# Energy efficiency potentials and energy management practices in Swedish firms

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## Keywords

energy management, energy efficiency gap, energy efficiency measures, policy

## Abstract

In order to improve energy efficiency and reach the EU:s 20-20-20 primary energy saving target, focus has mainly been on diffusion of technology. Previous studies have illustrated large untapped energy saving potentials from implementing energy management practices in firms. Energy management practices have large effects on energy utilization and also a short payback time. According to these studies, energy management practices also effect investment decisions and the outcome of investments in energy efficient technologies. This paper investigates to what extent energy management practices influence firms estimation of energy efficiency potentials. Further it investigates two Swedish policy programs that promote industrial energy management practices: The Programme For improving Energy efficiency in energy-intensive industry (PFE) and the energy audit program and whether these have increased energy management practices in Swedish firms. A multiple case study has been conducted in order to investigate energy practices in firms in different industrial sectors. Employment of energy management varies between firms. The firms estimate equal energy efficiency potentials from implementation of energy efficient technology as for energy management practices. In total the firms estimate energy efficiency potentials of 12 %. The study shows that firms that have participated in the programs work more actively with energy management. This can be illustrated by the fact that 75 % of the firms that have not participated in any of the programs lack a person responsible for energy management and 50 % also lack a long term energy strategy. For firms that have participated in the programs the corresponding figures are 30 % and 33 %. The results indicate an untapped potential of energy efficiency measures that could be reached through increased energy management in Swedish industries.

## Introduction

As energy prices increase, improving energy efficiency gradually becomes an increasingly important way for firms to reduce operating costs and increase competitiveness and productivity. Multiple studies of investment decisions in firms have illustrated that often, despite profitability, investments in energy efficiency have a low priority (DeCanio 1998; Rohdin et al. 2007). Inefficient use of energy is not only a consequence of insufficient diffusion of energy efficient technology. Improvements can be attained at low cost with energy management. Successful energy management can not only improve energy efficiency of existing business activity but may also overcome barriers to diffusion of energy efficient technologies and influence investments decisions. Therefore further research on energy management is of vital importance to acquire knowledge on how to increase the rate of energy efficiency in the industrial sector.

The Programme For improving Energy efficiency in energy-intensive industry (PFE) and the energy audit program are the two main policy instruments to increase awareness of untapped energy efficiency potentials in Swedish firms. The Swedish PFE was introduced in 2005 (Ottosson and Peterson 2007; Stenqvist and Nilsson 2011), and is a so called long term agreement program combining technology and management measures. The first five year program period lasted from 2005 to 2011. During the first two years, an energy audit was conducted in the participating firms. The following three years, energy management systems were introduced and certified, investment routines like life cycle costs was adopted within the organization (Stenqvist and Nilsson 2011). Evaluation of the results show that the implemented electricity efficiency measures implemented amounts to approximately 1.4 TWh/year and include 1066 measures (SEA 2010; Stenqvist and Nilsson 2011). Moreover, the voluntary reporting of measures related to other energy carriers has provided additional energy savings apart from electricity. Furthermore, the participating companies have reported voluntarily an increase in electricity generation of 1.0 TWh/year (SEA 2010).

Apart from the PFE, an energy audit program was introduced in 2010 and last until 2014 primarily targeting industrial Small- and Medium-sized Enterprises (SMEs), even though larger firms are also eligible. The subsidy covers 50 % of the cost of an energy audit, with a maximum of 3,000 Euro, available for firms using more than 500 MWh of energy per year.

The aim of this paper is to examine whether the PFE and the energy audit program have increased energy management practices in the participating firms. Furthermore, it investigates to what extent energy management practices influence firms estimation of energy efficiency potentials. This is relevant since energy management is an important means to implement energy efficiency measures in firms.

## Energy use in Swedish industry

In 2008 the EU introduced the 20-20-20 action plan which set the objective to reduce greenhouse gas emissions by 20 %, increasing the share of renewables to 20 % and improve energy efficiency with 20 %.This has increased attention for energy efficiency and as a consequence similar policy instrument as the PFE and the energy audit program has been introduced in numerous European countries. (EC 2006)

The aggregated energy end-use among the approximately 59,000 Swedish industrial companies is about 149 TWh/year (year 2010), among which more than 70 % is used among the approximately 600 energy-intensive companies (PWC 2007). In Figure **1** the annual energy use in Swedish industry from the 1970 and onwards is presented. The figure demonstrates that the energy end-use has not changed significantly in 40 years, but that a large part of the fossil fuel use has been reduced and the biofuel and electricity shares has increased. As can be seen in Figure 1, the economic recession which started in the fall 2008, affected the Swedish industrial energy use the year 2009, i.e. a large drop in energy use may be seen. In 2010, the figures where back to 2008 level again (SEA, 2011).

In Figure 2, the Swedish industries' energy intensity from 1993–2008 is showing that energy intensity has decreased with on average approximately 2.3 % annually.

As can be seen in the figure, the energy intensity for the Swedish industry has decreased. According to Martínez and Silveira (2012), this shift is majorly not due to structural changes but an effect of high energy prices, energy taxes, investments and consumption of electricity, suggesting that Sweden has applied for an adequate and effective energy policy (Martínez and Silveira, 2012).

### INCREASING ENERGY EFFICIENCY THROUGH ENERGY MANAGEMENT PRACTICES

According to the European Commission, the economic potential for energy efficiency in European industry is 25 % (EC 2006). However, research states that a part of the energy efficiency potential remains unexploited. The reason for this is commonly explained by the existence of different barriers to

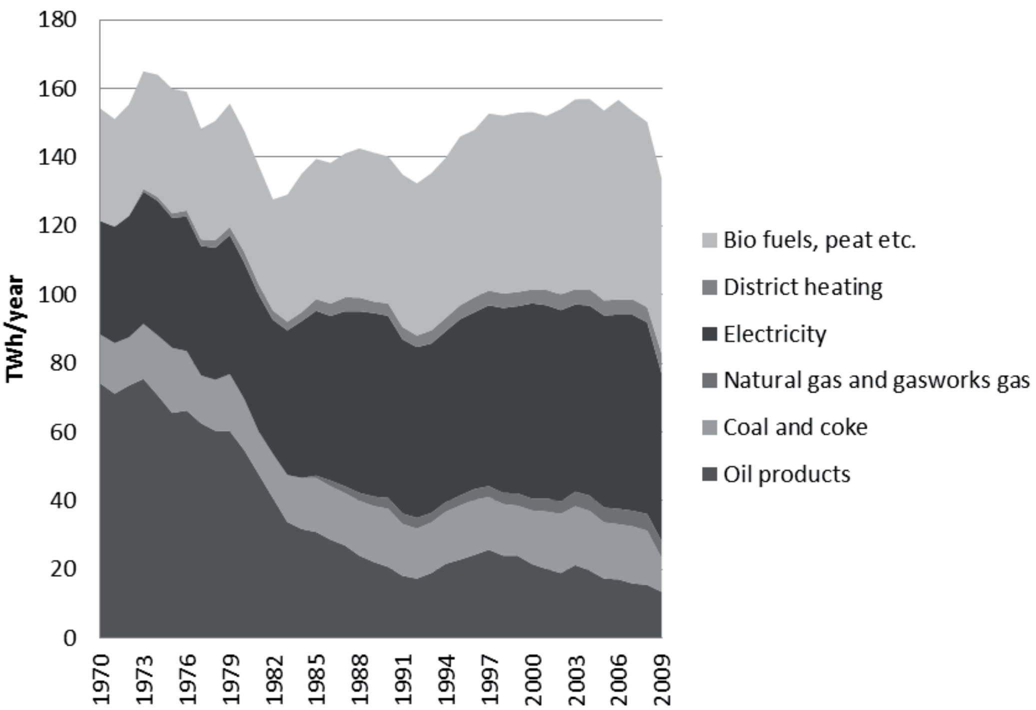


*Figure 1. Energy-end-use in Swedish industry in TWh/year per energy carrier (1970–2009) (SEA 2010).*

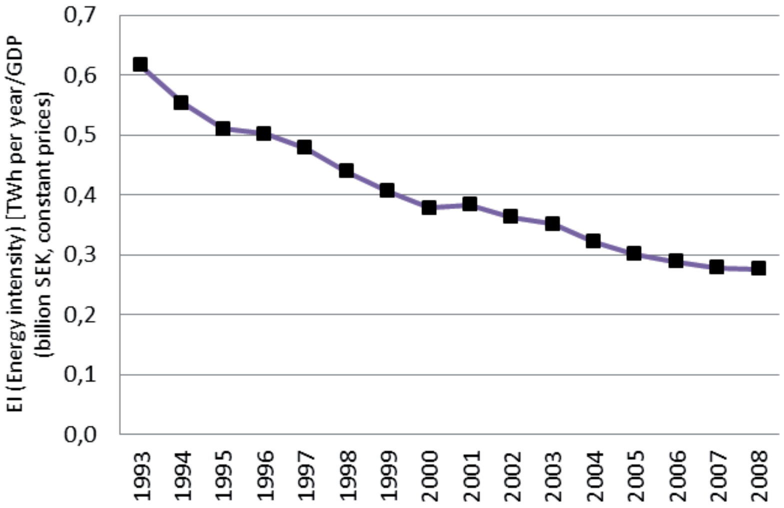


*Figure 2. Swedish industries' energy intensity development between 1993–2008 (SEA 2010).*

energy efficiency (Jaffe and Stavins 1994). Barriers vary considerably between different sectors, regions and countries (Sorrell et al. 2004). Research on management strategies show that firms that focus on core business create a risk of reinforcing barriers to energy efficiency. This is due to that a firm should allocate its resources to its core business. According to the notion of the core business theory, energy efficiency can never be a core business activity for a manufacturing industry, as it does not generate an income, only a saving. This is likely to lead to energy efficiency becoming a low priority issue within the firm (Thollander and Ottosson 2010). On the contrary, Worrell et al (2003) shows that apart from reducing energy costs, energy efficiency investments may deliver core benefits, i.e. increased productivity etc. One means to overcome barriers to energy efficiency is to outsource activities to an Energy Service Company (ESCO), whose core business is energy efficiency.

Energy management has been used casually in the academic literature but there does not seem to be a cohesive definition. Energy management includes both planning of energy efficiency investments, as well as care and maintenance of technology to maintain an efficient operation (Gordic et al. 2010). Since the industrial sector is heterogeneous, what is required by successful energy management practices in a firm depends on many different factors, for example the company size and type of industry (Mckeiver and Gadenne 2005). Despite these differences, studies and definitions of energy management practices tend to contain similar steps (Abdelaziz et al. 2011, John 2004, Swords et al 2008):

- Analysis: e.g. energy auditing and gathering of information regarding energy flows.
- Reporting: quantify energy efficiency targets and communicate targets in the organization.
- Action: both implementation of new efficiency measures and housekeeping, i.e. maintenance and operation.

Energy management requires continuous work for improvements (Gordic et al. 2010). An energy audit is typically the first step in initiating energy management activities. Results from the Netherlands and England have shown that adopting in-house energy management practices may improve energy efficiency by up to 40 % (Caffal 1995). The key to such success was stated to be a combination of management practices and traditional energy efficiency measures (Caffal 1995**).**

One way to work with energy management is to implement an energy management system. 2011 the international energy management standard, International organization for standardization (ISO) 50001, was introduced as well as the European EN 16001 standard. Without organizational support and an organizational culture of continuous improvement, any management system faces the risk of becoming ineffective, e.g. Rohdin and Thollander (2006).

In companies where energy management practices are successfully carried out, some factors are likely to be seen, e.g. (Thollander and Palm 2012):

- top management support of the energy management program
- create a long-term energy strategy with quantified goals for improved energy efficiency over the coming
- based on the formulated strategy, create two energy plans, covering one-year and multi-year periods, respectively; involved measures should be framed in terms of technology, behaviour, conversion, and reduced area to be heated
- create an energy manager position, i.e., an energy controller; this position does not need to be full-time but should be filled by someone with operational responsibility, for example, the production rather than the maintenance manager
- set aside funding for sub-metering installations, preferably at the division level, to overcome the split incentive barrier

## Method

This research was carried out as a multiple case study of the energy intensive industries in Gävleborg County, located in the central of Sweden on the Baltic Sea coast. The county holds a large share of energy intensive industries, e.g. pulp and paper and steel industry. Approximately 67 % of the county´s energy end-use in 2008 was used within the industrial sector (Statistics Sweden 2012) Gävleborg has currently initiated a research project to investigate how the region can become climate neutral by 2050, Climate neutral and competitive Gävleborg 2050. Due to its vast energy intensive industrial activity, industrial energy management practices becomes an interesting research area. Due to the complexity of energy flows in energy intensive industries the research was carried out using a questionnaire that focused on energy management practices, energy use and energy efficiency potentials in the studied firms. Using a questionnaire enables the industrial firms to contribute with their own data and estimations and at the same time enables a larger sample than when performing energy audits. An alternative, more detailed method to study this would be to use an industrial firm as a case study. This would have allowed even more detailed data. According to Yin (2003) case studies are advantageous when studying complex phenomena's. However, individual case studies can also be criticized for drawbacks regarding generalizations. A questionnaire allows a larger sample of industries, which allows for generalizations.

The web-based questionnaire was sent to 58 industrial firms in spring 2012. The firms included in the study were all the A- and B- classified producing firms in the region: a classification based on the firms' environmental impact where A- and B- classified firms have the highest impact. (Environmental Code 1998) The list of classified firms, i.e. the respondents, was obtained from the county administrative board of Gävleborg. The questionnaire was answered by the person in charge of energy at the firm, ether the energy manager or the production manager, and the study response rate summed up to 31 %.

Based on this questionnaire, the firms' energy management practices and estimated energy efficiency potential will be compared and evaluated. The answers from firms that have participated in the PFE and/or firms that have conducted an energy audit in the last three year (2009 until present) will be compared to the firms that do not fulfill any of these criteria.

It is worth noting that the respondent´s answers regarding energy efficiency potentials from technology and energy management at the plants, sectors and in Swedish industry are estimations affected by the respondent's personal opinion.

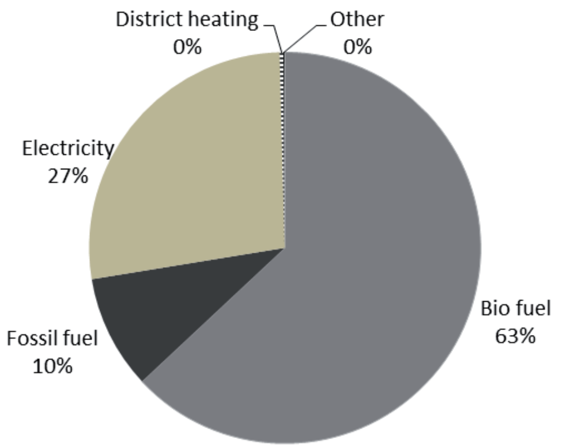


*Figure 3. Reported annual energy use of 9.4 TWh/year in the firms in the Gävleborg county, participating in the study.*

**Table 1. Annual energy use for firms in category X and Y.**

| Category | X | Y |
|---|---|---|
| Energy use (TWh/year) | 8.8 | 0.6 |
| Percentage of accounted energy use (%) | 94 | 6 |

**Table 2. Estimated energy efficiency potential.**

| | Category | Potential for energy efficiency (%) |
|---|---|---|
| From technology | X | 4.6 |
| | Y | 20 |
| | All firms | 6 |
| From energy management | X | 6 |
| | Y | 13 |
| | All firms | 6 |

## Results

The industrial sector accounts for a large proportion of Gävleborg's total energy use. The firms in the study report an annual energy use of 9.4 TWh. This equals approximately to 43 % of the region's total energy end-use. Figure **3** illustrates how the energy end-use in the firms is distributed between fuels. Biofuels and electricity account for the largest shares of energy of 63 % and 27 %, respectively. Fossil fuels accounts for 10 % and district heating and other fuels account for about 0.5 % each.

To investigate whether participating in PFE or conducting an energy audit improves energy management practices within firms, the respondents in the study were divided in to two categories. The firms were categorized according to the following:

- Category X: firms that have participated in PFE or conducted an energy audit in the last three years.
- Category Y: firms that have not participated in PFE nor conducted an energy audit in the last three years.

Fifty-six percent of the firms in the study belong to category X. These firms accounts for 94 % of the total energy use in the study. This can be explained by the fact that only energy-intensive firms participate in the PFE. Six of the firms in category X have used the Swedish Energy Agency's financial support to conduct an energy audit, two of these have also participated in the PFE. The total energy use in category X and Y is reported in Table 1.

### ENERGY EFFICIENCY POTENTIAL

The respondents were asked to estimate efficiency potential from both implementing new more energy efficient technology and implementing management measures. The estimations are reported in Table 2. The firms estimate total energy efficiency potentials of 12 %, including both technology and management witch sums up to 1.1 TWh/year for the firms in this study. Firms in category X estimate lower efficiency potentials from both technological improvements and energy management measures compared to firms in category Y. The largest estimated efficiency potential for firms in category X comes from management measures while in comparison respondents in category Y estimate higher percentage for both technology and management but rank energy efficiency potentials from technological improvements higher than energy efficiency potentials from energy management measures.

The firms were also asked to estimate energy efficiency potentials for firms in their sector as well as for the entire Swedish industry. For their own sector (the firms belong to different sectors) the firms estimated an efficiency potential of 15 % (8 % for technology and 7 % for management measures) which implies that the firms rate themselves as slightly more energy efficient than the average firm in their own sector.

#### ENERGY MANAGER

Figure 4 outlines the findings regarding the existence of an employee working with energy management practices among the studied firms. Notably, 75 % of the firms in category Y do not have a person working with energy management practices. Among the firms in category X most have an employee working with these questions part-time.

#### ENERGY STRATEGY

The existence of a long-term energy strategy has been found to be one of the most important factors for successful energy management practices (Thollander and Ottosson 2010; Caffal et al. 1995). A long term energy strategy is an internal document that emphasizes the firm's energy policies and is supported by the top management. Figure 5 summarizes the findings regarding the firms' existence and duration of a long-term energy strategy. As demonstrated in Figure 5 approximately 30 % of the firms in category X and as much as 50 % of the firms in category Y do not have an energy strategy. However, the greatest share of the firms in category X does have an energy strategy and most of these firms hold a strategy of 3 years or longer while more than half of the firms in category Y lack a strategy or do not know if they have a strategy with regard to energy. The results indicate that the firms in category X prioritize energy management higher than the firms in category Y.

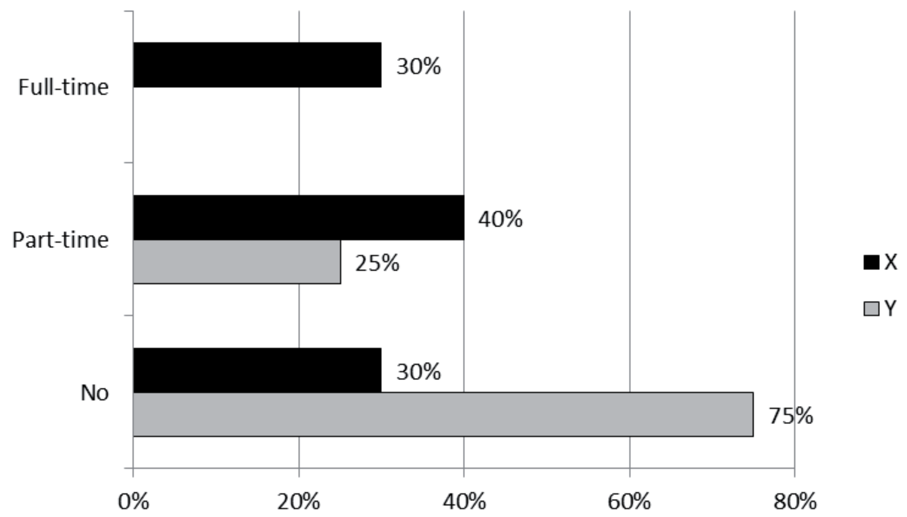


*Figure 4. Existence and form of employment of an employee working with energy management shown as percentage of the total number of respondents in category X and Y respectively.*

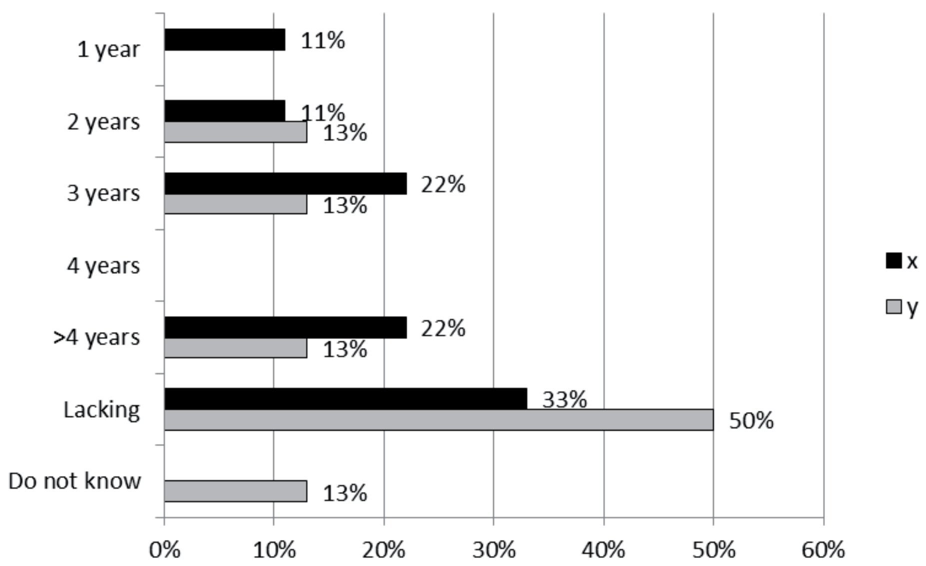


*Figure 5. Existence and duration of an energy strategy shown as percentage of the total number of respondents in category X and Y respectively.*

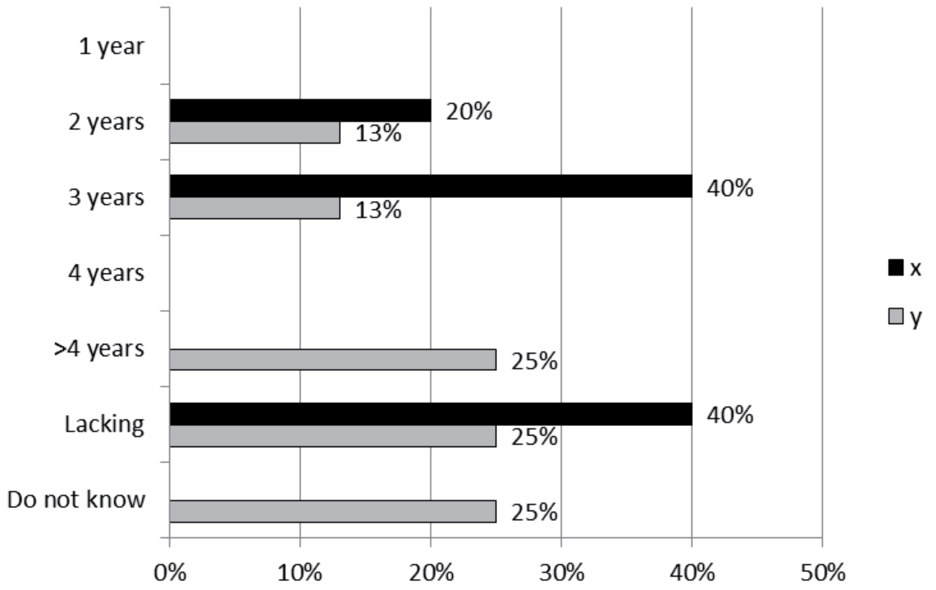


*Figure 6. Existence and length of pay-off criterion for energy efficiency investments shown as percentage of the total number of respondents in category X and Y respectively.*

**PAY-OFF CRITERIA**

Figure 6 illustrates the pay-off criterion for firms in the study. Most of the firms have a pay-off criterion for energy efficiency investments of 3 years or less. As for energy strategy, it can be seen that all of the firms in category X are aware of the existence and length of their pay-off criterion. However, 25 % of the firms in category Y have pay-off criterion longer than 4 years. It is worth noting that 40 % of the firms in category X and 25 % of the firms in category Y state that they lack a pay-off criterion all together for energy efficiency investments. The pay-off criterion for investments in energy efficiency has been highlighted as an important factor for implementation of energy efficiency measures. Studying this criterion gives an indication of the conditions for investments in energy efficient technology, hence diffusion of technology. Industrial investments are often related to both production efficiency and energy efficiency which can make it difficult to distinguish these investments from each other. (Thollander and Ottosson 2010)

**ALLOCATION OF ENERGY COSTS**

Allocation of energy costs are of great importance since it may affect the incentive for a firm to work with energy efficiency measures and energy management. Thollander and Ottosson (2010) illustrate the lack of incentive for firm's departments and divisions to work with energy efficiency if the energy costs are allocated by square meter since the individual department or division does not gain to any benefit from this allocation method. Also, to reach successful energy management the importance of a sub-metering system on plant level is highlighted (Thollander and Ottosson 2010). Figure 7 shows how energy costs are allocated among the studied firms. It is worth noting that more than three fifths of the studied firms do not allocate energy costs at all. Only 10 % respective 13 % of the firms in category X and Y use a sub-metering system and the same share allocate the energy costs per square meter.

**ENERGY SERVICES**

Energy services are often put forth as vehicle for promoting energy efficiency. (Marino et al. 2011) Consulting external services for internal energy management can be a complement to internal energy management. The advantage of consulting Energy Service Providers (ESPs) is often explained by knowledge and scale advantage, since ESPs core business or at least part of it is energy and energy management. ESPs can stay updated about technical and economical energy management solutions since they apply the information in many different settings. This reduces the cost of knowledge per kWh and this cost advantage is, up to a certain point, inversely related to scale. (Sorrell 2007; Goldman et al. 2005) The scale advantage is why ESPs often are specialized in generic technologies such as lightning, heating, ventilation and cooling i.e. support processes. (Goldman et al. 2005)

Eighty-five percent of the firms in the study have consulted some kind of ESP. All the firms in category X have employed energy services of some kind while 38 % of the firms in category Y have not used energy services. The consultation of energy services is reported in Table 3. As expected, a large majority, 80 %, of the firms in category X have used some kind of external consultation while only 25 % of the firms in category Y have used external consultation. Sixty-one percent of the firms in the study have used energy services for installation and 55% of the firms have used energy services for maintenance and operation of support processes. The employment of external services for support processes is slightly higher for firms in category X while firms in category Y have a higher employment of energy services for maintenance and operation amongst production processes. Sixteen percent of the firms have also used external financing to finance investments in energy efficiency.

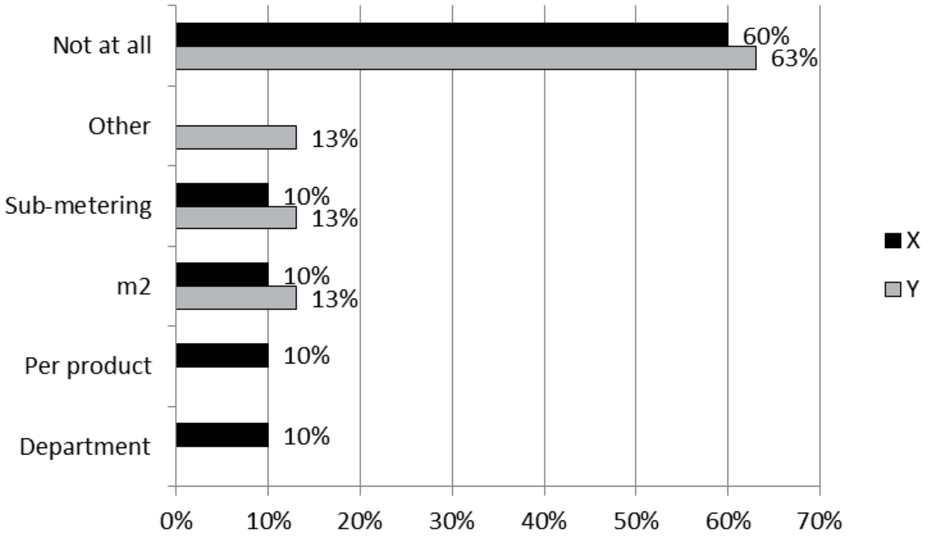


*Figure 7. Allocation of the energy costs shown as percentage of the percentage of the total number of respondents in category X and Y respectively.*

**Table 3. Employment of energy services.**

| Energy service | X (%) | Y (%) | All firms (%) |
|---|---|---|---|
| Consultation | 80 | 25 | 56 |
| Installation | 60 | 63 | 61 |
| Maintenance and operation of support processes | 60 | 50 | 55 |
| Maintenance and operation of production process | 10 | 25 | 16 |
| External financing of energy efficiency investment | 20 | 13 | 16 |

## Concluding discussion

### ENERGY MANAGEMENT AND SAVING POTENTIALS

The study covers 64 % of Gävleborgs industrial energy use. The mix of used energy carriers also corresponds well to the regions total industrial mix (Statistics Sweden 2012). The estimated efficiency potentials differ between the two categories. Category Y estimates larger energy efficiency potentials than the firms in category X. Despite that, since category X accounts for 94 % of the study's total energy use their total estimated efficiency potential (MWh) is larger. Category X estimates larger potentials from energy management while category Y estimates larger potentials from technology. In total the estimated efficiency potentials from technology and energy management sum up the same amount. Previous studies of energy efficiency potentials have focused on diffusion of technology, the results from this study underlines the importance of future studies of industrial energy management. Energy efficiency potentials from energy management measures are not negligible and can be reached without large investment costs.

The results indicate that firms in category Y do not prioritize energy management nor investments in energy efficiency to the same extent as firms in category X. None of the firms in category Y have a fulltime employed energy manager, three quarters lack an energy manager altogether. This may explain the fact that 63 % of these firms lack or do not know whether they have an energy strategy. In category X 70 % of the firms have a full- or part-time employed energy manager and 70 % have an energy strategy of one year or longer. The lack of energy management practices in category Y makes their ability to estimate energy efficiency potentials problematic.

Surprisingly, there does not seem to be a correlation between energy management practices and pay-off criterion for investments in energy efficiency. Forty percent of the firms in category X lack a pay-off criterion and 50 % of the firms in category Y either lack, or do not even know their pay-off criterion for investments in energy efficient technology. The lack of pay-off criterion is not necessarily negative; firms may use alternative evaluation of investments, e.g. net present value.

The majority of firms in the study, in both categories do not allocate energy costs. Allocation of energy costs and sub-metering in particular have been highlighted as an important tool to increase awareness of energy efficiency in sub-department of firms. The lack of cost-allocation provides weak incentives for departments within firms to work with energy efficiency, since it does not provide benefit for the individual department.

All firms in category X have employed some kind of energy service while 25 % of the firms in category Y have not consulted external support regarding energy. The result that firms in category X both work more actively with energy management and have a higher use of energy services indicates that employment of energy services is a complement and not a substitute to internal energy management. The main consulted energy services are consultation, installation and operation and maintenance of support processes. It is notable that one quarter of the firms in category Y have used energy services for maintenance and operation of production processes.

To conclude, the firms in category Y work less actively with energy management than firms in category X. This could explain why they estimate higher energy efficiency potentials; they might have higher potentials since they have implemented less efficiency measures. Moreover, the firms in category X are also more energy-intensive with the majority of their energy use allocated in the actual production, i.e. not located among cross-cutting technologies. A more general conclusion from this is thus that more energy-intensive firms seems to be more successful when it comes to adopting energy management practices, e.g. an employed energy manager and the existence of an energy strategy.

#### POLITICAL CONTEXT

The firms in the study estimated a total energy efficiency potential of 12 %. This can be compared to the EU´s estimated savings potential for industry of 25 %. The difference in estimations can be explained and discussed from various angles. Jaffe and Stavins (1994) describe how estimation of energy saving potentials depends on what one includes in the calculation. It is clear that the firms in the study and EU have different valuation of energy flows and investment costs.

Another explanation of the gap between the estimations is the nature of the industries. Sweden as Gävleborg has an energy-intensive industrial sector. The energy-intensive sector, pulp and paper, iron and steel and chemical industry accounts for more than 70 % the total energy end-use in Swedish industry. (SEA 2011) Energy-intensive firms have higher energy costs than small and medium sized industries which increase the incentives to improve energy efficiency. This is also demonstrated in our results were the energy intensive firms in category X estimate efficiency potentials of 10.6 % and less energy intensive firms in category Y estimates 33 %. Therefore energy saving potentials might be lower in Sweden than for other member states (Thollander et al. 2012).

In the industrial sector of Gävleborg, only 10 % of the energy mix comes from fossil fuels and 27 % from electricity. The largest share of energy use comes from bio-fuel; the proportions are similar in the entire Swedish industrial sector. The EU´s 20-20-20 targets for energy, the target to increase the use of renewable energy in the energy sector contra the target for energy savings, are therefore contradictory in a Swedish perspective. The energy savings target does not specify which energy to save. If the energy efficiency measures reduce the use of renewables like bio-fuels, the efficiency improvement will oppose the target for increased use of renewable energy.

## Nomenclature

ESCO Energy Service Company
ESD Energy Service Directive
ESP Energy Service Provider
PFE The Programme For improving Energy efficiency in energy-intensive industry (a Swedish energy policy)
SME Small and Medium Sized Enterprises

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