Energy-Efficient Housing Symposium
Edmonton, Alberta, November 1980.

Sponsored by Alberta Energy
& Natural Resources,
Energy Conservation Branch

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ENERGY, ENERGY CONSERVATION AND
THE BUILT ENVIRONMENT IN SWEDEN
- Improvements in the building envelope

Working report No 1980:3

Degree (°C) days:
Kiruna       6000
Stockholm    3600
Malmö        3000
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ENERGY, ENERGY CONSERVATION AND THE BUILT ENVIRONMENT IN SWEDEN
IMPROVEMENTS IN THE BUILDING ENVELOPE

The Energy Situation in Sweden

Energy consumption in Sweden has increased rapidly in the last few decades. During the period 1955-1972 consumption increased by an average of 4.6% p.a.

The increased demand for energy was connected with the development of the standard of living and of the rise in economic activity. Improved standards of living, increased car driving and continuing production development in industry had resulted in increasing consumption of energy for various purposes.

An ample supply of energy and competition between various forms of energy had led to low energy prices. This has not encouraged consumers to restrict their consumption of energy.

In recent years, however, questions regarding the expanded utilization and long term availability of natural resources have been discussed to an increasing extent on both a national and an international level.

Questions concerning the environmental problems involved in the use of energy, safety and waste problems connected with nuclear power, and emergency supplies in case of embargo, war or other cut-downs have also been discussed.

The energy consumption for dwellings and premises also increased continuously until the oil embargo of 1973/74. After that it is possible to note a change (Figure 1).

After correction to normal year (reference year) consumption has remained at a fairly constant level, approximately 170 TWh gross/year (Table 1). The major part of this energy requirement, approx. 70%, is produced from the combustion of oil. The share that buildings take of Sweden's total energy turnover is about 50%, so a high priority has to be given to economizing on energy within this sector. Moreover the possibilities of saving energy are considered to be significant (Table 2). Often only limited new research and development efforts are required. Cuts have been achieved by making existing research and development results readily available and by providing incentives for their application. This has given good results, as well as further extensive research and development.

Looking at the amount of energy consumption which can be traced to buildings it becomes obvious that the amount used during the actual construction process or in the production

Figure 1.
Total energy consumption in Sweden (TWh gross/year) - forecasts and actual.

Figure 2.
Energy consumption for construction, handling, building materials and heating in a building with a life span of approx. 40 years.
Table 1. Energy consumption in buildings 1975 TWh gross.

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Energy Consumption (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing</td>
<td></td>
</tr>
<tr>
<td>One-family houses</td>
<td>approx. 50</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>50</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td>15-20</td>
</tr>
<tr>
<td>Premises</td>
<td>Remaining buildings</td>
</tr>
<tr>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
</tr>
</tbody>
</table>

Table 2. Energy saving through improved building methods and energy conservation systems for 1990, TWh gross/year.

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>Energy Savings (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual dwellings</td>
<td>13</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>15</td>
</tr>
<tr>
<td>Industrial buildings</td>
<td>5</td>
</tr>
<tr>
<td>Remaining buildings</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
</tr>
</tbody>
</table>

Corresponding savings by 1990 for:

- Industry: 8-10 TWh
- Transportation: 3-14 TWh
- Remaining: 5-6 TWh

and transportation of building materials is negligible compared to the amount needed to heat homes (Figure 2).

Even if energy consumption in new buildings can be reduced to a minimum, buildings already in existence will still have a decisive influence on energy consumption in the housing sector over the next ten years.

Swedes use less energy than Americans and Canadians – see Figure 3 (energy consumption per inhabitant in relation to GNP per inhabitant in various countries, 1974), in Sweden about 50 000 kWh and in U.S. about 70 000 kWh per capita (Figure 4).

Higher energy prices may be one of the reasons:

- Swedes pay about 100% more than Americans for a gallon of gasoline
- about 30% more for a gallon of fuel oil
- the price of electricity, on the other hand, is generally about the same.

The climate is another reason, Figure 6 and 7, but it isn't as severe as Americans often believe. God bless the Gulf Stream!

Figure 3.
Energy consumption related to GNP, all figures per capita.

Figure 4.
Comparison between the different requirements on the transmission heat losses in different European countries (translated into a common form, \( u_m \), T/m).

Figure 5.
Cost of oil for single-family houses, kr/m² (tax included) 1970-1980.
TOTAL USE OF ENERGY RESOURCES:

Sweden
(37,000 kWh per capita)

U.S.
(90,000 kWh per capita)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Sweden</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>11.6%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>4.3%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Wood residue</td>
<td>7.9%</td>
<td>21.0%</td>
</tr>
<tr>
<td>Coal</td>
<td>3.9%</td>
<td>27.4%</td>
</tr>
<tr>
<td>Oil and petroleum products</td>
<td>72.2%</td>
<td>49.0%</td>
</tr>
</tbody>
</table>

ELECTRICITY:

Sweden
(10,000 kWh per capita)

U.S.
(10,000 kWh per capita)

<table>
<thead>
<tr>
<th>Resource</th>
<th>Sweden</th>
<th>U.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>63%</td>
<td>10%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>24%</td>
<td>11%</td>
</tr>
<tr>
<td>Oil</td>
<td>13%</td>
<td>48%</td>
</tr>
<tr>
<td>Gas</td>
<td></td>
<td>14%</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>17%</td>
</tr>
</tbody>
</table>

43% of all Swedish dwellings are single-family houses. One third have been built since 1960. (Figure 8.) They are heated by:

- oil-fired boiler 48%
- electricity 30%
- district heating 5%

The other 57% are apartments (43% have been built since 1960). They are heated by:

- oil-fired boiler 48%
- electricity 13%
- district heating (mostly oil) 49%

(Figure 9.)

The energy use per unit of living space as well as the energy use per capita is almost the same in apartments as in single-family houses. Compared to Americans, Swedes use:

- 15% less for space heating
- 65% less for lighting
- 35% less for appliances
- 100% less for air conditioning
- 40% more for hot water.

New Buildings - Swedish Building Code of Practice

In order to reduce the amount of energy utilized for heating purposes, more stringent thermal insulation requirements for buildings were introduced in the 1975 Swedish Building Code as well as completely new requirements concerning the airtightness of buildings. Pilot studies that have been performed have shown:

- Reduction of energy use in buildings
- Increased comfort levels for residents

Figure 6.
Map of North America with two maps of Sweden in it: where Sweden belongs latitude-wise (I) and temperature-wise (II).

Figure 7.
The power requirement (P) for space and water heating for a detached house in Stockholm, with an indoor temperature of 20°C, varies greatly over the year. It is evident that the warm water requirement is quite constant, and that only 15% of the total energy requirement occurs on days when the outdoor temperature is below 5°C. In general, heating is not necessary when a building is properly insulated.

Figure 8.
carried out indicate that considerable savings of energy can be achieved as a result of these new requirements (Figure 10).

In order to meet these requirements, completely new structural designs for the building envelope are needed. It is the considerable increase in the thickness of insulation that has led to the non-application of new design solutions. The new airtightness requirements have in turn involved new working methods and, in many cases, have required both new materials and new combinations of materials.

Experience gained mainly from the construction of single-family houses during the sixties and seventies has shown that defects in the airtightness of the building envelope have in many cases been considerable. This has caused discomfort as a result of drafts and in some cases difficulty in obtaining acceptable indoor temperatures. Serious defects caused by damp, particularly in roof structures, can in many cases be ascribed to defects in the airtightness of these structures. The reasons for building airtight buildings are therefore both numerous and important.

Earlier code requirements for an outside shell's thermal insulation and airtightness in Sweden were dictated by hygiene or comfort. Thermal insulation requirements were enforced but there were no requirements concerning a building's airtightness. In the Swedish Building Code 1975 (SBN 75) thermal insulation requirements for different building sections were made considerably more stringent. Completely new requirements for a building's airtightness were introduced and are stated in SBN 75 as upper limit values for an outside shell's different sections. In addition there are recommendations for maximum perviousness measured at a pressure difference of 50 Pa for whole buildings.

Table 3. Maximum permitted heat transfer coefficients (U-value) in W/m² K for parts of buildings adjacent to rooms to be heated to more than +18°C. Temperature zone I/II includes northern Sweden, entailing somewhat more stringent requirements than those for zone III+ IV covering southern Sweden.

<table>
<thead>
<tr>
<th>Section of building (Examples)</th>
<th>Max. permissible U-value allowed</th>
<th>Zone I+II</th>
<th>Zone III+IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed outside wall</td>
<td>0.25</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Roof and attic joist structure exposed to outside</td>
<td>0.17</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Joist floor exposed to outside</td>
<td>0.17</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Joist floor above crawl spaces and ground level floor constructions respectively</td>
<td>0.30</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Windows</td>
<td>2.0</td>
<td>2.0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 9.
Various forms of energy in single-family houses, blocks of flats and other buildings.

Figure 10.
Heat consumption for an apartment, 70 m², 1950-1977.
With regard to airtightness of completed buildings, extracts from the SB 75 recommendations for maximum air change rate in different types of buildings are given in Table 4.

Table 4. Recommendations for the highest air change rate in different types of residential buildings.

<table>
<thead>
<tr>
<th>Type of building</th>
<th>Max air change rate, change/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-family houses</td>
<td>3.0</td>
</tr>
<tr>
<td>Other houses with 2 floors max.</td>
<td>2.0</td>
</tr>
<tr>
<td>Residential buildings with 3 or more floors</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Two methods are at present available for the measurement of airtightness of entire buildings: the tracer gas method and the pressure method. The tracer gas method is used to measure the ventilation rate of a building under ambient weather conditions. The principle of the pressure method is that a powerful fan is employed to create a pressure difference across the building envelope (walls, roof, floor structures, etc.) and the resulting air flow through the fan is measured at constant pressure difference.

Airtightness is normally specified in terms of the average value of the air flows at 50 Pa overpressure and underpressure as read from the graphs. If the value has to be obtained by means of extrapolation, this should be specifically stated. The graph should be attached to the report. Figures 12 and 13.

The requirements for thermal insulation mean, for example, that the insulation thickness for mineral wool insulated wooden walls must be approximately 190 mm and 150 mm in zones I and II and III and IV respectively. For attic joint structures approximately 260 mm mineral wool and approximately 220 mm in zones III and IV, is normally required. These are significant increases in thickness, which mean more complicated wall and joint floor constructions than was the case. There is sufficient economic motivation to insulate to a greater extent than was stated in SB 75, bearing in mind the rapidly increasing price of energy.

Experience is now being gained of how well-insulated and airtight houses should be built and how they function. It appears that manufacturers, contractors, etc., have managed to change their methods comparatively quickly to build houses which meet the new requirements in the building regulations.

The maximum permitted U-value for windows means triple-glazed windows or double-glazed windows with a selective surface on one side of the pane. Such surfaces, which are often called thermal mirrors, can be produced either by thin coatings of various metals or by coatings of suitable semiconductors.
Regarding windows, weatherproofing of windows (and doors) is an inexpensive, effective measure for the reduction of energy consumption in a building. According to Swedish investigations a tubular strip (of synthetic rubber, type QR and EPDM) appropriate to the gap provides the best seal for both doors and windows. An appreciably higher air leakage was detected for expanded strips, foam strips and fibre strips. The latter two did not satisfy the new airtightness requirements in the Swedish Building Code, SBN 75. Figure 14.

Figure 14.
Tubular strip. Air leakage determined for different methods of mounting. The broken line curve indicates maximum acceptable air leakage according to the Swedish Code of Practice.
Examples of energy balances for single-family houses

As a background to the Energy Conservation Code for new buildings, Figure 15 shows an energy balance for a normal single-family house with a living area about 130 m² - built before the energy crisis at the beginning of the 70's. The energy balance is based on average values for houses in the Stockholm area. The required amount of purchased energy is on an average 27 MWh. Studies of energy consumption etc. in houses with an insulation level which complies with the requirements in the Energy Conservation Code and provides a very good airtightness have been carried out in the same area (Figure 16). By comparing Figures 15 and 16, i.e. the energy balance for an average house in central Sweden built before the advent of the new code, and the energy balance for a house built according to the requirements in the new code as regards improved thermal insulation and with an airtightness considerably better than that recommended in the code, it is seen that the reduction in additional energy required is about 9 MWh.

### Figure 15.
Energy balance for a dormer (1 1/2 storey) house of approx. 130 m², built in the early 70's, i.e. before the energy crisis. The required amount of purchased energy is on average 27 MWh in the Stockholm area.

<table>
<thead>
<tr>
<th>Component</th>
<th>Out MWh</th>
<th>In MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat losses from domestic electricity</td>
<td>1.0</td>
<td>3.2</td>
</tr>
<tr>
<td>Waste water losses</td>
<td>3.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Ventilation losses</td>
<td>10.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Transmission losses</td>
<td>17.2</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31.7</td>
<td>31.7</td>
</tr>
</tbody>
</table>

### Figure 16.
Energy balance for airtight and well insulated houses in the Stockholm area.

The average purchased energy requirement is approx. 18 MWh per year. This means approx. 9 MWh per year less than in corresponding houses built before the energy crisis.

<table>
<thead>
<tr>
<th>Component</th>
<th>Out MWh</th>
<th>In MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat losses from domestic electricity</td>
<td>22.6</td>
<td>3.2</td>
</tr>
<tr>
<td>Waste water losses</td>
<td>3.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Ventilation losses</td>
<td>4.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Transmission losses</td>
<td>13.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Total</td>
<td>22.6</td>
<td></td>
</tr>
</tbody>
</table>
Thermal insulation, wind protection, air sealing, 
vapour barrier in wooden constructions

Sweden has a long tradition of building insulated wooden 
houses. Mineral wool has been the most common thermal 
insulation material since 1950. The stricter requirements 
for thermal insulation demand in practice two or more layers 
thickness >150 mm) in wooden walls. Such designs are carried 
out in different ways with regard to wind protection, air 
sealing, functions etc.

Some examples of standard houses are stated below.

Instructions

1. Mineral wool slabs with \( \lambda = 0.040 \, \text{W/m°C} \). The slab shall be fitted 
   with wind paper with an overlap of 60 mm on the outside and with 
paper that can be nailed having a 40 mm overlap on the inside. 
   Where the angle of the wall changes, a wedge is cut out to half the 
   slab so that the insulation remains unbroken.

2. Minimum 0.20 mm thick age-resistant and transparent plastic foil.

3. Mineral wool slab with \( \lambda = 0.040 \, \text{W/m°C} \).

4. Floor chipboard with functional requirements. Type approved 
   (refers also to formaldehyde content). Handled according to the 
   erection instructions issued by the Chipboard Federation. Laid out 
   according to the building description.

5. Safety foil. Fitting according to the manufacturer's instructions.
   The foil also functions as a diffusion barrier and an air seal.

6. 22 x 95 mm, Type V, centre-to-centre distance 300 mm with a substructure 
   centre-to-centre distance 600 mm. 28 x 95 mm, Type V, centre-to-
   centre distance 300 mm with substructure centre-to-centre 1200 mm.

7. Mineral wool slab with \( \lambda = 0.040 \, \text{W/m°C} \). The slab must be covered 
   with wind paper.

8. The nogging pieces are fixed nailed to the floor joint structure using 
   a pattern of \( 6 \times 6 \) at \( 100 \times 37 \) mm. The nogging pieces also function 
as struts.

9. In the case of terraced and semi-detached houses the ventilated ridge 
   is to be made in accordance with the building description.

10. 45 x 45 mm members. In bathrooms with bathroom furniture loads on 
    walls, 45 x 70 mm. In toilets and bathrooms the whole of the 
    wall thickness is insulated.

11. 45 x 95 mm members. Top wall plates, beams according to shell 
    plan. Nogging piece for skirting board.

12. The plasterboard is fitted to the ceiling before non-load-bearing 
    walls.

Figure 17. Example of house with timber frame structure.
Figure 18. Example designs for outer wall and attic floor structure with three layers of mineral wool.
Fitting a wide sheet of plastic foil

Roll out along the outer wall.

Lift up, fold up the small flap against the ceiling, fix in under the flap.

Fold down the large flap and attach the foil to the wall.

The ceiling work is prepared by placing plastic foil under load-bearing internal walls, between these and gable walls and between gable walls and attic floor structures during the erection of the shell.

The upper floor's gables are covered in plastic foil first after which the roof is covered. In the roof, the foil is laid parallel with the roof trusses. The rolls can pass through an opening in the intermediate joint structure. The joints, with a good amount of overlap, are laid over supports and clamped with plywood strips or are taped.

Figure 10. Fitting plastic foil.

Figure 11. Two special framework constructions (and building systems) advantageous particularly in the near of greater thickness and in avoiding cold bridges etc.
Figure 21. Single-family house with special building system (Masonite Beam and Masonite Stud).
Existing buildings – Energy Conservation Plan

In 1975, the Swedish Parliament adopted an Energy Bill designed
to restrict energy consumption. For the period up to and
including 1985, total energy consumption was to be allowed to
rise by an average of 2 per cent a year. But no exact goal
was fixed for the heating of buildings. But when making
assessments for the overall objective, it was considered
that energy consumption for heating of houses could be
reduced by an average of 0.9 per cent a year during this
period.

The Energy Conservation Plan for existing buildings – an
outline of which is given below – was submitted to the

Energy Conservation Plan for Existing Buildings (the main
points in the government Bill).

- The Conservation Plan will run for ten years, but
  will be reviewed after three years.
- The goal is to achieve by 1988 a gross energy saving
  of between 39 and 48 TWh a year, or 25–30 per cent of
  the total energy consumption in existing buildings.
  This equals a saving of between 3.4 and 4.1 million
  tons of oil a year.
- The Energy Conservation Programme will cost the nation
  between 21 and 33 thousand million Swedish crowns over
  the ten-year period. Total investments are estimated
  at 31-48 thousand million crowns at prices prevailing
  in the first quarter of 1977.
- The Programme will be expanded by stages. For the
  fiscal year 1978/79 this will mean about 1.8 thousand
  million crowns, for the fiscal year 1979/80 2.7 thou-
  sand million crowns and for the fiscal year 1980/81
  3.6 thousand million crowns (at prices presumably
- The local authorities will play a central role in
carrying out the programme and will be given State
assistance for this. The costliest part of these
activities will be advisory and other services. The
Government proposes that assistance should after a
time be combined with some financing by charging for
services (e.g. for inspections). The Minister of
Housing moves that an appropriation of about 60
million crowns should be included in the 1978/79 budget.

In 1978, the Swedish Parliament resolved that energy consump-
tion in the existing stock of buildings in 1988 should be
about 35 TWh less than today, that means the bill was adopted.

Money was set aside for the first three years. The appropria-
tion for 1980 was about one billion dollars (more than 100
dollars per capita). Special subsidies and favourable loans
were included to provide sufficient stimulus (Appendix 1 and 11).

The Government allocates to house owners:

Grants: - Up to 35% of the approved cost for energy-saving measures. Maximum grant is 700 dollars per dwelling unit.

Loans: - For the rest of the approved cost. No security is required under 4500 dollars. Maximum mortgage time is 20 years and interest is well below bank lending rate.

A new decision on appropriations for the program is to be made in 1980, based on a major evaluation of experience so far.

The energy-saving plan is based on theoretical calculations (example, see Figure 22).

In order that our efforts to reduce the consumption of energy in existing buildings may be successful, it is essential that the data on which decisions concerning energy conservation measures are based should be of the strictest relevance. One of the ways in which this data can be obtained is to run pilot projects in different types of buildings and to study in depth the scope for energy conservation. The measures taken in these projects should be analysed and followed up systematically, and they should comprise accurate measurement over a long period.

Another way is to study a large number of randomly chosen buildings in which energy-saving measures have been taken.

The saving effects are obtained by comparing the energy consumption before and after carrying out these measures.

It is considered necessary to determine, by means of special methods of calculation, the energy consumption for the entire heating season both before and after the measures were carried out. An evaluation was made in cooperation with a number of institutes of technology in Sweden. About 800-900 buildings were studied in the Stockholm region, and about 400 each in southern, western and northern Sweden. An estimated total of 2000-2500 buildings is included in the study.

Figures 23, 24 and 25 briefly present results from one of the pilot projects. The results of energy conservation measures in a group of typical three-storey blocks of flats built in 1940 at Ulvsunda - a Stockholm suburb - comprising around 100 dwellings, are set out within the scope of the project.

The objective of this project was to determine the energy consumption of existing buildings by means of a program of measurements and calculations, and to describe the effects and profitability of various constructional and building systems applied with a view to conserving energy. The buildings - apartment buildings erected in 1940 - represent an important target group in that they are due for rebuilding and replacement. The measures taken were improvement of the boiler efficiency, weatherproofing of doors and windows, the application
Figure 23. Summary of the results of energy conservation measures from the Ulvsunda pilot project during the first three-year period, expressed in terms of normal annual consumption, l/m². The bar drawn with dashed lines indicates the results expected in stage II.

of additional insulation to attic floors and external walls and the proper adjustment of the heating system combined with a reduction in the indoor temperature.

In order that the best effect may be achieved with regard to both energy conservation and an improvement in indoor climate, however, building technology and service engineering measures must be coordinated. Experiences gained in the Ulvsunda Project show that an appropriate strategy for coordinated measures was:

1. additional insulation and weatherproofing
2. adjustment of the heating system
3. reduction in temperature.

A reduction in temperature in a building where the heating system is improperly adjusted does not result in a permanent reduction in temperature or a saving in energy — the difference between the coldest and the warmest dwellings is too great, and the tenants in the coldest dwellings will complain.

Nor will reductions in temperature, even if taken in combination with accurate adjustments, result in a permanent reduction in temperature in buildings if shortcomings in the building technology in the form of low thermal insulation and poor weatherproofing standard are concealed by giving the air in the rooms a high mean temperature. The tenants will not accept the deterioration in comfort.

The Ulvsunda investigation also shows that improvements in building technology should be accompanied by an adjustment of the heating system, since otherwise there is a risk that the result will be a rise in room temperature, and not all the saving in energy which the measures had been intended to achieve will be attained.
My point is that there is an interaction between weatherproofing/thermal insulation and heating equipment. Integration of installation and building technology is necessary if we are to produce low-energy houses with a good indoor climate and if we are to avoid mistakes.

The evaluation of the effects of energy conservation measures in a large number of randomly chosen existing buildings, also shows fairly good results. But the standard deviation is rather high. It is very important to combine different measures in an effective way, as was seen in the Ulvsunds pilot project concerning interaction between different measures; therefore an efficient technical advisory service and assistance in the inspections of houses are of vital importance in carrying out the energy conservation programme.

CONCLUSION

The waste of energy in new as well as existing buildings can be largely prevented by such simple means as good heat insulation/airtightness in combination with well-designed heating and automatic control systems. A higher degree of insulation in the external structure forms the basis for a lower room temperature without any detrimental effects on living comfort. Both these factors lead to a great saving in energy in the heating of dwellings. Well-designed automatic control systems for regulating the heat supply are a prerequisite for utilizing solar energy radiation through the windows, and result in more uniform and comfortable room temperatures. Even in very northerly latitudes a considerable quantity of free heat can be obtained in this way.

Only in sufficiently airtight houses can the ventilation be controlled and regulated to the required level in each section of the dwelling. Airtight houses are also necessary if heat recovery from the ventilation system is to function efficiently and profitably. It is possible to build "airtight" houses today, even if methods need to be further improved.

REFERENCES


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LIST OF ENERGY-SAVING MEASURES FOR WHICH PUBLIC SUPPORT IN THE FORM OF LOANS AND SUBSIDIES IS GRANTED

The extent of the support has varied somewhat from year to year.

Extra insulation
Attic
Ground flooring
Outer wall (also foam)
Triple-glazing
Sealing with foam - floor-wall joint
Sealing with foam - crawl space

Heat production
Replacement of heating boiler
Replacement of oil unit
Equipment for heating with wood chips
Heat pump
Solar heating system
Automatic heating system (damper regulator)
Connection to district heating

Heat regulation
Variable control equipment (multi-family houses)
Motor shunt valve with thermostat with outdoor temperature
sensor and time control (single-family houses)
Radiator valve with thermostat
Circulation pump
Adjustment of heating system

Heat measurement
Distribution meter
Flow meter
Energy meter
Remote meter

Heat storage
Electrical installation for night storage of tap hot-water

Ventilation
Adjustable flow of exhaust air
Heat recovery from exhaust air
Adjustment of ventilation system

Other (measures which as a rule do not qualify for subsidy)

Sealing of all windows
Removal of inner reveal and sealing around window frames
Reduced room temperature
Interest Grants

If the actual cost of interest for basic loans and housing loans exceeds a so-called guarantee level, the difference will be covered by an interest grant. This means that the rate of basic-loan interest can not exceed the rate of interest on the public loan market.

The interest grant is only valid for the part of the loan which applies to the loan for housing.

New Construction

The guaranteed interest rate during the first year after the loan is granted is 3.4 %. This rate is applicable to apartment buildings and cooperative building societies. The guaranteed rate increases by 0.25 % each year. The interest grant terminates when the cost of interest has reached the same level as on the public market.

Amortization on the State housing loan is not payable during the period when an interest grant is received.

Interest grants can also be obtained during the period between the completion of the house and the grant of the loan.

The guaranteed interest for small single-family houses which are occupied by the borrowers is during the year after the grant of the loan 5.5 %. The guaranteed rate increases by 0.35 % every year until the market level is reached. After that it terminates.

Amortization of the housing loan starts 6 months after grant of the loan. The period of amortization is 30 years.

Reconstruction

Interest grant can be obtained by owners of small single-family houses in accordance with the rules for new construction.

The same is true for reconstruction of apartment buildings and for cooperative building societies. The guaranteed interest increases in the same way as for new construction.

Housing loans for reconstruction have to be annuity loans and amortization starts 6 months after the loan is granted. The amortization period is not more than 30 years and the remaining life of the house is also taken into account.
LOANS AND GRANTS FOR HOUSING

State loans are granted for the construction and reconstruction of houses. These houses should be for permanent residence. In certain cases grants can be issued for houses that are occupied in a limited way. Other improvement measures are the reconstruction of courtyards and energy-saving measures.

Loans can not be granted for holiday houses.

Housing Loans (in general)

Housing loans are state-granted loans which are complementary to various kinds of other basic loans. Housing loans are also granted to premises that serve a residential district, for example: shops, banks and post offices. Premises in schools can receive loans if they are an integral part of the housing service and if the need for other premises as a result decreases. Loans can also be granted for environmental improvements and for measures that can receive energy grants. Housing loans to enable purchase can also be granted after approval by the Government. This benefit is allowed only if the house is built or rebuilt with a state loan. Other conditions are that the buyer must be a Local Government Authority or a housing enterprise which is a public utility company or a cooperative building society.

A State housing loan can not be obtained if the seller of the land is someone other than a Local Government Authority. This is called the land condition.

A condition for granting a housing loan is that the building must, if possible, be connected to a collective heating system.

Loans for new construction

The cost of the land and of the house are decisive factors for the granting of a loan.

A Building Permit is required from the local housing authority.

To obtain a housing loan for apartment buildings or estates of smaller houses it is necessary for the builder to invite tenders from a number of construction companies.

Interest on Housing Loans

The interest is to be decided every year by the Government and shall correspond to what it costs the State to borrow capital. The cost of administration is additional. The 1980 interest on housing loans is fixed at 11%.