

Non-energy benefits in energy audit and energy efficiency network policy programs for industrial SMEs

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Abstract

Improved energy efficiency is a key component towards sustainable and climate-neutral industrial energy systems. The potential for industrial energy efficiency varies between sectors and processes but is stated to be high. Implementation of energy efficiency measures and activities could also result in benefits in addition to energy cost savings, benefits that are more difficult to quantify in economic terms. Research shows that additional gains from investments are underestimated as non-energy benefits (NEBs) are often neglected when the financial attractiveness of energy efficiency investments are evaluated. In the literature, great attention has been given to realise industrial energy efficiency potential through industrial energy policies and programs, in order to promote investments and implementation of new, more efficient technologies and processes. The most internationally common industrial energy policies for industrial SMEs are energy audit programs, but energy efficiency networks have also received increased attention from policymakers. However, there is a scarcity of studies exploring NEBs in relation to industrial SME energy audits and energy efficiency network policy programs. The aim of this study was to identify and compare NEBs from two key energy efficiency policies: energy audit and energy efficiency network programs. Semi-structured interviews were conducted with executives at two groups of industrial companies: companies that participated in the regional Swedish energy efficiency network pol-

icy program, and participants from the national energy audit program, Swedish Energy Audit Program (SEAP). Commonly mentioned NEBs were related to production, such as increased lifetime of equipment and more reliable production. However, while participants from the energy audit program related these NEBs mainly to technical installations, network participants also saw these types of NEBs from energy management practices. If NEBs were to be included in energy audit programs the benefit of the audits could be increased, but will then particularly affect the technical installations. NEBs in terms of network participation were shown to lead to an increase in the general benefits of the networks, and for network companies NEBs are also linked to measures related to operation and maintenance, i.e., energy management practices. One difference between the two groups was that NEB improved the company's environmental image. Two of the companies participating in the network policy program had presented their participation on their public webpage perceiving this as a very important benefit, while respondents from the energy audit program could not relate their company image to their energy audit. One additional NEB that was found, not previously mentioned in the scientific literature on NEBs, was that among the network participants, establishing contacts with other companies in the region was considered of great importance, and further contacts that would not have been established outside of the network. Results even found new customer relationships as a result of the network. This finding is of a general nature, thus apart from the other commonly known NEBs, an additional NEB that primarily relates to participation in energy efficiency networks that this study found is establishing new relationships with other companies in the region.

Introduction

An energy audit is the first step towards adoption of energy management practices in a company. Research on energy management in SMEs shows a number of key factors needed to successfully implement energy efficiency measures and realise the full energy potential. Some of those factors are a long-term energy strategy, concrete goals and someone at the site being responsible for the issue (Backlund, Thollander, Palm, & Ottosson, 2012). National and international research shows that these factors are often lacking in industrial SMEs (Thollander et al., 2013). In addition to providing companies with energy audits for implementation of energy efficiency measures, industrial energy efficiency networks can give the SMEs the help and support needed to implement the success factors. Based on this, a research pilot network policy project, aiming to promote not only energy audits but also energy management practices, was implemented in the region of Gävleborg, Sweden, targeting industrial SMEs. The network model was inspired by Paramonova et al. (2014) including the major stakeholders: network administrator, network operator, participants, and technical experts. The project lasted from 2015 to 2018, included regular meetings at the company sites, with lectures given by energy experts, a free energy audit by an experienced auditor, and access to a database covering energy efficiency measures from previous industrial energy programs (Johansson, Stenqvist, & Thollander, 2017).

Improved energy efficiency is a key component towards sustainable and climate-neutral industrial energy systems. The potential for industrial energy efficiency varies between sectors and processes but is stated to be high. However, there is still a gap between the potential level of energy efficiency and the actual level in industry denoted the energy efficiency gap (Hirst and Brown, 1990; Thollander & Palm, 2013). In the literature, great attention has been given to realise the industrial energy efficiency potential through policies, in order to promote investments in new, more efficient technologies and processes.

Implementation of energy efficiency measures and activities could result in benefits in addition to energy cost savings, so-called non-energy benefits (NEBs). Nehler et al. (2014) show that there are effects such as improved health and well-being linked to improved energy efficiency in industries. At the company level, NEBs could include increased production and enhance competitiveness, and at the national and international level there are NEBs such as new jobs, improved energy security and reduced environmental impact (Nehler et al., 2014).

Quantification of the abovementioned NEBs in monetary terms is often difficult and therefore it is not possible to see the full potential of energy efficiency measures and investments. There are reasons to believe that gains from investments are underestimated since NEBs are neglected when the financial attractiveness of investments are evaluated, resulting in energy efficiency potentials being left untapped. When possible, NEBs should be given monetary values. In a case study (Finman & Laitner, 2001) covering 77 cases of documented NEBs it was possible in 52 of the cases to quantify the NEBs in monetary terms, resulting in shortened payback periods by a factor of two when NEBs were included. In many cases the NEBs were equal to or greater than the actual energy cost savings (Finman & Laitner, 2001). In addition to this study, similar results were

found by Lung et al. (2005), where 54 out of 81 cases of NEBs in US manufacturing industry could be quantified, cutting the payback time by a factor of 1.5, and Hall and Roth (2003) showed that when it was possible to assign a monetary value, NEBs were about 2.5 times greater than the energy cost savings.

The abovementioned studies of NEBs seem to indicate that NEBs should be included when assessing energy efficiency measures. If NEBs, in terms of monetary value, are included in the assessment of energy efficiency measures the measure becomes significantly more profitable to implement, compared to if NEBs are neglected and only energy cost savings are evaluated. Research on NEBs of energy efficiency measures is an emerging field publication related to industrial energy efficiency measures are scarce, as found by Nehler et al.'s (2018) review. Early contributions emanated from the US starting in 1999 and were later followed by contributions from Europe. These studies include energy efficiency measures, primarily related to general energy efficiency improvement measures with a few exceptions, e.g. Nehler (2018b) and Nehler, Parra & Thollander (2018) on NEBs and compressed air systems. However, studies on NEBs related to energy policy programs are even more scarce, one exception being a study by Nehler et al. (2018).

Further, the methodological approaches on how to study NEBs are also not so well described in the available published papers. Nehler (2018a) therefore presents a novel attempt to introduce a stricter methodological approach on how to study NEBs, both ex-post as well as ex-ante, including five steps. These steps include observation, measuring, quantification, monetization, and evaluation and impact assessment (Nehler, 2018a).

The most internationally common industrial energy policies for industrial SMEs are energy audit programs (Andersson and Newell, 2001). Such a policy program normally offers subsidized energy audits on level I or level II energy audits according to the classification by ISO 50002 (ISO, 2015). In a study by Price and Lu (2011), energy audit programs across the world were compared, and among other findings the authors concluded that country-specific conditions were of great importance for successful and efficient energy audit programs. Evaluation of the German energy audit policy program (Fleiter, Gruber, Eichhammer, & Worrell, 2012) showed that companies implemented three times more energy efficiency measures than they would have done if not participating in the program. When including planned energy efficiency measures the program had an implementation rate of 72 %, compared to 50 % and 40 % in the US IAC program and the Swedish Project Highland. The results from the evaluations of the German energy policy program and the Swedish Project Highland showed similar savings per implemented measure, 52 MWh/year for the German program and 56 MWh/year for the Swedish (Fleiter et al., 2012; Thollander, Danestig, & Rohdin, 2007).

Another policy program that in Europe has received increased attention from policy-makers are, are energy efficiency networks. A network policy program could in one way be seen as an extension or second generation of policy that begins with an energy audit. During a network period of a few years, a limited number of companies, around ten, meets on a regular basis a few times every year and exchange experienced and also receives hands-on practical support in terms of energy efficiency measure deployment, lectures on relevant topics etc.

(Koewener et al., 2011). One important thing to note is that of distinguishing between energy efficiency networks policy programs that can be seen as implementation networks, and general network programs, such as larger conferences. One major difference lies in that an energy efficiency networks program allows relationships with the networks coordinator and between firms to grow as the network program develops over time.

In a review of energy policy programs, Tanaka (2011) concluded that many of the policy programs target SMEs. Tanaka (2011) divided policy measures into three categories: prescriptive policies, economic policies, and supportive policies, where Voluntary Agreement Programs were seen as an effective and motivational means for industrial SMEs. Price (2005) reviewed and evaluated 23 Voluntary Agreements (VAs), finding that fully voluntary VAs had lower participation compared to VAs with a regulatory or economic component, where more of the latter also showed improved results. VAs are found to be a very relevant policy measure for energy-intensive industrial SMEs and medium-sized companies while energy efficiency networks are suggested to be the number one choice policy for non-energy intensive SMEs (IEA, 2014).

Two major energy efficiency policies for promoting improved energy efficiency in Sweden are energy audit programs and energy efficiency network programs. The Swedish Energy Audit Program (SEAP) provided financial support for energy audits in SMEs during the period between 2010 and 2014 (Paramonova, 2016). This one-time-only support for companies covered half of the price for an energy audit, with a maximum limit of €30,000. The audits had to cover an overview of the company's annual energy end use (MWh/year) together with price for each energy carrier well as suggested energy efficiency measures (STEMFS, 2015). Companies receiving the subsidy had to present an energy plan where energy efficiency measures planned within the next two years were listed. To receive the subsidy there were no requirements on auditor certification, as companies could do it themselves or use an external energy auditor, although SEA recommended the latter option to companies (Paramonova, 2016). From 2015 another similar energy audit policy program was initiated in Sweden.

As stated earlier, there is a scarcity of studies exploring non-energy benefits in relation to industrial SME energy audit and energy efficiency network policy programs.

The aim of this study was therefore to identify and compare NEBs from two key energy efficiency policies, energy audit and energy efficiency network programs. Semi-structured interviews were conducted with executives at two groups of industrial companies: companies that participated in the regional Swedish energy efficiency network policy and research project ENERGIG, and participants in the national Swedish Energy Audit Program (SEAP).

Method

This study was carried out as a multiple case study inspired by Yin (2009) who suggests general approaches for exploratory, descriptive and explanatory research designs. The explanatory case study, which is applied in this case, is a data collection prior to any definition of research question or hypothesis. The primary method for data collection was semi-structured interviews using an interview guide regarding questions on NEBs

and energy efficiency-related questions. The interview guide was developed based on a previous interview study on NEBs in Swedish industry (Nehler et al., 2014) and the initial step, ex-post observation, in the NEB guiding scheme by Nehler (2018a). The reason for only studying the first step of Nehler's (2018a) NEB guiding scheme was that this scheme is developed specifically for NEBs for energy efficiency improvement measures, not NEBs in general related to the participation of an energy audit or energy efficiency network policy program.

The most commonly seen NEBs from previous research and categorization of these are seen in Table 1, and from these categories and examples, NEBs were deduced and added to the interview guide.

In total ten respondents from companies were interviewed during the period November 2018 to January 2019. Six respondents had been participating in the regional energy efficiency network program that lasted from 2015 to 2018 (Johansson et al., 2017), and four respondents emanated from the Swedish Energy Audit Program that took place between 2010 and 2014. Companies from these two programs were selected because these two programs were the primary national policy means for overcoming barriers to energy efficiency and advocating improved energy efficiency among Swedish industrial SMEs.

The companies in the study consist of industrial small and medium-sized enterprises. Some details about the companies are presented in Table 2. The majority of the respondents were either co-owner of the company or had a position as senior economic controller.

The interviews were conducted via telephone and recorded, each lasting about 30 minutes. Interviews were partially transcribed and the answers were categorised in accordance with the NEBs presented in Table 1, e.g. Production, Operations and Maintenance, Working Environment, Waste and Emissions as well as Others.

Results

PRODUCTION

The most commonly mentioned NEB related to production for both groups of respondents was increased lifetime of equipment, as seen in Figure 1. This was often mentioned as a result of installation of new LED lights, i.e., directly related to the support process lighting. Some of the respondents participating in the network project also mentioned longer lifetime of air compressors, a measure which in turn came as a result of the network participation:

Increased lifetime of equipment ... I am mostly thinking of air compressors, the importance of reducing air leakage and such things which lead to the compressors' operating hours going down. We did have a lecture on that.

Also mentioned by the respondents was more reliable production, due to the fact that their knowledge was improved due to the audits and network participation and they could therefore prevent unnecessary production stops. Notably, network participants perceived NEBs also related to adoption of measures related to energy management practices, e.g. while participants from the energy audit program mainly saw NEBs from technical installations, e.g. LED installations.

Table 1. Types and typical examples of NEBs, based on (Nehler et al., 2014).

Types	Typical examples
Production	Increased production rate Improved quality of products Increased production reliability Increased life time of technology and process Shorter cycle time of process Raw materials use reduction
Operation and maintenance	Maintenance reduction Lower cooling demand Reduced labour demand Reduced need for engineering control
Working environment	Improved worker safety Reduction of noise Improved quality of air Improved control of temperature Improvement of lighting
Waste	Reduction of waste water Reduction of hazardous waste Reduced use of waste fuel, heat, gas Reduction in material use
Emissions	Reduced emission of e.g. CO, CO ₂ , NO _x , SO _x Reduced emissions of dust
Other	Improved corporate/public image Improved morale of workers Increased levels of sale

Table 2. Details about participating companies.

Company	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Nace Rev2 code	2892	2562	2594	2910	2899 2824 2573 2932	2562	2562	3312 2599	1610	1629
Employees	100	29	58	15	34	10	17	56	11	31
Network participant	X	X	X	X	X	X				
SEAP participant							X	X	X	X

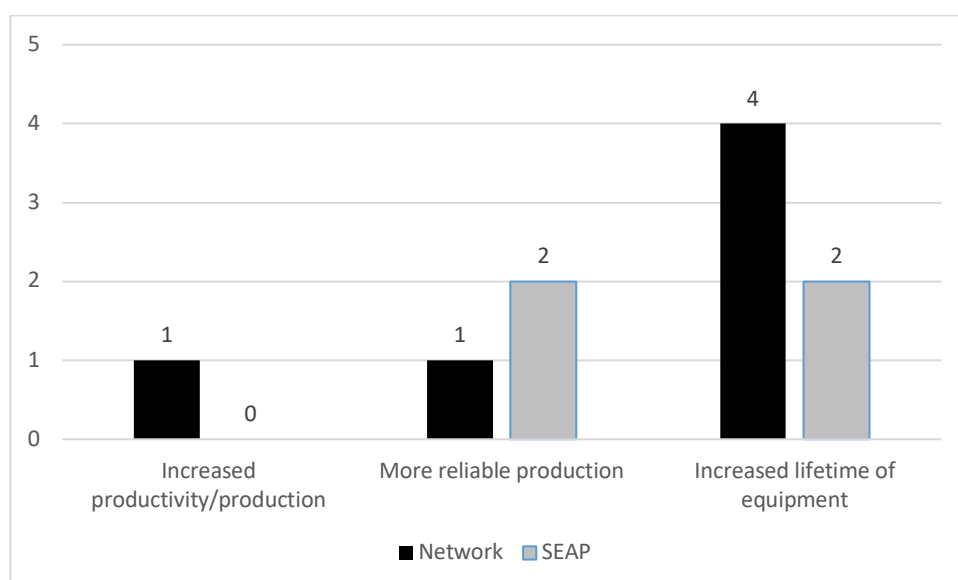


Figure 1. Number of mentioned NEBs related to production.

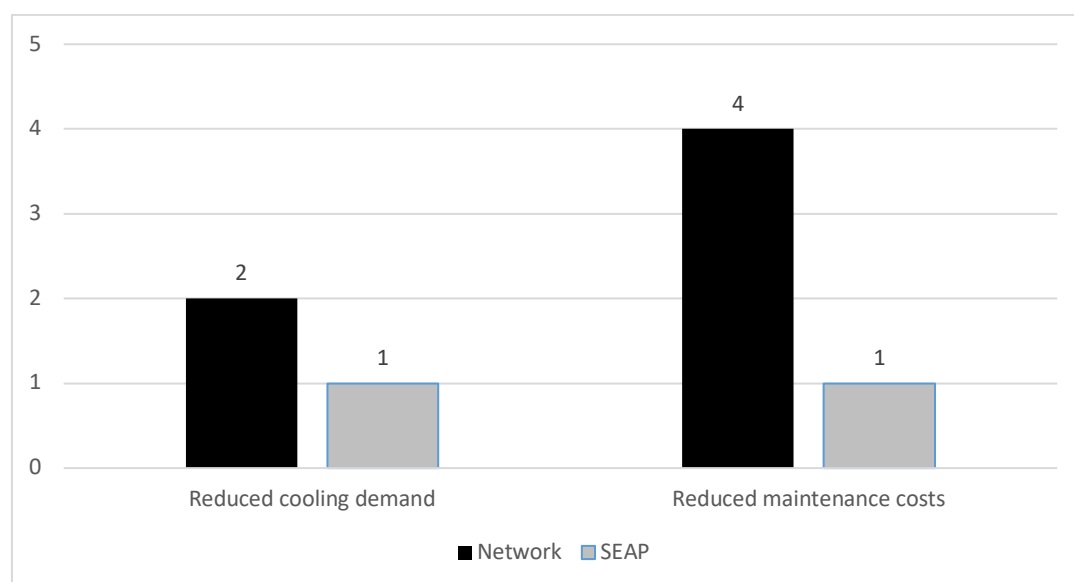


Figure 2. Number of mentioned NEBs related to operation and maintenance.

OPERATION AND MAINTENANCE

Respondents from the network program mentioned NEBs related to operation and management more frequently than respondents did from SEAP, see Figure 2. Reduced maintenance costs were most commonly noted among the respondents. The lectures in the network project and the knowledge obtained from those were mentioned as another reason for the reduction of maintenance costs, and they said that they now had more knowledge on how to reduce the maintenance for the equipment.

In addition to that, the cooling demand was reduced due to installation of LED lights in many of the cases. In one of the cases the cooling demand was reduced simply by moving the existing compressor from an area where they did not need the excess heat to an area where they previously had space heating that now could be eliminated:

Where we have free heat right now one can say. Previously, we were all caught up with getting rid of the heat because it was located down in the basement, underneath the offices and the dining area.

One notable finding here is that the network participants simply seemed more aware of the NEBs, which in turn seems to be related to a higher level of maturity when it comes to energy efficiency and in particular energy management practices.

WORKING ENVIRONMENT

As seen in Figure 3, both groups of respondents also mentioned NEBs related to the working environment, mainly due to improved quality of light, thanks to LED installations. The NEBs related to safer working environment related largely to the improvement of light conditions. Some respondents also noted

reduction of noise as a result of new fans and sealing of compressed air leaks. Respondents from companies participating in the network program also mentioned improved quality of air and improved temperature control as results of implemented measures such as roof insulation or new ventilation systems.

WASTE AND EMISSIONS

Only a few of the NEBs mentioned during the interviews were related to waste and emissions, and the respondents said that they do not measure external emissions and therefore can only roughly guess how these were affected. In cases where companies have changed from oil heating, the emissions had been reduced, and in cases where the companies significantly reduced their energy demand, the emissions were also reduced as a result of that.

Some of the respondents mentioned that they now use waste heat from the compressors, something they previously did not

do, and the installation of LED lights was mentioned as a reason for reduced waste since they have a longer expected life-time than previous light sources such as fluorescent lamps (e.g. primarily T8 and T5 lamps).

OTHER

A major difference was seen between the two group of respondents in this general category of NEBs, see Figure 5. Improved work ethic was mentioned by respondents from companies participating in the network, while this was not mentioned at all by respondents from the SEAP. Improved company image was frequently mentioned by the network participants, where the network participation was also mentioned on their public website, while it was only mentioned one time by one respondent from SEAP. When examples of NEBs such as improved work ethic, improved company image or increased sales were mentioned to respondents from SEAP they could not see how

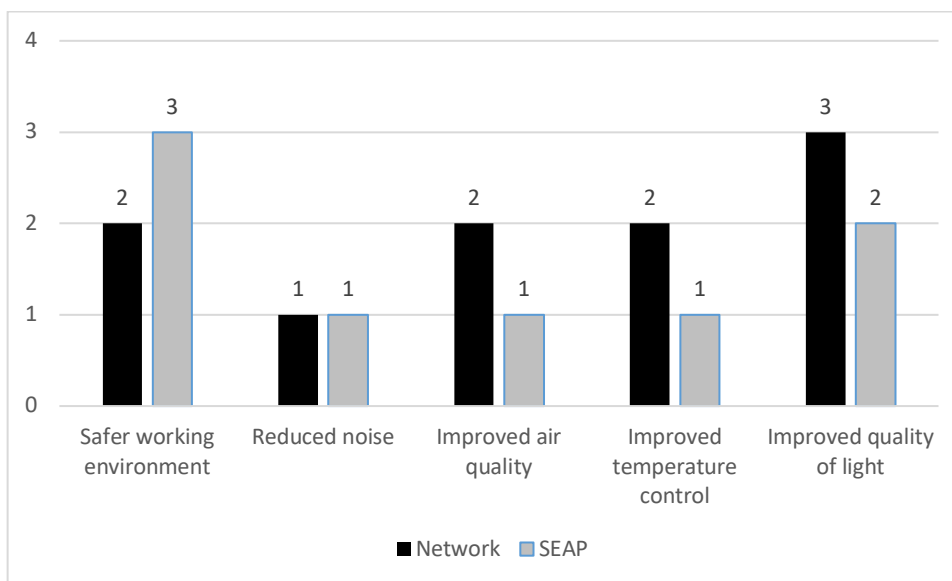


Figure 3. Number of mentioned NEBs related to working environment.

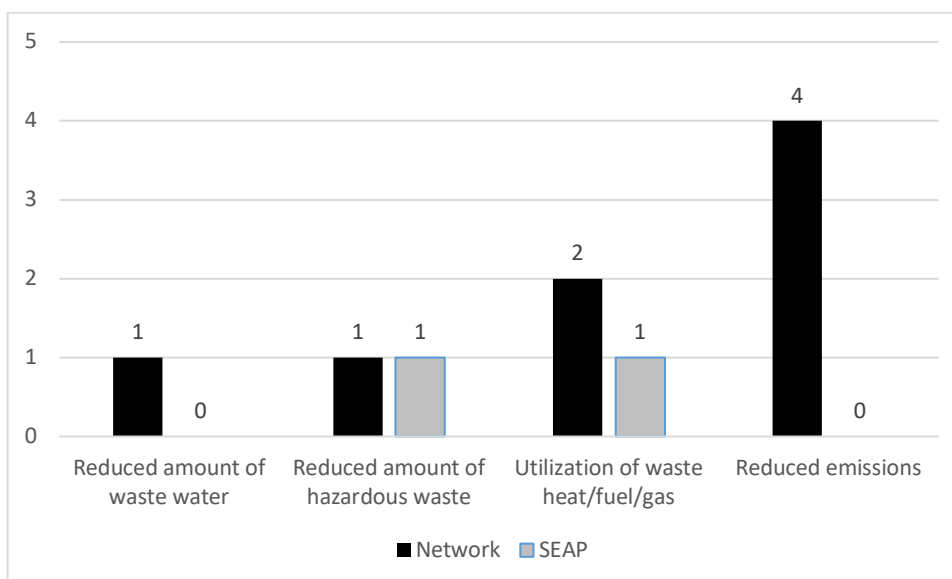


Figure 4. Number of mentioned NEBs related to waste and emissions.

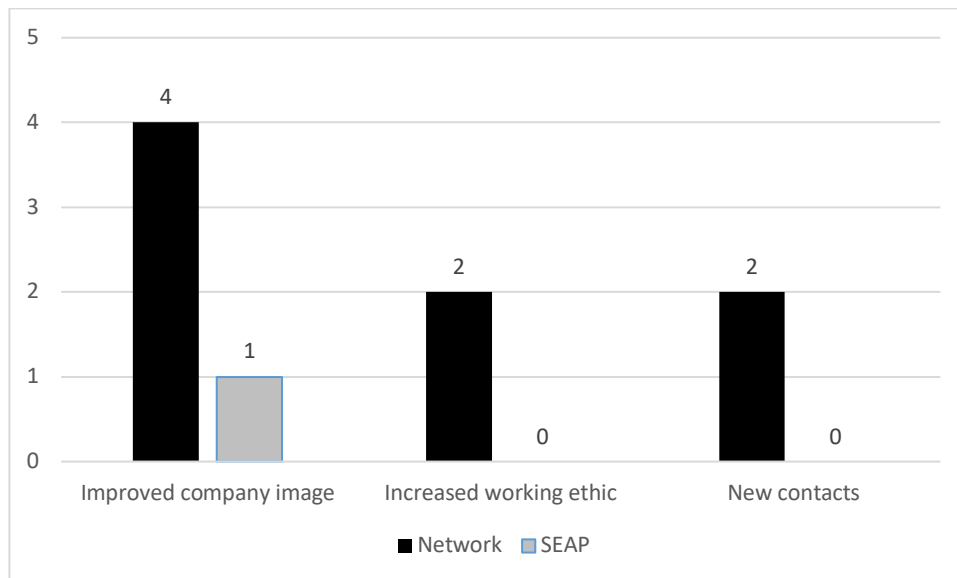


Figure 5. Number of mentioned NEBs related to other types.

that would be related to their energy audit. Once again, this also seems to be related to a difference in degree of awareness of energy efficiency and energy management in general. This in turn may indicate that as a company evolves into higher maturity levels of energy management practices, the perception of the various forms of NEBs increases in importance.

Additionally, respondents from companies participating in networks mentioned new contacts as a NEB which was not mentioned by the other group. These contacts were professional, such as new customers or suppliers, but also less formal contacts with companies in the same area and sector.

We've gotten to know some persons that are doing sort of the same thing in our area. I don't think I ever would have met them, were it not thanks to the network program. We actually share a few words nowadays, every now and then. It can be each and every day regarding minor things. It does not concern deep stuff, but more minor things.

Concluding discussion

The aim of this study was to identify and compare non-energy benefits (NEBs) from two key energy efficiency policies, energy audit and energy efficiency network programs targeting Swedish SMEs.

Commonly mentioned NEBs for both groups of companies were related to production, increased lifetime of equipment and more reliable production. However, while participants from the energy audit program related these NEBs mainly to technical installations, network participants also saw these types of NEBs from energy management practices. If NEBs were to be included in energy audit programs the benefit of the audits could be increased, but will then particularly affect the technical installations. NEBs in terms of network participation will lead to an increase of the general benefits of the networks, and for network companies NEBs are also linked to measures related to operation and maintenance, i.e., energy management practices.

One difference between perceived NEBs from respondents in companies participating in networks versus energy audit programs is the improved company environmental image. Two of the companies that participated in the network program had presented their participation on their public webpage, while respondents from the energy audit program could not relate their company image to their energy audit.

The NEBs mentioned by the participants are similar to the commonly seen examples of NEBs (see for example Table 1) except the additional NEBs mentioned by network participants related to the established contacts with other companies in the local area, contacts that would not have been established outside of the network. This finding is of a general nature, thus apart from the other commonly known NEBs, one additional NEB that primarily relates to participation in energy efficiency networks that this study found, is establishing new relationships with other companies in the region. With this limited study one should be careful in not generalizing results too far. However, one notable general finding is that an energy audit policy program seems to generate perceived NEBs particularly related to the regarded energy efficiency measures while energy efficiency networks, that could be seen as a second generation of energy efficiency policy programs, also generated perceived NEBs related to the policy (e.g. improved company image and new customer relations).

The paper's methodological ex-post deductive approach inspired by Nehler (2018a) seemed to work appropriately in answering the aim of the paper. However, it is suggested that future research be carried out using the methodological approach used in this paper in other countries and regions. Furthermore, with the low number of cases in the preliminary exploratory study, further research is emphasized in the area, not least concerning energy auditing where only four companies with such experience were interviewed in this study. As this study was delimited to one county in Sweden a new study is suggested to be conducted in another region. Further research in the area of NEBs in energy audits and energy efficiency networks is suggested to follow the consecutive steps in Nehler's

(2018a) NEB guiding scheme. If this is carried out, future research including NEBs in ex-post impact assessment evaluations of industrial energy efficiency policy programs would enable a real quantification of these benefits. This would in turn most likely provide an even stronger incentive for such policies to be considered by national governments. Future research is suggested to also study NEBs in relation to industrial energy management practices.

One major gain outside the scope of this paper that has been noted is that energy efficiency networks seem to deliver a higher degree of improved energy efficiency than stand-alone energy audit programs. This is backed up by previous research from the German LEEN networks (Koewener et al., 2011). This in turn indicates that energy efficiency network programs through activities such as lectures, workshops, and experience sharing with other companies lead to increased knowledge on how to perform sound energy management practices. This could be seen as an additional NEB that was initially beyond the primary scope of this study, but could be noted as a general important benefit of energy efficiency network policy programs (e.g. improved knowledge on how to improve energy efficiency). This could in part be related to the fact that an energy audit primarily focuses on delivering specific information. In relation to NEBs in this study, there seems to also be a difference in degree of awareness of energy efficiency and energy management in general between companies participating in the audit program and participants from the networks program. This in turn underlines that as a company evolves into higher maturity levels of energy management practices, the perception of the various forms of NEBs increases in importance. This finding may have implications beyond the scope of this study and that is the selling point or the logic of policy program participation may need to be different depending on the company's previous experience with energy efficiency-related issues.

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