Learning energy efficiency networks for companies – saving potentials, realization and dissemination

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Abstract
In Learning Energy Efficiency Networks (LEEN), 10 to 15 regionally based companies from different sectors share their energy efficiency experiences in moderated meetings. Following an energy review and the identification of profitable efficiency potentials in each company, all participants decide upon a joint target. Information regarding new energy efficiency solutions is presented by experts during these meetings, together with experiences concerning realized measures. The performance of each company is continuously monitored and is controlled on a yearly basis. The network operating period is typically from three to four years.

The LEEN management system consists of a variety of documents and calculation tools as well as regulations how to run a LEEN network. Thus it offers the participants a transparent evaluation of their saving potentials and ensures a quality standard. The energy review and the monitoring of implemented measures comply with the ISO 50001 standard. In the 360 participating companies of the publicly funded "30 Pilot-Netzwerke" (30 Pilot Networks) project, approximately 3,600 profitable measures were identified, corresponding to an energy saving potential of more than 1,200 GWh per year, and a CO_2 emission reduction of nearly half a million tons per year. The average internal rate of return of more than 30 % demonstrates the high level of profitability. The results of the monitoring process document the realization of these profitable saving potentials.

This paper analyses the data acquired in the energy review and monitoring processes of the 30 Pilot Networks project in Germany. In addition, it illustrates the role of this LEEN management system within the framework of energy efficiency policy, and discusses how the system can be disseminated so as to establish a successful efficiency strategy for industrial companies.

Introduction
In Germany, the industry sector, which currently accounts for about 30 % of final energy consumption, is second only to the transport sector in this regard (BMWi 2010). In the last two decades, German industry has already realized numerous energy efficiency measures, resulting in an increase in energy efficiency of 1.5 % per year from 1991 to 2011. In order to achieve the energy efficiency objective specified by the German Federal Government – doubling the current improvement in energy efficiency by 2020 – energy productivity must increase by 2.3 % instead of 1.5 % per year during the period from 2011 to 2020 (AGEB 2013). Various national and international studies outline the existence of huge profitable energy efficiency potentials in the industrial sector (e.g. Barthel et al. 2006, Eichhammer et al. 2009, Fleiter et al. 2013, Herbst et al. 2013, Pehnt et al. 2011, and Seefeld et al. 2007). If all the potentials were utilized to their full extent, final energy consumption could be halved by 2050. According to the assessment of numerous experts, the profitable measures realized so far fail to make full use of the existing energy efficiency potentials for reducing final energy consumption in industry. The essential obstacles and supporting factors are only partially addressed by the set of several

policy measures and instruments which have been developed. The obstacles to achieving energy efficiency are not homogeneous, but depend upon various factors such as company size, company structures involving shareholders and capital owners, the energy intensity, management preferences, and high transaction costs (Jochem et al. 2014, Fleiter et al. 2013). At present, company management often does not focus on energy issues, nor do the employees responsible for energy issues have enough time to spend on energy efficiency issues, because they are responsible for other tasks, too. In addition, investment decisions are often evaluated in terms of payback time rather than internal rate of return, and energy efficiency is not considered to be a strategic investment (Herbst et al. 2013).

In terms of overcoming these obstacles, as well as market limitations, Learning Energy Efficiency Networks (LEEN) provide a profitable option for reducing energy costs and energy-related CO_2 emissions for companies that have energy costs exceeding €500,000 per year (Jochem et al. 2007). LEEN networks serve to increase the priority of energy efficiency aspects within companies, while alleviating high transaction costs and assisting company decision-making. The primary advantage of this instrument lies in the fact that the benefits can be fully realized by industry itself, and the processes involved can also be financed by the companies themselves to the greatest possible extent. The main idea is to share experiences among companies in order to reduce transaction costs, while simultaneously using social mechanisms to motivate company management to focus on energy efficiency.

Due to the fact that this instrument originated in Switzerland and has now been transferred to Germany, the main focus of this paper is the presentation of the results of evaluated data within the framework of the German context. The possibilities and achievements of this instrument on the one hand, and the associated difficulties and limitations on the other hand, are discussed in terms of data derived from questionnaires, interviews, energy review reports and monitoring, primarily based on the 30 Pilot Networks project[1]. This project, initiated by the Fraunhofer Institute for Systems and Innovation Research ISI, has established 30 LEEN networks in Germany. The paper also puts the LEEN network approach into perspective in relation to the current energy efficiency policy of both Germany and Europe as a whole, and describes modification and dissemination prospects for establishing such networks as a successful strategy on a national and international level.

Background and characterization of the network concept

The concept of LEEN networks was originally developed in Switzerland in 1987. In 2002 the network concept was transferred and adapted to the German context, and between 2002 and 2006 the first energy efficiency network was established and put into operation in Hohenlohe (Germany). The energy efficiency network management system was then developed during the years 2006 to 2009, based on an additional five networks. Since then, the concept has been continuously developed and promoted in Germany. Currently about 50 networks involving approximately 600 companies are active in Germany. In Switzerland, companies that reduce energy-related CO_2 emissions within the framework of a negotiated and mandatory target, and undergo an annual evaluation, can be exempted from a steering tax on fossil fuels. Since January 2014 this tax amounts to CHF 60 (or €45) per ton CO_2. The steering tax, introduced at CHF 12 in the year 2008, provides substantial support for the network approach (Koewener et al. 2011). Currently 70 networks exist in Switzerland.

LEEN NETWORK MANAGEMENT SYSTEM

The LEEN network management system, scientifically developed during the 30 Pilot Networks project, aims to guarantee a minimum professional performance standard for consulting engineers and moderators, while facilitating a standardized evaluation of progress in attaining energy efficiency. A LEEN network usually consists of 10 to 15 participants from different sectors, which together determine a network target for increasing energy efficiency. In order to avoid competition between the participating companies, they normally come from different sectors, such as the manufacturing industry, the food industry, or health care. However, experience in recent years has shown that LEEN networks comprised of companies from uniform sectors can also be successful.

Overall costs for a typical participant[2] are approximately €35,000 to €40,000 for a four-year network operating period. This includes a 10- to 12-day energy review, 16 network meetings and three assessments of the monitoring results. Due to the costs of participation amounting to about €35,000, each participating company should have annual energy costs of at least €500,000 in order to guarantee that cooperation in the network will be profitable.[3] Additional transaction costs may arise for companies, e.g. costs for the internal preparation of data or participation at network meetings. These costs are to be covered by increases in energy efficiency within the company, which is the reason why company energy costs should not be less than €500,000. However, energy costs should also not exceed €50 million, due to the fact that companies with such costs often already have substantial energy technology know-how, and are thus unlikely to benefit from the exchange of experiences as much as companies with energy costs below this level (Mai et al. 2012).[4]

Furthermore, it is important that all participants share a common set of cross-cutting technologies, so as to guarantee an effective exchange of experiences during the network meetings. This common basis is required because the learning process of the network as a whole is not served if technologies relevant to only one company are considered. The typical network operating period is about four years. At the end of this period, each

1. For more information see the project websites: www.30pilot-netzwerke.de and www.leen.de.

2. The typical participant is a company/site with annual energy costs of about €1 million to €2 million.

3. The costs are sometimes reduced or fully covered if public or private funding is available.

4. For companies with energy costs below €500,000 there is currently a pilot research project referred to as "Mari:e – Mach's richtig: Energieeffizient!" (Do it right: Be energy-efficient!). The Mari:e project is also based on the LEEN network management system, with a modified approach for smaller companies. In addition another initiative, named "LEEN kommunal" (Municipal LEEN), is tailored to local authorities and focuses, among other things, on an energy review of buildings. A subsidy programme for this approach is in preparation.

company decides whether to prolong the operation of the network. Within the network there are three important positions, each with different competences and responsibilities: (1) the network host, also referred to as the network manager, who is responsible for the initialization and overall organization of the network, (2) the moderator, who organizes and manages the regular network meetings, and (3) the consultant engineer, who is responsible for the energy review, the annual monitoring of each company, and assistance at the regular meetings.

PROCESS OF LEEN NETWORKS

The usual network process consists of three phases. The acquisition phase (phase 0, see Figure 1) involves the initial establishment of the network. During this phase the network manager, designated by the institution initializing the network, such as the regional Chamber of Commerce, a municipality, an energy utility enterprise, or a regional industrial association, must undertake the acquisition of companies for the network, run information meetings, and select the consulting engineer and moderator. This phase is shown explicitly in Figure 1, as it is not an easy task to gather approximately 10 companies within a couple of months. The network process begins with an energy review phase (phase 1, Figure 1). An energy review is conducted by an experienced engineer for each company. The energy review involves a complete technical evaluation of energy saving potentials and a calculation of the profitability of these measures. All of the findings are then put down in a report. The engineer and moderator must be experienced individuals who have been trained by LEEN GmbH and awarded a LEEN certificate. The entire energy review process is in compliance with the energy review outlined in DIN EN ISO 50001. The report forms the basis for the company's own programme to reduce energy costs. After all of the reports for the companies participating in the network have been completed, two targets for the three- to four-year network operating period are first suggested by the consultant engineer, and then discussed with the participants and jointly determined: one target concerns the progress towards attaining energy efficiency, and the other concerns the reduction of CO_2 emissions.

The energy review phase concludes with a joint agreement by all participants regarding the targets for increased energy efficiency and reduced CO_2 emissions. These targets are to be achieved during the networking phase (phase 2, Figure 1). Competition among the participating companies resulting from peer pressure regarding the common network target is an important factor which promotes progress towards increased energy efficiency (Jochem et al. 2007). Continuous monitoring by the companies of measures that have been implemented permits the tracking of progress towards energy efficiency and the monitoring of reductions in energy-related greenhouse gas emissions for the company and for the entire network. This monitoring is assessed once a year by the engineering consultant.

In order to guarantee an overall performance standard, the *LEEN network management system* provides various tools such as a data collection form, software-based techno-economic calculation tools available via a joint interface, sample reports including a measures overview, and minimum requirements with respect to the energy review report. The LEEN standard is not an official standard that has been approved by a standardization organization. It is a voluntary quality standard for establishing and running energy efficiency networks. *LEEN GmbH*, founded at the end of 2009 in the context of the 30 Pilot Networks project, plays a key role regarding the development of the standard. On the one hand, this institution is responsible for the continuous improvement of the LEEN standard, based on both empirical data and changing political conditions. For instance, this includes the development and continuous improvement of electronic calculation tools and documents for the foundation, organization and implementation of a network. On the other hand, LEEN GmbH supports network hosts, in

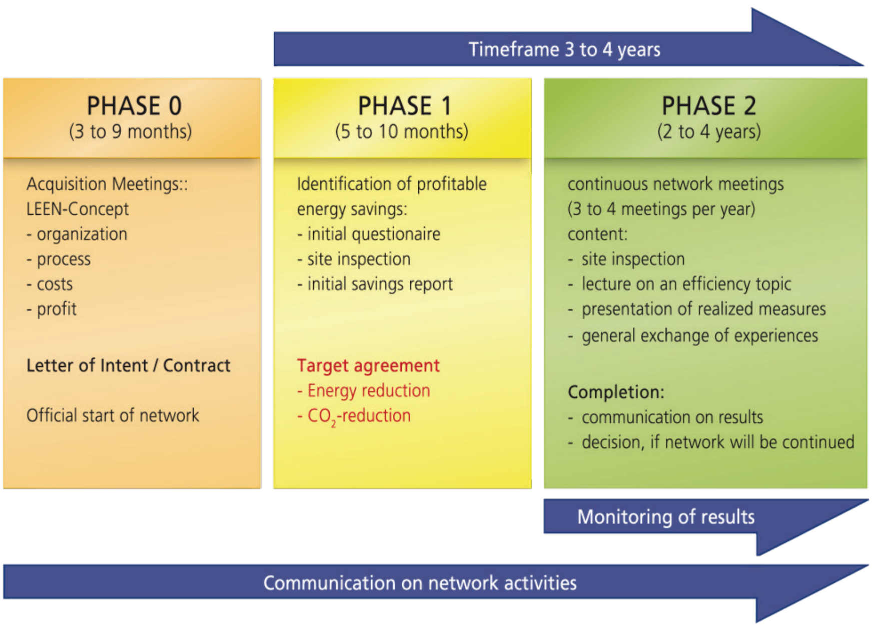

Figure 1. Phases of LEEN networks: acquisition (phase 0), energy review (phase 1), and networking (phase 2).

order to implement the concept nationwide and gradually also on an international level. In addition, this institution ensures a continuing education process for moderators and consultant engineers, who receive a LEEN certificate to validate the quality standard after completing the training.

A core element of LEEN networks is the moderated regular network meetings held three to four times per year (phase 2, Figure 1). These meetings facilitate the integration of the capabilities and skills of invited experts and the participants as well as the exchange of experiences. The participants also report on implemented measures (e.g. difficulties and achievements, and experiences with contractors). These points are particularly valuable for participants, since the information provided is objective, because the speaker is not trying to sell anything. The exchange of such information requires mutual confidence among the participants (Koewener et al. 2011). It is this exchange of practical experience and the possibility of utilizing synergies across the network that makes the LEEN networks so successful.

Methods and data basis

The insights described in this paper are based primarily on the following projects carried out in Germany:

- Environmental communication and energy efficiency in small and medium-sized enterprises (SMEs) (2006 to 2009): Developing an energy efficiency network management system and establishing and evaluating five energy efficiency networks (EENs).
- 30 Pilot Networks (2008 to 2014): Establishing 30 energy efficiency networks.
- Mari:e – Mach's richtig: Energieeffizient! (Do it right: Be energy-efficient!) (2012 to 2015): Transferring the network concept and LEEN standard to SMEs and establishing five networks.

During the 30 Pilot Networks project, various data were collected. First, all of the energy review reports for 366 companies were evaluated with regard to energy efficiency potentials and their profitability. In addition, all companies were surveyed with various questionnaires at three different times: (1) at the beginning of the network, (2) after the energy review phase and (3) at the end of the network operating period. The data base consists of 177 evaluated surveys. Several interviews with initiators, moderators and consultant engineers were also conducted. Parallel to the network process, the performance of each company was monitored on a yearly basis, the results were compared to the average performance of the network, and the overall increase in energy efficiency of the entire network was analysed. The LEEN monitoring serves to demonstrate the effects of the implemented measures and also acts as a tracking tool with respect to the jointly agreed target.

During the LEEN network operating period, the monitoring process for all companies is assessed annually on the basis of both final energy and primary energy consumption. This process ensures conformity with DIN EN ISO 50001. The development of the monitoring approach according to the LEEN standard was initially based on the following two methods (Ott/Jochem 2012); however, during the 30 Pilot Networks project this was changed to the bottom-up approach only.

The *bottom-up approach* takes into consideration the sum of all measures realized from the time of the base year to the year of analysis, expressed in energy units per year. This indicator includes measures that are documented as energy efficiency measures in the company. The effect of each measure is normally determined only once. Nevertheless, changing conditions that affect energy savings are taken into consideration by means of correlation factors, which adjust the energy savings in accordance with the changing conditions for each year the measure is in use (e.g. taking into account heating degree day values or changes in production). In order to capture all of the changes, the impact of each measure is calculated for the year to be analysed. In this approach, measures are not considered if they are not quantified, which may be the case for organizational measures or for production measures that influence energy consumption as a side effect. The bottom-up approach records both the increase in energy efficiency and the reduction of CO_2 emissions.

The *top-down approach* involves the calculation of energy consumption indicators for the whole company (e.g. in MWh per ton), followed by a comparison of the indicators over time. This approach captures all changes related to final energy consumption, and the top-down indicators generated help to determine the current status on the target path from the base year to the year of analysis. Of particular relevance is the fact that this method captures every energy-related change regardless of its origin or cause. For example, the indicators also capture changes in the production process and in capacity utilization. The highly aggregated top-down values show whether energy consumption fluctuates within a given time frame. They can thus indicate the need for adjustments if they fall outside certain limits. The top-down approach was used in the beginning as a second method of evaluating energy efficiency, but its use was later discontinued because values varied widely during the economic crisis of 2008 to 2010.

As explained above, overall network targets are based on an agreement among all the participating companies. The monitoring process at the company level is used to assess achievement of these targets. The base year for defining this target is the year in which the network is started. During the three- to four-year network operating period, the individual progress of each company is aggregated, monitored yearly and compared to the target agreement. Two calculation methods for the average value, the arithmetic mean and the weighted mean, are permitted (Ott/Jochem 2012):

- The *arithmetic mean* of all network results is obtained by adding the energy saving percentages achieved by each company, and then dividing the sum by the number of companies. This method is used for internal communication purposes only, as the results do not accurately reflect overall network savings. This calculation method is employed for psychological reasons. The arithmetic mean serves to equalize the contributions of all companies towards achieving the network target, so that the efforts of small companies have an effect comparable to that of large companies. This can be useful if large and small companies are combined in a single network. However, since the result is not correct in absolute terms, this calculation method is used exclusively for internal communications.

- The *weighted mean* is obtained by adding the absolute amount of energy saved by all network companies and setting it in relation to the total energy consumption of the entire network. In terms of the weighted mean, the contribution of small companies towards achieving network targets is relatively insignificant, if large companies are also participating. However, since this calculation method accurately reflects progress towards achieving network targets, it is used for external communications.

Findings/results

The participants of the 30 Pilot Networks project account for total energy costs of approximately €1 billion per year, total energy consumption of more than 15 million MWh per year and CO_2 emissions exceeding 5 million tons per year. This is equivalent to the consumption of nearly 1 million households. Approximately 74 % of all participants originate from the manufacturing industry, 5 % from health care, 3 % from the energy supply area, 3 % from trade and commerce, and the rest from various other sectors. Annual energy costs of the companies range from €150,000 to €43.5 million, with 54 % of the companies reporting energy costs of €500,000 to €4 million per year.

GENERAL ACCEPTANCE OF THE NETWORK IDEA

The evaluation of general acceptance is based on 177 questionnaires that were sent to participants during the period of operation of the 30 Pilot Networks project.

For the companies, network participation was found to have various advantages:

- Approximately 80 % rated the benefits of network participation as "rather high" in comparison to the effort required for participation. Likewise, more than 70 % evaluated the expenditure of time required for network participation as "rather low".
- More than 60 % indicated that contacts gained were used in other situations going beyond the network meetings. Around 20 % of these indicated use of the contacts gained for purposes transcending energy efficiency issues.
- As explained above, during the network meetings different topics were discussed, accompanied by a site inspection allowing participants to see e.g. measures implemented in another company. 90 % rated the topics discussed and site inspections as good or very good. In particular, viewing realized measures was seen as very useful. In terms of the exchange of experiences, more than 80 % rated the network meetings as good or very good.
- The measures identified during the energy review phase fully met the expectations of 80 % of the companies. Approximately half of the measures identified were described in sufficient detail to be implemented directly. At the same time, almost 80 % of the participants discovered new aspects of energy savings.
- More than 80 % of those surveyed had already implemented straightforward and cost-efficient measures, and 90 % indicated that they had implemented or planned to implement cost-intensive and organizationally more complex measures. The LEEN network concept succeeded in realizing untapped potential: approximately 80 % of those surveyed indicated that without a network some of the measures identified would not have been implemented in the company.
- The LEEN network increased the priority of energy efficiency in the companies: More than 60 % of those surveyed stated that the network enhanced the attention paid to energy efficiency by company management.

RESULTS FROM THE ENERGY REVIEW PHASE

The evaluation of the energy review phase is based on 366 reports for companies participating in the 30 Pilot Networks project and examines the saving potentials identified during the energy review. The energy review reports focus mainly on an overview of measures, in which all identified measures are assessed in terms of savings and profitability. About 7,000 measures were identified. Of these, approximately 3,600 measures were classified as profitable, meaning that the internal rate of return (IRR) exceeds 12 %. On average, for each company nine profitable measures were identified, with an energy saving potential of about 2,700 MWh and a CO_2 emission reduction potential of approximately 940 tons per year (Table 1; see also Jochem et al. 2014).

During the energy review phase, the measures identified were classified into ten different technological areas (see Table 2). The average total additional investment does not always reflect the total investment (e. g. additional investment: costs of high insulated window minus costs of standard insulated window; this additional investment causes the energy saving). Only the additional investment that leads to energy savings is relevant for the profitability calculation. Thus the energy-related investment figures may be lower than the total investment, but these figures were not always calculated by the companies.

On average, the most profitable measures were realized in the areas of compressed air and electrical devices, both with IRRs exceeding 40 %. In the case of compressed air, the rather low average investment of only €17,000 indicates that at least some of the investments did not involve compressors themselves, but rather controllers to ensure optimal coordination among the various compressors.

On the one hand the average internal rate of return of lighting is rather low, but on the other hand it is relatively predictable. Thus investments in lighting measures can be seen as low risk.

The change of energy carrier represents a special case. There are two main scenarios: One is the replacement of electricity by fuels used for combined heat and power production (CHP). The second possibility is the replacement of a fossil energy carrier by a renewable energy carrier. In the latter case, the energy savings are quite low, whereas the reduction of CO_2 emissions is very high.

It should be kept in mind that the energy reviews focused on cross-cutting technologies such as compressed air, lighting systems, and heat generation and distribution, as the time available for consultation was limited to eight to ten days. This may be one reason why a high proportion of the identified profitable measures required investments of less than €50,000 (see Figure 2).

Table 1. Results of the overview of measures for 366 participating companies.

Evaluated reports (overview of measures)	366
Total number of measures	7,030
thereof quantitatively evaluated measures	6,030
thereof profitable measures (where IRR is greater than 12%)	3,580
Ø IRR of all profitable measures	31 %
Ø static payback period of all profitable measures	3.2
Ø investment per measure [EUR]	55,700
Ø values per company/site	
Ø energy savings, if all profitable measures are realized [MWh/year]	2,670
Ø CO_2 emission reduction, if all profitable measures are realized [t/year]	940
Ø number of quantitatively evaluated measures	19
thereof classified as profitable	10
Ø total additional investment for realizing all profitable measures [EUR]	580,000
Ø reduction of energy costs, if all profitable measures are realized [EUR/year]	180,000

Table 2. Evaluation of identified measures by technological area.

	ventilation	lighting	compressed air	electrical devices	air conditioning
Number of profitable measures (where IRR is greater than 12 %)	270	429	490	513	122
Ø investment (operating life: 25 years[1]) [EUR]	67,000	24,000	17,000	36,500	22,000
Ø energy savings [MWh/year]	370	77	145	175	120
Ø reduction of CO_2 emissions [t/year]	87	29	43	54	30
Ø internal rate of return (IRR)	33.5 %	23.9 %	45.7 %	40.2 %	23.7 %
Ø static payback period [years]	3.0	4.2	2.2	2.5	4.2
	process cooling	**process heating**	**space heating**	**CEC[2]**	**other**
Number of profitable measures (where IRR is greater than 12 %)	223	535	488	49	106
Ø investment (operating life: 25 years[1]) [EUR]	45,500	46,500	21,000	150,000	34,500
Ø energy savings [MWh/year]	190	670	215	20	485
Ø reduction of CO_2 emissions [t/year]	67	103	34	340	62
Ø internal rate of return (IRR)	29.6 %	30.2 %	27.2 %	21.9 %	46.2 %
Ø static payback period [years]	3.4	3.3	3.7	4.6	2.2

[1] *Taking into account reinvestments, if the operating life is shorter than 25 years.*

[2] *CEC: Change of energy carrier.*

MONITORING RESULTS

It should be noted that the following results are preliminary, since many of the networks are still in operation and the evaluation process has not yet been completed. Whereas the energy review identifies potential savings, the monitoring process evaluates implemented measures on an annual basis throughout the operating life.

Table 3 shows the results for the first nine networks, based on evaluated monitoring data. Most of the agreed targets (see section "Background and characterization of the network concept") were surpassed, but some had not (yet) been achieved (see results for networks 1 and 6). Although reasons for not meeting the targets varied, a major factor was the economic crisis, which hindered energy efficiency progress. Nevertheless, in comparison to autonomous energy efficiency increases of approximately 1 %, network participants achieved increases that were double the average attained by German industry as a whole.

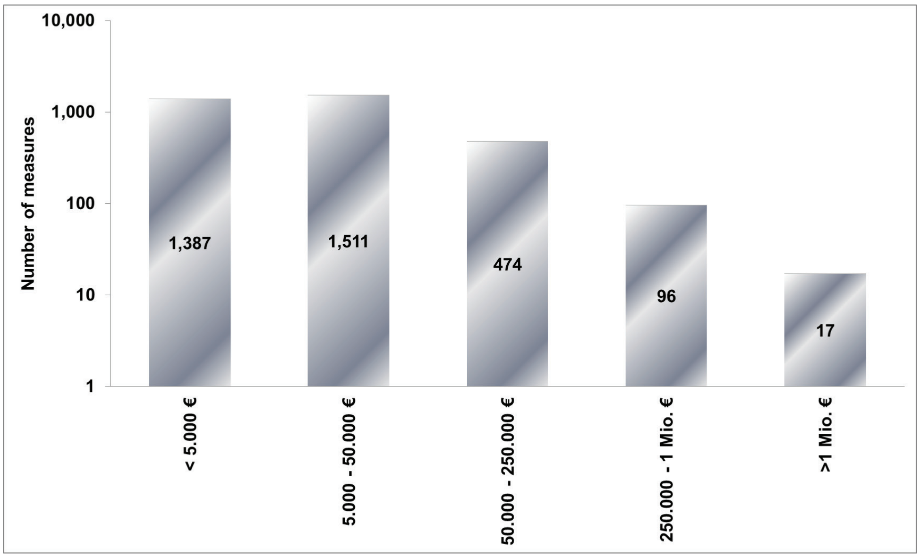

Figure 2. Investment volumes of measures.

Table 3. Network monitoring results.

Network	results for	base year	target for increase in energy efficiency	achieved increase in energy efficiency	target for reduction of CO_2 emissions	achieved reduction of CO_2 emissions
1	2012	2008	7 % weighted	6.0 %	6 % weighted	11.0 %
2	2012	2008	5 % arithmetic	6.4 %	5 % arithmetic	7.0 %
3	2012	2008	8.6 % arithmetic	11.4 %	7.6 % arithmetic	11.0 %
4	2012	2008	7 % arithmetic	8.3 %	10 % arithmetic	6.9 %
5	1st half of 2013	2008	8 % arithmetic	9.0 %	9 % arithmetic	13.4 %
6	2012	2009	10 % arithmetic	5.8 %	11.5 % arithmetic	6.6 %
7	2012	2009	7 % arithmetic	10.5 %	7 % arithmetic	9.8 %
8	2012	2009	7.5 % arithmetic	10.3 %	6.2 % arithmetic	9.8 %
9	2012	2010	5 % arithmetic	5.5 %	7 % arithmetic	5.4 %

Due to a change of energy carrier, some of the networks achieved a significant reduction of CO_2 emissions in comparison to their energy efficiency progress (see results for networks 1, 2 and 5). The contribution to climate protection made by companies in these networks was greater than that made by participants in other networks. This behaviour is not necessarily triggered by profitability considerations, but may be motivated by the corporate identity of the company. In network 1, for example, this was the case. One company had set a target of reducing CO_2 emissions for all of its production sites by 50 % by the year 2015, in comparison with the base year 2005. This target was established not for the sake of profitability, but in order to create a certain image. To meet this target, the network 1 company changed its energy carrier to renewable electricity (see also Figure 3). Without considering the contribution of this company, network 1 would have achieved a reduction of CO_2 emissions of about 7 %.

During the first three years, network 1 realized 109 measures in the following technological areas (see Figure 4).

For a number of reasons, it is rather difficult to calculate profitability:

- The total investment cost is comprised of equipment costs, installation costs, planning costs and other transaction costs. Only costs paid for by the company are easy to quantify. However, non-monetary costs can represent a substantial portion of the investment. Transaction costs in particular can be significant. For small investments they can comprise up to 80 % of the overall investment cost. For investments exceeding €60,000, transaction costs are generally less than 20 %, but in most cases they are not negligible. The average payback time can increase by 20 %, which is equivalent to 15 months (Dann 2013).

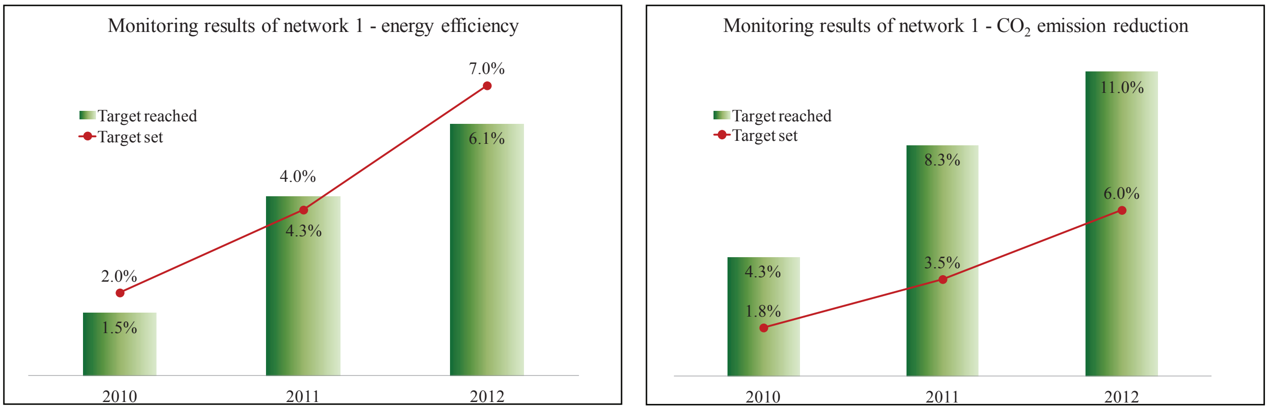

Figure 3. Monitoring the results of network 1: increased energy efficiency and reduced CO_2 emissions.

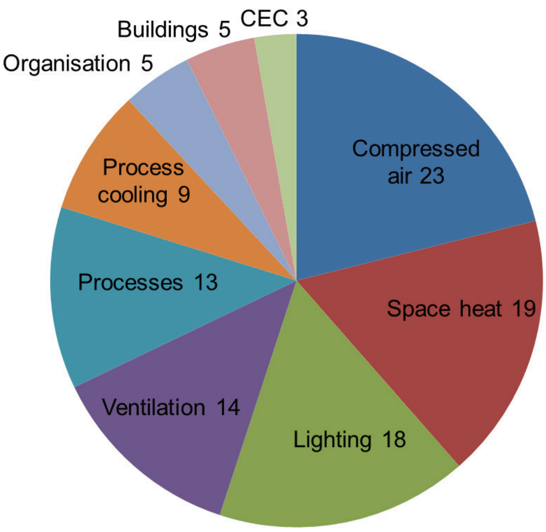

Figure 4. Number of measures realized by network 1 for each technological area.

- Not all investments are solely energy-related. For instance, it is often not possible to calculate the amount of an energy-related investment if it is part of a production investment.
- Energy efficiency is not yet a high priority for most companies, as on average energy accounts for less than 2 % of total costs. The willingness to monitor energy efficiency investments is therefore rather low.
- In addition, it is difficult to estimate profitability from the values used in the energy review, because in almost all cases the actual investment cost differs from the initially planned cost.

In the still ongoing monitoring process, 107 implemented measures in two evaluated networks have been quantified in terms of investment and energy cost savings. However, it is not known whether these figures reflect the total cost of the investments. It is very probable that non-monetary costs have not been considered. The average internal rate of return has been found to be about 33 % (see Figure 4).

It can be seen that these investments are smaller than the average values reported in the energy review phase. If additional non-monetary costs are estimated to be 15 % of the investment cost, the average profitability would decrease to an internal rate of return of about 29 %, which is still highly profitable.

LEEN in the context of energy efficiency targets

Increases in energy efficiency contribute to all relevant energy and climate policy targets. As shown above, LEEN networks can contribute substantially to achieving increased energy efficiency. The realization of current energy efficiency potentials has also a positive effect on the expansion of renewable energy. Increased energy efficiency combined with an absolute reduction in the final energy consumption results in a lower final energy demand and thereby in a less residual load. At the same time, an equivalent proportion of renewable energy requires less storage capacity and less extensive grid expansion. These positive effects also contribute to climate protection by reducing CO_2 emissions. Although the overall positive economic effects of increased energy efficiency are beyond question, current results regarding energy efficiency progress in Germany and in the EU as a whole have yet to reflect these advantages:

- *EU:* Because the energy efficiency target for EU member states is currently not legally binding, recent predictions estimate that the EU will not achieve its target of increasing energy efficiency by 20 % by the year 2020 (with base year 1990) (EEA 2013). Binding targets, also extending beyond 2020, are very important for the transformation to a decarbonized society. The EU has recently proposed energy and climate policy targets for 2030; a continuation of the energy efficiency target is not intended (European Commission 2014).
- *Germany:* Increased energy efficiency is one of two main pillars of the phase of energy system transformation ("Energiewende") and is a decisive part of German climate policy. For the German Federal Government, an important target according to the energy concept of 2010 and the "Energiewende" resolutions of 2011 is to increase energy productivity by 2.1 % p.a. resulting in a 50 % reduction of primary energy consumption by 2050 (with base year 2008, BMWi/BMU 2010). The "Energy for the future" monitoring report

of the German Federal Government published in December 2012 and the accompanying scientific report indicate a gap in achieving the set targets in Germany (BMWi/BMU 2012). From a historical perspective, the Germany industry only decreased final energy consumption by about 1.5 % in the recent years (AGEB 2013). To meet the required targets until additional efforts are necessary.

LEEN networks can contribute significantly to meeting the targets, and could be considered as an effective new instrument to be implemented internationally. Based on the results of the 30 Pilot Networks project, 200 networks in Germany could achieve energy savings of about 5 TWh and a reduction of CO_2 emissions of approximately 2.5 million tons per year. From a political perspective, in the design of energy efficiency policy instruments it is important to attach more importance to the fact that industry is capable of organizing itself, as already shown by the network approach. Socio-psychological aspects such as positive recognition within the company operating sector or on the part of the general public and higher priorities assigned by customers to sustainability and resource protection issues also contribute to the success of LEEN networks. So far, public discussion of the energy system transformation ("Energiewende") has focused primarily on the aspect of energy generation. In order to achieve the "Energiewende" targets of the German Federal Government, more attention needs to be paid to the aspects associated with energy demand by operators and end users (Bauernhansl et al. 2013). LEEN networks are an effective instrument for addressing the demand side of the equation. As a demand-oriented innovation driver, the networks stimulate investment in the respective network regions, thus ensuring regional added value (e.g. related to consulting activities, demand in the trade sector, contracting activities and financing services). Know-how concerning energy efficiency measures to reduce energy costs in participating companies will also be improved (Jochem et al. 2010). The LEEN networks provide numerous other benefits for the entire economy: faster innovation in industry, lower energy costs, reliable climate protection activities, and increased competitiveness of manufacturers of export goods, which can result in a more competitive economy.

Dissemination and future prospects

The numerous positive results and the experiences of participants, network hosts, moderators and consultant engineers collected during the pilot projects have established the necessary basis for the rapid spread of LEEN networks. Germany serves as a pioneer with regard to LEEN networks. One focus will be on the nationwide dissemination of the network standard, which will be continuously developed and accompanied by scientific research. Due to current policy conditions, the dissemination of LEEN networks in Germany presents a challenge. As there are no incentives comparable to those provided for instance by the Swiss CO_2 law, there is a special need to convince German companies to get involved (see section "Background and characterization of the network concept"). In view of the results of the empirical data presented in this paper, it is evident that the network approach can realize untapped energy efficiency potentials in the industry and service sectors. Even with no change in the energy and climate policy conditions in Germany, there is currently a potential to establish approximately 200 LEEN networks by 2020. If energy and climate policy conditions were modified, e.g. with an additional tax relief in Germany, approximately 700 LEEN networks could be realized (Jochem et al. 2010). This is indicated by experiences in Switzerland, where 70 energy efficiency networks were established between 2002 and 2005. If 700 LEEN networks were established in the future, German industry would be able to achieve a reduction of emissions amounting to 5 to 10 million tons of CO_2 equivalents, while generating additional profits of €100 million after taxes for the 10,000 companies that would be involved (Bradke/Köwener 2012). In order for this potential to be realized, there is a special need for initiators to convince companies to participate in a network. Supporting financial services such as energy efficiency funds could also promote the dissemination of networks (Gege/Heib 2013).

The performance of LEEN networks is and will continue to be accompanied by scientific research, and the network standard will be steadily improved based on recorded experiences. For example, in the near future an additional focus will be the integration of flexible electricity demand for companies in the LEEN management system. As the proportion of renewable energy rises, flexible demand will be increasingly relevant in the light of the overall energy system.

LEEN networks can serve as an important instrument for meeting the goal of an energy efficient economy. This instrument not only contributes to energy cost reduction and climate protection, but also provides opportunities for domestic manufacturers and installation firms. The network approach will help to reduce the burden on the energy infrastructure, while at the same time minimizing dependence on energy imports (Bradke/Köwener 2012). The idea of energy efficiency networks has already spread to other countries such as Austria and France. With the support of the German Chamber of Foreign Trade and TÜV Rheinland, the LEEN standard is currently being transferred and adapted to the Japanese context. Worldwide dissemination is a conceivable and above all desirable goal for the near future.

Table 4. Estimated profitability, energy savings and CO_2 emission reductions of realized measures.

Number of measures	107
Ø investment [EUR]	20,700
Ø energy cost savings [EUR/year]	6,750
Ø internal rate of return (IRR)	33.0 %
Ø static payback period [years]	3.0
Ø energy savings [MWh/year]	98.5
Ø reduction of CO_2 emissions [t/year]	25.6

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