Industrial Energy Management: Issues Paper

Prepared for Expert Group Meeting: Using Energy Management Standards to stimulate persistent application of Energy Efficiency in Industry, Vienna, Austria, March 21-22, 2007
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Abstract

Energy management standards provide a viable policy mechanism for encouraging energy efficiency in industrial facilities. Several energy management standards currently exist (Denmark, Ireland, Sweden, United States) and others are planned (China). This issues paper presents the current status of energy management standards development internationally, including an analysis of their shared features and differences, in terms of content, promulgation, and implementation. The purpose of the analysis is to describe the current state of "best practices" for this emerging area of energy efficiency policymaking and to suggest next steps toward the creation of a truly international energy management standard that is consistent with the ISO principles of measurement, documentation, and continuous improvement.

Introduction

Industrial energy use globally accounts for 40% of electricity use, 77% of coal and coal products use, and 37% of natural gas use and is a major contributor to CO2 emissions.[1] In developing countries, the portion of the energy supply (excluding transport) required for industry is frequently in excess of 50% and can create tension between economic development goals and a constrained energy supply. Further, developing countries with emerging and expanding industrial infrastructure have a particular opportunity to increase their competitiveness by applying energy efficient best practices from the outset in new industrial facilities, rather than following the slower path to implementation that occurs in existing industrial facilities in more developed countries.

Industrial energy efficiency is frequently overlooked by policy makers concerned about energy supply and use. The common perception holds that energy efficiency of the industrial sector is too complex to be addressed through public policy and, further, that industrial facilities will achieve energy efficiency through the competitive pressures of the marketplace alone. Neither premise is supported by the evidence from countries that have implemented industrial energy efficiency programs.

At present, both markets and policy makers tend to focus exclusively on individual system components, such as motors or pumps with an improvement potential of 2%–5% instead of optimizing systems. Equipment manufacturers have steadily improved the performance of individual system components (such as motors, boilers, pumps and compressors) but these components only provide a service to the users' production process when operating as part of a system.

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[1] International Energy Agency (IEA) Statistics Division and IEA 7 July 2006 Industrial motor system energy efficiency: Toward a plan of action.

Energy use in industry is much more related to operational practices than in the commercial and residential sectors. If energy efficient lighting or appliances are installed in a commercial or residential building, those devices supply the same level of service at a reduced energy use without any further intervention from the user. If a building is well insulated and favorably oriented to benefit from solar exposure, then those benefits will accrue for the life of the building unless extraordinary measures are taken to negate them.

By way of contrast, an industrial facility may change production volumes or schedules and/or the type of product manufactured many times during the useful life of the factory. The energy-using systems designed to support these production practices may be relatively energy efficient under an initial production scenario but can be significantly less so under subsequent production scenarios. The presence of energy-efficient components, while important, provides no assurance that an industrial system will be energy-efficient. In fact, the misapplication of energy-efficient equipment in industrial systems is common. The disappointing results from these misapplications can provide a serious disincentive for any subsequent effort toward system optimization.

While the energy efficiency of components, such as motors, may be quite high, when viewed as an entire system their overall efficiency is quite low. Motor systems, on average, lose 55% of their input energy before reaching the process or end use; steam systems lose approximately 45%[2]. Some of these losses are inherent in the energy conversion process; for example, a compressor typically loses 80% of its input energy to low grade waste heat as the incoming air is converted from atmospheric pressure to the desired system pressure (Compressed Air Challenge 2003). Many losses, however, can be avoided through the application of commercially available technologies and good engineering practices. The potential for industrial system energy efficiency improvement has been well-documented at 20% or more by program experiences in the US, UK, and China.

The same factors that make it so challenging to achieve and sustain energy efficiency in industrial systems (complexity, frequent changes) apply to the production processes that they support. Yet production processes typically operate within a narrow band of acceptable performance. These processes are frequently incorporated into ISO 9000/14000 quality and environmental management systems, which require regular, independent audits to maintain ISO certification, an attractive value for international trade.

Industrial System Energy Efficiency

The energy savings potential of industrial systems remains largely unrealized because it is deeply embedded in industrial operational and management practices. Industrial systems are ubiquitous in the manufacturing environment, but their applications are highly varied. System optimization cannot be achieved through component standards or labeling or “one size fits all” approaches.

Even when plant engineering and operations staff recognize the importance of optimizing a system and identify system optimization projects, they frequently experience difficulty in achieving management support. The reasons for this are many, but central among them are two: 1) a management focus on production as the core activity, not energy efficiency and 2) the existence of a budgetary disconnect in industrial facility management between capital projects (incl. equipment purchases) and operating expenses. Incentive structures within companies are frequently structured to reward lowest first cost rather than life cycle cost purchasing practices, which can also impede motor system optimization. As a further complication, experience has shown that most optimized systems lose their initial efficiency gains over time due to personnel and production changes. Since system optimization knowledge typically resides with an individual who has received training, detailed operating instructions are not integrated with quality control and production management systems.

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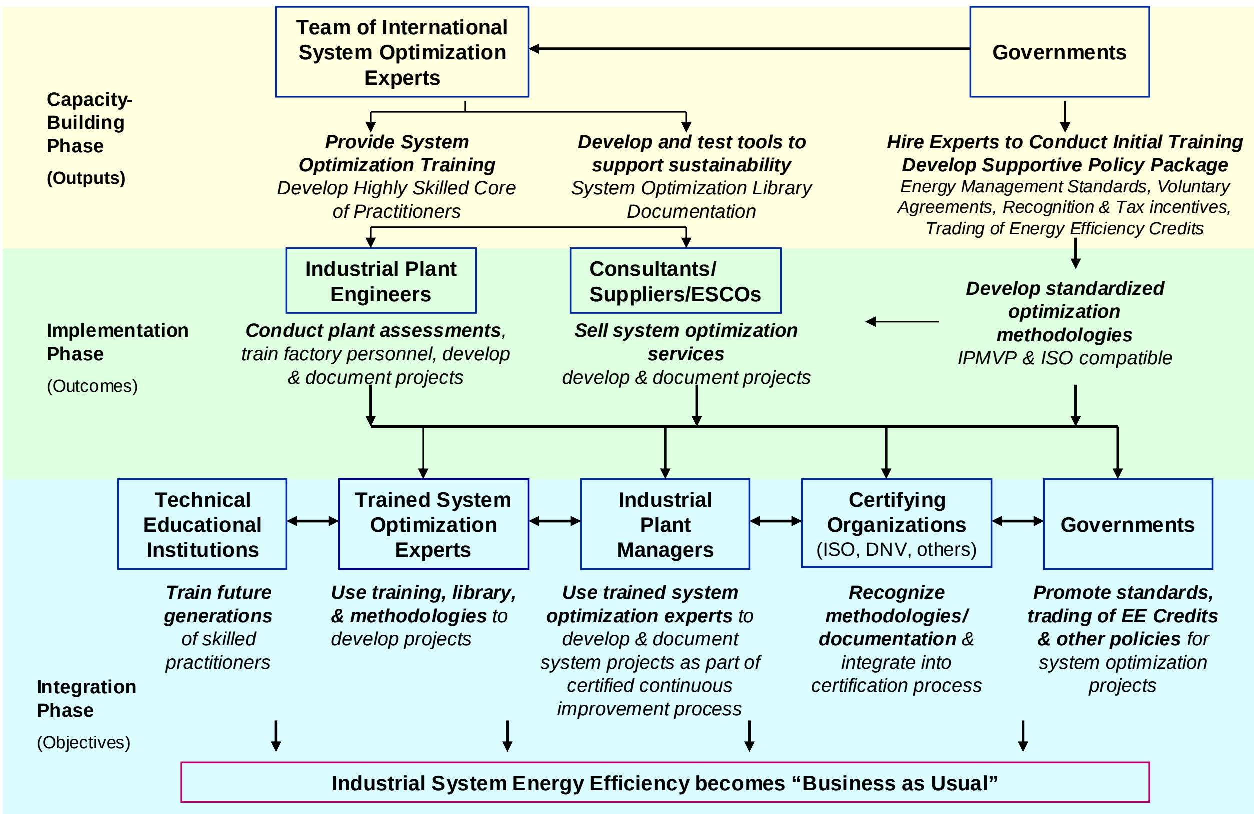
[2] US Department of Energy, 2004, Energy Loss Reduction and Recovery in Industrial Systems, prepared by Energetics and E3M, Washington, DC

The *Industrial Standards Framework* (see Figure 1) would establish a link between International Organization for Standardization (ISO) management systems and industrial system optimization. The Framework includes energy efficiency standards, policies, training, and tools that have the net effect of making system optimization for energy efficiency as much a part of typical industrial operating practices as waste reduction and inventory management. The purpose of this paper is to provide a detailed look at a key element of the Framework, an effective energy management standard, by examining the current status of energy management standards in five countries (China, Denmark, Ireland, Sweden, and the United States). Particular attention will be given to their link to ISO 9000/14000 quality and environmental management systems, their policy and program context, and their possible role in realizing the potential from motor system optimization.

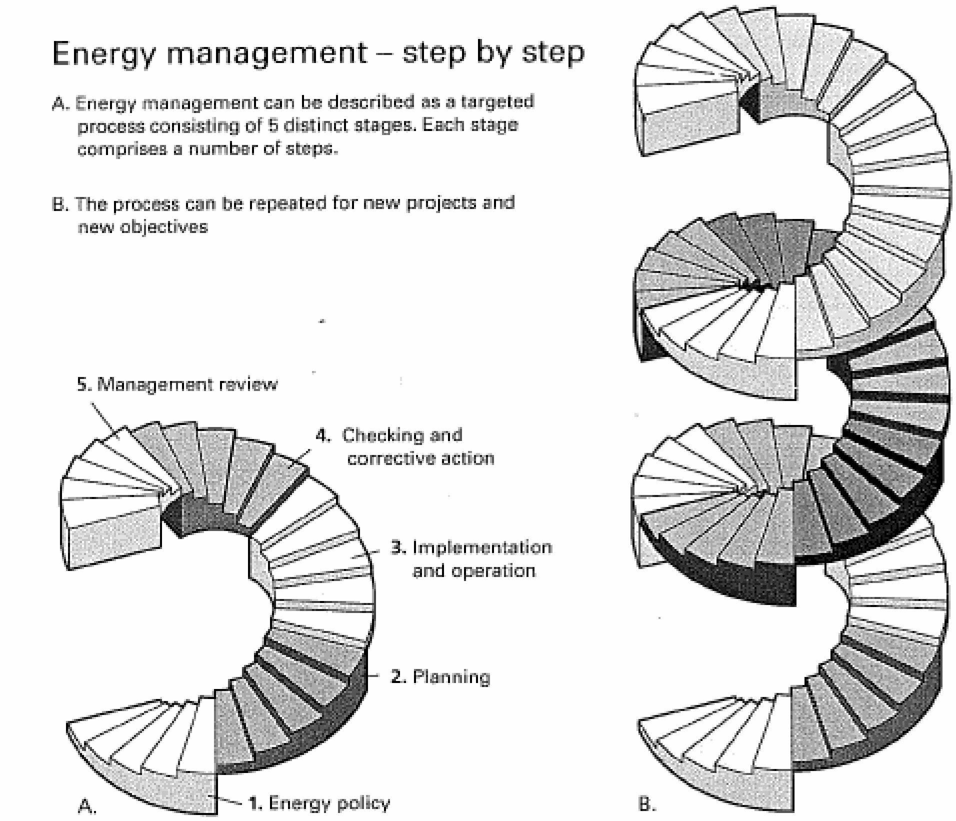
Figure 1: Industrial Standards Framework



Elements of an Effective Energy Management Standard

The purpose of an energy management standard is to provide guidance for industrial facilities to integrate energy efficiency into their management practices. All of the energy management standards studied for this paper use the "plan-do-check-act" approach as illustrated in the diagram below from the Danish DS 2403:2001, Energy Management-Specification.

Figure 2: Energy Management Diagram



Typical features of an energy management standard include:

- a strategic plan that requires measurement, management, and documentation for continuous improvement for energy efficiency;
- a cross-divisional management team led by an energy coordinator who reports directly to management and is responsible for overseeing the implementation of the strategic plan;
- policies and procedures to address all aspects of energy purchase, use, and disposal;
- projects to demonstrate continuous improvement in energy efficiency;
- creation of an Energy Manual, a living document that evolves over time as additional energy saving projects and policies are undertaken and documented;
- identification of key performance indicators, unique to the company, that are tracked to measure progress; and
- periodic reporting of progress to management based on these measurements.

In addition, for Denmark, Ireland, and Sweden, the standard includes explicit reference to a commitment to adhere to other applicable relevant regulations and requirements that pertain to the company's energy use.

Table 1 compares the elements of the energy management standards in the countries studied.

Table 1: Energy Management Standards, Details

Participating Countries	Management Commitment Required	Develop energy management plan	Establish energy use baseline	Identify Energy Coordinator	Establish Cross- Divisional Implementation Team	Emphasis on Continuous Improvement	Document Energy Savings	Establish Performance Indicators & Energy Saving Targets	Document & Train Employees on Procedural/ Operational Changes	Specified Interval for Re-evaluating Performance Targets	Reporting to Public Entity Required	Energy Savings Validated or Certified	Year Published	Approx Market Penetration by Industrial Energy Use
Existing														
Denmark	yes	yes	yes	yes	yes	yes	yes	yes	yes	suggests annual	yes	optional*	2001	60%**
Ireland	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	yes	optional*	2005	25%
Sweden	yes	yes	yes	yes	unclear	yes	yes	yes	yes	yes*	yes	optional*	2003	50%elect
United States	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	no	no	2000	<5%***
Under Development														
China	yes	yes	yes	yes	yes	yes	yes	yes	yes	industry sets own	not avail	not avail		

*Certification is required for companies participating in voluntary agreements (also specified interval in Sweden). In Denmark & Sweden linked to tax relief eligibility.

** as of 2002, latest date for which data is available

*** To date, the US government has encouraged energy management practices, but not use of the standard, therefore market penetration has been very limited. Program policies new in 2007 are designed to address this.

For all the four countries with existing energy management standards, the standard has been developed to be entirely compatible with the ISO quality management program (ISO 9001:2000) and environmental management program (ISO 14001). In the case of Denmark, Ireland, and Sweden, the assumption is that industrial facilities participating in ISO 14001 will integrate the requirements of the standard into their existing management documentation and procedures.

Supportive Policies and Programs

In the five countries studied, the energy management standards are designed to be applicable to all types and sizes of companies; however, in each instance, the largest, most energy intensive industries are the focus of additional programs and initiatives. By concentrating efforts on these large energy users, policy makers seek the greatest reduction in industrial energy consumption and overall GHG emissions. Not surprisingly, the proportionally greatest impact on industrial energy consumption has been in Denmark, which has had financial incentives since 1992 in the form of a CO_2 –tax rebate, coupled with voluntary agreements and, as of 2001, energy management standards. An entirely different approach has been taken in the US, which has concentrated on educating industry about system energy efficiency opportunities. The US has not explicitly promoted use of its energy management standard nor offered either financial incentives or penalties for meeting energy reduction targets. As a result, relatively few plants are using the energy management standard. Table 2 below provides a comparison of these supporting policies.

Table 2: Energy Management Standards, Programmatic Context

Participating Countries	Voluntary or Mandatory Standard	Financial Incentives for Compliance	Technical Assistance Available	Penalties for Non-Compliance	Recognition Program	Linked to Voluntary Agreement	Training Available on Standard Compliance	Industrial Systems Training Available	Case Studies Published	Targeted Plants
Existing										
Denmark	vol	yes*	yes	yes*	yes	yes	yes	not known	not known	yes
Ireland	vol	yes	yes	no	yes	yes	yes	limited***	yes	yes
Sweden	vol	yes**	yes	yes**	yes	yes	no	no	planned	yes
United States	vol	no	yes	no	planned	no	planned	yes	yes	yes
Under Development										
China	vol	info not yet available						yes		yes

* Denmark has had a CO2 tax since 1992 that affects larger industries. Tax relief is linked to participation in a voluntary agreement.
**Sweden has had a CO2 tax since 1/2005.Tax relief for process-related electricity linked to participation in a voluntary agreement.
*** Ireland plans to expand training offerings

Denmark

Denmark has had a CO_2 tax in place since 1992 on all energy sources in Denmark. Because of concerns that the tax would make energy-intensive Danish industries non-competitive, the government introduced voluntary agreements that offered a CO_2- tax rebate for adopting energy management practices and undertaking energy efficiency measures. To be eligible, companies had to be listed by the Danish Energy Authority as energy-intensive and the company's energy-tax load had to exceed 4 percent of the company's value added in the year prior to signing the agreement. These agreements have become an important driver in encouraging use of the energy management standard in Denmark. Energy-intensive companies that enter into agreements for tax benefits must implement all energy-efficiency measures related to heavy processes with a payback period of four years or less; for less energy intensive companies signing agreements, the implementation requirement expands to measures with payback periods of six years or less.

According to Persson and Grudbjorg [2006]-

> The Danish Energy Authority has implemented several different policy measures to make industry invest in energy-efficiency and energy conservation actions. The most effective ones used by the Danish Energy Authority have been:
>
> - Voluntary agreements
> - Subsidies
> - Information activities

The Danish Energy Authority, as the result of a 2002 evaluation of the voluntary agreement system, found that half of the companies involved had reduced their energy usage by 20%. According to Larsen, *et al* [2005]-

> The intentions behind the development of Danish energy management during the last 10 years has been to transform it from a rather technical monitoring and measurement system to a management system with more focus on information, communication, internal and external audits and employee involvement.

The energy management system (introduced as a standard in 2001) was felt to be an advantage to the participating companies. Participating companies have cited other benefits such as better product quality, increased production capacity, and increased employee engagement. Active energy management in Denmark has been positively correlated for industrial firms with number of employees, CO_2- tax agreements, subsidies, and the number of environmental inspections by the local government. The role of training in system optimization techniques in achieving energy savings needs clarification.

Ireland

Sustainable Energy Ireland (SEI) has a well-integrated array of program offerings to encourage use of their energy management standard, IS 393, introduced in 2005. A three-day training session is offered on energy management that addresses topics such as energy management goals, benchmarking, establishing energy performance indicators, and an overview of energy improvement opportunities with a focus on motor driven systems. Companies are encouraged to join the Large Industry Energy Network (LIEN) to share and learn from each other during implementation of the energy management standard. The most energy intensive sites in Ireland (annual energy bill of €2 million or greater) are being recruited to participate in the Energy Agreements Programme, entering into an agreement with SEI that requires implementation of IS 393, including certification of compliance by an outside party. The target group comprises 60-100 industrial energy users, particularly those subject to the requirements of the EU-Emission Trading Scheme. As of January 2007, 25 companies were participating. Participants are eligible for an array of services to assist them in setting and meeting their energy management goals. Participation in a recognition program and case studies are also encouraged. A separate program for smaller companies is under development. For more information, see http://www.sei.ie/ .

Sweden

Sweden has had a voluntary agreement program since 1994, but only added an energy management standard as a program requirement in 2003. Prior to that time, the voluntary agreement had few incentives for participation and the results of the program could not be measured (Linden and Carlsson-Kanyama, 2002, as cited in Price 2005). In 2005, after Sweden imposed a tax on industrial process-related electricity, the Programme for Improving Energy Efficiency in Energy-Intensive Industries (PFE) was launched. Managed by the Swedish Energy Agency, the PFE offers reduced taxation for companies that introduce and obtain certification for a standardized energy management system and undertake electrical energy efficiency improvements. The program requires a five-year initial commitment, with specific milestones to report by the end of two years, as follows:

- implementation of the energy management standard that is certified by an accredited certification body;

- completion of an in-depth energy audit and analysis to baseline use and identify improvement opportunities. A list of measures identified in the energy audit with a payback of three years or less must be submitted to the Swedish Energy Agency;
- establish procurement procedures that favor energy efficient equipment, and
- establish procedures for project planning and implementation.

By the end of five years, the company must implement the listed measures, demonstrate continued application of the energy management standard and procurement procedures, and assess the effects of project planning procedures. As of January, 2007, 126 companies had signed up to participate in PFE, representing approximately 50% of all industrial electricity use. To join, companies must be in certain eligible classes, use electricity in their manufacturing process, have energy costs of at least 3% of production value or pay at least 0.5% of value-added in energy-related taxes, and have the economic means to carry out the program. To assist companies in compliance, the government has published handbooks on energy management, energy audits and analysis, routines for purchasing and planning, and a template for calculating life cycle cost in accordance with program requirements. The role of training for participating companies needs to be clarified. For more information, see http://www.stem.se/ .

United States

Georgia Institute of Technology (Georgia Tech) first developed a comprehensive energy management standard for industry in 2000 that has served as a model for several subsequent national standards. Although the standard was adopted by the American National Standards Institute (ANSI), it has received little public recognition or support and is not widely used in the US. The US has, however, developed a great deal of technical capability in industrial energy efficiency, especially motor, steam, and process heating systems.

Since 1993, the US Department of Energy (USDOE) has been developing and offering an extensive array of technical training and publications to assist industrial facilities in becoming more energy efficient through its BestPractices program. In October 2005, USDOE initiated a program to offer an Energy Saving Assessment (ESA) demonstration for steam or process heating systems in 200 plants with an annual energy use of 1TBtu or higher. Six months after completion of the assessments, 71 plants had reported almost $140 million worth of energy savings recommendations either completed, underway, or planned. Based on the success of the first year, the program was expanded in 2006 to include motor systems. For more information about BestPractices see
http://www1.eere.energy.gov/industry/bestpractices/ .

In 2002, the US Environmental Protection Agency (USEPA) began a voluntary program, Climate Leaders, which works with companies to develop long-term comprehensive climate change strategies. Using the GHG emissions protocol developed by the World Resources Institute and the World Business Council for Sustainable Development, 59 companies have set and report progress on a corporate-wide GHG reduction goal to be achieved over 5 to 10 years. These goals are evaluated against the projected performance of the relevant sector. In 2003, the USEPA began offering information on energy management guidelines and benchmarking as part of its ENERGY STAR for Industry program. The program also includes energy performance indicators for selected industries that companies can use to benchmark their performance, gaining recognition if they are in the upper quartile. For more information, see http://www.energystar.gov/ .

Collectively, these activities encourage companies to manage energy, but do not explicitly encourage use of an energy management standard. However, recently USDOE and USEPA have joined together to develop a collaborative program to certify plants for energy efficiency that implement energy management standards, based on an updated version of the Georgia Tech/ANSI energy management standard. This program is expected to greatly increase use of the standard by US industries.

China

The China Standard Certification Center (CSC) has been authorized by the Chinese government to develop a series of national energy management standards. Three standards are planned for release by March 2008-- Management System for Energy –Requirements, Management System for Energy-Guidelines for performance, and Management System for Energy- Guidelines for Auditing. The draft Requirements standard has much in common with the other energy management standards in use elsewhere.

In 2005, the Chinese government announced a plan to reduce energy consumption per unit of GDP by 20% over 2005 levels by the year 2010. A major initiative included in this plan is Monitoring and Guiding of Energy Efficiency Improvements of Top 1000 Energy-Consuming Enterprises in China. A total of 1000 large energy using enterprises from nine sectors have been selected for participation. Their estimated 2004 final energy use was 673 Mtce or 18.7 Quads which represents almost 50% of China's industrial energy consumption and 30% of China's total final energy use. The total energy reduction goal for these enterprises after five years is 100 Mtce (2.8 Quads).

Under the plan, the enterprises participating in the Top 1000 Energy-Consuming Enterprises program are required to report annually on energy use, and, within the first five years and every five years thereafter, conduct an energy audit, develop an energy conservation plan, formulate energy efficiency goals and adopt energy conservation measures. It is assumed that the planned energy management standards will be linked to these program activities, once they become available.

Going Global: An International Approach to Industrial Energy Management

As shown in Table 1, the existing energy management standards have many features in common. This is not accidental. All the standards reviewed in this paper have been developed by individuals well-versed in the ISO management model for continuous improvement. The US standard, developed by Georgia Tech/ANSI, was based on ISO management principles. The Danish standard, issued a year later, has most of the same features and makes explicit references to ISO 14001. Both the Irish and Swedish standards acknowledge their similarity and relationship to the Danish standard. The Chinese standard now under development is using the Georgia Tech/ANSI standard as a reference.

The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) have formed a task force and undertaken development of a set of three European standards related to energy management including: energy service companies – ESCOs, energy managers and experts, and energy management systems. The Task Force 189- Energy Management convened in November 2006 with 24 participants from 10 countries, and decided to create three ad hoc Project Teams to develop the standards. The standard on energy management systems has been assigned to Sweden and will be a simple compilation of existing Danish, Swedish and Irish Standards and the Dutch Specification, conform to the ISO 14 000 structure and requirement. It will also take in account the German VDI Specification on EMS and the US ANSI MSE 2000. A draft is expected by October 2007.

The purpose of the Experts Group Meeting is to bring together countries with both practical experience and interest in industrial energy management to share information about energy management standards and supporting program activities with each other and with the ISO Secretariat. The objective is to build on the progress to date, especially in the EU, and to further the dialogue concerning development of an international energy management standard recognized by ISO.

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