Energy efficiency networks – a group energy management system as a business model?

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Abstract

During the initial phase of setting up and operating energy efficiency networks in industry (in the 1980s and 1990s in Switzerland and in the early 2000s in Germany), their initiators did not realize how effective and adaptive this concept would turn out to be. This paper reports on the lessons learnt about this "group energy management system", where ten to 15 companies or production sites regularly exchange their experiences, set joint efficiency targets and perform a yearly monitoring of their efforts.

Energy efficiency networks have been implemented with great success in different settings: (1) as centrally organized instruments with an operating standard set by government (Switzerland), or with an open standard set by the state utility (China), or (2) as an open standard with a minimum specification (Germany, Austria). In every case, participation is not obligatory, but encouraged by incentives offered by the national government.

Initially designed as regional company networks where energy managers could meet locally, the concept is now evolving into (1) networks of industrial branches and (2) group-internal energy efficiency networks. Other changes include:

- the initial energy audit has been expanded to include demand-side management analysis and the flexibility potentials of on-site electricity generators (co-generation, standby set);
- information about organizational measures and financing options is added continuously;
- process-oriented workshops on energy-efficient solutions in production processes are offered to the members of all 80 networks operating in Germany (examples: solid painting, drying);
- participating companies have taken their own initiatives to improve their products' energy efficiency. Innovative energy managers have even asked their plant and machinery suppliers to improve the energy performance of their products, speeding up innovation in the efficiency field.

An association of energy efficiency networks (AGEEN) was founded in Germany in 2014 to develop a quality standard for operating energy efficiency networks, to promote networks in Germany, and to share their experiences and ideas for further improvements and market transparency. The German federal government launched the Energy Efficiency Network Initiative together with 22 industrial and business associations in December 2014. The objective of this voluntary agreement is to support the establishment of 500 energy efficiency networks until the year 2020 in Germany that are expected to make primary energy savings of 75 PJ and CO_2 reductions of 5 mill. tonnes.

Introduction – large profitable efficiency potentials in unfavourable boundary conditions

Many national and international studies describe the existence of large profitable energy efficiency potentials in the industrial sector (Eichhammer et al. 2009; Fleiter et al. 2013). This knowledge is not new, but has been reported since the 1980s in Europe (Morovic et al. 1987), North America (Levine et al. 1995; Romm 1999), and Japan. Energy efficiency has been described as the EU's biggest energy resource and one of the most cost effective ways to enhance the security of its energy supply and decrease the emissions of greenhouse gases and other pollutants (COM 2011 (0109)). Based on the data that for every 1 % improvement in energy efficiency, EU gas imports fall by 2.6 %, many European governments are now treating energy efficiency as a main driver of strategic development and CO_2 emission mitigation.

Our own recent empirical analyses of 366 energy audit reports came to the conclusion that more than 3,000 profitable energy efficiency investments with an average internal rate of return of 31 % should reduce the companies' final energy demand by around 10 % within four years (Köwener et al. 2014). The internal rate of return varies from 12 % (minimum rate) to more than 100 % in many cases. On average, the annual energy bill should be reduced by some €180,000 per participating production site (mostly industrial companies) and the energy-related CO_2 emissions should decrease by around 1,000 tonnes per year. Obviously, there has been no change in the situation observed by Romm (1999) or Morovic et al. (1987) 20 to 30 years ago: "Consulting engineers usually return from on-site visits in companies with substantial and profitable energy efficiency potentials that are easy to realize and usually have high rates of internal return."

In addition to this business economics' perspective, microeconomic aspects and even macroeconomic issues may be important. A high density of energy efficiency networks – similar to today's situation in Switzerland (EnAW 2015) – will create different business opportunities for companies in industry, construction, services, and the energy sector. Additional jobs in consulting, construction, manufacturing, banking, maintenance, and research will be created by raising the demand for energy-efficient solutions and reducing energy imports.

The multiple benefits of the energy efficiency approach as defined by the International Energy Agency (IEA, 2014) represent a broad range of potential positive impacts on the economy, society, and the environment of a country (see Figure 1). The IEA analysis concluded that improving energy efficiency has the potential to support economic growth while reducing energy demand, as large energy imports are substituted by domestically produced investment goods and services. The induced economic growth enhances social development, speeds up environmental and climate protection, supports sustainability tendencies, and improves the energy system security of a country (see Figure 1).

The profitable energy efficiency potential of the German industry, trade and service sectors is currently estimated at some 350 PJ that could be realised between 2015 and 2020 (Jochem et al. 2014). This would reduce the energy costs of the two sectors by around €9 billion in 2020 (-10 %), CO_2 emissions by about 30 mill. tonnes, and generate 35,000 additional jobs (net), mostly in the investment goods industry and installing and maintenance, but also some in construction, consulting, contracting, and the banking sector (Jochem et al. 2014).

Obstacles and unused supporting factors

The limited realization of profitable energy efficiency potentials in industry and the service sector has been the subject of many discussions about obstacles and market imperfections for more than two decades (IPCC 2007), and the heterogeneity of these obstacles and potentials has been tackled by several sets of policy measures and instruments (Levine et al. 1995, DeCanio 1998).

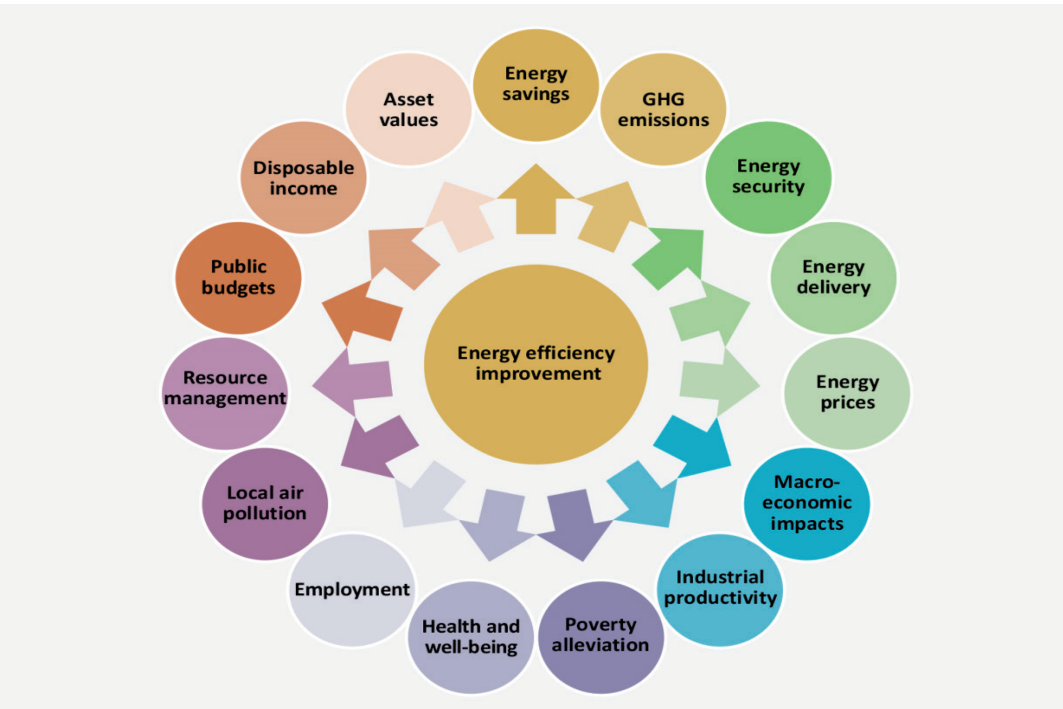

Figure 1. The multiple benefits of improving energy efficiency. Source: IEA 2014.

Surveys and interviews show that often the amount of attention paid to energy efficiency investments in companies is very limited and is heavily influenced by the priorities of those responsible for the company or the production site (Rahmesohl 2000, DeGroot 2002, Schmid 2004). There are many reasons for this limited attention that depend on factors such as the size of the company, its energy intensity, ownership, and the awareness and leadership of its management, and also its financial strength and access to capital. Classical obstacles include (see also Jochem et al 2014; Sorrell et al. 2010):

- lack of knowledge and market surveys of energy managers, particularly in SMEs (Trianni et al. 2016), but also of consulting engineers, architects, system installers, or bankers;
- high transaction costs of the energy manager (to search for solutions, for tendering, decision making, installation; (Ostertag 2002)) and high cost for professional training of the other groups of actors are perceived in order to overcome the lack of knowledge;
- lack of equity, fear of borrowing more capital for investments in off-sites or relying on the competence of a contracting company; energy efficiency investments are generally not considered a strategic investment (Cooremans 2011);
- technology producers or wholesalers often pursue their own interests and may be opposed to the innovations of more efficient solutions;
- 80 % of companies use only risk measures (payback periods), not profitability indicators (e.g. internal interest rate, present net value) for their decisions (Schröter et al. 2009).

Besides the economic reasons for the priority setting of companies, there are also psycho-social, motivational, and behavioural aspects that have rarely been analysed except by some sociologists and psychologists in the 1990s (e. g. Stern 1992, Jochem et al. 2000, Flury-Kleubler et al. 2001). The authors call these aspects "scarcely used supporting factors":

- Traditional investment priorities steer staff motivation and behaviour and determine the career of young engineers and their activities; energy engineers often have difficulties to "make a convincing case" to the management about efficiency improvements (Schmid 2004).
- The co-benefits of energy-efficient new technologies are rarely identified and not included in the profitability calculations by the energy or process engineers due to the lack of a systemic view of the whole production site and possible changes related to the efficiency investments (Madlener/Jochem 2004).
- Management is often not aware that the workforce may suffer from criticisms made by friends or relatives that they work in a "polluting" or wasteful industrial site.

Social relations such as competitive behaviour, mutual esteem and acceptance not only play a role between enterprises, but also internally within a company. Efforts to improve energy efficiency are influenced by the intrinsic motivation of companies' actors and decision makers, the interaction between those responsible for energy and the management, the internal stimuli of key actors and their prestige and persuasive power (InterSEE 1998, Schmid 2004).

Given the existence of several obstacles (and often several unused supporting factors) within the supply chain of an energy-efficient solution, policy analysts ask for a bundle of policy measures to address them simultaneously (e.g. Sorrel et al. 2010).

One way of addressing the dilemma of large profitable energy efficiency potentials and the various obstacles and unused supporting factors preventing their exploitation is the instrument of energy management systems such as ISO 50001 or national energy management standards such as the DIN EN 16247-1 for performing energy audits. These instruments raise the awareness for energy efficiency in companies, help to re-think and restructure the priorities of investment plans and set a minimum standard for how energy audits should be performed and how companies should organise the process to implement energy cost savings and sustainable energy use at their production sites.

However, these energy management systems work on an individual basis. The consulting engineer or the auditor may not be well informed about all the possible fields of energy efficiency. They may have little knowledge of thermodynamics, electrical systems, or electronic control and communication systems. The board of the company may have an interest in formally implementing the Energy Management System (EMS) in order to receive a subsidy or reimbursement of an energy tax or a CO_2 surcharge.

The following section describes energy efficiency networks (called "Learning Energy Efficiency Networks", LEEN) with a particular focus on how they are operated in Switzerland, Germany and Austria; they will also be established in Belgium and Sweden in 2016. These networks can be considered a learning "Group Energy Management System" as they benefit from 10 to 15 energy managers sharing experiences and know-how in a very structured and well organised manner. A four-year long evaluation of 30 learning energy efficiency networks in Germany with 366 participating companies or production sites concluded that the efficiency progress of the participants was twice as high as that of non-participating companies on average (Jochem et al. 2014). The LEEN concept was developed in Germany between 2002 and 2015 and now represents a premium standard applied in Germany, Austria, and most recently in Sweden and Belgium. The next section describes the concept against the different energy and climate policy frameworks in different countries and their impact on how the networks are operated and their results.

An energy management system – operating in a group context

The complex obstacles and the scarcely used supporting factors of energy-efficient solutions in companies require a bundle of policy instruments – something that is rarely known or considered by policy makers in administration or the management in industrial associations or companies. However, in 1987, a Swiss consulting engineer, Thomas Bürki, had the idea for an action involving eight companies in Zürich: the Zurich Energy Model (Bürki 1999, Graf 1996): After an initial energy audit of each participant, the energy managers of the companies met four times a year to exchange the experiences gained with energy efficiency investments and organizational measures in a structured manner. At these meetings, the participants discussed a specific topic in more detail, possibly with a presentation by an external expert, and moderated by the consulting engineer. The performance of each company was monitored at least once a year.

The results of this first energy efficiency network were so convincing that the Swiss government's Federal Office of Energy funded several pilot networks as the Swiss Energy Model for industry and the service sector. The average annual energy cost savings were 165,000 CHF per company. It was confirmed that the companies participating in such networks made much faster progress in improving their energy efficiency (Kristof et al. 1999; Konersmann 2002).

Since Switzerland's CO_2 law came into force in 2006, companies which reduce energy-related CO_2 emissions by a negotiated target, accept a yearly evaluation on its efficiency progress, and participate in an efficiency network can be exempted from paying the surcharge on fossil fuels. This was first introduced at a level of 12 CHF per tonne of CO_2 in 2008. The surcharge most recently approved by the Swiss Parliament in line with the Swiss CO_2 law in 2016 is now 84 CHF per tonne. The Swiss Energy Agency for Industry, EnAW, acts as an intermediary to negotiate target agreements on CO_2 reduction for 10 years between companies and the Swiss federal government (EnAW 2015). The target agreements are based on energy efficiency improvements or substitution options for fossil fuels such as industrial organic wastes, renewables, or electricity (which is almost CO_2 free in Switzerland due to 60 % hydropower and 35 % nuclear power generation).

Until 2000, most of the 20 existing energy efficiency networks were regional networks. However, over the last 15 years, networks of branches (e.g. hotels) or of company groups (e.g. retail companies) have also been developed as well as networks for SMEs (small and medium-sized enterprises). Currently, about 90 energy efficiency networks (or 2,000 companies or production sites) operate in the Swiss industry and service sectors, which contribute much more to reducing energy demand and CO_2 emissions than the other sectors (mainly private households and transportation).

The Swiss Energy Model was transferred to Germany in 2002 by modifying two elements from the very beginning:

- A professional moderator was introduced in addition to the consulting engineer as a second neutral person. He prepares and moderates the regular meetings and writes the minutes; the idea behind this change is that such a moderator is not as technically biased as a consulting engineer might be, but is specialized in dealing with extroverted participants and getting more introverted ones to report their experiences. The moderator may also chair the annual meeting when the participant's monitoring report is discussed with the company board or management.
- The original ten-year target of the Swiss concept was reduced to three to four years. Two network targets (on energy efficiency and CO_2 mitigation) were introduced for internal use to generate a team spirit and an atmosphere of playful competition among the energy managers and for external use for the public image of the participating companies and the network, to demonstrate their engagement in climate protection and resource efficiency.

Between 2002 and 2008, the concept was tested in some 10 energy efficiency networks; five of them were evaluated in a pilot project between 2005 and 2008 with very positive results (Jochem/Gruber 2007; Bauer et al. 2008). The German version of these networks was finally called "Learning Energy Efficiency Networks" (LEEN) and was widely tested in 30 pilot networks between 2008 and 2014, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

THE LEEN CONCEPT – A SUGGESTED STANDARD

The establishment and operation of an energy efficiency network is usually considered in three major phases of activity (Köwener et al. 2014, see also Figure 2).

1. *Initiation of the network*: the initiator who may be the president of the regional chamber of commerce or industrial association, the mayor of a larger city, or the CEO of a utility motivates companies in the region to join the planned network. The network operator supports this and considers suitable candidates for the role of consulting engineer and moderator in the planned network. This phase of getting 10 to 15 companies to participate is the crucial challenge. If a network is established, experience and evaluations show that almost all the participants are quite satisfied with how they benefit from the exchange and the network's services (Dütschke et al. 2016).
2. *Energy audit and targets*: In Phase 1, every participant undergoes an energy audit by an experienced engineer, who also suggests a (confidential) medium-term efficiency target for each participant as well as a joint network target, which is publicly communicated. The energy audit has to be performed in line with detailed standards for identifying energy efficiency potentials and their economic evaluation in all areas of cross-cutting technologies and organizational measures. The entire process including the report complies with ISO 50001.
3. *Regular meetings and yearly monitoring*: In Phase 2, the essential cornerstone of a network's success is built upon the regular meetings held over the three to four years at different companies participating in the network. These not only encourage the exchange of experiences at the four meetings per year, but also bi-laterally when an energy manager consults his network colleagues in specific cases of investments and planning. The meetings, which are well prepared by the moderator, generally cover one topic of an energy-efficient solution. This topic may also be covered by the presentation of an invited external expert, followed by a detailed discussion. Each meeting also includes an on-site inspection at the participant hosting the event. Continuous monitoring of the measures that have been implemented permits the yearly tracking of reduced energy costs and their contribution to higher profits. The monitoring (including the report) complies with ISO 50001. At the level of the network, the consulting engineer can also report on the network's progress in energy efficiency or CO_2 mitigation on a yearly basis, keeping track of the medium-term target adopted by the network in phase 1.

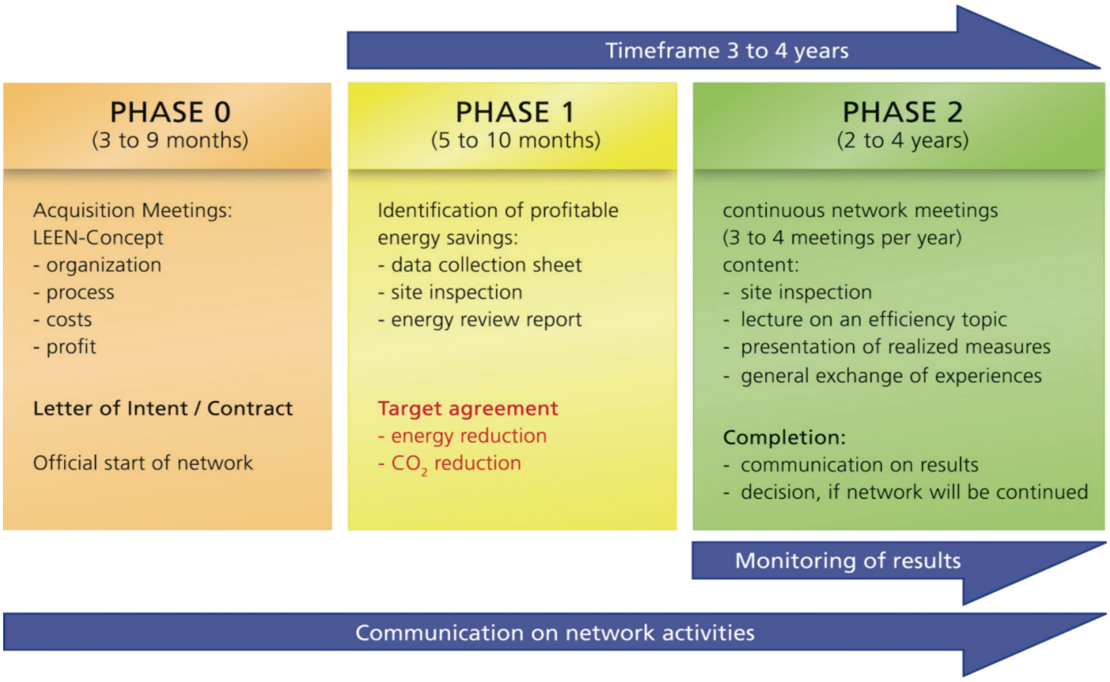

Figure 2. Three phases of establishing and operating an energy efficiency network.

The network initiator is also the network operator in many cases. He organizes the contract with the participating companies, the consulting engineer, and the moderator. The cost for operating a network depends on whether the participating company has already had an energy audit, the frequency of the network meetings and the hourly rate of the network operator, the engineer and the moderator. A cost calculator is available on the internet (www.energie-effizienz-netzwerke.de). In general, the network costs are financed by the participating companies; in some cases, financial support may be provided by the federal or local government.

The major components of the underlying theoretical concepts for local learning networks can be summarized as follows:

- The heuristic approach of *innovation systems* is used to explain the network of actors who are involved in bringing about an innovation (Kuhlmann 2001). An investment in new energy-efficient technology does not come about due to an isolated decision of the management of a company, but is the result of complex interplay among many actors with influence upon a decision in a particular case: consultants, equipment suppliers, installers, architects, outside maintenance staff, key accountant of the energy supplier or cooperating bank, investment decisions of competitors or management colleagues in the region.
- One element follows the *dynamics of a product or investment cycle,* applying them in two dimensions: (1) the consulting engineer can take the initiative to present new and reliable efficiency technologies just being introduced to the market and (2) changes to the production and product quality at the production site caused by the efficiency investment are analysed in order to identify risks and co-benefits which are often neglected in energy efficiency investment considerations. Examples include absorption technologies substituting the compressor technology for cooling or concentrating exhaust air contaminated with organic solvents in order to use the concentrated air as an auxiliary fuel in cogeneration plants or boilers. An example of a co-benefit is constant product quality after introducing improved control technology to avoid overheating in ovens at high temperatures.
- Aspects of innovation research, i.e. the concept of *first movers*, followers, and late applicants are considered along with the competences and motivations of these types of companies and their management, company size and whether they can employ specialists from the field of efficient energy use as internal staff or as external consultants. There are examples where participating companies asked their technology providers to improve existing machinery or plants; there are also cases where participating companies started thinking about improving the efficiency of their own products (e.g. ventilators) or developing new energy management equipment for small and medium-sized companies. The participating companies seem to be "potential first movers" in many cases. The authors therefore suggest offering them specific incentives to contact technology providers, applied research institutes, and energy agencies with their new ideas for energy-efficient solutions.
- Finally, the concept also integrates *approaches of social and individual psychology*. These include social dynamics such as mutual affirmation and acknowledgement within a company and among the energy managers of several companies or administrations. Social cohesion is another example as well as responsibility and sanctions once a common target has been agreed. In addition, behavioural elements play a role such as the low competitive behaviour in acquainted groups and individual behaviour. This latter also includes several aspects to do with motivation – of individual professional careers, of experts sharing their knowledge with colleagues, or of management with regard to a positive pub-

lic image and acceptance of the company at its production location (Schmid 2004, Flury-Kleubler et al. 2001). One good example here is the generation of so called “energy scouts”: apprentices at a production site are given specific measurement appliances to identify energy losses (losses of heat, compressed air, cooling; idling machines, etc.) and the specific training to use them und evaluate their results (ebmpapst 2016). These young people are highly motivated to conduct this task as they get very positive feedback from the energy manager for each relevant energy loss they detect. The concept was so convincing that 33 chambers of commerce in Germany now offer specific training courses for energy scouts. More than 1,000 energy scouts of many companies have been trained during the last two years (DIHK 2016).

The LEEN management system, developed with financial support from the German Federal Ministry for the Environment, now features more than 100 elements to support the network operator, the consulting engineer, and the moderator, but also initiators or multiplicators such as trade associations, chambers of commerce, or business developers. These elements comprise recommendations on how to approach and acquire potential participants and for the agenda of a first information event. They also cover the description and division of tasks for the network operator, the consulting engineer, or the moderator, master contracts for all actors, including the participating companies and how to report the energy audits and conduct the yearly monitoring. Training material as well as training courses are offered for consulting engineers and moderators, and other assistance including 17 calculation tools to evaluate the energy efficiency options of cross-cutting technologies in technical and economic terms such as boilers, compressors, electrical motors, and pumps (Rohde et al. 2015). Most of the elements of the LEEN management system can be downloaded on the project’s homepage in German (https://www.energie-effizienz-netzwerke.de/een-de/info-pakete/downloads.php). An English version is also available for most elements. A 3-day training course is required to be able to use the investment calculation tools properly. A licence is required to use the LEEN MS outside Germany (licence holder: Fraunhofer Gesellschaft).

A well structured report on the obligatory energy audit or a related, electronically calculated list of measures with their energy and cost savings, risk and profitability measures, and the avoided CO_2 emissions are essential for the LEEN MS. This list forms the basis for the monitoring process, which complies with the energy review outlined in ISO 50001. Compliance has been certified for the following steps (Rohde et al. 2015): energy review, energy baseline, energy performance indicators, energy objectives and targets, monitoring and measurement, and input to management review.

THE ACHIEVEMENTS OF LEEN-NETWORKS IN GERMANY FROM THE PERSPECTIVE OF THE PARTICIPATING COMPANIES

The 366 companies participating in 30 pilot energy efficiency networks between 2009 and 2014 have been evaluated by several analyses including the results of their energy audits, the yearly monitoring as well as questionnaires at the beginning and end of the four years’ first operating phase (see Figure 3).

The participating companies were asked about their past energy efficiency activities, their expectations at the beginning of the network and their judgment of the network’s performance and what they gained from it at the end of the four-year period. The systemic nature of the energy efficiency networks contributes to reducing many of the obstacles to energy efficiency mentioned in section 1 (e.g. lack of information and knowledge, low awareness of the topic, high transaction costs, decision routines solely oriented to investment risk). The network approach also means that often unused supporting factors (such as motivation, acknowledgement, or self-responsibility) are applied during the meetings and site visits, or in the meetings with the board or management to discuss the results of the annual monitoring.

On average, network participants doubled their energy efficiency progress compared to non-participants of the branch, resulting in an efficiency increase of 2.1 % per year (Rohde et al. 2015). The average annual savings were €180,000 per participant (with annual energy costs of around €2 mill.), induc-

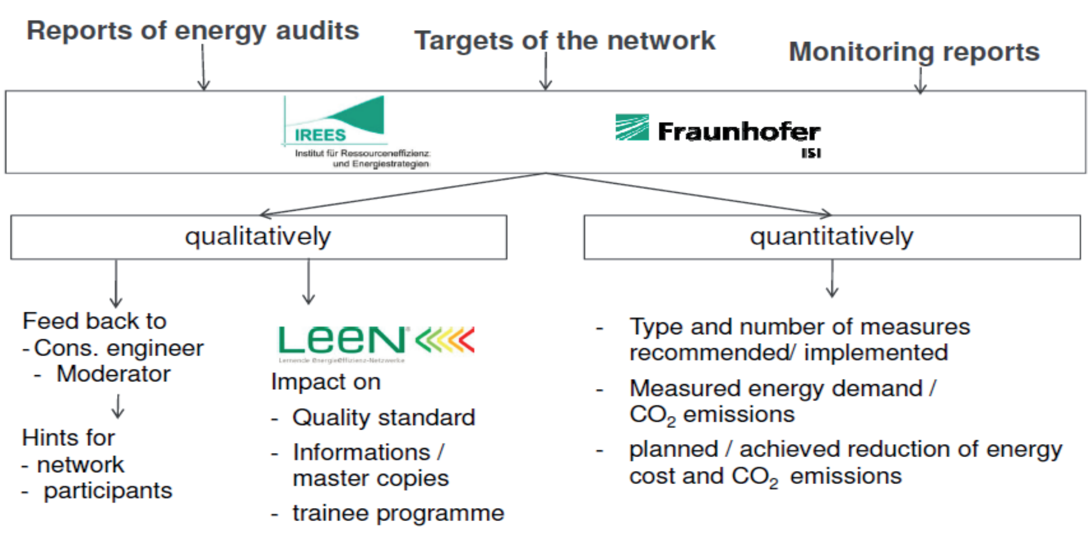

Figure 3. Evaluations of the performance of 30 pilot energy efficiency networks with 366 companies.

Table 1. Distribution of net energy efficiency investments according to their monetary size.

Range of net investments in euros	Number of net investments	Share of total net investments in %
< 5,000	1,387	39.8
5,000 to 50,000	1,511	40.4
50,000 to 250,000	474	13.6
250,000 to 1 mill.	96	2.8
> 1 mill.	17	0.5

Source: own evaluation of 366 participating companies.

ing investments of almost €600,000 over the four-year period. Of course, these average figures do not reflect the specific situations of companies, branches, the status of efficiency at the beginning of a network or the engagement of the participating company during the network's four-year operation. Two networks improved their efficiency by less than one percent per year, but two others by more than four percent: 14 networks were between 1 and 2 %, and 10 between 2 and 3 %annually.

Investments in additional energy efficiency also varied substantially by type (e.g. economizer of a boiler, heat exchanger added to an air compressor, high efficiency motors instead of a normal motor, pumps or ventilators) and size depending on the energy services or energy demand at the production site, building or factory (see Table 1). About 80 % of all net investments were below €50,000. However, the basic re-investment also has to be considered that usually accompanies have to undertake, for instance a new boiler, a new air compressor, a new normal pump, ventilator or efficient electrical motor, or they may invest in a cogeneration plant substituting the capacity of a new boiler investment. The value of this basic re-investment is several times higher than the net energy efficiency investment, but not reported here. This is important when considering financing these investments by third parties like contractors or banks.

Some further results have been reported by Rohde et al. (2005), Köwener et al. (2014) and Dütschke et al. 2016). They all report convincing results regarding overcoming several obstacles on energy efficiency and speeding up new ideas on energy efficiency improvements of technologies and organisational measures.

THE INITIATIVE 500 ENERGY EFFICIENCY NETWORKS BY THE GERMAN GOVERNMENT AND INDUSTRIAL ASSOCIATIONS

Early in 2014, the evaluation of the 30 pilot energy efficiency networks was finished. At that time, about 60 energy efficiency networks were operating or finished. While the companies of the 30 pilot networks received a subsidy of about 30 % of their participation fee cost during a four years period (and five networks für SMEs as well), the other networks were established and operated by experienced network operators, mostly by a large utility, a few regional company associations and an applied research institute. In many cases, the operators also covered the role of the moderator. In many cases, the operator could cover the network's expenses and earn a small margin. The network operators considered the efficiency networks as a business case for different reasons: utilities and also regional company associations regarded the efficiency networks as a deep and costless insight into the participating companies and as an acquisition tool for further energy services they offer (e.g. contracting, planning, consulting). Active utilities in Germany also regarded the networks as a mean for customer binding, or the regional company associations and a few chambers of commerce recognised them as a responsive service to their member companies. A few utilities in Austria took up the networks as one option to meet the legal obligation since August 2014 that obliges them to increase energy efficiency of their customers (see below).

Given the impressive success of the LEEN networks in the industrial sector (and to some extend in the service sector as well), the German government decided in 2014:

- To implement an agreement with 22 business associations and organisations to establish and operate approx. 500 energy efficiency networks until 2020. This agreement is part of Climate Action Programme and the National Energy Efficiency Action Plan to reach German climate targets. The government expects energy savings of 75 PJ primary energy and to reduce CO_2 emissions by 5 mill. tonnes per year (Initiative Energieeffizienz-Netzwerke 2016). By June 2016, some 65 energy efficiency networks had been initiated and are now up and running (About one third is operating with the LEEN MS and two thirds with other standards). The agreement defines an official operating minimum standard to count established energy efficiency networks. Six networks are not regional networks but branch networks (non-ferrous metals, electric steel, glass production, hotels, machinery manufacturing, refineries) where aspects of competition have to be handled and anti trust laws have to be considered.
- To set up a funding scheme for energy efficiency networks for cities and counties with between 20,000 and 200,000 inhabitants (BAFA 2014). This is based on the LEEN management system for companies and has been adapted to public authorities and more building-focused technical topics. The funding conditions request the applicants to respect the rules of the communal energy efficiency networks. The grant scheme for cities and counties has been rapidly accepted: by the end of March 2016, more than 35 communal networks were in the process of convincing the necessary eight communes or cities to form an energy efficiency network. 15 networks are already operating.

The German government also sparked a debate on the introduction of energy efficiency networks during its G7 presidency. The result was a survey on energy efficiency networks in industry in several G20 countries (IPEEC 2016), which will be followed by an international workshop on this topic in Berlin in September 2016.

The role of policy boundaries

The type of energy efficiency network, its initiation, standards, and development depend on the energy and climate policy boundary conditions in the various countries:

- The exemption from the very high CO_2 surcharge in Switzerland when companies join an energy efficiency network induced government involvement in setting the standard, how to operate the networks and how to monitor the results. Until the end of 2014, this task was performed by the Energy Agency of Industry (EnAW) as a mediator between government and the Swiss industry. Since 2015, a second institution has been able to set up networks under similar conditions.
- In contrast to Switzerland, Germany's voluntary agreement allows a large variety of network standards, as the government did not rule on a specific performance standard, but negotiated a minimum standard with defined criteria (e.g. minimum duration: two years; minimum number of participants (5–8); no specific certification of the consulting engineer or the moderator. Any institution or company can initiate and operate an energy efficiency network. There is an obligatory monitoring on the savings of each participant, however, aspects of duration of the measures' impact, of the effect of growing or shrinking production or varying weather are not included in the monitoring calculation scheme. A monitoring institute will evaluate a randomly selected sample of these reports on an annual basis. At present, the government has no way to guarantee the set objectives, whether the 500 networks will be established, the planned 75 PJ saved or 5 mill. tonnes CO_2 avoided.
- In Austria, the parliament decided in August 2014 to demand that the customers of utilities and other energy suppliers achieve a 0.6 % efficiency improvement. As energy efficiency networks promise a high rate of progress in energy efficiency improvements, the Austrian utilities adopted the idea of energy efficiency networks from Germany (mostly the LEEN MS) to deliver these savings and report the results to the government. The diffusion of energy efficiency networks has been rather moderate here because it is permitted to bank any energy saved above the 0.6 % savings (which is very easy in industry).
- In China, the central government decided in 2011 to ask the State Grid Company of China to set up energy efficiency networks in Chinese industry. For each installed energy efficiency network, the State Grid would acknowledge a 0.3 % improvement in energy efficiency without any monitoring. German network experts trained 50 Chinese engineers and 50 moderators in 2012 and 2013. In 2015, China has reported 573 operating energy efficiency networks. However, their performance is expected to be rather low based on the insights into the process at the State Grid Company during the trainee programme and the results of the exams after the trainee programme. In June 2016, many energy efficiency networks had stopped operating because the maximum share that can be accounted for by operating energy efficiency networks is 5 % of the total savings State Grid has to achieve among its customers.

Although the energy and climate policy boundary conditions of a country co-determine the quality and performance of energy efficiency networks in industry and the service sector, the authors are convinced that both the quality and impacts of energy efficiency networks will continue to rise in any country, mainly due to the benefits realised by the participating companies, but also due to the consulting engineers, the network operators, and the manufacturers of energy efficient equipment. The utilities soon realise that energy efficiency networks are a zero cost acquisition option for their various energy services and also provide them with detailed insights into their customers' production sites and decision making processes as well as an opportunity for closer ties to their customer.

The diffusion of energy efficiency networks through a country's industry also offers a chance to reduce energy imports and substitute them by investments, capital and additional jobs. This is why chambers of commerce, regional and national governments, but also industrial associations are becoming more interested in this "policy instrument of industry for industry". Finally, governments striving for sustainable development are also considering the opportunities offered by energy efficiency networks.

Conclusions

Energy efficiency networks do respond simultaneously on several obstacles and unused supporting factors. The impact of the networks' collective knowledge and ever increasing experience is the major factor why participants of the networks have above average success by implementing energy-efficient solutions.

Energy efficiency networks do not only respond to obstacles and unused supporting factors, but are extremely innovative regarding efficiency improvements they ask for their technology suppliers and regarding their own products in many cases.

The costs of operating an energy efficiency network can be covered by the participants as the participation fee represent only a small share of the total energy cost savings. This observation gives governments the option to negotiate a voluntary activity with the associations of industry and commerce or to set rules where participating in those networks induces a financial incentive. In both cases, operating energy efficiency networks offers the opportunity to make it a business case. However, the crucial challenge of the business is the initiation of a network, the acquisition of the participants in particular.

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