

# Exploring energy management in the Swedish pulp and paper industry

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## Abstract

The Swedish pulp- and paper industry is a considerable user of energy, accounting for about 50 percent of the Swedish industrial energy use and 2 percent of the EU-25 industrial energy use. Its high energy use makes this industry particularly important in terms of energy efficiency. Previous research has emphasised the need for companies' to have well functioning energy management practices in order to increase energy efficiency. This paper describes and analyses energy management practices in the Swedish pulp and paper industry. A questionnaire was sent out to the person in charge of the energy issue at all Swedish mills and 40 replies were received, a response frequency of 68 percent. The results show that the energy issue has been given increasingly higher priority over the past 10 years. However, in spite of this, overall results from the questionnaire show that there is still potential for improving energy management in the studied industry. More than 20 percent of the studied mills lack a long-term energy strategy, and less than half of the studied mills have an energy strategy covering at least five years. These results indicate that the implementation of a long-term energy strategy in this energy intensive industry, in combination with other means, could be of utmost importance for increasing energy efficiency. In conclusion, based on the research results presented in this paper, a different energy policy design for the industry seems to be needed, which could be very fruitful if it focuses on establishing more efficient energy management practices and includes all energy carriers. Moreover, the fact that more than 20 percent of the studied mills

lack a long-term energy strategy and the fact that the Swedish EMS standard does not require such a strategy to be formulated indicates the need for further studies regarding a plausible inclusion of a long-term energy strategy in the EMS standard.

## Introduction

Increased global warming resulting from the use of fossil fuels is posing a major threat to the global environment (IPCC 2007). Industrial energy efficiency is one of the most important means of reducing the threat of increased global warming (IPCC 2007). Studies of the implementation of cost-effective energy conservation measures show that these measures are not always implemented because of the existence of various obstacles to energy efficiency such as market barriers and failures, e.g. imperfect information, split incentives, adverse selection and principal-agent relationships, resulting in a so called energy efficiency gap. According to mainstream economic theory, barriers related to market failures may justify public policy intervention in the market (Jaffe and Stavins 1994). Studies of barriers to energy efficiency have shown that they differ depending on the type of industrial production and country and industry specific conditions (Sorrell et al. 2000), such as split incentives, imperfect information, and hidden costs and risk, indicating a need for country and industry specific studies in order to identify these barriers. To overcome the barriers, both organisational and behavioural factors such as, for example, the implementation of a long-term energy strategy, people with real ambition, and public policies, e.g. various industrial energy programs and other country specific instruments, are important factors.

Between 2000 and 2006 Swedish industries have faced significant increases in energy prices. While electricity prices almost doubled, oil prices rose by about 70 percent during this period (Johansson et al. 2007, SEA 2006). For the industrial company there are two main means for overcoming the threat of rising energy prices focusing on managing the energy supply side with diversified portfolios etc and energy management focusing on a reduction in energy end-use. This paper will focus on the latter, viz. energy end-use issue. Previous studies have shown that there is considerable potential for energy efficiency improvements in Swedish industry (EEC 2008). How large the potential is, however, is open to discussion and is dependent, for example, on the magnitude of the specific barriers to energy efficiency related to the industrial sector. About one third of the energy use in Sweden, 157 TWh, 56 TWh of which is electricity, is used by industry (SEA 2008). Among the Swedish energy intensive industries using more than 70 percent of the total industrial energy, the pulp and paper industry accounts for nearly 50 percent of the annual industrial energy use, which is about 2 percent of the EU-25 industrial energy use (SEA 2008, Eurostat 2007). The Swedish pulp and paper industry's substantial energy use makes this industry particularly important to study in terms of energy efficiency. Previous research has confirmed the existence of an energy efficiency gap in the industry and found the largest barriers to energy efficiency to be technical risks such as risk of production disruptions, cost of production disruption/hassle/ inconvenience, technology inappropriate at the mill, lack of time and other priorities, lack of access to capital, and slim organisation (Thollander and Ottosson 2008). As regards the driving forces for energy efficiency in the Swedish pulp and paper industry, the highest ranked driving forces were related to organisational factors within the mills such as cost reductions resulting from lower energy use, people with real ambition and the existence of a long-term energy strategy, emphasising the need for further studies of the existing energy management activities within this particular industry. The aim of this paper is to describe and analyse energy management practices in the Swedish pulp and paper industry. The aim has been divided into four research questions:

- How has the mill's priority of the energy issue changed between 1996 and 2007?
- How are energy costs allocated at the mill?
- Does the mill have an existing long-term energy strategy and if so, what period does it cover?
- What payoff criteria are used when investing in energy efficiency measures at the mill?

This paper, thus, provides important knowledge of energy management practices in the largest energy intensive industry in Sweden, one of the most energy-intensive countries in the world. The paper is structured as follows: first, the energy use in the Swedish pulp and paper industry is presented, followed by description of the papers method. The results are then described and analyzed and the conclusions drawn are presented.

## Energy use in the Swedish pulp and paper industry

In 2005, Sweden was the third largest exporter of paper products and the fourth largest exporter of pulp in the world: about 80 percent of the pulp and paper produced is exported (SFI 2005). As stated above, the magnitude of the energy savings potential is open to discussion (and the subject of dispute). As far as the authors are aware, no figure of the potential for energy efficiency in the Swedish pulp and paper industry has ever been given. However, related research in the Finnish pulp and paper industry found an economic savings potential of 10-15 percent for heat and fuels and 1-4 percent for electricity, with an average payback period of two years (Hietaniemi & Ahtila 2007). Notably, the largest potential lies in heat savings and not electricity. It should be noted that other research indicates, at least technically, that potential also exists for further significant energy efficiency improvements in other areas, for example process heat integration (pinch) analysis (Wising et al. 2005). The industry consists of about 60 mills, employs some 27,500 people and accounts for about 6 percent of the Swedish aggregated production value (SFI 2005, SEA 2007). The production of pulp consists of three basic types of mills: mechanical, chemical, and chemical-mechanical pulp production (CTMP). While the chemical pulp process mainly uses biomass as primary energy source, the mechanical pulp process uses more electricity. The Swedish pulp and paper industry uses about 50 TWh biomass, 22.9 TWh electricity and 7.3 TWh fossil fuels. Furthermore, chemical pulp mills generate about 5 TWh electricity through the use of back pressure (SFI 2007). Since the 1970s, the industry has gradually grown less dependent on fossil fuels. This is due partly to energy efficiency improvements (the Swedish pulp and paper industry has a reputation as one of the most efficient in the world (Nilsson et al. 1996)) and partly to increasing use of electricity (SEA 2008, SCB 2006).

## Method

This research was carried out as a case study. Case study research is particularly advantageous when 'how' or 'why' questions are asked about a contemporary set of events over which the investigator has little or no control (Yin, 1994). The research was carried out by means of a questionnaire centring on energy management. The questionnaire is a result of several years of research and experience in Swedish industry and includes issues identified by previous in-depth interviews as well as literature reviews (Thollander et al. 2005, Rohdin and Thollander 2006, Rohdin et al. 2007, Thollander and Ottosson 2008). Four issues of importance were more explicitly studied due to the fact that these factors were found to be of importance in previous studies: the existence and length of a long-term energy strategy, the priority of the energy issue the past 10 years, the pay-back criteria, and how the companies allocate their energy costs. The four questions covered in the questionnaire were:

- How has the mill's priority of the energy issue changed between 1996 and 2007?
- How are energy costs allocated at the mill?
- Does the mill have an existing long-term energy strategy and if so, how long is it?

## Electricity prices on Nord Pool

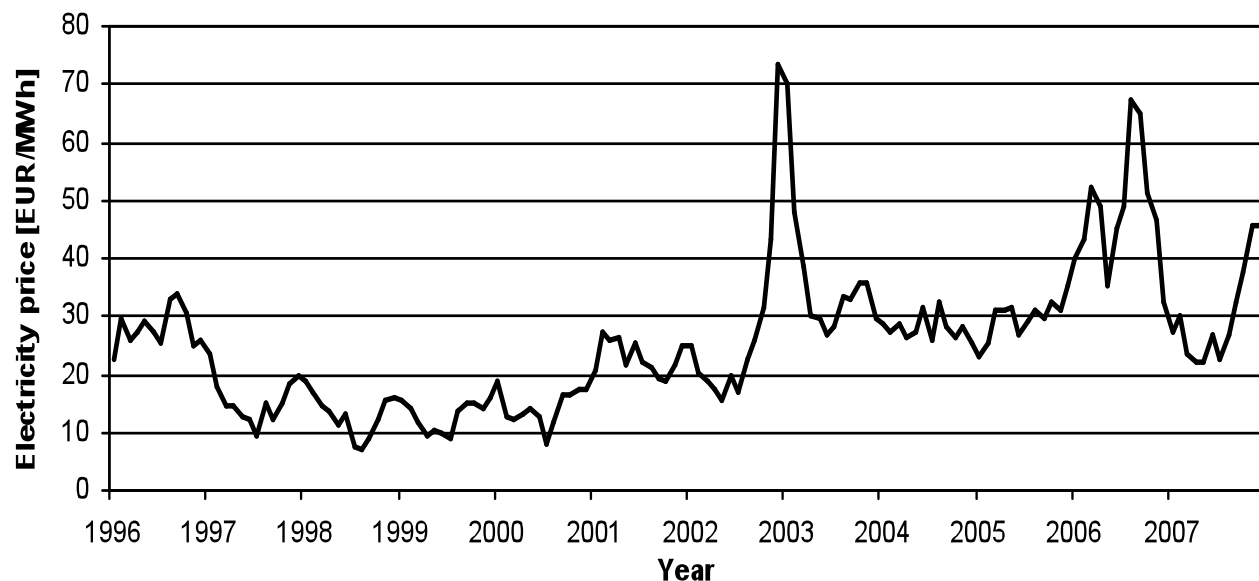


Figure 1. Average monthly electricity prices on NordPool for the period January 1996 to August 2008 (NordPool, 2008).

- What payoff criteria are used when investing in energy efficiency measures?

The reason for studying the first research question was that the Swedish electricity market was deregulated in 1996, leading to initial drops of prices. From 2000 however, electricity prices started to rise and fluctuate more and oil prices rose by 70 percent between 2000 and 2005. From 2005, electricity prices were expected to rise even further due to the implementation of the EU ETS (EU Emission Trading Scheme). Please see figure 1, which shows the fluctuations in Swedish electricity prices on the Nordic spot market. Moreover, the adoption of the Swedish PFE (the Programme for Improving Energy Efficiency in Energy-Intensive Industries) in 2005 should plausibly have led to greater attention being paid to energy efficiency issues.

One common barrier to energy efficiency is split incentives, due for example to inadequate allocation of energy costs at plant level. If the department manager is not responsible for the energy costs, energy management is likely to fail as there are no incentives for him or her to focus on the issue. This was the reason why the second research question was explored. Previous research has found that a long-term energy strategy is of great importance if energy management is to succeed, emphasising the importance of the third research question to be studied (CADET, 1995, Rohdin and Thollander, 2006). The reason for studying the fourth research question is the existence of the principal-agent relationship or moral hazard barrier leading to strict monitoring and control of the MD such as strict payoff criteria set by the board.

When presenting the results in this article, the questions were translated from Swedish to English. In accordance with Yin (1994) the questionnaire was reviewed by staff at the Swedish Forest Industry and the Swedish Energy Agency as well as by senior colleagues before being sent out. The questionnaire was submitted to 59 mills in autumn 2007 and was intended to be answered by energy managers or people in charge of energy issues. The response rate was 40 replies, or a 68 percent

response frequency, which may be considered high compared to similar studies, e.g. Velthuisen (1995) and de Groot (2001). The results were originally split into two groups, one consisting of mechanical mills and the other chemical mills. However, no major differences in results were found between the two groups and the results are therefore presented on an aggregated level.

### Industrial energy management

Research and experience have shown that industrial companies who take a strategic approach by adopting energy management practices may save up to 40 percent of their total energy use (CADET, 1995). Successful industrial energy management demands a strategic approach and also full support from top management. The strategic approaches vary but do have some elements in common such as (CADET, 1995):

- An initial energy audit.
- Senior management support.
- The monitoring of energy use.
- An energy policy.
- Recognition that management is as important as technology.
- An ongoing and co-coordinated programme for energy saving projects.
- The last should include:
  - A long-term energy saving scenario.
  - A factory-wide plan for the medium term.
  - A detailed plan for the first year.
- Actions to improve energy management, including the establishment of an energy monitoring system.

## Priority of the energy issue

3) increased priority; 2) unchanged priority;  
1) decreased priority

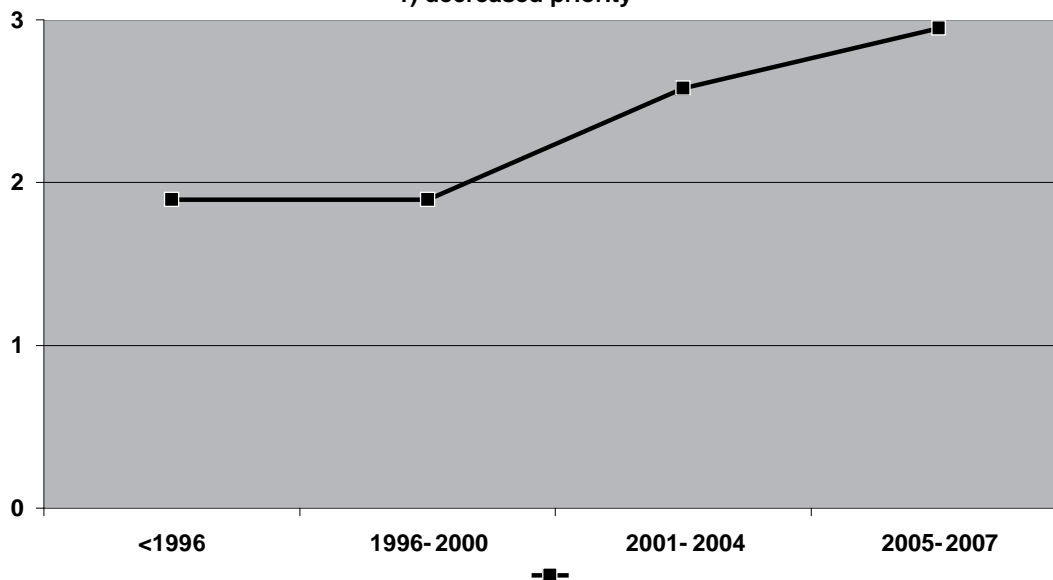


Figure 2. Ranked results from the questionnaire regarding the priority of the energy issue at the studied mills.

One large part of the in-house energy management programme should involve the motivation and training of staff. A successful energy management approach includes both the managerial techniques described above as well as technical measures (CADDET, 1995). It is of importance to remark that the goals in an industrial energy management system, are on a lower organizational level than a corporate energy strategy. While strategy is a plan that deals with how company leaders try to establish direction for the organization and includes pre-determined courses of action and goals, industrial energy management could be one of many goals within such a strategy (Mintzberg, 1987).

### Energy management in the Swedish pulp and paper industry

In the following section of this paper, the results from the questionnaire will be outlined and analysed. Initially, the result as regards priority of the energy issue is outlined, followed by a presentation of the results regarding the allocation of energy costs. Then results regarding the existence and length of a long-term energy strategy are presented, followed by results regarding the industry's pay-back periods.

#### THE PRIORITY OF THE ENERGY ISSUE

Extensive energy price increases during the studied period, 1996-2007, combined with increased environmental concern, e.g. increasing emissions of anthropogenic green house gases, have plausibly led to greater attention being paid to the energy issue in this industry. A number of public policy instruments, both on a European and on a Swedish level, have also affected the energy issue in the industry. Examples of such policy instruments on a European level are the EU ETS and the IPPC (Integrated Pollution Prevention and Control). Examples of policy instruments on a Swedish level are the Environmental

Code and the PFE. Furthermore, since 1991 Swedish industries have been faced with a carbon tax of approximately 21 Euro/ton and in 2005 an electricity tax was introduced of approximately 0.55 Euro/MWh (resulting in the above presented PFE).

All these changes has plausibly affected the Swedish pulp and paper industry's priority of the energy issue. As shown in figure 2, there has been an increase in the priority of the energy issue since 2000.

The figure refers to the mean average of the received answers from each period. The answers refer to the previous time period.

#### THE ALLOCATION OF ENERGY COSTS

In many companies, and in particular those with multiple departments and divisions, inadequate allocation of energy costs may lead to very slack energy management (Rohdin and Thollander, 2006). For example, if the energy cost is allocated per square metre, there is no incentive for a department or division manager to pay any attention to the issue as there is nothing for him or her to gain. The implementation of an energy efficiency measure does not produce any additional benefit for the single department. In other types of ownership where another company is in charge of, or even owns, the company's facilities, the allocation is again of utmost importance. If the energy costs at department or division level are not properly included in the rent, the likely outcome is that energy costs will be ignored. This is often defined as a split incentive and may be categorised as a market failure or organisational failure (Sorrell et al. 2000). A split incentive refers to when a person or department cannot gain benefits from an energy efficiency investment, probably leading to the implementation being of less interest (Jaffe and Stavins 1994). For the PPI this type of barrier would be assumed to be of less importance with thorough sub-metering of boilers etc. at the mills. Nonetheless, the issue remains unexplored within the PPI and, based on previ-

## Allocation of energy costs

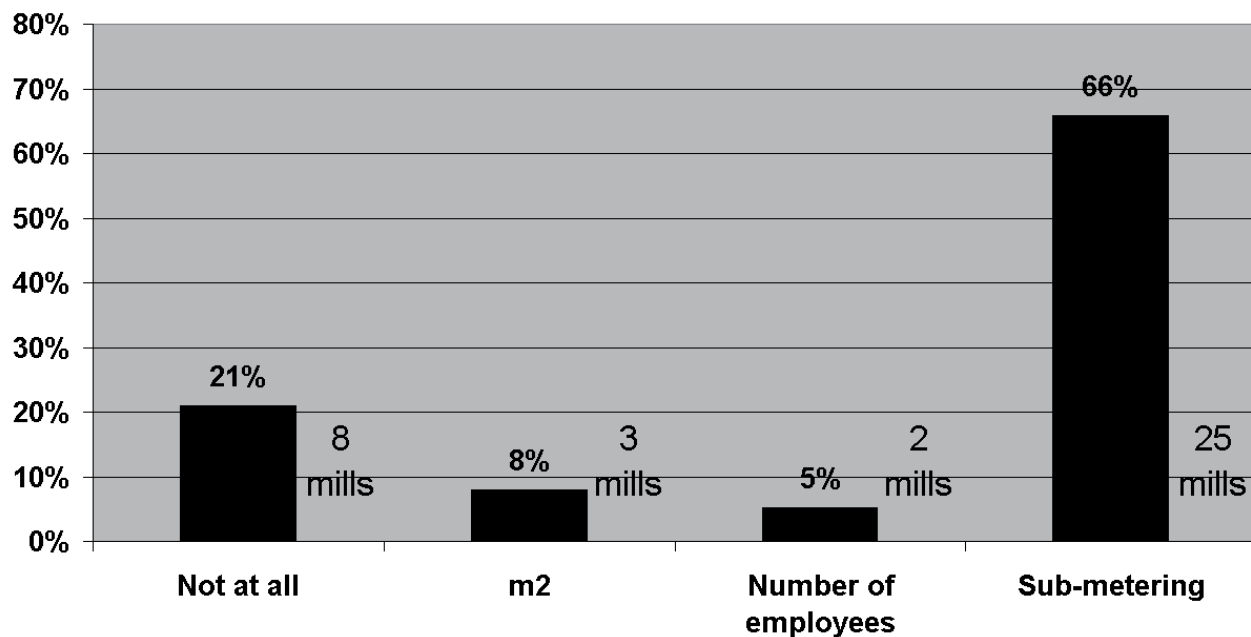


Figure 3. Allocation of energy costs at the studied mills.

ous research regarding barriers, should be important to study. Figure 3 presents results of how the energy costs are allocated at the studied mills. 21 percent of eight of the studied mills do not allocate energy costs at all and at three and two mills energy costs are allocated per square meter and number of employees respectively. Sub-metering at plant level is a prerequisite for proper energy cost allocation. However, it is not installed at all manufacturing companies and even where it exists, it is not always used for energy cost allocation, with the result that other, less appropriate, means are used (Rohdin and Thollander, 2006). This would seem not to be the case at Swedish PPIs. As expected, the majority, 66 percent or 25 mills, allocate energy costs using sub-metering.

### THE EXISTENCE AND LENGTH OF A LONG-TERM ENERGY STRATEGY

Previous research has shown that a long-term energy strategy is one of the crucial factors in successful energy management practices in industry; successful in terms of implemented energy efficiency measures, both technical and behavioural (CADET 1995, Thollander, 2008). This has also proven to be the case in the Swedish pulp and paper industry where a previous study – directed at the energy managers at mills – stated that a long-term energy strategy was one of the most highly ranked factors promoting energy efficiency (Thollander and Ottosson, 2008). A long-term energy strategy is not the same as an EMS, which is adopted on a more operational level lower down in the organisation. Energy management should have top management support and adopting a long-term energy strategy is an important means of emphasising this (Thollander, 2008). Figure 4 shows the existence/non-existence and the length of a long-term energy strategy among the studied industries.

As shown in figure 4, 22 percent or eight of the studied mills lack a long-term energy strategy, and less than half of the studied mills have an energy strategy of at least five years. Adopting an energy strategy of one year or three years and name it a “long-term” strategy could of course be questioned. Neverthe-

less, this could not be excluded in the questionnaire and the result thus shows that the majority of the mills either lack a strategy or have strategies, with regard to energy, of three years or less.

### PAY-OFF CRITERIA

Several different ways of calculating potential investments exist. One of the most common and straightforward methods is the pay-off method. Even though this method does not include an interest rate it gives some indication of the studied companies’ investment criteria for energy efficiency investments. These are outlined in figure 5.

As seen in figure 5, the majority of the mills apply pay-off criteria of 3 years or less for energy efficiency investments. It should be noted that it is often problematic to categorize different investments as energy efficiency investments and production related investments as an investment are for instance in many cases related to both production efficiency and energy efficiency. Moreover, a discrepancy between operational and strategic measures should also be noted. While many of the energy efficiency investments related to the support processes, e.g. ventilation, space heating and lighting, have lower initial cost compared with heavily capital-intensive production processes, the support process measures may be taken on an operational level while many of the heavily capital-intensive production process related investments are more closely related to strategic activities.

### Conclusion

Already in 2000, before large energy price increases in the Swedish industry had occurred (Johansson et al., 2007), many Swedish PPIs faced energy costs well beyond 20 percent and thus had large incentives to prioritize the energy issue (SEA, 2000). The importance of the energy issue was also shown in figure 1 in this paper. As expected, the priority of

### Existence of a long-term energy strategy

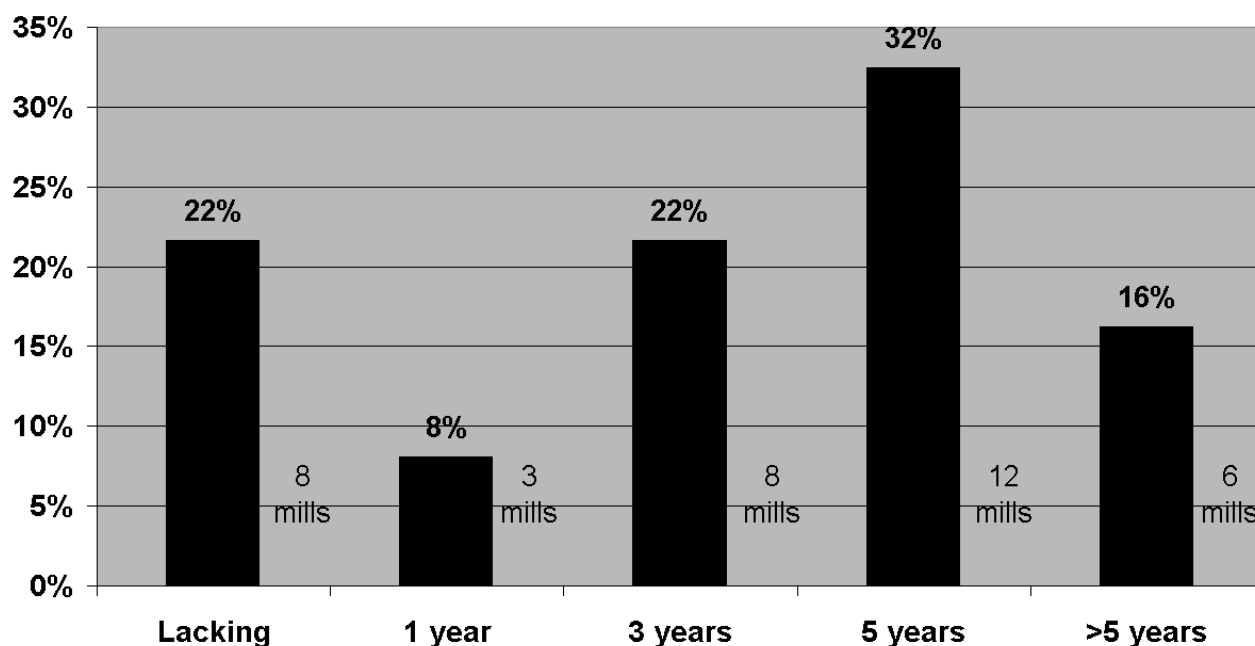


Figure 4. The existence and length of a long-term energy strategy at the studied mills.

### What pay-off criteria are used for energy efficiency investments

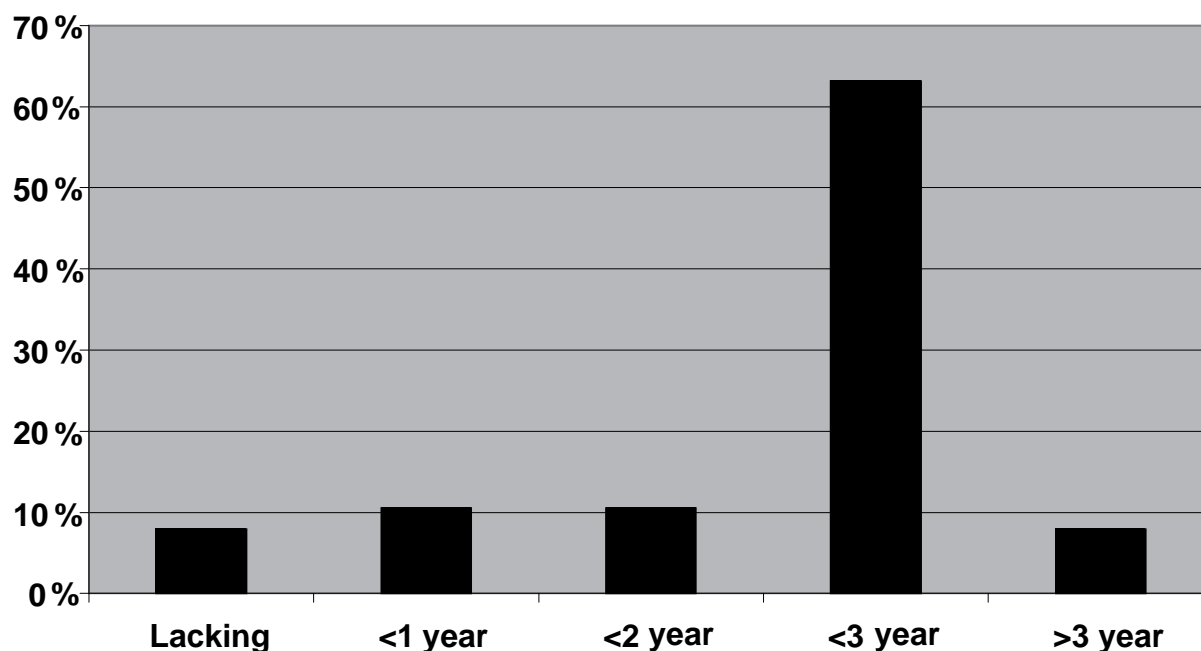


Figure 5. Pay-off criteria applied at the studied mills.

the energy issue had increased during the past 10 years within the studied industry, and not least since 2000. However, even though this is the case, overall results from the questionnaire show that potential still exists to improve energy management in the studied industry. One such result is derived from the fact that one third of the studied mills do not allocate energy costs by means of sub-metering. Instead, other means like allocating per square metre etc are applied, most likely contributing to reinforce certain barriers to energy efficiency, for example

split incentives. Another result is that 20 percent of the studied mills lack a long-term energy strategy, and less than half of the studied mills have an energy strategy of at least five years. These results are striking. Even in one of the most energy intensive industries in the world, energy management seems not to be a highly prioritised issue for a considerable part of the industrial population. Notably, the Swedish EMS standard lacks such a component in its design (SEA, 2009) indicating the need for further studies regarding a plausible inclusion. This fact should



be of utmost importance both for the industry organisation as well as for policy makers designing future energy policies for the industry.

As regards the studied mill's pay-off criteria, the majority of the mills applying periods of 3 years, from which the conclusion may be drawn that the principal-agent relationship barrier leading to strict monitoring and control of the implementation of energy efficiency measures seems to be of less importance in the studied industry.

LTAs (Long-Term Agreements) in various forms have been stated to be a very promising policy approach (Bertoldi, 2001). The Swedish LTA, called PFE, involves some 100 companies (Ottooson and Peterson 2007), including the majority of the Swedish pulp and paper industries. In fact, the industry represents about 70 percent of the energy use among the companies involved in the PFE. However, the Swedish LTA only concerns electricity and the majority of the savings in the Swedish pulp and paper industry lie in areas other than electricity, mainly related to heat savings. Based on this, a restructuring of the Swedish PFE programme to involve other energy carriers and also provide tax exemptions on these energy carriers is suggested. It is also suggested that PFE include a mandatory requirement to formulate a long-term energy strategy. The acceptance of such would most likely be high as previous research has found that the existence of a long-term energy strategy was the third high-ranked factor promoting energy efficiency investments (Thollander and Ottooson 2008). Moreover, the Swedish PFE was considered the sixth<sup>1</sup> largest driving force for energy efficiency in the Swedish pulp and paper industry among the 23 studied driving forces (Thollander and Ottooson 2008). In conclusion, based on the research results presented in this paper, a different energy policy design for the industry seems to be needed in order to promote energy management activities even further. LTAs and EMSs are very fruitful approaches to increased energy efficiency in industry but results from this study nevertheless indicate further improvement potential in the formulation of these instruments, such as increased promotion of energy management practices and the inclusion of other energy carriers in addition to electricity.

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1. As regards the other high-ranked driving forces for energy efficiency identified in Thollander and Ottooson (2008), these were, presented from one to five: cost reductions resulting from lower energy use, people with real ambition, long-term energy strategy, the threat of rising energy prices, and the electricity certificate system.

## References

- Bertoldi, P., 2001, Effective policies and measures in energy efficiency in end-use equipment and industrial processes. In the 2001 Workshop on Good Practices in Policies and Measures.
- CADDET, 1995, Learning from experiences with energy management in industry, Sittard, Den Haag, the Netherlands.
- de Groot, H., Verhoef, E., Nijkamp, P., 2001, Energy saving by firms: decision-making, barriers and policies, *Energy Economics* 23 (6): 717-740.
- EEC (Energy Efficiency Committee), 2008, Vägen till ett energieffektivare Sverige [The road to a more energy efficient Sweden]. SOU 2008:110. Stockholm.
- Eurostat, 2007, Final energy consumption, by sector. Retrieved October 25, 2007, from the Eurostat's Web site: [http://epp.eurostat.ec.europa.eu/portal/page?\\_pageid=1996,39140985&\\_dad=portal&\\_schema=PORTAL&screen=detailref&language=en&product=sdi\\_cc&root=sdi\\_cc/sdi\\_cc/sdi\\_cc\\_ene/sdi\\_cc2200](http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,39140985&_dad=portal&_schema=PORTAL&screen=detailref&language=en&product=sdi_cc&root=sdi_cc/sdi_cc/sdi_cc_ene/sdi_cc2200).
- Hietaniemi, J., Ahtila, P., 2007, Energy conservation agreements within Finnish pulp and paper industry – methods and results, Retrieved October 8, 2007, from the Motiva's Web site: <http://www.motiva.fi/attachment/f16d4d543f99d7a59f54560a69063a0e/dcda18330aa306eb83d12fd3b6e09cbd/PP2004-teksti.pdf>
- IPCC, 2007, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers. Retrieved October 8, 2007, from: <http://www.ipcc.ch/SPM040507.pdf>
- Jaffe, A.B., Stavins, R.N., 1994, The energy efficiency gap: what does it mean? *Energy Policy* 22 (10): 60-71.
- Johansson, B., Modig, G., Nilsson, L.J., 2007, Policy instruments and industrial responses - experiences from Sweden. In: Proceedings of the 2007 eceee summer study "Saving energy - just do it", Panel 7, 1413-1421.
- Mintzberg, H. (1987). The Strategy Concept II: Another Look at Why Organizations Need Strategies. *California Management Review*, 30, 25-32.
- Nilsson, L., Larson, E., Gilbreath, K., Gupta, A., 1996, Energy efficiency and the pulp and paper industry, Report Energy Efficiency number IE962. Washington, DC: American Council for an Energy-Efficient Economy.
- NordPool, 2008. The homepage of the Nordic Power Exchange. Retrieved August 27, 2008, from: <http://www.nordpool.no>
- Ottooson, C., Peterson, K., 2007, First results from the Swedish LTA programme for energy efficiency in industry. Paper presented at the 2007 European Council for an Energy-Efficient Economy (ECEEE) summer study "Saving energy - just do it", Panel 7, 1517-1525.
- Rohdin, P., Thollander, P., 2006, Barriers to and Driving Forces for Energy Efficiency in the Non-energy Intensive Manufacturing Industry in Sweden. *Energy* 31 (12): 1836-1844.
- Rohdin, P., Thollander, P., Solding, P., 2007, Barriers to and drivers for energy efficiency in the Swedish foundry industry. *Energy Policy* 35 (1): 672-677.

- SCB, 2006. SCB's statistical database, statistikdatabas, Retrieved October 8, 2007, from the SCB's Web site: [www.scb.se](http://www.scb.se).
- SEA (Swedish Energy Agency), 2000, *Energianvändning inom industrin* [Energy use within the industry]. Swedish Energy Agency Publication Department, Eskilstuna. [in Swedish].
- SEA, (Swedish Energy Agency), 2006, *Energy in Sweden 2006*. Swedish Energy Agency Publication Department, Eskilstuna.
- SEA (Swedish Energy Agency), 2007, *Energy in Sweden 2007*. Swedish Energy Agency Publication Department, Eskilstuna.
- SEA (Swedish Energy Agency), 2008, *Energy in Sweden 2007*. Swedish Energy Agency Publication Department, Eskilstuna.
- SEA (Swedish Energy Agency), 2009. Personal communication with Karolina Petersson (2009-02-24), Executive officer for the Swedish PFE (Programme for Improving Energy Efficiency in Energy-Intensive Industries).
- Swedish Energy Agency, *Energy in Sweden 2007*. Swedish Energy Agency Publication Department, Eskilstuna.
- SFI (Swedish Forest Industries) 2005, *Energiförbrukning i massa- och pappersindustrin 2000* [Energy use in the pulp and paper industry 2000], Retrieved October 8, 2007, from the Swedish Forest Industries' Web site: <http://www.skogsindustrierna.se/LitiumDokument20/GetDocument.asp?archive=3&directory=27&document=257> [in Swedish].
- SFI (Swedish Forest Industries) 2007, Retrieved October 8, 2007, from the Swedish Forest Industries' Web site: <http://www.skogsindustrierna.se/LitiumInformation/site/page.asp?Page=10&IncPage=626&IncPage2=232 &Destination=227&destination2=226&ohKatID=5&ohID=13&lang=sv>
- Sorrell, S., Schleich, J., Scott, S., O'Malley, E., Trace, F., Boede, E., Ostertag, K. Radgen, P., 2000, *Reducing Barriers to Energy Efficiency in Public and Private Organizations*. Retrieved October 8, 2007, from the SPRU's (Science and Technology Policy Research) Retrieved October 8, 2007, from: <http://www.sussex.ac.uk/Units/spru/publications/reports/barriers/final.html>
- Thollander, P, Karlsson, M, Söderström, M, Creutz, D., 2005, *Reducing industrial energy costs through energy efficiency measures in a liberalized European electricity market - case study of a Swedish iron foundry*. *Applied Energy* 81 (2):115–26.
- Thollander, P., Ottosson, M., 2008, *An energy efficient Swedish pulp and paper industry – exploring barriers to and driving forces for cost-effective energy efficiency investments*. *Energy Efficiency* 1 (1): 21-34.
- Thollander, P., 2008. *Drivkrafter för energieffektivisering i svensk gjuteriindustri* [Driving forces for energy efficiency in the Swedish industry]. Swedish Foundry Association, Jönköping. [in Swedish].
- Velthuisen, J., W., 1995, *Determinants of investments in energy conservation*, Dissertation, Rijksuniversiteit.
- Wising, U., Berntsson, T., Stuart, P., 2005, *The potential for energy savings when reducing the water consumption in a Kraft Pulp Mill*, *Applied Thermal Engineering* 25 (77): 1057-1066.
- Yin, R.K., 1994, *Case Study Research: Design and Method*, *Applied Social Research Methods*, vol. 5. Sage, London.