# A Swedish success story: How to get astonishing results in energy efficiency due to implementation of a long term agreement with energy intensive industry

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## Abstract

The Swedish long term agreement (LTA) for energy efficiency for energy intensive industries (PFE) gives energy-intensive companies the opportunity to obtain tax exemption on electricity use, in line with the EU Tax Directive. In return the companies commit themselves to several actions in order to improve their energy efficiency. More than 100 companies from e.g. pulp and paper industry, wood product, chemical, food and beverages, steel, iron and metallurgy, ore and mining joined the programme in 2004-2005. During the autumn 2009, these companies presented their final reports on their energy efficiency improvements. The companies have thoroughly gone through their use of electricity, fuels and heat, and found and carried out measures for energy efficiency. The reported results and figures were above all expectations – about three times more electricity than expected had been saved. The major success factors have been the systematic work outlined by the Energy Management System, starting from the thorough energy review, as well as the enhanced status of the energy efficiency issue and the network meetings among the participants.

During the five year programme, the companies have increased their energy efficiency by 1.45 TWh – and this on electricity alone! Furthermore the participants have:

- invested 708 MSEK (appr. 70 Million Euro) in more than 1,200 electricity efficiency measures,
- carried out more than 350 other measures in order to increase their energy performance, e.g. converted energy use from fossils to renewables, increased production of electricity (appr. 1 TWh) and increased delivery of surplus heat to external parties,
- implemented and certified standardized energy management systems.

This paper will present the PFE-programme and the participating companies as well as the results from the final reports together with lessons learned from the use of this policy program.

## Introduction

More than 100 of Sweden's most energy intensive industries, with 240 separate production sites, have participated in the first five year programme period of the Programme for energy for energy efficiency (PFE). The overall objective of the programme is that participating companies increase their knowledge of energy use and improve energy efficiency. Participating companies get a tax reduction on electricity (€0.5/MWh) if they in return improve their energy efficiency and use a number of energy management tools. The construction of the programme therefore offers two possible ways for companies to save money: the tax reduction *and* reduced energy costs.

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 use approximately 30 TWh electricity annu-

ally, which is about 20 % of the total electricity use in Sweden and more than half of the consumption in the industry sector. In addition, the companies use approximately 80 TWh of other types of energy (fuels and heat).

All efforts are coordinated through the PFE-programme launched by the Swedish government in January 2005 and implemented and operated by the Swedish Energy Agency. The first programme period ended in June 2009.

Industries have a possibility to join the programme for two consecutive periods. The majority of the 100 companies have chosen to. There are also a number of companies that entered the first programme after 2005. This paper only deals with the first 100 companies and their achievements in the first programme period.

## About the programme

The programme for energy efficiency in energy intensive industries (PFE) was introduced in January 2005 by the Swedish Energy Agency. PFE is a voluntary economic policy instrument directed to energy-intensive industrial companies in Sweden. Programmes such as PFE are often denominated VA (Voluntary Agreement) or LTA (Long Term Agreement). PFE will run for two five year periods for each participating company.

The background of the programme is the EU directive leading to a new tax on electric power beginning on 1 July 2004 [1]. The new energy tax of 0.5 Euro/MWh affected Swedish industrial companies, with the exception of certain manufacturing processes. Companies who join the program are eligible for a tax reduction during the five year programme, provided that they adopt energy management in a systematic way and carry out energy saving measures in their companies. The regulation that has to be applied by participating companies in order to get the tax exemption are stated in detail in [2] and [3] and also described below.

### REQUIREMENTS AND ELEMENTS WITHIN THE PFE PROGRAMME

#### Energy review

All the participating companies shall, according to the PFE regulations, perform energy reviews[1]. The energy review 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 (EnMS)[2]. The reviews 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 over the short- and long term as a consequence of planned or expected changes in the production process. Electricity, fuels and heat should be considered. Data and results from the energy review shall be reported to the Swedish Energy Agency.

#### Energy Management Systems, EnMS

The participating companies shall also implement a standardized energy management system, EnMS. The system must, within the first two years of the programme, be certified by an independent certification body. From the very beginning of the programme, the standard SS 627750 was available for the companies. In 2009, the European standard EN16001 replaced the Swedish standard.

Within the remaining three years of the programme, the company must continuously improve its energy management system.

Documentation from the third party EnMS certification shall be submitted to the Swedish Energy Agency. The Agency also cooperates with the certification bodies and SWEDAC (the Swedish Board for Accreditation and Conformity Assessment) in order to verify see that the certifications and re-certifications continue according to plans.

#### Procedures for purchasing and planning

In addition to the energy management system, the companies must implement and follow specific procedures (routines) for planning, modifications and renovations and for purchasing high-consumption electrical equipment, based on LCC-methodology (Life Cycle Cost). When purchasing high-consumption electrical motors, the highest efficiency class must be chosen. The certifying bodies check that the procedures for purchasing and planning are implemented and used in the energy management system. The companies must also report the effect (in MWh-savings) of the use of these specific procedures.

#### Energy measures

Due to PFE being a programme leading to tax reduction on electricity, the companies must focus on electricity reduction when reviewing and reporting energy measures. However, as a result of the energy review and the energy management system focusing on *all* energy use, possible measures for fuels and heat will also be identified by the companies. It is not a requirement within the PFE to implement measures on fuels and heat, but it can be reported to the Swedish Energy Agency on a voluntary basis.

#### Programme life cycle

The PFE programme can be summarized as in Figure 1. The idea is that the programme shall establish a structure for ongoing energy management within each participating company.

## Results show a win-win for participants and society

In 2009, the PFE-companies sent their final reports to the Swedish Energy Agency. Only when the final report had been submitted, reviewed and accepted by the Agency, the companies could know for certain that their five year tax exemption was approved. In this chapter, summarized facts and figures from the final reports are presented. In addition, a number of interesting side-effects and spin-off activities have taken place during the period, due to the programme.

1. Energy review is sometimes called "energy audit" or "energy mapping".

2. An Energy Management System (EnMS) can be compared to and Environmental Management System (e.g. ISO 14001), but is focusing on energy instead of environmental issues. An EnMS can also be described as a set of interrelated and interacting elements of an organisation to establish an energy policy and energy objectives and to achieve those objectives.

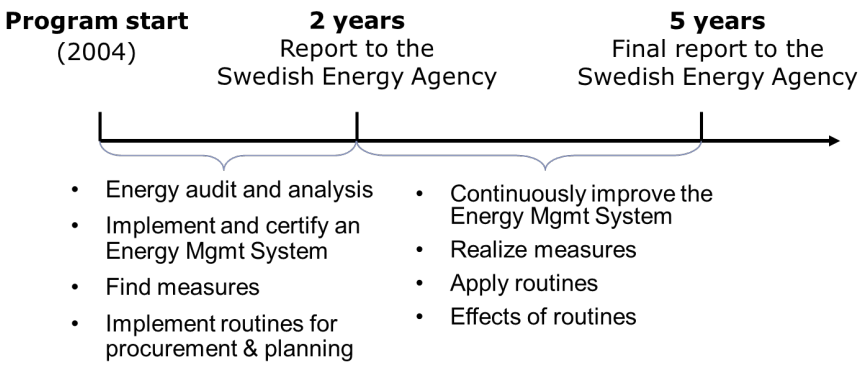



*Figure 1: The PFE programme.*

## EXPERIENCES OF ENERGY REVIEWS AND ENERGY MANAGEMENT SYSTEMS

The energy reviews have formed the basis for the companies' energy management systems and also helped identify important measures for improved energy performance. Some companies have hired external expertise to perform the reviews, i.e. consultants or ESCOs and some have used only internal resources. The Swedish Energy Agency has not collected or checked the reviews in detail, but focused on the result of the reviews (i.e. the measures and the identified energy performance indicators) instead.

All but two of the participating companies had succeeded in the implementation, certification and re-certification of their energy management systems. Seven different certification bodies had been accredited for SS627750 and had been used for the certifications.

Besides the final reports, the Swedish Energy Agency has made additional studies on the experiences of Energy Management Systems, which is summarised in [4]. Overall, the implementation of EnMS at the companies turned out to be *more* valuable than most companies had expected. The fact that most of the companies already had certified Environmental Management Systems simplified the implementation considerably, but had also made many companies believe, when the programme started, that no extensive profit could come out of the expanded management system. This however proved to be wrong, according to the companies. Reported positive effects of the introduction of EnMS are e.g. the engagement of new personnel and expertise to a great extent: electrical engineers, energy specialists (incl. consultants), process engineers, buyers of production equipment etc. This resulted in a lot of new ideas in the energy efficiency area. The EnMS also lead to more elaborated measurement, calibration and monitoring of energy use in most companies. The certification bodies also conclude that *all* certified companies have found new efficiency opportunities that they have not found when energy was only a part of the environmental management system.

It total, 117 companies have chosen to join the PFE. Of these 117, 103 have fulfilled the whole programme period so far. Two companies have been expelled from the programme because they didn't meet the requirement of having certified EMS during the whole five year period. Some companies have closed down or emerged and some have withdrawn their applications. One reason for withdrawal has been, according to the companies in question, that the requirement of a certified energy management system had proven to be too hard. This applies mainly to small companies or companies that did not have a management system in place prior to the PFE. The companies that do not fulfil all the requirements during the whole programme period have had to pay energy tax concerning the period in question.

Among the companies that have fulfilled the first programme period successfully, an important achievement in the energy management area is that all the companies now have raised their energy awareness and created a structure and on-going system for continuous improvement of energy performance. This will continue after the PFE has ended. Also from a society perspective, energy and climate awareness in the industry sector is crucial.

## ELECTRICAL EFFICIENCY IMPROVEMENT MEASURES

Concerning measures and actual savings, the companies well exceeded the expectations. The Swedish Energy Agency and the Swedish Government expected electricity savings around 0.5 TWh (which is equivalent with the tax reduction). In the end, 1.45 TWh of electricity savings were reported! Results from the companies' final reports are summarized in Table 1.

As seen in Table 1, the companies have invested 708 MSEK (around 70 million Euro) in the measures increasing the electricity efficiency. This should be compared to the savings due to the tax exemption, which is about 15 million Euro. If calculating with an average electricity price, the companies will also save around 700 MSEK (70 million Euro) in decreased energy costs. Hence, the measures found from the energy reviews and via the energy management system have shown to largely exceed the tax exemption in savings for the companies. The investment cost is 0.49 SEK per kWh on company level.

The 100 participating companies have reported savings around 1.45 TWh of electricity per year. This figure includes both electrical efficiency improvement measures and also the effect of the improved procedures for planning, modifications and renovations and purchasing of high-consumption electrical equipment.

Figure 1 shows the type of improvement measures concerned. About 25 % of the total number of electricity efficiency measures has been identified in the production processes, with the remainder in what are known as auxiliary systems. In MWhs saved, production processes account for 50 %.

Among auxiliary systems, pumps and other motor drives account for the greatest electricity savings. The fact that much

**Table 1: Results from the companies' final reports.**

| Results | Reported by 100 companies after five years |
|---|---|
| Total annual reduction in use of electricity | 1.45 TWh |
| Total number of measures (electricity) | 1247 measures |
| Total investment cost at companies | 708 M SEK (euro 70 million) |
| Average pay-off time for electricity measures | 1.5 years |
| Total number of other energy-related measures | 357 |

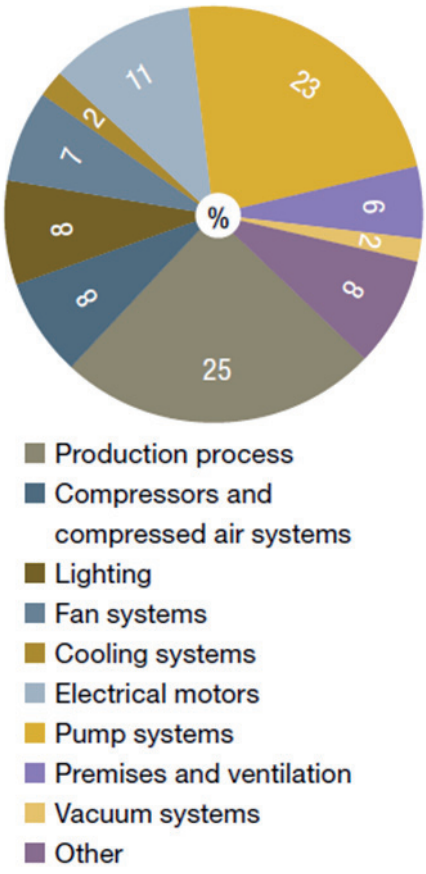



*Figure 2: Number of electricity efficiency measures per area (per cent).*

of the electrical efficiency improvements is in pumps can be partly explained by the fact that the majority of the participating companies are in the pulp and paper industry and thus have a lot of pumps installed.

In general, it can be said that many of the improvement measures concern load control (such as speed control), proper adjustment of processes, or optimization. Changing to more energy efficient equipment is also a common measure, as is also the realization that some equipment is unnecessary, and can simply be shut down. The improvement measures generally have a short payback time, and some require no investment at all.

Improvements or changes to compressors and compressed air systems provide a substantial element of energy savings. Savings can be found in areas such as repairing leaks, making better use of waste heat from the compressors or replacing equipment by more energy efficient equipment.

In certain cases, the electrical efficiency improvement measures carried out by the companies also result in a reduction in the use of some other form of energy. However, measures that involve a direct conversion from electricity to some other form of energy carrier, such as oil, are not accepted within the programme.

In addition to the measures that have been described above, the programme's requirements for better procedures and routines when purchasing equipment with a high electrical energy demand, as well as those for planning, modifications and renovations have resulted in further efficiency improvements. Savings from more energy focused planning procedures account for 174 GWh of the total result. Savings from more energy focused purchasing account for 36 GWh of the total result. The programme requires these procedures to be implemented *and* the result of this to be documented. The documentation part has however shown to be difficult for many companies. Therefore the figures 174 GWh and 36 GWh are not completely reliable – the savings due to the procedures are probably much larger.

## ELECTRICAL EFFICIENCY IMPROVEMENTS BY SECTOR

Figure 3 shows the shares of savings by sector.

The pulp and paper industry is responsible for by far the greatest part of the improvement (about 65 %), but is also the sector in the improvement programme that consumes the most electricity, amounting to about 22 TWh.

## INVESTMENTS

About 708 million SEK (70 million Euro) have been invested in electrical efficiency improvement measures during the five year period of the programme. The figure is based on the total investments costs that the companies have notified. The average payback time for the various improvement measures is 1.5 years. Participating companies also have various other costs for participating in the programme for exemple for the energy reviews and the energy management systems. This can also be seen as a type of investment, but is not covered by the 708 million SEK.

The largest investments are made in the pulp and paper industry, followed by mining and ore processing, plastics and chemical companies and steel and metals production companies.

## OTHER ENERGY-RELATED MEASURES

By carrying out the energy review and implementing the energy management system, the majority of the companies have also found measures for improved energy performance in areas beyond improved electrical efficiency. Common types of measures identified are for example increased efficiency of fuels, steam and heat use, conversion of fossil energy use to

renewables, increased production of electricity (appr. 1 TWh) and increased delivery of surplus heat to external parties. 357 such measures have been reported to the Agency. It is voluntary for the companies to report this type of measures. The 357 measures derive from about 1/3 of the participating companies, which can lead to believe that even more measures exist at companies that have chosen not to report additional information to the Swedish Energy Agency.

#### SUPPLEMENTAL ACTIVITIES, SIDE-EFFECTS AND SPIN-OFFS

Thanks to the programme, a number of interesting spin-off activities and side-effects have taken place, as a more voluntary part of the programme, or due to the programme.

During the first five year period 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), etc. Most of the PFE-companies have participated in these activities. This has strengthened the co-operation and created better understanding between different companies, and between industry and authorities.

Informal and formal networks between companies have also been created thanks to the PFE, both regionally and within certain industry sectors.

There have been academic studies of the programme and its effect on organisations and energy use. Examples are [6] and [7]. Ongoing research programmes, focusing on industry, have via the PFE network found new companies for possible collaboration in research projects.

Sweden also took the lead when developing the European standard for energy management systems, EN16001, and has also taken an active part when developing the international standard ISO50001. In addition to the Swedish Standard Institute, the Swedish Energy Agency and a number of PFE companies have participated in the international work.

The programme has had a lot of attention from Swedish media, industry organisations, industrial networks etc. This has led to an increased interest in energy efficiency in industries also *outside* the PFE companies, e.g. in small and medium sized companies. The Swedish Energy Agency has therefore arranged seminars and published tools and manuals also for industries outside the PFE network.

## Lessons Learned & Discussion

The energy efficiency measures that have been carried out by the companies are economically viable with a relatively short pay-off time (in average 1.5 years). Energy reviews and energy management systems have also been proven useful. One obvious question at issue is therefore: Why is it necessary to have a governmental programme and a tax reduction, would the companies not carry out all these measures by themselves anyway (i.e. free riding)? Obviously not, since these things had not been done before the PFE started. Barriers for energy efficiency in industry have been studied in e.g. [8]. When studying these barriers in relation to PFE, it is obvious that PFE has helped overcoming some of them.

Several benefits of having a formalized programme like the PFE have been discussed over the last years:

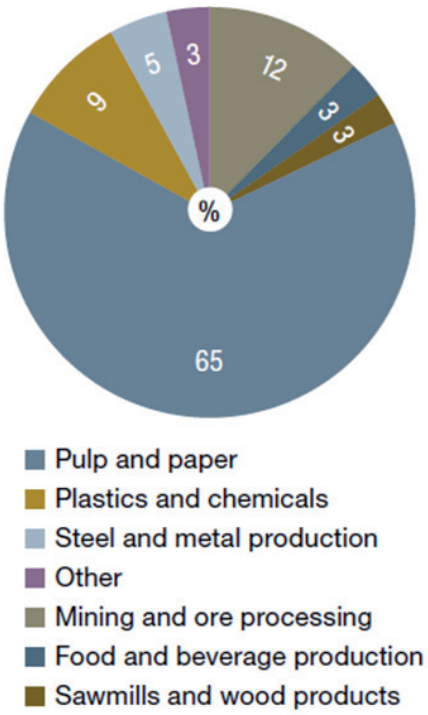



*Figure 3: Number of electricity efficiency measures per industry sector.*

- One of the main benefits of PFE is that the energy issues received a higher attention in the companies, according to many participants. Due to the fact that PFE involves tax money, energy issues have become a management task. Energy-related issues now have a higher priority, both regarding access to capital and personnel. Lack of time, slim organisations and poor access to capital are some often mentioned barriers for energy efficiency [8], which have been remedied by the PFE. PFE has helped overcoming these barriers. This has shown to be a big part of the success for many companies.
- Management commitment and one or several persons officially dedicated to the energy area are crucial for success. Several PFE companies have now educated all employees in energy issues, due to the energy management system. This has raised the awareness and technical skills of the personnel. With many people involved in energy management, new ideas for savings will come up in the organizations.
- Working with the participants as a network and bringing forward good practices has substantially lowered the perceived risk to introduce new solutions. Investment risk is claimed an important barrier for energy efficiency improvements.
- The methodology of the PFE programme has also shown to be useful for many companies. By beginning with an energy review and analysis, the companies have a good basis to identify measures. The energy management system then creates the structure needed for planning, implementing, realizing, following-up and reviewing the progress, as well as securing continuous improvements in the energy field. The procedures for purchasing high-consumption electrical equipment and project planning ensure that energy effi-

ciency is also considered when the companies continuously upgrade their equipment and make new investments in the plant.

- The deadlines involved in the programme ensure that "things are being done". Specified requirements and clear deadlines are important to ensure that energy efficiency is not put aside for other strategic or more acute issues.
- Voluntary agreements between governments and companies (such as the PFE) can provide the extra incentive that makes companies starting to realize the potential.

Another question to be asked is whether the energy efficiency measures would have been implemented irrespective of the PFE (i.e. free-riding). This is of course difficult to evaluate. Since half of the measures were found when performing the energy review, and the review is a strict requirement of the PFE, one could conclude that these measures would not have been known to the companies if it was not for the PFE. Concerning the other measures, some of them would not have been carried out either due to its pay-back times that are considered to be too long (companies normally require a pay-back time of less than one year for this type of non-strategic investments). The free-riding effect is further elaborated in [6].

Another lesson learned is that there is still a large potential for cost-effective energy efficiency measures in industries, even in energy-intensive industries. In addition, many energy efficient measures can be implemented using existing technology, i.e. without R&D.

Energy management systems have proven to be a useful tool for creating a structure for energy management within an organization, including for companies that already have environmental management systems.

Auxiliary systems had often been neglected in previous energy efficiency projects, but have proven to provide a good opportunity for energy efficiency.

The tax exemption provides an external incentive for the companies to start a structured and strategic way of working toward energy efficiency. The total tax exemption amounts to approximately 15 million Euro per year for the participating companies. Within the PFE, yearly electricity savings amount to 1.45 TWh. If energy efficiency is considered a major objective for governments, one can also conclude that the return of investment from the PFE programme is rather good. The cost effectiveness of the PFE as a whole has been studied in [6]. In paper [6], the authors calculate the unit cost per MWh, including a discussion on free-riders etc.

For the authorities responsible for this type of programmes, there are also lessons to be learned. 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 for example would decrease the use of electricity for sure. It would also increase the $CO_2$ emissions, which is of course undesirable. However, no such measures have been approved within the PFE programme.

Mechanisms such as the PFE can also strengthen cooperation between companies and authorities/the Government.

The methodology defined in the PFE can and has also been adopted by companies outside the PFE programme, e.g. non-energy-intensive companies. Unlike "command and control" based regulations, the PFE has a more flexible approach. The participating companies perform their own energy review (within certain general requirements) and are free to choose the measures that are most suitable for their unique type of production (again, within certain limits). This approach has been very appreciated by participating companies.

Lack of time, lack of investment capital, competition between different types of investments (where e.g. production or quality related investments are more prioritized than energy efficiency), insufficient knowledge about technology options etc. are barriers for implementing energy efficiency measures. In addition, many companies have an internal policy saying that non-strategic investments need to have a pay-back time less than one year to be interesting. As mentioned before, an external incentive such as the PFE can help overcoming these barriers.

PFE has also shown to have several positive effects in addition to energy savings. Joining PFE was a strategic decision that companies' managers have made. More persons in companies have become involved with energy issues as a result of implementing an EnMS, including operating and maintenance staff, buyers, co-ordinators for environmental and quality matters, project leaders and managers. In addition to increased energy competence, most companies have also learned a lot about their production processes and their organisations as a whole when doing an energy review and implementing the energy management system. This has sometimes led to better production capability and quality, improved environmental work and other positive side-effects.

For companies, PFE has increased awareness and expertise on effective and sustainable energy use. The required energy reviews and EnMS provide companies with tools for structured energy efficiency improvement efforts. At the same time, the EnMS 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 procedures for purchasing high-consumption electrical equipment and planning, in turn, lead to a greater demand for energy efficient equipment. Therefore, PFE decreases environmental impact as participating companies use energy more efficiently and also with less negative impact on the climate.

Joining PFE has given companies increased knowledge of improving energy efficiency and using non-fossil energy forms. PFE's requirement of energy management system improves companies' capacity to mitigate $CO_2$ emissions. This means that companies participating in PFE are able to operate more efficiently within the framework of the Emissions Trading System, EU-ETS. The EnMS requirement also improves companies' chances of defining responsibility, authority and procedures 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.

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 [5], which states that "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" and "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."

Besides the PFE-companies, another group has been benefitted from the programme: the suppliers of energy efficient equipment and related energy services. The PFE-companies now ask for energy efficient equipment based on LCC. The energy intensive industries in the PFE constitute a great market for suppliers of this type of equipment, since they consume more than 50 % of total electricity use in Swedish industry. With this increase in demand for energy efficient equipment, the suppliers can put more efforts into this market segment, e.g. more product development, marketing and in the end possible reductions of production costs. This in turn can lead to more companies, outside the PFE, starting to take an interest in energy efficient products. Consequently, the market shares of energy efficient products can increase substantially. This can be described as a multiplier effect of the programme.

According to the Swedish Energy Agency, the most important achievement in the energy management area is that all the companies now have raised their energy awareness and created a structure and on-going system for continuous improvement of energy performance. This will continue beyond the PFE's lifespan.

## Conclusions

The PFE has proven to be a win-win solution for all parties involved. Companies save money and reduce their negative impact on environment and climate. Society benefits from a more energy efficient industry with an increased energy and environmental awareness. Networks and new ways of cooperation have been created.

The second period of the programme has started. Due to changes in the EU State Aid regulations, it is not yet decided whether PFE will be approved after 2013. Nevertheless, participating companies and also companies outside the programme can benefit from the methodology used in the PFE. Therefore, the Swedish Energy Agency will aim for continuous promotion of energy management in the industry sector.

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