THE DANISH ENERGY-CONSERVATION PROGRAM IN BUILDINGS

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ABSTRACT

The present paper gives a view of the Danish actions to save energy in buildings, in particular existing buildings and in particular in relation to space heating.

Since 1975 Denmark has implemented several energy conservation programmes. The paper gives a review of Danish grant legislation to buildings and is mainly focused on "Act on Reduction of Energy consumption in buildings", which is the most important instrument employed in the efforts to reduce energy consumption. Where conditions permit, the act aims at bringing existing buildings up to the standards applying to new buildings.

The grant scheme will continue until the end of 1984, and after 1. January 1985 a requirement to documentation of the energy condition of a building in the even of sale will come into force.

As far as public buildings are conserned, the act calls for efforts to be made to complete the necessary work to bring these into reasonable energy condition before the end of 1989.

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PREFACE

Since 1975 Denmark has implemented several energy economy programmes. These programmes concern mainly existing buildings, but must also be seen in relation to the Danish Building Regulations, which contain requirements to new buildings.

In this review, attention will mainly be focused on existing buildings. The "Act on Reduction of Energy Consumption in Buildings", which entered into force on 19 June 1981, is the most important instrument employed in the efforts to reduce energy consumption. Where conditions permit, the Act aims at bringing existing buildings up to the standards applying to new buildings.

It can be mentioned in passing that in connection with the exploitation of renewable energy recources, an Act was passed in 1979, providing for government grants for the installation of plant for the exploitation of solar energy, wind energy, terrestrial heat, biogas, straw, and similar energy resources. This scheme, with various adjustments, is still in force, under the Ministry of Energy.

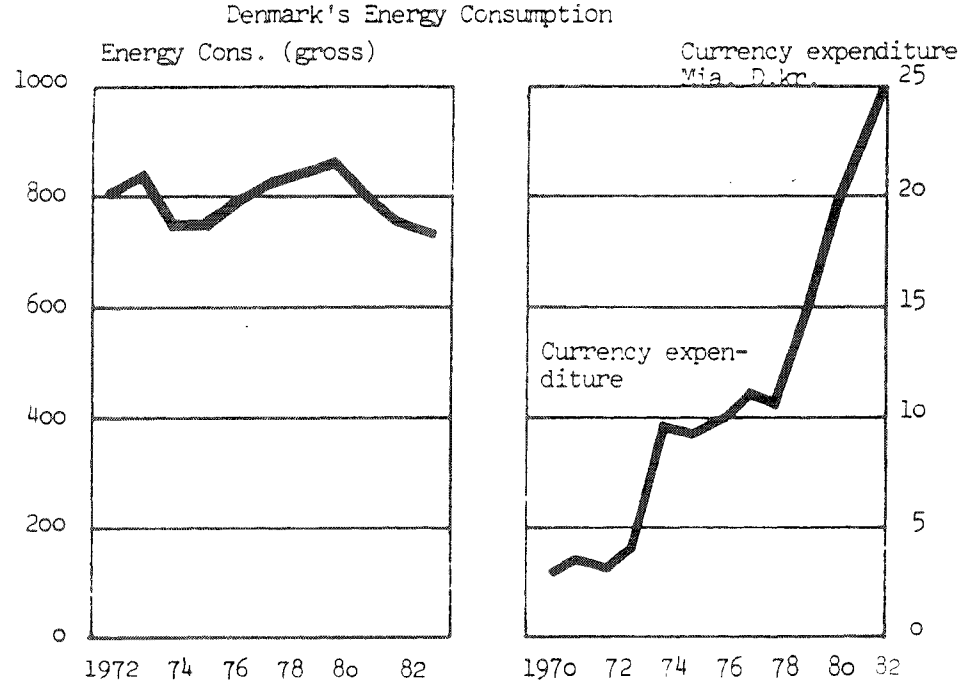


Figure 1. Development of net currency expenditure on energy imports 1970-80.

As will be seen from the figure, Denmark's net currency expenditure on energy imports has increased heavily 6-7 times more than in the years 1970-72 - to Dkr. 25,800 million in 1982. Generally rising import prices and the higher rate of the American dollar are the main reasons for the increase, and these tendencies mean that energy costs constitute an ever-increasing share of total expenditure for both consumers and industry. 1 Dkr. = US$ 0,10.

There is undoubtedly a tremendous potential for economies, and great savings have, in fact, already been achieved in existing buildings. It is difficult, however, to determine whether the savings have been due to the implementation of energy-conserving measures, a reduced level of comfort, or a change of attitude among the consumers. They are, in fact, presumably due to a combination of all three factors.

The efforts to economize on energy in Denmark have been - and still are - based mainly on a combination of voluntary grant programmes, compulsory control schemes and the Government's price and energy policy, which incorporates various levies on oil, petrol, electricity, etc. In addition, several institutions and organizations, for example the Danish Energy Conservation Committee under the Ministry of Energy, with partial or total financial cover by the State, support energy-saving activities in Denmark, and private industry and verious trade organizations have taken important steps to economize on energy.

The results achieved so far in the energy sector in Denmark have produced not only considerably energy savings, but also an improvement of the housing concerned.

However, it is essential to bear in mind that it is not enough for energy-saving measures to be carried out correctly from a technological point of view; the householder must also be informed of changes in the indoor climate that may result from the measures taken.

ENERGY POLICY

Introduction

The energy crisis in 1973-74 made it clear that Denmark would have to plan its energy supply and energy distribution in order to ensure a continuing supply of energy and to limit as far as possible the effects of the heavy price increases. The need for national energy planning was underlined by Denmark's heavy dependence on imported oil products.

As a consequence of this, the Ministry of Commerce drew up an energy plan for Denmark in 1976: Danish Energy policy 1976 (DE-76)

The principal aims of DE-76 up to 1995 were as follows:

- to reduce Denmark's vulnerability and dependence on oil by:

(1) slowing down the growth of energy consumption

(2) building up emergency stocks

(3) building up a multiple energy supply system

(4) coordinating and intensifying energy-oriented research and development.

These aims were to be met by means of a series of initiatives, including:

- consumer economies, mainly on room heating
- stricter requirements to new buildings
- heat planning
- utilization of surplus heat from the power stations
- introduction of natural gas
- exploitation of renewable energy resources.

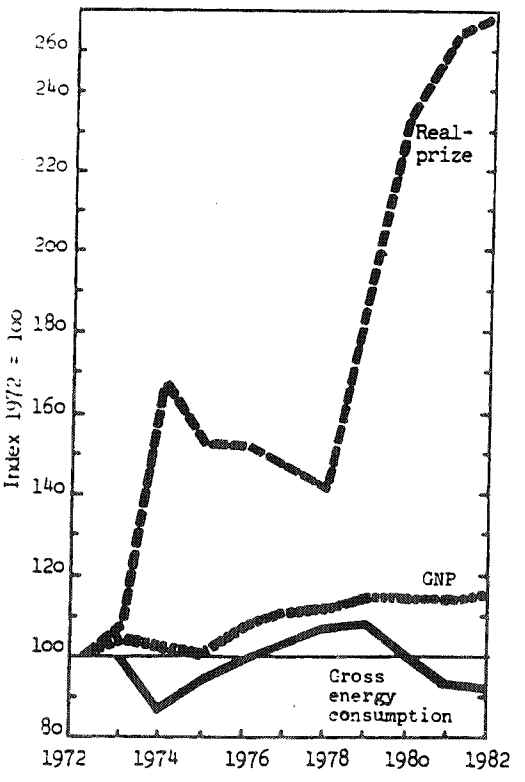
Of these components of the overall energy plan, only room heating are dealt with in this review.

EP-81. Although the gross energy consumption for room heating transport, electricity and manufacturing processes was 9 percent lower in 1982 than in 1972, the real price of energy rose by about 160 per cent from 1972 to 1982. This reflects one of the factors that has affected the economic development in Denmark since 1970s, in which period the Danish balance of payments has shown a large deficit (figure 2).

Whereas Denmark's gross energy consumption (fuel consumption) for room heating and hot water amounted to 40 per cent of the total energy consumption in 1972, by 1982 this share had fallen to about 31 per cent.

In the period 1972-82 the gross energy consumption for room heating and hot water in houses, institutions, service and trade, etc. (excluding heating of production building in industry and agriculture) was reduced by about 27 per cent. As the heated area increased in the same period by about 23 per cent, the consumption per square metre was actually reduced by about 40 per cent.

The latest figures of gross energy consumption show, that consumption for room heating are continuing the decreasing trend. The gross energy consumption for room heating fell 4 per cent from 1982 to 1983.



Source: Energy Plan 1981

Figure 2. Development of gross energy consumption 1972-80, compared with the development of the weighted energy price and the Gross National Product.

These savings have been achieved by:

- investments in energy-conserving measures
- improved operation of heating plant
- stricter requirements to insulation in new buildings
- changes in behaviour of consumers.

Many consumers have tried to reduce their energy consumption by:

- maintaining lower room temperatures
- heating fewer rooms

- lowering the temperature outside actual "using time"

- reducing consumption of hot water

- showing a general energy-awareness in daily life.

In addition, considerable investments have been made in energy-conserving measures. It is estimated that such investments amounted to about Dkr. 5,000 million in the period 1975-80. The measures involved:

- additional insulation of floors, walls and roofs

- establishment of double-glazing etc.

- tightening joints in outside walls

- replacement of supply plant

- automatic regulation of heating plant

- adjustment of heating plant.

The very heavy increases in the prices of oil products in 1973-74 and again in 1979-80 have, in themselves, provided sufficient motivation to invest in energy-saving measures, but as mentioned, since 1975 the consumers have also had the incentive of various schemes for government grants towards energy-saving measures in homes and, to a more limited extent, in industrial buildings.

Finally, the overall efficiency of heating systems has been improved since 1972, with an increase in the ratio between net and gross heat consumption from 0,62 in 1972 to 0,71 in 1982. Apart from the general incentive provided by increasing energy prices, this has been due partly to technological advances, resulting in an improvement of new installations, and partly to the introduction on 1 October 1978 of compulsory control of oil-fired heating plant.

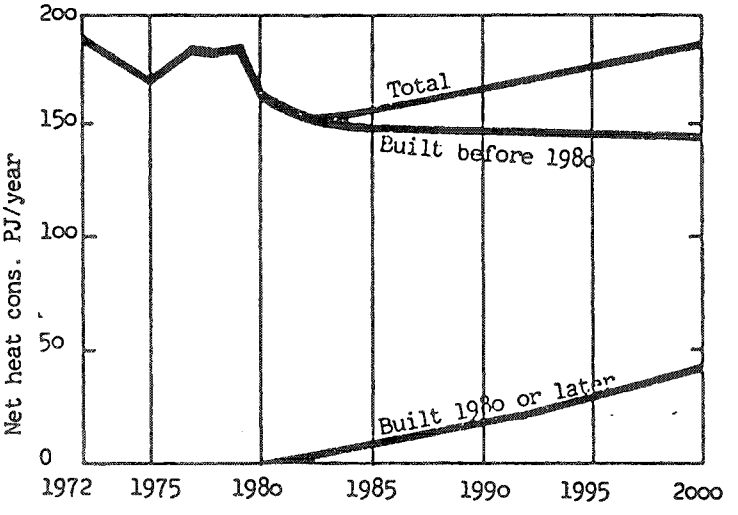
Whereas the above factors mainly concern existing buildings, the stricter requirements to insulation contained in the Building Regulations 1977 (revised version BR 82) have resulted in a substantial reduction of energy consumption in new buildings. The provisions on insulation - which almost double the requirements to the insulating capacity of building structures - entered into force on 1 February 1979 and will naturally produce increased savings as the proportion of new buildings to total buildings gradually increases.

Energy consumption for room heating increased in the period between the two energy price chocks, and a fall-off of the level of economies in this area can not be excluded as consumers become accustomed to the

higher price level since 1980. It is not known how large a part of the saving achieved can be attributed to investments in energy-conserving measures and thus be characterized as a permanent saving. It is also unclear how much of the "behavioural" energy saving will be lost as people grow accustomed to the new price level.

In extension of the energy planning work from 1976, a new energy plan was drawn up in 1981: "Energy Plan 81" (EP-81). This includes forecasts for the development of energy consumption up to the year 2000, and presents development trends up to the year 2030.

The forecasts for net heat consumption for room heating show a slight increase in consumption up to the year 2000 (figure3). The size of the increase will depend partly on national economic growth in general and partly on the stringency of the controls applied to achieve a reduction of energy consumption. The increase is due primarily to the fact that the number of square metres heated will increase and that the economies achieved in 1971-81 can not be expected to be fully sustained.



Source: Energy Plan 1981

Figure 3. Net heat consumption, total.

The Government's action programme includes the following initiatives:

- thigtening the building regulations' energy requirements to new buildings, principally in respect of the technical installations

- a reduction of the energy consumption in existing buildings, partly by means of "Act No. 301 of 10 June 1981 on Reduction of the Energy Consumption in Buildings" (latest amendment May 1984, this Act contains a grant scheme for housing up to 1984, together with provisions to the effect that efforts must be made to bring public buildings into good energy condition by the end of 1989

- an extension of the control schemes for technical installations.

GRANT SCHEMES

Review of Danish grant legislation relating to buildings, 1975-85

The first grant schemes in connection with existing buildings were introduced in 1975, and up to the end of 1980, Government grants amounting to about Dkr 1,500 million were made under these schemes, resulting in turn in estimated investments of about Dkr 5,000 million. The grants varied between 20 per cent and 35 per cent of the total investment in the years 1975-80, the maximum grant in the housing sector being Dkr 2,000 per dwelling. In addition, in the period 1978-80, householders also had the possibility of aid in the form of a tax deduction. Considering the very great potential for economies in the freehold housing sector, the result of the tax allowance scheme must be described as unsatisfactory. The explanation presumably lies in the time lapse between carrying out the energy-conserving measures and benefiting from the effect of the deduction for tax purposes.

In the period 1975-80, a scheme also existed for grants in respect of industrial buildings, but this programme has not been carried over to the present scheme.

On 5 November 1980 two new schemes went into effect, replacing the previous grant programmes. One of the new schemes had a financial framework of Dkr 325 million and concerned only energy-conserving measures, while the other, with a framework of Dkr 275 million, concerned not only energy-conserving measures, but also maintenance and reestablishment of houses. These grant schemes, offering a maximum grant of Dkr 6,000 per dwelling, were implementet in such a way that the entire appropriation of Dkr 600 million was reserved by the middle of March 1981.

On 19 June 1981, both schemes were replaced by "Act on Reduction of Energy Consumption in Buildings". With amendments of June 1981, December 1982, December 1983 and of May 1984. This scheme is a long-term energy-conservation programme, the aim of which is to bring all buildings into reasonable condition from an energy economy point of view.

Current legislation - Act on Reduction of Energy Consumption in Buildings

Intentions of the Act: As mentioned above, the principal aim of the Act is to bring all buildings erected before 1 February 1979 into reasonable energy-economic condition, in other words, to bring them as far as possible up to the standards applying to new buildings. In evaluating the steps to be taken in each building, account must be taken of the age and use of the building, structural factors, the heat supply situation of the area in which it is situated, and the costeffectiveness of the investment.

As far as residential property is concerned, the means provided for achieving the above aim are a grant scheme, which will continue until the end of 1984, and a requirement to documentation of the energy condition of a building in the event of sale after 1 January 1985. As far as public building are concerned, the Act calls for efforts to be made to complete the necessary work to bring these into reasonable energy condition before the end of 1989.

Instruments and controls of the Act, including the energy consultant scheme

To encourage householders to initiate energy-conserving measures, the current scheme includes a grant scheme that differs considerably in several respects from the ealier schemes.

The maximum grant payable in respect of energy-conserving measures in any one dwelling is Dkr 7.000 in the entire period up to 1985. The scheme is designed for a reduction of the percentage of grant up to the end of 1984. This is intended to encourage householders to initiate energy-conserving measures at the earliest possible time. For freehold properties, the grant amounts to 20 per cent in 1981, 1982 and up to 31 August 1983. The rest of 1983 and in 1984 the householder can obtain 10 per cent. The corresponding figures for leasehold properties are 30 per cent, and 15 per cent.

The grant scheme will lapse at the end of 1984. After that time, the seller of a property must inform the purchaser of the energy condition of the property by means of either a heat inspection report or an energy certificate both prepared by an energyconsultant. A heat inspection report is a list of the measures to be taken to bring the building concerned into reasonable condition from an energy economy point of view. An energy certificate is the house-owner's proof that the building has been brought into reasonable energy condition.

As far as concerns the public sector, the means provided to achieve the aim of the Act is an annual appropriation for government buildings and for municipal and county council buildings.

An analysis of the ealier grant schemes seems to show that householders do not always have the most profitable measures (from an energy point of view) carried out, often attaching considerable importance to improving the comfort and quality (appearance) of their property, which in many instances results in a relatively long repayment time for the measures carried out.

In order to encourage the householder to have the most profitable measures (from an energy point of view) carried out the Act provides for the participation of an energy consultant. This is, in principle, a continuation of a consultant scheme established in 1975.

At that time, the task of the energy consultant was to give assistance and guidance on the implementation of energy-conserving measures to householders requesting these services, against a fixed fee. 100 consultants were initially trained for this scheme.

In connection with an amendment of the grant legislation in 1978, the consultant scheme was also modified, assistance by a consultant being made compulsory in respect of certain categories of buildings. This change was made for two reasons: from a wish to ensure that the grants were used for the most cost-effective measures from an energy point of view and, at the same time, to ensure that the work was carried out correctly from a technological point of view in order to minimize the risk of damage resulting from the insulating work. The consultant's tasks and responsibilities were thus considerably extended and increased in 1978: he became responsible for part of the administration of the grant scheme and now acted in the capacity of intermediary between the house-owner and the public authorities - the municipality. This consultant scheme comprised about 750 consultants. It continued until June 1981, when "Act on Reduction of Energy Consumption in Buildings" went into force.

The way the scheme operates today is that the house-owner, if he wishes, can request an energy consultant to carry out a heat inspection (a complete inspection of the building) and, on this basis, prepare a heat inspection report for the building, before initiating the energy-conserving measures.

This report is prepared on the basis of a so-called positive list as contained ad § 1 of the Promulgation Order. The list gives 11 items for which a government grant can be made and which are regarded as the most warrantable measures from the point of view of energy economy. The measures have a normal return time of 8-10 years; estimated saving in kroner.

The measures in the positive list means that, where technically feasible and financially warrantable, the parts of the building and installations affected will satisfy the energy requirements made to new buildings.

The consultant is an engineer or architect, or has some other, similar education. As mentioned, the consultant is appointed by the Ministry of Housing, but acts as a private consultant to the house-owner. The consultant must have at least five years' documented relevant experience and have attended the National Building Agency's courses/information meetings.

There are at present about 1200 energy consultants working under the current scheme.

The house-owner can get the energy consultant's fee for the inspection 80 per cent refunded by the State, although within the maximum limit of the Dkr. 7.000 per dwelling mentioned. This applies regardless of whether, on the basis of the heat inspection report, the housing-owner actually decides to carry out the energy-conserving measures or not.

Economy of the Act, including energy-conservation and employment aspects

In the period from June 1982 to December 1983 the house-owner could get the consultants fee for inspection fully refunded. Due to an amendment in December 1983 this "free" possibility was reduced.

For the housing sector no upper limit has been set on the amount which the State may pay out in the form of grants up to the end of 1984, always provided the conditions for making grants are satisfied. At present it is estimated, that grants totalling about Dkr 2.000 million will be made under the scheme up to the end of 1984, corresponding to a total investment of about Dkr 8.000 million.

The cost of the necessary energy-conserving measures in public buildings is at the end of 1982 estimated at Dkr 3,700 million. This estimate based on reports from almost all municipalities, and counties and all ministries. It is considered that government buildings will account for about 30 per cent of this, and municipal buildings for the remaining approx. 70 per cent. The investments are expected to be made before the end of 1989.

In connection with the preparation of EP-81 it was estimated that the net heat consumption in existing buildings (excluding production buildings in agriculture and industry) could be reduced by 35-40 million GJ or about 20 per cent of the net heat consumption in 1980, simply by improving the buildings' energy-economy standard. The investment required to achieve a saving of this magnitude was estimated at Dkr 19-20,000 million, assuming a degree of control of the investments corresponding to the control mechanisms incorporated in the Act. Without these controls, it was estimated that the investment would be twice the above figure.

In April 1984 around 220.000 heat inspections had been performed, covering 620.000 dwellings (approx 29 per cent of the total 2,1 million dwellings in Denmark). The total estimated costs on the heat inspection reports amount to around Dkr 10.000 million.

Table I. Heat inspection, dwellings, inspected, and estimated costs distributed over one-family dwellings, apartment houses, and other buildings. (Percentual distribution). June 1981 - April 1984.

	One-family dwellings	Apartment buildings	Other buildings	Total	N
Heat inspection	89	10	1	100	218.525
Dwellings covered by heat inspection report	36	63	1	100	621.011
Total est. costs (Dkr mio.incl. (VAT)	41	56	3	100	10.187

It will be seen from this table that 63 per cent of the heat-inspected dwellings are in apartment buildings. Thus, 43 per cent of all dwellings in apartment buildings have been subjected to a heat inspection, against 18 per cent of all one-family dwellings.

A detailed analysis of the reports gives the following results:

Table II. Heat-inspected dwellings and total number of dwellings. Percentual distribution over one-family houses and apartment buildings and age. June 1981 - April 1984.

	One-family houses		Apartment buildings	
	Heat-inspected dwellings	All dwellings	Heat-inspected dwellings	All dwellings
- 1939	19	37	28	50
1940 - 1959	19	16	29	21
1960 -	62	46	43	28
No info.	-	1	-	1
Total	100	100	100	100
N	224.758	1.238.572	398.593	895.941

Table III. Average estimated costs per dwelling and per m^2, distributed over one-family houses and apartment buildings and age of the buildings: Dkr. All amounts incl. VAT. 1981 and 1982.

	One-family houses		Apartment buildings	
	per dwelling	per m^2	per dwelling	per m^2
- 1939	36.000	250	27.000	350
1940 - 1959	30.000	330	14.000	210
1960	17.000	130	13.000	170

It will be seen that the grants scheme has so far mainly encouraged the owners of comparatively newly erected buildings that are already in a relatively good energy-economy condition to invest in energy-conserving measures, whereas owners of buildings that look like needing extensive investments before they can be regarded as in reasonable energy-economy condition seem some-what more cautious.

At the end of May 1984 grants amounting to app. Dkr 1760 million had been made, corresponding to reported investments totalling Dkr. 7.100 million (VAT incl.).

Table IV. Grants divided into heat-inspected dwellings, dwellings with energy certificate issued and actual costs, until 30 June 1983 Percental distribution of grants.

	Heat-inspected dwellings	Energy-certificate issued	Grants paid for heat-insp.only	Grants paid without previous heat-insp.	Total	mio. Dkr.	Actual costs mio. Dkr.
Freehold properties	38	6	14	42	100	386	1811
Rental property	41	31	4	24	100	266	980
Non-profit-making housing	50	42	1	7	100	281	1017
Other all-year dwellings	41	20	5	24	100	49	200
Total	43	23	7	27	100	982	4008

It will be seen from the table that the grant scheme until now in particular has encouraged the rental property sector and the non-profit-making housing sector in investing up to the level of energy certificate. Untill 30 June 1983 energy certificate was issued in app. 70.000 dwellings: 40.000 non-profit-making dwellings, 21.000 in the rental property sector, 6.000 freehold dwellings and 3.000 in others.

Table V. Average grant and costs per dwelling, untill June 30 1983.

	Grants per dwelling					
	Heat-inspected dwellings	Energy-certificate essued	paid without pre.heat inspec.	Heat inspec. only	Total	Actual costs per dwelling Dkr.
Freehold properties	3.890	3.900	2.400	1.090	2.390	11.200
Rental property	2.450	4.020	2.250	440	2.310	8.490
Non-profit-making housing	1.830	2.950	1.300	200	1.930	6.980
Other all-year dwellings	1.810	3.610	1.780	400	1.660	6.820
Total	2.450	3.370	2.180	760	2.170	8.870

In order to encourage energy-conserving measures still further, an amendment of the "Rent Act" was introducted in June 1982 with special reference to privately-owned apartment buildings. This amendment opens the way for a majority of the tenants in an apartment building to demand that energy-conserving measures be carried out if the cost of heating amounts to more than 50 percent of the rent.

Information on Act on Reduction of Energy Cons. in Build.

In connection with the implementation of the Act it has been decided to launch an intensive information campaign. To ensure the effectiveness of this, an appropriation of Dkr 6 million was made for information activities in each of the years 1981 and 1982 and an appropiation of Dkr. 3 million in 1983 and 1984.

The principal aim of the 1981 information campaign was to drawn the attention of the population to the new Act and its possibilities. This was done primarily via advertisements in the daily newspapers and trade journals, and through TV and radio spots. In addition, various brochures were prepared for distribution via public libraries, post offices and municipal offices, and a real promotion drive was set up, with traffic advertisements, further advertising, exhibitions and displays, and direct mail promotion.

The information activities were continued in 1983, but this time with the emphasis of more specific topics and addressed to specific target groups. The same line has been followed in 1984.

PUBLIC BUILDINGS

Energy-conserving measures in public buildings

Public buildings means state, county and municipal buildings. For energy-conserving measures in this sector, state agencies have had the possibility since 1975 of applying for funds within the economic framework set by the annual appropriations. County and municipal councils have taken some independent initiative to have energy-conserving measures carried out - up to 1981 - but precise information on the scope of such work is not available.

A really systematic inspection of all public buildings is now possible through the "Act on Reduction of Energy Consumption in Buildings".

State buildings 1975 - 1981

In the period 1975 - 81 an amount of about Dkr. 335 million was spent on energy-conserving measures in state buildings.

The funds have been used in accordance with rules laid down in circulars issued by the National Building Agency. The Agency has issued a positive list of measures for which the funds may be used. The contents of this list largely correspond to those of the positive list mentioned in connection with the "Act on Reduction of Energy Consumption in Buildings".

In addition, there has been a requirement that an energy consultant should decide, on the basis of an inspection, which measures could be considered.

On completion of the work, information has been fed back to the National Building Agency on the work performed, the actual expenditure and any changes in relation to the original application.

Public buildings, including state buildings, 1981 - 89

In pursuance of the "Act on Reduction of Energy Consumption in Buildings", efforts must be made to bring all public buildings into good

energy condition before the end of 1989. Originally 1987 was set up as the time-limit, but this was changed with an amendment in May 1984. To achieve this, a plan for the energy-conserving measures was drawn up in 1982, together with a calculation of the cost of the activities and their distribution over the year. In 1985 plans for the activities in the years to 1989 must be revised. This applies not only to ministries and government agencies, but also to county and municipal councils. Public buildings used for housing purposes are entitled to grants on an equal footing with all other dwellings. These dwellings are therefore not comprised by the provisions on planning in 1982 and 1985 and performance before the end of 1989.

An instruction on planning energy-conserving measures in public buildings has been sent to all public authorities. The procedure described in this instruction is, briefly, as follows:

- collection of data on each building (m^2, date of erection, use, energy consumption, etc.)
- calculation of unit consumption, kWh/m^2
- comparison with normative key figures
- specification of sequence of works and estimate of cost
- detailed inspection of building
- design of energy-conserving measures
- execution of energy-conserving measures
- subsequent control of savings achieved in relation to actual investment.

In addition, attention is drawn to the importance of introducing systems for energy-economical operation and maintenance, since only in this way can the savings achieved be maintained in the future. Many public buildings are - to a greater extent than the housing sector - characterized by large technical installations and limited service life. This underlines the importance of energy-economical operation and maintenance.

Estimate of magnitude of investment

On basis of reports from the municipalities, counties and ministries concerning the investment needs on energy conservation it is anticipated that it will be necessary to invest a total of about Dkr 3.700 million in public buildings in the period 1983 - 1989 (Dkr 1160 million in state buildings and Dkr 2.540 million in municipal and county buildings).

The investment-needs are primarily concerning schools and hospitals in the municipalities and counties and education institutions, military

buildings etc. in the state-buildings.

The total investment need is corresponding to 720 Dkr. per capita. In 1983 the total amount used for energy conservation in public buildings was 425 million Dkr. and a similar amount are expected to be used in 1984.

Energy consultants in public buildings

In connection with the State's efforts to save energy in its own buildings as well, the Ministry of Housing asked all ministries and agencies in 1974 to have an inspection of their buildings carried out to ascertain the insulation condition. This inspection was to be performed by qualified technicians, and as the Ministry for the Interior followed the initiative up with a request to municipal and county councils to arrange for a corresponding inspection of their buildings, the energy consultant scheme for public buildings was established. About 440 technicians underwent the necessary training for this work.

In practice, today, the State employs only private energy consultants for building inspections and for designing energy-conserving measures, while the municipal and county councils are free to decide for themselves on the question of consultants. They may employ private energy consultants or appoint their own technicians as internation energy consultants, or simply use their own technicians. For the last category, courses have been established, dealing particularly with energy-conserving in public buildings.