

The CO₂ Scheme for Industry: The Energy Audit

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Introduction

In 1990, the Danish parliament formulated a national CO₂ objective, saying that CO₂ emissions should be reduced by 20% in the year 2005 compared to the level in 1988.

Since 1977, taxes on energy have been used for household, and in 1993 taxes were introduced to industry and amended in 1995 as a part the restructuring of the Danish CO₂ tax system. The legislation that came into force in 1996 introduced different CO₂ tax rates in the industry for heavy and light processes and space heating.

The tax rates are gradually increased from 1996 to 2000. All the revenue raised by the tax will be recycled to the industries through investment grants and gradual reduction in industry labour market contributions.

The programme aims at more efficient use of energy and encourages conversion to more energy-efficient technologies and production methods. A number of energy-intensive industries get a subsidy if they agree to implement energy efficiency measures under agreements with Danish Energy Agency (DEA). Agreements are signed for a period of three years.

The energy audit in agreement-industries must cover all energy used in the industry. All identified energy-saving projects with payback time < 4 years must be implemented. Grants up to 30 percent of the investment may be made for projects with a payback period between 3 and 9 years.

The agreement-industries must also implement an energy management system (which is not described in this paper). The agreement-industries must periodically report to DEA on the implementation of the agreement. Non-agreement industries can get up to 30 percent investment grants for energy-saving projects.

The grants are administered by DEA. In the period from 1996 to 2000 there is around 276 Mio. \$ for energy-saving projects, including energy audits.

The cost of the energy audit varies depending on the size and branch of the industry. The time on site varies from 8 hours to more than 100 hours. The average saving potential found in the energy audits is about 5 percent of the total energy use for all industries having an energy audit.

Currently, 70 energy-auditors are approved and authorised by DEA. About 10 percent of the audit reports are checked.

In this paper the energy audit will be described and the achieved results will be discussed.

General Description of the Scheme

In 1990, the Danish parliament formulated a national CO₂ objective, saying that CO₂ emissions should be reduced by 20% in the year 2005 compared to the level in 1988.

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The legislation that came into force in 1996 introduced different CO₂ tax rates in the industry for heavy and light processes and space heating.

The tax rates are gradually increased from 1996 to 2000 as shown in Table 1. All the revenue raised by the tax will be recycled to the industries through investment grants and gradually reduction in industry labour market contributions.

Energy use ¹	1996	1997	1998	1999	2000
Space heating ²	15.4 (30.8)	15.4 (61.6)	15.4 (92.3)	15.4 (107.7)	15.4 (123.1)
Light processes Without agreement	7.7	9.2	10.8	12.3	13.8
Light processes With agreement	7.7	7.7	7.7	8.9	10.5
Heavy processes Without agreement	0.8	1.5	2.3	3.1	3.8
Heavy processes With agreement	0.5	0.5	0.5	0.5	0.5

Table 1: CO₂ taxes in \$ per ton CO₂

1: On all energy use sulphur tax of 3.1 \$ per kg sulphur must be added

2: On space heating energy tax in parents must be added. The sum equalises the tax paid by household.

As shown it is possible for energy intensive industries get a subsidy if they agree to implement energy efficiency measures under agreements with DEA. Industries with light processes are defined as energy intensive – and obtain this right – only if the yearly tax of the energy consumption amounts to at least 3 percent of their value added.

Participating industries are called the agreement-industries. Thirty-five different processes are defined as heavy processes. The programme covers 61 percent of all energy used in Danish industry, and include processes like melting, burning, condensation and drying in relation to the production of metal, cement, mineral wool, paper, condensed milk, sugar, etc. The heavy processes are listed in the “process list”. The process list is approved by the Danish Parliament, as a part of the CO₂ tax law from 1995.

All industries opting for an agreement have to undertake an energy audit. These audits are supported financially. All other industries are called non-agreement industries.

Program Goals

The programme aims at promoting more efficient use of energy in enterprises by using the increasing pressure from the CO₂ taxes as an instrument. The fact is that the energy cost for the industry very seldom exceeds 1.5 to 3 percent of the turnover. This energy cost is not big enough to lead to special attention from the management.

The programme should encourage conversion to more energy efficient technologies and production methods.

The CO₂-tax Program is targeted to the industrial sector. The scope covers both building and process. It concentrates on the energy use; environmental issues are not included.

Energy Audit Models

DEA has set up requirements for the energy audit. The auditors must follow the requirements. There are very specific requirements for agreement industry and the report must be verified by an independent certified organisation. The agreement industries have six months to make the audit. Non-agreement industries need not have their report verified and the requirements are less specified, especially in the depth of the analysis of the energy used.

The requirements for the audit reports are:

1. description of the industry and its production processes and the previous energy-saving activities;
2. mapping of energy use;
3. analysis and assessment of energy use in different parts of the industry and possible costs and savings achieved by best available technologies;
4. analysis of the energy supply and possibilities to change energy source;
5. description of the energy-saving improvements found in the audit, and the energy savings must be calculated showing investment and payback time.

The Auditors

The auditors are approved and authorised by DEA. There are about 70 authorised auditors. The general requirements to the auditors are:

- able to quickly get an overview of the industry and its processes;
- have technical expertise within one or more relevant areas;
- carry out economic analyses based on the knowledge of the economy of the industry;
- able to motivate the industry to save energy.

The auditors are divided into A- and B-level auditors. Only B-level auditors are allowed to carry out energy audits for the agreement industries. Energy auditors of A- or B-level can carry out the audits for non-agreement industries. There are different detailed requirements for the A- and B-level auditors, concerning the basic education and occupational experience.

The Energy Audit Secretariat at Danish Technological Institute (DTI) is testing the validity of about 10 percent of the audit-reports. If the auditor provides two non-valid reports, he/she will lose audit authorisation. After a period of one year he/she can ask for new authorisation.

Description of the Industry and Its Production Processes

The energy audit must start with description of the industry including the produced product(s), the methods used in the production, and the annual turnover. The description must include everything necessary to get a general view of energy demand and energy use. Agreement-industry must state which part of the energy used in the process mentioned in the "process list." The industry must also describe its previous efforts about energy saving.

Energy use for the last 2 years must be stated to show differences in energy use. Energy use must be split into light- and heavy-processes and space heating. The energy used

for the different types of products must be related to the number of manufactured products in a way that it is possible to show key figures for energy use per unit product made.

The cost of energy must be split into energy price per unit product made and taxes paid. Prices used in the calculation of energy savings and payback time must be clearly stated.

Mapping of Energy Use

The energy use must be split into *process energy*, *secondary energy*, and *space heating*.

The production concerning *process energy* must be divided in single steps of the process and energy used for steps must be mapped. The mapping, if at all possible, must be based on measurements alternative to this can calculation be used. It must be referenced how the results were obtained.

The *secondary energy* (compressed air, ventilation, lighting etc.) must be described and mapped in a way that it is possible to see the amount of energy used for different purposes.

The *space heating* must be described and mapped in a way that it is possible to see which fuel is used, the size of the space, and space type: offices, stores, and production. It must be described if some of the heating demand is recovered from the production and if the working environment, e.g., keeping the room temperature at an acceptable level, demands some of the ventilation.

Analysis of Energy Use

Every essential step of the process must be analyzed separately and a total of 90 percent of the energy used for processes must be accounted for. The energy used for secondary energy and space heating must be analyzed in the same way. The analysis must be divided in process technical and system technical parts.

In the process technical analysis it must be considered if the used process is optimal according to the energy used or can a change of process minimize the energy use? Is it possible to save energy changing to the newest technology available? Can a change in the process management save energy?

The analysis must cover the production flow through the process, e.g., the evaluation from raw materials to the finished products. The changes of pressure, temperature, massflow and other relevant parameters must also be analyzed.

The system technical analysis follows the same guidelines, e.g., is the machinery used for the process optimal? Can a change in type reduce the energy use?

There must be made an energy balance showing energy input, used energy and losses, and finally a diagram showing the flow through the system.

In the analysis, technical expertise should be highlighted and the names and relevant experience of the expert must be documented in the report.

The secondary energy must be analyzed in the same way as mentioned above.

In industries with 3 or more energy flows used for heating and cooling and with an energy use of more than 10 GWh /year, the audit must include an assessment of process integration to show if it is possible to recover heat to be reused in the process or for space heating.

The Energy Supply

The energy supply must be analyzed in the same way as the process and the system energy. It must also be analyzed if it is possible to implement a combined heat and power generation system in the industry. If this is a possibility the system layout and size must be taken into consideration to document the possible energy savings found in the audit.

Energy Savings

After the mapping, the process- and system technical analysis are completed the potential for energy savings must be set up.

The energy savings must be separated in two parts: identified savings which is possible to implement immediately, and savings which must be investigated further during the agreement period. The savings, which must be further investigated, will only take place in the agreement-industries.

The energy savings must be described in both technical and economic terms so that people outside the industry can understand them. The savings, which must be investigated further, must be described so that it is obvious what and how it will be investigated on both technical and economic terms and the saving potential must be estimated.

Agreement-Industries

Heavy process industries are required to undertake all projects with a payback time of less than 4 years. Grants can be offered up to 30 percent of the initial expense for energy-saving projects that have a payback period of more than 3 years. The agreement-companies are obligated periodically to report to DEA on the status of implementation of the agreement.

Non-Agreement Industries

Investment grants up to 30 percent of the initial expense are offered to large industries for energy saving projects that have a payback time of more than 2 years and less than 9 years. To small- and medium-size industries the subsidy goes up to 50 percent. Energy audits are supported following the same guidelines.

EU defines an industry as large when it has more than 250 employees and has an annual turnover at more than 45 Mio. \$. All other industries are small and medium.

Financing

The program is administered by DEA. The subsidies for the investments and audits are not paid out before a full report of the implementation is received from the company. The company must also present an account for the project signed by a certified accountant.

The cost of the audit varies depending on the size and branch of the industry. The time on site varies from 8 hours in small non-agreement industries to more than 100 hours in the agreement industries.

Auditing volumes

Program year	Number of projects	Grants (\$)
1993 ¹	109	272,650
1994 ¹	106	203,900
1995 ¹	60	332,300
1996 ²	161	1,020,450
1997 ²	185	1,024,000
1998 ²	105	745,600
Total	621	3,598,900

Table 2: Auditing volumes by number of projects and grants paid

1: In the years 1993 to 1995 there was no CO₂ tax, but only a small tax on electricity (1.5 cent/ kWh) which could be reimbursed if the industry made a "light", e.g., an energy audit only covering the secondary energy use. It was possible to get 30% grant for the audit.

2: In the years 1996 to 1998 is 250 of the audits in agreements industries.

Results

The average found saving potential is about 5 percent of the total energy use. About 50 percent of the opportunities have been implemented in non-agreement industries. In agreement-industries must all the savings be implemented as a part of the agreement.

In non-agreements industries the saving potential mostly was found in the secondary energy use and was around 10 to 15 percent of the energy used for this purposes. The savings represented only 2 to 3 percent of the total energy use.

In agreement-industries the saving potential was around 3 to 6 percent of the total energy use and was found in the heavy processes. In the first two years with possibility of agreement the estimated CO₂ reduction was as shown in Table 3 below.

	1996	1997	Total*
Concrete saving projects	0.9%	1.9%	1.2%
Further investigations	0.7%	1.1%	0.8%
Energy management	0.6%	1.1%	0.8%
Total after 3 years agreement	2.2%	4.1%	2.7%

Table 3: Estimation of CO₂ reduction

Source: Michael Togeby et al. 1999 ACEEE Summer Study

***Estimated for the period from first agreement to 2005. E.g. the industries must enter three agreement periods if this result should be reached.**

All agreement-industry from 1996 has stated that they want to enter new agreement in 1999

Discussion

Some 12 agreements industries have participated in a case study (Michael Togeby et al., 1999 ACEEE Summer Study). The case studies describe qualitative aspects of the agreements--especially in relation to energy management. The case study also deals with the energy audit.

The energy audit is the basic tool to find energy saving projects, which must be implemented during the agreement period. Therefore, it is essential that the energy audit be of high quality. In general, the companies are satisfied that the energy audits give a good description of energy consumption and the energy consuming processes.

However, it is also recognised 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 specific knowledge about the specific processes. Therefore, the consultants are very dependent on the co-operation with the company staff. The evaluations show that the companies find that the energy audits sum up existing knowledge rather than help identify new potentials for energy savings. In spite of this, most companies find that the agreements have an effect because it puts energy efficiency on the company agenda.

The audit helps to map the energy consumption and to specify the profitability of investments. The companies value the audits as a useful tool towards improved energy efficiency.

The concept of further investigations is an opportunity to investigate projects more thoroughly. In general, the companies are also satisfied with the further investigations, especially in relation to complicated or uncertain projects. According to the evaluation the further investigations open up for new knowledge and thereby projects, which would otherwise not have been carried through. Against this background, the Danish Energy Agency values that the energy saving potential by the use of this instrument (further investigation) is not yet fully reached.

The energy audits in non-agreements industries, is not evaluated in the same way as the agreements industries, but because it is done voluntarily it must be assumed that the effect is about the same.

The Future

The grants of 276 Mio. \$ will end in the middle of year 2000, if the Danish Parliament don't decide to spend more money on this issue. The future of energy savings in the Danish industries is then depending of willingness of the management to spend money in energy savings. With no grants, of 30 percent, the payback time will raise and maybe exceed the payback time set by the management. This will specially effect non-agreement industries.

The possibility of joining an agreement with DEA will still exist for the heavy processes industries. The evaluation of the agreement system shows that the administrative costs of entering into an agreement are 10 and 20 percent of the tax reimbursement. This is mainly due to the energy audit and the verification.

DEA is considering a change in the demand for agreements to make it cheaper. The change will reduce the demand for energy audit in a way that the audit will stop with a very careful energy mapping, and without demand for verification. As a new part of the agreement there will be a demand for special investigation of the single step in the heavy process. Finally

the implementation of energy management must be described a lot more specific than before. The energy management report must be verified.

The above-explained changes are under consideration, but it will surely end up with something like that.