Evaluations of the Danish Agreement System

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ABSTRACT

Denmark has an ambitious energy policy with the objective of reducing the CO_2 emission by 20% in year 2005 compared with the 1988 levels. Taxes are widely used as policy instruments and several supply-side actions like introduction of natural gas, expansion of the district heating network, and strong regulation on the use of electric heating in new buildings.

In Denmark, energy regulation towards industry has traditionally been based on voluntary demand-side measures, e.g. free electricity audits funded by the utilities (since 1988), information or subsidies for energy efficient investments (1977-83). Since 1979, taxes on energy have been used for households, and in 1993 taxes were introduced for trade and industry. It was later found that the CO_2 objective would not be met unless new initiatives were applied, and that taxes on trade and industry would be the most efficient way to reach further CO_2 reductions. The taxes therefore were increased in 1996 especially on trade and industry and will increase in yearly steps until year 2002. The objective was that trade and industry would contribute with 4% of the CO_2 reductions. Taxes are now a very important element in the CO_2 regulation in trade and industry.

In the interest of maintaining competitiveness it was decided that all the revenues from the increased energy taxes should be recycled. Furthermore a number of energy-intensive enterprises will receive a reimbursement, provided they enter into a binding agreement with the Danish Energy Agency.

In this paper the Danish energy tax system will be described with the focus on the parts related to the agreements. We will present and discuss the main findings of three evaluation studies concerning the agreements.

1. The Danish Energy Tax System

The corner stone of the energy tax system is the taxes which give incentives to improve energy efficiency. Other elements are agreements and recycling of revenues.

1.1 Taxes

The taxes are phased in gradually in order to allow the companies to adjust. The effective level of taxation is the highest in the world for industry. The annual revenue derived from the tax is expected to be US$ 0.5 billion in year 2000 which is approximately 1% of the total state revenue. Due to the increased taxation, this revenue is recycled – mainly by lowering the non-wage costs of labour (Ministry of Taxation 1998).

The level of taxation depends on the purpose of the energy use, the energy type and whether an agreement between the company and the Danish Energy Agency exists.

Energy use: Three types of energy use are defined: Space heating, light processes and heavy processes. Heavy processes comprise several energy-intensive processes, e.g. melting, concentration and drying in relation to the production of cement, mineral wool, condensed milk and sugar. In total, 35 processes have been defined as heavy processes. Heavy processes account for 61% of all energy used in *industry*. The remainder is divided between light processes (27%) and space heating (11%) (Statistics Denmark 1998). In *trade and services* the energy use is divided between light processes and space heating. When companies use the same energy source for different purposes, several meters are required within the company.

Energy type: For each energy source the total tax is calculated from the content of energy, sulphur and carbon. In Table 1 the *CO_2 tax* is shown. A *sulphur tax* of 20 DKK per kg sulphur (US$ 3.12 per kg S) must be added for all purposes. The sulphur content varies with the fuels. E.g., natural gas does not contain sulphur while coal is subject to considerable sulphur taxes. An *energy tax* must be paid for energy used for space heating. This tax is approximately 47 DKK per GJ (US$ 7.3 per GJ) in 1999 and will increase to 51 DKK per GJ (US$ 7.9 per GJ) in year 2002. Tax levels for individual fuels can be found in (Ministry of Taxation 1998). The CO_2 and sulphur taxes are fully phased in in year 2000 while the energy tax is fully phased in in year 2002. The calculations of the taxes are usually based on standard values for each fuel, but the sulphur tax can be based on the actual emission. This is done for a few large coal consumers where pollution controls are applied.

Agreements: Energy-intensive companies[1] may enter an agreement with the Danish Energy Agency and thereby qualify for reduced CO_2 taxes for heavy or light processes. Table 1 shows the five different tax rates.

Table 1. CO_2 Tax by the Year 2000, DKK (and US$) per Ton CO_2

100 DKK = US$ 15.55	Space heating	Light processes	Heavy processes
Without agreement	100 (15.55)	90 (14.0)	25 (3.9)
With agreement	—[1]	68 (10.6)	3 (0.47)

Source: Ministry of Finance 1995.
1. Agreements cannot be entered for the space heating.

In reality the energy taxes thus decrease according to the energy intensity of the enterprises. There are two reasons for having these differentiated taxes. First, a major political interest is related to the distribution effects of introducing the system, e.g., redistribution among different sub-sectors and among individual companies. The differentiation in tax levels combined with the recycling partly proportional to the number of employees, reduces the volume of funds being redistributed because of the new system. Second, since the system was introduced unilaterally, the impact on the competitiveness of the few very energy-intensive companies was also a major concern. The agreements with a limited number of companies, and the differentiated taxes help to reduce the economic pressure on the very energy-intensive companies. Otherwise, these companies may be forced to move production abroad without involving global CO_2 reductions, (Ministry of Taxation 1998).

[1] The definition of energy-intensive companies in relation to agreements is described in Section 1.2.

Due to the recycling of the revenues, the total impact of the system is expected to be a (small) increase in employment (Ministry of Finance 1995).

1.2 Agreements

When the first Danish taxes on CO_2 were introduced in 1993, an exemption system was applied towards energy-intensive industry. In 1996, this was changed to an agreement system.

Companies with energy-intensive processes can enter into a three-year agreement with the Danish Energy Agency in order to qualify for a lower tax rate. After the three years the agreement must be renewed. Two kinds of agreements can be made: Individual agreements and collective agreements. Agreements can be entered for both heavy and light processes. While all companies with heavy processes have the right to enter into an agreement with the Danish Energy Agency, companies with light processes are defined as energy intensive – and obtain this right only – if the calculated tax of the energy consumption amounts to at least 3% of value added. Also, the calculated tax must exceed a certain minimum value. This condition excludes many small companies from the possibility of entering an agreement.

An agreement specifies several activities which the individual company must undertake to qualify for the reduced tax rate. These activities include a realisation of »profitable« energy-saving projects, introduction of energy management including energy accounting, motivation of staff and activities to ensure that investments in new equipment will be energy efficient. The guidelines for energy management are formulated in the line of environmental management systems, like ISO 14.001.

Energy audits form the basis for agreements. An energy consultant or company staff can carry out the audit. Today, all audit reports must be verified by an independent certified organisation. In theory, all profitable energy savings are described in the audit report. Payback periods of up to 4 or 6 years (lowest for agreements concerning heavy processes) are considered profitable by the Danish Energy Agency.[2]

The collective agreements are made with groups of companies from an industrial sub-sector with similar production processes. In the collective agreements negotiations with the Danish Energy Agency are conducted by the trade organisation instead of the individual company. The idea is to reduce the administrative costs of entering into an agreement. The group agreements are based on simplified energy audits adapted to the relevant sector. Analyses of energy consumption and production processes in the sector are made to identify the general potential for improving energy efficiency in the companies. The exact procedure is adjusted to the homogeneity of the individual sector. The result of the analyses is reported to the Danish Energy Agency and is used to formulate an action programme. Each individual company has to sign – and is committed to – the action programme.

All companies with an agreement must deliver a yearly progress report to the Danish Energy Agency. In this report the fulfilment of the agreement must be reported together with a status for the energy management.

When no profitable energy savings are identified in the energy audit, companies are considered energy efficient, and in consequence these companies need not carry out further

[2] When calculating the pay-back period, energy prices including the taxes, in absence of an agreement, are used, i.e. a company with heavy processes should use the energy price and a tax of US$ 3.9 per ton CO_2 in the calculations, while a company with light processes should use the energy price and a tax of US$ 14 per ton CO_2.

investments in energy efficiency in order to obtain the reduced tax rate. However, all companies must implement an energy management system and the management systems are supposed to be approved by the Danish Energy Agency.

1.3 Subsidies

The revenue from the energy taxes is recycled – mainly by lowering the non-wage costs of labour, but also, in a transition period, by granting subsidies for investments in energy efficiency improvements (Ministry of Taxation 1998).

Subsidies are granted for up to 30% of investments in energy-efficiency projects. Subsidies are only granted for projects with a medium payback period, which is calculated with the full tax burden (year 2000). The calculated payback period must be between 2 and 9 years. For companies with an agreement, the accepted interval is from 3 to 9 years. Furthermore, only projects with a certain minimum CO_2 reduction in relation to the investment are subsidised. A total of 1,800 million DKK (US$ 280 million) has been set aside for subsidies. It is expected that the subsidies will end these funds will be used in year 2000.

Two systems are used in the administration of the subsidies. For the large projects, an individual assessment is done by the Danish Energy Agency. For example, large subsidies have been granted to combined heat and power plants located in industrial companies.

For small projects, a standard procedure has been developed. If the project fulfils the requirements in the standard procedure, the administrative aspects are minimal. Popular standard projects are electronic ballast for fluorescent light, special ventilation in the wood industry (for removing wood chips) and variable speed regulation for ventilation.

Subsidies can also be used for other purposes than investments, e.g. energy audits, demonstration and development projects, and general projects related to energy efficiency.

2. Evaluations

The Danish Energy Agency has initiated several independent evaluations of the CO_2 system. As a result aspects of the system have been moderated and developed. For example, a new guideline for energy management and verification of all energy audits was put in place beginning in 1997. The guideline for energy management was further developed in 1998.

Below we shall summarise the main findings of three recent evaluations of the agreements. These studies have been the input to an evaluation of the total system (including taxes, recycling and more). This general evaluation is expected to be published in 1999.

The evaluations discussed here have combined several designs: Analysis of existing data on companies with an agreement (Section 2.1), case studies (2.2) and surveys (2.3 and 2.4). A database is used to describe the energy consumption and the expected savings due to specific projects described in the agreement. The case studies are process-oriented and are designed to help understand how the different elements are received by the companies and to identify barriers in the process. One survey is designed to capture the independent impact of agreements, and the other is focussed on the impact of subsidies.

2.1 Agreements – Database

The Danish Energy Agency maintains a database concerning companies with an

agreement and the related energy savings (Ahé, Fafner & Christensen 1998). Information about the energy savings comes from energy audits at the individual company. Important aspects concerning the agreements are illustrated by figures from this database.

From 1996 to 1998, the Danish Energy Agency has made 143 agreements with industrial companies (and 107 with greenhouses). This is illustrated in Table 2.

Table 2. Number of Agreements

Type of agreement	1996	1997	1998
Individual agreements			
Heavy processes	21	41	20
Light processes[1]	-	21	10
Collective agreements			
Condensed milk factories	9	-	-
Greenhouses	40	46	21
Brickyards	-	-	21
Total number of agreements	70	108	72

1. Many of the companies with agreements for light processes also have an agreement for the heavy processes.

Energy consumption in the companies which entered an agreement in 1996 and 1997 corresponds to 45% of the total energy consumption in industry. The companies with an agreement are expected to decrease their energy consumption by 1.7%, due to the specific projects described in their three-year agreements. The companies with an agreement from 1996 are among the largest energy consumers in Denmark. The results in these companies dominated the total result, see Table 3. According to a survey (see Section 2.3) 34% of the energy savings resulting from the specific projects, would have been realised even without the agreement.

Table 3. Energy Consumption and Calculated Reductions from Specific Projects Described in the Agreements[1]

Agreement, year signed	1996	1997	Total[1]
Consumption	48 PJ	13 PJ	61 PJ
Reduction due to specific projects	0.71 PJ = 1.4%	0.35 PJ = 2.7 %	1.06 PJ = 1.7%

Source: Ahé, Fafner & Christensen 1998.
1. The agreements with greenhouses are not included due to lack of data.

Further savings are expected since several companies have agreed to investigate a number of specific energy-saving opportunities during the three-year period (these special investigations are used for potential projects that are not completely described in the energy audit). Also, the agreed activities in relation to energy management are expected to result in further energy savings. In Table 4 the expected savings are given in relation to the total CO_2 emission in the agreement companies. Due to the fuel mix the 1.7% energy savings due to specific projects (described in the agreement) are reduced to 1.2% reduction of the CO_2

emission. It is predicted that the total reduction of CO_2 emission will accumulate to 2.7%. The three sources (specific projects, special investigation and energy management) each contribute with approximately one third of this reduction.

Table 4. Estimated CO_2 Reductions in the First Three-Year Period from Various Sources

Agreement	1996	1997	Total
Specific projects	0.9%	1.9%	1.2%
Special investigations	0.7%	1.1%	0.8%
Energy management	0.6%	1.1%	0.8%
Total after 3 years	2.2%	4.1%	2.7%

Source: Buhl Pedersen et al. 1998. In this report the values for energy management are estimated for the period until year 2005 – corresponding to three agreement periods. In Table 4 these values have been transformed to the first agreement period.

There is great uncertainty concerning the energy savings due to the special investigations and the energy management. The savings presented in Table 4 are on information in the agreements and the qualitative results from the case studies (see next section). The savings due to energy management for the 1996 companies are expected to increase in the next agreement periods due to the tightened guidelines. It is estimated that a continuation of the agreement system by 2005, relative to a situation without agreements, can lead to a decrease in the CO_2 emissions corresponding to 6% of total emissions in industry and trade. Energy management is expected to be the main source of the savings.

It is expected that the agreements in year 2000 will cover 50% of the total energy use in industry. The number of agreements is expected to increase to 370, as the economic incentive to enter into agreements increases over the next few years. Of these agreements, 160 concern industry and 210 greenhouses.

2.2 Agreements – Case Studies

The case studies include detailed information about 12 companies and describe qualitative aspects of the agreements in the companies – especially in relation to energy management. The study is based on interviews with the employees who are responsible for economy, energy and the agreement with the Danish Energy Agency. Also, consultants and representatives from the Danish Energy Agency are interviewed.

Energy Audits: The aim of an agreement is to ensure that the companies act energy efficiently. Therefore, the definition of »an energy efficient company« and the way in which this is interpreted in the agreements are key issues. In the Danish agreements, companies are considered energy efficient if they carry out all energy saving projects with a payback in less than four years (six years for light processes), and if it implements an energy management system, approved by the Danish Energy Agency. Thus, in principle, the definition of an energy efficient company is objective, but in practice it is very much influenced by the problem of asymmetric information: One negotiating party – industry – has detailed information on the opportunities and limitations in relation to energy savings in their specific production. The other negotiating party – the Danish Energy Agency – has little detailed information and must

rely on other sources, first of all the energy audit. The energy audit report determines whether the company is considered energy efficient or whether it has to carry out investments in energy-saving measures in order to enter into an agreement. Therefore, the energy audit plays a crucial role as the basis for negotiations between companies and the Danish Energy Agency and it is essential for the audit to be of as high a quality as possible.

The majority of companies with an agreement received their first energy audit in relation to the introduction of the CO_2 tax in 1993. This audit was concentrated on service equipment – such as lighting, compressed air and cooling (Ravn, Togeby & Ingerslev 1994). The second energy audit focussed on the core areas of production – the energy intensive processes. However, many basic issues on energy use and in relation to energy management were dealt within the first audit, and therefore the first energy audit has been useful in relation to the development of the new audit.

In general, the companies are content with the shift in focus of the energy audit, now concentrating on the energy-intensive processes. However, it is also clear that it is difficult for the consultants on their own to come up with energy-saving projects on these core areas of the production as they often lack knowledge about the specific processes. Therefore, the consultants are very dependent on company staff cooperation. The evaluations show that the companies find that the energy audits sum up existing knowledge rather than help identify new potential for energy savings. In spite of modest results in terms of identified energy-saving potentials, most companies find that the agreements have an effect as energy efficiency becomes part of the company agenda. It helps to map the energy consumption and to specify the profitability of investments. Most companies use an authorized energy consultant to carry out the energy audit. The evaluation also shows that the companies who have carried out an energy audit before have the best teamwork with the energy consultant.

Verification: While in the first year relying on the approved consultants and the expertise of the officials in the Danish Energy Agency to judge whether the audit reports were of sufficient quality, the Danish Energy Agency made verification of the audit reports obligatory for all companies by 1997. The verification agencies also handle cases of certification of environmental and quality management systems. Like the consultants, the verification agent is chosen by the company from a list approved by the Danish Energy Agency. The verification agent mainly checks that the audit report meets the documentation requirements. In order to check the technical quality of the audit report, a technical expert (a consultant, specialised in certain production processes) is chosen by the verification agents from a list of experts recognised by the Danish Energy Agency. Thus, the verification involves a kind of peer review (Krarup, Togeby & Johannsen 1997).

The cost of the verification is paid by the companies, but they can apply for subsidies of up to 50% of the costs. In general, the companies are discontent with the requirement for verification, as the verification as such is regarded to be of no use to the individual company (Krarup, Togeby & Johannsen 1997; Ingerslev et al. 1998). However, the obligatory verification appears to be useful to assure audit quality. In 1997, the Danish Energy Agency has placed eight consultants on an observation list due to unsatisfying audits. These consultants may lose their right to perform energy audits if future energy audits lack high quality. In three cases the Danish Energy Agency has decided to overrule the verification agency's approval of the audit report, and the verification agent has been warned that he could lose his right to perform verifications if it happened again (Pedersen, Rieper & Hansen 1998).

The Danish Energy Agency finds that the quality of the energy audits has increased

since the verification was introduced in 1997.

The Negotiation Process: The study of the 1996 agreements showed that very little negotiation took place in relation to the entering of most agreements. Part of the negotiation probably takes place between the consultants and the company staff and within the company before negotiations with the Danish Energy Agency are opened. When the energy audits were accepted by the Danish Energy Agency, the agreement was straightforward: The companies should carry out all profitable projects (Krarup, Togeby & Johannsen 1997). Although the definition of profitability with payback periods of 4 or 6 years (depending on the type of agreement) deviates considerably from payback periods that industry normally accepts, the companies have not protested against this criterion. One reason for the absence of protests could be that the companies evaluate the agreement as a whole. Often, the tax rebate is so advantageous that this can easily outweigh a few less profitable projects. The possibility of receiving subsidies for these investments may also reduce the problem of long payback periods. Furthermore, the calculation of the payback periods does not necessarily reflect the real profitability of the investment projects since several assumptions are necessary in most calculations (e.g., the benefits are dependent on how many hours the equipment is used).

When negotiation took place, it was in relation to aspects like the time table for realizing the projects and the need for further investigations. Few meetings (often one or two) were held and time was used on administrative questions, like the correct use of energy prices and interpretations of the guidelines. Also, questions concerning the adequacy of the audits were raised by the agency. E.g.: *Have all relevant parts of the energy use been analysed in the energy audit?* The main impression was that the process is one of rule-following – not of give-and-take negotiations (Krarup, Togeby & Johannsen 1997).

The concept of »special investigations« can play a role in the process of negotiation. If the Danish Energy Agency forced the companies to go through with the projects under uncertain conditions, the Danish Energy Agency could be held responsible if things went wrong. The concept of special investigations is an opportunity to investigate projects more thoroughly. In general, the companies are also content with the special investigations, especially in relation to complicated or uncertain projects (Ingerslev et al. 1998).

Energy Management: Since 1997 the fulfilment of the guidelines concerning energy management has also been a major issue in the negotiation phase. Many companies are not familiar with the more formal sides of energy management. The study of the 1996 agreements finds that the activities in relation to energy management are performed at a low level when compared to the intentions in the guidelines. Large energy flows are only measured at monthly intervals, and few key figures are calculated. In 1997 and 1998 the guidelines concerning energy management have been tightened.

The study of the 1997 agreements examines the energy management part of the agreements in more detail. In spite of the tightening up of the guidelines the implementation of the energy management systems only appears to progress slowly. The companies had entered their agreements approximately 9 months before the interviews. Most companies primarily concentrate on improving their *energy accounting* systems, developing more detailed key figures etc. Procedures for energy efficient investments are still largely informal and questions of targeting, motivating and educating staff remain yet to be addressed in some companies.

In the guidelines for the implementation of energy management the companies are asked to develop procedures to ensure energy efficiency of new equipment. This can include

the provision of alternative solutions before the decisions are made. The idea is, for instance, that the companies must demand that the different components (motors, pumps etc.) are energy efficient. However, some companies report that the suppliers, who produce the components themselves, are unwilling to replace their own components with other more energy efficient components of another supplier.

The technical elements of the concept thus seem to be easier for the companies to implement than the more managerial elements, which may have to do with insufficient management attention. However, for companies with quality management, and especially environmental management systems, the implementation of energy management appears to be more successful.

The difficulties of implementation do not make the companies give up energy management. In the case studies, the four companies with a 1997 agreement and the two companies with a collective agreement all intend to continue the work with energy management after the expiration of their agreements. Also, several of the interviewed energy managers have noted that their role in the company has been enhanced as an effect of the agreements and that energy efficiency has been put on the company agenda.

Monitoring and Sanctions: In comparison to many other agreement systems (e.g. see Larsen, Krarup & Kræmer 1998, who have studied agreements in Sweden, Finland, the Netherlands, Great Britain and Denmark) the monitoring and sanctioning efforts of the Danish agreement system are quite comprehensive. The companies must deliver a yearly progress report to the Danish Energy Agency documenting investments and the function of the energy management system. The evaluation showed that the opinions of the companies concerning the progress report differ quite a lot. Most companies are content with the requirement as they use the deadline for the progress report as an internal deadline. They point to the problem that companies often have trouble getting energy conservation projects carried out, because energy savings are of secondary importance to them. The progress report keeps the company focussed on the projects and helps the energy manager to get the attention of the top management. Other companies view the demands for documentation as just another administrative burden. If the companies are unable or unwilling to carry out the projects tabled in the agreement, the agreement can be renegotiated. In general, the Danish Energy Agency is considered to be flexible in relation to renegotiations. If the company does not want to implement a certain project that is included in the agreement, one possibility is to exchange the project with another with the same impact on the energy efficiency (Krarup, Togeby & Johannsen 1997; Ingerslev et al. 1998).

In one case, the Danish Energy Agency has cancelled an agreement with a company that did not fulfil its commitments. This company lost the tax reduction.

Discussion: The agreements consist of two rather separate activities, i.e. the energy audit and the energy management system. The energy audit gives the company an up-to-the-minute account of the energy consumption and a specific description of the possibilities to save energy. The energy management system is intended to be the basis for a long-term effort to save energy. The evaluation shows that the companies give priority to the energy audit at the expense of the energy management system. One of the reasons for this might be that energy audits are less complicated for the companies. The use of energy management as a part of an agreement furthermore raises the question of controlling the companies' energy activities. The specific investments from the audit are relatively easy to follow, while the control of the energy management system is more complex.

2.3 Agreements – Survey

A survey has been used to describe and analyse the energy efficiency activities (e.g. energy management, the use of key numbers, and realized energy-saving projects) in companies with and without an agreement. The purpose has been to test whether the agreements have an impact on the energy activities, when corrections are made for other relevant variables differing between companies with and without an agreement. As an example average energy intensity is higher in agreement companies than in companies without an agreement. Without correction for energy intensity a comparison could give misleading results. The four main elements in the survey are shown in Figure 1. The design was inspired by Megdal, Pertusiello & Jacobsen (1997) and Maxwell, Lyon & Hackett (1998). It is for instance shown that other policy instruments (earlier programmes) can have an impact on the activities.

The focus has been on energy efficiency activities instead of energy efficiency. This is a question of practical consideration. The Danish Energy Agency was interested in an early evaluation of the impacts of the agreements, but since the agreements were less than half a year old it seemed unrealistic to evaluate the outcome (energy efficiency) and instead the focus was changed to the output (energy efficiency activities). The energy efficiency activities are regarded as an indicator: If the energy activities increase, this is supposed to be followed by the realization of specific energy efficiency projects.

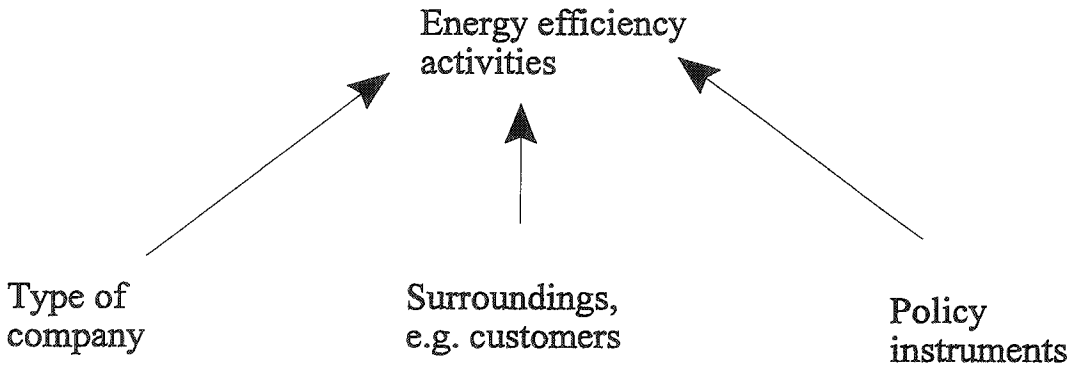

Figure 1. Main Elements in the Survey

The population of the survey consists of three groups of Danish industrial companies – see Table 5. In total 184 companies were selected. The energy managers in 150 companies were interviewed, corresponding to a response rate of 81%. The complete study is described in (Buhl Pedersen et al. 1998; Togeby & Hansen 1998).

Table 5. The Companies that Have Been Interviewed

Subgroup	Number of companies
Companies with a new agreement[1] (1996-98)	91
Companies with an old agreement[2] (1993-95) only	31
Other companies with between 250 and 500 employees	28
Total	150

1. Out of the 91 companies with a new agreement 44 also entered an agreement in the first period (1993-95).
2. From 1993 and 1995 the energy-intensive companies were exempt from the CO_2 tax, but it was not officially called an agreement. In reality, all the elements of today's agreements can be found in this system, although in a less strict version.

The procedure in the analysis is as follows:

- To develop questions that can reveal important activities relevant for good energy house-keeping
- Carry out the interviews
- To construct an indicator of energy efficiency activity based on nine questions
- To explain the variance in this indicator by use of a regression analysis, i.e. to test if energy intensity, company size, agreement or other policy instruments influence the constructed activity index in a significant manner.

The Indicator of Energy Efficiency Activities: A factor analysis[3] has been used to compress the information from nine questions related to energy activities into a single variable. The nine variables are shown in Table 6. The first three variables are dichotomous (yes/no) while the others are scale variables with five or more possible values. The new constructed variable is used as an indicator of the energy-efficiency activities in the individual company. It is a linear combination of the nine original variables and is transformed to range from 0 to 5. A value of 0 corresponds to the lowest level of activities in the sample, while 5 is equal to the highest level of activities.

The energy-efficiency activity index includes 32% of the original information in the nine questions. The signs of the loadings (defining the relationship between the nine questions and the activity index) show that an »energy friendly« answer always contributes to a higher activity index. The constructed energy efficiency activity index measures important aspects about how companies work with energy efficiency, but one should be aware that inclusion of other information than the nine questions would alter the index and could influence the analysis.

[3] See Kim & Mueller 1978 for an introduction to factor analysis.

Table 6. The Nine Questions Forming the Basis of the Activity Index

- Does your company use key figures relating energy consumption to production?
- Have staff been trained in energy management and energy efficiency within the last year?
- Is training of staff in energy management and energy efficiency planned for next year?
- The number of key figures evaluated each month (or more often)? *
- The share of staff that has been educated in energy efficiency or energy management *
- Number of energy efficiency projects that has been realized within the last year *
- To which degree is the management engaged in energy efficiency? (a scale from 1 to 5)
- To which degree is staff actively involved in the work with energy efficiency? (a scale from 1 to 5)
- How would you describe the energy savings realized due to the energy management system? (insignificant, neither/nor, considerable)

* These answers have been transformed to logarithms (base 10) before entered into the factor analysis.

The main question is whether companies with an agreement (and lower taxes) have a higher or lower activity index than other companies when controlled for other differences, like energy intensity. This is analysed with a multiple regression analysis. Parameters describing company type (11 parameters, e.g. energy intensity, industrial sub-sector, and type of product), and exposure to policy instruments (4 parameters, e.g. which energy and environmental regulation the company has been exposed to, the use of subsidies) have been tested. Originally, several other variables were tested, including some describing the customers and other company surroundings. Because of problems with endogeneity (that the activity index influences the explaining variables, i.e. a two-way relationship) the original 32 explaining variables have been reduced to the mentioned 15. In this way the analyses only include three out of the four elements in Figure 1.

The result of the regression analysis is described in Table 7. Four variables describing company type and two variables describing policy instruments are significant. Only parameters with a significance level of 5% or better are included. Only 124 companies are included in the regression analysis since 26 companies have not answered all questions, e.g. for 25 companies the energy intensity could not be calculated. With the included parameters 27% of the variance in the activity index could be explained. These variables have been found by using an automatic procedure for model selection.[4]

[4] The backward method was used: All 15 variables are entered in the first step and the insignificant variables are removed one by one.

Table 7. Parameters that Can Explain the Variance in the Constructed Energy Efficiency Activity Index (E)

Variable		Coefficient
Company type		
C_1:	Energy intensity (logarithm to energy costs per employee)	0.60
C_2:	Number of employees (logarithm)	0.29
C_3:	Are development and research central activities for the company?	0.13
C_4:	Sector 15: Food industry	0.45
Policy instruments		
P_1:	Energy agreement?	0.82
P_2:	The company does not have an energy agreement, but must the company publish an environmental account?	0.63
Adjusted R^2		27%
N		124

The regression analysis found a constant of 3.14.
C_1 has a range from -2.6 to 0.15. C_2 has a range from 0.3 to 3.7. C_3 has a range from 1 (not at all) to 5 (to a high degree). C_4, P_1 and P_2 are coded as follows: 0 = No, 1 = Yes.

The result of the regression analysis shows the independent influence of the six variables on the activity index: Four variables describing the company type and two variables describing the policy instruments. Other nine variables were not included, since they had no significant impact on the activity index when controlled for the six variables. The excluded variables are five describing company type (e.g. the importance of price, quality and the environment), two sector variables and two policy variables (e.g. if the company also has had an agreement in 1993-95).

With the symbols from Table 7 the results can be shown as the equation:

$$E = 0.60\ C_1 + 0.29\ C_2 + 0.13\ C_3 + 0.45\ C_4 + 0.82\ P_1 + 0.63\ P_2 + 3.14$$

For example, the agreements have an impact on the activity index of +0.82, also when corrected for company type (e.g. energy intensity and sector). The coefficients can be compared with the standard deviation of the activity index, which is 1.0. The range of the energy efficiency activity index is from 0 to 5.

Besides the agreements, the demand for environmental accounts has also had a positive impact on the activity level. Since 1996, more than 1,000 Danish companies have been required to publish an environmental account as a supplement to the economic account. The rules concerning the environmental accounts are a sub-set of the general environmental law which includes the demand for an environmental permit for around 7,000 companies.

Table 8 shows the impact of the two policy instruments on the activity index. The independent importance of the agreements varies from 0.82 (for companies without the demand for an environmental account) to 0.19 (for the rest). It must be remembered that agreements and taxes are related: Companies which have entered an agreement pay a reduced tax. So the positive impact of the agreement exists, although these companies thereby pay a lower tax.

Table 8. The Impact of Agreements (P_1) and Green Accounts (P_2) on the Energy Efficiency Activity Index

Environmental account?	Energy agreement and reduced tax?	
	Yes	No
Yes	0.82	0.63
No	0.82	0

The table only illustrates the impact of P_1 and P_2. For a complete description the impact of the constant and the parameters C_1 - C_4 must be included.

As mentioned earlier, the construction of the energy efficiency activity index is done as a second best solution. When data for the energy consumption and production volume for the first years after the agreement become available, a more direct analysis of the energy impacts can be made.

Discussion: The presented regression analysis indicates that companies with an agreement (but with lower taxes) have a higher level of energy efficiency activities than companies without an agreement (but with full taxes). If activities could be translated directly into the outcome – energy efficiency – agreements would be more efficient than taxes. However, it can be expected that the agreements to a greater extent can promote the abstract aspects of energy management than actual savings. With a full tax many companies would realize energy savings without the abstract concepts of energy management, like key figures and involvement of staff. The main conclusion from the analysis is that a positive impact of the agreements can be found. This is expected to lead to energy savings in the long term. In the short term the outcome is less clear.

2.4 Subsidies – Survey

An evaluation of the realized energy savings has studied 96 large projects randomly selected from the period 1993-97 (Ravn and Sørensen 1998). The average subsidy for these cases has been US $ 26,000 corresponding to 27% of the total investment. Each of the 96 companies with the selected projects has been visited, managers have been interviewed and the installation has been inspected. On average, each visit has lasted four hours. The expected savings have been calculated using information collected for this purpose. When measurements exist (for the individual project or for a production section) this has been used to evaluate the yearly savings.

The ratio between the realized and the expected savings has been calculated. For constant production the realized savings are 90% of the expected savings. When changes in production are taken into consideration, the realized savings are 98% of the expected. These values are weighted averages for 85 cases. 12 cases have been excluded because it was not possible to calculate the realized savings with a reasonable degree of certainty and 9 cases have been excluded because they concerned projects where only the energy source was changed.

About 61% of the interviewed companies would not have executed the projects without the subsidy. About 25% would have executed the projects later (1-4 years) and only 14% would have conducted the project without the subsidies at that time. These are a distinct

difference between these groups. Among projects that would have been realized without the subsidy 64% state that improved reliability is another benefit in addition to energy savings. For the group of projects that would not have been realized without the subsidy only 39% have these other benefits. This indicates that the subsidies especially are helping to promote energy-only projects.

3. Discussion and Conclusion

CO_2 taxes for industry were introduced in 1993 and a comprehensive exemption system was applied to the energy-intensive companies. In 1996, the taxes were increased and the exemption system was replaced by an agreement system, drawing heavily on the experience with the exemption system. The main purpose of the agreement system has been to allow the energy-intensive industry to pay a reduced tax rate, but at the same time to improve energy efficiency in these companies. Regulation of energy consumption in industry was a new area for the authorities and three evaluations have been performed to adjust the system. Strong efforts have been put into the design and enforcement of the agreements.

For the companies with agreements several studies suggest improvements in the order of 2-4% of the total energy consumption per agreement (after three years, i.e. exceeding business as usual by around 1% per year). The three sources (specific projects, special investigation and energy management) each contributes approximately one third of this reduction.

The impression from the case studies is that the major investments resulting in the largest energy efficiency improvements and included in the agreement would have been carried out without an agreement. These projects often have major advantages for the company in relation to production (e.g. increased product quality, more stable production processes and increased production capacity). The projects which would not have been carried out without an agreement or which have been accelerated by the agreement (and subsidies) are often projects which one may call »pure« energy projects, i.e. projects that have little or no other purpose than improving energy efficiency. In this way the agreements can be said to have some effect in putting energy efficiency on the company agenda and in promoting »pure« energy projects in the internal assessment of investment priorities.

The Danish agreement system is not without weaknesses. It is costly to carry out energy audits, and often the results in terms of identified energy saving potentials are modest. The energy accounting systems are often not very refined and in some cases only superficial. In spite of its relatively restrictive nature, the success of the Danish agreement system does – to some extent – depend on a positive dialogue between government and companies. The problem of asymmetric information cannot be solved completely by the use of audit reports and verifications. Detailed information about specialised production processes in industry is possessed by the individual companies, and even the consultants depend on the degree of cooperation of the company staff when they carry out audits. Therefore, government cannot risk demanding that the companies carry out projects without complete support from the company itself. However, this does not mean that the agreements are without any impact. The main advantage in the agreement system is the constant pressure from the government – e.g. in the form of demands for progress reports and renewal of agreements – because this pressure keeps energy as an issue on the company agenda.

A speciality in the Danish agreement system is the existence of taxes that support the

agreement system so that even the companies with an agreement must pay taxes. Also, as the agreement system works as a supplement to the CO_2 tax system, there are built-in economic sanctions in the system and the Danish Energy Agency has now shown that it is willing to use these sanctions if negotiations are not successful.

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