Industrial Energy Assessments: A Survey of Programs around the World

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ABSTRACT

Industrial energy assessments have been used in various industries and countries to identify major energy-saving areas and provide recommendations to realize the identified energy-saving opportunities. Energy assessments can assist industrial facilities to understand their saving potentials and make informed decisions on energy-efficiency investments. However, many plants do not have the capacity to conduct an effective energy evaluation. A number of government programs have been established around the world to encourage, facilitate or mandate industrial facilities to undertake energy assessments. This paper presents information from a survey of 22 industrial energy assessment programs in 15 countries (Australia, Canada, Denmark, Finland, France, India, Ireland, Japan, Netherlands, Norway, Portugal, Sweden, Switzerland, the United Kingdom, the United States) and one region (the European Union). The paper provides information on the establishment of these programs, including different program types, incentive policies, energy assessment manuals and tools, training and certification of energy experts, databases of energy assessments results, post-assessments follow-ups, and other integrated policy measures. The paper then compares stand-alone energy assessment programs and integrated policy programs that have an energy assessment component based on these key design elements. Finally, the paper makes recommendations for establishment of a robust energy assessment program, with the goal of providing guidance to policy makers and program designers, especially in countries that currently do not have such programs that are in the process of establishing new programs, or are improving existing energy assessment programs.

Introduction

Industrial energy assessments[1] have been used in various industries and countries to identify major energy-saving areas and provide recommendations to realize the identified energy-saving opportunities. Energy assessments can assist industrial facilities to understand their saving potentials and to make informed decisions on energy-efficiency investments. However, many industrial facilities either do not have the capacity to conduct an assessment, or they are not always aware of their overall energy-efficiency improvement potential or specific measures that can be implemented. One common policy to address these issues is through the adoption of a national energy assessment program.

An energy assessment examines the status of energy consumption in facilities. Usually, the results of energy assessments are presented in a formal report, showing findings on potential energy-efficiency improvements, estimated energy and cost savings, as well as anticipated costs of implementation (Russell, 2010). Energy assessment models vary, but generally fall into the categories of either preliminary or detailed energy assessments. Preliminary energy assessments can provide a basic understanding of energy use in the facilities, identify simple operation and maintenance improvements, and help to determine

[1] Based on the ASME Standards EA1 through EA4, energy assessments in this paper are defined as "a standardized framework", which "involve collecting and analyzing system design, operation, energy use, and performance data and identifying energy performance improvement opportunities for system optimization." Some activities mentioned in this paper are energy audits, but are included in the scope of energy assessments in this paper.

whether a more comprehensive assessment is needed. Detailed or comprehensive assessments can be targeted at specific systems or can cover most processes, equipment or facilities, to identify more wide-ranging measures.

An industrial energy assessment is a necessary first step for defining energy consumption by end use and identifying key areas for energy saving in industrial operations. Without baseline energy use data, it is impossible to have a clear understanding of the current situation or to make cost-effective decisions regarding energy-efficiency strategies. An industrial energy assessment is also an important impetus to encourage industrial facilities to implement energy-efficiency measures and technologies with the most saving potential. In general, preliminary energy assessments provide quick estimates of costs, potential cost and energy savings, as well as simple payback periods. Comprehensive energy assessments, on the other hand, provide detailed cost-effective analysis of all identified measures and technologies based on plant's specific operating conditions. Credible energy assessments provide packages of customized recommendations for plants to consider. In this regard, an energy assessment is often a key component of industrial energy efficiency programs and has been considered as a supporting policy tool for policies such as voluntary agreements or emissions cap and trade programs.

To leverage more energy savings from the industrial sector and to address barriers such as the issue of lack of interest in undertaking energy assessments, countries around the world often institutionalize industrial energy assessments into a policy or a program. This type of program, referred to in this paper as a ***stand-alone energy assessment program***, largely focuses on the energy assessment itself, and asks participants to perform energy assessments while offering technical support or guidance. The other type of program, referred to in this paper as an ***integrated energy assessment program***, combines energy assessments with other policy measures to better motivate participants, to help decision-makers to set a reasonable yet ambitious energy-saving target, and to achieve the broader goals of the program. Since energy-efficient technologies and measures improve over time, energy assessments should not be viewed as one-time only events, but should be performed periodically, and can be combined with other policies mechanisms to continuously promote industrial energy efficiency. A mature industrial energy assessment program not only institutionalizes energy assessments for the long-run, tracks the performance of energy auditors, and monitors the implementation of recommendations, but also provides feedback to industry participants, and provides insightful policy recommendations based on analysis of aggregated results for energy-use systems.

This paper first provides information on the establishment of these programs, and then compares stand-alone energy assessment programs and integrated energy assessment programs that have an energy assessment component based on these key design elements. Finally, the paper makes recommendations for establishment of a robust energy assessment program, with the goal of providing guidance to policy makers and program designers, especially in countries that currently do not have such programs, that are in the process of establishing new programs or are improving existing energy assessment programs.

Methodology

A review of 22 industrial energy assessment programs was conducted. One program in the European Union (EU) and 21 programs in 15 selected countries including Australia, Canada, Denmark, Finland, France, India, Ireland, Japan, Netherlands, Norway, Portugal, Sweden, Switzerland, the United Kingdom, and the United States were reviewed. A list of the selected programs by country as well as their program types is shown in Table 1. Information

on programs was gathered through databases of international energy-efficiency policies, program web pages, government announcements, legislation documents, program evaluation reports, research reports, and internet searches.

Table 1. Industrial Energy Assessment Programs

Country	Program Name	Assessment Requirements and Program Type
Australia	Energy Efficiency Opportunities Program (EEO)	Mandated by law (I)
Canada	ecoENERGY for Industry	Voluntary assessments in VAs (I)
Denmark	Voluntary Agreements (VA) with Greenhouse Gases Tax	Mandatory in VAs with tax exemption (I)
Finland	Finnish Energy Audit Program in Industry	Voluntary assessments in VAs (I)
France	Energy Audits for SMEs	Free energy assessments (S)
	AERES Negotiated Agreements with threatened tax	Voluntary in VAs with threat of using tax (I)
India	Energy Managers Training	Training programs for certified energy auditors (I)
Ireland	Energy Advice, Mentoring & Assessment for SMEs	Free energy assessments (S)
	Large Industrial Energy Network (LIEN)/Energy Agreement Program (EAP)	Mandatory in VAs with required energy management system (I)
Japan	Energy Conservation Audits	Free energy assessments (S)
	Certified Energy Managers (required by the Amended 2005 Energy Conservation Law)	Mandated energy assessments by law with required energy management system (I)
Netherlands	Long-Term Agreements (LTA)	Mandatory in VAs with required efficiency targets (I)
Norway	Industrial Energy Efficiency Network (IEEN)	Voluntary assessments in VAs with CO_2 tax (I)
	Energy management – companies in networks (EM-Network)	Voluntary assessments in VAs with required efficiency targets (I)
Portugal	Management System of Intensive Energy Consumption (SGCIE)	Mandated with required energy management system and efficiency targets (I)
Sweden	Program for improving energy efficiency in energy-intensive industries (PFE)	Mandatory in VAs with tax exemption (I)
	Energy Audits for Companies	Free energy assessments (S)
Switzerland	CO_2 Target Agreements	Mandatory assessments in VAs with tax exemption (I)
UK	Carbon Surveys of Carbon Trust	Free energy/carbon assessments (S)
US	Save Energy Now (SEN) LEADER	Mandatory in VAs with required efficiency targets (I)
	Industrial Assessment Centers (IACs)	Free energy assessments (S)
EU	EU Eco-Management and Audit Scheme (EMAS)	Mandatory in VAs with required efficiency targets and required environmental management system (I)

Source: IEA, 2010; MURE, 2010; Price, et al., 2008 and Galitsky, et al., 2004.

Note: S: stand-alone energy assessment program; I: integrated energy assessment program; VAs: voluntary agreements.

Stand-Alone Energy Assessment Programs

Stand-alone energy assessment programs were identified in six countries. These programs were established by the national governments to stimulate demand for industrial energy assessments. The stand-alone energy assessment programs either offer free energy assessments or subsidized energy assessments to partially cover the costs of energy assessments (see Table 2).

Table 2. Types of Stand-Alone Energy Assessment Programs

Category	Program (and National Agency)
Free energy assessments	US Industrial Assessment Centers (US Department of Energy)
	UK Carbon Surveys (Carbon Trust)
	Japan Industrial Energy Audits (Energy Conservation Center of Japan)
	Ireland Energy Advice to SMEs (Sustainable Energy and Authority of Ireland)
Subsidized energy assessments	Swedish Program of Energy Audits for Companies (Swedish Energy Agency)
	French Program of Energy Audits for SMEs (Ministry of Economy, Finance and Industry)

There are several common features of the stand-alone energy assessment programs. First, these national programs are all voluntary and are open to all interested participants. Second, except for the Program of Energy Audits for Companies in Sweden, all other programs focus on small-and-medium enterprises (SMEs). SMEs often do not have the resources that large enterprises possess in terms of expertise and information related to energy-efficiency (Nagesha and Balachandra, 2006; Worrell and Price, 2001; Reddy, 1991). Typically, due to the pressing issues of economic survival and limited management capacity, SMEs either are not interested in energy assessments or do not have the financial resources to afford a professional energy assessment. Thus, government-initiated energy assessment program can be a convenient channel for SMEs to seek expertise or financial support.

The U.S. energy assessment program provided through the Industrial Assessment Centers (IACs) targets small to medium-sized facilities in the United State. Industrial facilities need to meet the following criteria to participate: 1) gross annual sales below $100 million, 2) less than 500 employees, and 3) annual energy bills more than $100,000 USD and less than $2 million USD (US DOE ITP, 2010a). In the UK's Carbon Surveys, companies that are eligible for free energy assessments are required to have annual energy bills more than £50,000 ($77,300 USD) but less than £500,000 ($773,000 USD)[2] for plants in England (Carbon Trust, 2010a).[3]

To understand the robustness of the programs, eight elements that are key factors of stand-alone energy assessment programs are evaluated in more depth (see Table 3 below). These elements include: costs of assessments, standardized manuals, auditors training, databases, post-assessment follow-up, standardized tools, and availability of case studies.

Please note that financing for implementation of measures is not included here. Financing difficulties and long pay-back time are usually the most often cited reasons for facilities to fail to implement identified energy-efficient measures. However, due to limited funding and resources, providing direct investment support is not very common among the surveyed programs. On the other hand, energy-efficiency financing is becoming more popular and needed, and various financing models and programs have been developed to facilitate industrial plants to uptake energy-saving opportunities. Thus, in many countries, after a facility has undertaken an energy assessment, they can apply for financial support through other public or private financing channels.

[2] 1 GBP = 1.546 USD (average rate of 2010) for this paper. http://www.oanda.com/currency/historical-rates

[3] Starting in 2011, this program offers energy assessments in Scotland, Northern Ireland and Wales only.

Table 3. Availability of Key Components in the Selected Stand-Alone Energy Assessment Programs

Programs	Assessment Costs	Standardized Manuals	Auditor Training	Auditor Certification	Database of Energy Assessment Results	Post-Assessment Follow-ups	Standardized Tools	Availability of Case Studies
US Industrial Assessment Centers (IACs)	Free	Y	Y	N	Y	Y	Y	Y
UK Carbon Surveys (Carbon Trust)		N/A	N[1]		N		N	
Japan (Energy Conservation Center of Japan)			Y					
Ireland (Energy Advice to SMEs)		Y	N				Y	
Sweden (Energy Audits for Companies)	Cost-shared		N[2]				N	
France (Energy Audits for SMEs)			Y	Y		N	Y	

Y: available; N: not available; N/A: not applicable

Notes: 1: Although no specific energy assessment training is provided, each Carbon Survey is conducted by an independent accredited consultant. Online training on creating a customized "energy saving action plan" is available on the website of Carbon Trust.

2. Swedish Energy Agency provides a list of energy experts and professionals to provide advices to companies.

Cost of Energy Assessments

The costs associated with an energy assessment can be reduced through subsidies or energy assessments can be provided free of charge to participants. Governments can establish an upper limit for subsides, either as a percentage of the costs, or an absolute amount, or both. For example, the Energy Conservation Center of Japan (ECCJ), with funding support from the national government and the Japanese private sector, has carried out industrial energy assessments for factories in Japan since 1978 (ECCJ, 2009). These energy assessments are conducted at no cost for companies with a capital less than 100 million Yen (about 1 million USD) or less than 300 employees (Galitsky, et al., 2004).[4]

Program designers must consider the free-rider effect when developing incentive policies, especially for subsidy policies. Companies that are free riders may not view energy assessments as their highest priority, or they may simply use the subsidy to conduct a preliminary assessment. Some companies may use subsidies, which are designed to be used for energy assessments or other energy-efficiency measures, instead for feasibility studies or "condition assessments" (Vaisanen, et al., 2002). A Finnish program reported that the free-rider effect of the assessment program was around 10-15% of the realized actions (Thomas, 2008; Khan, 2006). In Denmark, it was assumed that about 50% of the implemented actions would have been implemented without subsidies for assessments (Gynther and Suomi, 2009).

Standardized Manuals and Standardized Tools

Standardized manuals are guidebooks and templates that provide standardized procedures for energy auditors to use when conducting energy assessments. Standardized manuals can ensure that the assessment has been conducted in a coherent manner and that the aggregate data can be synthesized to produce insightful results. Given that energy assessments will vary depending on different processes or industrial sectors, guidebooks or templates that are sector, process, or equipment-specific can be developed.

[4] Companies that are above the threshold are covered in an integrated energy assessment program, which is Japan's Certified Energy Managers Program.

Standardized tools can be checklists, excel-based or programmed calculation tools (often used in association with data collection forms), on-line tools, and downloadable or CD-based software. Checklists can be used in walk-through energy assessments by onsite energy managers for their own facilities. Simple calculation tools can be used for self-assessments, or can be used more widely as an awareness raising instrument. Software tools are portable and have more functions, but to achieve good output analysis, high quality data are required. By using energy assessment tools, energy auditors can identify possible issues, quickly estimate savings for recommendations, analyze various configurations of recommendations to determine potential impacts and optimal energy savings, and verifying results (Muller, 2010a).

The U.S. Department of Energy (DOE) has developed a series of system-specific industrial assessment software tools for use during energy assessments. These tools are available online at no cost. These system-specific tools serve as standardized energy assessment tools in the IACs Program. These tools are developed by experts in the field, and are designed to identify energy-saving opportunities in different sectors. Each tool comes with user manuals and case studies, and DOE provides further training on the use of these tools.

Training and Certification of Energy Auditors

It is essential that energy assessment programs employ high-quality and highly skilled energy auditors. The assessments and recommendations provided by the energy auditors are directly linked to the outcome of energy assessments. Energy assessment training can be provided in various forms such as webinars, introduction classes and practical sessions and may vary in content, i.e., training on energy assessment procedures or training on technical methodology and practical methods. Depending on the needs of the energy assessment program, training can be voluntary, recommended, or mandatory (Väisänen et al., 2002).

When energy assessment training is completed, a test or examination is conducted in order to determine if the trainees can be certified. Sometimes, if no training is conducted, certain pre-requirements or pre-qualifications can be used for certification. If the trainees pass the examination, they will be granted the authorization or "licenses" to perform energy assessments. The purpose of certification is to develop a group of highly skilled energy auditors or to control the minimum performance of all energy auditors. Both individual persons and companies or institutions such as energy service companies (ESCOs) can be certified. Program designers of energy assessment can decide if certification of energy auditors is required, recommended or voluntary, given specific program needs.

Energy assessments offered through the U.S. DOE's Industrial Assessment Centers and Save Energy Now Program are conducted by Energy Experts or Best Practices Qualified Specialists. Training of these experts covers energy assessment tools and system-specific practices. Usually, training takes three to five days. Trainees who wish to become a Qualified Specialist must not only meet prerequisites and take training programs, but also need to pass practical and written exams. If they successfully pass the tests, their names will be publicized by U.S. DOE on their website as a Qualified Specialist for cross-cutting energy consuming systems such as compressed air, fans, process heating, pumping and steam.

Databases of Energy Assessment Results

In the surveyed stand-alone energy assessment programs, only the IAC program in the U.S. has established a database of energy assessment results. The IAC database was initiated in 1981 and it now includes about 15,000 assessments and 110,000 recommendations. This

downloadable database provides geographic maps to view filtered assessments all over the U.S. It not only can record assessments and recommendations, but also can analyze and generate reports related to all program data. For example, according to the database, on average, identified energy savings for each assessment is about $70,000 USD, and achieved energy savings per assessment is around $23,000 USD. The searchable database is a good source for "training the trainers" as well. In addition, the database allows manufacturers to access the assessment results publicly, and thus to further benchmark and evaluate potential energy-saving opportunities.

The database is open to energy auditors, industrial plants, or other related partners. Wider access to the database will enable the data to be used in additional energy-saving programs and thus achieve more energy-savings. However, confidential or sensitive data should be restricted from the general access database (Muller, 2010b). A database can be used to monitor and verify the program. In the IAC program, after the data and assessment report are submitted to the database, the report will be reviewed and data will be error-checked. By using the IAC database, industrial assessment centers can identify and resolve any existing issues. The database also provides a platform for centers to conduct follow-up surveys and collect case studies.

Post-Assessment Follow-Ups and Case Studies

Post-assessment follow-ups are important for understanding how the recommended energy-saving measures are implemented after energy assessments. Only after understanding why plants have difficulties adopting measures can more targeted services be provided to facilities. In the reviewed stand-alone energy assessment programs, several programs surveyed the plants after the energy assessments were conducted.

In Ireland, the Energy Advice for SMEs program usually follows the plants for 90 days via phone and email, to provide any additional support and consultation (SEAI, 2010). In the United Kingdom, the Carbon Surveys Program provides feedback and follow-ups to clients through phone calls or email. In the United States, the IAC program contacts the assessed plants by phone six months after the energy assessment (Gopalakrishnan, 2010).

All of the stand-alone energy assessment programs provide case studies to the public. Case studies and other booklets are information tools, which can attract potential participants and contribute to training sessions. Together with other supporting measures, case studies can be utilized to increase public awareness or positive recognition of energy assessments. They can also be used to convince targeted groups (e.g. industrial plants) to participate in energy assessments, self-identify problems, or implement energy efficiency improvements.

Integrated Industrial Energy-Efficiency Policy Programs with Energy Assessments

In contrast to the stand-alone energy assessment programs, many industrial energy-efficiency policies and programs include industrial energy assessments as a key component which is combined with other policy measures to better motivate participants and to achieve broader goals. Sixteen programs in 14 countries and the European Union were identified in this survey as integrated industrial energy-efficiency policy programs that include energy assessments. The integrated policy programs include voluntary agreement schemes and mandatory regulations. Voluntary agreements (agreements signed between industry and the government) have been widely used (Price, 2005) and in many cases require energy assessments for participants. Mandatory requirements are regulations or legal mandates established by national governments, which often require facilities to conduct energy

assessments, meet energy-efficiency improving targets, or establish a certified energy/environmental management system. Often, energy assessments have been utilized as one of the effective tools to achieve broader goals of the national regulations.

Of the 16 reviewed programs, four require industrial facilities to conduct energy assessments and to meet other established requirements, such as to implement a certified energy management system. Twelve programs are voluntary agreement schemes, and seven of these require all participants to undertake mandatory energy assessments. Table 4 shows various policy measures that have been combined with energy assessments. Based on country-specific conditions, energy assessment program developers (e.g., policy makers) decide which program type to use (either voluntary or mandatory), and which measures to include.

Table 4. Policy Measures Applied in National Programs with Energy Assessment as a Key Component

<table>
<tr><th>Policy Scheme</th><th>Program Names</th><th>Voluntary or Mandatory</th><th>Energy or Environmental Management Systems</th><th>Subsidies</th><th>Energy/CO_2 Tax</th><th>Energy-Efficiency Improve-ments</th></tr>
<tr><td rowspan="13">Voluntary Agreement</td><td>Canada (ecoEnergy for Industry)</td><td rowspan="4">Voluntary assessments</td><td rowspan="5">Not required</td><td rowspan="5">Available</td><td rowspan="3">N/A</td><td rowspan="3">Not required</td></tr>
<tr><td>Finland (Energy Agreement Program in Industry)</td></tr>
<tr><td>France (AERES)</td></tr>
<tr><td>Norway (EM-network)</td><td>N/A</td><td>Required</td></tr>
<tr><td>Norway (IEEN)</td><td>Apply taxes</td><td>Not required</td></tr>
<tr><td>US Save Energy Now LEADER</td><td rowspan="12">Mandatory assessments</td><td rowspan="4">N/A</td><td>Required</td></tr>
<tr><td>EU EMAS</td><td rowspan="2">Required</td><td rowspan="3">N/A</td><td>Not required</td></tr>
<tr><td>Ireland (LIEN and EAP)</td><td>Required</td></tr>
<tr><td>Netherlands (LTA)</td><td rowspan="5">Not required</td><td rowspan="6">N/A</td></tr>
<tr><td>Sweden (PFE)</td><td rowspan="3">Tax exemption</td><td rowspan="5">Not required</td></tr>
<tr><td>Denmark (VA with GHGs Tax)</td></tr>
<tr><td>Switzerland (CO_2 Target Agreements)</td></tr>
<tr><td rowspan="4">Mandated by Law</td><td>Australia (EEO)</td><td rowspan="3">N/A</td></tr>
<tr><td>India(Energy Managers Training)</td></tr>
<tr><td>Japan (Certified Energy Managers)</td><td rowspan="2">Required</td></tr>
<tr><td>Portugal (SGCIE)</td><td>Available</td><td>Tax exemption</td><td>Required</td></tr>
</table>

Energy or Environmental Management Systems

Promotion and adoption of energy and/or environmental management systems is a key foundation for energy-efficiency in industries, assisting them to continuously use rigorous procedures to assess their energy use patterns, develop energy-saving goals, and identify and implement energy-saving measures (Taylor, 2010). Several countries have also developed regional and country standards on energy management, such as the EU standard of energy management (EN 16001), and country standards developed in Denmark (DS 2403), Sweden (SS 627750), Ireland (IS 393) and the United States (MSE 2000). Currently, the International Organization for Standardization (ISO) is developing an international standard

on energy management systems, i.e., ISO 50001, which will be released in 2011. ISO 50001 will help industrial companies to establish a framework to monitor, control, and conserve energy.

Ireland, Japan, Portugal and the European Union have connected energy assessments with certified energy management systems. In Ireland, companies that join the voluntary agreement program—the Energy Agreement Program (EAP) -are required to conduct mandatory energy assessments, obtain a certificate of the Irish Energy Management System IS393, and implement the standard to maximize energy-saving gains by signing a three-year contract with Sustainable Energy and Authority of Ireland (SEAI). In addition, companies in the EAP program also commit to conduct and complete three Special Investigations with an emphasis on applying energy-efficient technologies and/or key processes in energy-intensive areas (Price, et al., 2010). In exchange, participants of EAP receive technical assistance, tailor-made trainings, mentoring and advices on identifying energy-saving opportunities (Price et al., 2010).

In Japan, under the Amended 2005 Energy Conservation Law, both Type 1[5] andType 2[6] Designated Energy Management Factories[7] are required to hire or appoint energy managers/energy manager officers and submit reports on energy consumption and utilization of their facilities annually to the Ministry of Economy, Trade and Industry, through ECCJ (Kawano, 2007). Type 1 or Type 2 factories are required to have assessments conducted by in-house energy managers or energy management officers. These assessments are one important way for the energy manager or energy management officers to achieve their other responsibilities, including developing energy-consumption reports, inspecting and monitoring the situation of energy utilization on-site, and improving energy efficiency. Energy managers in Japanese industrial facilities are required to communicate the on-the-ground energy situation to top management, as well as to provide solutions for increasing energy efficiency to plant employees.

Both energy managers and energy management officers are authorized and certified by the Japanese government. To be licensed as a qualified energy manager, applicants must either pass a National Qualification Examination or complete a Training Seminar. In 2005, 8,950 applicants took the exam and only 22.5% passed. The annual Training Seminar for Energy Managers lasts seven days, including six days of training and a one-day examination. In 2005, about 2,700 trainees attended and about 65% passed.

Incentives for Energy Assessments

To attract and encourage industry participation in energy assessment programs, many governmental energy assessment programs use subsidies and other incentives to support energy assessments. Subsidies can be offered to cover partial costs of energy assessments, as was also seen in the stand-alone energy assessment programs. Subsidies can also be either provided to all companies that are involved in the energy assessment program, or the availability of a subsidy can depend on certain prerequisites or company performance in assessment programs.

In addition to subsidies, other instruments such as loans, tax incentives and investment aides have been used around the world to encourage participation and implementation of energy assessments. For example, in the EU Eco-Management and Audit

[5] Factories with annual fuel consumption equal to or higher than 3,000 kiloliter of crude oil equivalents are under the category of "Type 1 Designated Energy Management Factories".
[6] Facilities with annual fuel consumption no less than 1,500 kiloliter of crude oil equivalents but less than 3,000 kiloliter of crude oil equivalents to be the "Type 2 Designated Energy Management Factories"
[7] By August 2006, there are 7,433 factories in Type 1, and 5,860 factories in Type 2 (Kawano, 2007).

Scheme (EMAS) program, a number of Member States have developed incentive policies for organizations/companies that joined EMAS. EMAS organizations may "benefit from longer inspection intervals, reduction of permit fees, fast lane of obtaining permits and improved access to funding" (European Commission, 2010). Companies in the Portuguese Management systems of Intensive Energy Consumption (SGCIE) program can receive 25% compensation for their energy-efficiency investments, up to Euro10,000 (or $15,500USD) (SGCIE, 2010).

Exemption of Energy or CO_2 Tax

Some integrated industrial energy-efficiency policy programs allow for energy or carbon dioxide (CO_2) tax exemptions for participants that undertake energy assessments. Examples include the Green Tax Package with voluntary agreements in Denmark, the CO_2 Target Agreements Program in Switzerland, and the Management System of Intensive Energy Consumption (SGCIE) program in Portugal. Rewards for meeting agreed-upon targets are provided in the form of a reduction of the required energy tax (DEFRA, 2004; Togeby et al., 1999). The use of energy or CO_2 taxes can also be used as a "stick", i.e., as a penalty or threat on non-compliant companies. In the voluntary program (Association des Entreprises pour la Reduction de l'Effet de Serre, or AERES) in France, if a company did not fulfill its commitments, including energy assessments, it could face a CO_2 tax penalty (AERES, 2009).

In 1990, the Danish government set a goal of reducing CO_2 emissions by 20% in 2005 compared to 1988 levels. In addition, under the Kyoto Protocol and the following EU burden-sharing agreement, Denmark is also obligated to reduce green-house gas (GHG) emissions by 21% compared to 1990 emission levels by 2008-2012. In support of the national CO_2 reduction target, a CO_2 tax was introduced in Denmark in 1992 for households and January 1, 1993 for industry. In 1996, the Danish government established the Green Tax Package, which included an additional CO_2 tax, a new SO_2 tax and new energy taxes on space heating (Price, et al., 2010). Danish companies that signed agreements with the government could obtain CO_2 tax rebates if they met specified requirements, including undertaking mandatory energy assessments. After 2000, energy assessments were no longer mandatory; however, companies were still required to establish energy action plans based on their energy management systems (Price, et al., 2010).

A carbon tax was introduced in 1991 in Sweden, and in 2004, the tax on industrial process-related electricity was raised to a minimum 0.5 euro/MWh on electricity. This new tax directive affects most of Sweden's industries (Zhou, et al., forthcoming). As a consequence of this tax, Sweden launched the Programme for improving energy efficiency in energy-intensive industries (PFE) in 2005. Participating companies can receive tax exemption in exchange for undertaking solid steps to improve energy performance and implement energy-saving measures, such as mandatory energy assessments and standardized energy management systems (SEA, 2007).

Required Energy-Efficiency Improvement

Four of the reviewed integrated industrial energy-efficiency policy programs require participants to meet specified energy efficiency improvement targets and three of these programs mandate the use of energy assessments as one mechanism for meeting the goals. Energy assessment programs with required energy-efficiency improvement targets not only can significantly increase the implementation rates of recommended energy-efficiency measures, but also address other important factors, such as lack of top-level management

commitment to energy conservation, lack of continued efforts on improving energy-efficiency, and limited priority for energy efficiency.

The Save Energy Now LEADER Program in the U.S. engages companies who voluntarily pledge to cut energy intensity by 25% in ten years. In return, these companies are provided cost-shared energy assessments, higher priority in getting customized assistance, personalized resources, and financing opportunities (US DOE ITP, 2009a).The Long-Term Agreements (LTAs) in The Netherlands established clear targets and commitments for industry participants. For example, the overall commitment for industry in the LTA1s (1989-2000) was a 20% increase in energy efficiency over 1989 levels by 2000. Energy assessments were utilized by companies for establishing the required Long Term Plans, and also used for developing efficiency improvement targets (Kerssemeeckers, 2002; Rietenbergen et al., 1998). After conducting energy assessments and identifying potentials, the LTA program also required industry to invest in "all appropriate efficiency measures" with a payback period less than five years (MURE, 2010).

Findings

Energy assessments of industrial facilities are commonly used in many countries as a means of assisting industry in identifying energy efficiency opportunities. Countries that desire to initiate a program of energy efficiency assessment or that desire to modify an existing energy assessment program can learn from the experiences of the 22 programs in 15 countries that are reviewed in this paper.

Stand-alone energy assessment programs typically focus on SMEs and are offered free or costs are shared between the industry and government. Stand-alone energy assessment programs often emphasize how to build an effective, standardized, and practical system and are designed to ensure that industrial participants can implement the proposed cost-effective measures, that energy assessments are conducted in a comparable and coherent manner, and that the results are measurable, verifiable and useful to other manufacturers. Subsidies for energy assessments, training and certification of energy auditors, standardized tools and guidebooks, energy assessment databases, post-assessment follow-ups and dissemination of case studies are critical to a robust stand-alone energy assessment program.

In the integrated policy programs with energy assessments, energy assessments are either integrated into voluntary agreement schemes or required by governmental mandate. If it is not feasible to have mandatory energy assessments in designated facilities by law, energy assessment program developers may consider integrating energy assessments with other policy measures under a voluntary agreement scheme. Common complimentary policy measures identified include subsidies for energy assessments, certified energy management systems, use of energy or CO_2 tax (or tax exemptions), financing support for energy-efficiency investments, and target setting and required energy-efficiency improvement.

Energy assessment program developers should consider country-specific conditions to design a national energy assessment program. However, as the international experience has shown, several key elements are found in many stand-alone energy assessment programs. To better motivate industrial participation and to achieve broader goals, such as promoting of energy management systems or increasing the adoption of energy-efficient measures, an integrated policy program with energy assessments can be a good model.

More details about this report, including international examples of the energy assessment programs and analysis of program elements are included in the Lawrence Berkeley National Laboratory report of "International Energy Assessments: A Survey of Programs Around the World". The report is going to be published soon and will be available here:http://china.lbl.gov/publications/industrial-energy-assessments.

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