetwork.org/files/file_attachments/resources/MotorSystems.pdf
Selected further international organizations engaged in industrial efficiency [47]:

- International Energy Agency (IEA): www.iea.org[1]
- United Nations Industrial Development Organization (UNIDO): www.unido.org
- United Nations Development Programme (UNDP): www.undp.org
- United Nations Environment Programme (UNEP): www.unep.org
- International Partnership for Energy Efficiency Cooperation (IPEEC): www.ipeec.org
- International Copper Association (ICA): http://copperalliance.org
- World Bank (WB): www.worldbank.org
- Asian Development Bank (ADB): www.adb.org
- Inter-American Development Bank (IADB): www.iadb.org

1 The IEA Energy Efficiency Policy Database provides information on energy efficiency policies and measures: www.iea.org/policiesandmeasures/energyefficiency.

8.3.4 Conferences

Regular conferences dealing with energy efficiency in industry or specifically with efficient electric motor systems, both from the technical and the policy implementation point of view, are identified in Table 10. The audience at these conferences is composed of policy makers, electric motor manufacturers, members of academia and of power utilities.

8.3.5 Industrial fairs

Trade fairs relevant for motor systems in different regions of the world are shown in Table 11.

Region	Focus
China	
China (Shanghai) International Power and Generating Sets Exhibition www.powerchinashow.com/en	with a section for motors, compressors and pumps
Europe	
Hannover Messe www.hannovermesse.de/home	leading trade fair for industrial technology with a large motors & drive vendor presence
SPS/IPC/Drives www.mesago.de/en/SPS/home.htm	electric automation with a heavy motor & drive focus
USA	
International Manufacturing Technology Show (IMTS) www.imts.com	broad industrial show with significant motors & drive vendor presence
Electrical Apparatus Service Association (EASA) Convention & Exhibition www.easa.com/convention	electric motor manufacturing, repair and distribution show
Motor & Drive Systems www.e-driveonline.com/conferences	advancements in motion control and power electronic technology

Table 11: Industrial Fairs Relevant for Motor Systems in Different Regions Source: [49]

Name	Focus	Location	Organizer
Energy Efficiency in Motor Driven Systems (EEMODS) www.eemods2013.org	efficient electric motor systems	International	Joint Research Centre of the European Commission, in collaboration with the local organizers
Motor Summit www.motorsummit.ch	efficient electric motor systems	Zurich, Switzerland	Swiss Agency for Efficient Energy Use
eceee Industrial Summer Study www.eceee.org/industry	energy efficiency in industry	Europe	European Council for an Energy Efficient Economy (eceee)
ACEEE Industrial Summer Study www.aceee.org	energy efficiency in industry	USA	American Council for an Energy-Efficient Economy (ACEEE)

Table 10: Conferences Related to Energy Efficiency in Industry and Electric Motor Systems

9 References

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[71] www.clasponline.org

10 Glossary

Asynchronous Motor: An AC motor which does not run at synchronous speed. The ordinary induction motor is an asynchronous motor – single or polyphase.

Efficiency: The efficiency of a motor (or a motor system) is the ratio of mechanical output to electrical input. It represents the effectiveness with which the motor converts electrical energy into mechanical energy at the output shaft. The higher the efficiency, the better the conversion process and the lower the operating costs.

Frame: Standardized motor mounting and shaft dimensions as established by IEC or NEMA.

Frame Size: Usually refers to the IEC or NEMA system of standardized motor mounting dimensions, which facilitates interchangeability.

Induction Motor: An alternating current motor in which the primary winding on one member (usually the stator) is connected to the power source. A secondary winding on the other member (usually the rotor) carries the induced current. There is no physical electrical connection to the secondary winding; its current is induced.

Load: The work required of a motor to drive attached equipment. This is expressed in kW or torque at a certain motor speed.

Permanent Magnet Motor: Type of DC motor where the field poles and the armature poles are electromagnets. The only current used by the motor is that of the armature. It has high starting torque, good speed regulation and a definite maximum speed.

System Efficiency: The ratio of the mechanical power supplied to load to the total input power under specified operating conditions. The input power includes requirements for auxiliary functions, such as motor field, phase control, switching equipment, overload protection, and fans.

Variable Speed Drive: Electronic equipment to adapt the frequency to the necessary load.

11 Abbreviations

4E	IEA Implementing Agreement for Energy Efficient End-Use Equipment
AC	Alternating Current
ACEEE	American Council for an Energy-Efficient Economy
ADB	Asian Development Bank
AEMT	Association of Electrical and Mechanical Trades
ANSI	American National Standards Institute
ASAP	Appliance Awareness Standards Project
ASME	American Society of Mechanical Engineers
AUD	Australian Dollar
BEE	Bureau of Energy Efficiency
BMLFUW	Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management
BRICS	Brazil, Russia, India, China, and South Africa
CAC	Compressed Air Challenge
CC	Compliance Certification
CEE	Consortium for Energy Efficiency
CENELEC	European Committee for Electrotechnical Standardization
CFR	Code of Federal Regulations
CLASP	Collaborative Labeling and Appliance Standards Program
CO_2	Carbon Dioxide
CSA	Canadian Standards Association
DC	Direct Current
DCCEE	Department of Climate Change and Energy Efficiency
DIS	Draft International Standard
DOE	Department of Energy
DSIRE	Database of State Incentives for Renewables and Energy Efficiency
EAN	International Article Number (originally European Article Number)
EASA	Electrical Apparatus Service Association
EASY	Effizienz für Antriebssysteme (efficiency for motor systems)
EC	European Commission
ECA	Enhanced Capital Allowance
eceee	European Council for an Energy Efficient Economy
EE	Energy Efficiency
EEC	Energy Efficiency Contractor
EECA	Energy Efficiency and Conservation Authority
EEM	Efficiency of Electric Motors program
EEMODS	Energy Efficiency in Motor Driven Systems
EISA	Energy Independence and Security Act
EMSA	Electric Motor Systems Annex
EMWG	Energy Management Working Group
EnB	Energy Baselines
EnPI	Energy Performance Indicator
EPCA	Energy Policy and Conservation Act

ESC	Energy Supply Contract
ESCO	Energy Service Company
ESP	Energy Service Provider
ET&M	Energy Technology and Management
EU	European Union
EU ETS	European Union Emissions Trading System
GBP	British Pound
GDEMS	Green Deal Efficient Electric Motor Systems
GEMS	Greenhouse and Energy Minimum Standards
GFA	Guarantee Facility Agreement
GHG	Greenhouse Gas
GMLP	Global Motor Labeling Program
GSEP	Global Superior Energy Performance
GWh	Gigawatt hour
HEPS	High Efficiency Performance Standards
hp	Horsepower
HVAC	Heating, Ventilation and Air Conditioning
Hz	Hertz
IADB	Inter-American Development Bank
ICA	International Copper Association
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IECEE	Worldwide System for Conformity Testing and Certification of Electrotechnical Equipment and Components
IEEE	Institute of Electrical and Electronics Engineers
IIP	Institute for Industrial Productivity
IFI	International Financial Institutions
ILI+	Intelligent (motor) list
IMTS	International Manufacturing Technology Show
IPEEC	International Partnership for Energy Efficiency Cooperation
IPMVP	International Performance Measurement and Verification Protocol
ISO	International Organization for Standardization
kg	Kilogram
kVA	Kilovoltampere
kW	Kilowatt
LCC	Life Cycle Cost
LFI	Local Financial Institutions
LTA	Long Term Agreements
M&MS	Motors & Motor Systems
M&T	Monitoring and Targeting
MDM	Motor Decisions Matter
MEPS	Minimum Energy Performance Standards
MST	Motor Systems Tool
MVE	Monitoring, Verification and Enforcement
NAESCO	National Association of Energy Service Companies
NATA	National Association of Testing Authorities
NB	National Body

NC	National Committee
NEMA	National Electrical Manufacturers Association
NGO	Non-governmental organization
NIST	National Institute of Standards and Technology
NVLAP	National Voluntary Laboratory Accreditation Program
NWI	New Work Item
OEM	Original Equipment Manufacturer
PFE	Program for Improving Energy Efficiency in Energy Intensive Industries
PSAT	Pumping System Assessment Tool
QR-Code	Quick Response Code
rpm	Revolutions per minute
S&L	Standards and labeling
SAC	Standardization Administration of the People's Republic of China
S.A.F.E.	Swiss Agency for Efficient Energy Use
SC22	Special Committee 22
SDG&E	San Diego Gas and Electricity
SEAD	Super-Efficient Equipment and Appliance Deployment
SEP	Superior Energy Performance
SOTEA	Software tool for efficient motor systems
STR	Standard Test Report
TBT	Technical Barriers to Trade
TBtu	Trillion British Thermal Units
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
USD	US Dollar
V	Volt
VAT	Value Added Tax
VFD	Variable Frequency Drive
VSD	Variable Speed Drive
W	Watt
WB	World Bank
WTO	World Trade Organization

12 Appendix

A National Voluntary Laboratory Accreditation Program (NVLAP)

Accredited NVLAPs exist in the USA (5), in Mexico, Japan, Vietnam, Korea, Taiwan and China. See list below:

- Arizona Baldor Motor Design Lab, Fort Smith, AR [200537- 0]
- North Carolina Advanced Energy, Industrial Energy Laboratory, Raleigh, NC [200081- 0]
- Ohio Regal Beloit EPC, Inc., Tipp City, OH [200053- 0]
- Texas Toshiba/Houston Test Laboratory, Houston, TX [200088- 0]
- Wisconsin Regal Beloit Corporation – Wausau Engineering Lab, Wausau, WI [200134- 0]
- CHINA CQST/CNEX Efficiency of Electric Motors, 473008 Nanyang, Henan, CHINA [200609- 0] Shanghai Testing & Inspection Institute for Electrical Equipment, Shanghai 200063, CHINA [200407- 0] Tatung (Shanghai) Co., Ltd., Shanghai 201611, CHINA [200806- 0]
- JAPAN Motor Test Lab of Toshiba Industrial Products Manufacturing Corp., Asahi-cho Mie-gun Mie-ken 510-8521, JAPAN [200529- 0]
- KOREA Korea Electrotechnology Research Institute, 642-120, KOREA [200912- 0]
- MEXICO GEIMM Ultra Test Lab, Monterrey Garcia, NL 66000, MEXICO [200606- 0] USEM de Mexico, S.A. de C.V., Apodaca NL 66600, MEXICO [200506- 0]
- TAIWAN TECO Electric & Machinery Co., Ltd., Taoyuan, TAIWAN [200378- 0] Tatung Company, 23728, TAIWAN [200590- 0]
- VIETNAM Motor Test Lab of Toshiba Industrial Products ASIA Corp., Bien Hoa City, Don Nai Province, VIETNAM [200961- 0]

B IEC Round Robin

Laboratories who participated in the IEC Round Robin (see Section 7.4) between 2008 and 2011:

1 Brazil: WEG Equipamentos Elétricos S.A.-Motors, Jaragua do Sul
2 Brazil: Laboratories:Instituto de Eletrotécnica e Energia da Universidade de São Paulo – IEE-USP, São Paulo
3 Canada: Chercheur – Utilisation de l'énergie, Laboratoire des Technologies de l'Énergie, Institut de Recherche, Hydro-Québec
4 China: SEARI, Shanghai
5 Czech Republic: Siemens Elektromotory s.r.o., závod Frenštát pod Radhostěm
6 Czech Republic: VUES Brno s.r.o., Brno
7 Germany: Siemens AG Automation and Drives, Bad Neustadt
8 Germany: PTB Physikalisch-Technische Bundesanstalt, Braunschweig
9 Finland: ABB, Vaasa (Coordinated by ABB in France)
10 USA: Baldor-Dodge-Reliance – Fort Smith, AR
11 USA: Baldor-Dodge-Reliance – Greenville, SC
12 USA: Regal-Beloit Corporation – Wausau, WI
13 USA: Siemens Energy & Automation – Norwood, OH
14 USA: TECO-Westinghouse – Taiwan
15 Korea: Korea Electrotechnology Research Institute
16 Australia: CalTest

C EMSA Motor Systems Tool

Optimizing motor systems is about choosing the right components and getting them to work well together, thereby achieving the maximum possible efficiency of the entire system. In order to facilitate and support the optimization of an entire motor system, EMSA has developed the Motor Systems Tool (MST). The MST calculates the efficiency of a complete motor system, composed of:

- Load, thus the characteristics of the driven machine (pump, fan, compressor, conveyor belt, etc.)
- Transmission (belt and gear), if any
- Motor
- Variable frequency drive, if any.

The Motor Systems Tool is impartial and independent of manufacturers' specifications. It is built up of standardized models for all implemented components (motor, variable frequency drive, transmission, gear), thereby ensuring that no specific products or manufacturers are being favored over others.

Motor Systems Components	Available Features of the MST
Load	four basic torque profiles (speed/ torque relations) User input on specific duty point User input – complete load profile
Transmission	many different belt types helical / worm / bevel gear models
Motor	User input from motor nameplate or Standard efficiencies IE1 / IE2 / IE3 or permanent magnet motors
Control System	direct on-line / soft starter / frequency converter

Table 12: Motor Systems Components and MST Features

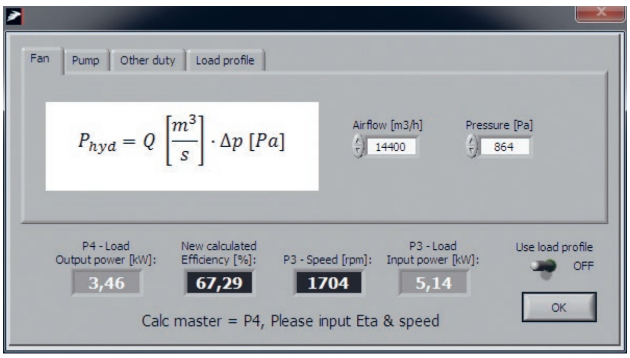

Figure 18: Motor Systems Tool Duty Point Input

Most of the models used are based on measurements during the last decade carried out at the accredited laboratories of the Danish Technological Institute, combined with the known theory of certain components, anonymous data from manufacturers, legislation rules, results of actual compliance testing, etc.
The Motor Systems Tool is intended for a broad global audience: engineers working in industrial plants, energy consultants, original equipment manufacturers, trainers and teachers at schools and universities as well as government officials responsible for creating policy instruments.

The Motor Systems Tool can be downloaded for free from www.motorsystems.org (registration required).
For more information on the MST see:
www.motorsystems.org/motor-systems-tool.

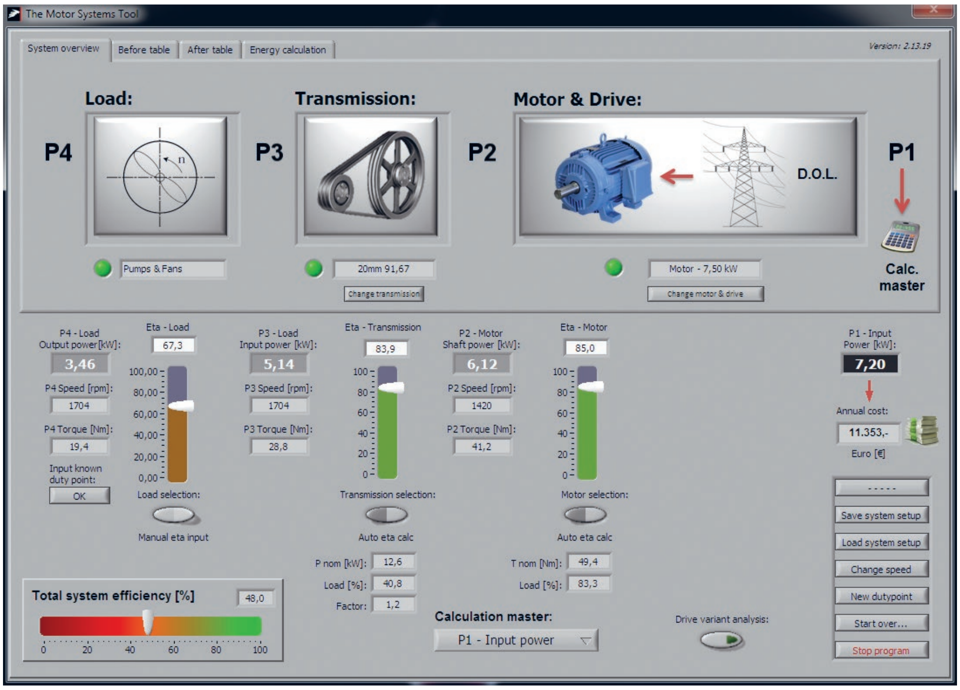

Figure 19: Motor Systems Tool Main Screen

The IEA Implementing Agreement on Energy Efficient End-Use Equipment (4E)

4E is an International Energy Agency (IEA) Implementing Agreement established in 2008 to support governments to formulate effective policies that increase production and trade in efficient electrical end-use equipment. Globally, electrical equipment is one of the largest and most rapidly expanding areas of energy consumption which poses considerable challenges in terms of economic development, environmental protection and energy security. As the international trade in appliances grows, many of the reputable multilateral organizations have highlighted the role of international cooperation and the exchange of information on energy efficiency as crucial in providing cost-effective solutions to climate change. Twelve countries have joined together to form 4E as a forum to cooperate on a mixture of technical and policy issues focused on increasing the efficiency of electrical equipment. But 4E is more than a forum for sharing information – it initiates projects designed to meet the policy needs of participants. Participants find that pooling of resources is not only an efficient use of available funds, but results in outcomes which are far more comprehensive and authoritative. The main collaborative research and development activities under 4E include:

- Electric Motor Systems
- Mapping and Benchmarking
- Solid State Lighting
- Electronic Devices and Networks

Current members of 4E are:

Australia, Austria, Canada, Denmark, France, Japan, Korea, Netherlands, Switzerland, Sweden, UK and USA.

Further information on the 4E Implementing Agreement is available from: www.iea-4e.org

4E Energy Efficient End-use Equipment
International Energy Agency