First results from the Swedish LTA programme for energy efficiency in industry

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Keywords
energy efficiency, voluntary programme, long term agreement, energy intensive industries, energy tax, electricity, energy management systems, energy audits, measures

Abstract
The majority of the energy intensive industries in Sweden, more than 250 production sites, are currently increasing their energy efficiency with around 800 GWh annually- and this on electricity alone! This is realised by standardised energy management systems and extensive energy audits identifying measures to increase the over-all energy efficiency. All efforts are coordinated through the Swedish LTA programme for energy efficiency for energy intensive industries (PFE) launched by the Swedish government in January 2005 and implemented and operated by the Swedish Energy Agency.

The PFE-Programme for Energy Efficiency gives energy-intensive companies the opportunity to obtain tax exemption on electricity, in line with the EU Tax Directive. In return the companies commit themselves to several actions in order to improve their energy efficiency.

The programme runs for five years. During the first two years an energy audit is done to identify measures to improve the energy efficiency. The company also implements a standardised energy management system (EMS), together with routines for purchasing, planning and renovating. During the following three years of the programme, the identified energy efficiency measures should be realised.

Participating industries are: pulp and paper, wood product, chemical, food and beverages, steel, iron and metallurgy, ore and mining and some other manufacturing industries. In total these companies are using approximately 30 TWh electricity per year, which is about 20 % of the total electricity use in Sweden.

The mid-term reports from the participating companies were received during autumn 2006. The first results and preliminary figures reported were very promising. The paper will present the results from the mid-term reports together with lessons learned from the use of this mechanism.

Introduction
The programme for energy efficiency in energy intensive industries (PFE) was introduced in January 2005 by the Swedish Energy Agency as a voluntary energy efficiency programme. PFE is an economic policy instrument directed to energy-intensive industrial companies in Sweden. The background of the programme is the EU directive leading to a new tax on electric power beginning on 1 July 2004. The new energy tax of 0,5 euro/MWh affected Swedish industrial companies, with the exception of certain manufacturing processes. PFE is a way of compensating for this tax. Companies who join the programme are eligible for a tax reduction during the five year programme, provided that they work systematically with energy issues and carry out energy saving measures in their own companies. An energy audit forms the basis for the measures the company will take and is also an important prerequisite for the introduction of a standardised energy management system (EMS). The energy management system must be certified within the first two years of the programme. In addition to the management system, the companies must implement and follow specific routines for planning and purchasing high-consumption electrical equipment, based on LCC-methodology. Within the remaining three years of the programme, the company must carry out its

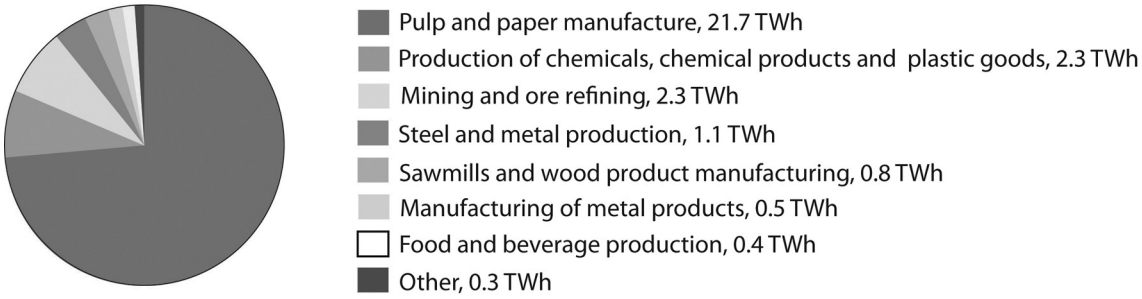

Figure 1. Use of electricity by industry

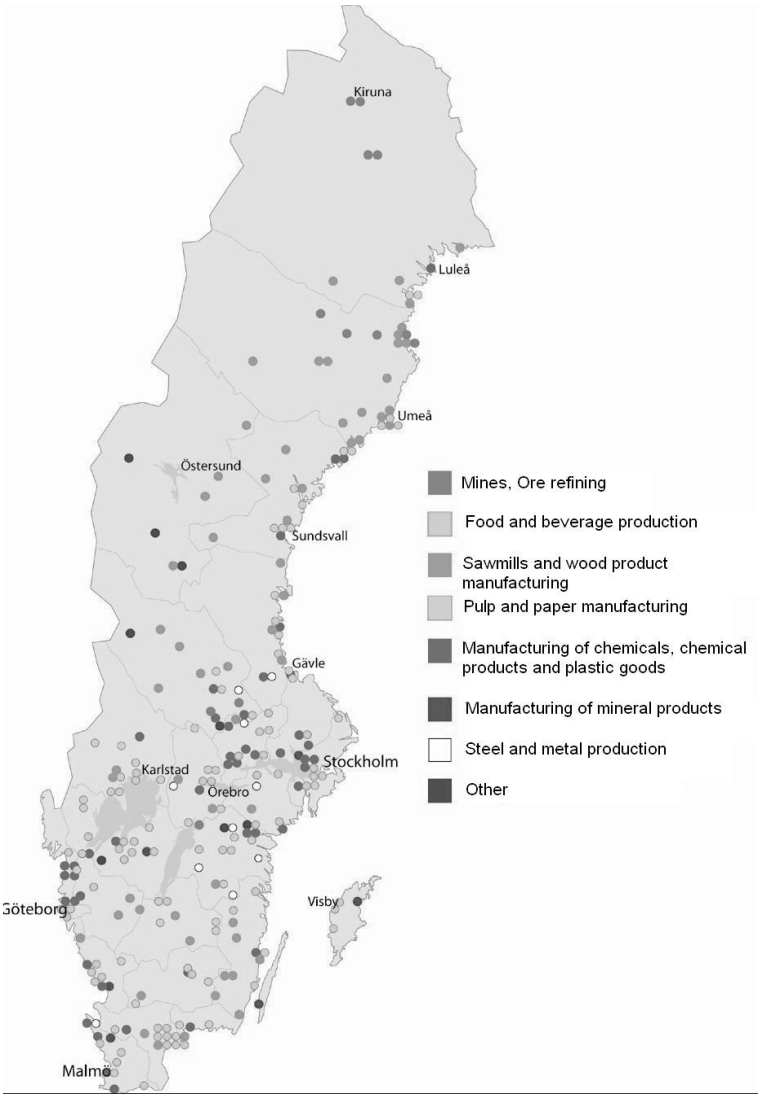

Figure 2. Geographical distribution of participating plants and their trade

planned measures and continuously improve the energy management system. Companies can apply to join the programme at any time during a calendar year.

In this paper, the PFE-programme and the participating companies will be presented. During the autumn 2006, the majority of the companies have presented a first report on their improvements in the energy efficiency field. The results look very promising. The companies have thoroughly gone through their use of electricity, fuels and heat and found a lot of interesting measures for energy efficiency.

Participating industries

Currently 117 companies are participating in the programme using more than 30 TWh of electricity annually, which is about 20 % of the total electricity use in Sweden. Participating industries are: pulp and paper, wood product, chemical, food and beverages, steel, iron and metallurgy, ore and mining and some other manufacturing industries. Almost 22 TWh of electricity are used by the pulp- and paper industry as shown in *Figure 1*.

The pulp- and paper industry is also the best represented trade in the PFE programme with 43 companies participating. Many of the companies participating in PFE have several plants. A total of 250 plants are taking part in the programme. The map (*Figure 2*) shows where in Sweden the plants are located and to which industry they belong.

ELIGIBILITY CRITERIA FOR JOINING PFE

Companies joining PFE must:

- Be engaged in the manufacturing industry, Industrial Classification 10-37
- Use electricity in their manufacturing processes
- Be energy-intensive (i.e. energy costs of at least 3 % of the production value, and/or paying energy-, carbon dioxide and sulphur taxes of at least 0,5 % of the value added).
- Have the economic means for carrying out the programme.

THE LARGEST ELECTRICITY CONSUMERS PARTICIPATE IN PFE

In total, the companies in the programme consume 31,5 TWh of electricity per year (including both purchased and self-produced electricity). This is more than a fifth of total Swedish

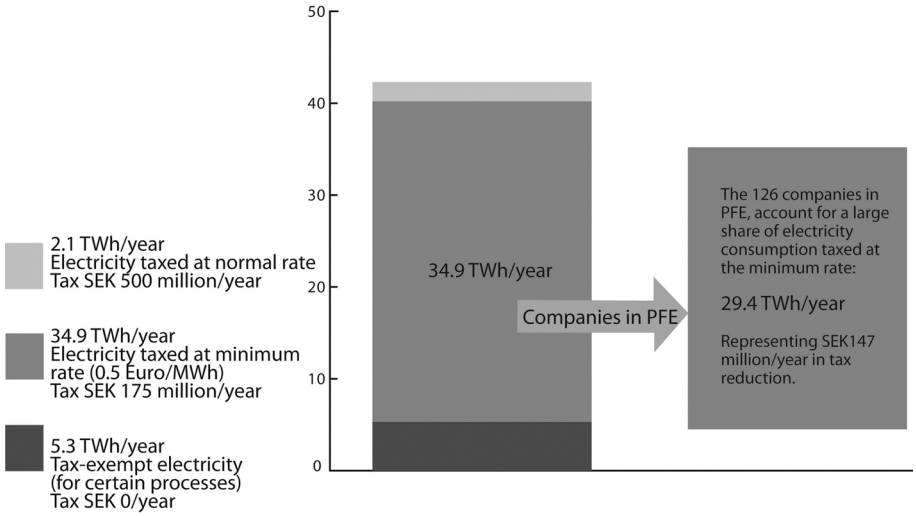

Figure 3: Total target group electricity consumption and result. The left bar shows the total electricity consumption of the target group, i.e. the 1 150-1 300 companies qualified to join PFE, according to Sweden Statistics. These companies pay electricity tax at up to three different rates, depending on where in the company the electricity is consumed. Electricity taxed at normal rates is used in offices, etc. Electricity taxed at the minimum rate is used in most manufacturing processes, and it is this tax, 0,5 euro/MWh, that companies can reduce to 0 euro/MWh by joining PFE. Completely tax-exempt electricity is used in processes exempt from electricity tax, i.e. chemical reduction and electrolytical, metallurgical and mineralogical processes. The right bar shows the minimum taxed electricity consumption of the companies in PFE. The target group's total consumption amounts to 84 percent of the electricity – 34,9 TWh – that could be made tax-exempt by joining PFE.

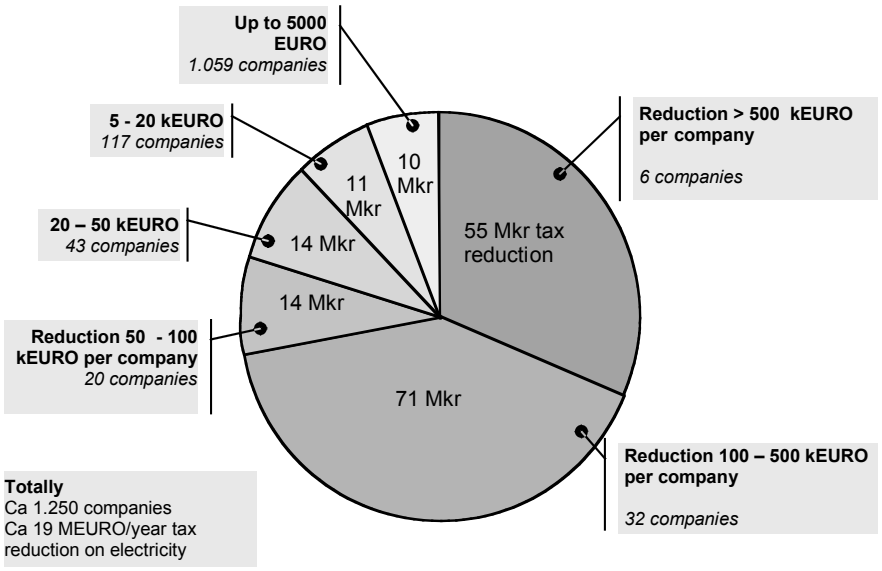

Figure 4: Result of target group analysis. 1 150-1 330 companies fulfil the eligibility criteria and are qualified to join PFE. However, most of these save less than 5 000 euro per year on electricity tax reductions

consumption, and more than half of the industrial sector consumption. Of the 31,5 TWh, 29,4 TWh is taxed at 0,5 euro/MWh. The companies participating in PFE are exempt from this tax, provided they meet the programme requirements. The tax reduction of these companies totals euro 19 million per year (based on the consumption during the base year indicated), *Figure 3*.

TARGET GROUP ANALYSIS

According to a target group analysis by the Swedish Energy Agency, based on data from Statistics Sweden (2002), 1 150-1 330 companies fulfil the eligibility criteria and are qualified to join PFE. However, most of these save less than 5 000 euro per year on electricity tax reductions. As joining PFE also entails certain additional costs, such as EMS certification, the Energy Agency estimated that around 100 companies would consider it profitable enough to join the programme. All companies qualified according to the analysis, would probably save even more money by systematically improving energy efficiency than on the tax reduction itself, and this is something that companies not participating in PFE can do as well. *(Figure 4)*

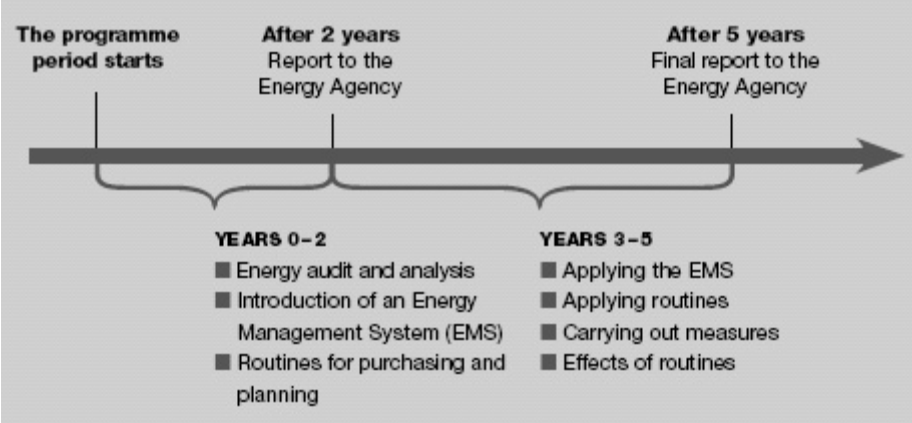

Figure 5: Time chart describing the five year programme period

PFE programme – basic requirements

The time chart in *Figure 5* shows how a company must work to improve energy efficiency during the five-year programme period. An energy audit forms the basis for the measures the company will take and is also an important prerequisite for the introduction of a standardised energy management system (EMS). The system must be certified within the first two years. Within the remaining three years, the company must carry out its planned measures and follow its routines for planning and purchasing high-consumption electrical equipment. Companies can apply to join at any time during a calendar year.

AUDITS WILL LEAD TO ENERGY SAVING MEASURES

During the first two years of the programme, companies taking part must perform a thorough audit and analysis of their total energy consumption. The main objective, for participating companies, is to find measures that can improve energy efficiency and to start using more environmentally adapted, renewable forms of energy. In addition to what the standard for energy management systems dictates regarding audit and analysis, companies joining PFE must also carefully audit and analyse their energy consumption with focus on electricity. The audit and analysis must:

- Be carried out while maintaining a systems perspective, which means companies have to determine how all or parts of manufacturing processes and auxiliary systems can co-operate to obtain energy efficiency.
- Take both long and short term effects into account, which means companies have to analyse which changes can have an impact on energy consumption in the course of a ten year period. Both the long- and short term analyses will then be considered when decisions are taken, regarding energy use.
- Result in electricity saving measures. Companies should implement measures that have a payback period of less than three years, within the programme period.
- The companies also define key performance indicators for their energy use, e.g. specific electricity use per production output.

STANDARDIZED MANAGEMENT SYSTEM

The purpose of PFE is to help companies improve their energy efficiency. One of the prerequisites for participating is to implement a standardised energy management system (EMS). Energy management makes it easier for companies to work consistently and systematically with energy matters to achieve increased energy efficiency, reduced energy costs and improved control of energy consumption. A standardised EMS shows how a company can constantly streamline its energy consumption, and increase its share of renewable energy as well as its energy exchange with the surrounding municipality. Energy consumption and thus costs can decrease through:

- Increased knowledge of where and how energy is consumed
- Monitoring of how energy consumption changes over time
- Decisions to implement measures that improve energy efficiency

In 2003, the Swedish standard for energy management systems SS 62 77 50 was introduced. This standard is used by the majority of the PFE-companies. Denmark and Ireland have similar standards for energy management. The European standardisation body CEN is currently developing a European standard. Sweden is hosting the project secretariat for this EMS task force, named CEN/CLC TF 189.

The energy management system at a PFE-company must be certified by an accredited certification body. As of the end of 2005, seven certification bodies had applied for accreditation at the Swedish national accreditation body, SWEDAC. One of these bodies obtained its accreditation in connection with the first certification of a PFE-company, mining company LKAB, in June 2005.

SPECIAL ROUTINES FOR PFE-COMPANIES

Besides introducing a standardised energy management system, the companies joining PFE are also required to implement and follow specific routines when purchasing high-consumption electrical equipment. When purchasing high-consumption electrical equipment (more than 30 MWh per year), companies have to choose the highest energy efficiency class. Alternatively, they can calculate the life cycle cost (LCC) of the equipment and compare it with the cost of conventional equipment. If

the surplus cost for an energy efficient solution will be paid-off within three years, the company must choose it over the conventional one.

REPORTING – MONITORING

The Swedish Energy Agency is the supervisory authority for the programme and issues directives and information. The participating companies have to report their activities to the administrative body, in this case the Swedish Energy Agency, twice during the programme period. The reporting is made in an electronic system, built for this purpose. This facilitates the monitoring of the programme by an easy way of dealing with the reports, both for the companies and the authorities. During the period between the reports after 2 and 5 years, the companies can be subject to supervision.

Other participants, too, perform important functions to make PFE work. The cooperation between the industries and authorities is of key importance in the development of PFE. The companies contain the knowledge of what opportunities they have for improving energy efficiency, while PFE provides the framework for this work.

On 1 April 2005, a programme council was set up, consisting of representatives from trade associations, responsible authorities and companies in the energy, pulp and paper, forest, mining, steel wood and chemical industries. The council meets four times per year to discuss issues that come up as PFE progresses, such as possible changes in directives issued by the Energy Agency. The council should help to improve the programme by representing the interests of the various industries.

The role of the Tax Agency is to manage the tax exemption. Companies submit their tax exemption applications here. If requirements are not met, the Tax Agency can revoke its decision.

Results so far

For the companies joining the programme from the beginning, the first reporting back to the Swedish Energy Agency was due 1 July – 30 September 2006. This resulted in 98 companies, around 250 plants, reporting back to the Swedish Energy Agency during this period.

ENERGY AUDIT

98 of the participating companies have performed energy audits and analyses so far. A number of the companies have hired external expertise to perform the audits, i.e. consultants or ESCOs. The audits are based on energy mappings and energy balances and should also contain information about essential variations in the energy use, connections between production processes and supporting systems, assessment related to considerable changes in the use of energy in a short- and long time view in consequence of planned or expected changes in the production. Both electricity, fuels and heat should be considered.

The summarised balances over the electricity purchased, produced and sold within the companies are shown in *Table 1*. The companies also use a number of other energy products. Combined about 16,7 TWh of fossil fuels and 58,7 TWh renewable fuels.

ENERGY MEASURES

Electricity

Almost 900 measures for more efficient use of electricity have been reported to the Swedish Energy Agency so far. In total the companies will reduce their annual use of electricity with around 765 GWh (at the same level of production). This means an increased electricity efficiency of 2,5 %, and about 0,5 % of the total use of electricity in Sweden. These measures mainly focus on reduced use of electricity, but they also contribute to a decreased use of other energy products (e.g. fuels or heat) with around 43 GWh/year! Hence, the total reduction of energy due to these measures is 808 GWh/year. 34 % of the measures reported were known before the energy audits were made and 54 % was found through the audits. 12 % of the measures were identified through other activities. Increased production of electricity has also been reported, but these measures are not included in the main results. Many other measures besides on

Table 1: Electricity balance

Purchased (MWh)	Produced internally (MWh)	Sold (MWh)	Used (MWh)	Net supplied (MWh)
26 437 128	4 953 609	238 685	31 182 054	26 228 442

Table 2: Summarized results of measures on electricity so far

Total number of measures	872 measures
Total annual reduction in use of electricity	765 425 MWh
Increased efficiency in use of electricity in percentage	2,5 %
Annual additional reduction on other energy sources	42 723 MWh
Total annual reduction in use of energy	808 148 MWh
Total investment cost at companies	1 304 892 505 SEK (ca 140 311 022 euro)

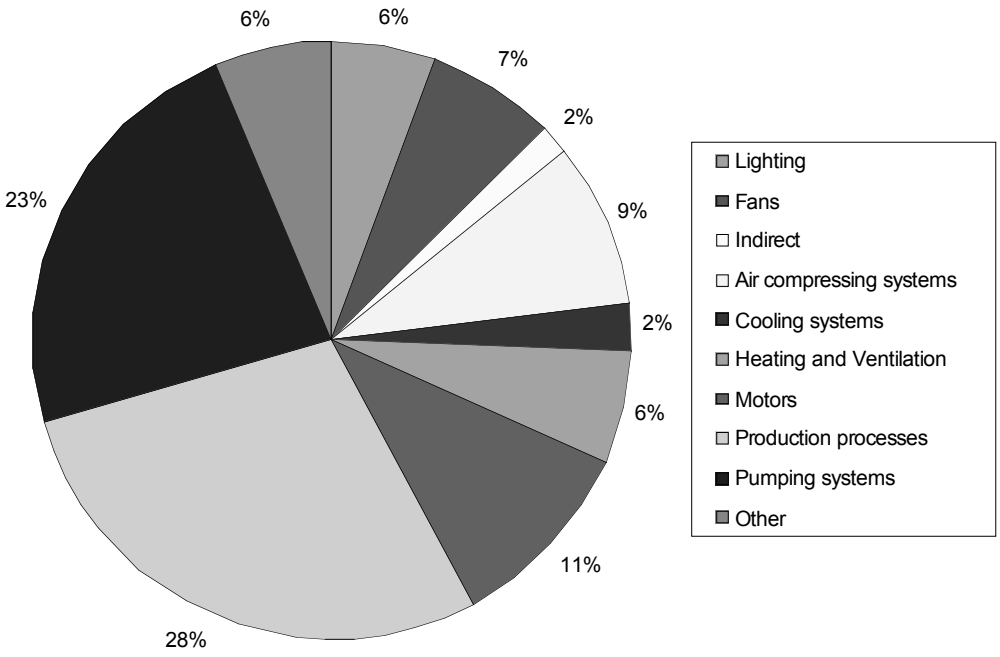

Figure 6: Number of measures in different categories in percent

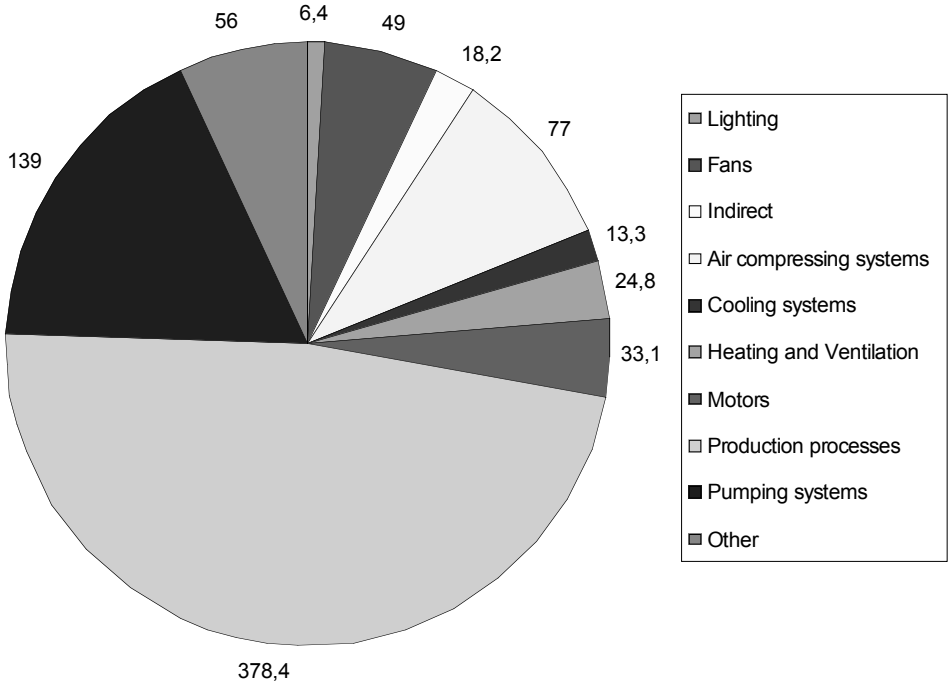

Figure 7: Reduction of electricity in different categories in GWh

the electricity have also been reported for example increased delivery of district heating, conversion from the use of fossil fuels to renewable energy sources, reduced need for heating and so on. Many of these measures have also been found due to the energy audits and analyses made within the PFE programme.

As seen in *Table 2*, the companies will invest around 140 million euro in the measures increasing the electricity efficiency. This should be compared to the savings due to the tax exemption, which is about 16 million euro. If calculating with an average electricity price the companies will also save around 43 million euro in decreased energy costs. Hence, the measures found from the energy audits have been shown to largely exceed the tax exemption in savings for the companies.

The measures can be categorised into several groups of equipment or processes, as seen in *Figure 6*. Among the measures, around 28 % are within the production processes and 72 % are

within the surrounding systems, such as pumps, fans, air compressing systems, lighting and ventilation.

A large part, 23 %, of the measures can be found in the category pumping systems. Pump measures often involves installation of steering- and control systems. In some cases, the measures are very simple and inexpensive, e.g. when the energy audit has shown that some pumps are too big for their purpose or even unnecessary. The measures in these cases are quite simply to replace the pumps with smaller units or to remove them. These measures have usually a very short pay-back time, often less than a year.

The fact that so many energy efficiency measures are on pumping systems can be explained by the fact that the largest number of participating companies in PFE are within the pulp- and paper sector with a huge amount of pumps installed. 90 % of the pump measures are reported by pulp- and paper companies.

Measures in fans and other motor driven systems are also mostly about installation of inverters.

Air compressing systems, vacuum systems and compressors represents the fourth biggest sectors when counting numbers of measures reported. The measures often involves leakage seeking, and sealing, which in many cases also have the effect that some compressing equipments becomes redundant and can be removed. Measures can also be about a better usage of waste heat from compressors.

In lighting, the measures concern demand control in order to reduce unnecessary lightning or changes into more energy efficient equipments.

As mentioned before, 28 % of the measures are within the production processes. In this field it is a bit harder to summarise the measures to general activities that will be made. Many of the measures are however about regulating and optimizing process flows and reducing operational disturbances.

If the measures instead are distributed in a diagram showing how much each measure category contributes to electricity efficiency, the diagram has a slightly different look. The measures within the category "production processes" the represents 48 % of the electricity reduced. *(Figure 7)*

FUELS AND HEAT

Due to PFE being a programme leading to tax reduction on electricity, the participating companies have been focusing on electricity reduction when auditing and reporting energy measures. However, as described above, the electricity efficiency measures have in some cases lead to reduced use of heat and/or fuels as well! Measures that simply exchange the use of electricity to other (fossil) energy are not accepted in the programme, e.g. converting from electricity to oil operated equipment.

Though, as a result of the energy audit including also fuels and heat, the majority of the companies have also found interesting measures for more efficient use of fuels and heat, e.g. better use of waste heat.

ENERGY MANAGEMENT SYSTEMS, EMS

The certifying bodies have certified the energy management systems, in most cases also including the routines for purchasing high-consumption electrical equipment and planning. All of the participating companies so far have succeeded in the implementation of their energy management systems.

Some of the companies had already certified Environmental Management systems, which simplified the implementation considerably. In these cases both systems have often been merged together.

Nor the results from using the EMS neither the routines have yet been estimated, but the effects are expected to be considerable.

Several positive effects of PFE

PFE was created in a period of rising electricity prices in Sweden, and at a time when the energy issue had become an increasingly inherent part of environmental thinking. For competitive and environmental reasons, industrial companies have showed interest in new ways of working that can affect energy consumption and costs.

PFE REDUCES ENERGY COSTS

As described before, companies who join PFE are exempted from electricity tax in their manufacturing processes. In addition, companies further reduce their expenses, because the programme's requirements regarding energy audits and management systems provide good opportunities to identify and carry out measures that improve the energy efficiency.

PFE CONTRIBUTES TO INCREASED COMPETENCE

Joining PFE is a strategic decision that company managements should make. More persons in companies become involved with energy issues as a result of implementing an EMS. All personnel who can affect the company's energy consumption must be identified and educated in how energy can be used more efficiently. All company functions, including operating and maintenance staff, buyers, co-ordinators for environmental and quality matters, project leaders and managers should be involved in the work.

In addition to increased energy competence, most companies also learn a lot about their production processes and their organisations as a whole when doing the energy audit and implementing the energy management system. This can sometimes lead to better production capability and quality, better work environment and other positive side-effects.

PFE HELPS TO SAVE THE ENVIRONMENT

For companies, PFE means increased awareness and expertise regarding effective and sustainable energy use. The required energy audits and EMS provide companies with tools for structured energy efficiency improvement efforts. At the same time, the EMS requires companies to identify measures leading to improved energy efficiency, decreased use of fossil fuels and increased energy exchange with surrounding society. The requirements on routines for purchasing high-consumption electrical equipment and planning, in turn, lead to a greater demand for energy efficient equipment. PFE decreases environmental impact as participating companies learn to use electricity more efficiently. As a rule, they should achieve this without increasing their consumption of other (fossil) fuels. Quantifying environmental benefit is not so simple. The environmental impact of electricity consumption is in some

dispute and depends on what the system boundaries are and on variations over time (such as time of day and year), among other things. Below is a calculation example: Together, the companies in PFE use about 30 TWh of electricity per year. Consequently, each saved percentage unit corresponds to 0,3 TWh/year. The decrease in electricity consumption means a decrease of the marginal electricity in the system. Supposing the marginal electricity is produced from coal or, in a few years' time, from natural gas, a decrease in electricity consumption also means a decrease in carbon dioxide emissions – 1 MWh of coal produced electricity corresponds to 820 kg and 1 MWh of natural gas produced electricity to 350 kg of CO_2 emissions. Based on the marginal electricity example, an average electricity efficiency improvement of one percent for the companies in the programme would amount to a total decrease of 100 000-250 000 metric tons in CO_2 emissions per year.

ENERGY MANAGEMENT SYSTEM FACILITATES FOR COMPANIES TO FULFIL REQUIREMENTS OF THE EU EMISSIONS TRADING SYSTEM

Joining PFE gives companies increased knowledge of improving energy efficiency and using non-fossil energy forms. PFE's requirement of energy management system (EMS) improves companies' chances of controlling their carbon dioxide emissions. This means that companies participating in PFE are able to operate more efficiently within the framework of the Emissions Trading System. The EMS requirement also improves companies' chances of defining responsibility, authority and routines for dealing with energy issues. One example is monitoring and documenting of emissions, which makes it easier for companies to comply with the rules of the Emissions Trading System.

PFE CONTRIBUTES TO BETTER FULFILMENT OF THE SWEDISH ENVIRONMENTAL CODE

Introducing an energy management system and carrying out energy analyses can help companies achieve the level of knowledge that they must have according to the Swedish Environmental Code:

- "Persons who are engaged in an enterprise or who take a measure or intend to do so must possess the knowledge that is necessary in view of the nature and scope of the activity or measure to protect human health and the environment against damage or detriment."[1]
- "Persons who are engaged in an enterprise or who take a measure shall conserve raw materials and energy... Preference shall be given to renewable energy sources."2

PFE STRENGTHEN COOPERATION BETWEEN COMPANIES AND AUTHORITIES/THE GOVERNMENT

During the first two years of the PFE, the Swedish Energy Agency has arranged a number of conferences and seminars for the participating companies. Topics that have been discussed are for example best practice in the energy efficiency area, implementation of energy management systems, life cycle cost methodology (LCC), etcetera. Most of the PFE-companies have participated in these activities. This has strengthened the cooperation and created better understanding between industry and authorities. Informal and formal networks between companies has also been created due to the PFE, both regionally and industry-vice.

Lessons Learned & Discussion

Out of the about 1200 companies that are eligible to join the PFE programme, only 117, about 10 % have chosen to do so. The main conclusion is that the tax exemption does not seem to be a big enough incentive for many of the energy intensive companies to join the PFE programme. However, as is has shown from the participating companies, the tax exemption is not the only way to save money. The implementation of the management system and the measures found from the energy audits have been shown to exceed the tax exemption in savings for the companies.

One of the main results of PFE is that the energy issues have gotten a higher status in the companies nowadays, according to many participants. Due to the fact that PFE involves tax money, energy issues have become a management task, which has shown to be a big part of success for many companies.

The methodology of the PFE programme have also shown to be useful for many of the companies. Start with an energy audit and analysis, implement an energy management system and routines. Then find measures and realise these. Follow the routines when purchasing high-consumption electrical equipment. Continuously improve the energy management system. The deadlines involved in the programme make sure that things are being done.

As discussed above, PFE has shown to have several positive effects in addition to tax reduction and energy efficiency. Within companies this can be for example increased knowledge of energy use, production processes and organisational issues and better preparation for requirements deriving from the Environmental Code and EU ETS. On the negative side, one can note that the PFE constitute yet another policy instruments for this group of companies, which already have a quite heavy administrative load due to the EU ETS, the Swedish Green Certificate System and other energy and environmentally based legislation.

There are also lessons to be learned for the authorities responsible for this type of programmes. When implementing programmes focusing mostly on one energy product, in this case electricity, it is important to keep the system perspective in mind. To convert from electricity to oil burning for example would decrease the use of electricity for sure. It would also increase the CO_2 emissions, which is of course undesirable. No such measures have been approved within the PFE programme.

Unlike "command and control" based regulations, the PFE has a more marked based approach. The participating companies perform their own energy audit (within certain general requirements) and are free to choose the measures that are most suitable for their unique type of production (again,

1. Chapter 2, Section 2, the Swedish Environmental Code, General rules of consideration

2. Chapter 2, Section 6, , the Swedish Environmental Code, General rules of consideration

within certain limits). This approach has been very appreciated by participating companies.

Some companies have however had difficulties in deciding which measures can be realised more than one year ahead, due to investment budgets being set one year at a time. In one part of the PFE-regulation, it is stated that the company have to ensure that measures that are reported back to the Swedish Energy Agency are actually realised within the five year programme. According to many companies, the audits have envisaged more measures than reported, but due to this specific part of the PFE-regulation, the companies have decided not to report all their measures. This however indicated that when the companies make their final report to the Swedish Energy Agency (after five years) even more measures will have been be carried out, leading to an even better result.

The administrative burden for the administrative bodies increases with the number of companies that join. An electronic system has been very useful but one should calculate the cost of the systems per participating company. The administrative burden for companies subjected to several policy instruments is also high as mentioned above.

All in all, PFE has proven to be a successful programme for energy efficiency in industries. During 2007, the Swedish Energy Agency will follow up the reported quantitative results with a qualitative investigation and analysis. Companies, industry organisations, politicians and other spokesmen of energy efficiency have expressed wishes to enlarge the programme in order to make it possible for more companies to join.

References

Swedish law for the Program for energy efficiency in energy intensive industries (2004:1196)

Swedish Directive on the program for energy efficiency (STEMFS 2004:7)

EU Directive on energy taxes (2003/96/EG)

Swedish Standard for Energy Management System (SS627750)

The Swedish Environmental Code (1998:808)