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Evaluating industrial energy management systems – considerations for an evaluation plan

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Abstract

Since year 2000 a number of national energy management systems (EnMS) standards and specifications have been developed. To support EnMS implementation in industry some governments have launched agreements centered around energy management practices. National experiences show that such policy programs can achieve significant energy efficiency improvements. Implementation of industrial EnMSs has gradually increased and uptake can be expected to accelerate as the international standard (ISO 50001) gains further recognition. Since EnMS complements, or replaces, other energy or climate policies (e.g. emissions trading, energy or carbon taxes) it makes sense to systematically evaluate its implementation in industry. Accurate information needs to be compiled and rated against relevant criteria to confirm desired impact. In their assessments evaluators need to address several issues. Firstly, EnMS are embedded in a context which makes it difficult to attribute results. Secondly, a principle of EnMS is that firms set internal targets to improve energy performance, but these targets might not be consistent with societal objectives. Finally, EnMS certification issued by external auditors gives approval according to standard but cannot guarantee a desired impact. These and other aspects are analyzed and also proposed to be considered in EnMS evaluation. The methods include literature studies, stakeholder consultations to gather empirical input from practitioners, and quantitative data assessments of energy performance. The main contributions are documented experiences from industrial EnMS implementation in Sweden and based on these a set of considerations to be addressed by policy makers and academics in developing a plan for industrial EnMS evaluation.

Introduction

Close to a third of global energy use and 40 % of carbon dioxide (CO_2) emissions are attributable to manufacturing industry (IEA 2010). Thus, it is vital that the industry sector contributes with a fair share towards the achievement of ambitious climate mitigation, energy savings and renewable energy targets. According to the European Commission's roadmap for a competitive low carbon economy the industry sector's CO_2 emissions need to be reduced with the heroic numbers of 83-87 % by 2050 compared to 1990 (EC 2011a). In a step towards this long-term challenge EU's climate and energy package has set a binding greenhouse gas (GHG) emissions target of at least 20 % reduction by 2020 compared to 1990.[1] To mitigate climate change and to achieve ambitious targets by 2050 and beyond, international studies cite energy efficiency improvement to be the least cost measure (IEA 2010). Especially for manufacturing industries, energy efficiency can be seen as a cost-cutter and thus a means to increase profits in competitive markets. By structuring a firm's energy related affairs an energy management system (EnMS) can, if well implemented, be a facilitator for continuous improvement of energy performance. Thus, for industry and especially energy-intensive firms, the implementation of an EnMS should be a compelling business case; especially in periods with relatively high energy prices and when prices are expected to increase. Despite the good motives for energy efficiency improvement, EU's target of 20 % primary energy savings will not be achieved without the implementation of new and effective policies and measures (EC 2011b). Though it seems rational for manufacturing industries they

[1] Other EU targets for 2020 are: to increase the share of renewables in the energy mix to 20 %; to achieve 20 % primary energy savings compared to baseline projections (still a non-binding target).

do not seem to implement EnMS on its' own merit. Industry will thus miss out the attention-raising effect from an EnMS and fail to invest in cost-effective energy efficiency improvement actions. A policy implication is that authorities, to address the market failure of imperfect information, could encourage the uptake of EnMS which conform to standard. However, with a decision to use public funds to stimulate EnMS the issue of evaluation needs to be addressed. EnMS evaluation raises many questions and some dealt with in this paper are: Why and under what circumstances should industrial EnMS be evaluated? What are the objectives for EnMS implementation from a private and a public perspective? Which are the essential EnMS practices? Which indicators could be considered for monitoring and rating the success of an industrial EnMS?

The structure of the paper is as follows. The next section gives a background to EnMS, describes its role in industry and provides examples of countries which have promoted industrial EnMS implementation and certification. The methodology section presents the sources of information that have provided input for the discussions and findings on EnMS evaluation. The empirical findings are presented in the section of results. The final section concludes with considerations to address when evaluating industrial EnMS or energy efficiency programs with EnMS as a main component.

Background to EnMS

The role of industrial EnMS

Energy services are of particular importance for energy-intensive industries where energy represents a significant share of total production cost. In the past, access to low cost energy supply has involved strategic considerations in response to changes in relative energy prices and environmental policy making. For instance, for Swedish pulp and paper industry (PPI) the high oil market prices of the 1970s initiated a fuel switch from oil to biomass and electricity. This preference has been supported by national energy and carbon taxes and more lately the EU ETS. Between 1973 and 2007 the Swedish PPI reduced its share of fossil fuels from 43 % to just below 10 % of total fuel consumption; an absolute reduction of 66 PJ (or 75 %) and 4.5 Mton CO_2 emissions (Wiberg 2007). A recent development and trend break is the renewed interest and investments in electricity generation (e.g. back pressure turbines and wind power). In the 1990s the PPI divested its off-site power assets (e.g. hydro and nuclear power). The strategic reorientation follows from policy driven changes in underlying economic conditions of the PPI (Ericsson et al. 2011).[2] Correlated with the main goal of industrial EnMS practices (i.e. to reduce a firm's energy costs) is that increasing energy prices over the post year 2000 period has motivated an increased focus on energy efficiency improvement besides fuel shifting. Energy cost reduction is seen as the most important driver for industrial energy efficiency (Thollander & Ottosson 2008) but it is also essential that energy efficiency is made a strategic issue in organizations (Cooremans 2012). It implies that upper management decision makers, in addition to process engineers, embrace energy efficiency and enable such investments and related organizational changes to improve the competitiveness of the firm (Cooremans 2012). The importance of the strategic dimension is supported by the evidence that "people will real ambition" and existence of a "long-term energy strategy" is ranked as the second and third most important drivers for energy efficiency in the Swedish PPI (Thollander & Ottosson 2008). To make energy efficiency a strategic issue the Plan-Do-Check-Act approach and the EnMS standard requirements provide a comprehensive tool, tested also in other areas of management (e.g. quality and safety).

[2] Three main energy policies at play are: the electricity market reform in 1996; the scheme of tradable renewable electricity certificates since 2003; and the introduction of EU ETS in 2005.

National experiences and promotions of industrial EnMS

As a policy option for public governance of industrial energy and environmental issues standardized EnMS has evolved rather recently. Though there are companies that have practiced energy management activities in the past, national EnMS standards and specifications started to evolve first after year 2000. To be compatible with procedures of established management systems they derived from standards like ISO 90001 and ISO 14001 (McKane 2009). Table 1 describes experiences from three countries where EnMS standards have been applied over the last decade. More recently, in 2009, EU consolidated national standards with EN 16001, and in June 2011 the internationally recognized ISO 50001 was published (ISO 2011). International organizations (e.g. UNIDO and IEA) promote EnMS implementation globally. As one of 25 Energy Efficiency Policy Recommendations IEA advise governments to require energy-intensive industries and stimulate other industrial energy end-users to implement EnMS which conform to ISO 50001 or equivalent (IEA 2011).[3]

Table 1. Some national experiences of industrial EnMS promotion and uptake.*

Country / EnMS standard	EnMS promotion activities and industrial uptake
USA / ANSI MSE 2000:2008	After the first, year 2000, version of the U.S. EnMS standard the standard development organization Georgia Tech Energy and Environmental Management Center made updates in 2008 to facilitate increased implementation (Kahlenborn et al. 2010). The Department of Energy has encouraged energy management practices by provision of tools and guidelines, but the use of the standard per se has not been emphasized so far. The industrial uptake has been low, it is estimated that less than 5 % of the industrial energy use is covered by standardized energy management practices (McKane 2009). Literature make evident that some large U.S. companies have long experiences from energy management and achieving substantial energy intensity improvements (Capehart et al. 2008). Currently the Superior Energy Performance Program is launched to stimulate ISO 50001 uptake and certification and so far some 30 large companies have announced their participation.
South Korea / KSA 4000	South Korea published an EnMS standard in 2007 to complement its industrial voluntary agreement (VA) for energy conservation and GHG emission reduction. Companies formulate their individual energy savings targets, plan and implement measures for fulfillment. The government support consists of providing energy assessments as well as financial support. Since the introduction the EnMS standard is intended to play a key role for companies' target achievement, but so far the uptake is low. Through a pilot program, eight companies had achieved EnMS certification between 2008 and 2010 (Kahlenborn et al. 2010).
Sweden / SS 627750	The EnMS standard was introduced in 2004 in conjunction with a VA for energy efficiency in energy-intensive industry (PFE). PFE grants eligible companies a tax exemption of 0.5 Euro per MWh electricity use (ETD Article 17 2003). In the first PFE period (2005-2009) companies were obliged to achieve EnMS certification (according to 627750 or EN16001) and fulfill other program requirements (e.g. auditing, identify and invest in electricity savings, report progress, adopt procedures for procurement and project planning). Some 100 companies and 250 industrial plants participated. Since companies are energy-intensive EnMS certification has reached a market penetration of 70 % of total industrial sector energy use. Bottom up evaluations of companies' reporting estimate gross annual electricity savings to be 5 % of the base year electricity use (SEA 2011). In the ongoing second period, companies will implement ISO 50001 and certification of about 90 companies is underway.

* In addition, there are various EnMS experiences in other countries: Japan stipulate legal requirements on industrial energy management practices since 1979; Ireland has an Energy Agreement scheme since 2006 which provide technical and informative support to companies, 70 sites have achieved EnMS certification conform to Irish standard (Cahill 2011); in Denmark at least 100 companies have ten years of experiences from a VA for industrial energy efficiency which involves tax rebates, EnMS certification and other requirements (Reinaud et al. 2012); Spain has a national standard since 2007 but uptake has so far been low (Kahlenborn et al. 2010); the Netherlands has experience from long-term sector agreements on energy efficiency which stipulate EnMS practices but until now without requiring certification.

[3] By January 2012 some 100 organizations in 26 countries had achieved ISO 50001certification (ISO 2012).

Methodology

The aim of this paper is to explore and identify aspects of EnMS evaluation to be addressed by evaluators (i.e. energy authorities and contracted partners or free standing energy policy researchers) which are to evaluate impact and outcomes of industrial EnMS practices. The methods include stakeholder consultations, literature studies, and quantitative data assessments. The stakeholders belong to three categories of actors with different roles in the Swedish PFE. Firstly, through personal communication, staff at the Swedish Energy Agency (SEA) responsible for program operation and evaluation has shared views on evaluation. Secondly, semi-structured interviews were conducted with EnMS coordinators at eight pulp and/or papers mills. For more than five years, these mills have had certified EnMS that conform to Swedish or European standard. Relevant for the scope of this paper are answers provided on objectives and target setting under the EnMS framework, as well as the monitoring practices at the mills.[4] Thirdly, certification companies that conduct external audits and issue EnMS certification have been addressed, through secondary sources and personal communication. Input from certification companies has been useful to identify essential EnMS practices, and to understand what an external audit includes and if the stamp of approval can secure the desired impact of improved energy performance. The energy performance concept is further investigated with the eight mills as an empirical base. Three potential indicators of energy performance have been analyzed to test the improvement under the EnMS framework. Numbers on physical production, energy use, and CO_2 emissions have been compiled from a database of the trade association Swedish Forest Industries Federation (SFIF 2012).

Results

EnMS evaluation

In Sweden, as in Denmark and Ireland, a comprehensive program approach has been effective to promote and support industrial EnMS uptake and certification (see Table 1). The IEA and the Institute for Industrial Productivity (IIP) recommend governments to launch such energy management programs (EnMP) with EnMS at the core and provides a checklist for implementation (Reinaud et al. 2012). Given these recommendations and the release of ISO 50001, it can be anticipated that governments will initiate and enhance policy activities to promote and incentivize EnMS. Thus adequate evaluation practices to assess the contributions from EnMPs, and EnMS in particular, will become increasingly important as:

- EnMPs may complement or replace alternative energy and environmental policy instruments like taxation, pricing of emissions, energy efficiency regulations (e.g. Denmark and Sweden).
- Evaluation is required to revise and adapt policy programs (Reinaud et al. 2012).
- Also when freestanding industrial EnMS implementation and certification is promoted without an EnMP approach, evaluation may be beneficial.[5]
- Whenever public funds are involved there is a justified demand for knowledge on results and effectiveness.
- For the broad category of less energy-intensive SMEs it sometimes argued that a full EnMS implementation and certification is exaggerated but there is little knowledge about the practical implementation of EnMSs in SMEs.

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[4] In a previous paper we have investigated how a standardized EnMS is structured in this industry (Stenqvist et al. 2011).

[5] The *U.S Superior Energy Performance* is a relevant example, by which industrial EnMS certification is promoted without economic incentives for companies and at a moderate level of federal funding for administration and technical assistance. There are intentions to evaluate the energy performance improvement of certified companies through a detailed best practice scorecard methodology, and thus give recognition to successful companies (Georgia Tech 2011).

An important issue in the policy planning and evaluation phase is why governments at all need to intervene in the private sphere with economic incentives for business to implement EnMS? EnMS standards are designed to help companies improve their energy performance in accordance with their internal objectives. Policy makers need to ask themselves, which are the desired social benefits from industrial EnMS and improved energy performance that motivates the use of public funds to stimulate such implementations? These questions deserve attention due to some main findings of theory-based evaluations of 20 energy efficiency policy instruments in a number of countries (Harmelink et al. 2008). Firstly, energy efficiency policies often have multiple and unclear objectives, lack quantitative targets and clear time frames. Secondly, an important success factor is the existence of clear goals and mandates for the implementing agency. Thirdly, monitoring information is often insufficient to determine impact on energy saving, cost effectiveness, and target achievement (Harmelink et al. 2008).

EnMS evaluation in the case of PFE

The SEA is responsible for operation and evaluation of the Swedish PFE, which has the overall objective to stimulate industrial energy efficiency and in particular electricity efficiency (SFS 2004:1196 2004). In addition to this objective there are a number of requirements related to the different program components. There is no quantified impact target for PFE, but due to the tax exemption the companies must submit a list of planned actions and later implement these so to achieve electricity savings of the same level that would have been achieved if the tax were to be applied over the same period.[6] The SEA admits it is a challenge to evaluate impact (e.g. energy efficiency improvement) and other intended outcomes of the PFE (Moberg 2012). Among a rich set of program components (e.g. legal requirements, tax rebate, EnMS, tools, networks and recognition etc.) it is difficult to isolate the main drivers for desired change and to conclude what this change consists of. Similarly, it is difficult to identify program components that fail to generate desired change, due to being unnecessary or deceptive. The SEA has progressively carried out a variety of monitoring and evaluation activities to identify and demonstrate program results (Moberg 2012; Reinaud et al. 2012):

- To assess program impact (i.e. the level on energy efficiency improvement) a bottom-up methodology has been applied. Based on companies' reports the SEA has compiled data on e.g.:
    - gross annual electricity savings from required actions and procedures
    - value of investments and straight pay back periods
    - gross annual energy savings from voluntary reports of other non-required actions
- Through a number of interviews and surveys directed to different stakeholders qualitative information about EnMS implementation and compliance has been collected.
- Correction factors like free-rider, spill-over, double counting have not been estimated by the SEA, but attempts have been made in academic evaluations (Stenqvist & Nilsson 2012).
- The isolated impact (i.e. energy efficiency improvement) from specific program components, like the EnMS, has not been estimated.

The SEA regards the EnMS to be a tool which contributes to the companies' achievement of the overall PFE objective. The program context makes it difficult to separate and attribute results solely to the EnMS. Moreover, it is a principle of EnMS that companies set their internal energy performance targets of relevance. The certification provides a best available quality check of the implementation. In case a PFE company submits a poor report to the SEA, examination of the audit protocol can be motivated as part of the assessment of that company's compliance (Moberg 2012).

[6] For an analysis and interpretation of this counterfactual situation see Stenqvist & Nilsson (2012).

The conclusion after the first five year period is that PFE has generated cost-effective gross annual electricity savings of almost 5 % (or 1.45 TWh per year) compared to a 2004 baseline situation (SEA 2011; Stenqvist & Nilsson 2012). Almost all of the 100 companies complied with the program requirements including the EnMS certification. Reports from the ongoing second period, during which companies will implement ISO 50001, show that companies plan to slightly increase their investments in electricity savings actions compared to the first program period (Moberg 2012). These experiences have led the SEA to promote energy management also outside PFE. The interest for EnMS appears to be on the rise but there is still resistance among SMEs against full scale implementation and certification. Some of the SEA promotion activities include: an energy audit program for SMEs; manuals for systematic energy management; a communication platform for energy efficiency in industry; a Lean Energy training course (Moberg 2012).

Input from certification companies

To obtain views from the standard certification companies about PFE and EnMS implementation the SEA commissioned an operational evaluation. At the time, in 2008, the first five year program period of PFE was more than half way through and almost all the 100 participating companies had received their EnMS certification according to Swedish standard. Six out of seven authorized certification companies were interviewed and shared their experiences in the evaluation report (Franck & Nyström 2008). To complement this information, an interview has been conducted with an EnMS auditor (Modig 2012).

At the outset, the PFE tax exemption of 0.5 Euro per MWh of electricity use was imperative to attract managements' attention and will to participate and comply with the program requirements. The EnMS implementation was at first, from a management perspective, seen as a necessary obligation to receive the tax rebate (Franck & Nyström 2008). At the same time, the EnMS requirement was well-timed with underlying conditions of increasing energy prices. The interest for strategic and systematic energy management was on the rise and the EnMS was gradually given enhanced attention throughout many organizations (Modig 2012). According to certification bodies the most important EnMS practices have been (Franck & Nyström 2008):

- **Energy audit and analysis:** the energy audits revealed large and profitable energy saving potentials which strengthened the business case for energy efficiency improvement in many companies. The EnMS framework has resulted in more thorough technical and economic analysis of potential measures, especially as firms have identified significant energy aspects. When energy audits have been conducted entirely by external consultants the results have sometimes been less useful for the firm's practical implementation. For some companies there could be a stronger focus on energy efficiency improvement from operation and maintenance measures.
- **Roles and responsibilities:** EnMS coordinators are appointed by top management and take responsibility for facilitating compliance with PFE and standard requirements. In many companies the EnMS coordinators feel they have support and a clear mandate from management to perform their tasks. This has been important for the EnMSs to become established and continuously maintained in the companies. Especially at larger industrial plants the chief EnMS coordinator has access to division level EnMS coordinators (i.e. process engineers) and together with other staff (e.g. technical experts from maintenance department) they form an EnMS team.
- **Dissemination in the organization:** with EnMS the awareness of energy issues has spread across the organizations. The EnMS teams hold regular meetings to plan the implementation of actions (Modig 2012). EnMS practices have also involved new categories of employees like production/process developers, maintenance engineers, and staff working with procurement. Some companies have trained their staff to raise general awareness on energy related issues as

well as specialized knowledge among operators who influence significant energy aspects.

- **Life cycle cost (LCC) procedures for energy efficient procurement and project planning:** PFE requires that companies use LCC procedures to evaluate their purchase of new electrical equipment, and to plan larger investment projects like plant retrofits. These new procedures have sometimes been difficult to communicate within organizations, between purchasing and maintenance division. The service from equipment suppliers has gradually improved upon the demand for LCC information. ISO 50001 requires such procedures which are expected to become increasingly important (Modig 2012).

In principal all the EnMS requirements are reviewed by the external auditor at yearly site visits. Ideally the external auditor is a person with technical degree and long experience from working with energy analysis in manufacturing industry. The auditor plans the visit by preparing a relevant audit program based on examination of previous audit protocols, the energy balance of the plant, and other relevant documents provided by the company. Depending on the size and complexity of the plant the external audit can last between one and three days. At the opening meeting a number of company staff attends like the EnMS coordinator, parts of the EnMS team and top management. Thereafter the auditor goes through different divisions to observe ongoing practices and ask different employees about their role and influence under the EnMS framework. In a final meeting the auditors delivers a statement about the compliance with the EnMS standard and describes any identified abnormalities in relation to requirements, the company's energy policy and procedures. Serious abnormalities must be explained by the company to be acceptable or the company can lose the EnMS certificate. For instance, the companies' energy performance targets and monitoring practices are tested. If a company fails to meet its targets the deviation needs to be explained, for instance, by demonstrating how a temporary shutdown has altered the baseline energy use. (Modig 2012)

The companies in general request a critical assessment and expect the external auditor to be knowledgeable and in position to scrutinize and challenge existing EnMS practices. The conclusion among certification companies is that the EnMS standard, with few exceptions, has been well received and implemented by the companies (Franck & Nyström 2008). Compared to the Swedish standard the ISO 50001 puts further emphasize on some essential issues like the role of the EnMS team, the commitment from top management, the possibility to include transport related energy use in the EnMS, the objective to reduce GHG emissions (Modig 2012).

Input from industrial energy end users on EnMS target formulations

Interviews were conducted with EnMS coordinators at eight pulp and/or paper mills that participate in PFE.[7] The respondents were asked about strategies, objectives, targets, and monitoring practices under the EnMS framework. The mills are organized under larger company groups, sometimes with global business activities, but each mill operates as an independent business unit. Each mill is organized into multiple divisions, and each division typically represents a cost center (Stenqvist et al. 2011). Consequently, targets and monitoring can exist on different hierarchical levels, from group-wide to site-level, at division and for certain production processes:

- **Group-wide:** the mills are often subordinated group-wide strategies and targets. Six mills declared group-wide targets to reduce specific energy use (i.e. production related) which were quantified and with clear time frames. Typical levels of targeted reductions are 1-2 % per year, or

[7] At all mills the EnMS coordinator was the representative appointed by top management. In some cases also other staff members of the EnMS team participated in the interviews (see ISO 50001 for definitions).

5-10% when targets cover periods of about five year. It is also common with group-wide strategies and targets to reduced specific CO_2 emissions. The mills should contribute to overarching targets, but need to formulate their site-level strategies and targets that are dictated by their production and energy related situation and outlook.

- **Site level:** the site-level EnMS objectives vary between different mills, but usually the EnMS strategy is focused on reduced specific energy use. While some mills declare explicit target levels other only monitor the development. Some mills also set targets for separate energy carriers, e.g. to reduce specific electricity, steam or fossil fuel use. Other site-level EnMS objectives for some mills are: increased internal electricity production; increased use of biomass fuels; and increased energy deliveries to adjacent society (e.g. waste heat and/or electricity).
- **Division and process level:** each major production process represents a division and for a large integrated pulp and paper mill it involves: wood preparation; debarking; pulping; bleaching; paper making (often by multiple paper machines). Five mills have automatic meter readings to assimilate data from electricity and steam meters at the division and process level. The sub-metering systems allow these mills to identify significant energy aspects at process level and to track specific energy use of individual installations. An example is refiners used in thermo-mechanical pulping, for which the specific electricity use is monitored to ensure that acceptable levels are maintained. Monitoring data is used to compare performance and analyze opportunities for improved energy performance, e.g. by changing refiner plates. Process level monitoring thereby contributes to site-level EnMS target fulfillment.

This examination of targets formulations demonstrates that the EnMS framework is used to improve energy performance in different ways, as summarized in Table 2. Energy efficiency through reduced specific energy use is one common interpretation of improved energy performance, but the EnMSs also contain supply side oriented strategies and targets. In one occasion the respondent had low awareness of the existence of EnMS targets and a few mills lacked quantified targets with clear time frames. This is not acceptable and needs to be improved for compliance with ISO 50001.

Table 2. The presence of EnMS objectives and targets among eight pulp and paper mills.

Group-wide Reduce specific energy use	Site level Reduce specific energy use (for all or certain energy carriers)	Site level Increase use of biomass fuels	Site level Increase energy supply to adjacent society	Site level Increase internal electricity production	Site level Low awareness of targets
6	7	2	2	5	1

Indicators of energy performance

According to ISO 50001, energy performance is the measurable results related to any of the three aspects: energy efficiency; energy use and energy consumption. Results are measured against the organization's energy policy, objectives and targets. Thus companies can manage a variety of energy performance activities under their EnMS, as demonstrated for the eight mills in the previous section. For these mills, three indicators are used to analyze how the performance has developed with EnMSs between 2005 and 2010, compared to a baseline period represented by the average annual performance between 2001 and 2004 (i.e. prior to the EnMS implementation). The three energy performance indicators, based on the physical output of tonnes market pulp and final paper products, are: specific total final energy use; specific final electricity use; and specific fossil CO_2 emissions.[8]

[8] The data is retrieved from the Environmental Database of the Swedish Forest Industry Federation, to which the companies report their annual production volumes, energy use, emission to air and water etc. (SFIF 2012).

Figure 1 demonstrates how the specific total final energy use has developed for the eight mills. In 2010, the energy intensity had increased for six mills between 1 and 12 % and decreased only for two mills by 6 and 14 % respectively. Since the latter two mills have large production volumes the aggregate for the eight mills is a decrease in energy intensity by 2 %. Given that seven mills have site-level objectives or targets to reduce specific energy use the development is rather discouraging. One explanation can be low production outputs in 2008-2009, which tends to increase specific energy use. Another issue is the potential target conflict between increased use of biofuels and internal electricity production on the one hand, and reduced total specific energy use on the other. Fuel shifts from fossil fuels to biofuels of diverse qualities tend to increase total energy use. In addition, some mills have, in accordance with their site-level objectives, improved boiler and turbine installations to increase internal electricity generation from biofuels and thus expanded production beyond pulp and paper products.

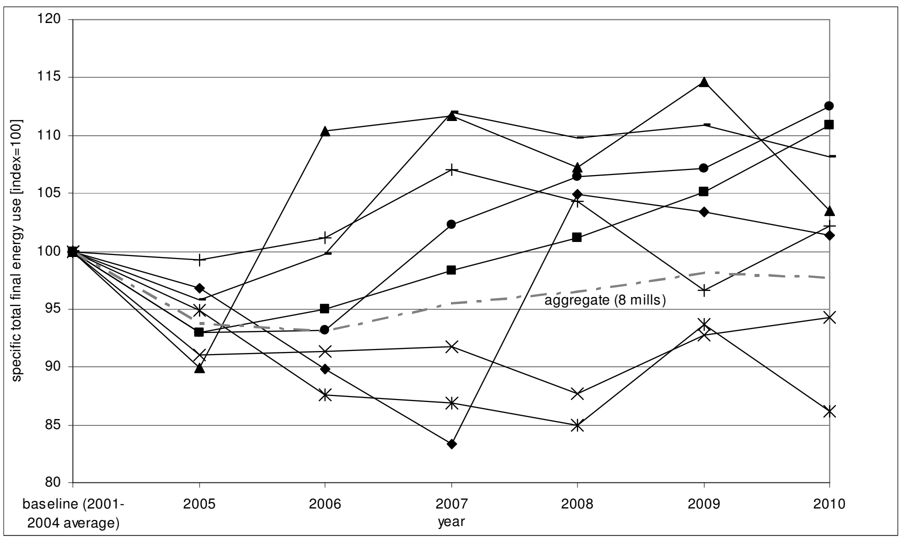

Figure 1. Specific total final energy use for eight mills (2005-2010). Source: SFIF (2012)

Figure 2 demonstrates how the specific final electricity use has developed for the eight mills. Decreased electricity intensities can be expected as PFE requires electricity savings in particular and the mills have reported bottom-up estimated electricity savings of between 1.5 and 9 % compared to their 2004 electricity demand (Stenqvist et al. 2011). In 2010, the electricity intensity had decreased for six mills; by 0.5-4 % for five mills and an extraordinary 21 % for one mill. For the two remaining mills the electricity intensity increased by almost 5 %. The aggregate for the eight mills is a decrease by 1 %. Again, for some mills low production outputs 2008-2009 can explain deviations from expected performance.

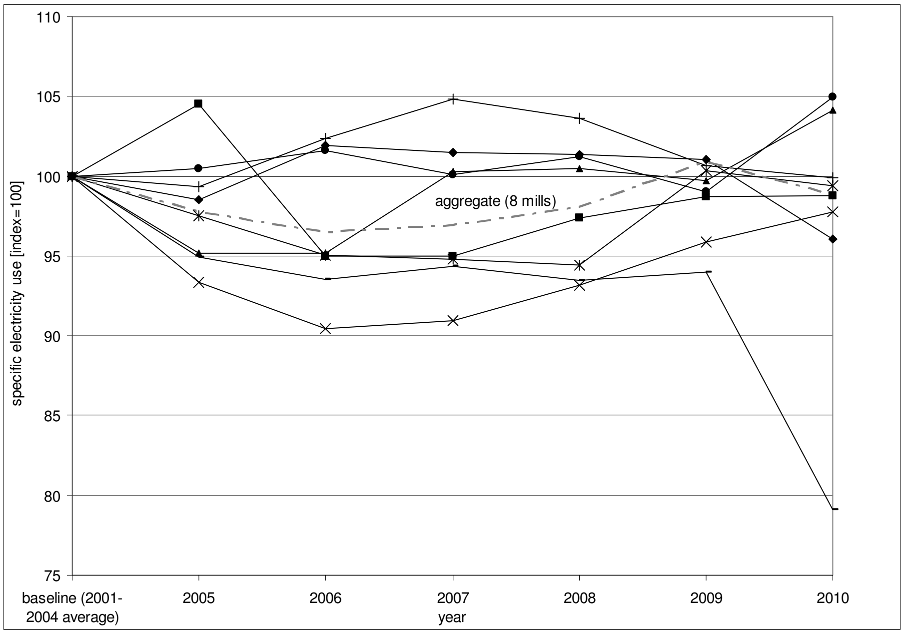

Figure 2. Specific final electricity use for eight mills (2005-2010). Source: SFIF (2012)

Figure 3 demonstrates how specific fossil CO_2 emissions have developed for the eight mills, which is closely related to their fossil fuel use. For this indicator an overall improvement is evident. In 2010, seven mills had decreased the CO_2 intensity with between 12 and 90 % and the aggregate for the eight mills was a 33 % specific reduction. In fact, over the period and compared to baseline, the aggregate fossil fuel use and related CO_2 emissions have decreased by 30 % in absolute numbers. For one mill the CO_2 intensity increased by 21 %. Notably, this is the same mill that decreased its electricity intensity by 21 % (see Figure 2). Thus the explanation appears to be a fuel shift from electricity to fossil fuels over this period. Interviews with EnMS coordinators could clarify the technical and economic conditions at the mill and thus improve the understanding about priorities of energy carriers and fuels.

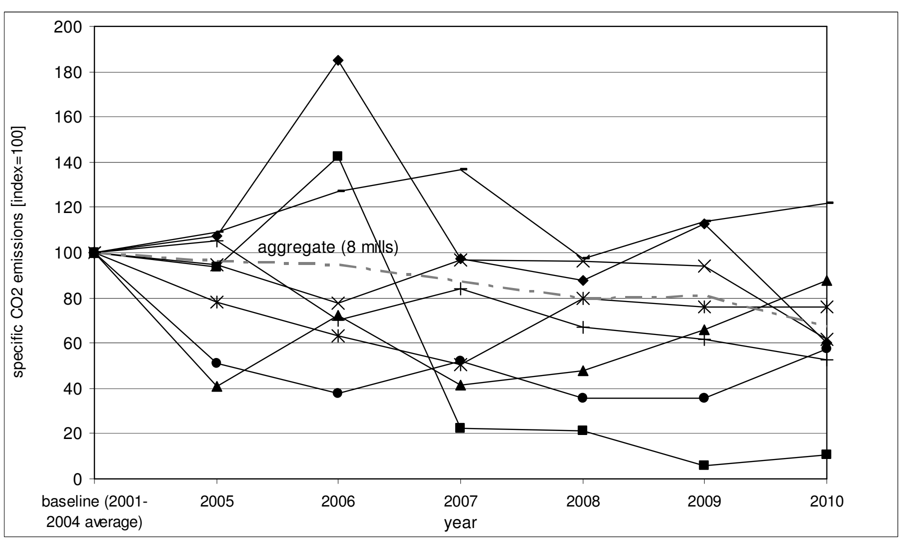

Figure 3. Specific CO_2 emissions for eight mills (2005-2010). Source: SFIF (2012)

Conclusions

With ISO 50001 and policy recommendations to stimulate industrial EnMS, through policy programs or somewhat less comprehensive measures, EnMS evaluation has come to fore. To monitor and verify desired impact is important for companies as well as public agencies. Companies need to ensure that efforts put into EnMS practices pay off, and from the public perspective the societal objectives behind EnMS implementation need to be defined, communicated and achieved. Non-quantified objectives like energy efficiency or improved energy performance appear as vague in this regard. Furthermore, such objectives are rather means to achieve other goals than goals in themselves. The actual societal goals, i.e. GHG emission reductions, increased industrial competitiveness, job creation etc., will have to be defined already in the planning phase and take count of the national context and political priorities. Ideally the societal objectives (formulated by policy makers) are consistent with the firm internal objectives of improved energy performance (formulated by the companies). Verification requires, at the minimum, that the constituents of improved energy performance are defined by the administrating agency as well as the company, and then monitored accordingly to ensure continuous improvement towards mutual objectives. Clear target formulations from the start will enable cost-effective monitoring and evaluation based on relevant performance indicators that are tracked through companies' reporting over the program period.

Requirements on companies to achieve certification can be motivated for several reasons and especially when companies are offered economic incentives to join an EnMP and introduce an EnMS. The external auditor validates that the EnMS conform to standard and thereby share the responsibility with the administrating agency to verify program compliance. Given that responsibilities are clearly defined the external auditor can play an important role in the overall evaluation plan. From a company perspective the critical test performed by a skilled external auditor is often appreciated. In the case of SMEs, for which there are concerns about the cost for certification, the potential benefits need to be examined as well. The scope of the external audit is of course adapted to the needs of the specific company/client with regards to its size, technical complexity etc.

Among EnMS requirements the external auditor reviews the company's energy performance in relation to energy policy and target formulations. However, the EnMS certification cannot guarantee improved energy performance in all regards. The data analysis demonstrated that several certified mills, despite EnMS targets to reduce specific energy use, have increased their energy intensity. In some cases this can be explained by increased use of biomass fuels and internal electricity generation, which are other site-level EnMS targets. In the Swedish case of PFE, bottom-up evaluations conclude that the program has been successful in generating large and cost effective electricity savings. However, the data analysis demonstrates that specific electricity use has increased for individual mills. In order to cross check companies' program compliance an evaluation plan could combine bottom-up methods with the use of top-down indicators. For the CO_2 intensity indicator the development is clearly positive. Specific and absolute fossil CO_2 emissions have decreased significantly for all but one mill. Though being managed and facilitated under the EnMS framework these achievements cannot be attributed solely to EnMS and PFE. A combination of market and policy related driving forces have influenced the decarbonisation of the Swedish PPI.

Essential among EnMS practice is the activity of the EnMS team. A cross-functional and multi-person team can be a key for energy management and improved energy performance to become a strategic issue in top management and across the organization. For evaluators, the organizational structure and documented activity of the EnMS team could be an indicator of the progress and the existence of real ambitions for energy efficiency improvement and other low-carbon solutions.

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