Too Expensive Energy Savings?

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1. SYNOPSIS

Why the Danish heating-audit scheme is an inefficient means to achieve energy savings and how it could be improved.

2. ABSTRACT

This paper presents an evaluation of the Danish heating-audit scheme (HA scheme).

The scheme was established in connection with a subsidy scheme to promote energy savings in private households in the period 1978 to 1980. Today, about 5.000 audits are carried out per year.

Under the HA scheme, heating consultants carry out heating audits, and recommended measures, based on a cost-effectiveness criteria of a payback period of approximately 10 years, are listed in a report. On average, each audit has resulted in approximately three recommendations per house. Most of the recommendations concern better insulation and change to thermostatically controlled valves for radiators. The recommendations represent a total estimated saving of 20% of heating energy.

Three years after the heating audit, 25% of the total number of proposed projects has been fully carried out and 8% partly carried out resulting in energy savings of 6% of heating energy of the 5,000 households. However, the results from the survey indicate that some of the improvements would have been carried out anyway, also if there had been no heating audit. The economic value in general is low, especially from a socioeconomic perspective because the real cost of heating (production cost excluding taxes, but including social costs) is only about half the price paid by the private households.

Making the scheme simpler and including only houses with large potentials for energy savings would better the economy of the scheme considerably.

3. HEATING-AUDIT BACKGROUND

The HA scheme was established in connection with a subsidy scheme to promote energy savings in private households in the period 1978 to 1980. It was intended to ensure proper use of the subsidy. Subsidies were also granted from 1981 to 1984 but in smaller proportions. The HA scheme in operation today is very similar to the one from the beginning of the 1980s.

The principal law governing the HA scheme is the Heating-Audit Act from 1984. This law requires that a report from the heating audit is available for the new owner whenever a house built before 1979 is sold. The current owner pays for the heating audit. The object of the scheme is

> "to reduce energy consumption for space heating and production of hot water in buildings constructed before 1 February 1979,1 ..." (Boligministeriets lovbekendtgørelse no. 342, June 20 1984).

The purpose of the heating audit is to help bring existing (old) buildings up to the energy standard required in the 1977 Building Code, taking into account the technical options and economic considerations. Heating consultants are appointed by the Danish Energy Agency.

Old houses that met the standards could be endorsed with a certificate. To achieve this certificate only investments with a payback period of less than approximately 10 years needed to be carried out. In the report from the heating audit all proposals are noted and investments which needed to be carried out in order to achieve the certificate are specified. However, only a few recipients made use of the possibility to achieve the certificate. The certificate is not required by law.

In the 1980s, subsidies in connection with the HA scheme totalled ECU 300 million2. The subsidy scheme required that a heating-audit report recommended an investment in order to get the investment subsidized. The subsidy scheme had a substantial influence on the level of activity in the HA scheme. The number of heating audits reached its peak at about 140.000 in 1984. Since 1985 there has been no subsidies in connection with the HA scheme. Today, about 5.000 audits a year are carried out by approximately 500 heating consultants. Most of these audits are carried out because it is statutory. Only 5% is motivated by other things such as information on potentials for energy savings.

By the end of the subsidy period (1978-1984), just under 30% of old single-family houses had had a heating audit. By 1 March 1993 the figure had risen to 32%.

4. RESEARCH QUESTIONS, METHOD AND DATA

The main questions to be answered with respect to the HA scheme are:
(1) Are the recommended measures or adjustments carried out?
(2) How much heat and fuel are saved?
(3) What is the present value of the measures carried out?

The question of which energy-saving measures are carried out on the basis of the heating audit has been answered by means of 225 telephone interviews of home owners who had a heating audit carried out in 1990. In that year, about 5.000 heating audits were performed.

By focusing on the three questions mentioned above the schemes have been evaluated in relation to their primary objective. We have not taken side effects into account. For example, a heating audit could result in a better indoor climate: less draughts. With a little luck, a heating consultant may also be able to indicate problems like dry rot, which will often be of much greater interest to the home owner than a modest energy saving.

5. PROPOSED AND IMPLEMENTED PROJECTS

The heating audit is conducted in accordance with a ten point »positive list« relating to insulation:

(1) Roof/ceiling, (2) Floor, (3) Outer walls, (4) Weather strips, (5) Windows and doors

and the functionality of the technical heating system:

(6) Heat production, (7) Heat distribution, (8) Automatic controls, (9) Regulation of heating system and (10) Ventilation

The main point regarding insulation is to check whether it is properly insulated according to the standards of the 1977 Building Code. The main points regarding the technical heating system are thermostatic valves to the radiators, replacement of ineffective water heaters, insulation of pipes and maintenance and replacement of ineffective boilers and oil burners. In some cases, conversion from oil-based systems to district heating is included in the proposals.

In 1990 3,1 proposals for improvements were made per heating audit, this corresponds to 15.420 proposals for the 5.000 heating audits in 1990. Three years later, 25% of the total number of proposed projects has been carried out, 8% has been partially carried out, and 47% has been rejected. Lastly, there is 19% whose fate is unknown3.

***Table 1.** Percentage of Implementation for Proposed Projects in 1990*

Positive list	Proposals per heating audit	Degree of implementation			
		Fully	Partly	Unsure	Rejected
		Per cent			
(1) Roof/ceiling	0,66	22	7	23	49
(2) Floor	0,10	27	4	12	58
(3) Outer walls	0,22	14	5	25	55
(4) Weather strips	0,45	27	7	21	45
(5) Windows, doors	0,47	28	20	15	37
(6) Heat production	0,22	25	7	16	51
(7) Heat distribution	0,28	10	8	24	58
(8) Automatic control	0,50	42	5	13	40
(9) Regulation of heating system	0,05	17	0	33	50
(10) Ventilation	0,10	13	4	29	54
(11) Other	0,02	40	0	0	60
All projects	3,07	25	8	19	47

The percentage of implementation is highest for projects requiring only a small investment, for example, changing to automatic controls, mainly in the form of thermostatic valves, where 42% of the proposed projects has been fully carried out and 5% has been carried out partially. Better ventilation is often required when the house is better insulated, this does not produce much energy savings. Only 13% of the proposed projects concerning ventilation has been carried out three years later.

The effect of the HA scheme is the observed activity compared to the estimated activity had there been no HA scheme. There could be some doubt whether it is the heating audit that is the reason for the energy- saving projects implemented. We asked the 225 property owners whether the implemented projects would have been carried out anyway. This is a difficult question for the respondents to answer because it requires the respondents to speculate about what their actions would have been. However, 79% of the respondents answered that the projects would have been carried out anyway.

It would be more satisfactory to compare the number of energy-saving projects in houses with and without heating audits. Birch & Krogboe (1986) compared 73 houses with heating audits with 29 houses without heating audits. In these two groups the same proportion had carried out energy-saving projects, but in the houses without heating audits the investment was three fold the investment of the houses with heating audit. This surprising finding indicates that the heating audit does not lead to more investments in energy saving. Teknologisk Institut (1989) compared 101 houses with heating audits with 88 houses without heating audits and concluded that houses with heating audits are in better condition regarding energy saving, automatic controls and insulation. But although the houses were chosen randomly it showed that households in houses with heating audits were more concerned with energy savings than the other group.

Because of the uncertainty as to whether the projects could be attributed to the heating audit we have assumed that half the respondents tells the truth when they say that the project would have been carried out anyway. This corresponds to 40% of free-riders. In the following this is called the AKF-assumption (referring to the name of the organisation carrying out the evaluation). However--as shown later--the economy in the HA schemes is not much affected by this assumption because many of the projects carried out cost more than can be saved. On the other hand, this assumption is critical to the effect of the HA schemes on savings and emissions.

5.1. Energy Savings

The heating audits in 1990 led to an approximately 6% reduction of energy consumption4 of the 5,000 properties. When only the savings attributed to the heating audit are counted (the AKF assumption), the savings come down to 4%. Table 2 shows how these savings are distributed among the proposals.

Positive list	Proposed savings per audit	Realized savings	The AKF assumption
	GJ	Per cent	
(1) Roof/ceiling	7,3	36	23
(2) Floor	1,0	20	10
(3) Outer walls	3,5	17	11
(4) Weather strips	1,1	27	18
(5) Windows, doors	2,2	55	32
(6) Heat production	0,9	56	33
(7) Heat distribution	0,5	20	0
(8) Automatic control	3,4	50	29
(9) Regulation of heating system	0,1		
(10) Ventilation	0,0		
(11) Other	0,0		
All projects	20,2	36	23

In total the proposed investments represent 20 GJ in energy savings per audit, this corresponds to approximately 20% of the total energy consumption of room and water heating. The main points are "Roof/ceiling", "Outer walls", "Windows, doors" and "Automatic control" which together represent 80% of the total proposed energy-saving investments. In addition, these categories have a higher rate of implementation than the rest of the proposals.

6. ECONOMY OF THE AUDITS

The private economy perspective shows the economic result of the heating audit to the private households. The economic result for the private households include payment to the heating audit, cost of energy-saving investments and benefits from the reduced energy bill, all inclusive VAT and other taxes on energy. The private economy perspective illuminates the private households economic incentives to have a heating audit of their own free will.

The socioeconomic perspective shows the effects of the HA scheme to the society as a whole, calculated in monetary terms. This excludes VAT and other taxes on energy, but includes socioeconomic benefit from reduced emission related to energy consumption. The net benefit from the socioeconomic perspective should be the criteria when deciding whether to keep the HA scheme or to change it into a more efficient direction if possible.

Both a socioeconomic and a private economic present value of the heating audits in 1990 have been calculated. The principal assumptions used in the analyses are shown in table 3.

	Time horizon (Year)	Average heating price (ECU/GJ)	Of this, valuation of externality (ECU/GJ)	Discount rate (%)
Private economy	5 and 10	13,9[1]	-	3,5
Socioeconomy	30	8,2	1,7	7/0[2]

1 Corresponding to ECU 17,5/GJ, incl. VAT (25%)

2 7% for real costs, 0% for external effects (ECU 1,7/GJ). Besides, the assumptions shown in the table, the price and tax increases used in energy planning in Denmark have been used (see table 4).

The discount rate for the private economy corresponds to an interest rate of 7%, an inflation rate of 0% and a tax on interest of 50%. In the socioeconomic calculations we have used 7%. This approximately corresponds to the interest rate at the time in 1993 when the evaluation was made. However, the interest rate was falling at that time, so calculations were also made with 5% discount rate to show the robustness of the results.

Further comments on the assumptions will be given in the discussion section later in the paper.

6.1. Private Economy

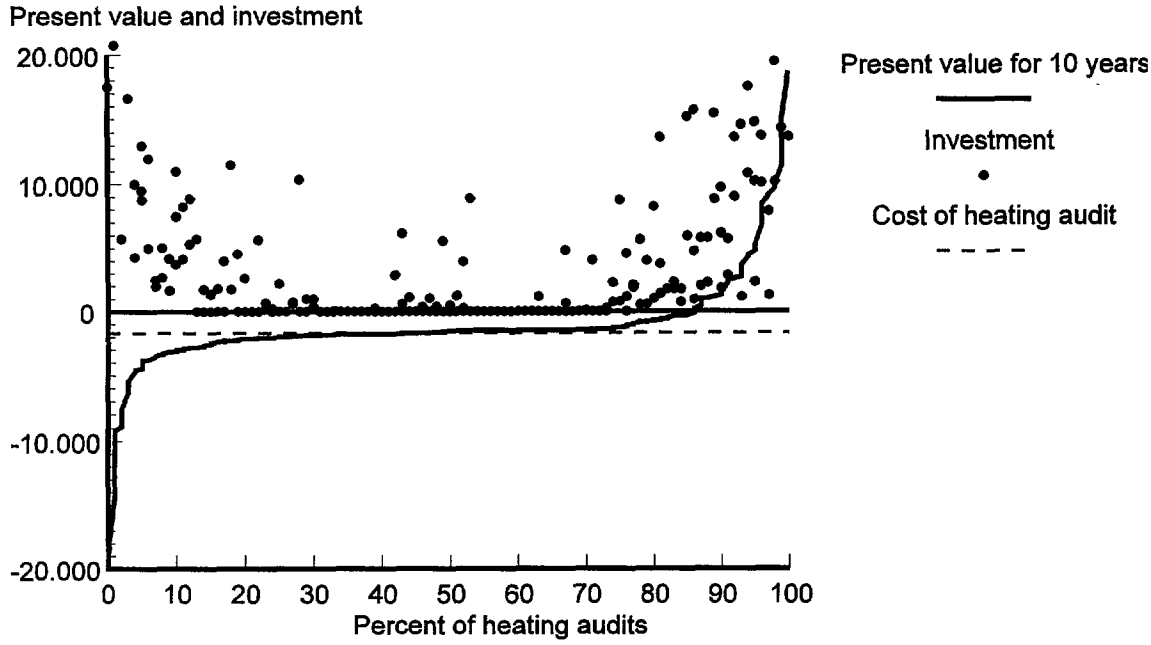
In the private economic calculations, actual observed marginal energy prices for the households have been used. The future energy prices have been calculated by adding expected rises in energy taxes and factor prices to the observed prices.

Heating source	1991	2000	2020
	ECU per GJ		
Electric heating	33,4	36,4	37,7
Oil boiler	15,7	16,9	20,6
Gas fired boiler	14,9	15,7	18,6
District heating	18,8	19,7	22,6
Co-generated heating	16,1	17,4	17,7

All heating costs are in the region of 14,9 to 18,8 ECU5/GJ in 19916, only direct electricity heating is more costly. Partly because of the high tax on electricity to private households in Denmark the heating price in electricity-based systems is approximately two fold that of the other heating systems7.

Seen from a home owner's point of view, the average present value of the investments that can be attributed to the heating audit is a gain of 110 ECU per audit, working with a time horizon of 10 years. If a horizon of 5 years is used instead the result is a loss of 181 ECU per audit. From this, we must subtract the cost of the heating audit, which averaged 220 ECU per audit inclusive VAT. All in all, this results in a loss of 110 ECU per audit with a 10-year horizon and a loss of 400 ECU with a 5-year horizon.

Figure 1 illustrates the general problem of the HA scheme seen from a private economic point of view. The figure shows the present value of the investments carried out and the total investment. The audits have been ordered according to the size of the present value.



The AKF-assumption (40% free-riders) is used here

To the left, there is a lot of expensive investments where the cost of the investment is not balanced with the gain of the energy savings, not even if the cost of the heating audit--approximately 220 ECU--is excluded. In the middle there is a lot of households (about half of all households) where no projects have been carried out, therefore the cost equals the cost of the heating audit. To the right, there is a few households where more than the costs of both the investment and the heating audit are payed by energy savings.

Why do the households carry out investments when the gain in energy savings far from balances the cost of the investment? It cannot be because they do not know; the report from the heating audit clearly points out which investments are favourable private investments. Either it could be because these households impose a longer time horizon, since some of the investments in fact last longer than ten years. Or it could be because the households ascribe more value than the pure economic value of the energy savings. The households could for instance ascribe a value to helping improve the environment or to improve the indoor climate. These proposals indicate that there might be substantial positive side-effects to the HA scheme--perhaps even bigger than the real economic effects (the energy savings).

Graphic analysis on the conditional dependence in the data showed that one of the main factors in determining the level of energy savings as well as the number of recommendations was the level of the energy consumption of the house. Unfortunately this is not an operational measure when implementing the scheme, simply because no data exist on energy consumption on each house in Denmark. However, it showed that the energy consumption is strongly correlated with the age of the building. Therefore, it is interesting to investigate the effects of the scheme in relation to the age of the building.

Table 5 shows a big difference in the economy of the HA scheme regarding the age of the building. The economic result is best in old buildings. However, there is no simple relation between the construction year and the benefit from the heating audit. For example, with a 10-year horizon there is an economic profit (positive net-present value) from heating audits of houses built between 1900 and 1940 of approximately 40 ECU, while there is an economic loss (present value of -145 to -240 ECU) for the youngest houses. This is because the relatively new houses are in good condition regarding energy consumption. More surprisingly, there is also an economic loss of approximately 180 ECU for the oldest houses, constructed before 1900.

	Construction year for the house					All
	Before 1900	1900-1939	1940-1959	1960-1969	After 1969	
	ECU per audit					
Present value for 10 years	-178	38	-150	-145	-240	-111

In the long term, the HA scheme is meant to cover all buildings. This means that the relevant potential for heating audits is the total number of houses not already covered. Unfortunately, the segment with the greatest potential only covers 26% of the total number of houses built in Denmark before 1979. Add to this that approximately one third of the total number of houses in Denmark has already had a heating audit. Assuming that these audits are randomly distributed this leaves 17% of the total number of houses where energy savings with good economy can be expected.

6.2. Socioeconomy

With the assumptions listed in Table 3, the 5.000 heating audits in 1990 produced a total socioeconomic loss of 1,2 million ECU, corresponding to a loss of about 240 ECU per audit. These figures include a valuation of external effects at 1,7 ECU per GJ (1,4 ECU per GJ constitute the valuation of CO2). No valuation of other side effects (such as improved indoor climate) are included.

As will be seen from Table 6, the socioeconomic profitability differs considerably by heating system.

ECU	Electric heating	Oil-fired boiler	Gas-fired boiler	Co-generated heat. prod.	District heating	Average
Present value per heating audit	-134	-154	-308	-402	-549	-241

Note: Also here the AKF assumption has been used.

The socioeconomic loss is greatest with district heating and co-generated heating. The reason why the loss is greater with district heating than with co-generated heating is that the home owners in the former made considerably greater investments. Similarly, the reason for the relatively favourable result for households with direct electric heating is that these house owners made relatively few investments, and the relatively high social cost of electricity production. However, the high price on electricity could also mean that houses with electricity-based heating are already better insulated before the heating audit, because the electricity price has been high for a long time. It has been shown, too, that houses with electricity-based heating are relatively new houses and therefore in better condition regarding energy consumption.

Also, in the socioeconomic case, the economy is best for buildings built between 1900 and 1940; the present value equals -157 ECU per heating audit. Combining construction year and heating system further reduces the social cost of the scheme. Heating audits conducted in oil-fired houses built in the period 1900 to 1940 have an average social cost of ECU -33 per audit.

Limiting the scheme to the segments with economic gain would considerably better the economy of the overall scheme and because of the relatively low energy savings in segments with economic loss this would not lower the reductions on emissions dramatically.

The perception of socioeconomy here is largely the same as that generally used in energy planning, apart from the fact that we have interpreted the Danish Parliament's decision of principle concerning a CO2 tax of 13.4 ECU/ton as the socioeconomic cost of CO2 emission.

The employment created through the scheme is neglected in the analysis. The fact that heating audits are, by their very nature, labour intensive leads to some under-estimation of the profitability of the heating-audit scheme.

7. IMPLEMENTATION OF THE HEATING-AUDIT SCHEME

Within the law, there is no sanction if there is no heating audit when the house is sold. This means that the implementation of the HA scheme must rely on the incentives to have a heating audit conducted voluntarily. It is in fact the new owner who is in the position to demand a heating audit.

The number of sales of homes with heating audit is falling. In 1992 it was 42,5% for single-family houses. There are geographical differences in the proportion of heating audits in connection with sale of real property. In the Copenhagen region, about 60% of all sales of property is lawful from the Heating Audit Act point of view. In other parts of the country this is only the case for about 30% of the sales.

During the interviews, the property owners were asked whether they had benefited from the heating audit: 51% answered yes, while 42% said that they had not benefited from the audit. When we then asked those who had benefited why this was the case, most replied that it was useful to have information about a house one was thinking of buying. Feeling safe about buying a house thus takes priority over the main objective of the scheme: energy savings.

Apart from supplying the heating-audit report, the consultant is not required to inform or guide the house owner. Even if this was the case, it would probably not have much effect on energy savings. Most audits are carried out because of house sales and are organized by the owner or the estate agent. Any information not included in the heating-audit report would be lost when the new owner moves in.

8. DISCUSSION

8.1. Side Effects

In the evaluation of the HA scheme only the benefits relating directly to the purpose of the scheme are included. There might be other effects which could make the scheme more favourable. In section 5 improved indoor climate is mentioned as a possible explanation of why apparently unprofitable investments were carried out. As mentioned above 51% answered that they had benefited from the heating audit. Of these, 25% ascribes the benefit to improved indoor climate.

Also the heating audit itself might have effects other than pointing out profitable energy-saving investments. The interviews showed that many of the households took the heating audit as a neutral evaluation of the house giving valuable information. This adds a value in itself to the HA scheme, but because this was not the intention with the scheme this value is not included in the economic analyses.

8.2. Discount Rates

The discount rates used in the analyses correspond relatively close to the observed market rate of interest. From a household perspective the calculations are relatively insensitive to the discount rate because of the short time horizon.

There is a lot of discussion regarding environmental effects in socioeconomic analyses. As noted by Cline (1992) and Pearce (1992), the combination of a long-time horizon and a discount rate of 5-10% means that all that happens after 20 years is disregarded. This would not mean anything if the environmental effect is short in time, but especially regarding CO2, where the effect is accumulating and the large effect comes many years later this is clearly problematic. Therefore, the calculations in the socioeconomic case are based on two different discount rates, the market rate for the real economic effects and zero for the environmental effects.

8.3. Time Horizon

From a household perspective a 5-10 year time horizon is used, although some of the investments have a technical lifetime of 15-30 years. However, the major part of the investments carried out is small investments like thermostatic valves which only live ten years or less. Add to this that the relevant economic lifetime is shorter than the technical

lifetime and that private households often have a relatively short time horizon when deciding on investments. All in all, we find that 10 years are an upper limit of a realistic time horizon in the private economic case.

Regarding the time horizon in the socioeconomic case this time horizon seems too short when the effect of CO2 comes many years later. However, this is more a problem of finding the right cost of CO2 emissions including the damage in the years to come.

8.4. Employment

Unemployment is a problem in all EU countries. The HA scheme is relatively labour intensive. Therefore, one could argue that the effect on employment should be considered a benefit from the scheme. This could be done by setting a lower price on the labour force. This, however, rises a lot of questions, for instance: would people who get work have been unemployed if there had not been a HA scheme?

In Denmark, it is a fact that a lot of public money is used to subsidize renovation and maintenance of houses for employment reasons. This could be an argument for including employment effects or using a lower price on the cost of labour force. (This would translate into a lower audit cost and a lower cost of the labour- intensive investments).

8.5. Value on the Environment

Only SO2, NOx and CO2 are taken into consideration in this analysis. With the present technology SO2 and NOx can be avoided. Therefore, the value of reductions in these emissions equates the cost of cleaning8. The environmental cost of CO2 emissions is more difficult to monetize.

The socioeconomic value of the HA scheme relies heavily on the monetarizing of the environmental cost from CO2. However, the monetizing of the effects of CO2 is very uncertain; a Risø (1994) study gives a result of 2 to 84 ECU/ton CO2 and cites other results from 8 to 12 ECU/ton CO2.

In Denmark, the parliament has agreed on a tax on CO2 of 13,4 ECU/ton CO2. This value has been used as the social cost of CO2 emissions in this analysis. Another related measure would be the alternative cost of reduction in CO2 by other means. The Danish Government intends to reduce the CO2 emission by a certain amount. If this intention is followed the alternative cost would be the relevant value of CO2 emission reduction for the Danish society, because CO2 emission reductions from the HA scheme would free the society from making other (more expensive) schemes to secure reductions in CO2 emissions.

9. CONCLUSIONS

The economic analyses have shown that the savings from the HA scheme are relatively expensive. However, there seems to be valuable side-effects to the scheme. For instance, some households take the heating audit as a guarantee of the quality of the house, a service they might be willing to pay for even at a market basis. There also seems to be side-effects in the form of better indoor climate and positive effects on employment from the scheme. However, it remains to be seen if these effects could be achieved more efficiently in another scheme or in a revised HA scheme.

Although these are positive side-effects of the scheme it does not bring any energy savings, and it might be discussed whether these effects should be included in the socioeconomic analyses. If so, it might improve the economy of the scheme considerably.

There are several possibilities to improve the economy of the scheme. Including only the most important measures (insulation and automatic controls) from the positive list in the audit would lower the cost of the heating audits without affecting the effect on energy savings considerably. Further, it would be more efficient to limit the audits to buildings with large potentials of energy savings, for instance oil-fired buildings built in the period 1900 to 1940 and exclude buildings with low social heating costs, e.g. district heating.

Lastly, it is a problem that the scheme in the implementation is pointing directly to the characteristics of the house rather than energy savings and information on how to save energy. It would be more appropriate if the new owner was present during the audit. In general, this is not the case under the present implementation.

10. ENDNOTES

1 The reason why this date is mentioned is that buildings constructed thereafter must meet the requirements of the 1977 Building Code.

2 This includes both subsidies for the heating audit and subsidies for the energy-saving investments.

3 Unknown means that the households have not carried out the project after three years, but asked why, they answer that they will carry out the project later.

4 Energy savings were calculated by the consultants in connection with the audit and are not measured in the survey.

5 1 ECU approximately equals 7,4651 DKK (5.12.1994).

6 The reason why 1991 prices on energy are used when the heating audits were made in 1990 is that it takes time before the energy-saving investments are carried out and therefore most of the savings will come no earlier than 1991.

7 Also without taxes electricity-based heating is more expensive than oil-based heating, but the high tax on electricity makes the difference relatively high.

8 This requires a situation with "optimal" reduction in emissions. Because these technologies remove SO2 and NOx almost completely this cost most likely overestimates the true value. However, this is the best available measure for the social cost of SO2 and NOx.

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