Energy efficiency networks: lessons learned from Germany

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Keywords

monitoring, assessments, evaluation, energy saving technologies, multiple benefits, energy management system, energy efficiency networks (EEN)

Abstract

The energy efficiency network (EEN) concept was first developed in Switzerland in the late 1980s and was adopted in Germany in 2002. During a long pilot phase between 2002 and 2013, the lessons from 40 Learning EENs (LEENs) in Germany led to a certain format for regional EENs for SMEs and larger companies. By the end of 2014, the Energy Efficiency Network Initiative (IEEN) was launched as a voluntary agreement between the German government and currently 22 industrial and economic associations, to support the creation of 500 new EENs until the end of 2020.This paper reports on two aspects of EENs of companies in Germany:

1. The results of ongoing evaluations regarding German EENs following different operational formats in terms of duration, number of participants, network energy saving target, etc. The evaluations regard challenges and means to improve EEN-related work as well as first results of a rough assessment of the IEEN impacts regarding energy savings and emission reductions.
2. The long-term impacts on energy use, innovative activities and changed decision routines in participating companies of regional LEENs. This evaluation gives deep insights into achieved energy cost savings within an investment period, into the diffusion of efficiency-related knowledge into subsidiary companies within groups and into the reaction of machinery manufacturers and plant planners to the demand of more efficient solutions by network participants.

Finally, this paper concludes with an analysis of the lessons learned from German EENs including barriers and challenges to initiate EENs as well as suggestions to improve EENs' promotion. The main finding is that EENs are not only a successful concept in terms of energy efficiency but it also offers multiple benefits to the participants such as innovative ideas for energy efficient solutions. However, a major challenge is to convince companies to join EENs.

Introduction

An Energy Efficiency Network (EEN) is a group of companies or public institutions whose energy managers meet regularly to share experiences on energy savings and to implement solutions (this paper focuses on companies' EENs). Switzerland developed and implemented the concept of Energy Efficiency Networks (EENs) in the 1980s and 1990s in order to foster profitable energy savings in the industry and the commercial sector (EnAW 2016). The Swiss experience was very successful, particularly after 2005 when additional incentives were introduced which exempted the voluntarily engaged companies from the CO_2 surcharge on fossil fuels, if they agreed on an individual efficiency target including a yearly monitoring. In 2018, the surcharge amounts to 82 Euro per ton of CO_2.

Based on this innovative way to promote energy efficiency in the Swiss economy (industry and the commercial sector), the concept of EEN was transferred to Germany in 2002 and adapted to the local context by Fraunhofer ISI and the regional association "Modell Hohenlohe e. V" in a first pilot network

which was financially supported by the Ministry of Environment of Baden-Württemberg. The network's contract was prolonged several times until 2011. A second pilot phase started in 2006 with four regional EENs of which the utility EnBW started two of them (Jochem and Gruber 2007). The development of a network management system was supported by the German Federal Environment Foundation (Deutsche Bundesstiftung Umwelt - DBU) and after 2008 by the German Ministry of Environment until 2014 within the "30-Pilot-Networks" project (Mai et al. 2016). The so-called Learning Energy Efficiency Networks (LEEN) are groups of 10 to 15 participants, usually companies, but sometimes public institutions, which meet around four times a year over the course of three to four years, as agreed upon in a first contract.

Such an approach with EENs was successfully demonstrated in Germany not only for large participants (i.e. yearly energy cost between 1 and 50 Mio. Euro) but also for smaller companies with yearly energy costs between 50,000 Euro and 1 Mio. Euro. Several papers (e.g. Mai et al. 2016, Dütschke et al. 2016 and Wohlfarth et al. 2016) have shown evidence of above-average energy efficiency improvements for the network participants compared to similar companies not involved in an EEN, additional economic benefits as well as further benefits in the organisation of the companies. The papers also documented later the key factors for the success of EENs.

Consequently, the concept of EEN has gained a growing interest in Europe (e.g. Sweden, Austria, Belgium, Croatia and Romania) as well as in some other countries in the world (e.g. Mexico and in particular in China) (Mai et al. 2016 and IPEEC 2017), but primarily in Germany itself.

In 2014, the Federal Ministry for Economic Affairs and Energy and the Federal Ministry for Environment introduced the next step for Germany: The Energy-Efficiency-Networks Initiative (IEEN) was launched as a voluntary agreement with the German economy. This instrument became one of the pillars in the "National Action Plan on Energy Efficiency" (NAPE, see BMWi 2014). The German Government and industrial associations and organisations (currently 22) committed to support the creation of 500 new EENs between the end of 2014 and the end of 2020. The Federal Government expects 75 PJ savings of primary energy and reduction of 5 Mt CO_2 emissions during that time frame. The German Energy Agency (Deutsche Energie-Agentur – dena) is the head office of the IEEN since December 2015. The IEEN plays the role of a national and neutral entity for EENs in Germany. As of February 6th 2018, 154 EENs, founded since December 2014, have been successfully registered as EENs of the initiative. This includes LEEN-networks as well as EENs following other models, like REGINEE[1] or adapted Ökoprofit-Clubs[2].

While the political interest for EENs is high and EEN participants are fundamentally satisfied by the achievements of their networks and their companies, one of the key challenges to unfold the full potential of the EENs is the generation of further new EENs in Germany as well as in other countries, where EEN is considered as a voluntary policy instrument too.

This paper reports on the development of the IEEN (including results of first preliminary evaluations) and on observed long-term benefits that participating companies and policy makers can expect from EENs. These long-term impacts cover further benefits besides energy cost reductions and CO_2 mitigation, like innovative ideas for energy efficient solutions, the diffusion of efficiency related know-how of participating sites within larger companies and groups, or changing investment decision patterns and transaction cost in participating companies.

IEEN: facts, figures and rough assessment

As mentioned previously, the goal of the IEEN is to support the creation of 500 new EENs in Germany from December 3rd 2014 until December 31st 2020. The main tasks of the head office of the IEEN (dena) are: to be the central contact point for all stakeholders of the IEEN, coordinate and support IEEN communication, inform and motivate multipliers on national and regional level about the concept of EEN (IEEN 2017), manage EEN-registration, represent the IEEN at events like fairs, conferences etc., organize own IEEN-events such as yearly conferences, coordinate stakeholder-processes, perform surveys on EENs and provide advisory service for the development of the IEEN and EENs in general. Moreover, the IEEN is the second most important political measure of the German National Action Plan on Energy Efficiency in terms of potential energy and emissions savings (BMWi, 2014). The German government estimates 500 EENs may lead to an overall primary energy saving of up to 75 PJ and a greenhouse gas reduction of up to 5 million tons CO_2-equivalent (BMWi 2017).

For registration at the IEEN, EENs have to fulfil following minimum criteria:

1. have been founded after December 3rd, 2014,
2. agree to at least 2 years running time,
3. have at least 5 participating companies or company sites in Germany,
4. be supported by qualified moderators and internal or external energy consultants,
5. define a common energy saving target[3] (at the latest one year after foundation), and
6. participate in the monitoring process of the IEEN.

A certificate of participation signed by the two German Ministers – for economy and for environment – is assigned to each company of every registered EEN once the EEN has defined its common energy savings target.

The IEEN-criteria have been defined in order to enable the registration of EENs following different formats (such as LEEN, REGINEE or Ökoprofit-Clubs adapted to EENs), while ensuring at the same time a minimum operational quality of EENs. In some aspects, these criteria are more flexible than those for

1. Regionales Netzwerk für Energieeffizienz (Regional Network for Energy Efficiency, see AGEEN 2018).

2. Ökoprofit-Netz (Ecological Project for Integrated Environmental Protection, see Ökoprofit NRW 2018). To be recognized as EEN, Ökoprofit-Clubs have to adapt their work to the IEEN-requirements (e. g. extend their running time from one to at least two years).

3. For the IEEN, an energy saving target is the total amount of final energy expected to be saved by all EEN-companies within the EEN-running time.

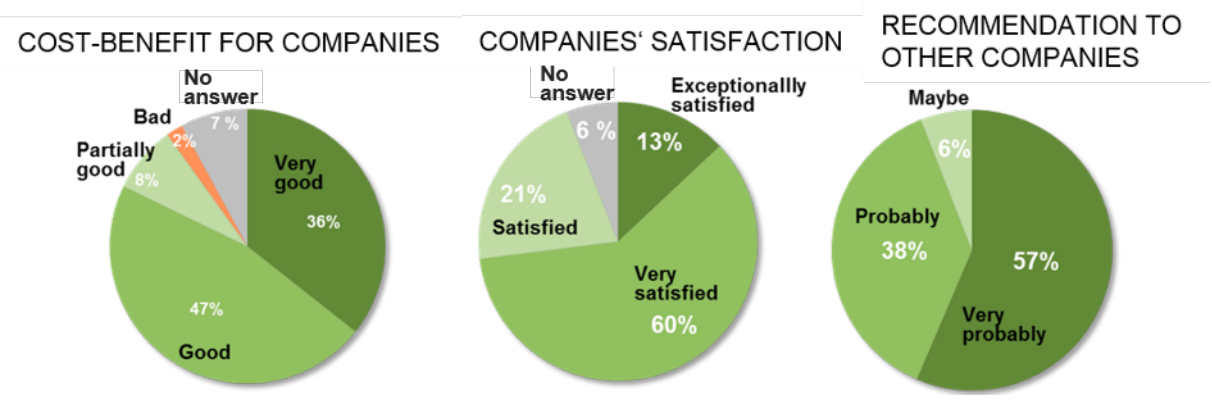

Figure 1. Company opinions on cost-benefit ratio, company satisfaction and recommendation to other companies (n: 53 companies) (GSIEEN 2017).

specific EEN-formats. For example, LEEN requires a minimum of 3 years in terms of running time, network moderators and consulting engineers must have a LEEN-certification, and the implemented monitoring is more extensive.

It is important to stress, that EENs participating at IEEN do not receive any direct financial support from the Federal Government for network activities. However, three federal state governments (Bundesländer) currently offer direct financial support programmes for EEN-activities. Some of these programmes focus on supporting the acquisition of network-participants (companies) while other programmes focus on activities during EEN-running time. A few other federal state governments indirectly support the generation of EENs via institutional support – often offered via regional energy agencies. In any case, companies can apply for different financial programmes supporting energy efficiency consulting or investments, for example the federal government funding programme for cross-sectoral energy efficiency technologies. More than 50 % of the companies applied or is planning to apply for this kind of financial support for their energy efficiency investments (GSIEEN 2017).

Furthermore, to fulfil their commitment to the IEEN, some associations offer special support to EENs (mostly for their respective branches) or manage EENs by themselves. For example, in the case of the Mechanical Engineering Industry Association (Verband Deutscher Maschinen- und Anlagenbau – VDMA) EEN-services (e.g. network moderation) are already included in the membership fee payed by its members. Another example is the Association of Energy Consumers (Bundesverband der Energie-Abnehmer e.V. – VEA), an association with more than 4,500 medium-sized companies, which focuses on energy consulting services. VEA member companies pay lower fees for EEN-services than non-member companies in REGINEE-networks. Finally, different tools such as sample contracts and calculations sheets[4] are available online for free for EENs.

As of February 6th 2018, the IEEN records 154 registered EENs, which accounts to a total of more than 1,500 companies active in EENs. Registration of EENs has significantly increased since the beginning of the IEEN: 29 by the end of 2015 and 73 in 2016. In 2017, only 45 EENs were registered, the reason for the slowdown is not clear yet. One thesis might be that the companies, which are very open to the concept, have already been harvested. However, the number of EEN-registrations has significantly increased in the first days of 2018. The EENs registered at the IEEN are divided into regional (78 %), sector-internal (16 %), company internal (4 %) and small companies'[5] (2 %) networks.

SURVEY 2016

By the end of 2016, a survey of the EENs registered at the IEEN has been carried out by the head office of the IEEN to gather information on EEN practice in order to – among other things – better understand EEN-work and improve support to EENs. (GSIEEN 2017). A total of 48 EEN operators, 41 moderators and 53 companies were interviewed by telephone. Some selected results of the IEEN-survey are presented in Figure 1. The key results are: 73 % of companies are exceptionally or very satisfied with their network and 94 % of companies would recommend network participation to other companies. Consequently, a large majority of the companies (83 %) evaluate cost-benefit ratio of network participation as good or very good.

Due to the good results and positive experiences, more and more EENs decide to continue their work after an EEN-cycle. This means, after having completed all EEN-phases (foundation, operation and monitoring) within the agreed running time, EENs decide to perform all EEN-phases again within a new running time. In this case EENs have the possibility to register again at the IEEN as a new network.

The survey results also showed that:

- 24 % of EEN operators and moderators are energy supply companies, 21 % are associations of different economic and industry sectors, 16 % are energy consultants, 14 % are chambers and the rest are organizations of different kind,
- common topics in EEN meetings are: experience exchange, energy efficiency measures development, expert presentations, site visits, Energy Management System (EMS), regulatory frameworks, cross-sectional technologies, founding programs, measurement concepts and energy supply,

4. Including many elements of the LEEN management system tools.

5. Companies with less than 80,000 Euro energy cost per year.

- around 4 working days (on average) are required to convince a company to join an EEN,
- on average, 4 network meetings are organized per year,
- EEN moderators need 20 working hours to prepare an EEN meeting on average, and
- network participation cost for companies varies between 1,000 and 5,000 Euro per year.

ROUGH ASSESSMENT

A "rough" assessment of IEEN impacts has been carried out by the head office of the IEEN based on 85 energy saving targets of registered EENs available as of January 12th, 2018. For the methodology of this rough assessment, it was assumed, that all EENs would reach their savings targets. Hence, this estimate can be considered as conservative, because companies usually prefer to agree on a lower EEN target, which is then exceeded, than vice versa. Moreover, these targets take into account only those savings achieved during EEN running time. The fact that companies continue saving energy after EEN ending has not been considered. This means that higher savings than those calculated are likely possible (see next section).

Energy efficiency measures can involve energy carriers of different kinds. A proper conversion of final energy into primary energy requires then an appropriate conversion factor for each energy carrier as well as the saved energy amount per carrier. In addition, in case of energy carrier change, it would be necessary to know the amount of energy consumed before and after the implementation of the respective energy efficiency measure. Therefore, statistics on energy consumption per energy carrier of the German industrial, trade and services sectors developed by the German Working Group on Energy Balances (Arbeitsgemeinschaft Energiebilanzen e.V.) have been taken into account to define a rough and general conversion factor. Respective energy conversion factors have been selected from the German Energy Saving Ordinance (Energieeinsparverordnung – EnEV, see EnEV 2014) and the norm DIN V 18599-1:2011-12 (Beuth 2011). The resulting conversion factor is 1,334 GWh primary energy/GWh final energy.

Following the same logic, but based on the results of the German study "Klimaschutzszenario 2050" (Öko-Institut and Fraunhofer ISI 2015), a rough conversion factor of 240 t CO_2-equivalent/GWh primary energy has been considered for the conversion of primary energy savings into greenhouse gas emissions' savings.

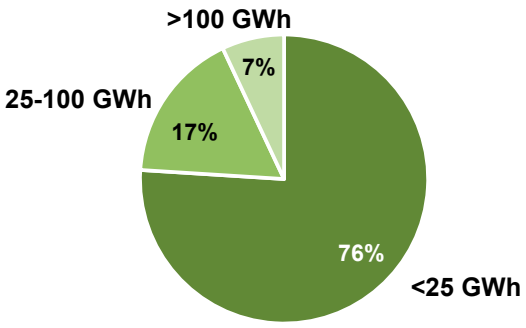

Figure 2. Energy saving targets distribution (GSIEEN 2017).

The results of the rough assessment show that savings expected by the German government for the IEEN are possible. The average energy saving target per network accounts for 31.8 GWh final energy. Around 76 % of energy savings targets considered for the assessment were under 25 GWh, 17 % between 25 and 100 GWh and 7 % over 100 GWh (see Figure 2). After converting average savings into primary energy and multiplying this by 500 (number of expected EENs at the end of the IEEN), the expected savings are around 76 PJ primary energy and 5 million tons of CO_2-equivalent. This suggests that the IEEN contributions to the NAPE are likely to be realistic, assuming that 500 EENs will be established and that these EENs will achieve their defined energy savings and CO_2 reduction targets.

The rough assessment results provide only an order of magnitude of possible energy savings of 500 EENs according to available information on energy saving targets. The official assessment of the networks registered at the IEEN, called "monitoring of the IEEN", started at the end of November 2017. This assessment will provide scientifically based results on effectively achieved results of first 30 EENs that have completed the cycle as well as further information. First monitoring results are expected by the end of March 2018 and are therefore not part of this paper.

After having provided an overview of the current situation and potential of EENs in Germany, the long-term impacts of the EENs are discussed in the next section.

Long-term impacts of the early EENs

One of the recommendations of the Working Group of EEN in Germany (Arbeitsgemeinschaft der Energieeffizienz-Netzwerke Deutschland – AGEEN) suggests a minimum running time for an EEN of at least three years (AGEEN 2017). This is based on the observation that participating in a long-lasting, well-operating network makes a considerable difference compared to companies searching for energy efficient solutions individually. However, long-running EENs as a contractual precondition may be a substantial impediment for companies to participate if they do not have any experience with EEN (see section "findings and lessons learned" below) and cannot anticipate the benefits of the EEN work for the several years to come.

The real running time of EENs varies depending on the political framework conditions of their country or their branch, on their company size or their conceptual framework. In Germany, the EEN running time is set by a first contract between the network operator and the participants. It ranges mostly between two and four years. However, this does not mean that the network ends after the first contract period. Often, the companies prolong the contracts for some years, often on a yearly or two years' term. Life times of EENs of eight to ten years (in several EEN-cycles) have been observed for about one third of the EENs in Germany.

Some of the participants may step out of an EEN after the first or second prolongation, so the network operators generally look for new companies to join the existing EEN.

In many cases, after an EEN-cycle, quite a few participants decided to keep an EEN running without following all EEN-

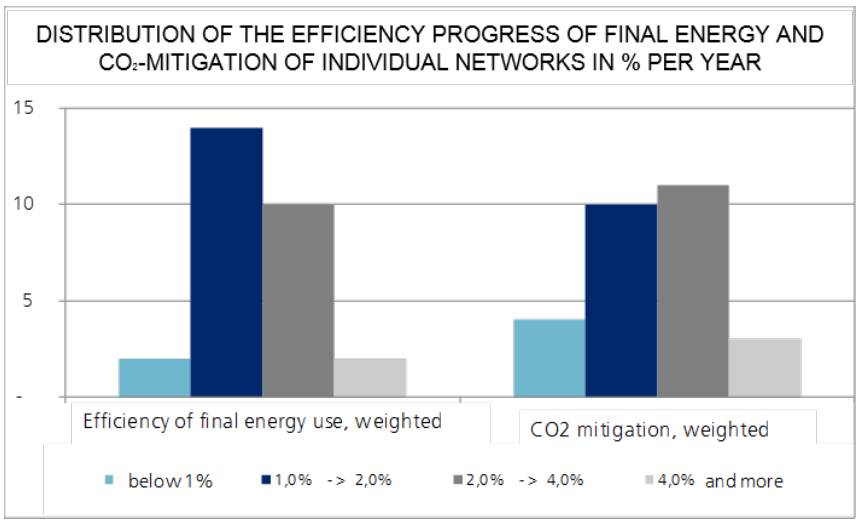

Figure 3. Distribution of average yearly savings and yearly CO_2 mitigation effects of 28 EENs (Fraunhofer ISI and IREES 2015).

rules. For example, companies do not commit to a new saving target or don't perform a regularly monitoring of the savings.

This section reports on observed long-term impacts of regional EENs starting between 2002 and 2012. There is no systemic evaluation so far on the impacts described below. The impacts described have been reported by participating companies, moderators or consulting engineers. In some cases, reported here, it remains unclear whether the company's action and related impacts can be directly referred to its participation in the EEN or whether additional or other reasons finally induced the action or impacts described below.

LONG-TERM IMPACT ON ENERGY USE AND CO_2 MITIGATION OF THE PARTICIPANTS

The energy savings achieved by 330 companies of 28 Learning EENs (LEENs) within four years amounted on average to 2.3 % per year. The average CO_2 emission reduction was slightly more successful (by 2.4 % per year) due to substitution of heating oil by natural gas, of fossil fuels by modern forms of wood use, or slightly increasing shares of green electricity. In absolute terms, the average yearly savings achieved after three to four years were 2.7 GWh per participant and 33 GWh final energy per EEN of large companies (on average: 12 participants per network); for the SMEs' EEN, the results were lower by a factor of eight on average (i.e. 4 GWh per Mari:e-EEN with ten participants per network). As mentioned in the previous section, for EEN registered at the IEEN, energy saving targets are not related to yearly savings; they correspond to the expected savings within the EEN-running time. The average energy saving target as of February 6th, 2018 is 31.8 GWh and, as previously shown in Figure 2, the range of saving targets varies from a few GWh to over 100 GWh.

However, the distribution of the yearly energy efficiency improvements and CO_2 mitigation results varied substantially among 28 evaluated LEENs (see Figure 3):

- two networks achieved less than 1 % annual energy efficiency improvements,
- half of the sample (14) achieved average improvements between 1 and 2 %;
- ten networks managed to achieve 2 to 4 % yearly efficiency progress and even two networks more than 4 % annually.

As the participants were in most cases manufacturing companies and non-basic materials industries, the baseline of the "autonomous" energy efficiency progress is about 1 % annually. The additional rate of improvement can be largely attributed to the participation in the EENs.

The reasons for this wide scope of distribution are manifold:

- Large, basic materials producing participants do not only dominate the share of the network's energy demand, but also determine the level of energy savings of the EEN, simply by their high energy share in the total energy demand of the EEN. In addition, the saving potentials of the cross-cutting technologies of a basic materials producing company may be small in absolute terms relative to the energy demand of the production process (e.g. cement kiln, fluorine electrolysis).
- In other cases, the present priority of decisions in investments either in the core processes or cross-cutting technologies of the participants or the degree of engagement in energy efficiency by the energy manager or the management may vary significantly.
- A substantial share of the participants may have been involved in energy efficiency activities for many years (leading to smaller energy efficiency improvements), while a majority of another EEN may still have many "very low hanging fruits" that they did not realise before starting off the EEN. A similar reason may be that the average of re-investment cycles of cross cutting technologies may vary among networks.

Given these different reasons, one may question whether the high energy efficiency improvements of more than 3 to 4 % annually last for more than four or five years. Often, the argument has been made that such a high efficiency progress is only possible for a few years to earn the "low hanging fruits" ("stair case effect"). However, there are several cases in the non-basic materials industries that show yearly efficiency improvements of around 3 to 4 % per year being maintained over the course

of ten years. One of the biggest bus producers in Germany, for example, achieved 45 % efficiency improvements within 10 years. The energy manager transferred the knowledge from a regional LEEN for one production site in Ulm to a second site in Mannheim and achieved similar results of energy savings and reduced CO_2 emissions (Uhl 2017). Another example is a small company as component supplier for the car industry using powder coating as the major production process. Within 15 years, from which the company participated the first nine years in a LEEN, it reduced its specific energy demand by 54 % and its specific CO_2 emissions by 56 % (Henkel 2018).

INNOVATIVE IDEAS OF PARTICIPATING COMPANIES AND REACTIONS OF THEIR TECHNOLOGY PRODUCERS

The longer companies participate in their EEN the more they are likely to question the energy efficiency of their production plants in more depth. They gain more competence and know-how in energy efficiency issues, they rely on the advice of other network participants or they may ask experts who have been invited to the network meetings. In quite a few cases, participating companies start searching for reduction of energy demand or energy waste heat in their production processes. In other cases, participating companies started thinking about improving the efficiency of their own products or developing new products or energy efficiency services. So far, there is no systematic study on whether companies participating in networks are more innovative in energy efficient solutions than non-participants. However, some examples may elucidate the aspect:

- A small company producing metallic components undertook a systemic analysis of its powder coating process looking at heat losses of the washing process, the drying, the oven, and the cooling process of the powder coated products. Besides small efficiency improvements (reducing the washing temperature by another detergent, heat recovery of the condensation heat of the fume and mechanical drying of the components), the company asked the oven manufacturer to substitute the hangers of the production chain with newly designed hangers with less internal heat capacity. In addition, the company is presently striving for a solution to use the internal heat of the products after they leave the oven. In many branches the internal heat of products is not used contributing to large "waste" heat losses. There are quite a few of these examples where network participating companies asked their technology providers to improve existing machinery or plants; in many cases, their providers took up the innovative ideas.
- A large ventilator producer, ebm-papst, participating in the first German LEEN, started reflecting its own products and possible improvements on energy efficiency. The result was a highly thermodynamically improved ventilator combined with a high-efficient electric motor and control system leading to a 2.4 fold improved efficiency. This efficient system is now installed in thousands of refrigerators and freezers in supermarkets.
- Another example is the development of a new energy management equipment (i.e. energy measurement systems, communication, central calculator and related calculation software) for small and medium-sized companies which was the idea of the energy manager of an electronic producing company participating in a network and realizing the need of such a product by his colleagues and its own competence to produce it.

New ideas for energy efficient solutions in production processes or in own products have been observed in quite a few companies participating in EENs. A systematic evaluation on this issue will be carried out in late 2018. A first indication of additional impacts induced by participating in EENs can be derived from a recent evaluation (Chassein et al. 2018):

- 58 % of the measures implemented by 85 interviewed companies participating in EENs since 2015, have been identified and implemented in addition to the measures suggested by foregoing audits,
- 45 % of the 85 companies said that they implemented measures because of their participation in their EEN (see Table 1).

Another indicator might be that many of the companies being a member at the front-runner group Climate Protection Companies (Klimaschutz-Unternehmen e.V.) are or have been a member in one EEN as well.

DIFFUSION OF EFFICIENCY-RELATED KNOWHOW OF PARTICIPATING SITES WITHIN LARGER COMPANIES AND GROUPS

In quite a few regional EENs, production sites of industrial groups participated in one or two networks. As they realised the unexpected fast energy cost reductions due to the participation, some groups started their group-internal EEN. Examples in Germany are Procter&Gamble, Evobus, Miele, BSH, Bosch, ThyssenKrupp, METRO (from the Swiss experience) and EnBW (from its own experience as network operator and moderator).

In many cases, the formation of group-internal EEN is accompanied by an energy efficiency and/or CO_2 saving target

Table 1. Impact of LEENs on measures undertaken by participating companies (Chassein et al. 2018).

How do the following statements apply to your company?	yes	no	I can not say	no information
Suggestions from the energy efficiency network were implemented in investments or organizational measures	78 %	14 %	5 %	4 %
Some of the implemented efficiency measures would not have been implemented without participation in network	45 %	40 %	11 %	5 %
The energy consultancy had a significant impact on the selection of measures to be implemented and the level of investment	34 %	53 %	9 %	4 %

set by the board. In these cases, the energy managers receive more than average attention by the board and the controller; the board often allocates increasing budgets for the highly profitable energy efficiency investments.

CHANGED DECISION ROUTINES IN THE PARTICIPATING COMPANIES AND REDUCED TRANSACTION COST

80 % of companies only use risk indicator (payback periods) and no profitability indicators (e.g. internal interest rate, present net value) for their decisions on energy efficiency measures (Schröter et al. 2009). And even more questionable is the decision rule that payback periods of more than 2 to 3 years are mostly not accepted for energy efficiency investments. As the life time of most energy efficiency investments (either cross cutting technologies such as condensing boilers, high efficient air compressor or cooling systems, high efficient electric motors, pumps or ventilation systems or production processes such as kilns, furnaces, washing plants, dryers etc.) ranges between 10 and 20 years, this decision routine implies that investments with an internal rate of return of around 33 % are not pursued.

In some cases, an uncertain or questionable future of the production site or the production may justify such a short payback decision routine. This major obstacle of the progress of energy efficiency was addressed in all LEEN audit reports, advising the reader to use both indicators of risk and profitability. The result after three to four years of network running time was that 5 % of the participants (out of 78 % deciding solely on payback period among 360 companies) changed their decision routines and included a profitability measure (mostly the internal rate of return).

The relatively high transaction costs for energy efficiency investments is one essential obstacle realising profitable energy efficiency potentials (Mai et al. 2014). The exchange of experiences and the site visits during the meetings, the various experts being invited by the moderator to the meetings and bilateral contacts reduced transaction costs of 75 % of 360 participants of 30 LEENs after three to four years of running time. The impact increases over time as a recent evaluation reported a 13 % reduction of transaction costs after one to two years of running time (Chassein et al. 2018). Transaction cost reductions were particularly observed in the phase of information gathering, planning, and decision making with focus on the acquisition of information about technologies and suppliers as well as investment prices. However, the interviewed energy managers could not quantify this effect of reduced transaction cost in monetary terms.

Findings and lessons learned

The results of several evaluations show, that once the companies get involved in an EEN, they are fully satisfied with the EEN concept (GSIEEN 2017, Mai et al. 2016 and Chassein et al. 2018). They obviously realise the advantages of the exchange of experiences, the regular site visits, the target setting and monitoring and the resulting mutual motivation brought about. A survey of the head office of the IEEN shows that the 94 % of EENs` participants would recommend other companies to join an EEN (GSIEEN 2017). In another survey, 81 % of 85 recently interviewed companies in LEENs that started one to two years ago recommend the participation in EENs as well (Chassein et al. 2018). Therefore, EENs can be considered as a quite adequate instrument to promote energy efficient solutions in the private sector.

Unfortunately, it is very cumbersome and cost-intensive for the initiator and/or network operator to convince companies to join an EEN. Many companies hesitate to sign a two, three or four-year lasting contract for EEN-services (e. g. network-moderation) that they do not know yet. Experience from different EEN formats in Germany shows that on average 3 or 4 working days are required to persuade a company to join a network (Fraunhofer ISI and LEEN GmbH 2014 and GSIEEN 2017). These acquisition costs are quite high and generally cannot be recovered by a fee that participants are ready to pay, especially not before being convinced by the benefits of the EEN concept.

There are several reasons for this cost-intensive acquisition of network participants. However, many of them are common to energy efficiency in general (Sorrell et al. 2004):

- Lack of knowledge and market surveys of energy managers, particularly in SMEs (Trianni et al. 2016).
- Lack of time of the energy manager who often has several other responsibilities such as safety and environmental protection (Trianni et al. 2016).
- 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 as strategic investments (Cooremans 2011).
- 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 new energy-efficient 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 and Jochem 2003).

Because of these general barriers, the possibility to convince a company to participate in an EEN is not very likely. This is particularly the case, as the new EEN-services are more or less unknown and as the participating company has to pay a yearly fee (ranging from 1,000 Euro to 5,000 Euro – or even 8,000 Euro) and to allocate own staff to the task.

Obviously, the acquisition has to simultaneously overcome several of the mentioned obstacles in order to convince the companies to participate. Joining an EEN in this situation may also often be a question of trust. Therefore, the trustworthiness of the information on EENs and their benefits and of the person that tries to persuade a company to join becomes a major issue during the acquisition phase. A recent review for energy managers of operating LEENs reports that about half of the convincing reasons to participate in EENs were personal contacts with the network operator, the moderator or the consulting engineer (Chassein et al. 2018).

The monetary aspect of a yearly fee for participation, in order to cover the EEN work, can be handled in branch-specific

networks when the association takes over the operating cost of an EEN. This was realised quite successfully by VDMA.

One way to develop trustworthiness leads to the question of a patron, like the president of the industrial association or of the local chamber of commerce, the local Mayor, or the district chief executive. For example, the REGINEE-EEN Franken of VEA was founded very soon after intense personal engagement of the Chief Executive Officer. Therefore, the authors observed quite effective generations of EENs when these patrons were involved with great enthusiasm in the acquisition phase. Acquisition cost could be roughly cut by one-third of the usual effort. A similar effect is possible, when a large and well acknowledged company of the region or the branch has already signed the contract to participate.

Even the name itself "EEN" might be misleading. There are plenty of free workshops or working groups offered by industrial associations, chambers of commerce or regional energy agencies; they all focus on some aspects of energy efficiency. However, the EEN concept has a strong focus on the exchange of experiences among energy managers of the participating companies, on the implementation of energy efficiency solutions and a common energy saving target that are monitored (yearly in the case of LEEN and only once at the end or after the EEN running time in the case of the IEEN). All these activities are followed and supported by experts (moderators, internal or external energy consultants etc.) In this sense, EENs are in fact Energy Efficiency *Implementation* Networks and shall be promoted as such.

Given the fact that production sites of large companies or groups participating in regional or branch EENs increase the probability of the foundation of group-internal EENs, the acquisition of those EENs could also be a task of multipliers such as industrial associations, chambers of commerce or energy agencies or a business case for moderators, consulting engineers, or utilities.

In principle, utilities and energy service providers are particularly well suited for their role as EEN operator: in Germany, more than 100 public and private utilities are involved in EENs. On the one hand, they have the business customer contacts, on the other hand, they are intensively involved in many dimensions of energy supply and, in part, in the energy optimization at their customers. Furthermore, there are many synergies with other business areas of the utilities or energy service providers.

Conclusions and suggestions of possible improvements promoting EENs

EENs simultaneously address several obstacles and unused supporting factors such as: increasing the acknowledgement of energy managers by colleagues, by the board or management, and by the controller; increasing the motivation of the staff and workers in the factories by special professional training, awards, prizes, or mentioning their successes in the company's newsletter. The impact of the EENs' collective knowledge and ever increasing experience explains why participants are very satisfied and successfully implement energy efficient solutions.

EENs are also extremely innovative regarding efficiency improvements in their processes and in their own products or services.

The long-term effects – whether energy cost savings, CO_2 emission reductions or innovative ideas in processes and own products and services – are unexpectedly high.

Some economists as well as actors in administration and industrial associations think that the profitable efficiency potentials (often called "low hanging fruits") will be exhausted after a few years and would slow down the potential energy efficiency progress of companies. However, there are companies in EENs, which have a 10-year long-term record on energy efficiency improvements. The authors will follow up this observation and search for the reasons of those long lasting high efficiency improvements.

In order to realise ideas of new energy efficient solutions in processes, products and services developed by network participating companies, the authors suggest to offer to those innovative energy managers and their companies specific incentives to contact technology providers, applied research institutes or energy agencies. The innovative ideas of the energy managers and/or the consulting engineers should be taken up in order to extend the potentials of energy efficiency. Networks of existing EENs would be the next promising step. A kind of meta-network for interested EEN operators and participants could raise the efficiency and professionalism of the EENs' work and also help EENs to share the knowledge in a broader group.

EENs are an adequate instrument to improve energy use in the industry and other economic sectors. Consequently, the German Government has recognized the importance of the mutual exchange of experience among energy managers. EENs are now a key feature of the main energy efficiency policy document in Germany (NAPE). For this reason other countries increasingly show interest in EENs.

This observation gives governments the option whether to negotiate a voluntary activity with industrial and economic associations or to set rules providing financial incentive for participating in those networks. In both cases, operating EENs offers the opportunity to make it a business case.

The diffusion of EENs in Germany is extending permanently but inconstantly. The crucial challenge is the initiation of a network, in particular the acquisition of the participants. The findings suggest that additional activities and improvements may accelerate the foundation of EENs towards the expected yearly rate. The authors stress following points:

- Promotion of the concept of EENs as Energy Efficiency Implementing Networks through a larger, branch cross cutting, and an intensive information campaign. This also implies the need for an important budget for professional marketing and advertising.
- Patrons, institutional multipliers, utilities, industrial associations and chambers of commerce as well as energy agencies can take up an important supporting role as a trustful personality or institution to convince the companies to join an EEN.
- The benefits of the EENs – the intended short-term and the indirect long-term impacts – are proven and obvious but still need to be studied and promoted with a higher intensity and more precisely conveyed to reach and convince the decision makers in the companies.

- It should become more attractive for companies to combine an EMS following ISO 50001/50003 and EEN activities. Already around 9,000 companies in Germany have a certified EMS.

The experience shows that companies with no EEN-experience feel insecure committing themselves for long periods as required for an EEN (at least 2 years in the case of the IEEN and at least 3 years in the case of LEEN). In some cases, to convince companies to participate at EENs, some network operators propose to first agree on a trial period shorter than the running time required for EENs. The success of such an approach still needs to be evaluated, but it has a serious potential to ease the decision process to join an EEN.

Experience shows that EENs in Germany often run much longer than the time agreed in the first EEN contract. As a remark, EENs have the possibility to register at the IEEN as "EEN in founding process", this means they can first be registered with a running time below two years and change this later, once the EEN has been formally founded or once it has defined a common energy efficiency target.

In the opinion of the authors of this paper, the above-mentioned improvements will help EEN to be an established instrument with an autonomous success story in Germany and abroad as well. EENs similar to those in Germany have been established or are planned in several industrial and emerging countries, e.g. Austria, Belgium, Canada, Romania, Sweden, Mexico and China (IPEEC 2017 and Mai et al. 2016).

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