Transaction Costs of Raising Energy Efficiency

Working Paper

presented at
The IEA International Workshop on Technologies to Reduce Greenhouse Gas Emissions:
Engineering-Economic Analyses of Conserved Energy and Carbon
5-7 May 1999 ♦ Washington, D.C., USA

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Transaction costs of raising energy efficiency

In the face of the uncertainties concerning the importance and the actual impacts of anthropogeneous climate change the extent to which measures should be adopted to avoid greenhouse gas emissions (GHG) already today and in the near future is highly controversial. More specifically, part of the debate evolves around the existence and importance of *energy saving potentials* to reduce CO_2 emissions that may be available at negative net costs, implying that the energy cost savings of one specific technology can actually more than offset the costs of investing into this technology and of using it. This so called "no-regret" potential would comprise measures that from a pure economic efficiency point of view would be "worth undertaking whether or not there are climate-related reasons for doing so" (Bruce et al. 1996, p.271).

The existence of the no-regret potential is often denied by arguing, that the economic evaluation of the energy saving potentials did not take into account transaction costs (Grubb et al. 1993). However, some case study evidence exists which suggests that transaction costs amount to only 3-8 % of investment costs and are by far not important enough to outweigh the no-regret potential (Hein, Blok 1995). Further analysis is now needed with a view to generalising these results. This paper will therefore re-examine in more detail the concept of transaction costs as it is used in the current debate on no-regret potentials (section 1). Four practical examples are presented to illustrate how transaction costs and their determinants can be identified, measured and possibly influenced (section 2). In order to link the presented cases to modelling based evaluation approaches the implications for cost evaluations of energy saving measures, especially in the context of energy system modelling, will be shown (section 3).

1 General considerations on the transaction cost debate

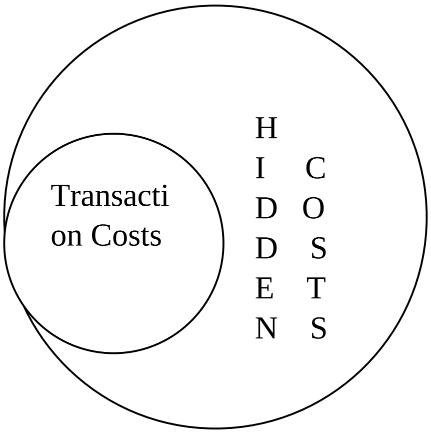
According to Ronald Coase, the pioneer of transaction cost economics, transaction costs are resources that have to be used to carry out a market transaction, i.e. to identify a market partner, to formulate one’s own demand, to negotiate and conclude the contract and to monitor and control its execution (Coase 1937). Thus, transaction costs comprise search costs, information costs, negotiating and monitoring costs. The concept may be further refined by comparing transaction costs to production costs: the latter depend on the production technology, while transaction costs depend on the organisational set-up and the routines for making and implementing decisions. However, transaction cost economics focuses not only on determining the level of transaction costs, but also analyses their determinants in order to identify the organisational set-up (or set of institutions and contracts) which reduces or – ideally - minimises the sum of transaction and production costs.

Contrary to this theory-based definition in the debate on no-regret potentials the concept of transaction costs is used in a different, sometimes much wider sense. Here, transaction costs often serve as a collective term for all cost impacts resulting from energy conservation measures, which have not yet been fully accounted for in cost analyses. A popular example is the amount of time necessary to determine which of the products on the market is the most energy efficient one. While this example refers to transaction costs in the narrow sense, other cost incidences, which are summarised under transaction costs are indeed parts of the "production" costs of energy efficiency, for example:

- costs for rebuilding the chimney after a condensing boiler has been installed, in order to reduce the diameter and assure proper ventilation despite the reduced temperature of the fumes;
- costs for being connected to the grid after a change of fuels from oil to gas;
- costs of potential production interruptions, which can arise during installation;
- costs for personnel, especially for measures that are not investments, such as leakage control of pressurised air systems by frequent supervision and basic maintenance (e.g. change of seals).

Even if these costs are not really transaction costs, they may still be subject to frequent omission in cost evaluations without justification. One aim, therefore, should be to integrate them into future analyses. In order to take account of these various types of neglected costs, we will call them "hidden costs", more generally. "Real" transactions costs as defined above are then a sub-group of hidden costs. Figure 1 illustrates this definition.

Figure 1: Transaction costs as subgroup of hidden costs



2 Four practical examples for transaction cost incidences

As the concept of transaction costs shows, it is not only their level in the context of energy saving measures that is of interest in cost analyses, but also their determinants. The following examples of energy saving measures are therefore chosen in order to demonstrate further specific aspects, which are relevant to their cost evaluation from the perspective of transaction cost economics. In addition, we will show other hidden cost impacts, which cannot be explained sufficiently by transaction cost economics but indicate starting points for a broader revision of cost evaluation approaches to energy saving projects.

2.1 Highly efficient electric motors (HEM)

According to transaction cost economics the procurement of an electric motor creates costs not only when it is actually purchased but already before for planning the purchase – this means for example for determining the technical specifications of the desired motor -, and for negotiating the terms of the contract and the delivery, because prices on this market are subject to bargaining despite the existence of price listings (Ostertag et al. 1997). In many enterprises it is immediately evident from the organisational structure, that the procurement of a machine creates costs over and above the purchasing price, since often there is a separate department devoted to procurement. Still these additional costs are not being accounted for in most cases or they are represented only in very simplified terms as a percentage share of the purchasing price (see for example the analytical framework of IKARUS) due to the lack of more precise empirical data.

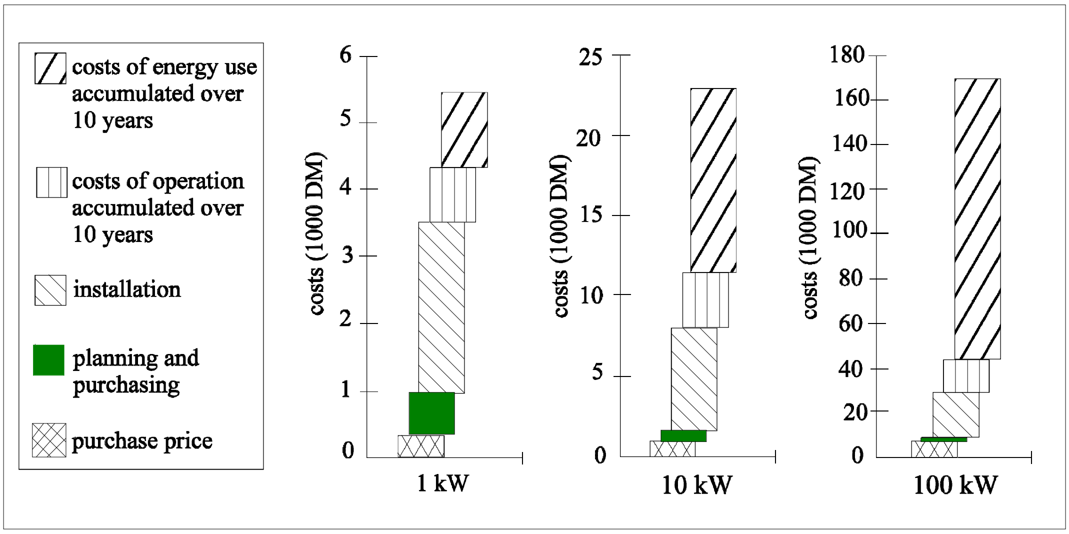
The following account of life cycle costs of electric motors is more detailed than common cost data, since it accounts for costs of planning and purchasing separately (see figure 2). Two important conclusions can be drawn from this figure:

- The share of costs for the planning and purchasing of a motor (exclusive of the purchasing price itself) in total life cycle costs decreases with the size of the motor. This means, that the costs for planning and purchasing are more or less constant and hardly depend on the price of the motor at all (or the power or the total life cycle costs). This partly affirms results of Hein and Blok (1995) on information costs as one component of transaction costs. They show that information costs, as a the fraction of investment, tends to decrease as the size of investment increases. More generally speaking, transaction costs do not or not directly depend on the volume of the transaction. Especially in the case of high purchasing prices the assumption that transaction costs are proportional to purchasing prices leads to an overestimation of transaction costs.
- Transaction costs (here for the planning and purchasing of a motor) accrue for the procurement of any motor – for highly efficient motor types just as well as

for standard types. Note that figure 2 distinguishes only by motor size but not by efficiency level.

The second point shows that in any transaction cost evaluation only the *differences* in transaction costs between energy saving measures and the less energy efficient alternative matter. Rather than asking for the absolute level of transactions costs, the key question in the example is therefore whether the transaction costs for planning and purchasing a HEM differ from the transactions costs for planning and purchasing an ordinary electric motor. Because only in the case of such a difference will the inclusion of transaction costs in cost evaluations have an impact on the cost ranking of HEM vis-à-vis standard motors.

Figure 2: Transaction Costs and life cycle costs of electric motors (Source: Bieniek 1998)



The demands for integrating transaction costs in the evaluation of RUE measures often implicitly assume that transaction costs of HEM be higher than transaction costs of standard motors. However, this need not be the case and deserves further investigation. Indeed, the suppliers of HEM are less numerous on the market. Also, it may be difficult to infer and compare the energy efficiency level of two models from the technical data provided due e. g. to diverging measuring standards. Thus, "search costs" for HEM may indeed be higher than for standard motors.

However, these circumstances are not unchangeable. A firm which has purchased an HEM before will not have to start searching a supplier every time it wants to buy another HEM. This means, that search costs may deviate only once and returning to their standard level for the following transactions. Thus, a firm which routinely includes the request for standardised data on energy efficiency in its tenders for motors will have to spend less time on searching supplementary data and making additional calculations in the evaluation process afterwards. This adaptation of the procurement procedure may need time and resources. But it does not necessarily mean, that the emerging new routine will be more costly than the previous procurement procedure. From this it follows that the analysis of transaction costs should be based on a comparison of these different routines rather than on the comparison of a routine (where the energy efficiency of a motor is irrelevant for procurement) with an exceptional situation (where a HEM is sought only once).

If the level of transaction costs depends on the factors described above, these factors also indicate how policy programmes could intervene to reduce transaction costs. The energy efficiency standards of motors promoted by the EU exactly pursues this approach of reducing search costs by making energy efficiency performance of electric motors more transparent (EM 1998).

2.2 Cost differences between internal and external use of waste heat

In conventional cost evaluations the costs of waste heat as energy source depend on the technology used for heat recovery and the amount of fuel that is substituted and thus saved. Normally, no distinction is made whether the waste heat is used in the same firm where it is produced (internal use) or whether it is sold to another firm for external use. The only reason for a cost differential is seen in the possibly higher investment costs for the longer pipe line required and resulting higher heat losses in the case of external use.

By contrast, in reality there is indeed a systematic difference in the costs of external and internal use of waste heat. Transaction cost economics provides several reasons for this which are related to some of the obstacles that have been identified in studies on the diffusion of external waste heat use (e. g. Roth et al. 1996).

The original empirical question treated by transaction cost economics concerns the choice of the appropriate "co-ordinating mechanism" for the exchange of goods and services. One possible co-ordinating mechanism is the exchange within a firm which is understood as a set of hierarchical relationships. This means that a superior hierarchical level gives instructions to one department concerning the services to provide for another department. If waste heat is used internally, one single decision maker – for example the technical director – determines, that department A (where the waste heat occurs) will recover waste heat and feed it into a suitable heat grid, while department B will use this waste heat for covering its heat demand (and perhaps pays for it according to the internal pricing system). In this case the decision on the supply of waste heat and its use are inseparably linked.

In transaction cost economics, the counterpart to the enterprise as co-ordination mechanism is the exchange of goods and services via the market. Based on a large number of buyers and suppliers the market, in this context, is seen as a "take-it-or-leave-it" relation between demand and supply side. This means, that the buyer is a pure price taker and does not possess any bargaining power. Correspondingly, the supplier does not depend on one or a few specific clients, but can chose his buyers freely. However, such a situation is not always given; market exchange is not always possible under such conditions. This is also true for the case of external use of waste heat. Since the energy carrier is distributed via a pipeline, the waste heat supplier commits himself to one specific client through the construction of this pipeline. Equally, the buyer of waste heat makes a commitment to one specific supply source of heat if *he* pays for the pipeline. This commitment is due to the "asset specificity" of the investment that provides the infrastructure for the transaction, i.e. the pipeline (Perry 1989). High asset specificity means that the pipeline can be used only for one very specific transaction, i.e. to deliver one specific product (heat) to one specific customer. For all other transactions the pipeline is of no value. Whoever has paid for the pipeline therefore has a major interest in continuing the transaction it supports. This creates a "hold-up" problem, since the other partner of the transaction can threaten to stop heat demand, or heat supply respectively, and therefore possesses bargaining power vis-à-vis the partner who has paid the pipeline.

In such a situation the exchange of goods (heat) requires careful negotiations and control of the underlying contracts. This includes the definition and distribution of property rights - for example establishing a bilateral financial commitment for the pipeline – since property rights are crucial in determining possibilities of control, incentive structures and uncertainties (Kreps 1990). The external use of waste heat may fail if the negotiating parties do not find a consensus on the contract because they consider the risk of a hold-up-problem (or more generally the risk of non-delivery or non-supply) as being too high. If firms can chose between internal and external waste heat use, the high asset specificity of the pipeline will, therefore, create a preference for the internal use.

This example shows that transaction costs heavily depend on actor relations, incentive structures and consequently on property rights. Note that the distinction between external and internal use of waste heat is based on transaction costs, without having quantified them. By referring to their determinants alone - in our case asset specificity -, a statement can be made about the relative (though not about the absolute) level of transaction costs of two alternatives.

2.3 Leakage control in pressurised air systems

This example shall demonstrate some delimitations of transaction cost economics in explaining cost differences between energy efficient and standard technologies. Bottom-up analysts often use leakage control of pressurised air systems as an example for an energy saving measure, that is highly profitable but still not realised. A possible explanation for this apparent paradox may be that (transaction) costs have been neglected in the evaluation. In order to answer this question it is necessary to take a closer look at the design of the control procedure which can take several forms.

- In firm A leakage control is assured in a weekend shift, when production is closed. Since all appliances using pressurised air are then shut down, a decrease in the pressure of the system while the compressor is running can easily be detected. Given that noise levels are low when production is down the place of an eventual leakage may also be detected easily just from the noise it emits. The repair itself is generally rather simple. This procedure for controlling leakages creates costs for the personnel doing the weekend shift. These costs can be attributed directly to the "production" of energy efficiency and are therefore not transaction costs. Still it is true, that these costs are often unduly neglected in cost evaluations. A possible explanation (though not excuse) for this may be that as a result of their technically very detailed approach bottom-up analyses focus on measures requiring investments. This creates a bias towards costs related to the purchase of machines and appliances, while personnel costs, notably of organisational measures such as the control system, are easily forgotten.
- In firm B another set-up is chosen. Here the security service regularly patrols the site on weekends. Since the management knows about the saving potential inherent in leakage control it has delegated this control to the security personnel. As the control does not require any specialised knowledge the security officer is sufficiently qualified to do the job. He also appreciates being entrusted with a task by the management and voluntarily fulfils this additional duty. This "best practice" of his job as security officer does not create any extra costs – neither production nor transaction costs - to the firm. However, not all security officers may appreciate this additional responsibility. And being asked to perform leakage controls they may perhaps not do the job. Since it is difficult to control whether the job really has been done – in the end a leakage may occur just after the controller has passed the site – this neglect may not be discovered.

In the current debate, lack of motivation to take up leakage control is often also included under transaction costs. However, if all potentials which are left idle are explained by postulating the prevalence of transaction costs, the explanation becomes tautological. Many studies show that there are barriers, e.g. of sociological or psychological nature, outside the economic realm, which inhibit the take-up of economically profitable energy efficiency opportunities (InterSEE 1998; ISI et al.

1997; Prose 1994). It must be recognised that the assumption that all profitable options will be realised out of the pure self interest of the actor, is not realistic and cannot be restored by transaction costs.

2.4 Contract Energy Management

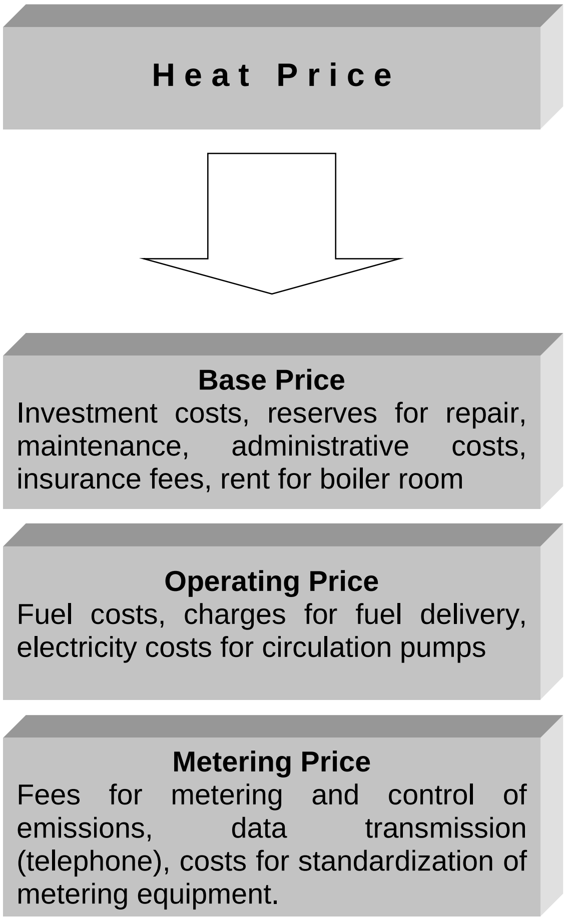
The emerging market for energy services, especially contract energy management may provide new opportunities to identifying and quantifying hidden costs. The reason is that energy service companies (ESCOs) have an economic interest in truly calculating all costs of the energy efficiency investments they implement for their clients, since it affects their core business. Some of the elements that make up the rates charged by the ESCOs unveil costs that normally remain hidden. Using the example of the model calculation scheme of the German association of heat suppliers (Verband für Wärmelieferung, VfW) the different types of hidden costs may be analysed in more detail in order to determine whether they are hidden costs of production (of useful heat) or transaction costs in the narrower sense.

The data that usually enter into private profitability calculations are investment costs, fuel and electricity costs and (average yearly) costs for repair, maintenance and insurance. Beyond these data, the heat price of the ESCO covers some parts of production costs, which mostly are not considered in the simplified calculation of an ordinary investor with little experience in RUE investments. Looking at figure 3 (Arnold/Krug 1996, OVE s.a.), these are

- parts of the base price: rent for the room where the heating system is installed.
- parts of the operating price: electricity costs for the pumps in the heating system, additional costs linked to the fuel purchase (such as costs for delivery).
- parts of the measuring price: costs for measurement and control of emissions, costs for standardisation of metering equipment.

These costs should generally be reflected in the evaluation of RUE measures, whether they are realised through an ESCO or the investor alone. Just the same, such costs would also have to be calculated for the evaluation of the alternative solution to the RUE measure in each case, for example the maintenance of the status quo. If, for example, a conventional fuel boiler is substituted by a gas condensing boiler, and an additional room where the oil tanks had been stored before becomes available for other purposes the cost comparison should include the rent for this room in the costs of keeping the fuel boiler. Another aspect is that only by including all costs in the evaluation can all cost *savings* be accounted for. Thus, only if electricity costs for circulation pumps are explicitly accounted for, the saving potential associated with the replacement of oversized inefficient pumps by more efficient and well controlled pumps can be revealed. This shows that even if hidden costs are systematically included in cost comparisons this not necessarily influences the result to the disadvantage of RUE measures but can just as well result in relatively higher costs of the alternative, e.g. the maintenance of the status quo.

Figure 3: Components of the heat price according to the model scheme (OVE s.a.)



By introducing a further division of labour, contract energy management may also cause some additional costs, which will enter into the price calculation. Most projects, for example, are remote controlled to allow the ESCO to assure smooth operation of the heat supply (or of other energy services), which creates (production) costs for data transfer (costs for telecommunication).

The residual component in the model calculation are administrative costs, which become visible as part of the base price. These may at least partially contain "real" transaction costs, such as for example costs for personnel for

- negotiating the contract with the client (heat user),
- gathering information on suitable heating systems and their suppliers,
- negotiating the terms of contract and delivery with the system suppliers,
- monitoring the installation and the starting of the new heating system.

Some of these transaction costs only accrue because the ESCO enters the game as the third contracting party. Thus, instead of one contract directly between the heat user and the supplier of the heating system, now two contracts have to be established: one between the ESCO and the system supplier, and one between the ESCO and the heat user. This aspect in itself creates additional costs for contract energy management compared to a conventional investment. On the other side, the division of labour and the specialisation of the ESCO in energy efficient heat supply imply a high frequency of planning similar systems and leading comparable negotiations with planners, suppliers, and specialised technicians. This creates an advantage in transaction costs compared to the individual investor, because the professional ESCO can use her technical knowledge on suitable systems several times. Her costs for information gathering for each project are therefore smaller (economies of scale) as for the individual investor under "normal" conditions. Over the years experiences are accumulated, for example on how to best reconcile the interests of the contracting parties, and standard contracts can be developed (for an example see Arnold/Krug 1996). Through such learning effects transaction costs may be reduced. The example shows that transaction costs are not static and fixed, but may decrease due to economies of scale and learning effects, just as production costs.

3 Implications for Energy System Modelling

In the controversy on the existence of the no-regret potential several main strands of research approaches may be distinguished. The first strand is the research on barriers to energy conservation. While the questions it treats are strongly interdisciplinary, the predominant methodologies are borrowed from the social sciences (e.g. case studies, surveys). The examples elaborated above are derived from this field of research. A second very important approach to identifying and quantifying energy conservation potentials is that of energy system modelling. Based on the examples above we will, therefore, present in this section some preliminary considerations on the implications of transaction costs for this kind of modelling.

Energy system models are aimed at giving a detailed representation of the energy system reaching from the extraction and the import of energy carriers over to the conversion and transport of energy up to the energy end use in households, enterprises, and the transport sector. In the optimisation approach (as opposed to simulations, for more details on this distinction see e. g. Ostertag et al. 1999) a simultaneous optimisation of the whole system takes places. This allows to systematically account for interdependencies between different energy technologies. Due to the consideration of the system as a whole, technical options for emission reduction can be taken into account consistently on both the side of energy supply and the side of energy use. In particular, comparisons can be made between technical options in different sectors and sub-sectors, and their combined effects can be investigated.

In investigating more closely the implications of transaction costs, or more generally hidden costs, for modelling two aspects are particularly relevant. First, the integration of this type of costs may affect data input. Secondly, it may have consequences for the structure of the model and the interpretation of its results. We will suggest a list of issues to be reconsidered for each of these two aspects.

Data Input

- Many of the costs which are summarised as transaction costs in the current debate are actually hidden *production* costs, i. e. production costs that are not yet included in cost analyses. Since from the type of costs they are close to the cost data already incorporated in the evaluations, they may be easier to integrate than transaction costs in the real sense.
- Transaction costs do not or at least not directly depend on the volume of the transaction. Therefore, it is unsatisfactory to represent them as a generalised percentage surcharge on investment spending, as it is done in current state of the art energy system modelling (e. g. Hein, Blok 1995).
- If transaction costs are taken into account, than this should be done for all technologies considered. Alternatively, the transaction cost *differences* of RUE technologies can be evaluated. The reason for this is that only the transaction cost differences between RUE and standard technologies will have an impact on the ranking and thus the priorities in technical choices.
- Transaction costs for individual investors in RUE may be reduced through appropriate instruments such as contract energy management through ESCOs.
- When quantifying transaction costs it has to be carefully considered whether the costs accrue only once or rather every year and how they develop in the long-run, e.g. if they decrease due to learning effects.
- Before adding additional costs to existing data bases the latter should be checked for latent tendencies of future costs being overestimated. This may be the case for several methodological reasons (for details see Ostertag et al. 1999). If, indeed, such tendencies exist they may be interpreted as an implicit account for transaction costs. In order not to exacerbate the tendency of cost overestimation, therefore, special caution is required when enclosing further costs.

Model structure and results

- Transaction costs depend on actor relations, incentive structures and on property rights. It is therefore questionable, whether models which represent costs purely in relation to technologies are principally suited to incorporate transaction costs, given their basic structure. Perhaps, a first attempt to integrate this aspect may be the adaptation of the diffusion rates of technologies. If, for example, the actual diffusion rates for waste heat usage rely also on external use of waste heat, more cautious estimates may be recommended.

- Additional transaction costs may accrue only once – for the first procurement of an energy efficient motor, or more generally speaking, for the change of routines. Also, additional transaction costs should be measured by comparing routines (organisational and working procedures) amongst each other and not by comparing routines to exceptional situations. This issue, too, raises the question whether technology based models are suitable to represent transaction costs, if they cannot depict routines as determining factors.
- In order to assure the logical consistency of a model, the hypotheses of behaviour on which it is based have to be compatible with those of transaction cost economics. For example, a model that assumes perfect information, must not incorporate search- and information costs in its data base.

4 Conclusions and Perspectives

Contrary to the wide-spread belief that the integration of transaction costs will necessarily reduce or even neutralise the no-regret potential the paper has shown that the result of a systematic integration of transaction costs of energy efficiency technologies and of the respective alternative standard technologies is not yet definitely clear (see figure 3). In fact, for the following reasons we do not yet know how much the picture without transaction costs changes once they are included:

(1) It is not certain that energy efficiency measures are systematically and continuously related to higher transaction costs than the competing technical (or organisational) alternative. This means, even if there are transaction costs there may exist little or no transaction cost *differences* between competing solutions.

(2) Even if some aspects hint to initially higher transaction costs of energy efficient technologies, their overall cost advantage may still persist (moving from upper left to lower right in figure 3). The fact that firms are constantly looking for improvements in any event and that energy efficiency improvements often require only minor changes to routines which already exist underlines that transaction costs for improving energy efficiency may be only marginally higher than "business-as-usual" transaction costs.

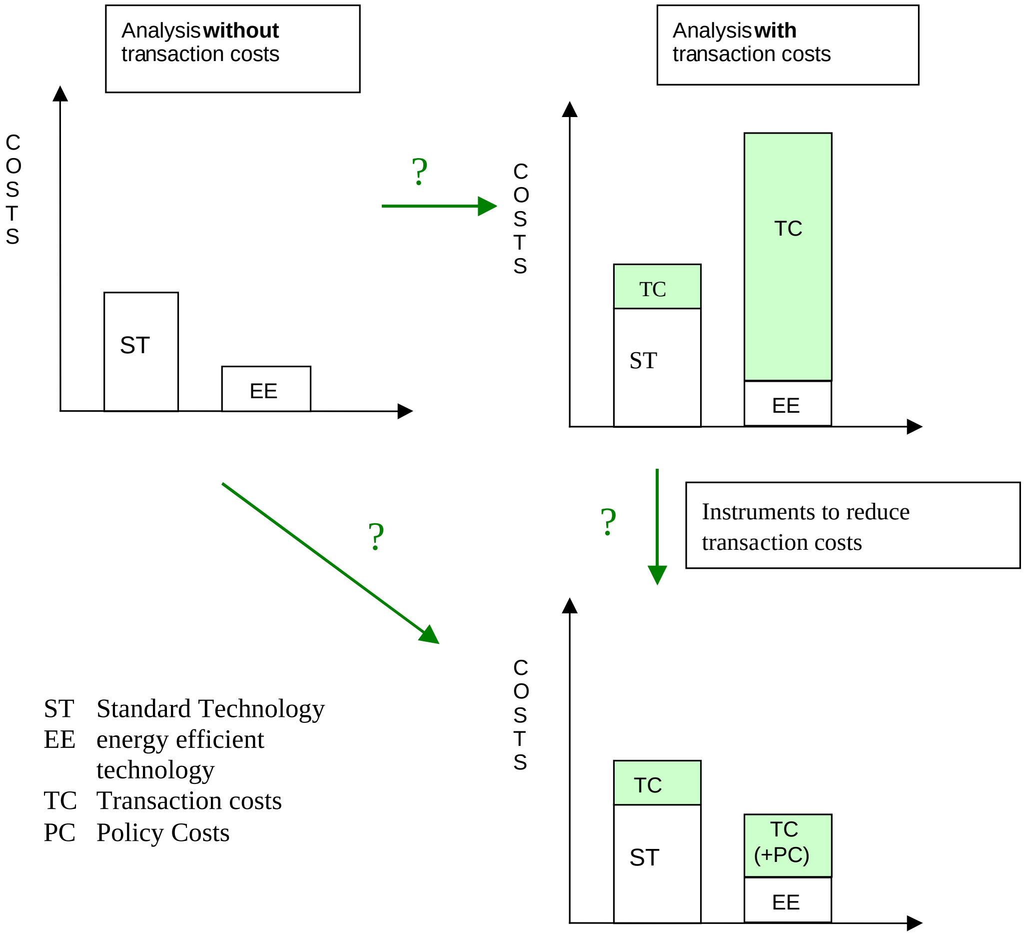
(3) Transaction costs may be reduced through economies of scale and learning effects. We may also encounter *non-recurrent* transaction costs, which then should be considered as investments (e. g. in the establishment of new supply chains), whose fruits may be harvested (e. g. reliable delivery of HEMs) in later periods.

(4) Policy instruments or institutional set-ups – such as energy efficiency standards and contract energy management - may be available to reduce existing transaction costs, where they reverse the cost advantage of energy efficient technologies over standard technologies (picture on upper right in figure 3). Transaction cost analysis can contribute important insights on possible starting points for policy intervention. Even if these instruments may cause (transaction or policy) costs themselves, these are not simply additive to other transaction costs. In fact, it is even possible that the costs of the instrument can be equilibrated by the transaction and production cost savings which it generates (moving to the lower right in figure 3).

The aim of further cost analyses should be to incorporate transaction costs, but also the other types of hidden costs shown in this paper. We have presented some preliminary approaches for doing so. In a very first step, the integration should focus on the question of transaction cost *differences* between the technological alternatives considered, rather than on the absolute volume of transaction costs, since the former may be easier to identify. A lot of further work is necessary, especially if the strands of research relevant in this field are to generate a more productive influence on each other.

For reasons of analytical precision the focus of this paper lies very strongly on transaction costs and other hidden costs. *Co-benefits* of activities to improve energy efficiency are outside the scope of this paper. However, we want to point out that such co-benefits can be very important. They take, for example, the form of cost savings through simultaneous reduction of other inputs, increased throughput or quality improvements (see e. g Avadikyan et al. 1999). Further research is necessary to explain, quantify and integrate them.

Figure 3: Possible results of integrating transaction costs in cost comparisons



ST	Standard Technology
EE	energy efficient technology
TC	Transaction costs
PC	Policy Costs

Acknowledgements

This work was partly supported by a grant from the German Federal Agency for the Environment for the research project „Energiesparen – Klimaschutz, der sich rechnet" (FKZ 297 97 202), within which the original German version of this paper was prepared. I highly appreciate the comments made by many participants of the workshop where the paper was presented, especially Jonathon Koomey, John Skip Laitner and Alan Sanstad. An earlier version of this paper was presented at the meeting of the Advisory Group to the JOULE project *Barriers to Energy Efficiency in Public & Private Organisations*, Brighton, 11 December 1998.

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