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An energy efficiency program for Swedish industrial small- and medium-sized enterprises

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Abstract

Industrial energy programs such as energy audit programs and Long-Term Agreements (LTAs) are one of the most common means of promoting energy efficiency in industry. As a result of the European Energy End-Use Efficiency and Energy Services Directive from 2006, the Swedish Government Bill proposed a national energy program towards industrial small- and medium-sized enterprises using more than 500 MWh energy annually. The aim of this paper is to present the structure and design of the program, adopted in 2010, the logics in brief behind the structure, as well as an ex-ante evaluation of the program's cost-effectiveness. The proposed design primarily includes a subsidized energy audit with some minor LTA-elements, such as the need to report results from the energy audit, to present a plan over which measures to conduct, and for a period of three years annually, to present which measures that were implemented. The ex-ante evaluation of the program shows a cost-

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effectiveness of 0.25-0.50 Eurocents/kWh, yielding savings of about 700-1 400 GWh annually.

Keywords: energy efficiency; energy audit; industrial energy program; long-term agreements; industrial SMEs

1. Introduction

Climate change coming from the use of fossil fuels is posing a threat to the environment. Industrial energy efficiency is one of the most central ways of reducing this threat as there is a large untapped potential for energy efficiency in industry [1]. However, there are a number of publications stating the existence of a ‘gap’ between potential cost-effective energy efficiency measures and measures actually implemented [2-4]. This is often referred to as the ‘energy efficiency gap’ or the ‘energy paradox’ [5]. The existence of this ‘gap’, in turn, is explained by the existence of various barriers to energy efficiency [5]. Industrial energy programs such as energy audit programs and Long-Term Agreements (LTAs) are one of the most common means of overcoming barriers to energy efficiency in industry [6-8]. A overview of Swedish industrial energy end-use programs shows that Sweden have not had any national programs towards industrial small- and medium-sized enterprises (SMEs¹) since 1990 [9], and an international comparison shows that this is not an endemic feature related solely to Sweden [10]. The three largest Swedish industrial programs include [9]:

- EKO-Energi (1994-1997), a voluntary agreements program towards around 70 energy-intensive companies [11];

¹ In this paper, SMEs are defined as companies with less than 250 employees.

- PFE – Program for Improving Energy Efficiency in Energy-Intensive Industries (2005-), an LTA towards electricity intensive industry involving about 120 companies; and,
- Project Highland (2003-2008), a local clean-cut energy audit program in six Swedish municipalities involving 340 SMEs among where about 140 were industrial enterprises.

As a result of the European Energy End-Use Efficiency and Energy Services Directive from 2006, the Swedish Government Bill [12] proposed a national industrial energy program towards industrial SMEs using more than 500 MWh annually. The aim of this paper is to present the structure of the Swedish energy program towards industrial SMEs adopted in 2010, the logics in brief behind the structure, as well as an ex-ante evaluation of the program's cost-effectiveness. So far, no such paper has, to the authors' awareness, been published. As Väisänen *et al.* [13] writes: *it looks like most of the energy audit programs have been built by using the learning by doing method, which is not the most efficient way of developing program level activities.* The importance of this type of research is vast as the design of successful industrial energy programs enables large reductions in CO₂ emissions to be achieved [1]. Moreover, the transparency regarding the logics on which an industrial energy program may be based upon, enable pros and cons to be spotted, which in turn enables for more efficient design of future programs.

2. Methodology

Initially, a group was set up by the Swedish Energy Agency, which, on behalf of the Swedish Government, were asked to propose a design of the future industrial energy program [12]. The group consisted of various national specialists in the field of industrial energy efficiency, the

majority working within the Swedish Energy Agency. Two lawyers, one external and one from the Swedish Energy Agency, were also engaged. Moreover, one external specialist (the corresponding author) was responsible for delivery of a proposed program design, based mainly upon related scientific research in a Swedish context, in the area on how a program could be designed.

The methodology was in brief carried out as follows: first, an initial meeting was held at the Swedish Energy Agency with numerous executives in the energy field. Thereafter a group was formed. Next a literature study was conducted leading to a report on how a program could be designed. The working group then reviewed the report, and in addition, seven interviews were held, either by phone, or by meeting the person, and a workshop was held within the National Research group STIND (STatistics in INDustry), where national specialists on energy efficiency in industry were asked to give their view on the design of the program.

The method used was in particular a literature study of related scientific journal and conference papers, national and international reports on energy audits and energy programs towards industrial SMEs, and publications on studies regarding barriers to energy efficiency among Swedish industrial SMEs. Moreover, the proposed design of the energy audit program was partly based on the comprehensive work done by Väisänen *et al.* [13]. Based on Christensen and Aamodt-Espegren [14], results from the Norwegian and Finnish programs in terms of cost-effectiveness were also included². It should be noted that a full comparison between the Finnish and the Swedish program is not unambiguous as the Finnish energy audit program, in 1997 also included VA (Voluntary Agreement) elements such as investment

² In order to compare figures, one Euro was assumed to be equivalent to 10 Swedish SEK in this paper.

subsidies [15]. For a more in-depth analysis of the Finnish program, please see Khan [15]. For a more in-depth analysis of the Norwegian program, please see Modig [16].

In addition, and inspired by Yin [17], the proposed structure on how a program could be designed, based upon scientific research, was triangulated³, using semi-structured interviews as well as a workshop with seven participants, covering a total of 14 respondents, where the proposed program design was asked to be commented upon. One may question why triangulation was used to increase the validity of the program design? However, research in the field state that barriers to energy efficiency differ widely between sectors and regions [18]. It is thus of great importance that the design is contextualized into the region's specific conditions. One may also question the triangulation as in-depth interviews, which may include a degree of bias including personal or organizational opinions, etc.? As the numbers of respondents were spread among various different organizational representatives⁴, and the answers from the respondents turned out to coincide fairly well with both each other and the research which the design was based upon, the degree of social desirability biases (SDB) may be stated to be, if not insignificant, of lower importance.

Fig. 1. shows, based on Vedung [19], a simple system model. The paper describes the inflow into the “political black box”. The methodology presented in this section regards the formation of knowledge on how the Swedish industrial energy program was formed. However, after this theoretically developed design was presented, various other factors influence the practical implementation, such as political goals, the national budget, and of

³ Triangulation means that more than one method or information source is used [17].

⁴ The persons interviewed were related to the future program, either by working at some of the plausible Operating Agents, such as Regional Energy Agencies or the County Administrative Board, or by leading scientific research related to industrial energy efficiency and industrial energy programs. In addition, one government official as well as energy auditors who had been working with the largest, in terms of participating firms, Swedish energy program, were interviewed. Moreover, an interview was held with a respondent involved in the Norwegian program.

course various other factors, wherefore the final design of the program deviated some from the initial proposition.

Fig. 1. A simple model on political decision-making. The dashed line represents the system boundary on how far scientific research can make contribution to energy policy decision-making (based on Vedung [19]).

3. Industrial energy management and programs

3.1. Public policy decision-making

As stated in the introduction, research states that there exist a number of barriers to energy efficiency which inhibits adoption of cost-effective energy efficiency measures [2-4]. The mere existence of barriers may however not justify adoptions of public policy instruments aiming to eliminate these barriers. Public policy decision making often relies on mainstream economic theory stating that in order for a policy instrument to be adopted [20]: i) the barriers it aims to eliminate should be regarded as market failures or market imperfection such as information imperfections and asymmetries; ii) it should be able to state that the cost-effectiveness of the policy is high enough to justify the public money put into the program. Barriers which are not classified as market failures or market imperfections may be classified as solely market barriers which in principal refers to any factor which account for the energy-efficiency gap [5].

3.2. The European Energy End-Use Efficiency and Energy Services Directive (ESD)

In order to promote energy efficiency within sectors not covered by the EU Emissions Trading Scheme (EU ETS), EU launched the ESD. The ESD was put into action in 2006, and propose a reduction in energy use of nine percent in each member state, to be achieved by the ninth year of application of the directive [21]. The purpose of the ESD is to enhance cost-effective improvements of energy end-use efficiency in member states by: (a) providing the necessary indicative targets as well as mechanisms, incentives and institutional, financial and legal frameworks to remove existing market barriers and imperfections (market failures) that impede the efficient end-use of energy, and (b) creating the conditions for the development and promotion of a market for energy services and for the delivery of other energy efficiency improvement measures to final consumers [21]. In other words, the ESD takes a leap further than traditional public policy decision-making based on mainstream economic theory as the directive's aim is to reduce not only market failures or market imperfection but also market barriers.

3.3. Barriers to energy efficiency

An industrial energy program aims to reduce barriers to energy efficiency. The ESD gives the existence of barriers to energy efficiency, and in particular, gives the elimination of market barriers and market imperfections a central role in the transition of the energy system. By so, it is of importance to detect which barriers that are restraining markets for energy efficient technologies in order to effectively reduce these barriers. In Sweden, a few studies on barriers to energy efficiency have been conducted [9,22-23]. The major barriers to energy efficiency were found to be: *lack of time or other priorities/other priorities for capital investments, lack of access to capital/lack of budget funding, cost of production disruption/hassle/inconvenience, technical risk such as risk of production disruptions, difficulty/cost of obtaining information on the energy use of purchased equipment* [9,22-23].

Apart from *cost of production disruption/hassle/inconvenience* and *technical risk such as risk of production disruptions*, the spotted barriers indicate a clear need for external support (*lack of time and other priorities*), that this support should be of low cost (*lack of access to capital*) and should involve information to the companies (*difficulty/cost of obtaining information*) [9,22-23]. It should be noted that the spotted barriers also could indicate a need for other types of external support, such as from ESCOs (Energy Service Companies), apart from the provision of energy audits in an industrial energy program.

3.4. Industrial energy management

Industrial energy management is stated to play a central role for industry in becoming less carbon-intensive [24]. A number of important elements need to be included in the set-up of a full-scale in-house industrial energy management program. These include a strategic approach, including the formulation of a long-term energy strategy with full support from top level management [25]. Moreover, it should involve an initial energy audit to be conducted at the company, the adoption of a monitoring system, as well as a well structured energy plan [25]. An industrial energy program for industrial SMEs that goes beyond the traditional energy audit approach, and which also included energy management practices thus seems desirable. It should be noted that the national Swedish LTA-program, the PFE, involves the certification of an EMS (Energy Management System) according to the European standard. A full-scale energy management program, including, e.g. the certification of an EMS however, may not be possible to implement among the majority of the industrial SMEs, not the least if it would be included in an energy program based on the previous research on barriers to energy efficiency in the sectors, such as *lack of time and other priorities*, etc. [9,22-23]. Some energy management elements, which do not demand too much effort from the company, and

which aims to promote a more comprehensive work with energy efficiency, would though be desirable to include.

3.5. Industrial energy programs

The design of an industrial energy program covers a number of elements that needs to be considered, such as the formulation of program goals, choosing implementation instruments, identify key players, and set up the structure of administration [13]. Adequate goals are of outmost importance for program success [13]. The formulation of the program goals include, e.g. target sectors to be chosen, the free-rider coefficient to be estimated, total energy audit volumes, as well as the effects of the program to be considered [13]. Legislative framework, subsidy policy, promotion and marketing are found among the implementation instruments. As regards key players, four main players are of importance according to Väisänen *et al.* [13]: the Administrator, the Operating Agent, the Auditor, and the Client. The Administrator is the one initiating the program, usually a governmental department, while the Operating Agent is responsible for operating the program and accountable towards the Administrator [13]. The Auditor in turn conducts the energy audit and has the closest contact with the Client. Usually, either the Auditor or the Client reports the results from the energy audit back to the Operating Agent [13].

The cost-effectiveness of a program is dependent on the size of the subsidy [13]. A too small subsidy will lead to participation only for those companies which would have conducted an energy audit anyway. A too high subsidy, on the contrary, reduces the cost-effectiveness of the program. The company's interest is also dependent on the relative size of the subsidy. A 100% subsidy creates the risk of low interest from the companies regarding the energy audit results. If the program is voluntary, marketing should be a central part of the program [13].

An industrial energy audit program demands more resources in the initiation phase than during the actual operation of the program. This means that the longer the program last, the more cost-effective it will be [13]. It is therefore important to consider a more long-term scenario for industrial energy programs than for example, for energy policies involving solely an investment subsidy for energy technologies [13]. As stated in the introduction, the Swedish Government Bill [12] proposed, partly based on result from Project Highland [9], energy audits towards industrial SMEs. The coming section outlines the proposed design of the Swedish energy program, including in brief the logics on which the proposed program was based.

4. A Swedish industrial energy program for industrial SMEs

4.1. Fully or partly subsidized energy audits

The degree of subsidy varies between programs and countries. The world's largest energy audit program – the American IAC (Industrial Assessment Centers) – offers industrial SMEs energy audits free of charge without any agreements [8]. The Finnish program offers a subsidy of 40% of the energy audit cost, while the Norwegian program offered energy audits free of charge, with some requirements to be met as regards energy management practices [13-14]. From a strictly public financial perspective, it is more effective to offer partly subsidized audits, this due to that the program's cost-effectiveness is enhanced, i.e. the kWh saved per public Euro invested in the program becomes greater. From the energy auditor's perspective, this is of course also beneficial, as this most likely will increase the attention given from the involved companies. Moreover, a partly subsidized program leads to companies joining the program that most likely have an interest in the issue. This is perhaps also the largest disadvantage with such a design – companies which may not have the time

(the largest barrier to energy efficiency among the evaluated SMEs within project Highland [9]) face the risk of not participating in the program if no demand for such energy audit is stated. On the contrary, such companies may not be as interested in actually implementing measures spotted in the energy audits. How such a subsidy is to be designed is thus not easy to state, and as stated above, international comparisons show that subsidies differs widely between programs. As the Swedish industrial energy program is a means in line with the EU's intention to lower the overall energy use (through e.g. the ESD where energy audits is stated to have a central role to play), it seems desirable that as many companies as possible joins the program. In other words, it seems desirable to offer partly subsidized energy audits. The Finnish program was found to be the most cost-effective in an evaluation of 42 European programs [13-14], which in the beginning offered energy audits with a 50% subsidy (and later 40% when the program turned mature), wherefore it was decided that the energy audits should be offered with a 50% subsidy, i.e. half of the audit cost.

4.2. The scope of the energy audits

The cost-effectiveness of an energy audit depends on both the size of the subsidy and if the energy audit includes investment assessments. The Swedish energy program, Project Highland, which in terms of participating companies is the largest Swedish energy program since 1990, involved so called "walk-through" audits, not including investment assessments. When comparing this program with the world's largest energy audit program towards industrial SMEs, the American IAC, where some 13 000 energy audits have been made since the 1990ies, and which included investment assessments, it was seen that the number of implemented measures were higher in IAC [26]. Around 50% of the measures were implemented in the IAC program and 20% in Project Highland [9,26]. In the above figure for Project Highland it should be noted that planned measures were not included. If these are included, the figure rises to about 40% [9]. Another comparison with the Australian EEAP

(Enterprise Energy Audit Program), offering energy audits with a 50% subsidy, and which also included investment assessments, showed that around 80% of the measures were implemented [27]. As regards proposed measures in the energy audit reports, the average number of measures in Project Highland was considerably larger; 13 compared to IAC's and EEAP's seven measures on average [8-9,27].

Even though the inclusion of investment assessments of the measures spotted in the energy audits may increase the number of implemented measures, it may be difficult to include as there are extensive costs (for the energy auditor) related to this, which in turn creates a risk of lowering the program's cost-effectiveness. To include investment assessments in form of straight pay-off periods for each measure is however more simple and should not lead to extensive cost increases for the energy auditor. The audits within the program were therefore suggested to include simple investment assessments in form of straight pay-off periods. Moreover, it was suggested that the Swedish Energy Agency should present general figures for common energy efficiency measures⁵. The latter would support the energy auditors in the important work to include pay-off periods and by the same time reduce the audit cost, and thus also increase the cost-effectiveness of the program.

Another important aspect regarding the scope of the audits and the energy program was that the program, unlike the PFE, was suggested to focus on all energy carriers, however with a primary focus on reducing the use of electricity. The latter was due to the fact that many Swedish industries are using considerably more electricity than their European competitors,

⁵ The implemented measures from project Highland included the following measures (implemented/(implemented and planned)): Space heating: 22%/27% Ventilation: 24%/23% Water: 3%/4% Lighting: 14%/19% Compressed air: 17%/17% Production processes: 13%/15% Educational: 5%/11% [9].

and that the harmonization of the European electricity market will lead to higher prices in Sweden, leading in turn to the risk of competitive disadvantage for the sector [28].

4.3. The coverage of the industrial sector

In the Swedish Government Bill [12], it was proposed that the companies using 500 MWh per year or more should be targeted. No argument for this was stated. With an estimated energy cost of 40 Euro/MWh, this means that companies using 500 MWh annually have energy costs of at least 20 000 Euro/year. Based on the evaluation of the Swedish energy program, Project Highland, with energy audits taking about two days of work, such “walk-through” audits should be seen as an absolute minimum. With a cost for a consultant of around 100 Euro/h, the cost for an audit was estimated to be around 1 500 Euro, excluding costs for metering and travel expenses. With all costs included, a total cost of 2 000 Euro for the audit seemed reasonable, which is about 10 percent of the smallest company’s annual energy costs. To offer subsidized energy audits amounting to 10% of the company’s energy costs, yet at the very least 1 000 Euro, would yield a natural lower boundary, with the constraints of a minimum of 500 MWh in annual energy use, the latter minimum proposed by the Swedish Government [12]. However, using this criteria and an estimated energy cost of 40 Euro/MWh, companies using 5 000 MWh per year, would gain a subsidy (10% of the company’s energy use) of around 20 000 Euro or more, something which may be considered way too high, this due to the fact that the costs for audits towards larger SMEs may not increase linearly. Not the least, taking into consideration that the average energy use for the industries in Project Highland was about 4 000 MWh/year, which revealed an audit cost of around 1 500 Euro/industry on average. This indicates that energy audits for industries using up to around that size is assumed to be able to conduct in about two days. A proposed size of the subsidy for the energy audits was thus set to be, at the very lowest 1 000 Euro, which is half of the estimated cost of a two day audit, excluding cost for program administration. As the program’s target

sector were industrial SMEs, an upper limit of 3 000 Euro was suggested, excluding cost for program administration. The latter upper boundary may be argued to be a bit arbitrary and was not based on research in the field as no such could be found. Rather it was a consequence of attempting to minimize the free-rider effect and maximizing cost-effectiveness of the program. If no limit is set, then larger companies joining the program would use considerable parts of the program budget, even though they are not the target sector of the program. Moreover, it may be assumed that these companies have the resources and the economic capability to conduct audits even without subsidies.

4.4. A clean-cut energy audit program or a LTA program

Studies that have been conducted on industry's view on various energy policies state that industrial SMEs are not interested in full-scale LTAs like the PFE [29]. Based on previous research on barriers to energy efficiency in Sweden, outlined in section 3.3, and previous international studies regarding energy programs towards industrial SMEs, e.g. Shipley and Elliot [6], this may be explained by severe limits of time, resources, etc. While a larger company may have its own staff working fully committed to energy efficiency and energy management, SMEs do not have such abilities [6]. However, based on research on energy management, and its potential outlined in section 3.4, it seemed reasonable to include some LTA-elements into the program. Based on Caffal's [25] research on important factors for energy management, and partly based on the Norwegian program, which in the previously cited evaluation of 42 European energy programs was the second most cost-effective [13-14], the design of the Swedish program were suggested to include the following LTA-elements:

- that the company reports the results from the energy audit, including the annual energy use;
- that the company presents the potential energy efficiency measures spotted in the energy audits, including an overall energy efficiency potential;

- that the company presents a simple energy plan over which measures they plan to conduct, including when, in time, this is suppose to take place. Mandatory requirements to implement the measures however, were not included; and,
- after receiving the subsidy, the company should annually, for a period of three years, present which measures that were implemented, alternatively, that no measures were implemented.

Yet another requirement is that the companies are not participating in any other Swedish industrial energy programs such as the PFE.

4.5. The choice of Operating Agent and involvement of the local authority

As regards the Operating Agent, there were three main actors to choose from: the Swedish County Administrative Board, the Swedish Energy Agency, and the Regional Energy Agencies. The outcome of letting the Swedish County Administrative Board operate the program was considered uncertain, as they would both have the role of promoting energy efficiency (through the program) and their role as enforcer of the Swedish Environmental Code. Despite this, the Swedish County Administrative Board could enforce industries to actually conduct energy audits and by so, increase the number of participation companies. This design was supported by a respondent from the Swedish County Administrative board. It would then be of great importance that these enforcements are not set stricter than the requirements included in the program. The Regional Energy Agencies' role as Operating Agent may also be seen as somewhat uncertain as the agencies currently lacks industrial experience on a national level. This was confirmed by a respondent from a Regional Energy Agency.

Regarding the Swedish Energy Agency's role as Operating Agent, it seems to be the most adequate choice with a clear competence on industrial energy efficiency, without the role of enforcer, and with years of experience with the other Swedish program, PFE. The Swedish Energy Agency was therefore suggested as the Operating Agent for the program.

As regards the role for the Regional Energy Agencies, it was proposed they become responsible for collecting the energy audit reports and for the annual evaluation of the energy audits, this due to three major factors: first, this enables an overview of what is being done in the region, which is crucial in the evaluation of the regional climate goals set by e.g. the Swedish County Administrative Board. Secondly, this enables for the participating industries to address questions regarding the energy audits to an objective actor. This would plausibly also increase the degree of participation in the program and not the least the implementation of measures. Thirdly, it promotes the set up of regional networks. Inspired by the Norwegian program, the Regional Energy Agencies are also proposed to be responsible for the accreditation (education) of the energy auditors.

Based on the design of the Swedish program, Project Highland, it was suggested that the public-sponsored local authority energy consultants become responsible for the marketing of the energy program. According to some companies involved in Project Highland, the project was perceived "the best" the municipality had ever done to support their business, which supports a local base of the program. By involving the local authority energy consultants in the marketing, the program is anchored locally, as also argued by e.g. Persson [30] to be a successful approach.

In summary, the Operating Agent for the program was decided to involve three actors, the Swedish Energy Agency, the local authority energy consultants, as well as the Regional Energy Agencies. Furthermore, the Administrator of the program was decided to be the Swedish Energy Agency. Moreover, the Auditor was decided to primarily include private consultants.

4.6 Program goals

As stated previously, the formulation of program goals are of outmost importance for program success [13]. As regards the target sector, the Swedish Government Bill stated industrial SMEs to be the primary target sector [12]. As regards the life-span of the program as well as total energy audit volumes, the former was set to five years, 2010-2014, with the aim of achieving a total energy audit volume of 900 companies or 25% of the Swedish companies able to join the program. As regards the cost-effectiveness of the program as well as an estimation of the free-rider effect, these goals are presented in the following section.

5. Ex-ante evaluation of the proposed industrial energy program

5.1. Cost-effectiveness of the program

The economic potential for energy efficiency in European SMEs is at least 20% according to Bertoldi [7]. Figures on potentials for the Swedish industrial SMEs vary between 50% [28] and downwards to between 15-20% [9]. Even though, the evaluation of the largest Swedish program, Project Highland, was too small in order to draw any general conclusions, the European economic potential of 20% support the potential outlined in Project Highland. The evaluation of Project Highland showed savings of 1.16 Eurocents/kWh (86 kWh/Euro) [9]. When planned measures are included, the figure decreases to 0.51 Eurocents/kWh (195 kWh/Euro) [9]. Results for the two most cost-effective programs in Europe showed figures of

0.18 Eurocents/kWh (Finland, 4 900 companies) and 0.30 Eurocents/kWh (Norway, 530 companies) where the cost-effectiveness originates from the program period [14]. It should be noted, however, that these programs were mature programs, which had been under operation for many years, unlike Project Highland, which was running only a few years. While the Finnish program has overhead costs of about 15%, Project Highland had figures of around 50% [9, 14].

A pessimistic estimation of the results for the proposed program, in terms of reduced kWh per public Euro invested in the program, including cost for program administration based on the evaluation of Project Highland, is about 1.0 Eurocents/kWh. As these energy audits did not include more than half of the measures being quantified, and moreover, did not include investment assessments, a reasonable estimation would be at least twice more effective, i.e. 0.50 Eurocents/kWh. However, the latter does not include the fact that the proposed program only offers about half of the audit costs, i.e. 1 000 Euro per audit is offered in subsidy compared with an estimated cost of about 2 000 Euro per audit, excluding program administration costs, compared with Project Highland's fully subsidized energy audits. A more optimistic estimation, based on this, would thus be 0.25-0.33 Eurocents/kWh. Comparing this optimistic estimation with the outcome of the Norwegian and Finnish programs, 0.30 Eurocents/kWh and 0.18 Eurocents/kWh respectively, confirms these results [13-14].

The proposed budget for the Swedish program was estimated to be around 3 500 000 Euro, where about 30% of this or 1 000 000 Euro, was estimated to be allocated for program

administration. This implies implementation of energy efficiency measures saving about 700-1 400 GWh annually⁶.

5.2. Validation of the ex-ante evaluation including an estimation of the degree of free-rider effect

Indeed, the above outlined figures may be stated to be quite effective, compared with other European programs than the Finnish and the Norwegian, and moreover, do not include an analysis of the business as usual case, i.e. how many of the measures that would have been implemented anyway due to rising energy prices, etc. However, the previous evaluation of Project Highland revealed, through triangulation with the local authority energy consultants, that measures would not have been implemented without the energy audits [9]. As regards the free-rider effect for companies that would have conducted an energy audit anyway, this free-rider effect is known to be very low for industrial energy programs majorly involving energy audits [13]. The stated figures may therefore be seen as a probable and valid outcome of the program. Moreover, it should be noted that research on evaluation of energy audits reveals that an audit may lead to extensive behavioral changes as large as the energy saving measures implemented from the energy audit report [31]. Furthermore, due to the fact that industrial energy audit programs create new business opportunities, tax revenue will increase and cost for unemployment will decrease [13]. If these factors are included, a program may even lead to net positive revenue for the public finances, i.e. increased tax revenues and decreased unemployment costs exceeds the public cost for the industrial energy program [32].

⁶ It should be noted that this figure includes cost for administration.

6. Conclusions

The methodology by Väisänen *et al.* [13] was shown to provide adequate support in the design of an energy program toward industrial SMEs. Some additional methodological improvements, such as the need to include the addressed issues from the ESD, was found to be of importance, in addition to Väisänen *et al.* [13]⁷, when setting up an industrial energy program such as . For example, the availability of both Regional Energy Agencies and local authority energy consultants in a Swedish context implied the need to extend the key players outlined by Väisänen *et al.* [13] to include more than one actor as the Operating Agent. Furthermore, the inclusion of results from recent research on barriers to energy efficiency in a national context proved to be highly useful.

The proposed energy program aims towards industrial SMEs with an annual energy use of more than 500 MWh. The design primary includes a subsidized energy audit with some minor LTA-elements. The program is estimated to result in saving of 700-1 400 GWh annually, offering half of the audit cost, at the very lowest 1000 Euro, with an upper limit of 3000 Euro. The ex-ante evaluation of the program shows a cost-effectiveness of 0.25-0.50 Eurocents/kWh. Moreover, the free-rider effect is estimated to be low in the program. In conclusion, the ex-ante evaluation and the estimated low free-rider effect thus clearly indicate that the program fulfils the criteria for adoption of the program, i.e. the benefits outweigh the costs.

The Swedish energy audit program is a result of Sweden's obligations to fulfill the European Energy End-Use Efficiency and Energy Services Directive. The program is planned to last for five years up until 2014. Based on the fact that Sweden previously have shown minor interest

⁷ It should be noted that the work was written before the ESD was finalized.

in regard to national energy programs towards SMEs, it is uncertain whether the program will last beyond the planned period. If cancelled after the program period, it is unquestionable that the Swedish program's ex-post evaluation figures will not turn out to be as good as the well-structured, mature American and Finnish programs. Based on evaluation of, e.g. the Finnish program, stating that it takes many years to reach high auditing volumes, it is however most likely that the Swedish program will last up until 2020, if Sweden is aiming to fulfill the 20-20-20-targets set by the EU. It should be noted that the proposed program design, based on the above outlined methodology, is presented for Swedish conditions. This implies that while the logics on which the design was based upon may be generalized, some parts of the actual design may not, this due to that e.g. results from the empirical studies on barriers are strictly country specific. Moreover, as the research on which the design was based upon involves complex real-world phenomena, involving people, organizations, and technology, etc., the proposed program design may be understood as a theoretical construction, not as the perfect design of an industrial energy program for industrial SMEs. The design may also be criticized for focusing on energy end-use rather than on primary energy – these concepts were intensively debated during the Energy Efficiency Committee that preceded the Swedish Government Bill [35]. A simple way to consider primary energy as well as greenhouse gas emissions may be to prioritize measures using tools like e.g. the heating hierarchy presented in Fig. 2. Yet another general critique towards energy programs and in particular energy information programs like energy audit programs, are that underlying information barriers may not be categorized as market failures or imperfections but rather is a consequence of “normal” market phenomena. Future research and experience will certainly enable design of programs to be improved as well as ex-ante figures to be validated against ex-post evaluation figures. The importance of presenting the structure and design of energy programs for industrial SMEs, including the logics in brief behind it, should however not be understated, in

the ongoing important process of transitioning energy systems including industrial such, into increased sustainability.

Fig. 2. The Heating Hierarchy. States the priority order for how energy sources shall be chosen for heating purposes. Surplus energy is energy that is wasted if it is not used for heating. Waste fuels are e.g. household waste. Residues are secondary biomass from e.g. agriculture or forestry. Primary biomass is biomass for immediate energy use, e.g. energy crops. Electricity is a high-value energy carrier that is more suitable for other purposes than heating. And finally, fossil fuels have an obvious negative effect on both climate and the use of primary energy (based on Larsson and Persson [33] and Gode et al. [34]).

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