Process and impact evaluation of PFE – a Swedish tax rebate program for industrial energy efficiency

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Abstract

Before the minimum tax directive (2003/96/EC) took effect in 2004, Swedish industries had enjoyed untaxed electricity for over a decade. While the introduction of the tax increased costs for many companies, energy intensive industries were eligible for exemption if they entered an agreement on energy efficiency. Sweden quickly implemented the directive and simultaneously launched the Programme for improving energy efficiency in energy-intensive industries (PFE). Since then, over 100 companies have entered the five-year voluntary agreement which requires participants to do energy audits, implement energy management systems and make profitable investments.

PFE has been hailed as a major success. Participants cite it in bringing organisation and structure into their energy management activities. Companies and industry associations now advocate for policies of this kind to receive precedence when targeting increased energy efficiency. According to ex-ante estimates PFE has resulted in gross annual electricity savings of at least 1 TWh, equivalent to 3 percent of the total consumption of participating companies.

This paper presents an intermediate program evaluation focusing both on the PFE process and impact; it evaluates under what conditions the program meets stated objectives. It is evident that gross and net impact will deviate significantly from the officially reported results. Considering EU energy saving targets, the development of policy for energy efficiency in industry as well as monitoring and evaluation to assess program impacts is becoming increasingly important. This paper contributes to this process through an in-depth understanding of PFE, and more broadly to voluntary agreements of similar kind.

Introduction

In a country like Sweden, where industry accounts for one third of energy use, energy efficiency policies targeting industry ought to be a prominent feature on the policy arena. Within this heterogeneous sector the opportunities for energy efficiency improvement will certainly vary widely. Small and medium sized industries can have saving potentials between 30 and 50 percent (Trygg 2006). In energy intensive industries the potential will in general be smaller considering their past experience on working with energy management.

The real challenge for policy makers is to design and implement instruments that will provide clear incentives for energy efficiency improvements that will support (or at least not harm) industrial competitiveness. In one sense these two societal goals go hand in hand; the more competitive company is often the one that can improve profit margins through cost reductions. There are substantial cost savings to be made in lowering energy demand. This dynamic is especially true in energy intensive industries where energy costs may account for as much as 40 percent of added value. Yet, there is also a risk that supportive instruments, like voluntary agreements (VA), might distort industrial competitiveness between sectors or between Member States. One concern is ensuring these agreements do not provide overly generous incentives. Since the 1990s however, the set up of VA ha been viewed a passable policy road

Table 1. Development of industrial energy consumption 1970-2006 (SEA 2007).

Industrial energy use (TWh)	1970	1980	1990	2000	2006
Electricity	33.1	39.8	53	56.9	56.2
Oil products	74.2	54.8	20.8	21.6	20.2
Coal and coke	14.2	14.8	16.9	15.6	16.6
Natural gas	–	–	3.2	3.4	5.7
District heating	–	3.1	3.6	4	5.5
Biomass and peat	32.7	35.2	42.8	51.7	52.8
Total energy end-use	154.2	164.8	140.2	153.2	157

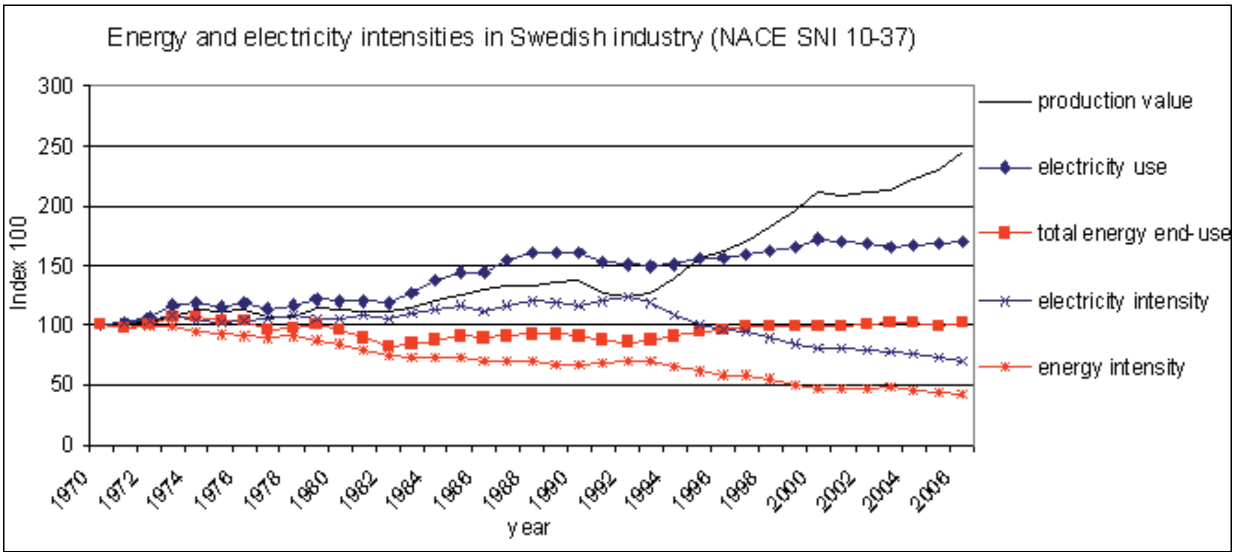

Figure 1. Energy and electricity intensities in Swedish industry (SEA 2007a).

towards improving industrial energy efficiency in several industrialised countries (Price 2005). With PFE the government is trying to establish the Swedish counterpart.

OBJECTIVES

This paper presents the Swedish PFE; a program that exploits the opportunity to replace the EU harmonised minimum tax on electricity with incentives for increased industrial energy efficiency. This window of opportunity should be open to all Member States, but seems to have been seized by few. The paper tells the story of how Sweden went ahead implementing PFE, gives some insights into the policy process of PFE, and elaborates on how impact from PFE and programs like it should be evaluated. The paper aims to reason and provide evidence that the unbridled enthusiasm for PFE as a clear success is unfounded.

Swedish energy intensive industry

With 1970 as the reference year the Swedish energy system has made a notable shift away from oil as the dominating primary energy source. Nuclear power has been scaled up considerably and together with hydropower it accounted for 90 percent of the produced 145 TWh in 2007. The decommissioning of two reactors in 1999 and 2005 has led to the ongoing work of expanding capacity of the remaining ten. Combined heat and power (CHP), using primarily biomass and waste fuels, has become a main player for heat supply distributed in well established district heating systems. Electricity from CHP together with a small but increasing wind power capacity was producing the remaining 10 percent of electricity in 2007.

The industry sector has been contributing to the development by shifting its energy end-use away from oil products towards more electricity, as demonstrated in table 1. The energy demanding pulp and paper industry has increased its use of biomass sources; in 2007, 78 percent of fuel consumption was covered by internal biomass resources, primarily black liquor and bark (Wiberg 2007). A policy effect of the green certificates system introduced in 2003 is an internal electricity production of 5.6 TWh (2007), which is an increase by 40 percent since 2000. This is enough to cover 25 percent of total electricity consumption of the entire pulp and paper sector. The use of natural gas as well as district heating shows a steady increase since the introduction during the eighties. The use of coal and coke has remained more or less constant owing to its function in reducing iron oxides in blast-furnaces within iron and steel manufacturing.

In addition to the shift in energy sources, Swedish industry has a good record on energy efficiency improvement. Figure 1 depicts that industrial energy end-use has remained more or less stable since 1970, whereas the total production value has increased by 150 percent. Considering the primary energy demand for electricity production the decoupling effect becomes weaker. Applying a generation efficiency of 40 percent means primary energy use has increased almost 40 TWh, or 20 percent, over the period due to the shift towards more electricity use.

When studying electricity use independently, figure 1 shows that the trend of decreased intensity does not start before the second half of 1990. The industry sector categorised with NACE code SNI 10-37 comprises both primary industry and manufacturing industry. Structural changes over the last decades have led to the latter becoming more important to the national economy than the more energy intensive sectors of the primary industry. In 2005 almost 50 percent of the industrial value added was produced in the manufacturing industry, including for example the electronics and vehicle industries (Johansson et al. 2007). This development is enhancing the effect of an overall decrease in industrial energy and electricity intensities.

According to a survey the average Swedish energy intensive industry faced a 32 percent increase in electricity price between 2002 and 2005, from 20 öre/kWh in 2003 to 26,5 öre/kWh in 2005 (SEA 2006)[1]. During 2008 a realistic long term power contract (stretching over 8-10 years) for the large electricity consumers within the energy intensive industry was on the level of more or less 45 öre/kWh (Westin 2008). In parallel with the price increases there has been an intensive debate in Sweden regarding energy prices and industrial competitiveness. To gain better control over the situation Swedish industries are striving to make continuous improvements in electricity efficiency. First and foremost, reduced demand for watt-hours means smaller bills. Reduced demand will also have an effect on overall electricity prices in the Nordic power system.

Characterisation of the Programme for improving energy efficiency in energy-intensive industries

BACKGROUND

In 2000, the Swedish government commissioned a study to prepare decision support for a program based on long term agreements (LTA) targeting energy efficiency in energy intensive industry[2]. The stated objective was to reduce greenhouse gas emissions in order to make contributions to both national and EU common undertakings of the Kyoto Protocol (Ds 2001:65). The investigation was inspired by LTA-systems practised in Denmark, Finland, the Netherlands and UK. Although these programs have key structural differences they share the basic concept that while the government offers an economic incentive (e.g. a tax rebate) the company participants are required to take some measures to improve energy efficiency. The government energy policy bill (prop. 2001/02:143) supported the program proposal, but expressed the need for further investigation. In particular a suitable economic incentive had to be identified; the proposal had vaguely suggested some kind of tax credit related to energy or carbon taxation. Since industrial processes were already exempted from energy taxes in Sweden, a further reduction of the carbon tax remained the only viable option. This difficulty in finding an appropriate incentive to offer an already generously treated energy intensive industry stalled the policy formulation process. In 2003 however, the EU Energy Taxation Directive (2003/96/EC) became an impetus for renewed program plans. The directive enforced changes to Swedish energy taxation by demanding EU harmonised minimum taxes on different energy products. For electricity used in businesses a tax at the level of 0.5 Euro per MWh was to be applied. At the same time the directive made some exceptions from stated taxation levels as exemplified by consideration 29, which declared that:

> *"Businesses entering into agreements to significantly enhance environmental protection and energy efficiency deserve attention; among these businesses, energy intensive ones merit specific treatment."*

The conditions for such an agreement and the possibilities to apply reduced taxation are to some extent further developed by article 17 of the directive. In the second and actual proposal for a policy program for energy efficiency in energy intensive industries (Ds 2003:51) these formulations are exploited. Finally, after another government bill (prop. 2003/04:170) had been processed, the "Programme for Improving Energy Efficiency Act" (SFS 2004:1196) was passed and PFE could be launched in January 2005, being approved by the Commission as a valid state-aid for a maximum of ten years.[3]

POLICY TYPE

The foundation that governs the set up of many LTA's, targeting industrial energy efficiency, is the inherent challenge for governments to impose revenue generating instruments like energy taxes on industrial sectors that are vulnerable to international competition. The widespread opinion among policy makers and industry representatives is that competitors in other countries do not face similar tax pressure. Therefore, to maintain industrial competitiveness the government resorts to these kind of agreements as a second best policy solution, being the alternative or complement to taxation. Being made voluntarily for the industry to enter, LTA are often refereed to as VA. VA programs can be of different kinds and have to be characterised based on the content. Price (2005) makes a division into three categories: completely voluntary programs, programs that use the threat of future regulation or taxes to motivate participation, and programs that are implemented in conjunction with existing tax policy or strict regulation. Hence, a VA can involve both incentives and penalties, be more or less voluntary, be binding or be non-binding and in the first case thus imply consequences for non-compliance. The EU directive on energy end-use and energy efficiency services (2006/32/EC) makes no definition of VA but refers to an agreement between a stakeholder and a public sector body. For the purpose of monitoring and evaluating a VA the directive proposes that it: "should be transparent and contain, where applicable, information on at least the following issues: quantified and staged objectives, monitoring and reporting".

PFE can be described as a voluntary agreement implemented in conjunction with a tax policy, in that it allows exemption

1. 1 Swedish krona (SEK) is divided into 100 öre. 1 Euro was equal to about 11 SEK in early 2009.

2. At this time the term energy intensive industry was used without a clear cut definition. The implicit meaning was the industry sectors: mining and quarrying, pulp and paper, basic chemicals, non-ferrous mineral products and basic metals.

3. N 253/2004 Fullständig befrielse från skatten på elektricitet för energiintensiva företag

from the minimum tax. The agreement can only be signed and entered by individual companies[4]. The VA-scheme is supported by a law (SFS 2004:1196) that defines the binding commitments of all parties. It is not possible to negotiate the terms of the agreement since these have been set already in the stage of planning for PFE. During this planning process however policy makers have worked in close contact with industry representatives to reach mutual understanding about the VA-scheme (Ds 2001:65, p.55). The threat in case of non-compliance is that the tax must be paid. A voluntary agreement does not have to exclude other policy options, e.g. taxes and regulation, but can be supplementary to existing or planned instruments. PFE illustrates a situation of substitution in that it replaces the mandatory minimum tax on electricity. The policy effect of PFE is also intended to be broadly equivalent to the effect of a minimum tax (article 17(4) 2003/96/EC).

THE TARGET GROUP

PFE targets the energy intensive industry which during the planning and design phase, in lack of a clear definition, was considered to consist of the industrial sectors of: mining and quarrying, pulp and paper, basic chemicals, non-ferrous mineral products and basic metals (Ds 2003:51). These sectors are known to be energy intensive and consist of companies for which the cost of electricity can be a considerable share of the added value. It was not until the minimum tax directive was introduced that a threshold for energy intensity was defined, which resulted in that companies also in other sectors could be classified as energy intensive. This definition (see point 3 below) along with some other requirements constitutes the eligible criteria stating that for a company to get admission to PFE it must[5]:

1. Pursue industrial activities under the classification code SNI 10-37.
2. Use electricity in the manufacturing processes.
3. Be an energy intensive business according to article 17(1) of 2003/96/EC, meaning that costs of energy products and electricity amounts to at least 3 percent of the production value and/or energy-, carbon dioxide and sulphur taxes amounts to at least 0,5% of added value.
4. Be expected to achieve its commitments according to 5-14§ in SFS 2004:1196 and have the economic means for doing so. In short the paragraphs state that the participating company is obliged to implement and follow an EMS, pursue specific routines for procurement, and report its energy efficiency measures to the administrating body.

Hence with the broader definition of energy intensive business, the criteria allows for more industrial sectors to join the program than originally planned for. Examples of these additional sectors include the food industry, wood and wood products, chemical products, as well as rubber and plastic products. In a target group analysis conducted by the Swedish Energy Agency (SEA), where the stated eligibility criteria were tested against industry statistics from Statistics Sweden (SCB), it was concluded that all in all between 1150 and 1300 companies were eligible to participate in the program (SEA 2005). In 2002 these companies used 42.3 TWh electricity, of which 34.9 TWh was subject to minimum tax according to the directive, and therefore part of the PFE scope. This corresponds to 62 percent of total industrial electricity use and 23 percent of the total electricity use in Sweden.

In Figure 2 the annual tax exemption through PFE is allocated on a potential target group consisting of 1250 companies. Seeing that the tax exemption is proportional to electricity use, it is clear that a large part of the tax exemption is expected to be offered a small number of companies with high electricity use. A group of six companies, each using more than 1 TWh/year, will be able to benefit 55 MSEK, while a group of 1059 companies, each using less than 10 GWh/year, will benefit only 10 MSEK.

PROGRAM COMPONENTS

Given the number of program components it includes, PFE should be viewed as a package containing a blend of policy instruments rather than a single instrument. Figure 3 outlines the essential components of PFE as presented by the SEA, the program's operating agent.

PFE has been open for applications since January 2005, and will remain open until the end of 2009. Companies apply on a voluntary basis by completing an electronic form with relevant information on energy use, production values etc. Stated data is then tested against the criteria to decide whether the company is eligible or not. The program period is five years, beginning from when the decision on participant admission takes effect.[6] The five years are divided into two periods: year 1-2 and year 3-5. By the end of each period, with a second- and a fifth-year report, the participants have to report their achievements in relation to the stated obligations for each period.

During the initial two years the participants have to conduct an energy audit and analysis of the industrial site(s). Audits are expected to identify, evaluate, and quantify profitable energy saving actions. The importance of having a system perspective when evaluating energy use is emphasised in the auditing handbook for participants (SEA 2004). However, since PFE specifically targets electricity use, owing to the economic incentive, it is likely that the search will be focused on electricity saving actions. Moreover, companies are only required to report the electricity related savings actions. Of the identified actions a list of those having a pay back time of less than three years should be submitted together with the second year report. Also an Energy Management System (EMS) must be implemented, according to the specifications of SS675520, developed by the Swedish Standards Institute (SIS). In the second year report companies have to confirm that the EMS has been certified. During the first two years the companies also have to start implementing routines for procurement and project planning.

4. There are other examples of sector based VA, where the signatory is an industry sector association, i.e. the Long Term Agreements on Energy Efficiency of the Netherlands (Nuijen and Booij 2002).

5. SFS 2004:1196 3§

6. The minimum tax however was introduced already in July 2004. The tax payments during the six month gap until program start was retroactively repaid to early program applicants. For these companies (a majority of participants) the program start is registered as July 2004 (SEA 2008a).

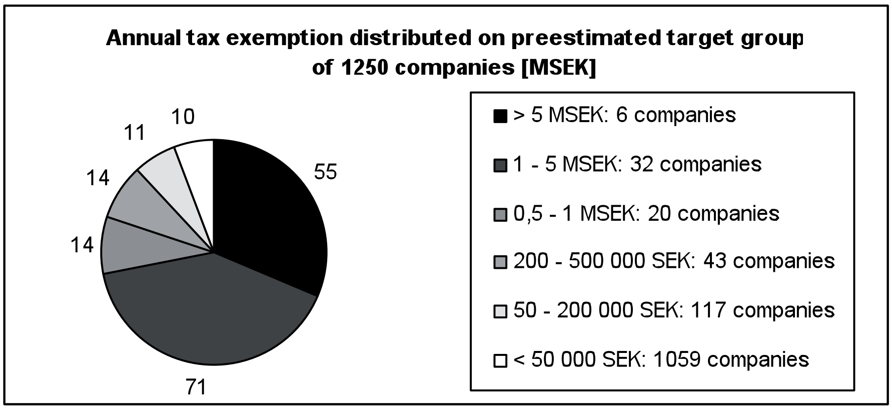

Figure 2. Tax exemption distribution on target group. The potential annual tax exemption of 175 MSEK for an estimated target group of 1250 companies is here allocated to groups of companies depending on size of exemption (proportional to electricity demand)(SEA 2005).

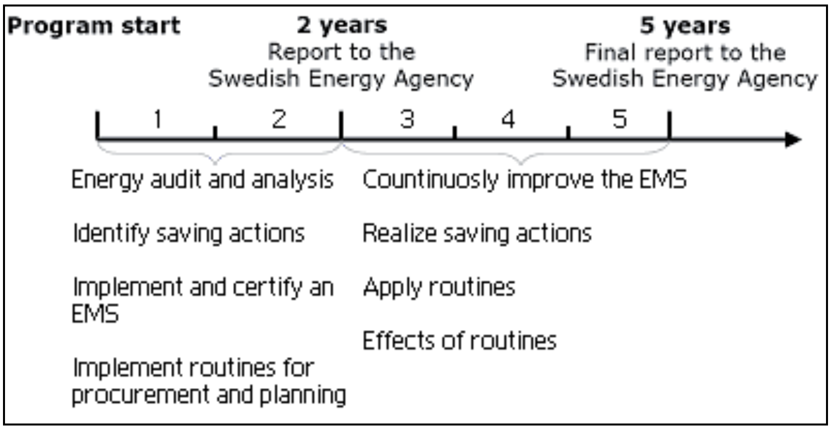

Figure 3. PFE outline (SEA 2005).

These routines include a set of requirements which involves life cycle cost (LCC) assessment based on energy use.

After the second year report and during the remaining three years the companies are expected to realize all reported electricity saving actions and continuously improve the EMS. Also the routines should be continuously applied. In the final fifth year report the saving impact from the routines as well as the EMS have to be reported. 2009 will, for most of the participants, mean the end of the five year period. SEA will then, based on submitted data, take on their task of evaluating the full effects of the program. Before any results from this ex-post evaluation can be communicated it is likely that a second PFE period has been running for some time.

Process evaluation

A THEORY BASED EVALUATION APPROACH

The process oriented Theory-Based Evaluation (TBE) approach has been used to evaluate PFE. Theory should here be understood as "the set of beliefs and assumptions that undergird program activities" (Weiss 1997 p. 503). Thus, the program theory constitutes the basis for how program activities are expected to bring about desired changes. Advocates of TBE claim that it is superior to an impact evaluation in that it can answer to not only if, but also why, targeted impact is achieved. In case there is no evident impact the evaluator, by using TBE, should be able to answer to where in the chain of program activities that the policy failed to function as expected. This in turn can support program administrators in determining what specific modifications that are needed for an effective operation.

For the evaluator TBE calls for a system analytic procedure of: assessing the program by separating its components, examine these, and communicate the interpretations. In the following are presented two program components that are found to be of importance for understanding the results of PFE, and to have in mind when making judgement about success or failure.

PARTICIPATION ADMISSION

Figure 2 showed how the tax exemption was distributed over the whole group of eligible companies. In figure 4 the same allocation has been done for a participant group of 90 companies, comprising some 220 business units, which joined PFE at an early stage. Currently, there are 10-20 additional companies in the program. By comparing the two figures it is evident that less than ten percent of the target group is participating in PFE. The low result can be explained by the positive relationship between participation and size of the annual tax exemption. Large electricity consumers will receive large tax cuts and are therefore keener to join the program. Small electricity consumers will receive small or moderate tax cuts making PFE far less attractive. Out of the 1059 companies eligible for a tax exemption of less

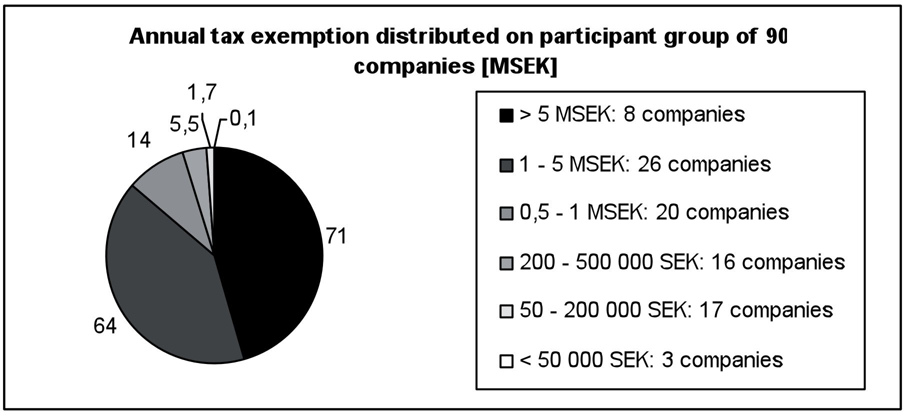

Figure 4. Tax exemption distribution on PFE participants. The annual tax exemption of 156 MSEK granted to 9 PFE companies are allocated to groups of companies depending on size of exemption (proportional to electricity demand) (SEA 2009).

than 50 000 SEK (i.e. consuming less than 10 GWh annually) only three participate in the program. Attractiveness increases with the size of the tax cut, but it is only for companies granted an exemption of 0.5 MSEK or more (i.e. consuming more than 100 GWh annually) that the number of participants is becoming consistent with the target group analysis, which becomes evident when comparing figure 2 and 4.

Whether it is a program failure that companies with lower electricity demand have chosen not to join PFE depends on one's perspective. That less than ten percent of eligible companies have joined the program may appear disappointing. At least staff at SEA would like to see as many as possible in the program (SEA 2008a). In terms of electricity use however, the few participating companies use almost 90 percent of eligible electricity. Hence, PFE comprise most of the eligible saving potential. On the other hand, as Henriksson and Söderholm (2008) points out it is more likely that EMS could do a good job in detecting cost-effective energy efficiency measures in non-participating companies. This is due to their lack of prior experience of energy efficiency improvements compared to the truly energy intensive companies. The way participation is currently set up does reduce cost for administrating the program. Supposing that the 1250 eligible companies would have joined PFE, the administrative burden would have increased several times. In this sense the tax incentive has been successful in attracting a significant share of eligible electricity use, and thereby potential savings, while keeping the administrative burden at a low level. Ultimately PFE is a VA and so by definition participation is voluntary. For non-participating companies the tax incentive is often judged as insufficient to cover the costs involved in complying with program requirements (Sjögren et al. 2007). If policy makers desire a higher rate of participation it seems probable that the economic incentive needs to be modified.

THE SECOND YEAR REPORT

The second year report has been an important program component in serving as an intermediate checkpoint for testing the PFE policy theory. This ex-ante assessment provides the basis for the current expectations on successful program results. In the reports the companies had to confirm their compliance with the program requirements as formulated in the PFE Act (SFS 2004:1196 11§). This means they had to demonstrate:

1. that the EMS had received certification by an authorised certifier,
2. the results from the energy audit and analysis,
3. the list of electricity saving action where the sum of the savings should be expected to lead to savings that broadly speaking would have been achieved if the minimum tax had been applied during the same period,
4. documentation showing that routines for procurement and planning had been implemented.

All companies that submitted their second year report got approval by the SEA. Yet, of the requirements above it is the third point, which appears to be difficult to test, that is elaborated on here. The requirement origins from article 17(4) of the minimum tax directive and is a basic condition for allowing Member States to replace the intended harmonizing tax with an agreement on energy efficiency. In lack of other quantitative targets this has become, also in the national context, the criterion for what level of savings PFE is to achieve. Although the SEA is responsible for making this judgment, as a part of the second year report the companies were asked if they could comply with the requirement. All companies (with one exception) answered they could. It should be pointed out that how the companies interpreted the requirement, and thus how they argued for compliance, varied widely. Indeed, there is no clear-cut answer on how to understand the issue and neither has the SEA provided any definition.

In essence it is a matter of estimating the level of electricity savings that would have been realized from an electricity tax. If the sum of reported savings is about equal to this estimate, the requirement is to be judged as achieved. One approach to estimate the effect from a tax would be to apply a coefficient describing the price elasticity of demand (PED) for electricity within the concerned industry sector. In general, electricity is as a product having low price elasticity. For the industry sectors participating in PFE electricity demand has been estimated to be relatively inelastic, and much closer to zero than -1 (Sjögren et al. 2007). This implies that the assumed tax increase of 0.5 öre/kWh would have only a moderate effect on electricity savings.

However, among the various interpretations to be found in the companies' second year reports the one made above is not so frequent. Many companies have instead, without framing it in terms of price elasticity, interpreted the requirement as a demand to report savings actions as if they were facing a unitary elasticity of -1. In their words it is argued that if electricity cost savings due to reported actions are equal to, or exceed, cost savings due to tax exemption, the requirement is fulfilled. If all companies, and the SEA, were to make this interpretation there would be a problem with fulfilment. Assuming a general electricity price of 40 öre/kWh, there are in fact 20 percent of the companies that profit more from the annual tax exemption than from the annual electricity savings (due to reported actions). In conclusion, the hard to grasp program requirement (of point three) have led companies to make individual assumptions about their achievement. If policy makers are to authorize that program requirements are met, indeed the SEA is responsible for making these judgements, it should be considered how the absence of clear and quantified objectives are influencing opinions on achievement.

Impact evaluation

ESTIMATED IMPACT

As the program operating agent, the SEA has to monitor and report the results of PFE. A majority of the participating companies submitted their second year report during 2006. The data analysis presented in this section is based primarily on data from these reports and more specifically on the list of program results (dated Mars 7th 2007) that has been compiled and communicated by the SEA (SEA 2009). After this list was made official additional savings actions of about 50 GWh have been reported which explains why the results presented here will differ somewhat from other ex-ante assessments of PFE results (e.g. Ottosson and Petersson 2007). Currently, the SEA is expecting annual electricity savings of at least 1 TWh which reflects their confidence in that also other program components will deliver a significant impact (SEA 2007b).

GROSS IMPACT

The gross impact refers to the energy savings of a policy instrument without taking into consideration that also other driving forces could have caused parts of the impact. How to express gross impact will depend on the purpose, but could typically be expressed as:

i. the amount of kWh or GJ of annual energy savings

ii. the ratio between annual energy savings and the energy use for a selected base year (i.e. in percentage)

iii. the cumulative energy savings over a selected saving period

All the reports on deemed savings from PFE that has been presented so far are expressed as gross impact of either i) or ii). As mentioned it is expected that the program will result in at least 1 TWh annual electricity savings, which corresponds to about 3 percent of electricity use in the base year (which is 2003 for most companies). The only supporting evidence for the made expectations comes from the second year report including the list of actions that the companies are obliged to implement. Table 2 compiles the reported actions as of Mars 7th 2007. In total 860 actions were reported. The large variety of actions has been subdivided into types of end-use technology. Initially, a split was made between production processes and auxiliary systems. Actions related to auxiliary systems are further categorised. Actions on pumping systems are common which reflects the large participation from the pulp and paper industry that uses pumping equipment throughout their mills.

Based on reported actions figure 5 suggests three ways to make ex-ante assessments of the impact achieved by the PFE companies. The bars add up actions with the assumption that each action starts to have a full effect the year after investment/implementation. Even though it is only required that identified actions are realized during the second phase of the program (see figure 2), some actions have been implemented already during the first and second year.

First in 2010, after the program is finished, and hence when all reported actions have been implemented the full saving effect of 726 GWh can be realized. The three scenarios are explained shortly in the following:

a. The case assumes that the actions have a limited lifetime during which they result in electricity savings. Factors influencing the end of performance can be: intended design lifetime, economic reasons, or social/behavioural manner (CEN 2007). The lifetime issue has special importance in relation to the Energy Service Directive (ESD) that allow for already existing policies, and even early actions implemented after 1995 (or even 1991), to contribute to the saving target of 9 percent conditional a lasting effect exists by 2016 (Annex I 2006/32/EC). Hence, the choice of saving lifetime will have direct consequences on the size of realized savings from a policy program, just as it will be a crucial factor in determining Member States target achievement.

   Here, regardless of type, all reported actions have been given a default saving lifetime of 8 years (CEN, 2007). For actions that were implemented in 2005 this means an end of performance in 2014. Cumulative savings of almost 6 TWh is equivalent to yearly savings of 726 GWh over the 8 year saving period. In 2016 only a moderate contribution of 100 GWh saved end-use electricity can contribute to the ESD target.

b. Saving lifetime is not a straightforward issue. While a default value of 8 years is conservative for many types of technical actions, for organizational actions (e.g. resulting from good energy management of existing electricity using equipment) it is probably exaggerated. This case avoids the difficulty of choosing a uniform saving lifetime by assuming no restriction in the lasting effect. It assumes that there is no deterioration in technical performance and at time for replacement, equipment with equal energy performance is being reinstalled. Based on these assumptions the yearly savings (as compared with the base year) will remain unchanged over time.

   Here, the cumulative savings will continue to grow at a constant rate with the yearly savings equaling the first year (after program conclusion) annual savings of 726 GWh.

Table 2. Reported actions categorised by type (SEA 2009).

Type of action	Number of actions	Reported savings in GWh	Share of reported savings
Production processes Site specific measures that commonly involves optimization of motor related processes	243	353,9	48,8%
Pumping systems Commonly including measures like variable speed drive control and shifting equipment	214	142,4	19,6%
Compressed air systems Sealing of air leakage is a common measure. The category also includes measures on compressors and vacuum systems	78	75,8	10,4%
Other electricity efficiencies Common are measures related to control of motor heaters and electrical boilers	47	42,5	5,9%
Industrial motors Change to motors with higher efficiency and control of motor driven equipment	85	30,4	4,2%
Fan systems Typically time and demand control	58	22,7	3,1%
Space heating and ventilation Often measures on heat recovery and time controlled ventilation	50	20,9	2,9%
Indirect electricity efficiency Commonly phase compensation	18	20,6	2,8%
Cooling systems	19	10,1	1,4%
Lighting systems Time and presence controlled lighting are common measures	48	6,7	0,9%
Total	**860**	**725,9**	**100%**

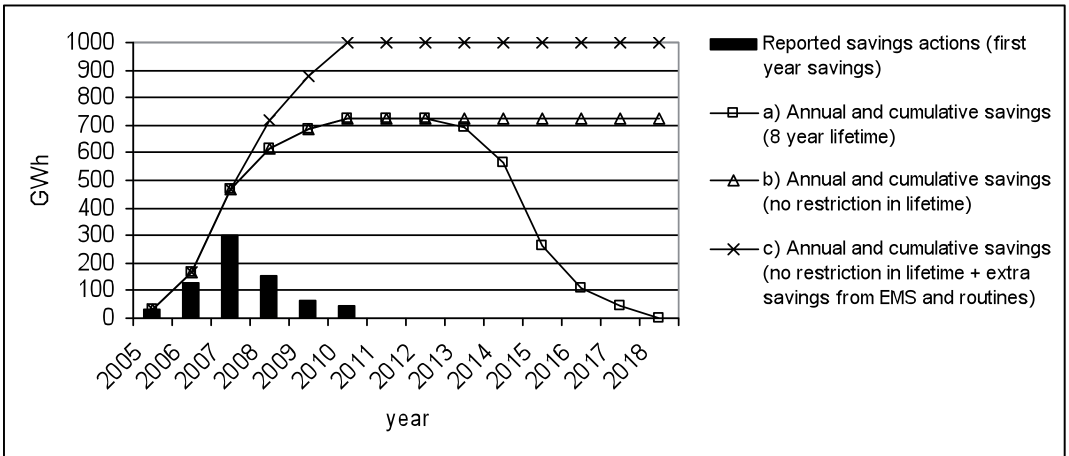

Figure 5. Three scenarios for annual cumulative savings.

With this perspective of an endless saving effect it is irrelevant to talk about cumulative savings. With respects to the ESD target the program will be able to contribute with 726 GWh of saved electricity.

c. Also this case avoids setting a restricted savings lifetime but it is distinguished from the former in that it makes estimations about extra saving impacts arising from the use of the EMS in combination with the routines for procurement and planning. Since this possible impact remains to be evaluated by the fifth year report and since no data has been presented so far on this issue, what is being depicted in figure 5 is a hypothetical example used for illustrative purposes only.

An assumption is that the EMS and the routines will start delivering an impact first within the second half of the program period, i.e. following year 2007. According to the program outline, this is when the EMS has been certified and the companies are obliged to apply the routines, assuming they joined PFE in 2005. Additional savings together with reported actions are suggested to achieve an impact of 1 TWh of yearly savings compared with base year. In lack of a restricted lifetime a scenario with persistent saving impact is described. The scenario is intended to illustrate a low estimate of the SEA expectation that PFE will result in yearly savings of at least 1 TWh. Nevertheless this scenario is the

$$\text{Net impact} = \text{Gross impact} \times \left(1 - \text{free-rider coeff.} + \text{multiplier coeff.}\right) \times \text{double-counting factor}$$

Figure 6. Calculation for conversion from gross-to-net impact.

most optimistic in that it put a lot of faith in that the EMS and the routines will deliver additional savings.

NET IMPACT

When doing a gross-to-net impact conversion the evaluator typically seeks to answer the question: How much energy savings would not have been made if the policy program had not existed? The answer which is often difficult to find, and in all cases suffers from uncertainties, is the net impact of the program. When using a bottom-up evaluation methodology the conversion is done by applying relevant correction factors as shown in the formula of figure 6.

Correction factors

Free-rider coefficient: The free-rider coefficient of an energy efficiency policy is the share of savings, ranging between 0 and 1, performed by actors (i.e. free-riders) who would have implemented the saving actions also without the support from the policy program (Vreuls et al. 2008).

Some guidance for determining the free-rider coefficient of PFE is given in the second year report where the participants state for each electricity saving action, whether it was identified through the energy audit or if it was known from before. Of the 860 actions with a saving potential of 726 GWh, 47 percent of the saving potential became identified through the energy audits. In absence of PFE, that requires the audit to be conducted, the identification of these actions would have been deferred, or perhaps never occurred. Consequently, assuming honest reporting, a minimum of 47 percent of the electricity savings from reported actions can be attributable to PFE.

Of the 53 percent of the saving potential that was known already before the PFE-audit it can be assumed that some actions would be implemented also without PFE. Many of these actions have payback periods of between zero and two years, thus being clearly profitable also without economic incentives. There can be many explanations for the seemingly irrational behaviour for a company to disregard profitable investments. Without going into details it can be concluded that PFE, by putting focus on energy issues and by obligating actions to be implemented, seems to overcome all hesitation. So, even though there are actions that would have been carried out anyway PFE has meant that these investments have been made before they would have been made anyway. Consequently, there is some support to claim that the free-rider coefficient of PFE will be lower than 0.5.

Multiplier coefficient: The multiplier, or spill-over, effect enhances the initial influence of the policy instrument in causing market actors (program participants or not) to implement measures without any further involvement (by incentives) of the instrument (Vreuls et al. 2008). The range of the multiplier coefficient can take on values from zero, i.e. no savings have occurred apart from what has been reported, to in principle very large numbers.

There can be identified at least two ways in which multiplier effect can arise: a PFE participating company implements more saving actions than what is being reported to STEM or, a non-participant (company or business unit) starts implementing saving actions under influence of PFE but without enjoying the incentives. Concerning in particular the EMS component of PFE, its introduction and certification within Swedish industry has clearly been motivated by the program. The use of standardised EMS is very rare outside PFE. Yet, there are a few examples of subsidiaries to PFE companies that have become comprised by the EMS when management have decided to implement the EMS over the whole organisation (Sjögren et al. 2007). Through PFE a number of manuals on energy management have been prepared for the participating companies. This information material is accessible also for non-participating companies. With this guidance and upon recognition of a saving potential it is possible that also companies outside PFE will implement cost efficient actions. Another potential source for a multiplier effect is that more energy efficient equipment, due to the routines for procurement applied in PFE, would become the standard choice in various applications. Seemingly, there are many potential sources for a multiplier effect. Nevertheless, no supporting evidence has been found for attempting to quantify the coefficient, why no more than his qualitative discussion can be made.

Double-counting factors: Depending on the mix of policy instruments operating in a country there is a possibility that industrial companies are affected by overlapping instruments which then involves the risk for double-counting the effects of one or several of them. The range of the double-counting factor is between 0 and 1, where 1 represents a situation without overlapping, and 0 means a complete overlap in such a way that no energy savings are attributable to the instrument of interest.

There are no other policy programs in Sweden that like PFE specifically target electricity savings within the energy intensive industry. However, there are still other instruments in place that could interfere with the policy effect from PFE. The EU ETS has caused an additional charge on electricity prices, and a high electricity price is most likely the most important driver for making electricity savings. As a regulative policy instrument the Swedish Environmental Code (SFS 1998:808) includes a paragraph on general consideration on energy conservation. Because of the set up of PFE with requirements for reporting actions combined with procedures for documentation, measures have been taken to reduce the risk for double-counting. No attempts can here be made to quantify the existence of a double-counting factor.

COST-EFFECTIVENESS

The cost-effectiveness of a policy instrument for energy efficiency improvement can be expressed as the ratio between the program expenditures and the amount of saved energy during a specified period, considering that the program may have saving impact also after it is concluded. This calculation is based on the assumptions made in scenario (a) of figure 5. Hence, the saving period/lifetime is restricted to 8 years and only savings from reported actions are accounted for. Cost-effectiveness is being calculated from the perspective of government, end-users (i.e. program participants) and society as a whole.

Government

Governmental expenditures relates to administrative issues in the planning, formulation, implementation and evaluation of the policy. Also the reduced government revenue due to lower tax levels is added to the governmental expenditures:

- For the SEA, being the responsible agency, PFE involved expenditures of about 35 MSEK between 2004 and 2008 (SEA 2008b). Assuming that the average annual of 7 MSEK is valid also in 2009, the rough estimate of the total expenditures for administrating PFE over the program period 2004-2009 is 42 MSEK.
- The annual tax exemption is proportional to the electricity use of the participating companies. The annual electricity use is assumed to be more or less equal to 30 TWh which implies an annual tax exemption of 150 MSEK. During the five year participation the foregone tax revenue amounts to 750 MSEK.

Hence, the total government expenditure from 2004 to 2009 will be 792 MSEK. Assuming a 4 percent interest rate and an 8 year depreciation period for all reported actions (set equal to the default saving lifetime), the annualised government expenditure is 118 MSEK.

The cumulative gross savings of 5.8 TWh over the 8 year saving lifetime is equivalent to annual gross savings of 726 GWh. Adjusting for the potential free-rider effect which has been estimated to be in the wide range 0 to 50 percent, means net annual impact is somewhere between 363 and 726 GWh.

As a result the ratio between government expenditures and net annual impact is in the range 0.16-0.32 SEK/kWh, which converted to Euro equals about 0.015-0.029 Euro/kWh. This relatively high programme cost is clearly a result of the tax exemption. Including only the administrative costs the government programme expenditures is equivalent to 0,008-0,017 SEK per kWh saved.

End-users

For the end-users the expenditures involved in PFE are the investments for the reported actions, as well as the administrative expenditures for implementing the EMS, applying the routines and coping with the documentation and reporting procedures. In the second year report the companies have stated that the 860 actions involve investments of almost 1,120 MSEK. In an evaluation of the administrative expenditures due to the PFE obligations it is estimated that PFE involves expenditures of about 130 MSEK (Nutek 2008).

Hence, the total expenditures for the companies will be 1,250 MSEK over the program period. Assuming a 10 percent interest rate and an 8 year depreciation period, the annualised expenditure is 234 MSEK. This figure is adjusted with the benefit of the annual tax exemption of 150 MSEK, resulting in an annualised end-user expenditure of 84 MSEK.

The cost-effectiveness from the companies' perspective is thus 0.12-0.23 SEK/kWh (corresponding to 0.011-0.021Euro/kWh). The ratio is lower than the electricity price that these companies nowadays meet, which shows that it has been rational for the companies to increase electricity efficiency. The rationale becomes more evident when acknowledging the cost savings made by the companies from reducing their electricity bills. Assuming a general electricity price of 40 öre/kWh means that PFE through the reported actions (adjusted by the estimated range of the free-rider effect) has reduced companies' costs for electricity with between 145 and 290 MSEK annually.

Society

From the perspective of society the total expenditure is the sum of the expenditures for government and end-users excluding the tax exemption which is merely a transfer of resources within the society. The sum is 1292 MSEK and when applying a 4 percent interest rate and 8 year deprecation period, the results is an annualised expenditure of 192 MSEK.

The cost-effectiveness ratio for society is thus 0.26-0.53 SEK/kWh (equal to 0.024-0.048 Euro/kWh). In the lower end of this range, which reflects a low free-rider effect, the cost-effectiveness of PFE compare favourable with establishing new generation capacity.

Discussion and final remarks

Reporting about PFE has so far cited the program as successful. Voices repeating this message belongs to the SEA, participating companies and industry associations, which all refer to: that substantial savings are expected, that the set up provide benefits in being both generous and flexible, and that the program is helpful in organising energy management within the companies. Can these positive statements, more than showing that PFE has been gladly accepted, also provide evidence for a successful policy implementation?

What is the meaning of success or failure in an evaluation context? With a theory-based evaluation approach the judgement is a more complex issue than it is for a strict impact evaluation. In the latter case a policy program is successful if it induces energy savings that fulfil expectations. Expected impact is preferably manifested by clear targets that have been formulated already in the planning process of the policy program. Since no clear targets have been formulated for PFE it is not possible to judge success based on target achievement. A second important indicator of success in the impact evaluation is at what cost the policy instrument has created its impact. A policy instrument that, at a defendable cost, is able to fulfil its energy saving or efficiency targets is clearly successful from an impact evaluation standpoint. Again, the lack of clear targets makes it difficult to make this judgement. However, it has been possible, as shown in this paper, to estimate the cost-effectiveness of the reported actions. Assuming a low free-rider effect the cost-effectiveness from the society point of view is indeed favourable compared to establishing new generation capacity.

A TBE approach shares with the impact evaluation approach the ambition to evaluate whether impact agree with expectations and if cost-effectiveness is reasonable. Moreover, a TBE suggests that indications of success and failure are to be identified throughout the policy process, from early planning and design phase to implementation and evaluation. By taking an interest in the subordinated program components of cause and impact TBE can make judgement about success and failure also at the more detailed level. This paper has confirmed PFE to be successful in attracting a large share of eligible electricity use, but failing by missing out on the large group of eligible companies that have little experience in energy management. The second example of the process evaluation showed that the question if whether required electricity savings can be expected is resting on shaky grounds. No real effort has been made to translate the vague requirement into something uniformly understood by participating companies and other possible stakeholders. Anyhow, acknowledging the low price elasticity on electricity it is most likely that the sum of the reported saving actions will exceed what would have been the effect of the minimum tax. Admittedly, with its blend of policy instruments PFE should be capable of providing more creative impetus for energy efficiency improvement than the insignificant 0.5 öre/kWh cost difference that the minimum tax would bring. Participating companies often state that the program has been helpful in putting energy issues on the agenda and organising energy management work. These are program outcomes that may prove to have a long term effect.

Glossary

EMS – Energy management system
LCC – Life cycle cost
LTA – Long term agreement
PFE – the Swedish programme for improving energy efficiency in energy-intensive industries
TBE – Theory-Based Evaluation
VA – Voluntary Agreement

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