

Effects of the energy audit obligation for large companies in Germany

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Abstract

In February 2015 the German Government enacted a law which targets non-SMEs in order to implement the EU Energy Efficiency Directive of 2012. According to the EU definition non-SMEs are companies or institutions with more than 250 employees or 50 million Euro turnover. They were obliged either to complete an energy audit by the end of 2015 or to introduce a certified energy management system by the end of 2016.

A very early evaluation of the measure was commissioned in autumn 2016. Its aim was to determine energy savings, reduction of emissions, investment and administrative expenses for the companies as well as effects on the German energy service market. An online survey has been carried out with 462 companies which have completed an energy audit and 403 which have introduced a certified energy or environmental management system. The quantitative impact of the law was extrapolated to Germany. The questionnaire covered the quantitative data mentioned but also aspects such as quality of the audits and reports, involvement of external or internal experts, management elements implemented, qualitative impacts and side effects.

Most of the companies surveyed would not have completed an energy audit without the law. About half of the companies, which had introduced a management system, did it before the Act came into force, in order to benefit from the exemption of eco taxes for energy-intensive enterprises. With regard to the audit performance not all quality criteria were met and the

audit reports often covered only part of the elements specified in the EN 16247-1 standard. However most of the respondents were very or quite satisfied with the audits including the reports.

The extrapolation to the whole country resulted in energy savings between 14 PJ and 30 PJ by 2020 which amounts to 1 to 2 % of the final energy consumed by non-SMEs. Insofar the expectations of 50.5 PJ by the German Government were only partially fulfilled.

Introduction

In order to reach the 20 % energy efficiency target by 2020, the 2012 EU Energy Efficiency Directive established in Article 8 a set of binding measures (European Commission 2013a). The transposition of the Directive into national legislation had to be done in all Member Countries (Hirzel et al. 2016). In addition, Germany has its own ambitious GHG reduction targets which aim at a decrease of 40 % by 2020 and 80 to 95 % by 2050 relative to 1990. Its Energy Concept was adopted in September 2010. In June/July 2011 the German Government decided to transform Germany's energy system, the so called "Energiewende" (energy transition). A further objective is to have an annual increase in energy productivity of 2.1 %.

Industrial enterprises were already in focus of energy efficiency policy for several years: in 2008 a program was launched which provides grants for energy audits in SMEs (Schleich et al. 2015). Large enterprises were addressed by the European Emission Trading Scheme and the eco-taxation in Germany raising the fuel taxes and a tax on electricity whereby exemptions from this taxation are granted for energy intensive sectors and in-

dustries in strong international competition. In addition, some funding programs for energy-saving investments and management systems are available.

As announced in the NAPE (Federal Ministry for Economic Affairs and Energy 2014, p. 21) the German Government implemented the EU audit obligation by law. The law was published in February 2015. It specifically targets non-SMEs according to the EU definition (European Commission 2003), i.e. companies and public institutions with more than 250 employees or 50 million Euro turnover or a balance sheet exceeding 43 million Euro in total. They are obliged to complete an energy audit according to EN 16247-1 (European Committee for Standardization 2012) by December 2015 and then every four years. The enterprises are exempted from the energy audit obligation if they introduce a certified energy management system according to ISO 50001 (ISO 2011) or EMAS (European Commission 2013b) by the end of 2016.

All non-SMEs active in Germany are obliged, regardless of their legal structure, registered office or their respective business sector. The size of the companies is defined including all sites of the company group, including subsidiaries abroad, but audits are only required for sites which are located in Germany. The energy audit has to cover a minimum share of 90 % of the total energy demand of a company. If companies have a number of similar sites, e.g. supermarkets or banking subsidiaries, they can carry out a so-called multi-site audit in a representative number of sites concerning their business and energy usage profile. A subordinate authority of the Federal Ministry for Economic Affairs and Energy, BAFA (Federal Office of Economics and Export Control), verifies the implementation and can impose a penalty in case of non-compliance. Two trained energy engineers of the authority examine a selected sample of audit reports and reject insufficient reports; the auditors have to remedy defects. Every four years a new audit must be carried out.

The German Government included the measure in its National Energy Efficiency Action Plan with presumed energy savings of 50.5 Petajoule (PJ) by 2020 (Federal Ministry for Economic Affairs and Energy 2014, p. 21). The energy audit law was accompanied by many other measures which also concern large enterprises, such as funding schemes for energy efficiency investments, support for cross-cutting technologies and waste heat utilization, Eco tax cap for manufacturing industry if they have introduced an energy management system, Energy Efficiency Networks, and individual energy saving concepts by external energy consultants. This bundle of measures makes it difficult to identify the influence of single measures on increasing energy efficiency.

Due to the fact, that the audit law does not include an obligation to implement the energy saving measures identified within the audit or by the management system, an empirical study was commissioned in order to evaluate the effectiveness of the law and to provide findings about types of measures carried out as a result of the audit or the management system, achieved energy savings, reduction of emissions, costs and administrative expenses for the companies as well as effects on the German energy service market. The results can also be used to fulfil the duty of the provision of a comprehensive annual report on energy demand and energy savings according to the EU Energy Efficiency Directive.

Methodology

The evaluation was based on an online survey of companies concerned. The addresses were recruited from two sources: an address database with companies who agreed on participating in a survey made available by BAFA, and randomly selected 9,700 purchased addresses of companies which fulfil the criteria of non-SMEs. In sum, a link to the questionnaire was sent via e-mail to 10,500 companies. A satisfactory feedback of 900 companies was achieved of which 350 came from the BAFA database. 462 companies have completed an energy audit and 403 had introduced a certified energy or environmental management system. Each of these groups of companies received a specified questionnaire and the groups were evaluated separately. The remaining 35 companies did not comply with the law mainly because they argued that they do not fulfil the criteria of non-SMEs.

The questionnaire was very long, comprehensive and detailed. It covered issues in accordance with the information required by the Ministry and which were necessary to calculate the quantitative effects of the law. Issues addressed were

- Structural characteristics of the companies such as economic sector, number of employees, number of subsidiaries, turnover
- Energy consumption broken down by energy carriers
- Energy efficiency measures implemented in the past years, measures identified by the auditor or resulting from the energy management and measures carried out
- Investment for measures and administrative costs for the audit or the introduction of a management system
- Satisfaction with the performance of the audit and with the audit report
- Accomplishment with external or internal experts
- Elements implemented in management systems
- Qualitative impacts of the audit or the management system, e.g. to attach more attention to energy efficiency in general, to detect main energy consumers or to evaluate energy efficiency measures
- General opinion on the law, the information about it and the contact with the authority.

In order to receive precise data on energy consumption, potentials and savings the respondents from companies with energy audits were asked to extract the technical information required from the energy audit report. In case of companies with subsidiaries they had to fill in data for the whole company as well as for a single site for which they had the audit report in hand. Companies with energy management systems were also asked to select a single site and present data for this site and for the whole company.

In addition, a number of 13 energy audit reports selected by BAFA have been evaluated with respect to their quality measured by their compliance with EN 16247-1.

It has to be taken into account that the time available between the public notification of the law and the deadline for the completion of the audit was only eight months. The

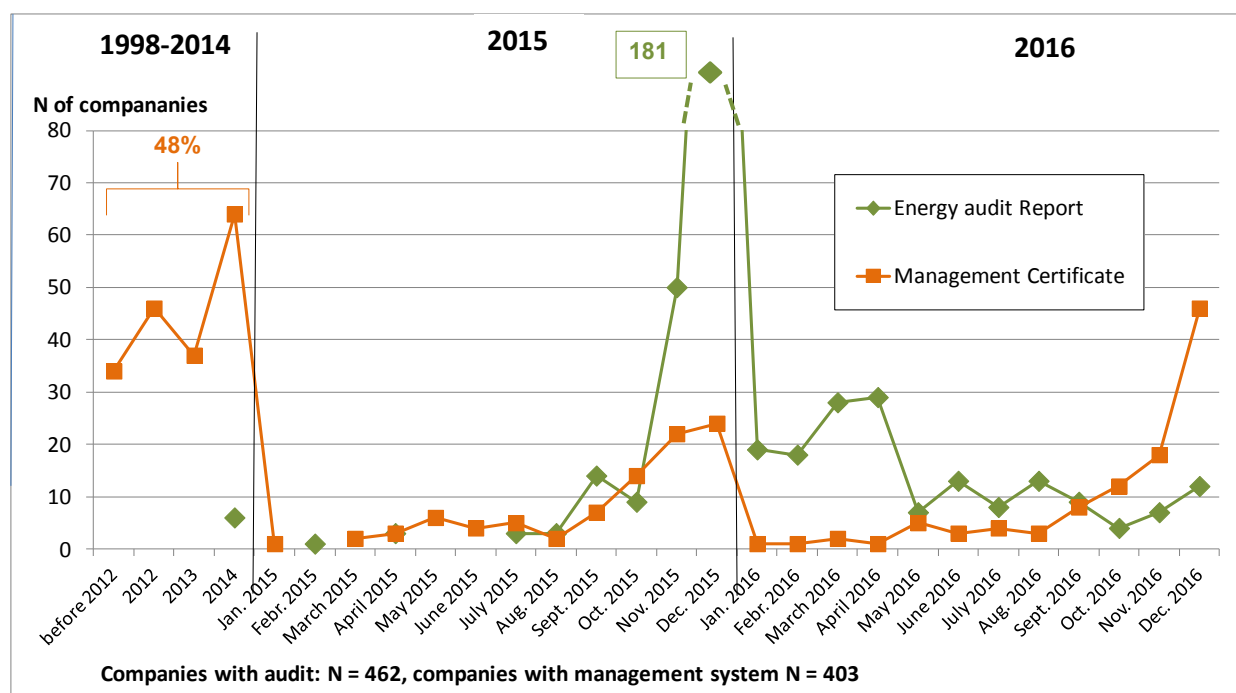


Figure 1. Fulfilment of obligations over time.

deadline for the introduction of a management system was only in December 2016. The survey took place between December 2016 and mid-January 2017. Giving consideration to reinvestment cycles not too many effects can be expected within a short time span. In order to include not only short-term organizational and low-cost measures the questionnaire also contained questions about firmly planned energy saving measures.

As the total number of companies concerned is not clearly defined, statistical representativeness cannot be applied. Therefore the assessment for Germany was not based on the number of companies but on the total energy used by the non-SMEs in each sector.

Official statistics on energy end-use distinguishing between SMEs and non-SMEs are not available. Therefore, many different sources were used to identify the current energy end-use of non-SMEs and their sites in Germany broken down by 24 subsectors (DESTATIS 2014, 2015, 2016a, 2016b, 2016c, Schlomann et al. 2015, Soellner 2014) for an assessment of the energy end-use. In the bottom-up analysis, based on 609 cases with complete data on measures taken and savings achieved, separate calculations were made for individual and affiliated companies. A projection to all sites was necessary when companies have more than one site. The data of each case was intensively checked for plausibility and internal validity. The type of business was considered because the questionnaire often was filled in for an energy-intensive production site whereas other sites of the same company are subsidiaries with low energy demand, e.g. sales offices. Finally an extrapolation of energy saving potentials by the end of 2020 was carried out on the basis of the potentials identified in each case and taking into account the autonomous technical progress and the effects of other relevant policy instruments.

Results

Almost all audit processes started in 2015, 41 % of the reports were delivered in December 2015, 19 % earlier (Figure 1). 40 % were completed only in 2016 and delivered late; these companies did not fulfil exactly the obligation, but this was accepted by the authority.

About half of the companies opting for the alternative solution had already introduced the management system before the law came into force. This means that the reason for introduction was not the law but mainly the eco tax exemption¹; the earlier they introduced the management system and the higher their energy intensity the more important was the tax exemption as a reason (Figure 2). Generally, energy-intensive companies, e.g. energy suppliers, paper, chemistry, glass, metal or plastics industries, and other manufacturing industries are more represented among the companies which chose the management option whereas construction, trade, hospitals and the service sector account for a higher share of those with energy audits.

94 % of the audit companies would hardly have completed an energy audit to the same extent and at the same time without a legal obligation to do so, whereas almost half of the companies having introduced a management system in 2015 or 2016 would have done it in any case (Figure 3).

1. In 1999, the German Government had introduced an "Eco-tax" on electricity (1999). A special equalisation scheme provides energy intensive industries and companies in strong international competition lower electricity prices by reducing taxes and levies and limiting the payments for the EEG surcharge (§§ 63 ff. Renewable Energy Law) in order to ensure their international competitiveness. This tax exemption is based on a voluntary agreement with the industry: the energy intensity has to be reduced by 1.3 % per year and the companies have to introduce a certified energy management system.

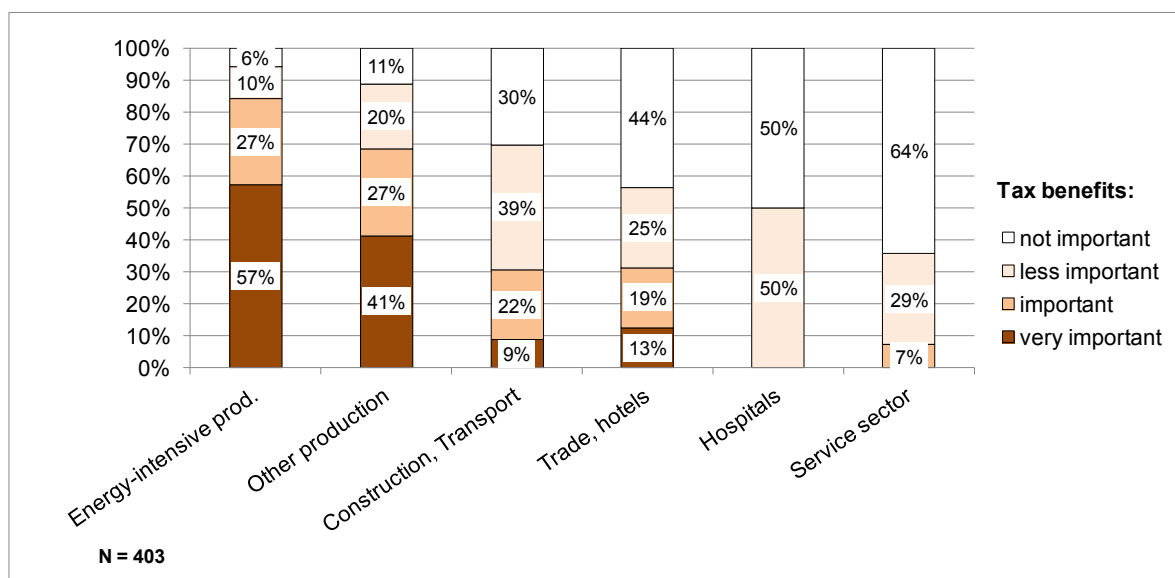


Figure 2. Energy intensity and importance of tax reduction for the implementation of management systems.

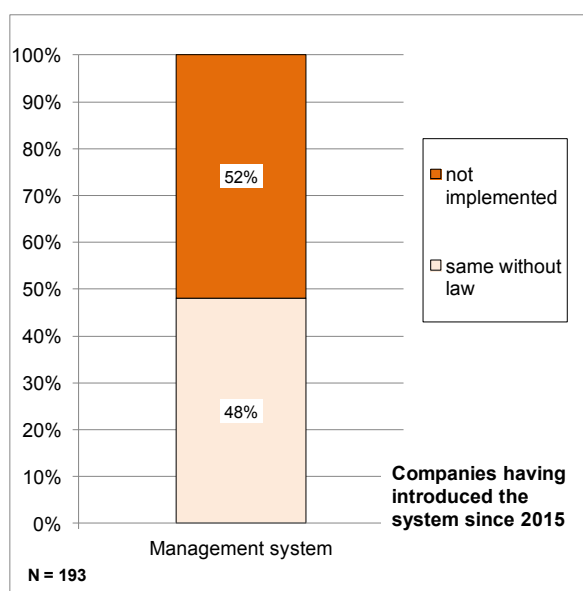
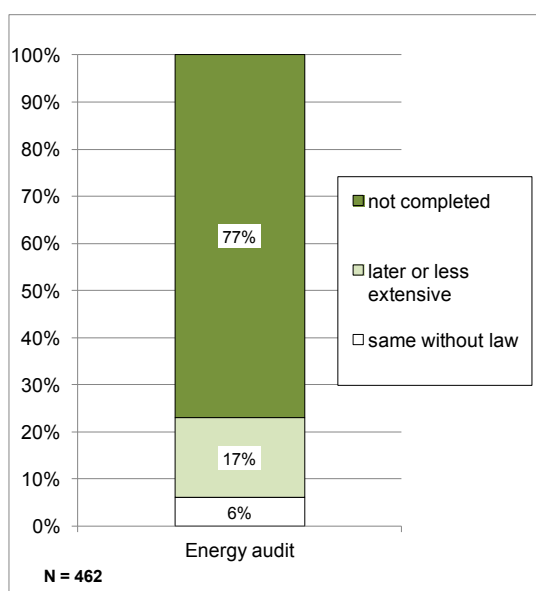


Figure 3. Completion of an energy audit or introduction of a management as result of the law or as a voluntary action (some kind of free rider effect).

STRUCTURAL CHARACTERISTICS OF NON-SMES

The structure of the non-SMEs is rather complex. Only 8 % of the companies have just one site, on the average they have about 30 locations. The greatest number of sites was reported by retailing, hospitality and service companies as well as by health services. Companies with similar branches often chose the multi-site audit option. Also the business ownership structure of non-SMEs is complex: about 75 % are not independent, but part of a company group. The head offices have been located either in Germany or abroad; in case of companies with audit 92 % are located in Germany, in case of companies with management systems only 55 %. This is relevant not only for the national extrapolation of the results but also partially for the implementation of energy saving measures and corresponding business strategies across all sites. Account should also be

taken of the fact that a single energy audit covers only one site, a multi-site audit covers several sites and a management system can cover a whole company with all locations.

PERFORMANCE OF AUDITS IN COMPANIES CHOOSING THE AUDIT OPTION

To find an auditor one third of the respondents used the official energy auditor list provided by the authority. Other companies went back to an already trusted consultant or they received a recommendation from professional colleagues.

With respect to quality the respondents were asked about the process of consulting. Many but not all quality criteria were met (Figure 4). The criteria were specified by the Ministry and supplemented by the research team.

The questions were as follows and several answers were possible:

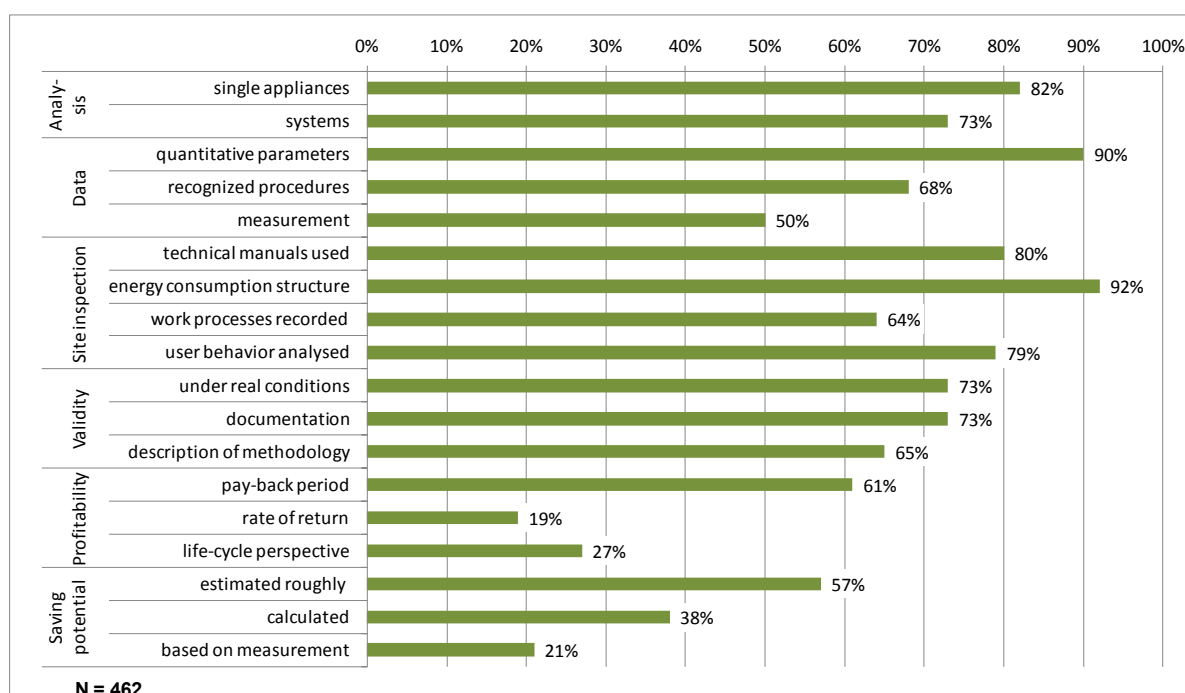


Figure 4. Percentage of companies responding to what extent quality criteria for audits have been fulfilled.

- Did the auditor analyze single appliances or systems (e.g. production lines) or both?
- In which way data were recorded?
- How was the site inspection performed?
- What steps have been taken to ensure that the measurement was representative (reproducible)?
- How did the auditor calculate the profitability?
- How did the auditor identify the saving potentials?

Many consultants did not take economic viability criteria into account sufficiently. Most of them only mention the pay-back period, but did not calculate a rate of return. Further criteria such as the analysis of complete systems, proof of reliability and validity, a clear breakdown of energy used, clear report on calculation methods and assumptions as well as a list of saving potentials were given in most cases. Generally, with regard to almost all criteria internal energy audits – which account for 12 % of all audits – perform better than audits done by an external consultant.

98 % of the respondents confirmed that the auditor made recommendations for energy-saving measures, but not always appropriate ones. In the opinion of 40 % they were directly implementable, further 53 % said they were partially applicable and 7 % considered them to be useless. Implementation plans were provided in 64 % of the companies.

Finally, the audit reports often covered only part of the elements specified in the reference standard. Almost all reports covered a summary, recommendations for measures and a documentation of the auditing process (80 up to 86 %). Two thirds cover documentation and analysis of the present energy status and quantified saving potentials. 58 % describe the background. Only 36 % mention possibilities to receive subsidies, 29 % make suggestions for recording savings achieved, and 21 % describe possible interactions between measures. The

analysis of selected audit reports by the evaluators revealed a similar result: Very few reports comply completely with all the criteria listed in EN 16247-1.

Nevertheless the respondents were very or quite satisfied with the audits including the reports. 73 % would recommend other companies to complete an energy audit, and 83 % would recommend their auditor. Various criteria were used to evaluate the satisfaction; two criteria did not score well: the cost-benefit relation and the internal time spent for the audit (Figure 5).

PERFORMANCE OF MANAGEMENT SYSTEMS

In companies which introduced an energy or environment management system, requirements associated with the system were mostly met: the appointment of an energy or environmental manager, establishment of an energy team, elaboration of an action plan, recording of energy data, defining of saving targets and implementation of energy saving measures (80 up to 92 %). A majority carried out measurement and took measures for continuous saving activities (75 % each). 60 % purchased metering technologies, and 32 % management software, 56 % analyzed work processes and 51 % user behaviour. Metering technologies and management software was purchased mainly in the manufacturing industry. 54 % of the respondents worked together with an external consultant. In 90 % of the companies employees have attended training courses on energy management.

DURATION AND COST OF ENERGY AUDIT AND MANAGEMENT CERTIFICATION

In cases where energy audits were carried out by external auditors, the companies reported a period of 4.4 months on the average between the commission of an audit and the report delivered. The audit itself, i.e. the presence of the auditor on site took 6.7 days on the average with a wide range between one day and 60 days. After the auditor left the site, the companies waited for the report between less than one month and two years.

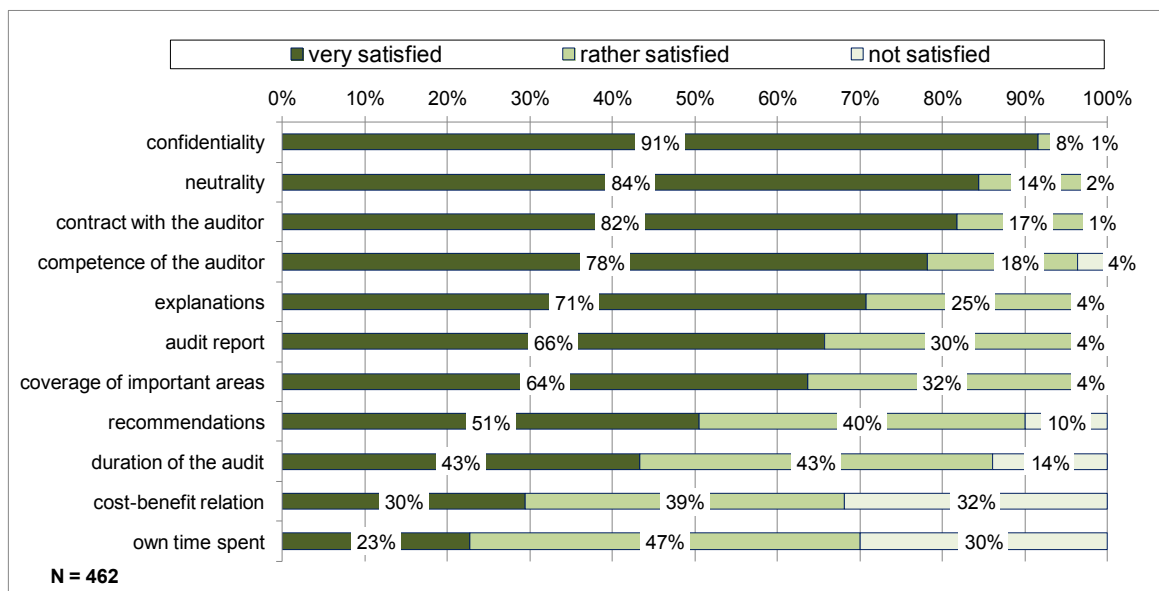


Figure 5. Satisfaction with the audit.

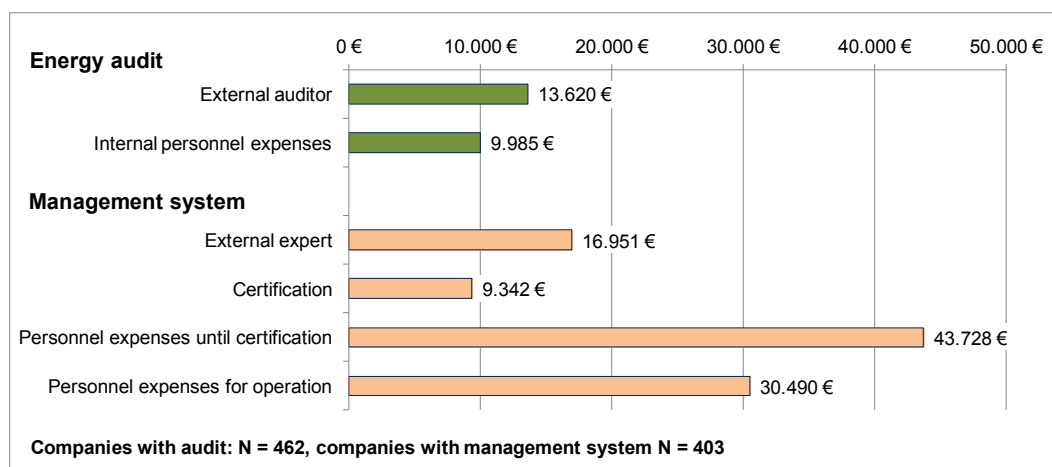


Figure 6. Average cost of audits and management systems.

In companies with a management system the certification audit took 7.1 days on the average with a range between less than one day and almost one year, two thirds of the respondents said that it took less than 10 days.

Companies with audit reported audit costs of €13,620 for external auditors and €9,985 for internal personnel on the average. Higher costs were associated to the introduction and operation of a management system (Figure 6). Multi-site audits were more expensive than single audits, but they cover about ten subsidiaries on the average. When audits were carried out internal staff was used to compile data on energy demand, technical documents, operational data of plants, etc. When a management system was introduced 54 % of the companies have engaged external consultants, above all for detailed recommendations on measures to be taken. Companies having introduced a management system since 2015, mention 25 % lower cost than those having introduced it earlier. The certification and operation costs also decreased.

Extensive experiences with energy audits in projects with “Energy Efficiency Networks” in Germany (Rohde et al. 2015)

showed that the relatively high average cost corresponds to an audit of 10 to 15 days according to the respective daily rate and that this should result in a high-quality audit with well-founded recommendations of measures.

QUALITATIVE IMPACTS OF ENERGY AUDITS AND MANAGEMENT SYSTEMS

70 to 80 % of the respondents agree that the energy audit played an important role because it made a contribution e.g. through analyzing the energy demand thoroughly, evaluating possible energy saving measures, confirming own considerations or pointing out the economic viability of measures (Figure 7).

For almost 60 % was important, that they received information on energy saving potentials for the first time. An indication for a continuous impulse is that 50 % of the respondents “now attach greater importance to energy efficiency in general”, a statement agreed by 80 % of the companies with management system.

A crucial question of the study was the measures undertaken as a result of the audit or the management system respective-

ly. Measurement is not possible to answer this question. The study must rely on information provided by the respondents. An open question would lead to answers with very different degrees of precision. Therefore areas were specified where energy efficiency measures can be implemented. These areas were addressed in three respects: measures before the audit or the introduction of the management system, potentials identified and measures implemented including firmly planned ones. Figure 8 shows for companies with audit and Figure 9 those for companies with management system which percentage of the companies surveyed mentioned recommended, implemented and firmly planned measures in defined areas, such as room heating, process heat, etc. In cases where companies introduced a management system, above all when it was long time ago they often could not distinguish whether measures were taken before or after the introduction. Therefore, the respondents sometimes said they took more measures than identified by the management system (Figure 9).

The focus of measures recommended and taken in audit companies is lighting, followed by ventilation/air condition, room heating and user behaviour. Companies with management system also mention lighting most frequently, but process-oriented measures, e.g. in the area of compressed air, motors, heat recovery and process heat, are much more relevant than for audit companies. On the one hand, this reflects the fact that companies with management system mainly cover manufacturing industries whereas audit companies mainly cover the service sector. On the other hand, companies with management system implement or plan more measures than audit companies. In the case of companies with management system a large part of the measures was identified and implemented before the law entered into force.

There are various obstacles which inhibit the implementation of energy saving measures (Figure 10). The most important are reasons concerning profitability, other investment priorities and waiting for a suitable time for investments, e.g. when important

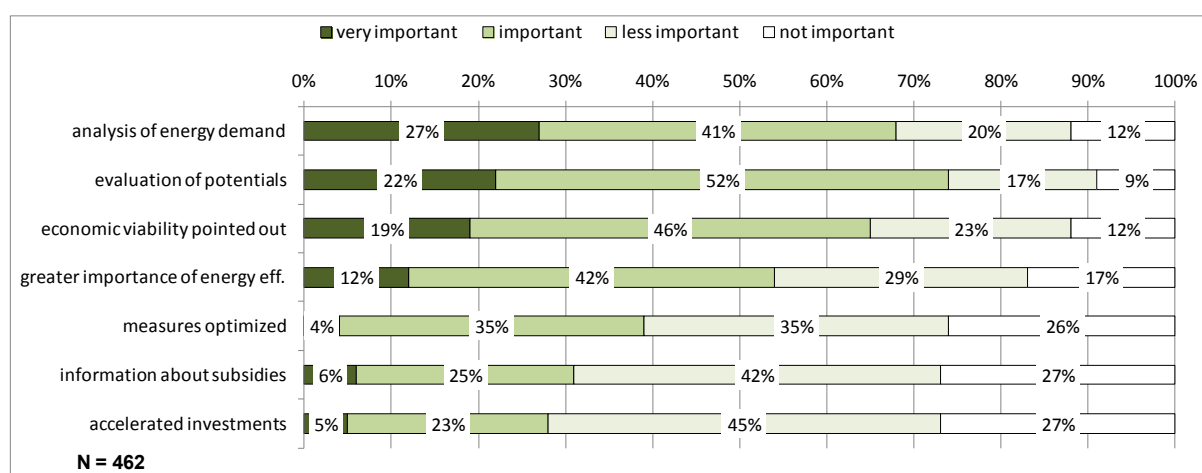


Figure 7. Qualitative impacts of energy audits.

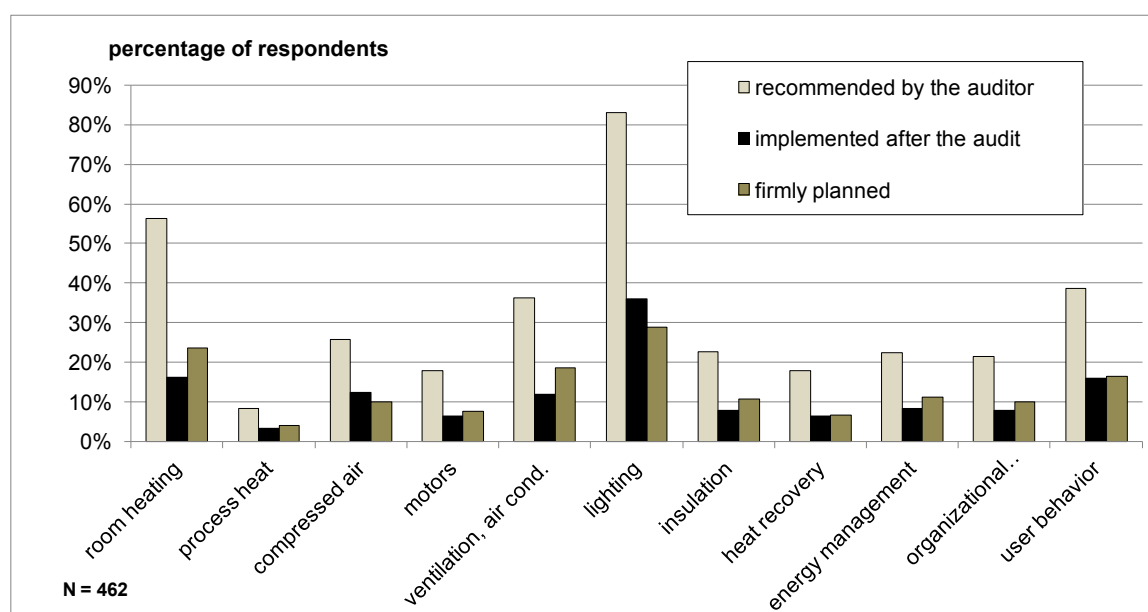


Figure 8. Areas for saving measures – companies with audit.

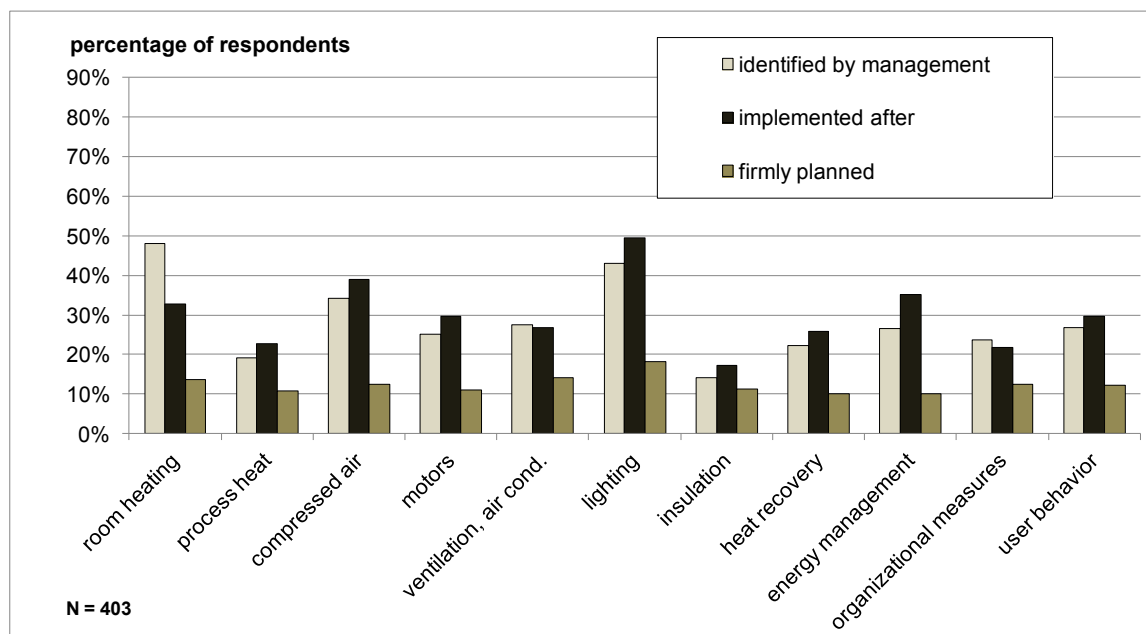


Figure 9. Areas for saving measures – companies with management system.

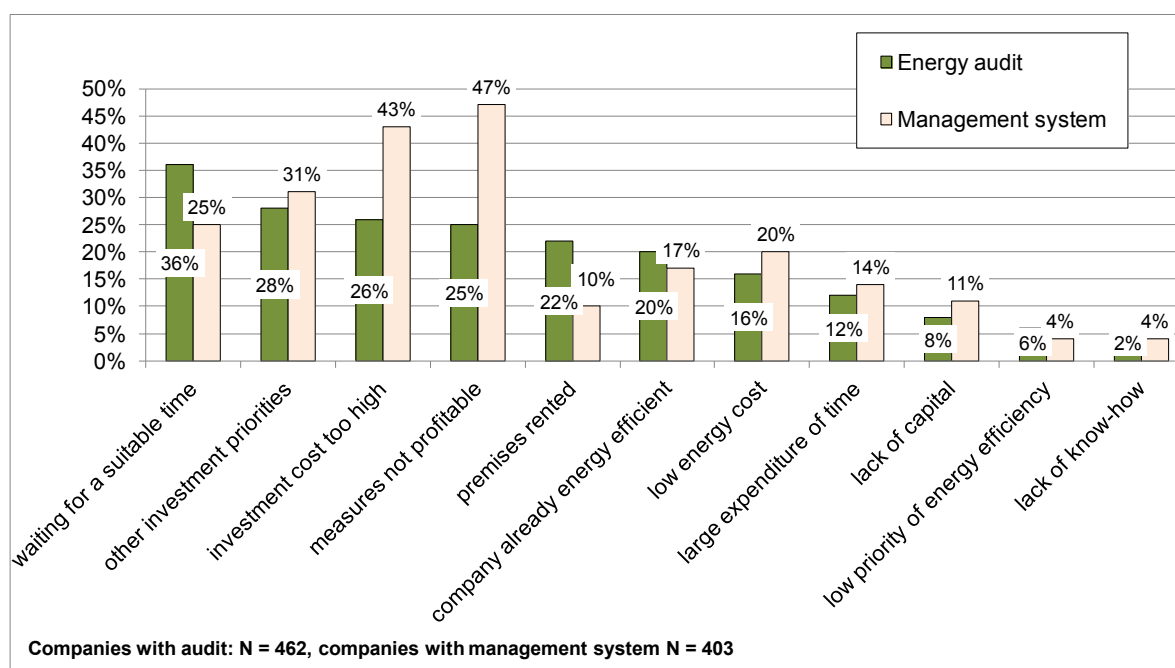


Figure 10. Obstacles to the implementation of measures.

operational changes occur such as expansion, renovation work, extensive reinvestment, etc. The high share of companies with management system who mentioned lacking profitability could indicate that profitable measures have been implemented earlier. Another problem for energy efficiency investments is the owner-tenant dilemma. 37 % of the companies with audit and 24 % of those with management system have rented their premises, e.g. retail stores or bank branches. In these cases this obstacle is the most serious constraint. Even some of the manufacturing premises are rented, when real estate subsidiaries are founded. Often the rent includes the whole equipment, lighting, etc. and the tenant is not responsible for any technical energy saving measure.

EXTRAPOLATION FOR ALL NON-SMES IN GERMANY

The total energy end-use of non-SMEs concerned by the audit obligation can be estimated to amount to 937 TWh (3,373 PJ) per year, of which one third is electricity and two thirds fuels (gas, oil, district heating, etc.) – without vehicle fuels because there are no data available for non-SMEs. The companies of which data were gathered in the survey altogether cover about 5.5 % of the total energy end-use of non-SMEs (52 TWh or 187 PJ).

For the calculation of the quantitative impact two types of data were used: the saving potentials identified by auditors or within the management system, and the actually implemented or firmly planned measures (Figure 11). In sum, the potential

is about 3.9 % of the energy used per year, and savings of 3.4 % of the energy used are or will be achieved. This would suggest that a large part of the potential is put into practice. Taking into account an autonomous technical progress (ca. 1 %/a) and an impact of other policy instruments, energy savings of 14 PJ will be achieved by 2020 or even 30 PJ if effects of a further audit are included (Table 1).

The expectations of the German Government associated with the audit law would then be fulfilled between about 30 and 60 %. The latter figure includes effects of further audits in 2019 and increasing saving activities due to the fact that in the short time the law could not be fully effective.

The potential resulting from the survey appears to be relatively small in comparison with findings from Energy Efficiency Networks in Germany. In about 360 participating companies, mainly non-SMEs, energy audits were carried out at the beginning, and external consultants identified a potential of 10 %/a on the average (Rohde et al. 2015). The audits were also based on the standards of EN 16247-1.

Conclusions

The study revealed that the audit obligation led to significant effects. The findings suggest that audits or the introduction of a management system also have a sustainable impact in terms of strategic importance of energy efficiency and priority setting. The quantitative expectations of the German Government regarding the impact of the energy audit law – energy savings of 50.5 by 2020 – will be realized only partially. However the

evaluation took place at a very early stage. The planning of larger investments in energy-saving measures often depends on reinvestment cycles of two or more years.

Although most companies were satisfied with the audit, objectively seen there are some doubts about the quality of many audit reports and of the performance of the audit. Various deficits are apparent, e.g. in the profitability analysis. Lacking quality of audits may be one reason for the relatively low energy saving potential identified.

Above all, the energy saving potential identified is very low. It can be assumed that the legal obligation often results in cursory inspections instead of detailed examination and that even in energy intensive production sites the focus was lead on crosscutting technologies. Therefore larger saving potentials could be found in the replacement or optimization of production and process technologies or in the logistics division. Generally, an important point is the quality of the audits and the audit reports. In half of the cases it appears not to be satisfactory and does not comply with the standards of the EN 16247-1. It must be taken into account that the energy audit law created a high demand for energy consultants: several ten thousand audits had to be made in a very short time of nine months. Experts interviewed in a second part of the project – such as representatives of industry associations – said that many micro-enterprises and newcomers came into the market and part of the consultants offered energy audits at low prices. However this observation is in contradiction to the relatively high prices reported by the respondents. Efforts should be made to equalize the demand for consulting ser-

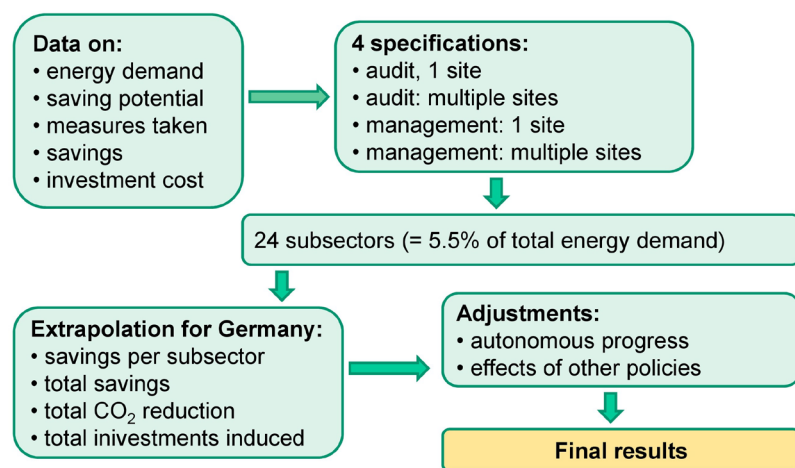


Figure 11. Extrapolation of the effect of the law.

Table 1. Extrapolation of the results to German non-SMEs.

	2016–2020 5 years	2016–2020 4 years and next audit 2019
Savings (PJ)	113.06	145.90
./. autonomous progress (ca. 1 %/a)	84.32	84.32
Result	28.74	61.58
Effects of other policies (./. 50 %)	14.37	30.79
Final savings (end of 2020)	14.37	30.79

vices to avoid that a similar situation occurs after four years when the next audits are scheduled.

The authority responsible for the check of the reports rejects unsatisfactory reports and examines carefully the qualification of consultants for the official auditor list. However it is impossible to remove a person having delivered insufficient reports from the list. One of the recommendations of the evaluation team was to enlarge the number of audit reports to be checked by the authority's own independent engineers. In addition, companies could be obliged to upload the report together with the form on the completion of the audit. Finally, higher quality requirements for auditors and appropriate training could be helpful.

Numerous respondents suggested that other criteria should be relevant for the definition of the target group of the law instead of number of employees or turnover, e.g. the yearly energy used. This would mean that administration services, sales offices or very small subsidiaries would not have to make the effort of an audit. Some said the whole service sector should be exempted from the obligation, or the law should provide a less extensive procedure of data recording in these cases. Above all, personal services and facility management companies have a very low energy demand because their employees work in premises of the clients. The evaluation team suggested to introduce a lower limit of the yearly energy consumption for the audit obligation, e.g. 100,000 kWh as used in Denmark (Dandanell 2014). Another problem is rented premises. This was mentioned as an obstacle for energy saving investment. The law does not address landlords specifically. Tenants have restricted possibilities to improve energy efficiency. For example, when the auditor recommends insulation of exterior walls or replace the heating plant, tenants can only try to motivate their landlords to implement the measure.

From a methodological point of view the evaluation was faced with some challenges. The survey was conducted online (for financial reasons) and had to be strictly anonymous so that queries relating to unclear answers were not possible. The questionnaire itself was very long and detailed. For an extrapolation exact data on energy used, potentials and savings, as well as on energy and investment costs were necessary. Many companies have cancelled the interview because the search for data required too much effort as expressed in phone calls with the research team. Others considered the questions to be not sufficiently specific and therefore their company could not be adequately portrayed. This is certainly true, but more details would have enlarged the questionnaire even more. A further problem is that effects cannot be measured physically but only indirectly through the statements of the responding companies. However, the returned questionnaires finally included in the evaluation show great efforts of the respondents and a high precision of answers.

References

- BfEE (Federal Office for Energy Efficiency) (Hrsg.) (2017): Untersuchung des Markts für Energieaudits, Energiedienstleistungen und andere Energieeffizienzmaßnahmen. Projekt 06/15. Eschborn.
- Dandanell, J. et al. (DI Energi) (2014): Energy Audits. Copenhagen.
- DEnBAG (German Society of Energy Auditors) et al. (2016): Markterhebung Energieaudit 2016. Befragung zur Wirksamkeit von Energieaudits. Berlin.
- DENEFF/PwC (German Industry Initiative for Energy Efficiency/ PricewaterhouseCoopers) (2016): Branchenmonitor Energieeffizienz 2016. Berlin.
- DESTATIS, Federal Statistical Office Germany 2015. Volkswirtschaftliche Gesamtrechnungen. Fachserie 18 Reihe 1.5. Wiesbaden.
- DESTATIS Federal Statistical Office Germany 2016a. Produzierendes Gewerbe. Kostenstruktur der Unternehmen des Verarbeitenden Gewerbes. Fachserie 4 Reihe 4.3. Wiesbaden.
- DESTATIS, Federal Statistical Office Germany 2016b. Betriebe, Tätige Personen und Umsatz des Verarbeitenden Gewerbes nach Größenklassen. Fachserie 4 Reihe 4.1.2 Wiesbaden.
- DESTATIS, Federal Statistical Office Germany 2016c. Unternehmensregister. Status 31.5.2015 WZ08. Wiesbaden.
- DIHK (German Chambers of Commerce and Industry) (2016): Weiter auf steinigem Weg – IHK-Energiewende-Barometer 2016. Berlin.
- European Commission 2003: Commission Recommendation concerning the definition of micro, small and medium-sized enterprises. Brussels.
- European Commission 2013a. Guidance note on Directive 2012/27/EU on energy efficiency, Article 8: Energy audits and energy management systems. Brussels, 6.11.2013, SWD (2013) 447 final.
- European Commission 2013b. EMAS – Eco-Management and Audit Scheme – User's Guide. 2013/131/EU. Brussels, 4 March 2013.
- European Committee for Standardization 2012. EN 16247-1 Energy audits – Part 1: General requirements. Brussels.
- Federal Ministry for Economic Affairs and Energy 2014. Making more out of energy. National Action Plan on Energy Efficiency. Berlin, December 2014.
- Hirzel, S. et al. 2016. A Study on Energy Efficiency in Enterprises: Energy Audits and Energy Management Systems. Report on the fulfilment of obligations upon large enterprises, the encouragement of small- and medium-sized companies and on good-practice. Brussels: EU, April 2016.
- ISO, International Organization for Standardization 2011. ISO 50001 Energy management systems – Requirements with guidance for use. Geneva.
- Rohde, C. et al. 2015. "Learning Energy Efficiency Networks – Evidence based experiences from Germany". ACEEE Summer Study on Energy Efficiency in Industry, Buffalo, NY, 2015, August 4–6, p. 6–1ff.
- Schleich, J. et al 2015. "Effect of Energy Audits on the Adoption of Energy-Efficiency Measures". ecee Summer Study on Energy Efficiency. Presqu'île de Giens, June 2015.
- Schlomann, B. et al. 2015. Energy consumption of the tertiary sector (trade, commerce and services) in Germany for the years 2011 to 2013. Karlsruhe, Munich, Nuremberg.
- Seefeld, F. u. a. (2013): Marktanalyse und Marktbewertung sowie Erstellung eines Konzeptes zur Marktbeobachtung für ausgewählte Dienstleistungen im Bereich Energieeffizienz. Berlin, Heidelberg, Mülheim a.d. Ruhr.
- Soellner, R.: Die wirtschaftliche Bedeutung kleiner und mittlerer Unternehmen in Deutschland. DESTATIS, Wirtschaft und Statistik 2014, p. 40 ff.