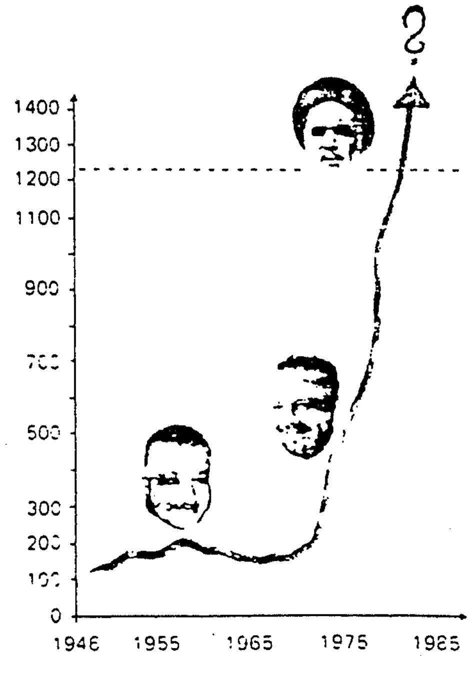
Ingemar Höglund

THE ULVSUNDA PROJECT
- ENERGY SAVING IN EXISTING HOUSING

Working report No 1980:6



Cost of oil, Sw kr/m³.

ROYAL INSTITUTE OF TECHNOLOGY

Division of Building Technology

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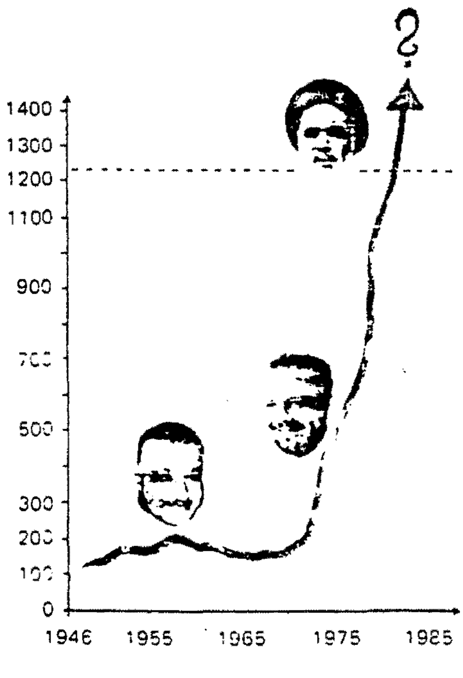

Cost of oil, Sw Kr/m³.

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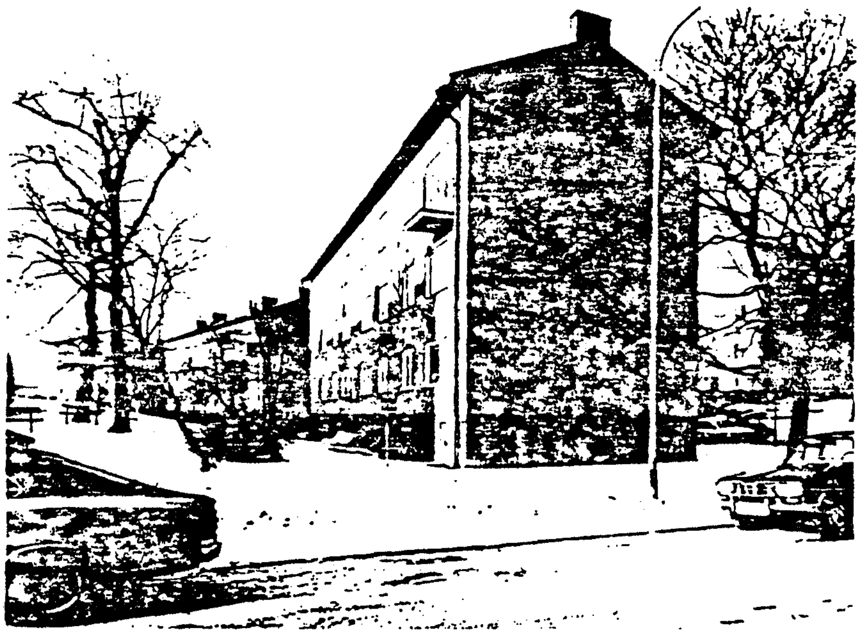
SUMMARY. SOME CONCLUSIONS

In order that our endeavours 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 measurements over a long period.

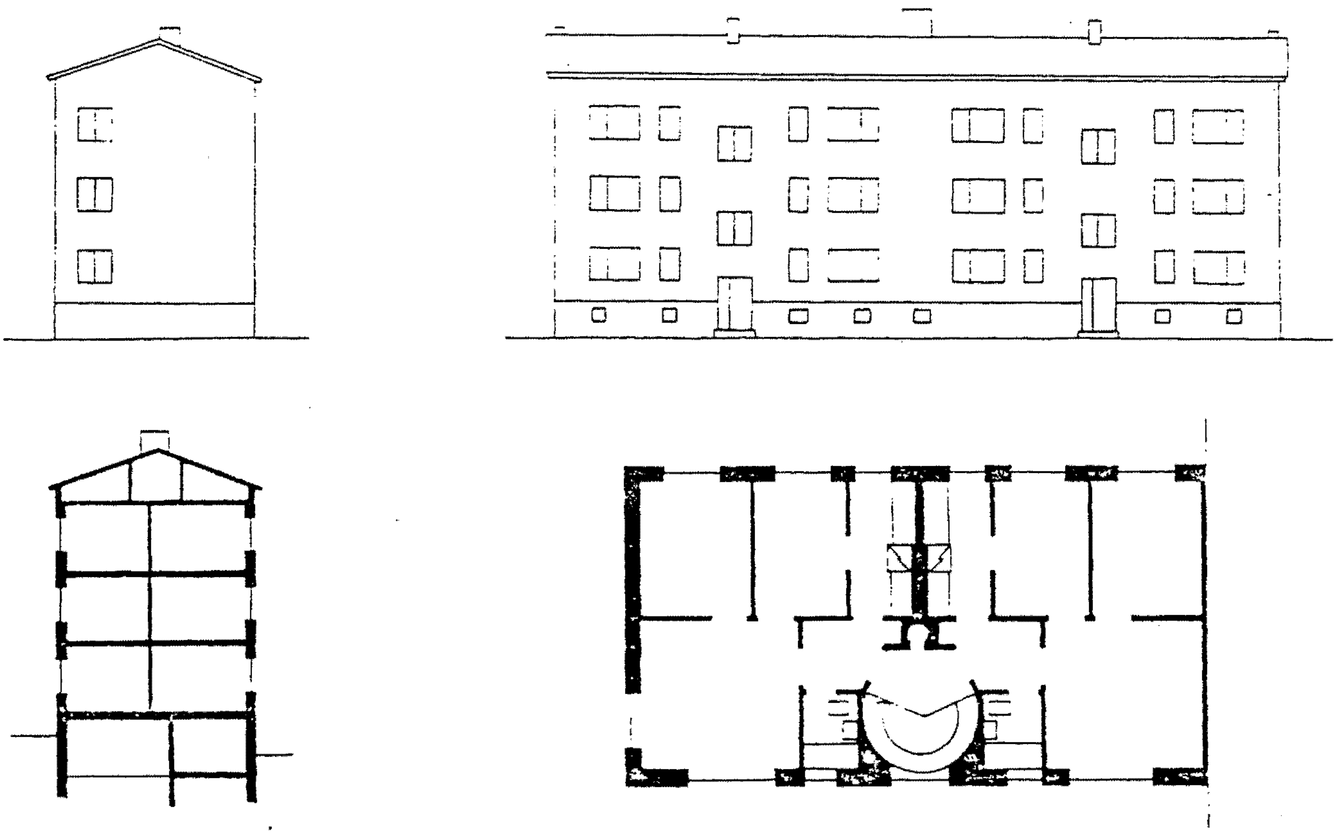
This paper briefly presents such a pilot project. The results of energy conservation measures in a group of typical three-storey block of flats built



The three blocks of flats in Stockholm, vintage 194[illegible], which have been the subject of a controlled renewal project with energy saving and better indoor climate in mind.

1940 at Ulvsunda - a Stockholm suburb - comprising around 100 dwellings, are set out within the scope of the project. It is worth noting that the size of a flat is very small, only about 45 m^2. The windows are of the usual double-glazed design and air change in the flats takes place through natural ventilation. Heating in this area is supplied by an oil-fired boiler plant. The results refer to a test period of three years.

The object of the investigation has been to determine energy consumption in existing buildings by means of calculations and measurements, and to analyse the effect and profitability of building services engineering measures taken in order to save energy.

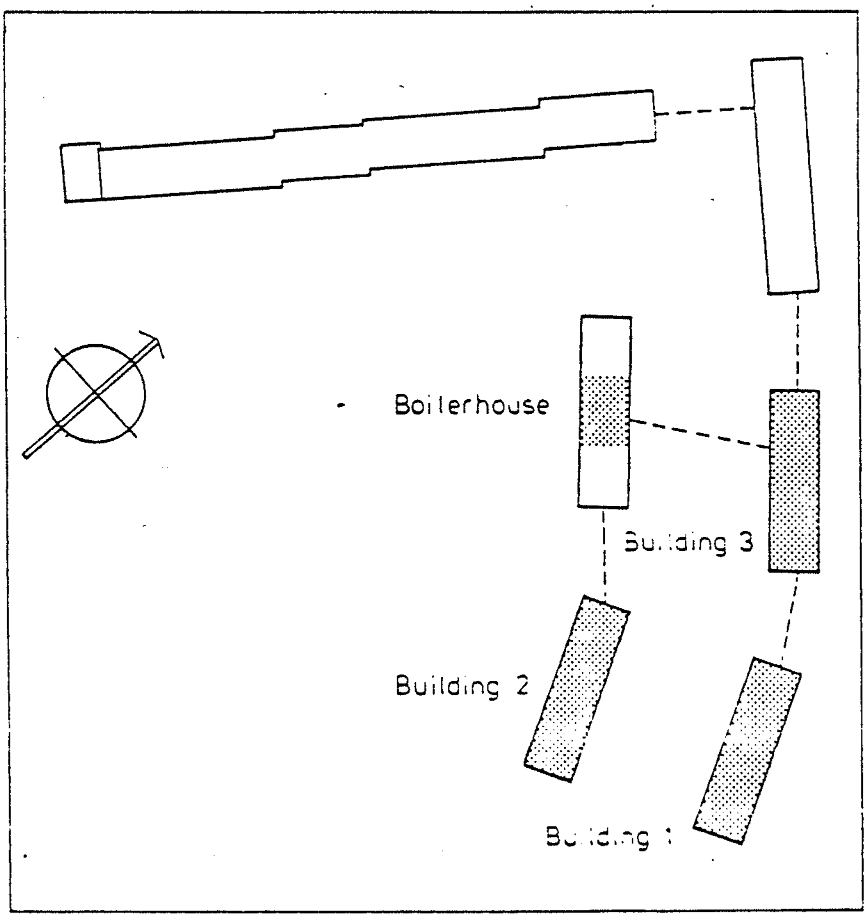


Floor plan, elevations and cross-section of the blocks studied.

The Ulvsunda-Project has been financially subsidized by the National Swedish Council for Building Research.

The flats in question

The Ulvsunda area is one of the areas comprising blocks of flats which were built in the suburbs of Stockholm in the thirties and forties. The intention was that these blocks should, in contrast to the compact housing areas in the centre of the city, provide good and helathy family dwellings. These dwellings would be light and sunny and would have through ventilation. The buildings were therefore made so narrow, 8-10 (12) m, that even



Site plan showing the four subjects of study. The full alterations scheme was implemented in Building 1, and parts of it in Building 2. Building 3 is a reference building and will be maintained in its original state throughout the study period.

small flats could be made through flats. From the energy point of view the shape factor is relatively unfavourable, since the envelope area is large in relation to the heated volume. In addition, the level of thermal insulation in the external walls and attic floors is low by Swedish standards.

The reason why this type of buildings was chosen for the investigation is that it represents a fairly common and uniform type which is also due for renewal and modernisation in the eighties. If improvements are made e.g. in thermal insulation along with these other alterations, the additional cost often proves to be relatively low. This type of buildings is therefore an importent target group. In Stockholm alone there are about 45.000 dwellings in buildings of this type constructed between 1934 and 1952.

Some results of the pre-study

Preliminary investigations for this project included an interview survey among those living in the area. One of the statements was that the opinions of the inhabitants concerning the indoor climate indicated very great variation. 30 % of the tenants considered that the standard of heating was satisfactory, 10 % considered that it was too warm, and 52 % that it was at times too cold. 21 % opened the windows because it was too warm, and 27 % used the gas oven as an additional source of heat when it was too cold. These differences indicated that the heating system was incorrectly adjusted.

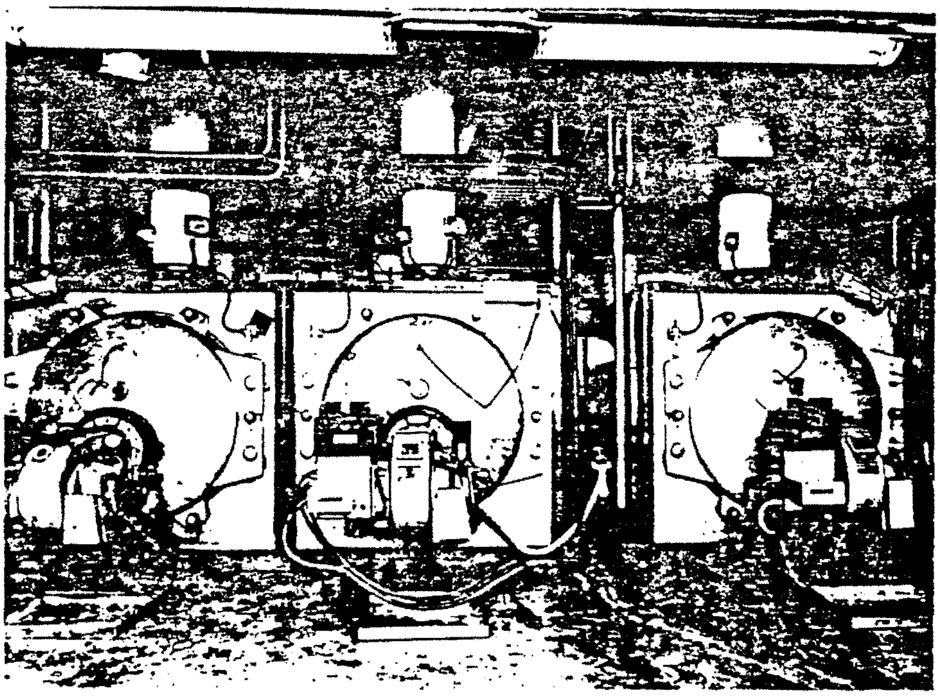
The interviews also showed that 69 % of the tenants were bothered by draughts, mainly from windows and the entrance doors opening onto the staircase. This indicated that the weatherstrips in the windows and doors were no longer performing satisfactorily.

At the beginning of the investigation, the oil consumption was high, about 60 litres/m^2. This figure can be compared to oil consumption in more modern buildings, which is 25-30 litres/m^2 floor area. Some of the reasons for this high consumption were touched upon above - unfavourable building shape, small flat area, low standard of thermal insulations in the walls and roofs, improperly sealed windows and doors, and shortcomings in the heating systems, such as uneven temperature distribution between different flats. These shortcomings were concealed by a high average room temperature which further increased oil consumption.

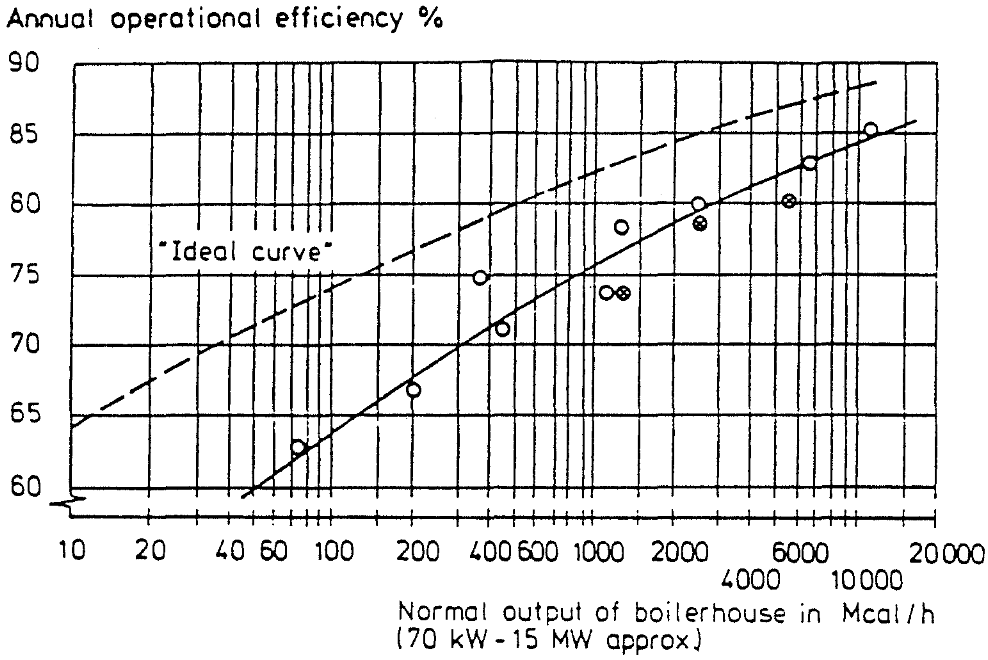
Different measures analysed

When the preliminary investigations had been completed, it was decided that the following measures would be taken in a first - now completed - three-year test period.

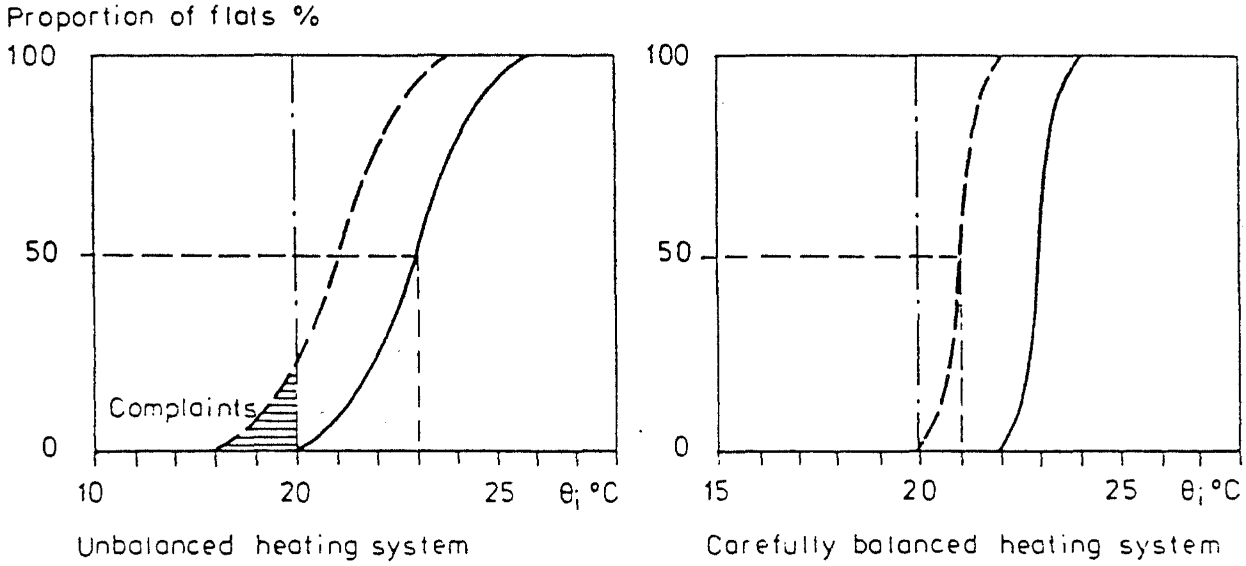
1. Improvement of boiler efficiency
(conversion of burners, e.g. fully modulating burner on one boiler, insulation of boilers, adjustment and regular cleaning of heating surfaces, improved regulation)



The oil-fired boilers.



Calculated annual operational efficiency levels based on tests of three different groups of boiler-houses plus the "ideal curve", compared to the normal output of the boiler-house. The difference in output is around 10 per cent for the area as a whole (1 000 Mcal/h corresponds to 100 flats).



Temperature distribution before (——) and after (---) a fall in temperature in a building with a heating system which has not been balanced and in a building with a meticulously balanced heating system. (Vertical axis: percentage of flats with a temperature of $<\theta_i$). 20°C is assumed to be the lower limit for complaints. When the heating system is incorrectly balanced, the temperature in the warmest flat can be as much as 25°C, while the temperature in the coldest flat is 20°C. A fall in temperature in such a case would result in temperatures below 20°C in a number of flats and lead to complaints. Careful balancing of the heating system makes it possible to reduce the difference in temperature between different flats to 1-2°C. The temperature in the coldest flats will then increase, thus rendering an overall temperature reduction possible.

2. Weatherproofing of windows and doors

   (replacement of old weatherstrips by more effective new strips made of materials of higher ageing resistance)

3. Adjustment of the heating system and reduction of indoor temperatures

   (replacement of radiator valves, installation of control valves, adjustment and temperature reduction)

4. Additional insulation of attic floor

   (insulation using mineral wool about 170 mm thick)

5. Additional insulation of external walls

   (insulation on the outside using a new method comprising 100 mm mineral wool and with rendering as facing material).

The first three of these measures may be regarded as improvements in operation, while the last two had the aim of reducing heating load in the buildings. Measure No 2, e.g. the weatherproofing of windows and doors, also has the same effect. In addition we also endeavoured to achieve a voluntary saving in domestic hot water consumption. The most radical measure, additional insulation of the external walls, was carried out in conjunction with the renovation of the facades which had become necessary.

The different measures were considered from the point of view inplementation, cost, financing and profitability.

Measuring systems

It was essential for the purposes of this research project that the effect on the consumption of energy of each individual measure and of all the measures taken together should be evaluated. This required a comprehensive programme of measurements and sophisticated instrumentation in order that the results may as far as possible be unambiguous and of general application. A large number of measuring instruments and sensors were installed in the buildings, both in those in which no conservation measures at all had been planned, and in dwellings in which different kinds of measures or combinations of these were to be carried out. A monitoring unit comprising meters and recording equipment was placed in the basement of one of the buildings. The installation had the capacity to take readings at hundreds of points every 15 minutes and thus to make possible accurate evaluation of the effect of the measures taken at different temperatures, wind conditions etc, during a number of heating seasons.

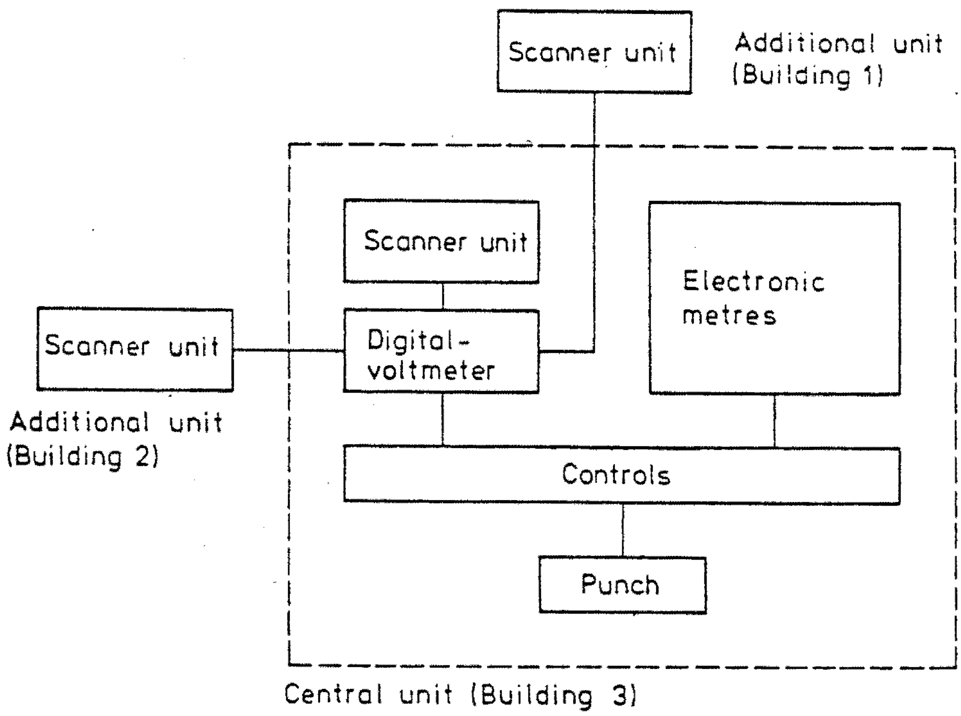


Diagram showing the structure of the measuring system. The central data collection unit in Building 3 and the scanners in Buildings 1 and 2 make it possible to record more than 15[illegible] readings.

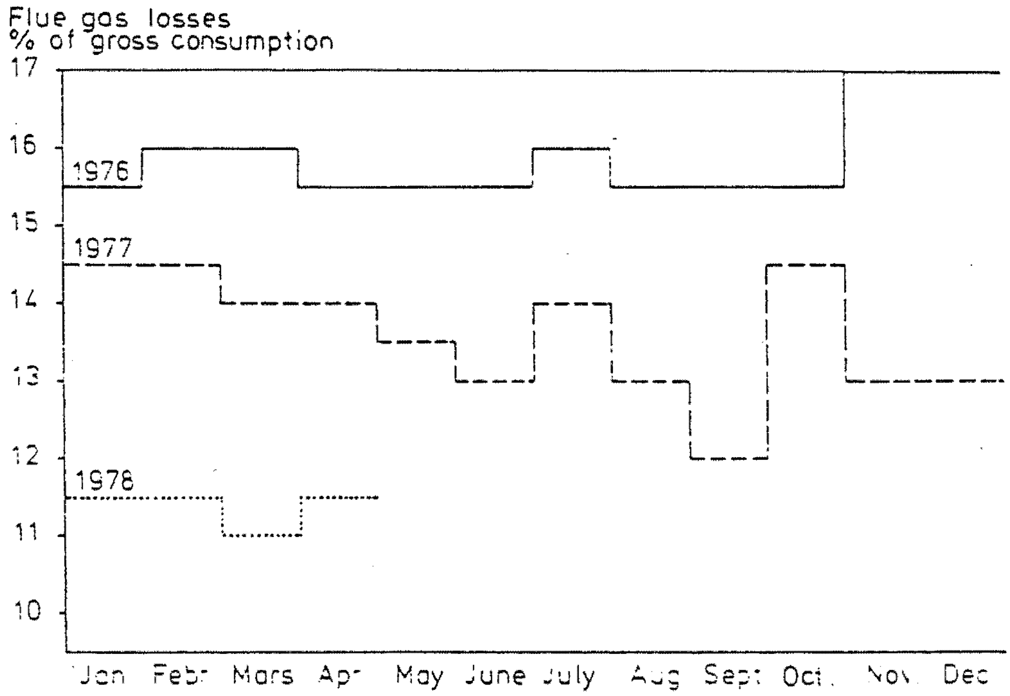
Some results

In one building where all five measures had been taken, a saving of 47 % has been achieved. Oil consumption has thus dropped from about 60 to about 32 litres of oil per m^2 of floor space.

The initially calculated saving in energy has thus been achieved without one of the initially planned measures, the installation of hot water meters, having been necessary. It has also been possible to verify in practice in all essentials the effects of the various measures.

With respect to the *energy conservation effect* of the five measures, they can be ranked as follows:

1. additional insulation of external walls
1. weatherproofing of windows and doors
2. adjustment of the heating system and reduction of temperature
2. additional insulation of attic floors and
2. improvement of boiler efficiency.



Flue gas losses. Average values per month during the test period. The flue gas losses have been reduced by about 4.5 % from 1976 to 1978.

The economic result of the various measures has also been calculated. Since the research project was being planned, oil prices have risen at a faster rate than the other relevant costs, and have now passed Skr. 1200 per m^3. All the measures taken are profitable. Even such a costly measure as the new and relatively complicated method chosen for additional insulation of the external walls - rendering as the surface material was to be retained in view of the character of the surroundings - is justifiable.

On the basis of *profitability*, the following ranking of the measures taken may be made (with respect to energy subsidies and energy loans):

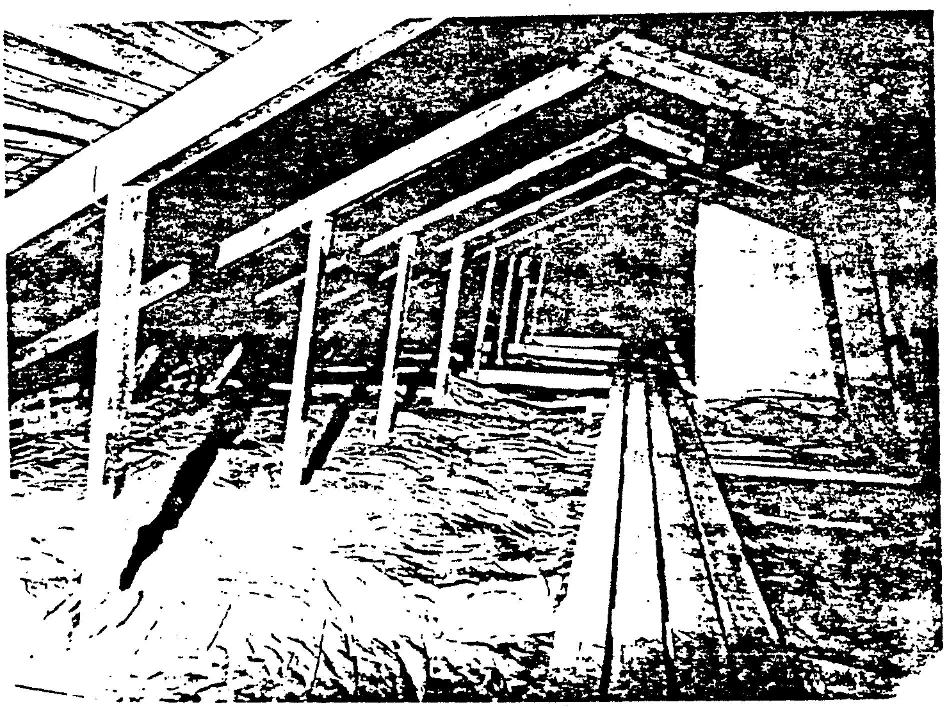
1. additional insulation of attic floors

1. weatherproofing of windows and doors

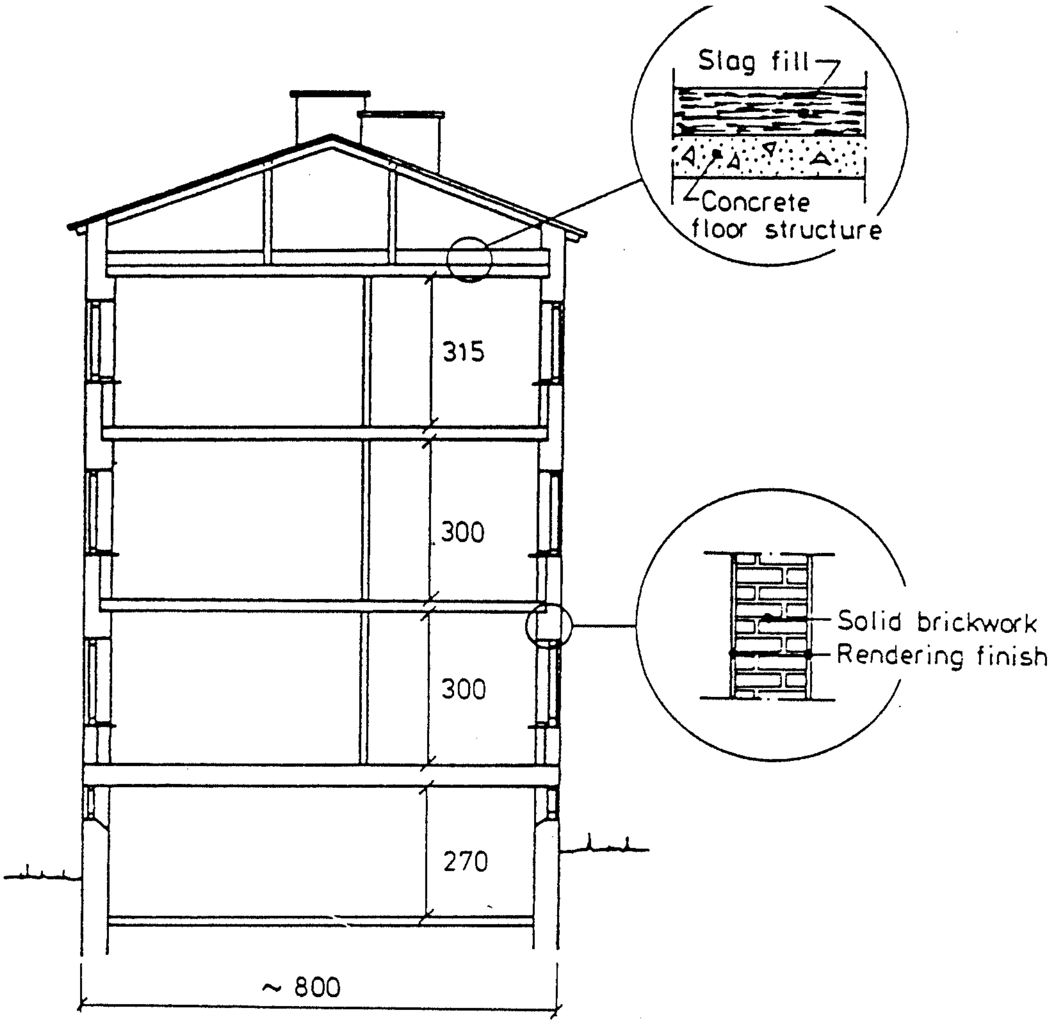
1. adjustment of the heating system and reduction of temperature

2. improvement of boiler efficiency and

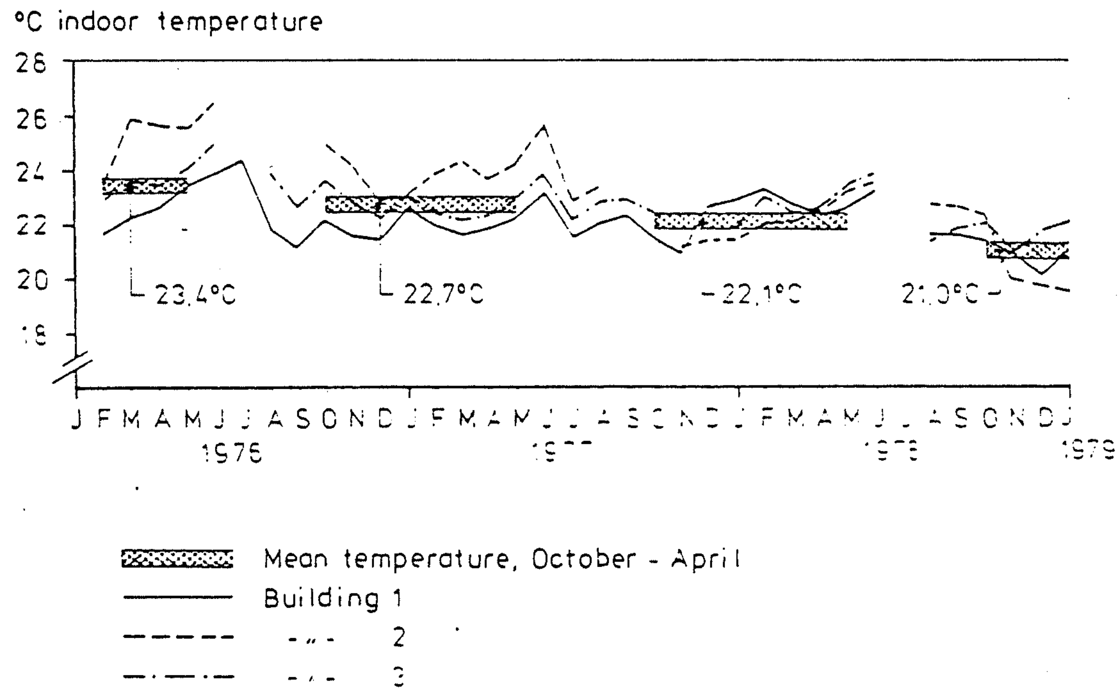
2. additional insulation of external walls.



Extra insulation in attic.



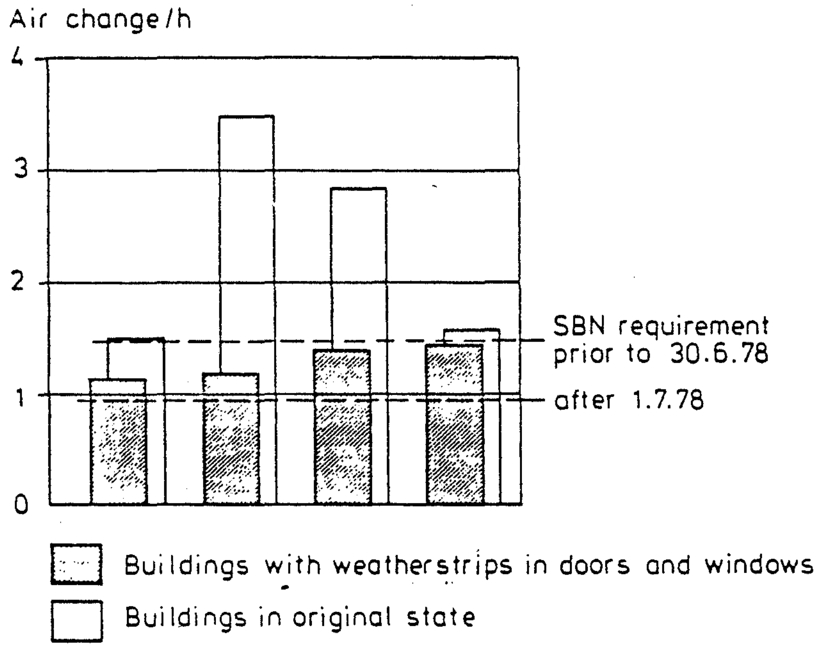
Cross-section.



It has been possible to make an average reduction in temperature of 2.4°C. This reduction would be higher when all buildings have been given extra insulation of external walls.

Air changes, radon, radon daughter products in four flats after installation of new weatherstrips in windows and doors.

Flat	Air changes/h	Room	Radon gas		Radondaughters	
			Bq/m^3	pCi/l	Bq/m^3	pCi/l
1	0,49	sitting room	75	2,0	27	0,7
		kitchen	75	2,0	32	0,9
2	0,60	sitting room	68	1,8	35	0,9
		kitchen	116	3,1	39	1,1
3	0,53	sitting room	59	1,6	34	0,9
		kitchen	57	1,5	28	0,8
4	0,33	sitting room	99	2,7	43	1,2
		kitchen	118	3,2	47	1,3

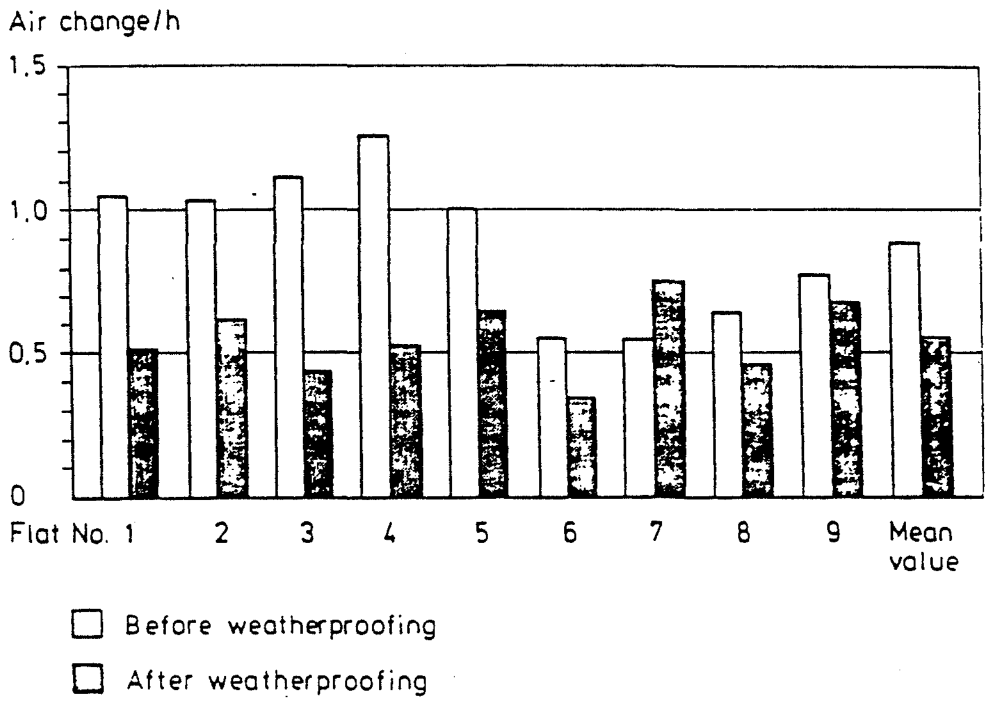


Air changes/h determined at an outdoor-indoor pressure difference of 50 Pa for four flats before and after installation of new weatherstrips in windows and doors.

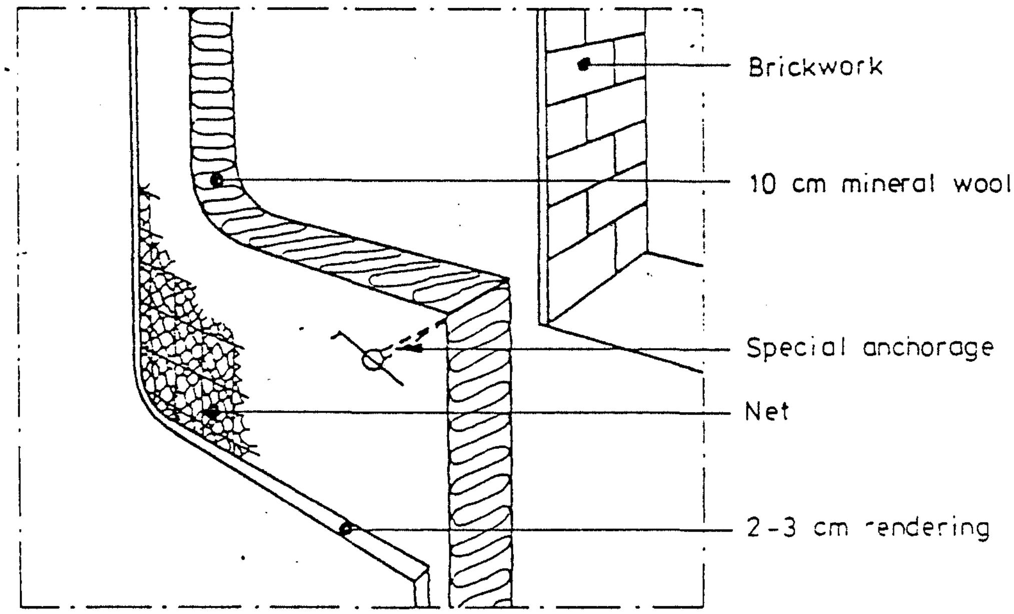
On average, air leakage was cut from 2.3 to 1.3 air changes/h (note that these air change rates are not directly comparable with those determined by the tracer gas method).

The voluntary saving in domestic hot water comsumption has also resulted in some saving in energy.

By taking further measures which appear profitable in view of the steep rise in oil prices, it should be possible to reduce oil comsumption to about 25 l/m^2. In stage II the basement floor will



Result of air change rate determinations before and after mounting of weatherstrips in a test building at Ulvsunda. On average, the air change rate was reduced from 0.90 to 0.53 change/h. (Malmros & Sahlin, 1977).



Method of additional insulation of external walls, Building 1.

namely be provided with additional insulation, the windows will be converted to triple glazed windows, and further adjustment of the heating system will be carried out.

Some conclusions

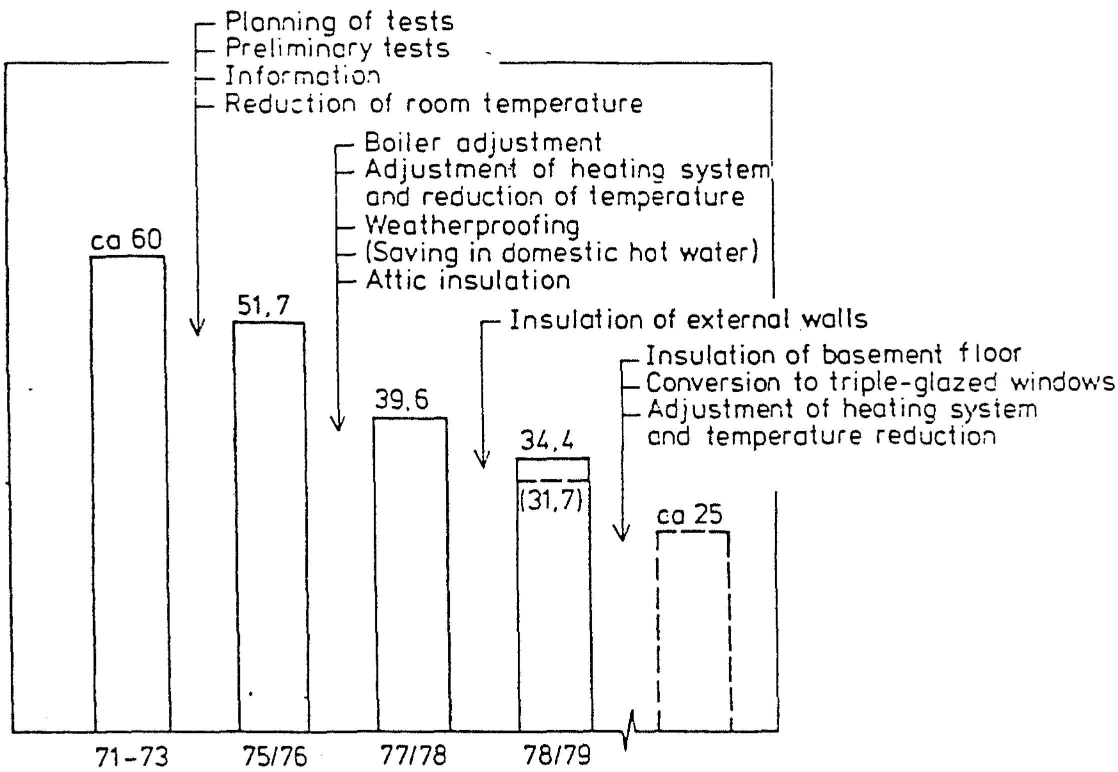
However, in order that the best effect may be achieved with regard to both energy conservation and an improvement in indoor climate, the building technology and building services engineering measures must be coordinated. Experiences gained in the Ulvsunda-Project show that an appropriate strategy for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

1. improvement of boiler efficiency, additional insulation and weatherproofing
2. adjustment of the heating system and
3. reduction of temperature.

A reduction of temperature in a building where the heating system is improperly adjusted does not result in a permanent reduction of 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 of temperature, even if taken in combination with accurate adjustments, result in permanent reduction of temperature in buildings if the building technology shortcomings in the form of a low thermal insulation and weatherproofing standard are concealed by giving the room air a high mean temperature. The tenants will not accept the deterioration in comfort.

The Ulvsunda investigation also shows that building technology measures 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 all the saving in energy which the measures had been intended to achieve will not be attained.

In conclusion, it must be pointed out that one of the most effective measures was the simple one of replacing the weatherstrips in the naturally ventilated 1940s buildings. On average, the number of air changes per hour dropped from 0.9 to 0.5. Pressure testing prior to the installation of new weatherstrips had shown that air leakage occured at the windows, while testing after the measure showed that the airtightness of the building had increased by about 40 %. Now it thus has an airtightness of the same order as that required in new buildings in Sweden. After weatherproofing, the concentration of radon daughter products is less than the provisional threshold value prescribed for new buildings. To our knowledge, there are no more complaints relating to direct draughts, i.e. there has been a palpable improvement in indoor climate. A further improvement in indoor climate can be expected when the measures in test period II have been taken.



Summary of the results of energy conservation measures at Ulvsunda during the first three-year period, expressed in terms of normal annual consumption, l/m². For 1978/79 the oil consumption has been calculated on the basis of results for Building No 1. The bar drawn with dashed lines indicates the results expected in stage II.

REFERENCES

Höglund, I & Johnsson, B, Byggnadstekniska och installationstekniska åtgärder för energibesparing i äldre byggnader. Meddelande nr 108. Stockholm 1976.

Höglund, I & Johnsson, B, Energy saving in existing housing. Building Research and Practice May/June, London 1977.

Höglund, I, Johnsson, B & Lagerström, J. Ulvsundaprojektet - resultat av energisparande åtgärder i befintlig bebyggelse. (Institutionen för byggnadsteknik, KTH), arbetsrapport Stockholm 1979.

Höglund, I, Johnsson, B & Lagerström, J, Ulvsundaprojektet. Effektivare energianvändning i äldre byggnader - etapp I. (Byggforskningen). T5:1981. Stockholm 1981.