Evaluation of Industrial Energy Audits in SMEs

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Abstract

If conducted properly, energy audits in industry are a powerful tool to overcome market imperfections and support the implementation of cost-effective energy efficiency measures. Internationally, energy audit programs in industry have proven to be successful. Up until now Sweden has not provided low-cost energy audits to Swedish industry on a national scale. However, on a regional scale, energy audits in industries have been performed in five Swedish municipalities. The aim of this paper is to evaluate, ex-post, the implementation of cost-efficient energy efficiency measures in these five municipalities and also to outline the major barriers to implementation. Results show that the degree of implementation differs widely between industries due to several factors, e.g., a perceived lack of time for energy efficiency, competing priorities for capital investments and long decision-chains.

Introduction

Society is currently on an unsustainable course (Steffen et al. 2004; Millennium-Ecosystem-Assessment-(MA) 2005; IPCC 2007) and current energy systems are significantly contributing to this problem. Specifically, in Europe, electricity generation is linked to high CO_2 emissions (Trygg and Karlsson, 2005). Efficiency measures to reduce electricity consumption are therefore particularly interesting. In Sweden the per-capita use of electricity is among the highest in the world and a large part is used for processes that are not electricity specific such as heating and drying. A likely explanation for such high use is the historically low price of electricity. The price of electricity in most other European countries is roughly twice the price of that in Sweden. However, with a common market and increasing transmission capacities between countries a European “equilibrium” price will most likely result (Trygg and Karlsson, 2005, Thollander et al., 2005). Thus, both from a climate point of view and a more short-term economic point of view, there is good reason for Swedish industries to make their use of electricity more efficient and, in some cases, to convert from electricity to other types of energy. Identification and efficient implementation of such measures will consequently be of increasing importance in order for Swedish industry to maintain its competitiveness. In the view of the high use of electricity in Swedish industries, several energy audits have been performed with the purpose of analyzing if, and in that case how, Swedish SMEs (Small- and Medium-sized Enterprises) can make their use of energy more efficient (c.f. Trygg and Karlsson 2005, Trygg 2004). Generally, these studies show that there is a great potential for improved efficiency. This paper analyzes aspects affecting the implementation of energy efficiency measures derived from the previous energy audits. The aim is thus to study implementation of energy efficiency and conservation measures in

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Swedish SMEs. This includes driving forces and barriers to implementation and energy management.

Studied industries

Energy audits in SMEs situated in the Swedish municipalities of Borås, Ulricehamn, Vingåker Örnsköldsvik and Oskarshamn are analyzed ex-post. In the municipality of Oskarshamn, industrial energy audits were carried out in 2001 (Trygg 2005). The municipalities of Örnsköldsvik, Ulricehamn, Borås and Vingåker were part of a pilot project of the programme "Sustainable Municipality", financed by the Swedish Energy Agency. The energy audits were carried out during 2003-2004 in about ten SMEs each municipality (Henning et al 2004, Bohlin et al 2004, Gebremedhin et al 2005, Gebremedhin et al 2006).

Result from previous industrial energy audits

The above-mentioned energy audits showed that the industrial plants could reduce their use of electricity mainly through the following measures:

- More efficient use of electricity for the processes of lighting, ventilation and compressed air
- Reduced use of electricity when no production is taking place
- Conversion of processes that are not electricity specific: for example, heating and drying

For each industry, energy use was divided into unit processes, which is a way of splitting industrial load management into smaller parts (c.f. Trygg and Karlsson, 2005, Thollander et al., 2005). The unit processes are the smallest components an industry is built upon, and consist of production processes and support processes. The production processes produce products, while the support processes support production. Space heating and lighting are examples of support processes, while drying and shaping are examples of production processes. Of all the industries studied, those with the greatest potential for reducing electricity use were in found in the support processes. The average possibility that industries could reduce use of electricity varied from 58% of their total electricity use down to 20% as can be seen in Table 1.

Table 1. Average possibility for the studied industries to reduce their use of electricity.

Municipality where the industries are situated	Possibility for reduction of industrial electricity use
Oskarshamn	48%
Borås	20%
Ulricehamn	58%
Vingåker	20%
Örnsköldvik	50%

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Methods

The case study methodology used in this study is inspired by Yin (1994)[1], including both interviews and a questionnaire. Moreover, the methodology used to collect data and conduct the evaluation is inspired by Thollander et al. (2007), implying that various measures are categorized into unit processes. A number of qualitative, semi-structured, in-depth interviews have been conducted with respondents at the industries. Moreover, the respondents were asked to fill out a questionnaire concerning factors regarding management of energy efficiency, efficiency measures that have been implemented and the cost of such measures. According to systems researchers such as Boulding (1956), systems consisting of man and technology and interaction between man-man, are among the most complex systems that can be studied. It is therefore important to stress that in spite of having high standards regarding accuracy and using a methodologically well-structured data collection, in this study the respondents' answers can still contain various degrees of distortion. For example, there is always a risk that a respondent answers in a way that he/she believes that the researcher wants him or her to respond, the so-called social desirability bias (SDB).

Research on barriers to energy efficiency may be considered to be well established, while research into factors driving energy efficiency is relatively new. Some exceptions are Thollander and Ottosson (2009), Thollander et al., (2009) and Thollander and Ottosson (2008). According to Churchman (1968) system thinking is initiated when the world is seen through the eyes of others. In this way this study can be said to have a more comprehensive system approach in which industries responded to what driving factors they consider important and what they consider to be less important in order to invest in energy-efficient technologies. The questions about driving factors and barriers that respondents have been asked to answer were primarily obtained from Thollander and Ottosson (2008). Furthermore, some questions about Swedish and European policy instruments have been included and also questions concerning driving forces from two previous scientific studies in the field (de Groot et al. 2001, del Rio Gonzalez 2005).

The in-depth interviews were completed with a final questionnaire. This was inspired by Rohdin and Thollander (2006), Rohdin et al., (2007) and Thollander and Ottosson (2008). In all the interviews a brief introduction and overview of the purpose and background of the study have been presented. Interviews have been conducted with CEOs, energy managers, and operators within the different companies. Interviewing representatives who were from various levels within their companies rather than only from similar positions was a strategic choice. This has provided an opportunity to see how the energy issue is dealt with within separate parts and at different levels in the studied industries. In some cases up to eight years have passed since the energy audit was carried out. Therefore it has not always been possible to interview the person who took part in the energy audit. However, all respondents were aware of the performed energy audits.

[1] For a more detailed methodological description of case studies regarding industrial energy efficiency, see Thollander (2008) and Thollander and Ottosson (2008).

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Results

Results from interviews

The interview questions and the respondents' answers were structured along four "dimensions": (1) changes in market conditions; (2) energy management practices; (3) energy investment policies; and (4) engagement among top management and staff ("evangelists").

Changes in market conditions

Since the energy audits were performed several years ago, the industries are now facing a different market situation. Energy prices have increased, and some of the industries have shut down their production, while others have doubled their sales volume. Several respondents stated that there is a much stronger need for an energy audit today than when the energy audit was in fact performed. According to these respondents, the energy audits in the beginning of 2000 were often made out of curiosity and there was consequently no intention to implement the results. Now, however, there is a stronger economic driving factor. Most industries pay an electricity price that is two to three times higher than that of eight years ago. Below are some typical quotes, indicating the new market situation and the awareness of it among the industries.

- "There are completely different market conditions now compared to 2001, when the energy analysis was performed".
- "We had sales of 150 million in 2001, our product was a scarce resource and we had very good profit margins. Why should we save when we instead could concentrate on earning even more?"
- "Volumes have fallen, and we are facing increased competition from other countries, mostly due to lower transport costs".
- "In 2001 we paid an electricity price of 11-21 EUR[2]/MWh, today we pay 45 EUR/MWh."
- "Today, we certainly would need an energy audit".

Energy management practices

The interviews show that energy management practices varied from industry to industry. In most of the studied industries energy efficiency was not always an issue prioritized by top management. Several respondents state that the financial incentive of a project is a much stronger driving force than possible environmental benefits.

- "Either we can focus on saving money or on saving the environment; we choose to focus on making more money".

[2] 1 EUR equals 10 SEK. Source European Central Bank. Information obtained through the European Central Bank's homepage: http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html, 2010-03-12

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Several respondents state that energy efficiency issues do not have the focus within the industry that they actually deserve. They identify problems and find energy-efficient solutions, but lack momentum to get the energy efficiency measures implemented. For example, most of the industries know that they have a high use of electricity even when there is no production (idle losses), yet they do not take action to reduce it. How these industries look at energy efficiency is summarized by some respondents with the following words:

- "It has not been a central issue".
- "It is time to do something".
- "It has fallen between responsibilities since we do not have someone appointed for it".

Energy investment policies

Most respondents say that there is no difference between energy efficiency investments and other investments. Payback time is what determines if the investment is carried out or not.

- "The investment with the lowest pay-off time is the investment that the management decides to make".

Nevertheless, because energy issues are a non-core activity within the industries, energy investments are perceived to be more difficult to evaluate compared to other investments.

Top management and staff engagement

According to several respondents, energy efficiency is a management issue. To intensify energy efficiency work it is necessary that the top management of the industry clearly show their interest. A CEO of a company says:

- "To succeed it requires that I (the CEO) say that it (energy efficiency) is important, and that each of my directors says the same".
- "The top management of the industry has not given the organization a mandate to work with energy efficiency".

One respondent states that the lack of professional energy managers within their own organization is a reason for the low interest in energy efficiency issues. All of the respondents also strongly believe there are many energy efficiency measures that would lead to economic benefits, but the measures are still not implemented due to a lack of interest from the top management.

- "There is most likely considerable money to earn just by disciplining us".

According to the respondents it would affect their work with energy efficiency in a positive way if a person with real ambition existed within the company.

- "An 'guiding spirit' fixes everything".

How to create personal engagement is, in turn, a management issue, according to several of the respondents. One CEO states the following:

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- "I know who could be a 'guiding spirit'. There are even many, a large group of people who could become really engaged persons".

- "We can see from their behavior that they are driving spirits".

Offering education is regarded as a concrete action to stimulate engagement within the organization. It was also believed by many respondents that there are more opportunities to find such persons in a project concerning energy efficiency issues than there would be for a project making a production line slightly more efficient.

- "I (CEO) could address it on our Lean[3] meetings. Management must show interest and make energy efficiency a focal point. Then we can come up with engaged people".

Results from the questionnaire

In the questionnaire the respondents were asked to evaluate to what degree energy efficiency measures have been implemented within the areas of: lighting, compressed air, ventilation and conversion to district heating. Furthermore, the respondents were asked to rank the following areas on a six-level scale:

- Sources that provide valuable information about possible energy efficiency measures
- Barriers to energy efficiency
- Driving forces for energy efficiency
- Presence of economically profitable energy efficiency measures
- Allocation of energy costs within the industry
- Payback time for implementation of energy efficiency measures
- Existence and length of a long-term energy strategy

Implementation of energy efficiency measures

Implementation of energy efficiency measures within industries are shown in Figure 1. As can be concluded from the figure, measures within ventilation have the highest rate of implementation in energy efficiency of the analyzed industries. 55% of the proposed measures in ventilation based on the previous performed energy audits have been realized, followed by compressed air and lighting with 48% and 46%, respectively. Space heating has the highest proportion of planned implementation but only 30% was, in fact, realized according to the respondents. Altogether, 41% of the suggested measures have been implemented, 9% are planned to be implemented, and the remaining 50% are not being considered for realization.

[3]Lean manufacturing (Lean) is a generic process management philosophy derived mostly from the Toyota Production System

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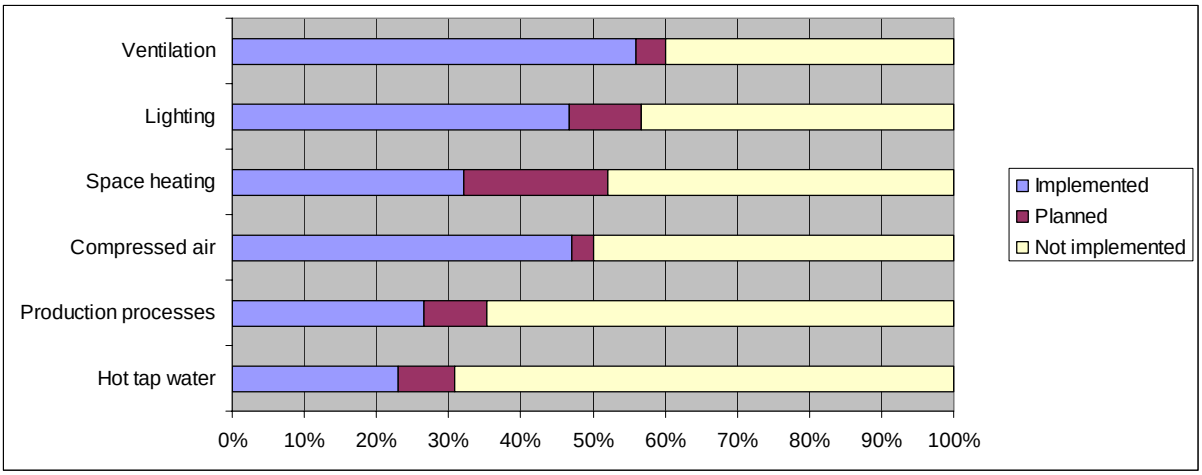

Figure 1. Implementation of energy efficiency in industries located in Ulricehamn

Sources for information about energy efficiency

The most valuable sources that provided information about possible energy efficiency measures were, according to the respondents, product information from suppliers of equipment, followed by colleagues in the industry and within the company. The County Administrative Board and Regional Energy Agency were ranked as the least valuable sources of information (Figure 2).

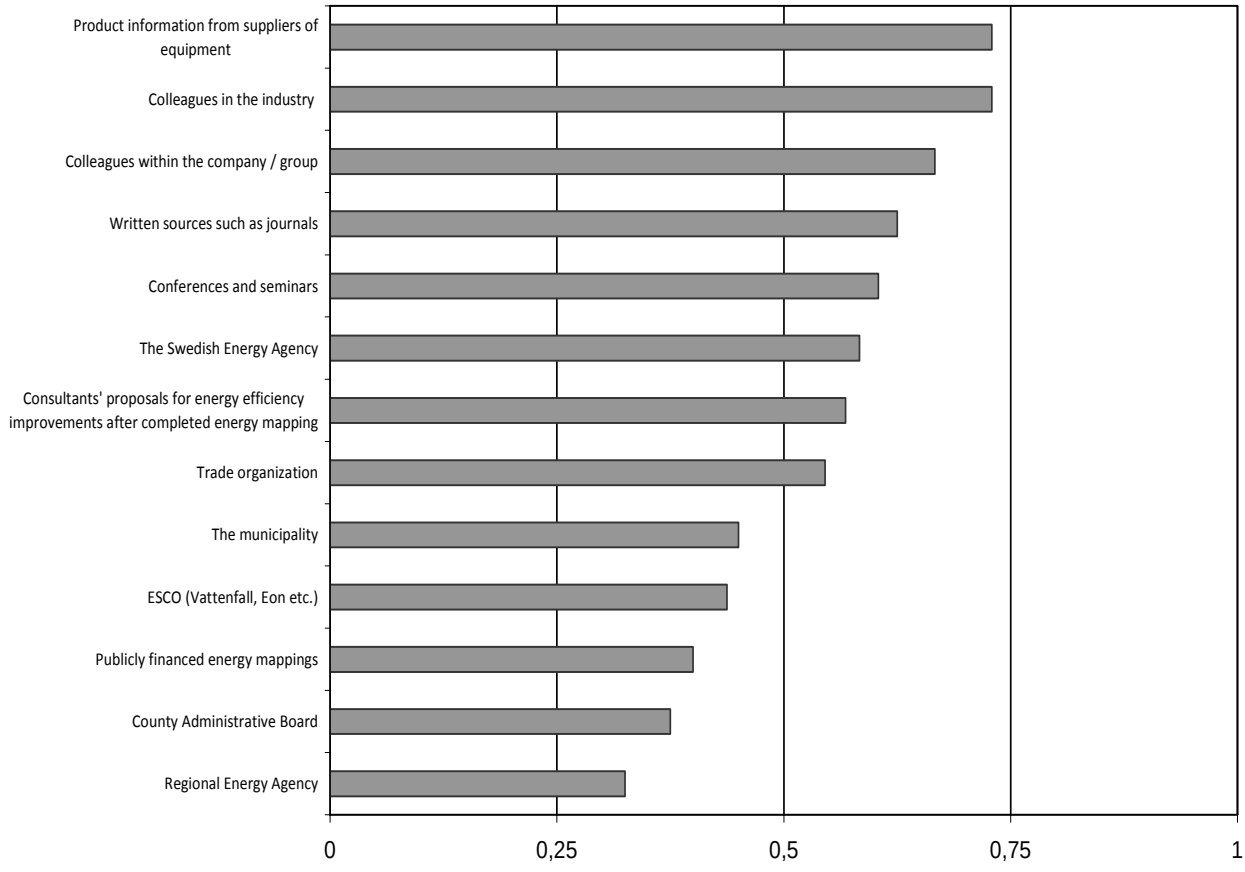

Figure 2. Sources of information regarding energy efficiency measures.

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Driving forces

The questionnaire ranks as the five strongest driving forces for energy efficiency: (1) reduced costs, (2) presence of engaged people (guiding spirit) within the industry, (3) threat of future higher energy prices, (4) full support from top management and (5) investment support for energy efficiency (Figure 3). The questionnaire also showed that the five major barriers to implementation of energy efficiency measurers are: (1) lack of time, (2) other priorities, (3) long decision path, (4) non-integration of energy into the industry's practices and (5) risk of production disruption (Figure 4).

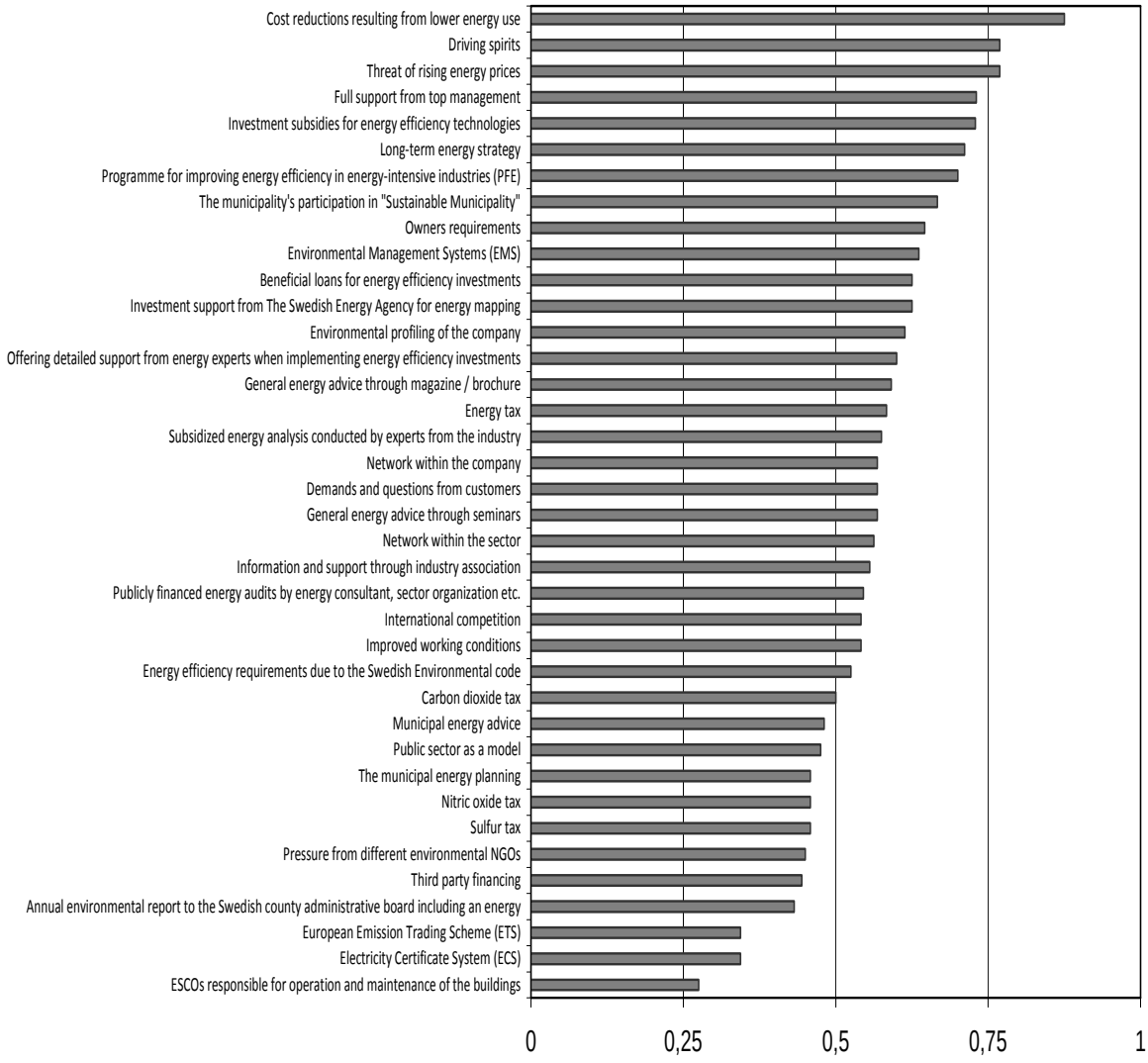

Figure 3. Factors driving energy efficiency.

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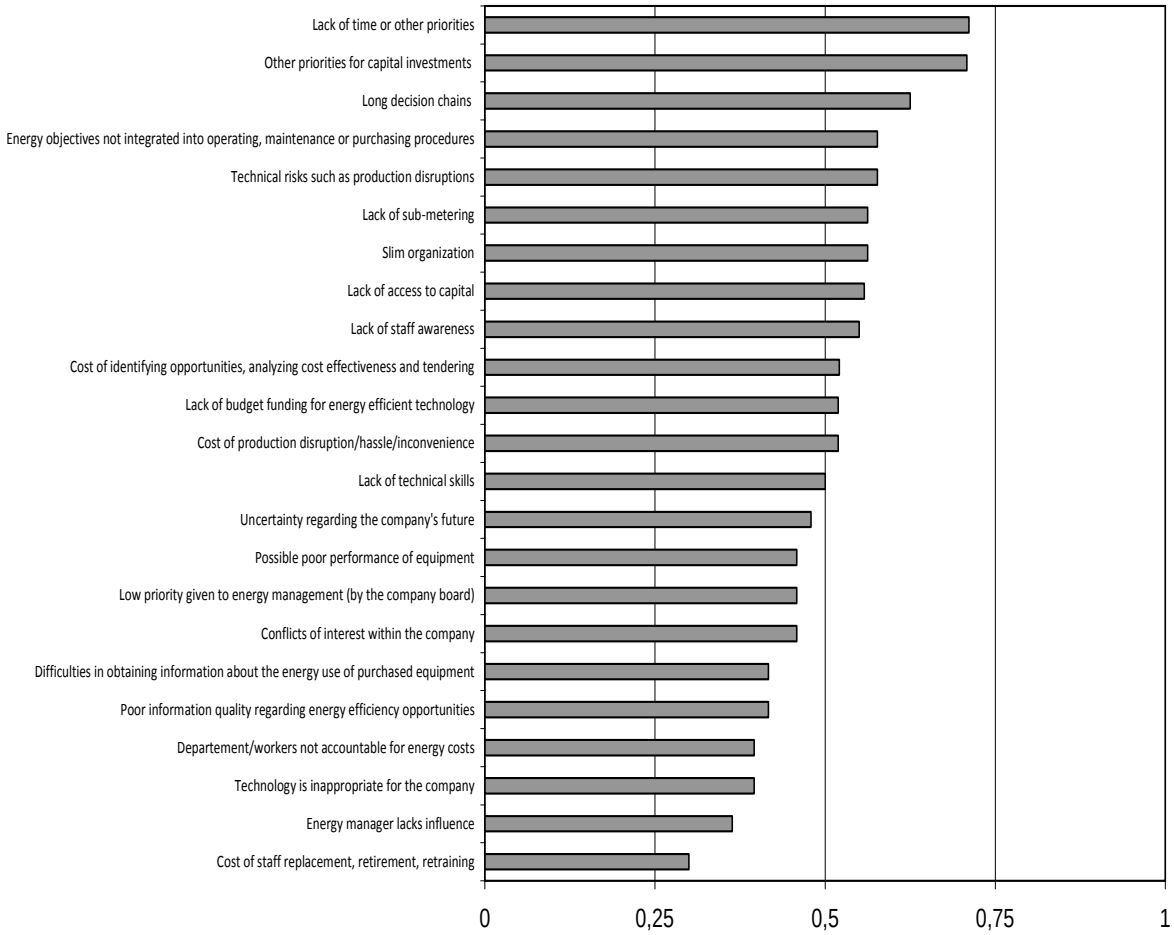

Figure 4. Barriers to energy efficiency.

Energy management

58% of the respondents state that energy costs are not allocated, 21% allocate energy costs in relation to the area of the industry (m^2), 13% divide the energy cost within the industry according to internal measures and finally, 8% allocate energy costs in relation to the number of employees.

Over 60% of the industries lack a long-term energy strategy. 15% had a “long-term” energy strategy (three years), while the remaining had strategies of two, four or five years. 75% of the industries agree that there are energy efficiency measures which can be economically profitable to implement. In nearly 70% of all studied industries the pay-off time for implementation of energy efficiency measures is not allowed to exceed three years while the rest of the industries claim a pay-off time of maximum two years. In Table 2, total investment costs, reduced electricity use and pay-off time for different measures implemented in the studied industries are presented.

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Table 2. Pay-off time for implemented energy efficient measures in three support processes.

Process	**Total investment** (Euro)	**Reduced use of electricity** (GWh/year)	**Pay-off time**[1] (year)
Lighting	7 303 000	4.1	2.2
Space heating	1 700 000	1.14	1.9
Compressed air	1 020 000	0.19	6.6

[1]Electricity price 80 Euro/MWh (Nordpool, February 2010)

Conclusions

Based on an ex-post evaluation of the outcome of industrial energy audits in five Swedish municipalities, the following conclusions are made:

- Energy efficiency is a management issue. In order to intensify energy efficiency work, it is important that the top management of the industry clearly show their interest.

- The strongest driving forces for energy efficiency measures are, in consecutive order, reduced costs, the presence of engaged people (guiding spirit) and the threat of rising energy prices. The largest barriers to implementation are, in consecutive order, lack of time, other priorities, other priorities for capital investments and long decision-chains.

- Offering education is a concrete action to stimulate engagement for energy efficiency issues within the organization.

- A long-term energy strategy is important for the realization of energy efficiency measures. Yet over 60% of the industries lack a long-term energy strategy. Further studies are needed to understand the reasons for this.

- Lack of sub-metering and weak or absent allocation of energy costs are strong barriers to improved energy efficiency.

- Colleagues within the industry are one of the most valuable sources for information regarding energy efficiency. This implies the importance of sharing good examples.

Considering the high use of electricity in Swedish industries, in combination with increasing electricity prices and increasing awareness of the situation of global climate change, it is of vital interest to find measures that will redirect industrial energy use towards less electricity dependence. A basic foundation for improved energy efficiency is to conduct an energy audit to identify concrete measures that could lead to reduced costs as well as lower emissions of carbon dioxide. By evaluating a number of energy audits, ex-post, and the major

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driving forces and barriers to the implementation of energy efficiency measures resulting from the audits, this paper has shown that the degree of implementation has ranged from some 20% up to 60%, but that there are still a number of barriers yet to be overcome and many energy management practices still to be improved.

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