

What role do transaction costs play in energy efficiency improvements and how can they be reduced?

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Abstract

Ex-ante policy evaluation requires a detailed understanding of how the subjects addressed by the policy react to its implementation. In the context of energy efficiency, policy measures typically aim at influencing investment decisions towards more efficient options. As has been discussed widely in the context of the “energy efficiency gap”, investments in energy efficiency improvements are frequently not conducted even though they seem cost-effective from a simple cost-benefit perspective. Transaction costs have been identified as one important barrier. While transaction costs have been discussed widely from a conceptual perspective, empirical studies quantifying transaction costs and measures to reduce them are rare. This paper presents approaches, results and insights from a recently completed research project funded by the German Federal Agency for Energy Efficiency (BfEE), addressing transaction costs of various energy efficiency measures and the role of energy efficiency services to overcome the barriers. The paper analyses a set of eleven energy efficiency investments covering private households, public institutions and the private businesses. Based on a collection of data on direct investment costs and energy cost savings, a detailed analysis of the various barriers and transaction costs associated with their implementation is conducted. As a next step, the costs of existing energy efficiency services are analysed using data provided by the BfEE. We compare the different cost elements and analyse the potential of energy efficiency services to reduce transaction costs and find

that the role of transaction costs differs substantially between households, public institutions and companies and that the impact of energy efficiency services on transaction costs needs to be evaluated using different methodological approaches. The paper concludes that while data availability on disaggregated transaction costs is a major challenge, energy services can reduce transaction costs considerably.

Introduction

Cost-benefit analyses are used to evaluate energy efficiency measures as a general approach. These evaluations can be derived from different analytical perspectives: e.g. from a social or state perspective, a programme perspective or from an investor perspective (see e.g. EPA 2008). The different perspectives are combined with different methodologies depending on the evaluation target. For example, for the evaluation of programmes or measures from a social perspective, the social net costs/benefits (e.g. environmental costs) are important. From a programme perspective, the assessment of subsidies is interesting due to the fact that the analysis should show costs or effects triggered by the programme.

The choice of the analytical perspective also determines which cost and benefit components must be taken into account in the analysis itself. This study is interested in the investor perspective.

Directly linked to the cost-benefit analysis is the question: why are energy efficiency investments not made even though they could significantly reduce the energy bill? This issue is known as the “energy efficiency gap”. The “energy efficiency gap” shows that investment decisions in energy efficiency mea-

asures are often influenced by further aspects aside from direct costs (e.g. investment decision) and benefits (e.g. saved energy costs). Reasons for this can be on the one hand “hidden” costs and risks (e.g. costs for the procurement of information), costs due to production downtime or uncertainties about future energy prices. On the other hand, there are a large number of non-monetary barriers that have to be overcome when making investment decisions.

In their contribution on the “energy efficiency gap”, Jaffe and Stavins (1994) describe the observation that cost-effective energy efficiency measures are often not implemented. The energy efficiency gap can be explained by a large number of factors, which can be summarized by the following three categories (e.g. Gerarden et. al. 2015):

1. market failure, e.g. tenant-landlord dilemma
2. behavioural economic aspects, e.g. limited rationality
3. hidden costs not considered in the cost-benefit calculation (e.g. transaction costs for information procurement)

Against this background, it is of particular interest that energy efficiency measures can also be stimulated or implemented by service providers (for example by making knowledge available for potential investors). Such energy efficiency services can contribute to the reduction of the barriers. Due to this fact, the quantification of these effects is relevant for energy efficiency policy-making in order to focus on the factors that influence decision-making of investors.

The study analyses a set of energy efficiency measures covering the three sectors private households, public institutions and the industry sector by gathering data on direct investment costs and energy cost savings. The study provides a detailed analysis of the various barriers and transaction costs associated with the implementation and gathers existing energy services on the market incentivising the measures. The paper analyses different cost elements and examines how energy efficiency services can influence transaction costs.

Methodology and evaluation approach

In order to obtain a broad understanding of the extended cost-benefit analysis and the possibilities for providing energy efficiency services, a range of different measures was examined. This is due to the fact that barriers, cost-benefit components, availability and prices of energy efficiency services can vary widely in different dimensions.

Numerous studies indicate that different groups of actors differ significantly in terms of both their barriers and their decision-making behavior (e.g. Thomas (2007), Toro et al. (2017), Trianni (2013), BMU (1997b), DBU (1995a), ENQUETE-Kommission (1995), Energiestiftung SH (1996), Klimabündnis (1995), Damm (1996), Baginski und Weber (2017), SBI (2015), Fleiter et al. (2012), O’ Malley et al. (2003)). As a first central dimension, a distinction is made between three different groups of actors who act as decision-makers in the investment process:

1. Households
2. Private businesses
3. Public institutions.

As the barriers and decision-making processes differ depending on the level of investment, a further distinction is made between low-investment measures and high-investment measures.

The two dimensions (actors and investment volume) span a matrix whose fields are covered by the selected energy efficiency measures. This procedure ensures that the measures to be examined cover a wide selection of decision-making situations as possible.

The following decision criteria are defined for the selection of measures within the matrix:

- Relevance in terms of total energy consumption and saving potentials (high energy saving potential)
- data availability
- suitability for addressing by energy efficiency services

Other aspects that are taken into account are the complexity of the measure, the sectoral allocation, the energy sources addressed and structural factors on the part of the investors (e.g. company size). Table 1¹ lists the covered measures and provides a brief description.

In the first evaluation step, the additional energy investments and energy cost savings were gathered. This was followed with the second step by an extension of the cost-benefit analysis, which was derived from an analysis of transaction costs to overcome possible barriers.

Therefore, the quantification of transaction costs required a qualitative understanding of the barriers and an understanding of costs associated with planning and implementation of energy efficiency measures. When considering the barriers, a distinction was made between:

- barriers that fundamentally hinder the implementation of measures (e.g. lack of capital and borrowing power), and
- barriers, associated with transaction costs, i.e. the overcoming of which is associated with transaction costs (e.g. lack of knowledge).

The study focused on the latter category.

Based on a literature review the barriers were examined for each different actors group (private households, public institutions, private businesses). The next step was to conduct a literature research on the transaction costs relevant in connection with the measures. Where relevant, explorative interviews were conducted to provide further insights into the role of transaction costs. The interviews included the following two aspects:

- In particular for energy efficiency measures in public institutions, the existing literature provides limited information on the quantification of transaction costs. For the examples covered in this area (see Table 1), interviews were conducted to gather information on transaction costs. The main aim of the interviews was to get a detailed understanding of the elements and size of transaction costs for the specific measures covered in this study.

1. Case study about organisational, technological and behavioural measures for reducing electricity and heat consumption at the faculty for psychology: <http://www.psychologie.uni-freiburg.de/zentrale.einrichtungen/energieeffizienz/ergebnisse/Chronik>

Table 1. Energy efficiency measures covered.

Private households	
Thermal retrofit of multi-family dwelling	Aggregated average values from over 270 KfW-supported retrofits analysed by the German Energy Agency (dena 2012). Building specifications: 350 m ² floor area, 4 apartments, construction year 1958–1978, retrofit to "Effizienzhaus 70" standard (70 kWh/m ² /a). Sub-measures: wall, cellar, roof-top insulation, 3-layer windows, high-efficiency heating oil boiler and solar thermal for water heating, ventilation with heat recovery.
New-built of high-efficiency single family dwelling	Single family house new building. Comparison of additional costs, transaction costs and energy savings from efficiency level above legal requirements.
Lighting optimisation	Replacement of all lighting by LED lighting in a 4-person household at costs of €5/light bulb.
High-efficiency refrigeration	Replacement of inefficient fridge-freezer with A+++ appliance. Assumption of replacement before life-time end of old appliance, consequently, full investment costs are energetic additional costs.
Public institutions/commercial buildings	
Thermal retrofit of school building	Thermal retrofit of a Wuppertal primary school within the federal pilot project "low-energy schools" of dena. Deep retrofit of façade and roof, building technologies incl. heating (pellet) and ventilation.
Low-investment measures to reduce energy consumption	University of Freiburg participated in the project "Decentral monetary incentives for energy saving" since 2007. Case study analyses organisational, technological and behavioural measures for reducing electricity and heat consumption at the faculty for psychology. Faculties received 50 % of cost savings as an incentive. Total project energy savings: 1 GWh, €118,000. Cumulated investments ca. €43,000.
Public street lighting	Switch to LED street lighting in the city of Kaarst 2012–2017. Exchange of 6,253 points at a cost of €2.6 mn. Annual energy savings of 1.4 bn kWh electricity and €300,000.
Business/industry	
High-efficiency electric motors	In the industry sector, electric motors consume 70 % of electricity (AGEB 2016). The example case is a replacement of old motor (efficiency class EFF3) by a new IE3 motor.
High-efficiency compressed air	Use of compressed air is widespread in the industry sector and has large savings potential. The example case includes a CA station with total annual consumption of 1,000 MWh.
Thermal steel treatment	Example case: new furnace for thermal steel treatment in Italian factory 2014 (MERC database, ID 1300009).
Efficient cooling	Innovative system with H ₂ O as refrigerant and use of free cooling.

Note: The table is summarised from Wuppertal Institut and Öko-Institut (2018).

- For private businesses, two interviews were conducted with energy consultants providing services to private businesses in order to increase the understanding of the role of energy services to reduce transaction costs.

As a third step, the study developed a methodology to integrate the prices for energy efficiency services into a cost-benefit analysis. This included the collection of data on prices for energy efficiency services and, where relevant, the splitting of the costs between different measures. The methodology was used to determine whether and to what extent the costs of energy efficiency services to overcome barriers can be mapped. However, this was not possible to implement for every type of service: energy management systems for example have significant setup and operation costs and are expected to lead to a continuous stream of implemented measures. An attribution of costs to individual measures is thus difficult.

Due to these methodological challenges, the study concentrates on the analysis of energy consulting and gives only some few examples on the introduction and implementation of energy management systems. The study further included an own calculation tool for the extended cost-benefit analysis. The tool

was implemented in MS-Excel. It contains two central spreadsheets for calculating, presenting and comparing the extended costs and benefits of energy efficiency measures.

The prices for energy efficiency services were derived from empirical studies on the German energy efficiency services market (BfEE 2018) and on energy checks from on-site consulting (VBZ 2018). For the various energy consulting services, market prices were recorded both on the supply side and partly on the demand side. Prices on the demand side showed a large variance due to numerous subsidy programmes and heterogeneous situations in clients and applications. For this reason, the study focused on provider prices in order to estimate the actual expenditures. The paper analyses the range of empirical costs and locates estimated prices for our cases with the help of expert interviews. Relevant national level funding programmes, such as Germany's Reconstruction Loan Corporation (KfW) providing financial support for homeowners for energy efficiency investments, were also included in the extended cost-benefit analysis.

The energy consultants interviewed within the framework of the project pointed out that it is not possible to attribute costs for a general, possibly indefinitely running system to individ-

ual measures. Consequently, this study focuses further on the different forms of energy consulting. The conceptual basis is formed by eligibility criteria for the subsidy programmes “energy consulting for residential buildings”, “energy consulting for small and medium-sized enterprises” and “energy consulting for municipal non-residential buildings”.

Identification of barriers and derivation of transaction costs

BARRIERS TO IMPLEMENT ENERGY EFFICIENCY MEASURES

In the literature, the influence of barriers to investment decisions in energy efficiency measures is considered both qualitatively and quantitatively in different research areas. In this study, all factors that stand in the way of the implementation of energy efficiency measures are regarded as barriers. This is based on a microeconomic view.

For the consideration of barriers, a distinction is made between different phases in the implementation of energy efficiency measures:

- Phase 0: Stakeholders are aware that they have the potential to improve their energy efficiency through appropriate measures.
- Phase 1: Stakeholders obtain the necessary information (internal and external) to support the possible implementation of energy efficiency measures. Information processing aims at later decision making.
- Phase 2: The decision to implement energy efficiency measures is taken.
- Phase 3: The energy efficiency measures are implemented.

- Phase 4: The implemented measure is integrated into the operational processes (e.g. employee training, etc.).

TRANSACTION COSTS TO IMPLEMENT ENERGY EFFICIENCY MEASURES

Transaction costs include all costs not related to direct investments and maintenance costs, but necessary for the preparation and implementation of an energy efficiency measure. When quantifying the respective transaction costs, it should be noted that only the additional costs incurred for the implementation of the energy-efficient measures are accounted for.

In companies and public institutions, the transaction costs include both activities carried out by employees of the company and costs arising from external contracts (e.g. consulting services). With households a conversion of the expenditure of time resulting in the household is usually not meaningful, so that the transaction costs are limited essentially to additionally resulting costs by external achievements (e.g. consulting costs, legal costs for resolving conflicts when increasing the rent due to modernisation measures in rented buildings, etc.).

Quantification of barriers and transaction cost in the three sectors

While conceptual and qualitative considerations of barriers to the implementation of energy efficiency measures in companies are comparatively extensive in the literature, there are only a few studies on empirical quantification of barriers and transaction costs.

HOUSEHOLDS

Many studies analyse barriers of the implementation of energy efficiency measures in private households, conceptually and empirically (e.g. Ohlhorst et al. 2015, Groba et al. 2010, Schlo-

Table 2. Description of barrier categories.

Category	Description
Information deficit	The category considers barriers related to a lack of information that can occur in different decision phases: Even in the run-up to the actual decision-making process, a lack of information or attention can lead to the fact that potential efficiency potentials are not known and thus no decision-making process can be initiated.
Preferences	Non-economic factors are considered that counteract with the implementation of efficiency measures, independent from economic circumstances (e.g. noise and dirt during renovation work, preferences for certain technologies regardless of their economic viability, etc.). Barriers from this category play an important role in the area of private households.
Access to capital	This category includes different barriers, e.g. inability to obtain credit, costs for raising capital or opportunity costs for lost alternative investment
Organisational barriers	The category comprises a large number of barriers where structural factors hamper or prevent the implementation of efficiency measures, e.g. are lack of time, lack of human resources, complex communication or decision-making structures as well as shared incentives (e.g. tenant-landlord problems).
Risks perceived and identified	The category perceived and identified risks includes both barriers that completely prevent the implementation of efficiency measures (e.g. risk of production stoppages in core processes in industrial companies) and barriers that generate additional costs to eliminate/reduce risks (e.g. higher expected returns due to uncertain savings). Expectations about savings potential of future technologies also represent an obstacle. In the extended cost-benefit analysis, only those risks are considered that can be overcome by accepting additional costs.

Source: Thomas (2007), Toro et al. (2017), Trianni (2013), BMU (1997b), DBU (1995a), ENQUETE Commission (1995), Energy Foundation SH (1996), Climate Alliance (1995), Damm (1996), Baginski and Weber (2017), SBI (2015), Fleiter et al. (2012), O' Malley et al. (2003).

mann 2012). Nevertheless, there is less empirical work available on the quantification of transaction costs in households. Only a few sources quantify transaction costs in the building sector (e.g. Ürge-Vorsatz et al. (2012). Moreover, it is not clear which measures are implemented and how the transaction costs are calculated.

In contrast to companies and public institutions, the lack of literature on the quantification of transaction costs can be explained by the fact that the time taken to overcome barriers (e.g. search costs, decision costs) in households is not reflected in the actual costs. Although the time spent by households, for example during the conduction of a thermal retrofit measure (e.g. planning the measures, searching for and coordinating with skilled crafts enterprises, finding suitable subsidies, making decisions, etc.) does not result in transaction costs.

The evaluation of barriers in the area of private households shows, that the time spent on activities in connection with energy efficiency improvement measures is an important barrier, but it is not perceived as a monetary factor. This usually also corresponds to reality, since the time spent on such matters does typically not correspond to a reduction of working hours. The use of energy efficiency services therefore generates additional costs in households which do not lead to a reduction in transaction costs due to the non-monetary nature of the time spent. The approach of comparing transaction costs and costs for energy efficiency services therefore reaches its limits in households.

PRIVATE COMPANIES

A first empirical quantification of transaction costs for energy efficiency investments in energy-intensive companies in the Netherlands was carried out by Hein und Blok (1995). The transaction costs determined are – in some cases significantly – less than 10% of the investment. Ostertag (2003) quantifies the transaction costs for the procurement of energy-efficient electric motors based on empirical data from the chemical industry. The study covers various engine outputs and comes to the conclusion that the relative share of transaction costs in the total acquisition costs is significantly higher for smaller engine outputs (and thus lower purchase prices). For smaller engines, the transaction costs determined are sometimes higher than the actual acquisition costs.

The most comprehensive study on transaction costs for energy efficiency investments in companies was conducted by Mai et al. (2014) within the framework of energy efficiency networks in Germany. The estimation of the transaction costs is based on a survey in which 35 companies participated and data on 40 different energy efficiency investments were collected. The energy efficiency measures include different technologies (e.g. insulation/heat insulation), heat recovery, exchange of engines/pumps, refrigeration technology, lighting, etc.) with investment sums between €1,715 and €800,000. The study covers different industries with production sites of 25 to 3,000 employees and an annual energy consumption of 1.3 to 1,000 GWh.

The results of the study by Mai et al. (2014) show a wide range of the share of transaction costs in the total investment. The analysis shows a correlation between the share of transaction costs and the total investment. The relatively higher proportion of transaction costs with a lower investment sum is in

line with the results from Ostertag (2003) and can be explained by the fact that the transaction costs are independent (or only slightly dependent) of the investment sum.

The quantification of transaction costs within this study showed that the transaction costs account for a total share of approximately 10–20 % of the investment. Furthermore, it was observed that the saved energy costs exceed the total costs even taking the transaction costs into account. It could be seen that transaction costs account for a relatively larger proportion of lower investments.

Transaction costs of companies result, among others, from information procurement and consultation processes. However, they are empirically hardly evaluated. Mai et al. (2014) were able to show in their study that the relative transaction costs of various energy efficiency investments decreases as the investment increases and they showed first indications of further influencing factors (e.g. the complexity of the investment and the size and energy intensity of the company).

PUBLIC INSTITUTIONS

In the area of public institutions, staff bottlenecks represent an important barrier. In contrast to this the monetary level does often play a minor role as compared to the organizational level (approval of jobs, etc.). The time required for the implementation and/or planning of energy efficiency measures is often not documented. The public sector has a high potential to act as a multiplier. The implementation of energy efficiency is here often not mainly a question of costs, but a problem of the lack of time and thus the lack of decision-making authority to plan and implement measures.

In the literature analysis, no studies on the quantification of transaction costs in connection with energy efficiency measures in public institutions could be found. For this reason, primary data were collected based on exemplary case studies and interviews. Figure 1 presents the case study of a university building, where a series of energy efficiency measures with low investment costs were implemented. The measures include technical aspects such as the exchange of thermostats, organizational measures such as an adjustment of heating schedules, as well as measures addressing the behaviour of the building occupants. While the investment costs and energy cost savings of the measures were monitored, no information on transaction costs had been collected. Within this study, interviews were conducted with the staff responsible for conducting the measures, resulting in a detailed description of the time that was invested in the various activities related to the implementation of the energy efficiency measures. The transaction costs were then estimated by multiplying the time with the monthly rates of the employees involved. The faculty responsible for conducting the measures does not pay for the energy costs, which are covered by the central administration. For this reason, a programme to overcome the barrier of split incentives was introduced in which half of the energy cost savings are transferred to the faculty.

A comparison of the transaction costs with the annual savings shows that the transaction costs are higher than the investments. With regard to the energy cost savings, the case study showed that due to the costs of overcoming the barrier of split incentives, the monetary benefit due to energy cost savings for the faculty is considerably reduced.

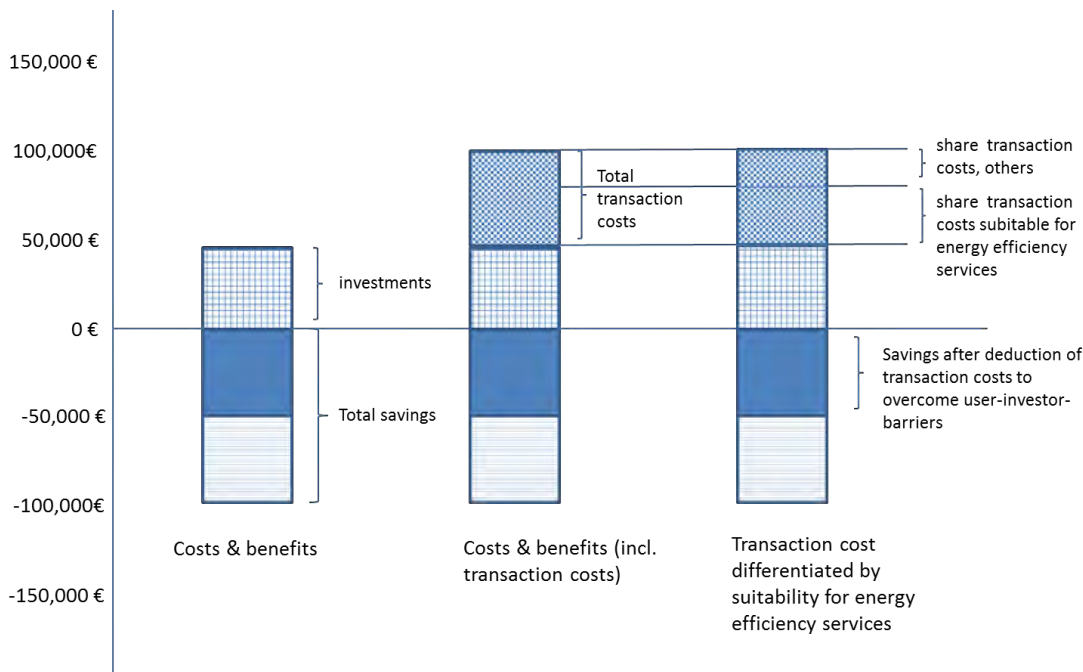


Figure 1. Extended cost-benefit-analysis, case study: public institution. (Source: based on BfEE 2018.)

Analysis of the potential of energy efficiency services to reduce transaction costs

Energy efficiency services help to overcome certain barriers to the implementation of energy efficiency measures. Energy management systems have the potential to overcome organisational barriers and counteract non-economic preferences within a company. Energy management leads to a considerable store of knowledge and converts energy analysis into a routine activity, whereby search-, information- and decision costs can be reduced (Schmid 2004).

Energy consulting services can also address information deficits and reduce search costs. The paper considered higher-quality energy efficiency measures for which energy consultants must have a special qualification and which require an on-site inspection of the building. Stationary advice (such as offered in advice centers or online advice) and information tools on CO₂-consumption were not considered.

The analysis of barriers shows that direct consulting has a particular impact on the information deficit and has the strongest influence regardless of the target group (household, company or public institution). By reducing information asymmetries, decision making can be simplified, the quality of investment improved and misinvestments avoided. The energy checks – as an energy efficiency service offered e.g. online² or by the German Consumer Agency are similar in nature to direct consulting. However, these consultations are less detailed. The impact in terms of overcoming information deficits is more limited compared to detailed direct advice. Access to capital can be facilitated, as information on funding opportunities can be provided (see Table 3).

Costs for energy services were gathered from available statistics (BfEE 2018 and VBZ 2018). The attribution of costs for energy efficiency services regarding energy consulting measures for residential and tertiary buildings and for industry processes is shown in the following boxplots. The blue box is bounded by the upper and lower quartiles. Accordingly, the middle 50 % is located within the blue interquartile range. The middle line shows the median. The whiskers reach down to the 2.5-percentile and up to the 97.5-percentile. This ensures that absolute extremes are excluded. The red line shows the costs of energy efficiency services. Subsidies are not considered.

Figure 2 shows the results for the target group households, respective for energy efficiency measures in the area of residential buildings (here: thermal retrofit)³. The appropriate energy efficiency service is the direct energy consulting for residential buildings. The costs for the advice taking into account the subsidy can be fully allocated to the implemented measures. Half of the prices for direct consulting for residential buildings are between €800 and €1,500. The median is about €1,200. In the extended cost-benefit analysis, the price for the energy efficiency service is €1,600. Subsidies between 60 % and a maximum of €1,100 are taken into account. Therefore, the investor has costs around €640 (see Figure 2, red dashed line, BAFA 2018).

The results of public non-residential buildings include energy efficiency measures for thermal retrofits. The corresponding costs can be fully allocated to the bundle of implemented individual measures. The example shows, that the average price for direct consulting is about €2,100. It is particularly noticeable that the values below the median are comparatively low. Thus 25 % of the prices are between €1,450 and €2,100, while the 25 % of the values above the median are between

2. https://www.verbraucherzentrale-energieberatung.de/service/ratgeber_strom.html

3. Subsidies are provided through Germany's Reconstruction Loan Corporation (KfW).

€2,100 and €4,500. The maximum without extreme values is now €10,000.

According to the BfEE (2018), the median cost of energy consulting for industry and processes is €4,000 (average €5,800). The average 50 % of the prices are between €1,500 and € 8,000. Accordingly, the interquartile distance of €6,500 is comparatively large. A reason for the large interquartile gap is the difference of subsidies for energy consulting within the “Energy Consulting for SMEs” support program. Companies with annual energy costs of up to €10,000 and more than €10,000 in annual energy costs get different subsidies. The adjusted range of the total distribution is €0 to €25,000. The results of expert interviews quantified the price for an eligible consultation for a company with annually energy costs of more than €10,000 to €5,000 to €8,000 (see Figure 2). This is 80 % of the consulting costs up to a maximum of €6,000 on subsidy. This results in costs between €1,000 to €2,000 by the investor for the energy consulting of industry processes.

The different types of energy efficiency services were evaluated qualitatively as to their potential to overcome barriers for the implementation of energy efficiency measures and to reduce transaction costs. In particular, information asymmetries can be reduced and information deficits reduced through energy consulting. Information may also help to counteract preferences that stand in the way of energy efficiency measures. In addition, access to capital can be improved by subsidy-related advice. Energy management systems, on the other hand, are

particularly suitable for overcoming organisational barriers and counteracting non-economic preferences within a company and for regularly leveraging the potential of dynamic processes such as those in industrial production. Information deficits can only be partially compensated. Energy management systems help to reduce search costs for energy efficiency measures.

While energy efficiency services have the potential to overcome implementation barriers, we integrated them into the cost-benefit analysis. However, this is only practicable if the services can be assigned to the efficiency measures. This approach is well suited, for example, if a comprehensive consultation for a residential building (with a renovation schedule to a certain efficiency house standard) is subsequently implemented accordingly. In the context of energy management systems, the approach is not practicable.

The following table shows the results of the descriptive analysis of the impact of energy efficiency services on transaction costs associated with energy efficiency measures.

Synthesis and conclusion

This study considers the influence of transaction costs and energy efficiency services on the implementation of energy efficiency measures. Based on a literature review combined with the collection of data through expert interviews, the quantified costs for the energy efficiency services were estimated.

Table 3. Overcoming of barriers by energy efficiency services.

	Information deficit	Preferences	Access to capital	Organizational barriers	Perceived risks
Direct Consulting	++	+	+	o/+	+/-
Energy Check	+	+	+/o	o/+	+/-
Energy Management System	+	++/+	(+)	++	0/+

++ strong influence, + moderate influence, (+) influence on specific companies who profit from German EEG, 0 no influence, - negative influence.

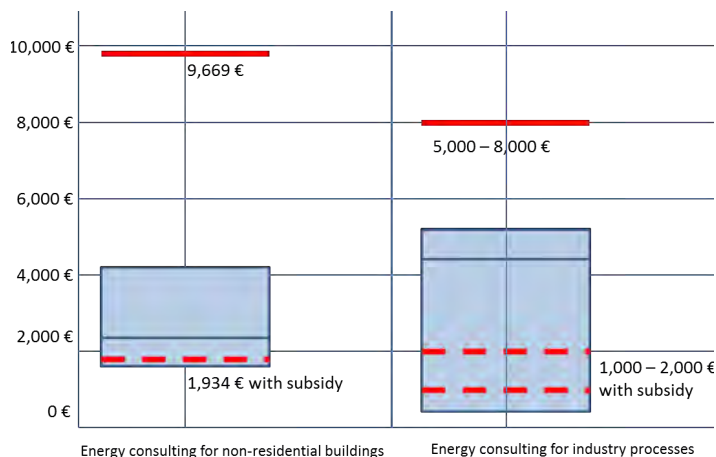


Figure 2. Boxplot for energy consulting of residential buildings, non-residential buildings and industry processes based on BfEE 2018.

Table 4. Overview of the impact of energy efficiency services on transaction costs of energy efficiency measures.

Measure	Investment Costs	Transaction costs	Investor costs for energy efficiency services	Energy savings (per year)	Reduction of transaction costs (descriptive)
Private Households					
Thermal retrofit	€61,576	No data	€640	€4,372	++
New-built of high efficiency single family dwelling	€9,200 (€1,100 with funding)	€3,500 (€1,750 with funding)	No energy consulting used	€700	Not specified
Lighting optimisation	€35	No data	€10	€90	+
High-efficiency refrigerator	€500	No data	€10	€70	+
Public institutions					
Thermal retrofit of school building	€70,000	€20,000	€1,934	€11,000	++
Low-investment measures to reduce energy consumption – case study	€43,000	€66,000	€11,571	only total saving known: €120,000	++
Communal street lighting – case study	Mio. €2,560,000	€35,000	Not specified	€210,000	++
Companies					
High-efficiency electric motors	€2,000	€400	€667	€1,248	++
High-efficiency compressed air	€73,300	€15,000	€667	€30,428	++
Thermal steel treatment	€94,400	€10,429	€667	€18,296	++
Efficient cooling	€250,000	€25,000	€667	€24,700	++

Source: own compilation and calculation based on literature research and expert interviews, ++ strong influence, + moderate influence.

The use of energy efficiency services by households or public institutions is motivated differently: “is it value/time saving” and monetary calculation “make or buy” as well as by the regulatory framework. The difference between technically more complex consulting, energy audits, direct consulting for non-residential buildings and direct consulting for plants and processes can be attributed in particular to the time spent on specific consulting types.

The extended cost-benefit analysis for energy efficiency measures take into account investment costs, transaction costs, costs for energy efficiency services and energy (cost) saving potentials. In addition to the energy savings, these included all further investment costs. The determined transaction costs have a share of about 10-20% of the investment. The analysis of transaction costs showed that data availability is insufficient for all three groups of actors considered. Empirical studies on the quantification of transaction costs are available only to a very limited extent. In addition, the interviews also revealed a very low awareness of transaction costs.

The amount of transaction costs depends on numerous factors. Consequently, a generalization of the findings from individual case studies is not possible. The amount of transaction

costs does not rise proportionally with the investment sum, so that the transaction costs make a higher portion of the investment with low investment measures. Across all areas, transaction costs in connection with energy efficiency measures are often perceived by the actors not as costs (but as time loss) and therefore not quantified. This is particularly true for households, where time loss is nevertheless an important barrier, but it is the lack of time that is perceived as such rather than the monetary component.

Although energy efficiency services are associated with direct costs, these services can help to reduce transaction costs, for example by reducing search costs. This can improve the cost-benefit balance (due to reduced transaction costs) from the investor’s point of view. However, the literature provides limited information on the extent to which energy efficiency services reduces the level of transaction costs, so this effect could be considered only on the level of an individual case study. On this issue, more empirical research is needed.

A review of existing literature on barriers showed the following results: in the area of private households, the time spent on activities e.g. for energy-saving renovation measures is an important barrier, but it is not perceived as a monetary factor

(which usually corresponds to reality, since flexible adjustment of working hours is not provided for). The approach of comparing transaction costs and costs for energy efficiency services reaches its limits in households.

For further investigations, it may be useful to study the “willingness-to-pay” of consumers, i.e. to what extent consumers are willing to contract energy efficiency services in order to reduce the amount of time spent on the implementation of energy efficiency measures. A future survey could examine how different household types could reduce time spent for energy efficiency information (e.g. discrete-choice approach).

In the area of public institutions, personnel bottlenecks represent an important barrier, although the monetary level does not play an important role in contrast to the organisational level (approval of jobs, etc.). The time required for the implementation and/or planning of energy efficiency measures is often not made available. The public sector has a high potential to act as a multiplier. The implementation of energy efficiency is here often not mainly a question of costs, but a problem of the lack of time and thus the lack of decision-making authority to plan and implement measures.

A standardisation of processes through an energy management system (e.g. according to ISO 50001) or other monitoring systems can significantly reduce transaction costs in connection with activities for the disaggregated recording of energy consumption and the optimization of periods of use. At the same time, the introduction of an energy management system is also associated with not inconsiderable expenditure and is insufficiently taken into account in the personnel and position plans. While engineering services in the newer buildings has a measuring infrastructure for disaggregated recording as standard, this is not currently the case for older buildings. The aim of energy management systems is to continuously develop and realise efficiency potentials. However, the systems have relatively high introduction-, certification- and operating costs, and typically lead to a large variety and number of measures being implemented over a period of time.

Overall, the paper concludes that the data basis for the implementation of an extended cost-benefit analysis currently represents a challenge. Thus, in the future, emphasis should be placed on obtaining quantifiable insights into the reduction of transaction costs through energy efficiency services. In addition, the amount of transaction costs incurred on commissioning energy efficiency services and the effect such services have on other transaction costs should be examined more closely.

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