NON-PEER-REVIEWED PAPER

Swedish energy manager networks for energy-intensive industry as a driver for improved energy efficiency

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Keywords

energy-intensive industry, energy efficiency policy, energy efficiency network

Abstract

While the potential for improved energy efficiency in industry is large, deployment of measures is often inhibited by a number of barriers. In order to overcome these barriers, a number of energy end-use policies is functioning in Sweden, the two largest being a Voluntary Agreements (VA) for energy-intensive industry, an energy audit program, and in addition, various energy manager networks for improved energy efficiency. While the two former have been evaluated and are well-known, the Swedish energy efficiency networks have so far neither been presented nor evaluated previously. The aim of this paper is to present the current Swedish energy efficient network, and their role in the energy policy mix from a theoretical viewpoint. The Swedish energy network, Energiintensiven consisting of about 100 companies from the major electricity-intensive sectors is administrated by the Swedish Energy Agency. Participating companies are all part of the Swedish VA, the PFE. In addition the aluminum companies have an energy network (GeniAl), one network is functioning among Swedish saw mills (EESI), as well as there is a network in the iron- and steel industry ENET-Steel. Results of the paper show that despite the low emphasis on networks as a part of the policy mix, the networks have an important role in overcoming barriers to energy efficiency among the participating companies.

Introduction

Energy efficiency in industry is given more attention than ever before due to increased regulation from the EU, in turn a consequence of the Union's strive for a more carbon-neutral and competitive society. While the potential for improved energy efficiency in industry is large, deployment of measures is often inhibited by a number of barriers. In order to promote improved energy efficiency in industry and overcome barriers to energy efficiency, the Swedish government has designed and implemented a number of energy end-use policy instruments, the two largest in terms of participating companies being the Program for Improving Energy Efficiency in Energy-Intensive Industry (PFE), and the Swedish Energy Audit Program (SEAP). The first is voluntary agreement (VA[1]) in the most energy intensive industry, and the latter is a program for subsidized energy audits in industries with energy consumption above 500 MWh annually. In addition, the Swedish Environmental Code (SFS 1998:808) is a law that may be used to force industry to invest in technologies with high efficiency.

In addition to this, the Swedish Energy Agency has initiated several networks for energy managers aimed to facilitate energy efficiency in industry: Energiintensiven, consisting of about 100 companies from the major electricity-intensive sectors is administrated by the Swedish Energy Agency. Participating companies are all part of the PFE. Also, the enterprises within aluminum business as well as saw mills and iron- and steel industries have branch specific networks for energy efficiency. While the PFE and the SEAP have been evaluated and are well-established, the Swedish energy efficiency networks have so

1. For a more comprehensive presentation of VAs, please see Price (2005) Rezessy and Bertoldi (2011).

been scientifically scrutinized evaluated. The aim of this paper is to present the current Swedish energy efficiency networks among the energy-intensive industry, and analyse their roles in the energy policy mix in relation to previous research on barriers for energy efficiency.

This paper initially gives an overview of industrial energy use in Sweden and then presents some of the major obstacles and barriers to energy efficiency identified in previous research. Thereafter the present Swedish energy manager networks in energy-intensive industry are presented. The information about these networks is primarily based on information from the Swedish Energy Agency. In order to understand the networks' role in the Swedish energy policy mix, the networks' characteristics are related to the known barriers to energy efficiency. Hence the networks' potentials to aid the networks members to overcome the efficiency barriers are analyzed. Finally, the networks are being related to the actual investment process, using the decision-model outlined in Cooremans (2011), and the complexity ladder of energy efficiency measures.

Energy in Swedish industry

The aggregated annual energy end-use among the about 59,000 industrial companies in Sweden is about 152 TWh (year 2010). About 75 % (about 115 TWh/year) is used in the energy-intensive industry including about 600 companies (PWC, 2007). In Figure 1 and Figure 2, the annual energy end-use in Swedish industry from 1970, is presented. The aggregated energy end-use has not changed significantly over the last 40 years, but a major transition from fossil fuels to biomass and electricity has taken place.

Barriers to energy efficiency

Numerous studies have studied the theoretical and empirical issue of barriers to energy efficiency, e.g. Trianni et al (2012). In Swedish energy-intensive industry, studies have revealed that there are some barriers that are of general nature (Thollander and Ottosson, 2008, Rohdin et al., 2007):

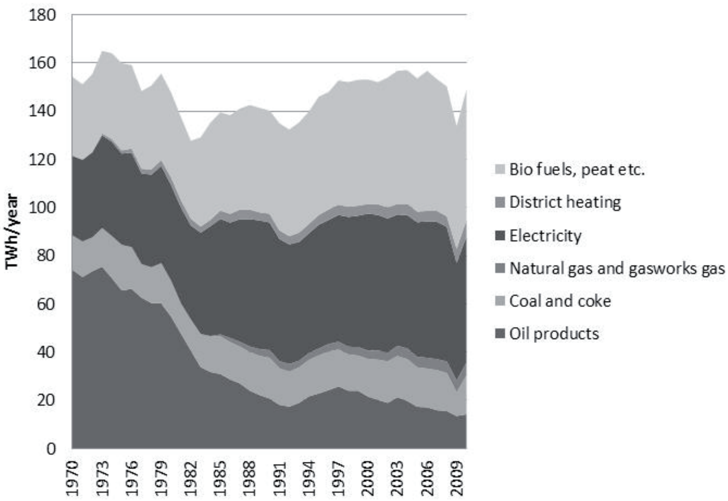

Figure 1. Swedish industries' energy-end-use in TWh/year per energy carrier between 1970–2009 (SEA, 2011). The lower end-use figures for 2009 can be explained by the world-wide economic crisis.

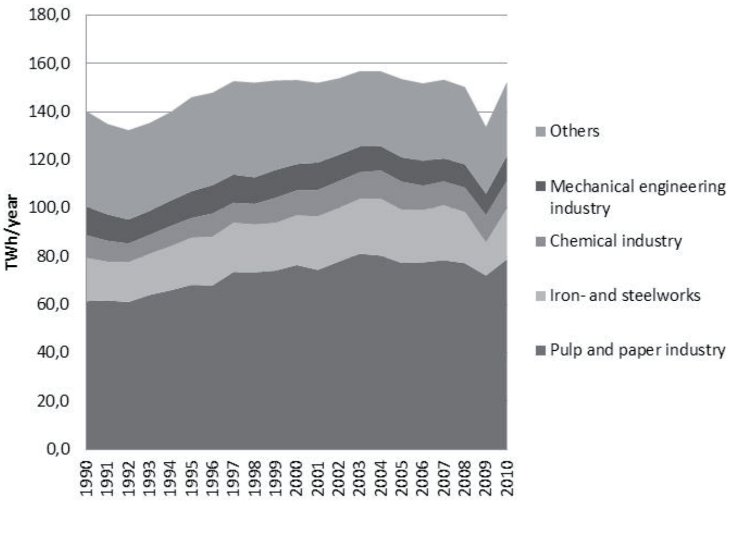

Figure 2. Swedish industries' energy-end-use in TWh/year per sector between 1990–2010 (SEA, 2011).

- Technical risks, such as risk of production disruptions/risk for poor performance of purchased equipment (especially in the pulp- and paper industry).
- Lack of access to capital/lack of budget funding.
- Lack of time and other priorities/other priorities for capital investments.

Barrier studies are specifically focusing on the actual investment decision when it comes to cost-effective energy efficiency investments with the aim to explain why such investments are not made. Using the taxonomy initially presented by Sorrell et al (2000), Thollander and Palm (2013) have presented a revised taxonomy of barriers to energy efficiency investments, see Table 1.

Table 1. Barriers to energy efficiency (Thollander and Palm, 2012).

Classification	Theoretical Barriers
The technical system	Access to capital Heterogeneity Hidden costs Risk
The technological regime	Imperfect information Adverse selection Split incentives Form of information
The sociotechnical regime	Credibility and trust Principal-agent relationship Values Inertia Bounded rationality Power Culture

Swedish energy manager networks in energy-intensive industry

In the following section, the four ongoing manager networks in Swedish energy-intensive industry are presented, and summarized in Table 2. In addition, several local and regional networks are in operation but these are not included in this paper.

NETWORK OF COMPANIES PARTICIPATING IN PFE

The national venue, Energiintensiven, administrated by the Swedish Energy Agency, which began 2005, is a network connected to the Swedish VA-program PFE. This network was created with the aim to share the information about PFE, communicate and exchange experience of participating in PFE companies (Energimyndigheten, 2013). The network, even though entitled a network, only gathers on occasions, not even once a year, and comprises the about 100 companies that are participating in the PFE. On some occasions, there have also been regional network meetings to discuss both technical and organizational issues. These meeting were also open to companies not being participants in the programme. In January 2014, the last gathering took place. As the PFE, as a policy, is now ending in December, 2014, so is the network. The efficiency of the network has not been evaluated and the results have not yet been presented.

ALUMINIUM INDUSTRY NETWORK (GENIAL)

GeniAl (Joint Network for Aluminium enterprises) started in 2011 supported by the Swedish Energy Agency, with the aim to facilitate cooperation within the aluminum business regarding energy efficiency issues (BS, 2013). The overall long-term goal is 20 % energy efficiency improvement in 2020. The network includes companies in the whole aluminum life cycle process from raw material production into upgrading, production of parts for automotive and building industry, foils, boats and finally aluminum recycling. This cooperation gives an opportunity for optimization and innovation within the whole aluminum chain process since it includes many producer–customer connections.

The first phase, running from 2011 to 2013 of the project focused on mapping energy use within the companies in the network, and to build up a branch network. The main goal for the mapping was to identify common challenges in terms of energy losses and thereby finding joint focus areas for implementing efficiency measures. The network was managed by an advisory board with representatives from the branch organization *Svensk Aluminium* together, universities and independent energy experts. The advisory board met every two months and also organized workshops with aluminum companies as part of the mapping and network building.

The results of the first mapping phase showed that the aluminum production phase had the highest impact on energy use and environment. During the use phase aluminum has higher impact from environmental and energy aspect in comparison with its competitive materials. As for the recycling phase, there are not so many other materials with such a high level of recycling as well as rather high energy savings. The results showed also that there is a potential for improvements and how big it is (BS, 2013). During the second phase, which started 2013 and will last until second half of 2015, several subgroups will focus on identifying energy saving potentials, preparing for further investments for different companies. At the same time, energy management systems in several major and innovative companies will be introduced. The information of the results of energy efficiency measures will be shared in the subgroups in order to stimulate the dissipation of experiences towards companies with less developed energy management systems. As regards a third phase, this is not yet decided.

EESI (ENERGY EFFICIENCY IN THE SAWMILL INDUSTRY)

Within the project EESI, supported by the Swedish Energy Agency, a network between sawmills was created with SP (Swedish technical research institute) as a coordinator in 2010. The purpose was to find and demonstrate measures to improve energy efficiency in the sawmill industry by at least 20 % per produced m^3 by 2020. To further support the sawmill industry in improved energy efficiency, one goal of the network is to develop computer models and routines for follow-up the results.

The first phase (2010–2011) included the creation of a general model, and collect energy data from the participants. The evaluation of the first phase showed that there is a great energy saving potential. Moreover, a number of energy saving measures was identified.

During the current phase, phase two, (December 2011–September 2014) the network focuses on implementing the previously proposed measures, and aims to establish sawmill customized energy management system to implement and maintain long term performance. The network contains three main groups with different objectives.

- Research Executors – identify potential solutions and evaluate them.
- Sawmills – owners of the energy issue, identify and work with energy efficiency improvements.
- Suppliers – provide equipment and system solutions that solves sawmills' demand of new technology.

ENET-STEEL

ENET-Steel, supported by the Swedish Energy Agency, was created in 2005 in order to support improved energy efficiency in the mining and steel industries. The aim was experience-sharing within the network regarding operation, maintenance etc. The moderator of the network was the Swedish steel producer association *Jernkontoret*. The moderator organized two types of meetings. The first type was in form of lectures aimed to increase the knowledge about the technical systems as well as to present the energy efficiency requirements. The second type of meetings was held as conferences where the management of the mills could share their experiences of energy efficiency work and discuss the results of their work. The participation of the companies' management was considered important due to this could further facilitate the implementation of energy efficiency measures (Nordqvist and Axelsson, 2011).

Even though no ex-post evaluation of the networks has been done, the network was regarded as successful:

> Very good results have been achieved. The technology and network meetings have had 400 participants, mainly technicians and managers at different levels in the companies.
>
> (Nordqvist and Axelsson, 2011.)

Table 2 summarizes the results of the presentation of the four networks.

Apart from the four networks described above, there is also one network entitled ENIG which is further presented in Hrustic et al., (2011). The ENIG network is not an energy manager network but an organisation to spread energy related information in Swedish industrial sector and was therefore excluded.

The energy manager network's role in the policy mix

POTENTIAL FOR THE SWEDISH ENERGY NETWORKS TO OVERCOME THE ENERGY EFFICIENCY BARRIERS

The energy networks' effect on barriers to energy efficiency are outlined in Table 3.

As can be seen in Table 3, several barriers are related to credibility, uncertainty, and lack of information. The participation in a network, at least in theory, would mean a chance to overcome such barriers due to the opportunities for information-sharing and sharing of experiences. Observing the four Swedish networks described above in terms of their potential to empower participating companies to overcome the theoretically known barriers to energy efficiency it can be noted that there are two factors that are of key interest: how information is shared from experts and between peers and who is the receiver. In order to overcome the barriers it is of greatest importance that the networks are attended by top management, with power to influence investment decisions. Also it is important that these persons are given the opportunity to receive information from credible sources and also meet each other and share experiences. The forms for these meetings are very important: there must be room for peers to actually talk to each other and to have a continual dialogue. It is through dialogue learning is created, which lead to changes in attitudes, norms and values.

NETWORKS RELATED TO INVESTMENT ASSESSMENT AND TYPE OF TECHNOLOGY

Barrier models are normally used to study the non-uptake of cost-effective energy efficiency investments. As stated by Cooremans (2011), investments are not solely related to evaluation and implementation of energy efficiency measures and there is also idea generation, diagnosis, etc. in the investment process before the actual investment decision is being made. Cooremans stayed that a process of decision-making is not a linear process and comprises several constituents starting with an initial idea. Once given, the initial idea is followed by a diagnostic phase which basically is crucial to the decision making as it determines if the initial idea will proceed further. This diagnostic phase determines as well the pattern of the idea's development. After the diagnosis, the development of the idea undergoes the phase where the information is collected and weighted which results in a selection of solutions. This phase is followed by the evaluation and finally implementation phase (Cooremans, 2011). The process of decision-making is constantly affected by different factors: the structure of an organization and external factors on every phase. Figure 3 shows, based on Cooremans (2011)'s decision-model, the role of networks in this process.

Yet another component from the theoretical standpoint is the type of technology that is of primary interest in the networks. Westling (2000) presents the difficulty of measures' implementation in relation to various system levels of energy efficiency measures, se Figure 4. The higher the technology stays on the ladder, the more difficult the implementation of the measure is due to its apparently higher complexity.

Thus, the type of investment is dependent on the complexity of procurement. In the SEAP oriented towards industrial SMEs, the majority of the energy efficiency measures in terms of energy being saved, are found in the support processes such as ventilation, space heating etc. (Thollander et al., 2007, Karlsson et al., 2012). However, for large, energy-intensive industries within the PFE, a major part of the energy efficiency measures is related to the production processes and the pumping systems (Stenqvist and Nilsson, 2012). This provides evidence that the complexity of the investments that has the largest potential for improving energy efficiency in energy-intensive industry is larger than for industrial SMEs. Relating Westling (2000)'s complexity ladder with energy manager networks, it is evident that networks have an important role in Cooremans (2011)'s three first steps, and moreover that these steps may in fact be more difficult to bridge for technologies related to more complex processes, as also stated by Waide and Brunner (2011), Fleiter and Worrell (2012), and Thollander and Palm (2012).

Table 2. Summary of ongoing energy networks.

Network	Started	Sector	# of companies	Administrator	Policy-relation	# of annual meetings
Energiintensiven	2005	All sectors within PFE	100	The Swedish Energy Agency	VA (PFA)	1
Aluminium industry network	2011	Aluminium	57	Swedish Aluminium	None	1
EESI	2010	Sawmill	17 saw mills + 16 machine suppliers	SP	None	2 physical +2 phone
ENET-Steel	2005	Mining and steel industry	52	Jernkontoret	None	2

Table 3. Barriers to energy efficiency on which energy manager networks have potential effects on, based on the taxonomy by Sorrell et al. 2000, later developed by Thollander and Palm, 2013.

Category	Theoretical barrier	Potential effect from network participation
Technical system	Access to capital	No primary effect as this barrier refers to internal factors
	Heterogeneity	Sharing experiences about available measures and technologies within the network reduces the risk of technology inappropriateness
	Hidden costs	Hidden costs such as overhead costs related to investment, costs for collecting and analyzing data may be reduced, or even avoided
	Risk	As managers share experiences of previous technology investments and process improvements, networks contribute to minimized risk aversion
Technological regime	Imperfect information	Improved information on the positive effects of energy efficiency investments and process improvements, may lead to implementation of cost-effective energy efficiency measures
	Adverse selection	Information-sharing among managers already undertaken investment and process improvements, reduces the chance to select “wrong” technologies
	Split incentives	No effect as this barrier refers to internal organizational management
	Form of information	Information is exchanged in person, either by an expert or a peer, which improves the conditions for learning and adoption of ideas and knowledge
Socio–technical regime	Credibility and trust	Information provided by a trustworthy source, for example at network meetings is more likely to be received. The adoption of certain technologies or measures by peer business colleagues is more likely to be seen as credible (or as a norm)
	Principal–agent relationship	No primary effect as this barrier refers to internal management
	Values	The adoption of energy management systems or energy efficiency measures by peers affect what is perceived as a norm and ‘common sense’ in the business sector, and thus the possibilities to overcome this barrier
	Inertia	The adoption of energy efficiency measures by peers affect what is perceived as a norm in the business sector hence affecting attitudes and behavior, helping to reduce this barrier
	Bounded rationality	The downside of acting bounded rational in regard to energy efficiency is reduced as attitudes and what is regarded as a norm change and information is gained of other companies undertaken improvements
	Power	Low effect as this barrier refers to internal organizational structures
	Culture	Attitudes towards energy efficiency change as the norms change due to new knowledge and experiences gained in the network. In the long run, as staff changes positions, a ‘business culture’ where energy efficiency is a natural part evolves

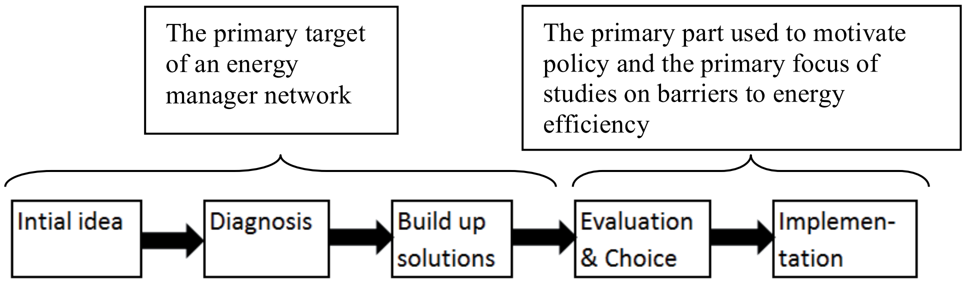

Figure 3. The role of energy manager networks in relation to Cooremans (2011)'s decision-model.

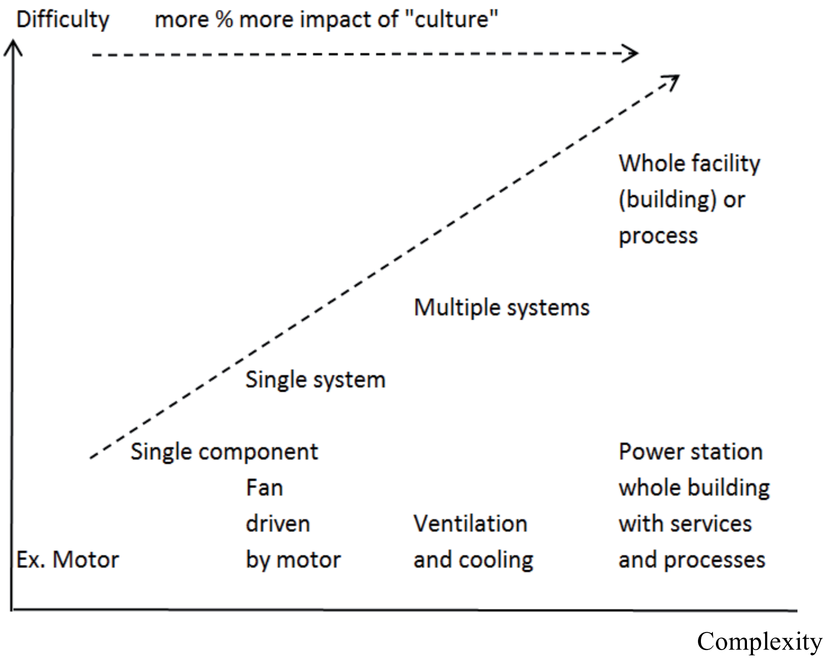

Figure 4. The complexity ladder of energy efficiency measures (revised from Westling, 2000).

Concluding discussion

Manager networks can facilitate implementation of energy efficiency measures in different ways. This is due to networks contributing to great opportunities for credible experts to provide information and also peer-to-peer information-sharing that fosters new norms and attitudes in the business.

Results show that improving energy efficiency in industry is more complex, with interrelated processes, not always buyable products, a number of persons in the organization being affected by the improvement, and different persons being in charge of the investments and the allocation of energy costs. These issues make the network of great value according to the network participants, and help increase information on available measures and its potential for improvement. Improving energy efficiency in industry many times means taking a high risk. The network helps the participants to overcome these risk-related barriers as sharing good examples means the risk barrier is reduced for the next person making such change.

The four existing networks for energy intense industries in Sweden all have potential to fulfil their important role when it comes to fostering awareness about energy efficiency: they cover large part of the business sectors, there are regular meetings, and invited experts and 'good examples' are important parts of the meeting agendas. There are, however, some weaknesses as the networks to large extent are organized as projects, leading to disruptions in the continuity. There are also risks that important opportunities for peer-to-peer meetings and information-sharing are removed from the meeting agendas in order to make meetings time-efficient and to reduce costs. The voluntary approach also leads to a loose structure of the networks, which can be a weakness, as noted by Price (2005) in regard to VAs.

To achieve higher degree of improved energy efficiency the involvement of the companies' top-management in the networks' activities can be needed. Being educated on the energy-related topics and LCC methods, the management can give a higher priority to energy-related investments. Depending on the organization and management, the energy efficiency networks have a great potential to facilitate companies to improve energy efficiency. Notably, a number of activities within the networks are also a considerable part of the fulfilment of some of the requirements in the Energy Efficiency Directive. Further work is emphasised in evaluating existing networks, and also to build models on how such optimally should be structured.

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