Commission of the European Communities

energy

Feasibility of a European model code for saving energy in space heating

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1) page VII, Préface de la Commission, dernière ligne, lire 1990 au lieu de 1980.

2) page 20, après 1er alinéa, remplacer $S = S_i$ par $S = \Sigma S_i$.

3) page 185, paragraphe 1.3, premier tiret, quatrième ligne, lire moyennement au lieu de moins.

4) page 199, paragraphe 3.1, 1er alinéa, dernière ligne, lire 9 juin 1980 au lieu de 9 mai 1980.

5) page 238, Annexe II, paragraphe c, première ligne, lire $(W/m^3\ {}^oK)$ au lieu de $(W/m^3\ {}^oh)$.

6) page 238, Annexe II, paragraphe G_2, 2ème ligne, lire $(W/m^3\ {}^oK)$ au lieu de $(W/m^3\ {}^oh)$.

7) page 239, Annexe II, 3ème alinéa, lire $(W/m\ {}^oK)$ au lieu de $(W/m\ {}^oh)$

Microfiche is already corrected.

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Feasibility of a European model code for saving energy in space heating

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PREFACE

The greatest challenge now facing the Community since it was set up is without doubt to ensure that its Member States have sufficient supplies to cover their energy requirements, not only so that they can hold their own against international competition, but also to preserve and reinforce the economic and social advances made over many decades.

One of the first tasks of the Community Institutions, and the Commission in particular, is to establish whether it is possible or how needful it would be to harmonize national energy saving policies, especially as regards the use of energy for domestic purposes and, above all, for space heating, which is the largest sector of energy consumption.

In this study the authors once again demonstrate that the potential savings in the heating sector are a real source of energy in themselves, representing between 8 and 12 % of total current primary energy consumption. This is far from negligible.

Since the first oil crisis virtually all the Member States have had to take energy-saving measures, albeit with varying degrees of intensity.

Although very effective at national level these measures differ widely and much more so than can be justified by differences in climate or energy prices within the Community. In addition, because they are not always applied as strictly as they should or could be, the Community does not demonstrate solidarity or a desire to form a united front in the fight against the shortage and rising price of energy.

In many Member States, such measures are embodied in unrelated laws which do not form a coherent whole.

Hence, it is not always easy to assess objectively whether there is a real convergence of policies, it is also true that a basic stock of common concepts is required for the requisite evaluations and comparisons

For this reason the Commission considered it would be useful to carry out a feasibility study of a European model code. The reader cannot fail to be impressed by the efficacious way in which the authors of the report have carried out their task.

Although the idea of a model code fits in perfectly with the Council Resolution of 9 June 1980 concerning new lines of action by the Community in the field of energy-saving (OJ N° C 149 of 18 June 1980) and in particular its Annex (guidelines for a basic energy-saving programme recommended to every Member State) and even though the Commission intends to improve this model, it does not plan for the moment to initiate any procedure leading to the adoption of a binding legal instrument.

The methodology worked out by the authors not only enables us to assess the feasibility of a model code - which is undoubtedly an important, if not indispensable, factor in ensuring convergence of policies - but also provides a unique and systematic way of cataloguing the requirements for a rational achievement of optimum energy-savings in the building sector.

These requirements concern not only calculation methods, standards, any legislation, studies or research but also measures in industry and their social and economic effects, in particular redeployment of industries and employment.

The "inventory" part of the study will provide a basis for formulating a cohesive action programme. It will also serve as an instrument for defining and making the best use of the many projects, particularly R&D projects, which have already been undertaken or are in progress within the Commission. These can then be utilized to prepare the next stage which is to help achieve the energy policy objectives set by the Community for 1990.

NOTE TO READERS

The authors of this report consulted the following experts :

Mr James B. DICK (Consultant)

Mr Salvatore MARTORANA (Prof. Dott. Ing.)

Mr RANG (Director of Bouwcentrum)

Mr J. UYTTENBROECK (Ingénieur Civil des Constructions, Head of Division Building Physics and Equipment, CSTC)

Mr OLIVE (Ingénieur Civil)

Mr Oele JENSEN (Master Sciences in Mechanical Engineering)

Although they have benefited from their collaboration they have not been able to follow their advice on all points, and the following report is solely the responsibility of the two authors named.

CHAPTER 1

Energy consumed in space heating of buildings

1.1 INTRODUCTION

The realisation that conventional natural resources are limited, and the actions of the non-industrialised countries that own what is for the present an essential part of these resources, have resulted in the industrialised countries being faced with the challenge of supplying the energy necessary to maintain and expand productive activities while at the same time preserving the main comforts and amenities of life to which their populations are accustomed.

The natural limitation of conventional resources should lead to their being used in accordance with the size of the reserves, and to the use of alternative resources. The facts of the problem that faces us in this context are fairly well known, and we have several decades in which to solve it.

The actions of the countries that own these energy resources are unpredictable. The same is true of the domestic or international conflicts that may cut off energy (and especially oil) supplies.

The time scale for this second aspect of the problem is no longer a matter of a decade or even a year, but in fact the few months for which European stocks will suffice.

Although the authors of this report do not intend to discuss global energy problems, the problem of saving energy when heating buildings must be placed in its context.

The consequences of the limitations and threats that affect our energy supplies are of different kinds : the scarcity of a product and the fear of being without it cause its price to rise. To the final consumer, this increase is a tribute which he pays to his suppliers. He is prepared to take any steps (economic steps, that is) with a view to reducing this expense.

For the energy-importing countries these individual tributes add up to a national tribute paid to the energy-exporting countries in foreign currency. This creates a balance-of-trade problem. And from this point of view, uneconomic measures in local currency could be considered if they stem the outflow of foreign currency. This is of course a move in the direction of autarchy with the economic snags it involves, especially the danger of a fall in national productivity, but which has the advantage of not linking the energy supply to the volume of exports, which are hazardous as well as being subject to capricious circumstances, being destined as they are for unstable countries.

The final consequence of the present economic situation is not material but real, namely the threat of being deprived of energy ; and for a country this means the threat of an economic collapse that would no doubt be disastrous. To the private individual (in the sphere with which we are now dealing) this means the danger of having a very cold home next winter. To prevent this (or at least to lessen the shock) countries and individuals should be ready to take steps at any cost. This is a conclusion of the same order as the previous one, but more absolute. In this case exports which create foreign currency cannot pay for imports of energy which would be purely and simply denied to us.

These three considerations (profitability in local currency, profitability in foreign currency, and contribution to self-sufficiency in energy) should govern the examination of measures that might be envisaged for dealing with the energy crisis in the sphere of heating.

The following corollaries can be drawn from these considerations :

The countries' reaction to the challenge to their energy supply leads them to develop economy devices and alternative resources, thus creating a new economic activity ; in the case of internal profitability, it is a development of activity, a growth, with a reduction in overall energy consumption.

If the activity is not profitable internally, but is so as regards foreign currency, productivity is reduced but the effect on national consumption is no worse than that which would result from the tribute paid to the outside producers, and the country gains independence.

Another corollary is that the more independence the consumer countries gain, the less they are exposed to the threat of scarcity : si vis pacem economicam, para bellum economicum.

The energy consumed for heating buildings and other domestic purposes constitutes the greater part of the energy consumed in the Community countries (cf. annex I) : 332 million tonnes oil equivalent in 1978, or 35% of the total. Heating proper accounts for between 70 and 75% of this amount.

A secondary characteristic of the consumption of energy for heating is that it is low-temperature energy. The purpose is to heat the air and the walls of a building to about 20° C. It is very deplorable that to do this we should consume "high grade" energy capable of producing higher temperatures, or destroy complex molecules that can be used to produce materials or foodstuffs. This remark should lead to the establishment of balances expressed not only in money and calories, but also in joules at a given temperature.

A primary characteristic is the ease with which we can (on paper, at least) make huge savings : in what other sector of energy consumption do we know of technically feasible (if not economic) solutions capable of fuel savings of 70%?

Another characteristic is that the heating of buildings is a very "elastic" requirement. People can manage with a very low level of heating. They did so until the 20th century. There are still great differences within the same country, even if it is a developed country. In the event of a serious energy shortage, it is certainly the sector in which the allocations of fuels such as oil or coal would be the smallest, because these reductions would be bearable.

The last characteristic to be mentioned is the extremely dispersed nature of energy consumption for heating purposes, for heating is still very rarely provided by urban district-heating installations, but in the main by one family (or even one room) at a time. Hence the application of energy-saving measures in Europe would affect millions of families.

To sum up, heating energy is not a vital requirement at its present level, its consumption is very dispersed, it is consumed at low temperature, and considerable savings are possible.

Private individuals affected by increased fuel costs try to reduce their expenditure by taking steps that are profitable in national currency. The fear of shortages ought to induce them to ensure their independence without considering profitability, but there is little sign as yet of this reaction.

It is in fact up to the States to ensure that the standard and quality of life of their people are safeguarded, both by enabling them to provide hygiene and comfort in their buildings and by helping to ensure that energy is available in sufficient quantity for the national product to increase rather than to decrease.

However liberal and non-interventionist a government may be, it must clearly intervene to achieve these aims : and this derives from two circumstances.

The energy problem is global, and its solution goes beyond the sphere of private interests, however great they may be : it is only the people as a whole (i.e. the State) that can press for savings of oil in heating so that the oil can be available for, say, transport or the petrochemical industry.

The solution of the problem calls for advance action that private individuals cannot reasonably take : for instance, taking the necessary steps to cushion the shock of a general oil embargo, or those needed to supply our industries several decades hence (when some resources have been exhausted) calls for unprofitable investments in production plant, stockpiling, research and more or less pleasant measures for saving and restricting which the machinery of a free market could never achieve.

It is also a task for governments to speed up the reactions of private individuals.

Hence the intervention of governments and States is indispensable, and has occurred everywhere. It can take very varied forms : mandatory requirements, tax incentives, financing facilities, propaganda, etc. Annex II of this introduction contains a tentative list of the steps that governments have taken or can take.

Governments are thus obliged to intervene in the solution of the problems posed by the energy crisis, and especially in the field of the heating of buildings.

But what about Europe?

Should it intervene?

And if so, how?

Europe has several good reasons for intervening in the field of energy saving in general and of heating in particular :

- The abolition of the technical obstacles to intra-Community trade is very useful in developing production of the new appliances used for regulating heating systems, for using conventional energy, etc., and of insulating materials or products. Very often these are new products whose development requires a large market. This is the very raison d'être of the Common Market.

- The existence of Community standards and rules or of national standards and rules based on Community models has a "driving force". It is possible to see how one's own efforts compare with those of one's neighbour, to make the measures more tolerable, and possibly to create a certain spirit of competition. This report tries to show how these standards and rules can be harmonised.

The Member States would no doubt render the greatest service to their harmonisation by equipping themselves with two common tools in this context.

The first is a rule (or rules accepted as equivalent) for calculating the energy needed to heat a given building in a given climate. The study in annex III to this introduction considers the establishment of such a calculation rule or rules.

The second is the means of determining the effect of a given measure in one of the Community countries, and the relevant cost. The cost and effect of building insulation has been studied in depth. It would obviously be necessary to be able to determine the same factors in respect of all the various kinds of measures. This is tackled when each measure is examined. But the determination of the cost and effects assumes the compilation of an inventory of the stock of buildings of the country according to an established system of classification, taking specific account of the characters of the buildings concerned by the measure. It is not within the scope of this study to establish such inventories. An effort will however be made "in fine" to determine these characteristics and their value.

When the means exist for determining on comparable bases the effects of a measure in each country, the effect of the measure on the Community would be calculated by adding the individual figures together. This operation will be useful in determining the Community energy policy.

- The national measures can then be harmonised by establishing in each country an energy policy based on a common model suggested by the Community. (Denmark is a case in which such a policy has been established). Objectives supported by facts and figures would form an essential part of it.

It is to this harmonisation that the "model code" which is the main object of this report is intended to contribute. This "model code" may be regarded as a collection of measures from which the countries would choose those they considered most useful, in the order appropriate to local circumstances.

The word "code" should not incidentally give rise to the idea that all the measures must be enforced by legislation : this is a question of national custom, and the same measure might be mandatory in one country, but be encouraged by grants and publicity campaigns in another.

- The Community may consider going beyond the harmonisation of the national policies : it may envisage a Community energy policy for heating. It would be based on the affirmation of the solidarity of the Member

States in view of the imbalance between Community resources and needs, and might involve resource-sharing, compensation for investments, a Community tax, etc.

The actual harmonisation of the energy-saving efforts of the Community countries, and even more so the existence of an internal heating energy policy, would place Europe in a better position in its discussions with the supplier countries.

The foregoing shows that it is worthwhile for the Community to consider what action it can take in the sphere of space heating.

The object of this study is to review the various measures for reducing heating energy requirements or for satisfying them from European or unrenewable sources, and thus to arrive at a draft European model code and other conclusions regarding Community action in the sphere of standardisation and research.

This report takes the form of a series of memoranda, in each of which a means of saving is examined. They are as listed below :

o <u>Reduction of heating energy requirement</u>.

- 1.1. Limitation of heating temperatures.
- 1.2. Limitation of heating period.
- 1.3. Limitation of ventilation.
- 1.4. Fixing the fuel allowance.

1.5. Pricing as a means of saving fuel.

o Measures regarding buildings and their installations.

2.1. Geometry of buildings.

2.2.a. Improvement of insulation.

2.2.b. Insulation of new buildings.

2.3. Control - Metering.

2.4. Heat pumps - Exchangers.

2.5. Operation - Maintenance - Boiler replacement.

2.6. Recovery of heat from waste hot washing water.

2.7. Urban heating - Combined production of heat and power.

o Substitute energies.

3.1. Passive solar energy.

3.2. Active solar energy.

3.3. Geothermal energy.

3.4. Renewable fuels.

Each memorandum is divided into the following sections :

1. Examination of the substance of the proposed economy measure.
2. Cost and effectiveness of the measure.
3. Limitations of the measure, particularly because of its effect on the satisfaction of the user's other requirements.
4. Application of the measure to existing and/or new buildings.
5. Industrial and commercial consequences.
6. Current use made of this measure in the Community countries.
7. Proposals for Community action.

As far as possible, point 2 has been subdivided under the following headings : cost, time scale, chances of success, effectiveness.

These memoranda are followed by a recapitulation of the findings regarding the feasibility of the various measures considered.

Next come the proposals and conclusions, comprising :

- a statement of the reasoning behind a model code of measures for saving heating energy in buildings ;
- a discussion of the provisions of the model code ;
- subjects of Community interest suggested for discussion : Community policy, standardisation and research.

The report ends with an annex containing a draft model code.

ANNEX I TO THE INTRODUCTION

Energy consumed by the European countries to heat buildings

(as a proportion of total consumption)

		B	DK	D	F	I	IRL	L	NL	UK	Eur. 9
Energy consumption MTOE (1)		45	20	270	190	135	8	4	65	210	947
Consumption in residential and service buildings (2)	MTOE	15	8.5	100	65	40	3.2	0.6	25	75	332.3
	%	33	42.5	37	35	30	40	15	38	35	35
Number of dwellings x 10^6 (3)		3.2	1.8	21.3	18.1	17.5	0.7	0.1	2.9	19.3	84.9
New buildings x 10^3 (3)		73	35	375	450	170	-	-	110	280	1493
Rate of renewal of stock of buildings %		2.2	1.9	1.8	2.5	1	-	-	3.8	1.45	1.75

(1) Source OECD - 1978 figures.

(2) Source OECD. The exact proportion for heating purposes in this consumption is not known. In France, it is between 70 and 75 %.

(3) Source : International European Construction Federation, 1977.

ANNEX II TO THE INTRODUCTION

of courses of action that governments have used or can use :

- o recommendations
  and propaganda (especially by means of the mass media) ;

- o financial incentives :
  - financing facilities for manufacturers creating products favourable to energy saving ;
  - grants, subsidies and credit facilities granted to owners who install energy-saving equipment ;
  - tax relief granted as above ;

- o legal provisions to encourage tenants to carry out energy-saving work ;

- o statutory obligations.

1.4 ANNEX III TO THE INTRODUCTION

Harmonised rule for calculating the consumption of a building from plans

The methods of calculating the heating consumption of a building may be placed in two categories :

- "manual" methods for technicians of a lower level of qualification than graduate engineers, or methods using minor computer programmes involving short machine times. In other words, "cheap" methods ;

- more complex methods using numerical calculation techniques and calling for major programmes.

For a variety of reasons, the method(s) to be recommended for use at Community level should be of the first type.

- Firstly, the simplicity and low cost militate greatly in favour of their widespread use throughout Europe.

- Secondly, in the present state of knowledge, methods of the second type are unlikely to be capable of general application to all cases and to all forms of buildings. For certain configurations they can solve such complex problems as the calculation of energy consumption under transitional conditions, but are ill-suited for calculating overall consumptions for a heating season. The development of data processing will certainly enable reliable methods to be devised, but we do not think that that stage has yet been reached.

- Lastly, it is not reasonable to seek undue precision, in view of the fact that no method can take account otherwise than statistically of one of the main factors, namely the human factor. Precise consumption calculations can be made by assuming optimum use of the building, but the real consumptions necessarily vary according to the behaviour of the occupants. Thus during a series of measurements carried out during two seasons by the Bouwcentrum of Rotterdam, Messrs. TAMMES and VAN BREMEN recorded respective consumptions of 0.61 and 2.01 m^3 of gas per degree/day for two flats of identical characteristics. According to the authors, there is no explanation for this ratio of 1 : 3.3 other than the behaviour of the occupants.

This does not of course lead us to the conclusion that a calculation method is useless, but that the problem is not capable of a high-precision answer.

What we shall try to calculate is the consumption of a building in "normal" use. Each user should be able to refer to this consumption to see if he is using his heating installation normally.

In accordance with the conclusions of CIB W 45* we shall direct our efforts towards defining and calculating a coefficient C which is the energy to be expended per cubic metre of building and per hour to maintain a permanent difference of 1°C between the inside and outside temperatures. This coefficient C should be calculated to take account of the average free solar and domestic gains, of the average changes of air, and of the average effect of the heat-recovery devices and heat pumps.

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*CIB W 45
Working Group 45 "Human Requirements" of "The International Council for Building Research, Studies and Documentation".

The European experts consulted unanimously acknowledged the expediency of considering such a coefficient, provided one knew how to calculate it reliably. It was accepted as preferable to calculate losses per m^3 of volume rather than per m^2 of shell or floor surface, when one takes account of such values as air changes and heat recovery.

Be that as it may, in order to calculate this "coefficient of thermal performance of a building" we have to calculate its energy expenditure for a standard use, and to do this we have to consider several factors :

- losses by transmission and changes of air ;
- "free" heat* of solar or domestic origin, or from heat-recovery appliances ;
- the supply of heat by the heating installation.

The difference between the first two amounts gives the heating requirements The study of the heat supply enables us to proceed from these requirements to the consumption of energy by way of considerations of efficiency.

* The word "free" is liable to cause confusion : free heat is heat obtained without the expenditure of energy (or at least the equivalent of energy). But it is not by any means always free as regards money : substantial investment is often necessary to obtain it. Thus solar or geothermal heat are free from the energy point of view, but certainly not from the money point of view.

The problems of the efficiency of appliances are technical problems which the heating people have fairly well under control. On the other hand, when calculating heating requirements one needs more exact methods than those used hitherto.

1.4.1 CALCULATION OF HEATING REQUIREMENTS

Scientific knowledge provides the basis for such a calculation, but the establishment of formulas for the purpose is not very easy.

1.4.1.1 In steady conditions, losses by transmission Dt through walls per hour and per degree of difference between the inside and outside are equal to :

$$Dt = \sum Ki\ Si$$

where Ki is the transmission coefficient of each wall in W/m2°K, and Si the surface of the wall.

Harmonisation of the calculation of these transmissions requires first of all agreement on the coefficients of transmission of the various materials ; it is then necessary to determine the various Ki values to take account of the thermal weak points as well as of the effect on those coefficients of the variations in surface exchange coefficients in the various possible wall positions, including such particular cases as floors laid over voids and under ventilated roofs.

ISO TC 163 (Thermal insulation) is working on this kind of harmonisation.

From the coefficient Dt one can derive :

. the coefficient of mean surface loss by dividing Dt by the total loss surface S :

$$Km = \frac{Dt}{S} \quad (W/m2^oK) \quad \text{where } S = \sum Si$$

. or a coefficient of mean volume losses, by dividing by the volume V of the building :

$$G_1 = \frac{Dt}{V} \quad (W/m3^oK)$$

(we shall continue to use these terms in the report, especially in memoranda 2.2.a and 2.2.b).

1.4.1.2 <u>Losses by ventilation</u> are characterised by the loss Dv in respect of a difference of 1° between the inside and outside air.

$$Dv = 0.34\ N.V. \quad \text{in } W/^oK$$

where N = rate of change of air per hour
V = volume of building in m3.

What is N? We know its regulation value in new buildings. This does not mean that the actual value will be the same. Its value is unknown in old buildings. Over a period of one year, it can vary on average from 0.3 vol/h in dwellings that have had all their apertures draughtproofed, to more than 1 vol/h.

Agreement would be necessary on the values of N to be taken into account for the purpose of harmonising the calculation of the heating requirement.

One may then consider the volume coefficient of loss by change of air :

$$G_2 = \frac{Dv}{V} \quad (W/m3^oK)$$

The sum of the coefficients G_1 and G_2 (which we shall call G) is the volume coefficient of total loss from the building in steady conditions.

Let us repeat at this point the items so far encountered on which Community agreement would be necessary :

- value of the thermal conductivity of building materials in their conditions of use ;
- choice of a common rule for calculating the transmission coefficients of building components, taking account of thermal weak points, including windows and other glazing ;
- common rule for calculating the average transmission coefficient of the shell of a building ;
- values of the rates of change of air used in the various types of building.

If agreement is reached on these points (several of which are currently the subject of international standardisation work), it is possible to calculate the various values of K and G according to a common rule.

1.4.2 HEATING REQUIREMENT

In a steady state without taking account of the solar and domestic free energy gains (i.e. if variations in outside and inside temperatures, solar radiation, etc. were slow compared with the inertial characteristics of the building) the heating requirement would equal losses :

$$D \text{ annual} = G.V. \int_{\text{heating year}} (Ti-Te)\, dt$$

which is currently expressed by :

$$D \text{ annual} = G.V.24.DJ \quad (10^{-3} \text{ kwh})$$
$$\text{or} = G.V.DH \quad (10^{-3} \text{kWh})$$

where DJ and DH are degree-days and degree-hours at the site considered.

In the hypothesis of negligible inertia, these are true or natural degree-days or degree-hours, i.e. they are calculated on the basis of real inside temperatures.

To proceed from these losses in steady conditions to real losses, and then to the heating requirement, account must be taken of the inertia of the building and of the free energy gains (i.e. those not derived from energy consumed in the heating installation) and solar energy gains.

The practice hitherto has been to take account of the internal free gains by reducing the inside temperature used for calculating the degree days by a given number of degrees. This ties up with the concept of the "inside calculation temperature" which is several degrees below the required temperature.

One can take account in the same way of the solar gains, e.g. by increasing the outside temperature used to calculate the D.J.

These adjustments of the D.J. are only rough, since they do not take account of the characteristics of each building or their intended purpose, which factors cause the free energy gains to vary considerably : and the better the insulation of the building, the greater the effect will be and it may even be 30 % of needs.

The value of free gains depends in particular on the following parameters, apart from the factors that govern the recovery of solar heat :

- the thermal inertia of the building ;
- the inertia of the heating bodies ;
- the control system ;
- the occupation pattern of the building, and the behaviour of the occupants.

The last two of these can only be determined statistically : a mean result and a dispersion.

Numerous methods for determining the free gains have been put forward in recent years.

We shall set aside the computer methods of calculation (such as exist for instance at the HUD* in the USA), which although very complete are also very unwieldy, and we shall concern ourselves with the "manual" methods.

HUD* : Housing and Urban Department.

We shall quote the method studied by the Directorate-General for Energy of the E.E.C. (D.G. XVII) under the URE Programme (Internal Document URE B.086 by Mr CHOFFE of "l'Instiut français du Pétrole"). The C.S.T.B.* of Paris suggests that one takes account of the inertia of the buildings and of the quality of the control system, and also of statistical data on the behaviour of the occupants : this method was worked out by analogue simulations.

There are others in Europe which are the work of the technical building centres and also (it seems) of oil companies.

In order to harmonise the calculation methods it would be necessary to compare these different methods with one another and with the results of the observation in order to assess their accuracy (a 10% error would currently be acceptable), and to choose a method or group or equivalent methods.

The result of the calculation would give in joules the free energy (recovered solar and internal) over a heating season : Q free.

We may write in an approximate manner that the heating requirement B equals B = D annual - Q free.

In particular, the free energy gains reduce the heating period, and hence the number of DJ or DH.

CSTB* Centre Scientifique et Technique du Bâtiment
Paris.

1.4.3 Supplying the heat

1.4.3.1 Performance of the installations

The requirement B is satisfied by heating installations whose performance is known in the laboratory. In practice the performance of the installations also depends on the effects of the control system and of the distribution losses, whose determination is under discussion.

In the case of heating systems using a liquid or gaseous fuel, the "Code of practice for controlling performance in conjunction with the installation of a heat generator burning liquid or gaseous fuels and used in a non-industrial building for space heating and producing hot water for washing"* gives an excellent example of what might be a calculation rule on this point.

Stoppage losses also affect the performance of the installation. It is thus necessary to determine an overall performance throughout the heating season, taking account of stoppage losses.

The question of the performance to be considered in the case of integrated electric heating systems is under discussion. It seems that its value, which is quite tricky to determine, is especially affected by users' behaviour.

1.4.3.2 Heat pumps

In an installation fitted with a heat pump, the energy consumed in the pump makes it possible to deliver a higher calorific energy at the output

*Annex to the proposal for a Council Directive amending the Directive N° 78/170/EEC.

temperature of the installation (cf. memorandum 2.4).

Quite a lot of formulas for calculating the performance coefficient have been established (e.g. by the CSTB and Electricité de France in France) using graphs or data-processing programmes. The results of these calculations are not often confirmed by actual experience, which shows lower performances.

This is a point on which a Community study (based on the work of the CIB)* would be useful.

1.4.3.3 Exchangers

Performance tables are given for each type of exchanger sold. The energy thus conveyed to the incoming air is in fact free energy. The defrosting energy, and the energy of air circulation and movement of the moving parts must be taken into account : the part transmitted to the incoming air as a gain, and the whole as consumption.

The requirement B is thus reduced by the first part.

1.4.3.4 Active solar heating

The effect of an active solar heating installation (i.e. one which uses collectors and a heat-carrying fluid other than the inside air) cannot be determined in terms of performance.

*C.I.B. : The International Council for Building Research, Studies and Documentation.

The heat gained by such an installation has been the subject of many studies, and numerous calculation methods using computers have been worked out both in the USA and Europe. They take account of the characteristics, orientation and area of the collectors, of the storage capacity, of the fluctuation of demand and in particular of very explicit meteorological data as regards sunshine.

In order to harmonise the calculation methods it is necessary first of all to reach agreement on these data, because it is not unusual for widely differing sunshine figures to be published in one and the same country.

Moreover, some people consider that we still lack the experience to establish one or more simple "manual" calculation methods.

1.4.3.5 Thus unwieldy methods are currently used to determine the performances of heat pumps and the gains of active solar systems.

The other coefficients involved in the supplying of heat (performance of the installations and effect of the exchangers) might be the subject of general agreements.

1.4.4 CONCLUSIONS

The information that is most urgently needed is the heat requirement for heating a building normally during a season.

This requirement is in fact a physical characteristic of the building, independently of the installation, and provides sufficient basis for statutory measures as regards the thermal quality of buildings.

It so happens that it is already possible either to establish a standardised Community method for calculating this requirement, or to recognise a number of national methods which are equivalent if not identical.

The heating requirement can be favourably expressed by the coefficient C, or

Coefficient of mean heat requirement of a building for a season, in terms of degree-hours and m^3 :

$$C = \frac{B}{V.DH}$$

or, in detail : $$C = G - \frac{Qg}{V.DH} \quad (w/m3K)$$

where G = volume coefficient of loss (in $W/m3^{o}K$)

Qg = free heat recovered (in 10^{-3}kwh)

V = volume of building (in m^3)

DH = degree-hours (in ^{o}K/hours).

Mean requirement means the requirement calculated on the average of (say) 10 years.

Controlling the thermal quality of buildings by fixing a maximum for the coefficient C has the effect of leaving to the builder the choice of limiting the heating requirement by reducing G (improving the insulation) or increasing Qg (improving the passive solar performance).

As it can now be calculated, the coefficient C would not include the effect of heat pumps and active solar installations. In other words, it would not apply to buildings so equipped. There is much to recommend the possibility of this effect being included, as it would give builders a wide freedom of choice of methods of saving energy.

In order to prevent easily-avoidable losses, however, it seems that one must recommend (or require) compliance with a maximum for wall and ventilation losses. It is moreover in the builder's own interest to reduce in this way the power and cost of expensive installations.

The analysis of the measures will repeatedly show the usefulness of this coefficient C, especially in the following memoranda :

- 1.4.	Fixing the fuel allowance
- 2.1.	Geometry of buildings
- 2.2a and 2.2b	Improvement of building insulation
- 2.4	Heat pumps - Exchangers
- 3.1	Passive use of solar energy
- 3.2	Active use of solar energy.

CHAPTER 2

Examination of energy-saving measures

2.1. Reduction of heating energy requirement

1. Background information

In theory, a reduction of 1°C in the heating temperature in buildings gives a fuel saving of 24 GV per heating day, V being the volume of the building, and G its coefficient of volume losses as defined in annex III to the introduction.

The saving in a season is :
N x G x 24V, where N is the number of heating days. Expressed as a relative value, this saving equals :

$$\frac{\text{Number of heating days.}}{\text{Number of degree days}}$$

In Paris, this is $\frac{192}{1755}$, or about 11% (taking account of solar gains and of a heating period lasting from 21 October until 30 April).

This relative saving will be less if the climate is colder and the number of degree-days is accordingly greater. In Stockholm, for instance, it is no more than $\frac{227}{2829}$ or about 8%. In absolute value however the saving is greater.

The real saving resulting from a statutory measure reducing the maximum permitted heating temperature is less than the result of these calculations, because certain rooms are not heated to the conventional heating temperature :
for part of the day (heating used intermittently) ; or
throughout the year, because (for reasons of economy or preference) the

occupants have their heating set below the conventional temperature.

In this case, a reduction in the authorised temperature results in only a part of the supposed saving, or even has no effect whatever.

How is this temperature reduction to be achieved in practice? The ideal way is to have a thermostat in each room, so that the desired temperature setting can be obtained throughout the building. In a very large number of installations the hot-water radiators have only "on" or "off" settings, which do not permit moderate temperatures to be maintained in certain rooms. In this case the only solution is to turn the boiler down, or the heating off in certain rooms.

Users in dwellings and service-industry premises also very often want their heating on intermittently, and have no facilities for this. The necessary installations are :

- room thermostats for each room or for groups of rooms that are not required to be heated much or at all for part of the day ;
- a time clock for turning on the heat again before the time at which the premises will be occupied or the time at which the normal temperature is required.

The installation of a time clock and thermostatic valves in an individual dwelling is not very expensive.

However, in shared dwellings, commercial and service-industry premises, the problems of intermittence, control and balance have all to be solved at the same time. A simple clock is nevertheless inexpensive and permits considerable savings.

2. Cost - Effectiveness

The general reduction of the heating temperature is a measure that calls for no capital investment. It might enable the power of the boiler to be reduced, which would be a saving in itself.

3. Limitations

The feasible temperature reduction is governed by two factors :

- the permissible discomfort ;
- the effects it has on the proper preservation of the building.

3.1. The resultant temperature of 22°C (which before the crisis was usually considered a comfortable winter temperature for waking persons in Europe) is linked to habits of dress, and in practice to clothing with a warmth value of 1/2 clo.*

It is possible to reduce the resultant inside temperature by a few degrees by wearing warmer clothing and using warmer bedding. Hence the measures taken in France to reduce the temperature to 20 and then to 19°C make it necessary to wear clothing of 1 clo and a little over. This involves no major change in living habits or significant loss of comfort.

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* The clo value determines the overall thermal resistance of an individual clothing ensemble.
1 clo = 0,155 m2°K/W.

Is it possible to go beyond this?
One might say that it is, bearing in mind that before the war it was generally accepted that bedrooms were not heated and that the temperature in them approached 0°, and that in living rooms the temperature approached 20° in a small part of the room (near the stove) only.

It is also well known that one can withstand even the coldest temperature if one is properly clad. The limit is set by the practical need to have one's face and hands uncovered in one's dwelling, and not to be muffled up unduly with clothes. No studies have been found on the minimum bearable temperature with bare hands and face. If clothing is limited to 1.5 clo, the thermal equilibrium temperature is 17° when physical action is almost nil. This is a bearable temperature for the hands and face. The resultant temperature of 17° may therefore be considered admissible and as giving relative comfort.

Subject to what is said elsewhere about auxiliary heating, the saving achieved by reducing the temperature is considerable : reducing the inside temperature from 22°C to 17°C results in a saving of about 50% in heating in Paris.

It is possible to envisage even greater temperature reductions during the night. Moreover, it is quite often the practice to turn the heating off and open the windows in bedrooms at night. There again we have found no studies on temperatures that would be admissible without a sense of discomfort. It should be noted that a higher temperature (probably 20°) is necessary when going to bed and getting up, and in the bathroom. A temperature of 12°C is probably bearable for most people in the middle of the night.

The adoption of a daily temperature cycle poses problems of controlling the operation ; the saving is slightly less than that which would result from a clear-cut calculation on the basis of the G of the building and the degree-hours. While waiting for studies on bearable limits to be carried out, it may be admitted that at the expense of a slight loss of comfort it is possible to make do with a day temperature of 17°C and a night temperature of 12°C (raised to 20°C when getting up, going to bed and using the bathroom, at least).

Exceptions will of course have to be made for elderly persons with reduced metabolism, for the sick and for young children. This might lead us to consider that a building and its installation should be constructed to give an inside temperature of 22°C, but that 19 or 17°C will generally do.

3.2 The reduction of room temperatures increases the risk of condensation on surfaces and in the body of the building.

This risk depends :

- on the inside face of the walls temperature, θi linked to the inside temperature by :

/equation : $\theta i = Ti - \frac{K\ell m}{hi}(Ti-Te)$ (where ℓm is the coefficient of heterogeneity of the wall insulation, Ti the inside temperature, Te the outside temperature, hi the coefficient of superficial exchange of the inside wall, and K the coefficient of thermal transmission of the wall);

- the rate of changes of air, i.e. ventilation ;
- the hourly amount of water vapour given off in the room : u (g/m3.h).

Surface condensation occurs if

$$N \leqslant \frac{u}{ps - pe}$$

where N is the number of changes of air per hour,
pe the amount of vapour in the outside air in g per m3, and
ps is the weight of the saturated vapour in the air at the temperature of the inside wall, in g/m3.

Condensation conditions are far from existing in most buildings fitted with central heating (except in the "wet" rooms, where they are accepted if only transitory).

At a given temperature the risk of condensation may be averted by improving the ventilation, increasing the insulation, or curtailing the production of water vapour.

If it comes dangerously close to condensation conditions, the reduction of temperature makes recourse to one of these solutions essential. Generally, a reduction of the inside temperature from 22 to 17°C needs an increase of about 30% to be made in changes of air. In the majority of cases, this does not call for increased ventilation.*

When it is necessary to increase ventilation, the increase in the heating requirement as a result of the increased ventilation is distinctly less than the saving caused by lowering the required temperature. The difficulty lies in finding a way to increase ventilation when necessary and not at other times.

Reducing the production of water vapour (steam), which in dwellings is essentially connected with kitchens, laundry and bathrooms, calls for somewhat unlikely changes in the way of life. The emission of steam in kitchens can however be reduced by placing the cooker under a hood connected to the air outlet.

As in all, it does not seem that the risks of condensation should change the above conclusions regarding possible temperature reductions.

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*Let us consider a dwelling where the average production of water vapour is 5 g/m3.h, i.e. a dwelling occupied by a fairly large number of people (6 persons producing 200 g/h in a dwelling of 250 m3, for instance). The temperature of the outside air is -5°C; the air is saturated with water and contains 3 g/m3 of water.

What happens when the required temperature is reduced from 22°C to 17°C? The ventilation rates necessary for a well-insulated wall (K = 0.8; pm = 1.5) and for a badly-insulated wall (K = 1.5 ; pm = 1.5) are shown in the table below :

		Well-insulated wall		Badly-insulated wall	
Ti	Te	θi	N	θi	N
22	-5	17.3	0.43	13.3	0.59
17	-5	13.2	0.59	9.9	0.74

4. Application of the measure to new and existing buildings

The measure of temperature reduction can be applied just as well to new buildings (without restriction) as to old ones, if these are provided with an adequate degree of comfort (correct insulation, acceptable temperature and ventilation levels, and correct air intakes). It can be reduced to as little as 17°C without damage to buildings.

5. Industrial and commercial consequences

The measure has limited consequences : for example the development of the use of guages for regulating the temperature.

6. Current use of the measure in the Member States

How can one get the occupants of dwellings or offices to accept a lower heating temperature than that to which they have become accustomed?

- A statutory maximum heating temperature can be laid down. This has been done :
  - in Denmark : 20°C in public buildings since 1.4.1979 ;
  - in France : 19°C in all buildings since 22.10.1979 (since 29.10.1974, the previous limit had been 20°C) ;
  - in Italy : for all buildings since 28.6.1977.
- In other countries, this limitation applies de facto to public buildings (Netherlands, United Kingdom).

It has been noted that whereas it is possible to check on compliance with a statutory obligation in public premises, it is impossible to do so in dwellings because of their private nature.

It should not be concluded from this that a statutory limitation is not effective. On the one hand, one can count on the public spirit of private individuals who may respect the limitation without special supervision. On the other hand, its application in public and office buildings not only has an exemplary effect, but also creates habits in users : after eight hours of work in an office with a temperature of 17°C, it becomes normal to find a temperature of 17° at home. The "habit" of comfort at 20° is after all a quite recent one, and it is possible to go back to a level of comfort that is far from being Spartan.

Moreover, there are in most European countries large numbers of dwellings managed by public bodies, or whose heating is operated by specialist firms: and such bodies and firms respect the regultations.

In France, 4.000 checks during the winter of 1977-78 showed that temperatures were exceeded in 37 % of cases, and of these 8.5 % exceeded 22°C. The average was found to be 19.3°C, as compared with the statutory temperature at that time of 20°C. However, these checks were made only in offices or at the homes of private individuals who had requested checks. Hence the level of application of the measure in the case of private individuals is as yet unknown.

It should be noted that firstly the expense and secondly the shortage of heating energy automatically cause temperature reductions. All in all, it is a matter of knowing whether people will agree to limit themselves voluntarily before circumstances compel them to do so.

A special measure has been taken in Italy, where the regulations specify a design temperature of 20°C. This means that the heating installation must be designed to provide the building with a maximum temperature of 20°C (except for hospitals and swimming baths).

This measure does not really limit the inside temperature except on the coldest days of the year (always provided no auxiliary heating is used), but it has the advantage of improving the seasonal performance of the installations (cf. memorandum "Control").

7. Proposals

7.a Proposals for Community action

The European model code might include the following measure :

- Statutory limitation of temperature in all buildings, with inspections and penalties in buildings open to the public.

The maximum temperature should not exceed 19°C ; the temperature of 17°C should be applied if there are signs of a shortage.

1. Background information

Essentially, this is a temperature-reducing measure.

It may take two possible forms :

(a) heating systems are not in use between certain dates ;
(b) heating systems are not in use when the mean or minimum daily outside temperature does not fall below a given value.

Measure b) is difficult to distinguish from the measure of limiting the inside temperature, for the outside temperature for switching on the heating will be determined from the latter.

Hence only measure a) will be considered here.

What this amounts to in practice is a requirement not to have the heating on in spring and autumn.

This measure can be justified by the fact that in the past (particularly before central heating came into general use) the heating periods were much shorter (15 November - 1 April in Paris, as against the period 1 October - 15 May now frequently encountered).

It is necessary to analyse the reasons for this difference to see how near one can get to the previous situation.

There are three reasons why the heating period used to be shorter :

- in towns, heating involved unpleasant chores : bringing up the fuel, taking down the ashes, and cleaning the area around the stove, so that people tended not to put the heating on in spring and autumn ;

- heating was relatively more expensive in an economic environment much poorer than that of today ;

- centuries of discomfort had accustomed people to put up with the cold and to dress accordingly. Moreover, the standard of warmth provided by the stoves and fires was nothing like as good as ours : the room temperatures varied considerably, and some rooms were unheated.

The first reason no longer exists (except during periods of extreme shortage when central heating systems are turned off).

The second reason may reappear, primarily in the poorest households (where incidentally it has always applied).

The effect of temperature limitation tends to cause a return of the third reason.

One might infer from the foregoing that a moderate limitation of the heating heating period is possible.

2. Cost - Effectiveness.

Theoretically, it is easy to evaluate the saving achieved by limiting the heating period.

2a - The heating requirement is reduced by $\Delta DJ . N.V.. 24$, where ΔDJ is the sum of the degree-days "cut out".*

In fact the concept of a degree-day is blurred in autumn and spring, as is also the very duration of the heating period. Indeed, consideration of the mean temperature no longer seems suitable for days when the outside maximum may produce an inside temperature higher than the required temperature, whereas if that temperature is to be attained when the outside temperature falls to its minimum, heating will be necessary inside.

The consideration of degree-hours then becomes necessary. But the connection between the "natural" degree-hours and the requirement is very much influenced by the inertia of the building (short-term inertia, if one accepts the possibility of cool temperatures at night).

A measure prohibiting heating between 15 April and 1 November corresponds to reduce about 100 - 150 degree-days in the case of a very well heated dwelling.

2b - The saving of energy follows from the requirement, noting two peculiarities of the present case.

Firstly, in periods of a low heat requirement, the performance of heating installations is especially poor : at least as far as single-boiler installations are concerned (for heating flats or buildings). On the other hand, in the case of block or district heating systems, only one or part of the boilers will be in use, in which case the performance will not

* i.e. The degree-day taken away from the heating period.

be so greatly reduced (1).

Then again, the saving is reduced by the fact that the heating is turned off when the solar gains reach their maximum. Even if these latter are poorly recovered (because of the inertia of the control system) when the heating is operating, they represent a greater gain in autumn and spring than in winter. As a result it is 14 or 15°C base degree-days and not 20°C base degree-days that are being cut out.

Without seeking accuracy, it may be estimated that the effect of cutting out the heating in autumn and spring would be a saving of between 5 and 10% in Paris, depending on buildings, installations and habits.

2c - However, if the temperature is limited at less than an acceptable figure, people will be likely to use auxiliary heating.

These are generally electric radiators. Except if electricity is rationed, it must be expected that a substantial part of the heating requirement that is no longer covered by the main heating system will be covered by the auxiliary heating, despite the deterrent effect of the cost of this kind of electric heating.

(1) If the performance of a current boiler is 78% with a 100% load,
it will be 71% with a 50% load
66% with a 25%
60% with a 10%
49% with a 5% load.
(Source I.F.P. "Institut français du Pétrole")
The performance of a single boiler in Paris in April will be about 65%.

The only study of the behaviour of users of auxiliary heating systems that we have come across is in France (source : EDF survey). 68% of users owning central heating and an auxiliary electric heating system never use the latter, and 20% really use it as an auxiliary system. This figure was obtained from a survey conducted when no limitation was in force.

If the comparison is to be accurate from the point of view of fuel imports, it is necessary to convert the electricity used in the auxiliary system into primary oil consumed in the power stations (coefficient 2.8). Even taking account of the poor performance of the boilers (0.65) and of overheating, it may be considered that the overall compensation in the form of auxiliary heating would more than cancel out the effect of the measure.

It seems therefore that it would be expedient to limit heating periods only if :

- electricity were to be rationed (in the extreme case), or
- the auxiliary heating system used fuel other than oil, electricity or gas.

2d - This measure does not involve the user (who will need warm clothing) in any great expense.

In actual fact, however, because of auxiliary heating it costs him :

- the amount paid for the auxiliary energy;

- the amount paid for the appliances that consume this energy.

3. Limitations

Limitation of the heating period affects other requirements besides the standard of warmth, namely the requirements of non-humidity and durability.

Autumn and spring are periods when the absolute atmospheric humidity is considerable (about 10 g/m3), and the drying power of the air is thus poor. This is why condensation is frequent in certain circumstances even if no vapour is produced inside.

The lack of heating in autumn and spring will result in :

- dampness on the walls, which is unpleasant to the touch, causes the wallpaper to become detached, and gives rise to mould ;
- dampness in the woodwork and parquet flooring, which will be deformed ;
- condensation in the body of the building.

If the building is to be properly preserved, it would in fact be advisable to finish off the cold period by giving the house a good heating to dry it out.

4. Application of the measure to new and existing buildings

A measure for limiting the heating period is applicable to all buildings. For the sake of the record, mention should be made of the advisability of providing flues in new buildings : there is currently a definite tendency to install these flues in new buildings, especially individual dwellings.

5. Industrial and commercial consequences

This paragraph does not apply to this measure.

6. Current use of the measure in the Member States

The experts are unanimous in rejecting this measure. It is considered unpopular, difficult to monitor (police surveillance of flues, inspections) and the resultant savings are doubtful.

The only country to mention the duration of the heating period is Italy, where a "conventional heating period" in days is shown in the table which defines the climatic zones. There is however no statutory requirement to comply with this period.

Last of all one might mention that one of the main objections to this measure is the fact that it does not take account of the possibility of cold days outside the heating period. Hence, a limitation in terms of the outside temperature only (which as we have already said is the same thing as a limitation of the inside temperature) is preferred to this measure.

7. Proposals

7a - Proposals for Community action. The fact that the measure is not very effective from an economic point of view and is closely related to measures for limiting temperatures, militates against its inclusion in a European model code.

7b - Standardisation proposals. Not applicable.

7c - Proposals for research. A study should be carried out on the savings that can be made by this measure : it would involve measuring in a wide sample of buildings the variation in boiler consumptions throughout the heating period (e.g. a periodical record of fuel-oil or gas throughputs upstream of the boiler). The comparison of consumptions in autumn/spring and the middle of winter would give some idea of the saving that could be achieved in practice.

This study would need to be supplemented by a study of the use of auxiliary heating systems.

1. Background information of the measure

The requirements of the occupant of a building include that of a sufficient purity air from the point of view of smells, dust and noxious gases ; they also include a requirement that the inside walls should be dry to the touch and be seen to be dry.

These two requirements are conventionally satisfied by replacing the humid and polluted inside air by fresh air from outside.

We shall not discuss here the permissible rates of the various pollutants or toxins, but note that for the purpose of keeping the air pure the health regulations have laid down rates of air changes in living rooms equal to 1 (generally) which, taking account of the volume of the "service" rooms and assuming a direction of ventilation from the living to the service rooms, involves a change of air by volume of 0.8 volume/h in all the rooms.

Before, there was a great difference between the regulations and the realities.

Little attention was paid to ventilation in very old buildings : the draught from the chimneys and stoves saw to the changes of air. Later, when the health regulations laid down change-of-air rates, the main solutions remained very unreliable : if there was no stove, the changes were virtually nil on windless days, and would have been excessive on windy days if the occupants had not draughtproofed all apertures.

With the appearance of heat extraction ventilation duct systems which extracted from the service rooms and had self-regulating, constant-flow air intakes in the living rooms, a start was made on mastering ventilation. Ventilation is really controlled in controlled mechanical ventilation systems of the single-flow, or particularly of the double-flow, type. If the volume of replacement air is properly controlled, it can be said, incidentally, that the quality of the air drawn in is not thereby increased.

The air-change rate of 1 vol. per hour was originally based on the rate of carbon dioxyde (CO_2) in a 20 m3 room, occupied by one person. It is now recognised that a lower rate can be accepted. The rate of 0.5 volume per hour in a dwelling is considered admissible if the air flow of the ventilation system is from the living rooms to the service rooms (Report EUR.6117 : in the case of a dwelling, the rate is 0.5 volume per hour for four persons (some of whom are smokers), and 0.6 for 5 persons).

Heating energy is consumed when the air is changed, because the inside air (polluted but warm) is replaced by outside air (more pure, but cold).

A variation in the hourly rate q of air change equal to dq involves a saving in the heating requirement of :

$$0.34 \, dq \, DH_{ti}$$

where DH_{ti} is the number of degree-hours calculated on the basis of the real inside temperature ti of the building.

The relative saving equals $0.34 \, dq \, \frac{1}{GV}$, where G is the coefficient of loss of the building per m3 , and V the volume of the premises.

In an insulated dwelling with a volume of 250 m3 and a G of 1.6 (statutory value in the Paris area), the relative saving is dq.0.085%.

If we take the hourly rate of air change $N = \frac{q}{V}$, the absolute saving is $0.34\ dN\ V\ DH_{ti}$ and the relative saving $34\frac{dN}{V}$ % and for the dwelling mentioned earlier, the relative saving is 2% per one-tenth reduction of N.

Hence a switch from an air change rate of 1 or 0.8 volume/hour to 0.5 involves a reduction in the heating requirement of 6 and 10% respectively.

This is the saving that may be expected in a recent building which has effectively controlled ventilation.

The real rate of ventilation in old buildings is not known. It may sometimes be assumed to be low in old dwellings, where rates ranging from less than 0.3 vol/h to much more than 1 vol/h in very windy weather have been noted. On the other hand, it may be extremely high in industrial buildings.

No statistical survey appears to have been carried out on this point. It might be worthwhile for governments and the Community to make good this omission.

2. Cost and effectiveness

2a - In a building fitted with controlled mechanical ventilation, the cost of reducing the ventilation is nil. A secondary benefit will be the reduction in ventilation energy consumed.

However, such buildings represent only a very small percentage of all existing buildings.

2b - In a building with snug-fitted windows, which is equipped with self-regulating air intakes and thermal extraction outlet ducts, ventilation can be reduced by means of the air intakes and/or outlets. It does not cost very much to adapt these.

2c - However, in buildings with ordinary windows, whatever the system of extraction, there is no control of ventilation other than by the wind in the main.

The prime aim of measures to be taken in such cases is control of ventilation by draughtproofing the windows and making controllable air intakes. This is more expensive. The saving can however be considerable, because in such cases the real air changes are certainly greater than 1 vol/h on average. If future changes are set at 0.5, one may expect reductions of not less than 10% in heating requirements, not to mention the increased comfort at times when there are strong winds.

2d - Until such time as an evaluation has been carried out, the measure may be assumed to be profitable.

2e - In view of the simplicity of the work to be carried out, the measure can be implemented in a very short time. The use of specialists may be necessary, but their work will not take long (e.g. it will be done much more quickly than work on improving insulation). They will however need directives on how the necessary air changes are to be achieved. Then again, the present rules will have to be altered where they call for changes of about 1 vol/h.

3. Limitations

The physiological possibility of reducing ventilation was examined in paragraph 1.

Memorandum 1.1 includes a table regarding the risks of condensation : a rate of air change of 0.5 is sufficient to avoid this risk in well-insulated buildings. A rate of 0.7 is necessary in poorly insulated buildings.

Hence this establishes the acceptable limit for ventilation reductions.

4. Application of the measure to new and existing buildings.

As we have seen, this measure (which can easily be applied in new buildings) can also be applied in existing ones.

5. Industrial and commercial consequences.

The work required by this measure is not very great : draughtproofing, and making air intakes. It does not require much material, and can lead to a substantial increase in the production of adjustable or self-adjusting air intakes ; it requires staff who understand the principles of ventilation (who will have to be trained), and general labour of the kind used in modernising buildings. It should be noted that much of this ventilation work could be done on a "do it yourself" basis.

6. Current use of the measure in Member States

The old health regulations contained somewhat vague requirements for minimal ventilation.

For instance : "it should be possible to ventilate the dwelling generally and permanently during the period when the temperature makes it necessary to keep the windows closed" (France - decree of 22.10.1969).

The energy crisis has often given rise to very vague references to energy saving :

"Ventilation must ensure conditions that are satisfactory from a health point of view, without excessive consumption of energy" (Denmark).

In some countries and for certain buildings, precise regulations limit the permissible changes of air. This is so in the French decree of 12 March 1976 concerning buildings other than dwellings, which specifies a maximum in litres/sec for many types of building.

7. Proposals

7a - Proposals for Community action. There are no difficulties in including in the model code a provision for limiting room ventilation. It would be a matter of laying down the values that people should endeavour to achieve for air changes (expressed in vol/h, m3/h or litres/min), and not a minimum ventilation value (as is currently the case in many countries) or a maximum value (for health reasons).

In the Member States where ventilation is the subject of descriptive regulations, this measure would be applied by changing the area of the air intakes, the cross-sectional area of the natural extraction ducts, and the rates of mechanical extraction.

One may ask whether it is possible to monitor compliance with this measure in private premises. The reply to this question is already contained in memorandum 1.1 in respect of temperature limitations.

7b - Standardisation proposals. Not applicable.

7c - Research proposals. It would be useful to continue research into the changes of air necessary in the various kinds of premises.

It would also be useful if statistical studies were carried out into the present rates of air changes in all kinds of existing buildings, and into the improved results that could be expected for a given cost, as has been done in the case of improving insulation.

1. Background information

1a - Rationing is a radical means of reducing the consumption of fuel for heating buildings.

However, the implementation of this measure involves many difficulties which Europeans experienced during and after World War II.

There are two main approaches to rationing :

- allowances are based on previous consumption ;
- allowances are based on a calculated need.

The comparative difficulties of these two kinds of rationing will be examined below. All forms of rationing have however two major snags :

- the appearance of a black market ; and
- the discretionary power of the authorities.

The black market, in which demand results from the selfishness of well-to-do consumers, defective distribution and the inadequacy of the overall supply, is supplied by savings made by ordinary users and by all kinds of trickery : favouritism, forged ration coupons and diversion of supplies.

This inseparable consequence of rationing rapidly destroys public morality. Entire generations were affected by the spirit of the black market that prevailed in Europe 35 years ago.

Since distribution is carried out by bureaucrats, it bears the imprint of the bureaucratic mind : it is slow, and sometimes Kafka-esque. There is virtually no channel of appeal, except through the hierarchy, and appeals through the courts take too much time. The abuse of power is widespread and corruption is a menace.

To these general snags of rationing must be added the snags inherent in each of the systems.

1b - Allowances based on previous free consumption. It is necessary to ascertain the previous consumption, and this can be done roughly by checking purchases during a reference year or checking bills kept by buyers or sellers.

The requirements of fuel for new buildings can be calculated without undue error thanks to the formula quoted in annex III to the introduction.

The method does not make it easy to take account of decreases in the requirement, as in the case of premises becoming empty or of voluntary savings being made (it would be very profitable to insulate one's home, reduce the temperature by 2° and supply the black market!).

1c - Allowances based on calculated requirement. It is theoretically possible to calculate requirements (by the formula given in annex III to the introduction) with acceptable accuracy.

However, all badly-heated premises will benefit from a fuel allocation in excess of former consumption : something that will not only supply the black market, but also create an overall demand greater than before.

On the other hand, determining (or checking) demands is a very important and lengthy job that might prove impossible to tackle.

1d - Partial rationing. The bad effects of conventional rationing are overcome, at least when rationing is not strict and :

- accompanies measures that lead to savings ;
- is applied by something approaching a recommendation rather than compulsion.

An example of this scheme would be to limit deliveries to retailers, who would pass on the effects to their customers. This system is currently used without difficulty in France for fuel oil deliveries.

2. Cost - Effectiveness.

Just like limiting temperatures, fixing quotas costs nothing and its overall result is certain, for one cannot consume more energy than is available.

3. Limitations.

The same limitations that apply to requirements of comfort and the proper preservation of buildings apply to temperature limitation (memorandum 1.1).

4. Application of the measure to new and existing buildings

It can simply be pointed out in this context that rationing based on requirement calculation is easier to apply to new than to existing buildings.

5. Industrial and commercial consequences.

This measure can result in the development of all the energy-saving systems and in the development of substitute fuels. It has the same effect as taxation.

6. Current use of the measure in the Member States

Belgium : Since May 1979, allocations have been 80 - 90% of the annual reference consumption.

France : Partial rationing has been introduced by cutting deliveries to wholesalers to 80% of previous consumption. This measure coincided with the reduction of the heating temperature, voluntary savings resulting from price rises, and recent mild winters : but the sources of this reduction must be sought elsewhere.

Measures also exist in the Republic of Ireland. The other European countries refuse to apply this measure. Rationing is the most apparent symptom of the shortage, and so far this has been avoided.

7. Proposals

7a - Proposals for Community action

Rationing requires a method for calculating annual heating consumptions. It is necessary to establish a reliable method, and in order to do this it will no doubt be necessary to compare thermal calculations and actual consumptions in respect of an extremely large sample over several years.

A reliable calculation method accepted by all the partners would be the most acceptable basis for rationing. In the event of an official shortage, European solidarity might lead to the nations themselves being rationed. This would involve determining standard consumptions for each country in Europe. However unpleasant the idea of rationing may be, one must realise that if consumption is not reduced so as to prevent a break in supply, shortages and rationing may become a reality one day.

2.1.5 PRICING AS A MEANS OF SAVING FUEL Memorandum 1.5

1. Background information.

The high price of a product always restricts its use. The high cost of energy has a fortunate effect on energy saving in two respects.

Not only does it reduce energy consumption, but it also permits new sources to be developed.

The price of energy should be examined from two angles : cost before tax and cost after tax.

It is the cost in foreign currency (the preliminary tax on imported fuels) that motivates governments to develop new sources of energy.

It is however the cost including tax that affects consumer attitudes and makes them save on the one hand and invest in energy-saving techniques on the other (insulation, solar panels, etc.).

Since governments fix the tax on the price, they have in their hands a means of causing savings both directly and indirectly.

2. Cost - Effectiveness.

The effectiveness of an increase in the price of heating energy is not known, but if one compares it to increases in fuel for motor cars one may conclude that small increases are ineffective and that the measure will not be effective unless there is a substantial increase.

We may quote the following figures in this context : in France, domestic energy represented 4.5 % of household budgets in 1976 (and heating probably between 3 and 3.5 %), as against 3.4% of such budgets for motor car fuel (national averages). In other words, heating energy (apart from domestic consumption) occupies an equivalent position in budgets to that for petrol for motor cars.

It is generally estimated that the price of fuels would have to be doubled to have any marked effect on their consumption. It is not certain whether the same reasoning can be applied to heating fuels.

3. Limitations of the measure.

A well-known snag of the measure is that it makes no difference to the rich but is unbearable to the poor.

It would in fact seem that the measure cannot be applied unless steps are taken to make it bearable to the poor.

However, the granting of exemptions from expensive fuel raises difficulties not unlike those of rationing (see relevant memorandum). It would on the other hand be easy to grant tax exemption on fuels used in low-cost rented housing.

Solutions can however be found, since we are dealing with money and not with materials.

An increase in taxation represents a new revenue for the State, which should thus reduce by an equivalent amount all the old taxes. It can do this by raising the starting point for tax. It can also increase old-age and retirement pensions, etc.

These latter measures are akin to the measure (the most liberal of its kind) of taxing fuels and raising low pay, and partly offsetting this for companies by reducing corporation tax.

These are measures that go beyond the sphere of fuel saving, and form part of a revenue policy. It may however be noted that government action to save energy should never aggravate social inequalities, although they might lead to a readjustment.

4. Application of the measure to new and existing buildings :

The measure is applicable to all kinds of buildings.

5. Industrial and commercial consequences.

The consequences of this measure are very difficult to forecast, and involve macroeconomic and even political considerations : increases are very unpopular, especially just before elections ; and the effect of taxation might be to slow down household consumption so that the State would have to reinvest the tax.

On the other hand, taxation has the great advantage of making new forms of heating energy more competitive. It is well known that the increase in the price of a barrel of oil is gradually making utilisable such fuels as oil from bituminous sands, geothermal energy and solar energy.

Taxation makes it possible to anticipate the increases, and to make an earlier start on developing substitute fuels. It thus appears to be a means of combatting the hold of the oil producing countries on the developed countries.

It must be borne in mind that by new price increases the oil-producing countries can recover the revenue from the taxes.

6. Current use of the measure in Member States

As a general rule, the experts consulted could not say what part taxation plays in the selling price of fuels. This fact indicates a lack of transparency in these prices.

It may however be noted that the Community has recommended that "market prices for energy should be as transparent as possible ..."*.

Be that as it may, all the Community countries tax fuels and energy with the dual aim of obtaining revenue and damping down consumption.

It does not however seem that these taxes are deliberately designed to enable a particular substitute fuel or energy to be developed or used.

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* Third report on energy-saving programme of the Community. (Communication from the Commission to the Council, COM(79) 313 final).

7. Proposals

7a - Proposals for Community action. The Community might recommend harmonisation of tax rates, but general opinion does not favour a general tax increase which might prompt the oil-supplying countries to raise their prices (although this was not the case when the USA recently decided to increase taxes).

On the other hand, the Community might introduce a Community tax on oil entering the Community, not so much to make other forms of energy usable as to finance research and development in connection with substitute forms of energy, the creation of industries to produce these, and their regional development.

Revenue from the tax could thus be used to help in developing the use of such energy (e.g. solar energy) where it is in abundant supply (in the Mediterranean regions).

7b - Standardisation proposals. Not applicable.

7c - Research proposals. Research into the effect of taxation on consumption of energy for heating would be worthwhile.

In Denmark, where taxation was first introduced in 1979, there was found to be a decrease of 18% between winter '78 and winter'79. Is it to be assumed that other factors have also played a part here? Will this saving continue? These are the points on which the research should look for information.

2.2 Measures regarding buildings and their installations.

1. Background information

1a - The instantaneous heat losses of a building per m3 of inside volume are as follows : $G_1(Ti-Te)$,which may also be written $\frac{S}{V} \cdot K_m \cdot (Ti-Te)$ by using the ratio $\frac{S}{V}$ where :

$S = \sum S_i$, in m2 = area of outside losses

V = volume to be heated

K_m= mean coefficient of heat losses in W/m2 °K, $K_m = \frac{\sum k_i \ S_i}{\sum S_i}$

(S_i, K_i = area and coefficients of loss of the different walls)

The ratio $\frac{S}{V}$ varies with the shape of the building.

We show in the following page for guidance only, the values of $\frac{S}{V}$ for different buildings of the same volume but of different shapes.

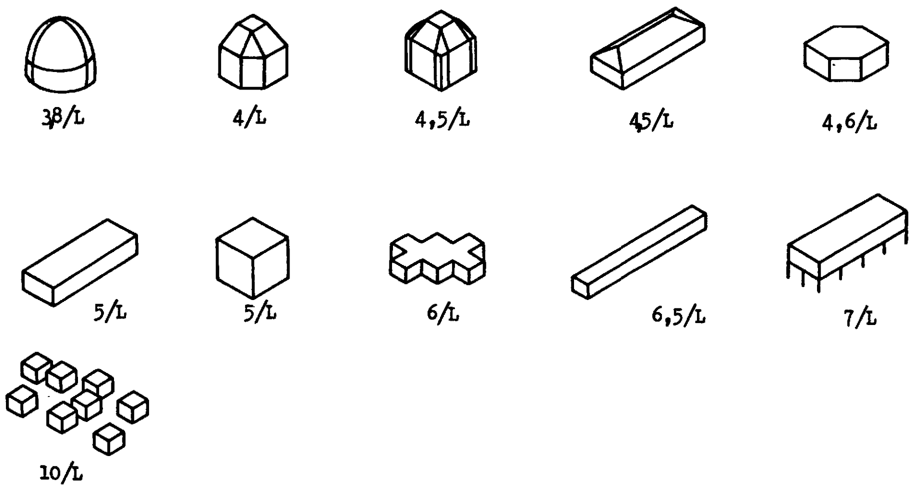
In the case of housing, single-family houses are much less efficient than blocks of flats, the best of which are those with a "convex" shape (the ideal being a hemisphere).

- The ratio $\frac{S}{V}$ for a building of the same shape varies according to its volume, as the inverse of the cube root of the latter.

Hence the ratio $\frac{S}{V}$ is proportionately smaller as the building is more "spherical" and larger.

- The geometry of the building also effects the second loss factor K_m because of the part played in S by the various elementary surfaces which do

Figure 1



Values of S/V for various types of buildings of a volume L^3.

not generally have the same K_i ; and as will be seen from memorandum 2.2.b roofs, walls, windows and floors have different thermal resistances.

Mr. Tammes of the Rotterdam Bouwcentrum has proposed the values that appear in the table for four buildings :

A : Large communal building (100 m x 10m x 30m) (S/V = 0.29)
B : Tower block (10m x 10m x 30m) (S/V = 0.47)
C : Terraced single-family house (6.25m x 8m x 6m) (S/V = 0.74)
D : Bungalow (10m x 10m x 3m) (S/V = 1.07)

Their respective K_i are the four values a,b,c and d below :

Structure	Values of K_i in W/m2°K			
	a	b	c	d
Floor	2.2	1.3	1.3	0.8
Roof	1.2	0.7	0.7	0.4
Windows	5.7	5.7	4.5	3.0
Outside walls	1.7	0.7	0.7	0.7

In all cases the glazed area is assumed to be 20% of the habitable area.

The coefficient K_m as a function of $\frac{S}{V}$ in the four types of buildings and four insulation levels is given in the table below :

Insulation levels \ Buildings	A	B	C	D
a	2.5	2.2	1.8	1.6
b	1.85	1.4	1.15	1
c	1.5	1.2	1	0.9
d	1.15	1	0.8	0.65

This type of study shows that the coefficient K_m is better for buildings of type D (bungalow) than for the large buildings, because of the preponderance of easily-insulated roofs and floors in the former, and of glazed facades in the latter. Nevertheless, losses are still much greater in small buildings. The former study shows that :

a large, well-insulated building has a loss of 0.47, and a bungalow a loss of 0.70 ; a badly-insulated large building has a loss of 0.71,and a bungalow of 1.71.

It should also be noted that the 10-storey building is very slender (10 metres thick), which gives it a low $\frac{S}{V}$ ratio.

There is nothing new in the finding that for an equal inside temperature an individual house consumes more energy for heating than a flat in a block of flats.

It is however possible that insufficient consideration has been given to the consequences of the choice of types of building on the energy consumption.

Is it necessary, when placing a statutory limit on maximum heat losses in buildings, to design the statutory requirements so as to be more or less proportional to $\frac{1}{L}$, which boils down to requiring the same wall insulation for all buildings and tolerating higher consumption in small buildings, or on the contrary to fix the same loss per m3 (and hence the same consumption) for all?

The choice of one or the other (or an intermediate) solution has major repercussions from a social and architectural standpoint. We shall return to this point later.

1b - The foregoing remarks concern the general shape of the building. Similar reasoning is possible in respect of the rooms or other details.

For instance, although the stacking of rooms according to the current fashion in France often assumes the favourable general form of a pyramid, this increases the total surface. Compared with the same volume in the form of a cube, the losses are multiplied by a coefficient of about 2.

The projecting ends of partitions and floors do not increase the losses (at least in calm weather) if they are made of concrete and are 15 cm wide.

1c - The geometry of buildings also includes their arrangement on the site and this has obvious consequences as regards sun and air.

1d - Lastly, the relative situation of the rooms inside the building affects losses.

Placing unheated premises (garage, storerooms) between heated rooms and the outside increases the insulation of the building.

2. Cost - Effectiveness

Reducing losses by varying the overall geometry of buildings involves no extra cost : quite the contrary.

The outer shell is an expensive part of a building. Hence reducing the ratio $\frac{S}{V}$ reduces the cost of the building.

Squat shapes offer less resistance to the wind, and result in savings in the load-bearing structure.

The initial building costs are reduced by over 10% (and maintenance costs as well) when the shape is cubic instead of parallelepipedic.

The measure can be very effective : improving the ratio $\frac{S}{V}$ from 10 to 20% for all new buildings (something that does not appear impossible) leads to a reduction of 5 - 10% in heating requirements. It should moreover be noted that this improvement of the $\frac{S}{V}$ (which corresponds to an improvement in insulation) produces the same effects as improved insulation, i.e. better use of free energy.

This gain will take many years to achieve, and in the year 2000 only the half (2.5 - 5%) of it will have been effected. Nevertheless, this represents a gain of 5,000 - 10,000 million TOE at Community level.

3. Limitations of the measure.

The main reason why the use of more or less cubic shapes is limited, is that rooms near the centre of the building cannot be given access to the outer world and daylight.

Thus in the case of housing it is difficult to build cubes with a side dimension exceeding 20m, and even this is quite a large building.

In the case of office buildings, however, there is nothing to prevent building large (or even huge) cubes. This would then cause a curious limitation.

Losses become very slight, and the more permanent lighting is used, the more free heat there is. There is no point in heating the building in winter. In summer however (even in a temperate climate) it must be refrigerated. A study has still to be carried out into the optimum shape and size of a large office building from a heat standpoint.

4. Application of the measure to new and existing buildings.

Saving by means of geometry applies only to new buildings.

5. Industrial and commercial consequences

If government regulations were to lay down the dimensions of small and large buildings, or require the small ones to be better insulated, this could have several consequences, viz :

increased consumption of insulating material, especially double glazing; reduced consumption of roofing materials (as a result of fewer small buildings) and of facing materials.

The measure would not however seem likely to create new industries.

6. Current use of the measure in Member States

Very few countries have mentioned the ratio $\frac{S}{V}$ directly in their regulations. They have however adopted a definite position by the manner in which they have linked their insulation requirements to the type and volume of the building.

Regulations in Belgium, Denmark, Germany, the Netherlands and the United Kingdom lay down values of K_i or K_m applicable to all types of buildings.

This means that they do not take account in this respect of the ratio $\frac{S}{V}$ and that they allow the occupants of small premises to consume more.

In France and Italy, where the requirements are incidentally expressed in G for dwellings and K (indirectly) for the other buildings, there are distinctions according to the volume of the building and to the ratio of the area of the outside walls to the habitable area which (if one assumes the room height to be constant) is indeed an $\frac{S}{V}$ ratio. Although small buildings are authorised to consume more per m3 than large ones, they must be better insulated. Thus an intermediate solution has been adopted between the same insulation for all and the same consumption for all.

7. Proposals

7a - Community action proposals. The Community might recommend that Member States adopt a law limiting consumption as a function of $\frac{S}{V}$ and L which, without making consumption per m3 the same for all buildings, would oblige the occupants of small buildings to make an additional effort.

By this indirect means it would aim at an improvement of 10 - 20% in the ratio $\frac{S}{V}$ of buildings.

7b - Standardisation proposals. The measure does not appear to require special standards.

7c - Research proposals. A study (and not research) would be useful, to determine the additional cost imposed on small buildings by complying with the same voluminal loss limits as large buildings.

It would also consider the optimum shape and size of large buildings (in particular office blocks) from the point of view of energy saving.

2.2.2.1 Improvement of insulation for existing buildings

1. Background information

Improving insulation in existing buildings is the measure that has the greatest impact on the consumption of petroleum products in Community countries. It allows large savings (of between 20 and 40%) to be made in a large proportion of existing buildings.

It is apparently easy to calculate the saving that a user can make by improving the insulation of his building. If the coefficient of loss is reduced from a value G to a value $G' < G$, the saving will be :

$$(G - G') \quad V \quad x \quad DJ \quad x \ 24$$

The calculation DJ in this case must be a function not only of the calculated inside and outside temperatures, but also of the domestic, solar and inertia gains.

The real saving will however differ from this value, because :

a - Not all families always have their heating at the inside temperature used as a basis for determining the DJ. DJ determined according to the heating habits of the family concerned would have to be inserted in the formula.

b - Improved insulation might encourage people to increase their heating temperature, since the insulation reduces the cost of heating. There is a special risk of this happening with individual heating.

c - Since improved insulation reduces energy requirements, the load on the boiler will be reduced and (in the case of a single boiler) its performance diminished.

If considerations a, b and c lead to a reduction in the anticipated saving in heating energy, a fourth factor will have a different and unexpected effect.

The effect of the insulation will be that during the mid- season the demand for energy will be covered entirely by the domestic gains, and the passive solar system. Hence the operating periods for such a system would be shortened, and it would be more difficult to recover the cost efficiency of the installations would decrease.

Hence the overall saving resulting from general measures for improving the insulation of buildings in a country cannot immediately be determined (see below).

The insulation measures that can be considered concern :

- Roofing. Roof losses can cause about 25% of wall losses in single-family dwellings insulated to pre-1974 standards ; the figure is lower in communal buildings (about 15%).

  In individual dwellings, substantial improvements in insulation can be made at little cost.

  In inaccessible roof spaces, a layer of glass wool on the floor results in a value of K of 0.5 and less, whereas the initial values are 1.2 (French average) or even 1.9 (old buildings in England). It is thus p ossible to achieve a saving of up to 20 % in badly-insulated buildings and (it would appear) 10 % on average. This improvement poses no financial problem, because it is profitable and costs very little (about 10 F/m2 of material, which is very easy to lay).

There are no technical snags.

The main limitation would be the limit in production of insulating material.

In the case of accessible roof spaces (especially those that are habitable the technical difficulties are greater : in the first place, the insulating material must be laid along the roof, and not on the floor. Precautions must be taken to maintain ventilation of the inside surface of tiled roofs. The work of laying the insulating material may involve taking down the panelling of attic rooms. The price of insulation may vary according to circumstances between 20 and 50 F/m2 of floor area. The saving will be of the same order as before.

In the case of flat roofs it will generally be impossible to lay the insulating material in the thickness of the roof, and to lay it between the roof and a suspended ceiling will be expensive.

The simplest and most economic solution is to construct a reversed roof and lay a water-proof insulating material on the damp-proof course. This arrangement (which has the advantage of protecting the waterproofing from the sun) requires measures to ensure the run-off of water. Although it is very effective, it will not equal the performance achieved by correcting pitched roofs. It nevertheless seems possible to achieve K of about 0.5 W/°C m2.

- Vertical opaque walls. These can have their insulation increased on the inside or outside, or the internal cavity (if any) can be filled.

In the case of walls with a continuous cavity, the injection of an expanding foam is a very simple and cheap solution, which gave rise to misgivings that now seem largely to have been dispelled.

In England, cavity walls have a K of about 1.7 W/m2K. The injection of a thickness of about 6 - 7 cm of foam makes it possible to obtain a K of 0.4 W/m2K. The initial criticism of this method was that it encouraged the infiltration of water in rainy areas. However, the experts consulted in the countries where this practice is most widespread (United Kingdom, Belgium and the Netherlands) consider that these problems have now been overcome.

Nevertheless, if the outer wall is thin, thermal shock, the effects of frost, and in all cases the possibility of capillary creep are to be feared.

The K of solid brick walls (like that of limestone walls) is typically 2; pre-1974 walls of hollow concrete blocks have a K of between 2.3 and 1.6, while walls made of conventional baked hollow clay blocks have a K of between 1.5 and 1.3.

The improvement of such walls on the inside or outside entails a lot of work : the outside solution (which is best from the heating standpoint) entails laying insulating material protected by rendering or weather-boarding, whereas the inside solution involves an insulating layer protected by plaster, and has the snag of turning a home into a building site, consuming useful space, and leaving heat channels at right angles to floors and inside walls. One may hope to bring the value of K down to as little as 0.4.

Ordinary glazed surfaces cause 15 - 20% of the losses of a building. They have a K that is typically 5 W/°Cm2.

Ordinary and french windows can be improved fairly simply if one accepts imperfect solutions such as fixing a plastics panel on the existing frame, or screwing a light secondary frame to the existing one.

If a quality solution is required, this will be the expensive one of replacing ordinary windows by double or triple glazing.

When putting forward the K value of a glazed bay, one must consider what is called the day-night K : for at night, an opaque protection can improve the insulation considerably, reducing total losses over 24 hours. An ordinary slatted shutter will reduce the night K to 2.5 and the day-night K to about 3.7. However, by using shutters with a high insulation capacity, the night K can be reduced to below 1, and the day-night K to below 3. This very simple solution produces a saving of 5 - 7% on overall consumption. It may have snags from an aesthetic point of view, and cause problems with the maintenance of the changes of air.

In individual houses, floors with voids cause 10 - 15 % of the building's losses. The coefficient K of conventional uninsulated floors is typically about 3, but if the void is only slightly ventilated the loss is only about 1.5.

The correction can be made by insulating the footings outside.

Correction is virtually impossible in the case of slabs laid straight on the ground.

2. Cost and effectiveness

The cost of improving the insulation of a building must be considered wall by wall and building by building. This cost (essentially labour) largely depends on the details of the building. Studies have nevertheless been carried out in Europe to evaluate the extent to which the various improvement measures are economically viable. A case in point is the study carried out by the Building Research Establishment. This study classes the various insulation improvement measures by their internal profitability rate (rate calculated without allowing for changes in energy prices, at mid-78 prices).

The highest rates of internal profitability (15 to 20 %) are obtained for dwellings which are heated above the national average, by using 80 mm of glass fibre on uninsulated cavity or solid walls. The next highest rate (10 - 15 %) is obtained by the same improvement, but in a normally-heated dwelling, and by filling the cavity walls of well-heated dwellings. Superinsulation in well-heated dwellings gives a profitability rate of 5 - 10 %, following by 0 - 5 % when cavity walls are filled, normally-heated dwellings are superinsulated, and insulating shutters are fitted. Unprofitable measures include double glazing, external insulation of solid walls, and insulation of floors.

Hence many insulating operations are profitable, and all the more so because of the rises in energy prices since 1978. However, these figures call for two comments.

Firstly, that the investment will not be profitable to private individuals unless they derive benefit from it over a long period. This poses the question of sharing the expenditure and savings between owners and tenants: if the owner pays for the improvement, he should be able to benefit from it by way of an increase in rent comparable to the saving achieved in heating costs ; if the tenant pays for the improvement, he should be able to recover part of its value if he leaves the premises.

Secondly, private individuals are tempted to confine themselves to profitable measures. In reality this calls for the remarks made in the introduction on the subject of the two effects of energy-saving measures : reduction of expenditure and insusceptibility to shortages.

Period for implementing the measure :

This measure should apply to virtually all existing buildings. Its rate of implementation is in any case governed by the production capacity of the insulation manufacturers, and the capacity of the insulation-laying firms.

To estimate the order of magnitude of the effort involved in insulating all existing buildings, we have made a very rough estimate in respect of the buildings in France, as we lacked data on the other countries.

The average cost of building a dwelling (if we start with housing) is about 175.000 F, and 2 $1/_2$ % of the existing stock of dwellings is built each year. It might cost 20.000 F to insulate a dwelling fully. Hence the cost of improving the entire housing stock would equal (in financial terms) 5 years of new buildings. To do this in 10 years would mean doubling the building activity in this sector.

It is possible to make the same comparison in a slightly different form. There are 18 million dwellings to be improved in France, and the cost of so doing would be about 400 G. francs. The turnover of the building trade totals 200 G.F. per annum (of which 80 G.F. for new buildings). The insulation programme represents five full years' work for the building trade. However, the turnover of the trades concerned in improving insulation is only a fraction of these 200 G.F. : perhaps a little more than 10 %. It is necessary to compare 400 G.F. to 20 G.F.

Any attempt to implement the whole insulation improvement programme for buildings in (say) 10 years would involve quadrupling the activity of the firms in question for only 10 years, after which their activity would return to its previous level.

The position would be even more unfavourable in the rest of Europe, for building activity there is currently lower in relation to the existing building stock (see annex I to the Introduction).

If we take account of the capability of the building industry and of the need to achieve tangible results quickly, we may conclude that a period of some 20 years will have to be considered.

Resolute efforts will be necessary to keep to this timetable.

Since this is a lengthy period in view of the speed of the crisis, priority action should be taken where the savings will be greatest and easiest. The following recommendations may be made :

o to give priority treatment to buildings with central heating, because buildings without central heating consume much less energy, and improving their insulation generally results in increased comfort rather than reduced consumption. This reduces almost by half (44 %, in France) the number of buildings to be treated ;

o to start with the measures that show a profit most quickly : insulating roof spaces and shutters. The relevant expenditure is very low (hundreds rather than thousands of Francs) and will account for a substantial part of the total improvement.

Effectiveness of the measure :

According to the examination made under point 1, one may lay down the following final target values for improving the insulation of a building :

Roof spaces	:	K = 0.35 W/m2°K
Walls	:	K = 0.6 "
Glazing	:	K = 3.5 "

The overall result for an individual house is a coefficient G_1 (1) of 0.75 W/m3°K.

The current French average for this type of building is estimated at 2 (and at 1.5 for all types of buildings).

If all buildings were provided with this level of insulation, a saving of 50 % would be made in heating energy.

These figures are only approximate, because :

- o improved insulation will often result in greater comfort rather than a saving of energy ;

- o many existing dwellings (over 35 % in France) have not yet been fitted with central heating : they will gradually be so equipped, and national consumption will be increased accordingly.

As they stand, these figures show how very large these potential savings are ; it would doubtless be possible to attain 30 % on 10 years. At European level, this means some 60 million TOE. Together with the reduction of heating temperature, it is the most effective measure.

(1) The coefficient G_1 is the loss through walls in W per m3 and per °K. The coefficient G is obtained by adding the losses caused by changes of air.

3. Limitations :

Improving the insulation of the walls of existing buildings may create technical difficulties.

Insulation fitted to the outside of the walls may seriously affect the appearance of the building.

Insulation by injection of foam into cavity walls may cause trouble in the outer leaf of the wall. We have seen that the risk could be overcome.

Insulation on the inside lowers the inertia of the wall and brings a risk of condensation in the body of the structure, which can easily be combatted by fitting a vapour barrier.

We have seen that it was not easy to improve the insulation of certain structures, e.g. loft conversions, glazed features and solid floors.

Only studies based on a knowledge of the number and types of existing buildings would make it possible to specify the improvements to which one should limit oneself in the various types.

4. Application of the measure to new and existing buildings

This memorandum concerns existing buildings only. Memorandum 2.2.b deals with new buildings.

5. Industrial and commercial consequences

Increasing the insulation of all buildings would represent a very

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expensive transaction for Europe : 850 G.F. for housing only.

This raises first of all a problem of materials : will the output of the insulation manufacturers keep pace with demand? One may imagine that it will, because the insulation manufacturers have noted the increased demand and expect a growth rate of 10 % per annum. In France, for instance, this growth rate would enable 1 million dwellings per annum to be insulated in 1982 (1), which is sufficient for the established objective. Moreover, the Community countries have at present a very low consumption per head of insulating material as compared with a country like Sweden (0.30 m3 per capita in France as against 0.90 in Sweden).

As regards labour, the increase in insulation would certainly create employment, and this is favourable to an economic growth poorly connected with increased oil imports. However, the great increase in activity required from this sector may make the support of the public authorities necessary. It would be useful to estimate the number of jobs that this expansion of activity would require, bearing in mind that the users could themselves do part of the work contemplated (roof spaces, double glazing).

This is a study that the Community could undertake.

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(1) Production of insulating material for buildings in 1977 : 12.10^6m3, of which 9.10^6m3 used in new buildings and 3.10^6 m3 for improvements. With a growth rate of 10 % per annum, there would be 18.10^6 m3 in 1982, of which 9.10^6 m3 would be for old buildings.

(Source : French insulation manufacturers.).

6. Current use of the measure in Member States

The governments have introduced various systems of financial aid in the form of grants, loan facilities or tax exemption.

Belgium provides aid for insulation or double glazing by means of grants (about 3.000 F per dwelling), depending on the region.

Denmark grants tax exemptions of up to 50 % of the cost of insulation. Subsidies cover 30 % of the cost.

Germany grants subsidies of up to 25 % of the cost, and tax exemptions of up to 10 % of the investment cost over 10 years.

France grants aid (of up to 400 F per TOE saved) for insulating existing dwellings. Tax exemption is given. There are ANAH* subsidies and grants to owners subject to an income ceiling.

The Republic of Ireland pays grants of up to 66 % of the cost within the limits of a minimum and maximum cost. Tax exemptions are granted.

Italy pays grants of up to 30 % of costs.

The Netherlands has a national insulation plan (200.000 dwellings per annum). Subsidies of 30 % of the cost are paid.

In the United Kingdom there is a 10-year basic insulation programme for public buildings. Subsidies of 66 % of the cost of insulating uninsulated dwellings are payable.

* ANAH "Agence Nationale pour l'amélioration de l'Habitat" France.

7. Proposals

7a - Proposals for Community action. The European governments have taken measures for insulated buildings. What part might the Community play in this field?

- o It might compare the insulation programmes of each country and the results already achieved, for the purpose of following their example and encouraging the least active countries to take the necessary steps ;

- o it might propose an insulation improvement programme (complete with figures), laying down a common time limit and an order of priority according to the saving to be expected, with different objectives for each Member State. The Community would monitor implementation of this programme.

7b - Standardisation proposals. ISO TC 163* has the following projects in hand :

- Sub-Committee 1 : test methods ;
- Sub-Committee 2 : calculation methods (heat channels, useful thermal characteristics) ;
- Sub-Committee 3 : specifications of building materials ;
- Sub-Committee 4 : specifications of industrial insulation materials.

7c - Research proposals. In order to evaluate potential national energy savings through insulation in each country, it is essential to carry out studies of types, and a census, of existing buildings :

ISO* International Standard Organisation. Technical Committee 163. Thermal Insulation.

- according to the type of building (industrial, commercial, cultural, etc. accommodation) ;

- according to building technology ;

- according to level of insulation ;

- according to the occupants' standard of comfort.

To our knowledge, such studies have been carried out in Great Britain (BRE)* and in France (Institut Economique et Juridique de l'Energie). The experts consulted in the other countries did not mention to us the existence of such studies (at planning stage in Denmark).

A complementary study would have to be carried out on the basis of this classification of existing buildings to determine what energy savings governments might make in the event of a voluntary insulation policy supported by the EEC (improving existing buildings in 20 years).

BRE* Building Research Establishment

1. Background information and examination

Although the same principles apply to the insulation of new as to existing buildings, they are easier to apply in new buildings.

One can thus aim at better performances than in existing buildings, and in particular require these by legislation. There is no theoretical physical lower limit to the value of K.

It will be recalled that the thickness of a sheet of insulating material having a K of 0.4 W/m2°K, or a thermal resistance of 2.5 m2 K/W, is :

- 10 cm if it is made of mineral wool or expanded polystyrene dry bulk of 20 Kg/m3 (λ0.04) (cost : about 20 F/m2) ;

- 7 cm if it is made of polyurethane dry bulk density equal to 40 Kg/m3 (cost : about 45 F/m2).

Such a sheet used in conjunction with a solid brick wall (thermal resistance : 0.5 m2 K/W) gives a K of 0.33 W/m2K ; in conjunction with a wall made of cellular concrete blocks (R = 1.3) it gives a total K of 0.26 W/m2°K.

This gives some idea of the insulation that can be obtained with a continuous section of wall. However, buildings necessarily have links between their different layers, and particular points that constitute thermal weak points.

In response to the reasonable requirements of the first insulation regulations introduced since 1974, we have already witnessed changes in techniques and in their relative competitiveness. The more stringent requirements that are necessary (and which are already in force in certain countries) will cause new upheavals regarding building materials themselves : cellular concrete, and multi-cell hollow bricks will have to be used with a lining of insulating material, otherwise they would be too thick.

The quest for a minimal thermal loss will also result in minimising the ratio of building area : building volume, and this will certainly affect architecture.

What insulation values should we aim at, and first of all, what coefficient of loss can be aimed at for the different structures?

Roofing. It will be noted that the Danish regulations (which are currently the most stringent, and are expressed in terms of K) specify the coefficient K of roofing for all buildings of 0.2 W/m2°C (in force since 1 February 1979).

Attaining this value in non-habitable, inaccessible roof spaces is, at present-day prices, a question of insulation thickness, which poses no problem. It should be borne in mind that the upper part of the walls should be treated to prevent them forming heat channels.

In accessible roof spaces (especially those that are habitable) the solution is less simple and costs more for insulation. It is nevertheless possible.

In the case of flat roofs a very careful study is necessary to avoid heat channels, particularly through the acroteria. New types of structure will have to be specified.

Opaque walls. Only continuous insulation over the entire surface (which in practice would have to be on the outside) can enable thermal weak spots to be avoided and coefficients K lower than 0.5 to be attained.

The Danish regulations specify 0.3 for light walls (under 100 kg/m2) and 0.4 for others. This would appear to be the limit, particularly as regards countries where building technologies are more diversified than in Denmark.

Lower floors. For these, it is possible to obtain K comparable to those of flat roofs, although they would be a little higher because of the complications arising from the need for mechanical continuity to allow for vertical loadings and the passage of pipes.

Glazed areas. These are the thermally weakest point in the shells of buildings.

Traditional wooden-framed, single-glazed windows offer a K of 5.0. If however one takes account of the protective effect of shutters, the average K over 24 hours (called day-night K) is lowered to 3.7 With traditional shutters.

The use of double glazing makes it possible to obtain a typical K of 3.0 for windows without shutters, and a day-night K of 2.4.

Triple glazing reduces these figures to 2.2 and 1.8.

With insulating shutters capable of attaining a characteristic K of 0.9, the day-night K are very considerably improved and attain 3.0 with single-glazing, 1.8 with double-glazing and 1.3 with triple-glazing.

The solution of double windows makes it possible to combine the insulations of the two windows if the wall constitutes a virtually complete thermal barrier and to attain values of about 2 without shutters.

It will be observed that the use of shutters in offices, schools and works is unfortunately the exception rather than the rule. Substantial gains can be obtained by insulating the (often very large) windows when the premises are unoccupied (often for 14 and more hours out of 24), in addition to lowering night-time heating temperatures.

In a typical individual house (100 m2 ground area, 16 m2 of glazing, 2.5 m ceiling height) the minimum insulation rates attainable (0.2 for roofing ; 0.4 for walls ; 0.2 for floors and 2.0 for glazed areas) give a coefficient G_1 of 0.42 W/m3°K, or an average K_m of 0.36 W/m2°K (1).

In 1975 a study for the EEC, in which J. Uyttenbroeck and G. Carpentier - CSTC - * compared the various European regulations, found that the

(1) G_1 and K_m being defined as follows :

$$G_1 = \frac{\text{total of losses by wastage}}{\text{volume of building}} \quad \text{in W/m3°K}$$

$$K_m = \frac{\text{total of losses by wastage}}{\text{total loss surface}} \quad \text{in W/m2°K}$$

We have the ratio $G_1 = K_m \times \frac{S}{V}$ (total loss surface) (volume of building)

*CSTC "Centre Scientifique et Technique de la Construction - Belgique"

4)

regulation values for this type of house (ratio $\frac{S}{V}$ = 1.2) were as follows :

- Italy (Lombard region)	K_m =	0.53 W/m2°K
- Germany	K_m =	0.73 "
- Belgium	K_m =	1.90 "
- France (region A)	K_m =	1 "

There is thus a very substantial difference between a value which although minimal is nevertheless attainable, and the statutory values (except in the case of Denmark).

It is thus possible (as several Member States have already done or are in the process of doing) to introduce more stringent insulation requirements.

The requirements should not be tightened up gradually : the steps planned for a few years hence(and which could have been taken when the oil crisis first began) can be taken now.

No time should be lost in taking these measures, for the building stock is renewed at a rate of some 2.5 % per annum. A measure taken in 1980 will affect only half of the buildings in the year 2000.

It is generally accepted that governments intervene by means of legislation to limit losses through the shells of buildings.

The regulations may speak in terms of C (the consumption for maintaining the required temperature), of G (total loss via the shell), or of K for walls, and of air changes.

The advantage of regulations laying down values of a more global magnitude is that it gives the builder greater discretion. There should be no objections to fixing global values of C or G, and to quoting values of K and of air changes by way of examples of solutions, whilst at the same time laying down maxima for these values so as not to be deprived of savings that can easily be made.

2. Cost and effectiveness

2a - Cost of the measure. It costs much less to increase insulation at the planning stage than it does to improve insulation in an existing building.

On the other hand, a saving is made at the time of building, since it will cost less to fit a less powerful heating installation.

It has not been considered (especially in France) that the obligation to comply with lower G or K than usual will result in a substantial increase in building costs.

The consequences of virtually doubling insulation would differ according to the processes : some of them would have to be modified, and others simply abandoned. In other cases, increasing the insulation consists in the main of increasing the thickness of the insulation material. The effect on the cost is obviously a function of the ratio $\frac{S}{V}$ (the price of the insulation material by itself may - according to the size of the building represent 2 % in a small building, 1% in a medium-sized building, and less in large buildings).

2b - Time scale. The building renewal rate of 2.5 % per annum sets the time scale for the effect of this measure. If in the year 2000 50 % of buildings were better insulated (G_1 = 0.4 ; G* = 0.65, as against the present G of about 1.3) - in other words, if they consumed only half as much - there would be a saving of 25 % on the present European total.

2c - Chances of success. Experience in recent years has proved that statutory requirements as regards insulation are complied with. A series of inspections in France showed that new buildings were on average slightly better insulated than required by the regulations.

3. Limitations

Increased insulation interferes with the satisfaction of some other of the user's requirements.

At least as far as concrete technology is concerned, the most effective (outside) insulation requires the facades of buildings to have a rather uncomplicated relief. Actually, this is the type of relief in current use. There will be no difficulties unless a return to more varied reliefs is required.

Still on the subject of concrete technology, increased insulation accentuates the effect of thermal shocks on the thin slabs covering the insulating material, and raises doubts as to durability.

$$G = \frac{\text{total of losses by thermal conductivity throughout walls and by the air renewal}}{\text{volume of building}} \quad \text{in W/m3°K}$$

$$G_1 = \frac{\text{losses by thermal conductivity throughout walls}}{\text{volume of building}} \quad \text{in W/m3°K}$$

Whatever has been said on this subject, the dangers caused by the combustion of insulating materials in the event of fire are negligible.

All in all, it is not these snags that can limit increased insulation.

It will be noted that the limitations are less than when insulation is improved in existing buildings.

4. Application of the measure to new and existing buildings

This memorandum applies only to new buildings.

5. Industrial and commercial consequences

The rate of new building is not destined to increase in future years, and the stepping up of insulation standards will cause an increase in demand for insulating material which the insulation manufacturers are ready to meet.

There will be practically no impact on labour requirements on building sites.

6. Current use of the measure in Member States

Belgium : Mandatory requirements for certain public buildings only (advised for other buildings).

Denmark : Stringent standards, tightened-up in February 1977 ; the most stringent regulations at present.

Germany : Standards increased in 1977. Plans are in hand for a further increase.

France : Standards in force since 1974 (they existed since 1958 for State-aided housing). These standards are in the process of being increased.

Luxembourg : No standards in force.

Republic of Ireland : Standards for State-aided buildings in force since July 1979.

Italy : Standards in force since February 1978.

The Netherlands : Standards in force since 1974. They are in the process of being stepped up.

United Kingdom : The 1975 standards are in the process of being stepped up.

The measure is applied :

- either by limiting the K of the different walls (UK, Germany) ;
- by limiting the global K_m of a building (Belgium, Denmark, Netherlands)
- or by limiting G, i.e. voluminal losses through walls and by ventilation (France, Italy). (Cf. memorandum 2.1, point 6 in this respect.).

7. Proposals

7a - Proposals for Community action.

- Comparisons.The paper by J. Uyttenbroeck and G. Carpentier entitled

" Comparaison des règlements d'isolation thermique dans les pays membres de la CEE" (dating from 1975) is a very good starting point for comparing the degrees of stringency of the governments. It would be a good thing if it were updated* to take account of the new regulations, and if efforts in the various Member States could be compared regularly.

- Community rules. One might hope that a Community regulation might be drafted for this measure, which is implemented by means of regulations. Because of the previous technological approach in each Member State, difficulties may be expected in reaching agreements on the points listed below.

- Whether the necessary regulation should lay down a maximum value of K for the different walls, a maximum value of the overall K_m of buildings, or a maximum value of G for buildings.

- Whether a distinction should be made between different climates.

- Whether distinctions should be made between the different types of buildings.

By way of guidance, we give in the annex the table compiled by the "Requirements" Working Group of the C.I.B. proposing the values of C coefficient for different climatic zones and for different types of buildings.

7b - Standardisation proposals. As set out in memorandum 2.2.a.

7c - Research proposals. It would be preferable to circulate particulars of the solutions used in the various countries to obtain high

* Brought up to date in 1980 and it was to be published.

standards of insulation, rather than to carry out research as such.

Research could then be encouraged into materials with mechanical qualities enabling them to be used for building, and which have interesting insulation qualities (λ less than 0.1/W/m°K, in order to build 30-cm thickness insulated load-bearing walls from a homogeneous material.

1. Background information

1. Control

Many central heating systems in blocks of flats or offices are controlled only by a thermostat on the boiler outlet, which is manually controlled by "rule of thumb" according to the outside temperature, or at best by means of an instruction table showing the outlet temperature in terms of the outside temperature.

This has serious snags, since the energy supplied to the radiators is the same irrespective of the free (and especially solar) gains : and this leads to waste.

Since the installations are very often badly balanced and the premises badly exposed (to the north, on a corner, under the roof), and since they are not over-insulated or fitted with larger radiators, it is necessary to overheat some of the rooms to heat the less-favoured ones sufficiently.

These same blocks lack individual meters, with the result that no occupant is interested in turning off his radiators when he is too warm.

It is very difficult to determine the extent of wastage caused in this manner or (what comes to the same thing) what savings could be made with a satisfactory control and metering system.

For if there are wasters, there are also public-spirited people who turn off their radiators when it starts to be too warm, or who use auxiliary heating rather than ask for water temperatures to be increased.

The problem is not quite the same in individual dwellings, where cost directly controls the user's behaviour.

Remedies for the situation described do exist : they are in order of importance a correct balancing of the installation, control systems and metering.

In actual fact, the possible solutions for remedying this state of affairs are as listed below.

a - Where central heating is installed in individual dwellings, the first requirement is an automatic control which controls the boiler burner, a mixer valve or the on/off contactor of a circulation pump. This control can be set according to the temperature of a reference room, or better still the outside temperature. Radiator controls can then be installed in the room (thermostats, thermostatic valves).

If the heating system uses electric radiators or a gas-fired boiler connected to a flue, it is advisable to have automatic control by means of a room thermostat. Recent surveys have shown (in France at least) that people living in individual dwellings would like to have a control for each room, so that they can set the temperature lower in certain unoccupied rooms (bedrooms, especially during daytime). This wish should be taken into account when organising the control system.

b - In the case of central heating in multiple-occupation buildings, the first appliance to fit is a central control operating in conjunction with an outside sensor and controlling the burner or a modulating valve.

The next improvement will be to have a control for each outside wall ; it can be actuated by a sensor located in a reference room, or better still by an outside sensor which takes account of the sunshine on the outer walls.

The fitting of thermostatic valves in each room can then be considered. Their effectiveness is however disputed, except with high-inertia systems such as underfloor heating in particular.

In all multiple-occupation buildings the control should be suitable for providing a daily cycle of temperatures : a night reduction that is more or less marked in dwellings, and very marked in buildings used for industrial and commercial/services purposes. A programming capability for these cycles should be mandatory.

How are the savings made by these controls to be quantified? In France, the Agence pour les Economies d'Energie takes as a basis for awarding grants to energy-saving schemes, figures from an in-depth study based on in-situ observations, theoretical calculations and analogue simulations.

The reference standard is a communal central heating installation, fairly well balanced, with manual central control.

- Central control by means of a mechanised valve gives a 15 % saving.

- If controls on outside walls are added, the saving increases to 20 %.

- The addition of thermostatic valves can make an additional saving of 5 %.

These figures are given by way of guidance only. They may vary considerably according to the installations, habits of occupants, etc. In particular, they will be much lower if balancing is defective, because the control will operate to satisfy the most disadvantaged premises, causing the others to be overheated. Balancing is always a prerequisite for improving controls, and it is in particular necessary to check it after the insulation of a building has been improved.

c - The foregoing remarks also apply to mixed communal heating (basic central + auxiliary heating), but controls on the auxiliary circuit will have a greater effect than those on the basic circuit.

B. Metering

The installation of evaporative heat distributors (which are rough-and-ready meters) is not very expensive (250 F per dwelling per annum), but it has tended to be abandoned because of the lack of accuracy. If it is true that it permits injustices and fraud, a survey has nevertheless shown that it has caused savings of between 13 and 17 % (source : CETIAT)*.

If a system that is generally favourable is not to be rejected, attempts must doubtless be made to remedy the snags mentioned, which are experienced

*CETIAT Centre technique des Industries Aerauliques et Thermiques (France) by the joint occupants of a building.

The installation of heat meters (3.000 Francs per meter) is more expensive, and not always possible in old housing. It is nevertheless more equitable, no doubt more efficient,and in particular more acceptable.

2. Cost - Effectiveness

The rate of potential savings (20 %) and the relatively low cost of controls ensure their profitability when used for heating systems in shared buildings. With individual heating systems the savings are much less marked because the users (who already tend to limit their consumption under the pressure of rising heating costs) will in fact use the controls more as an instrument of comfort than of energy saving.

The cost of outside-wall controls in a multi-storey block can be estimated at 1.500 F per flat (or equivalent). This investment pays for itself in 5 years.

Opinions differ widely as regards metering in communal heating systems. It is significant that evaporators (which originated in Denmark in about 1910) are no longer used there. Apart from the accusation that they can be manipulated and are unjust (they encourage the theft of heat), the Danes considered them unprofitable : but times have changed since then! At a rough estimate, distributors or heat meters can give a saving of 10 % if the user's behaviour is "average" (source : COSTIC)*. The use

*COSTIC - "Comité scientifique et technique de l'industrie du chauffage, de la ventilation et du conditionnement d'air" Paris.

and cost of metering must in fact be weighed in every case against other operations such as improving the insulation. Whichever measure is the most profitable will then be taken.

3. Limitations

The installation of controls and meters does not interfere with the satisfaction of the user's other demands.

4. Application of the measure to new and existing buildings

Controls and meters can be installed in both new and existing buildings, but not as easily in both cases.

One may hope that in future the installers will have learned to prevent waste in new installations in new buildings ; but since a "good" installation costs more than a bad one, the installers must be encouraged or compelled to use means of ensuring good use of heating, such as heat meters (or at least distributors), controls on outside walls, and satisfactory balancing.

In old buildings, one can only recommend the inspection and improvement of installations ; but the cost of these operations and their unprofitability in the short term are difficult obstacles to overcome, especially when the investment does not directly concern the user (see next paragraph).

In any event, a central heating installation in a communal building should be balanced before a control is installed. Nowadays, heating installers know how to do this balancing, but at the time when energy cost practically nothing, far too many installations were badly designed. It is also advisable to rebalance installations in buildings which have had their insulation improved.

5. Industrial and commercial consequences

The measures in question lead to the use of such devices as sensors, thermostatic valves, and meters. There will obviously be a great increase in demand (and thus in production) of these appliances. New techniques will appear, making use of microprocessors. European industry seems able to meet competition from Japanese and American products. Intra-European trade in these appliances should be encouraged.

6. Current use of the measure in Member States

Meters are compulsory in all new communal buildings in France. The regulations are mandatory in all new communal buildings (as well as in existing ones) if the boiler has a rating of more than 30 kW.

In Italy, metering is compulsory for the supply of hot washing water, but not for heating.

Regulations in the Netherlands require individual metering.

There are no regulations as regards controls or metering in the other countries.

7. Proposals

7a - Proposals for Community action. One may hope that the governments will compel the installation of controls in new buildings : automatic control on the boiler, controls on outside walls and (in individual dwellings) room controls. The regulations should require all buildings to have the means of programming daily (and weekly) temperature cycles, and (in individual dwellings) of setting temperatures by rooms. To encourage controls and metering in existing buildings, it is advisable to grant financial incentives and to give owners an interest in the results of savings.

Moreover, the use of controls would be encouraged if regulations of the "limitation of coefficient C" type were adopted, in which account would be taken of the type of control when calculating solar gains.

7b - Standardisation proposals. The standardisation at European level of thermostatic valves and sensors at least is a matter of some urgency for encouraging intra-European trade.

7c - Research proposals. The creation of reliable and inexpensive meters seems a good subject for invention and development. The Community might encourage it by means of research funds and perhaps competitions.

1. Background information

A. Heat pumps

The economy principle (1) of heat pumps using electrical energy is as follows : they use "noble" electrical energy produced with an efficiency of 0.35 and transform it with an "efficiency" that may exceed 3 into low-temperature thermal energy. This is not strictly the efficiency of the pump, but its "performance coefficient". Total efficiencies exceeding 1 are expected, whereas the efficiency of a boiler using conventional fuel cannot be expected to exceed 0.8.

In practice many experiences have proved disappointing. The main cause of this is that although theoretical performance coefficients and those measured in the laboratory are very high, the same is not true in actual working conditions : the temperatures of the heat source (ambient air, warm air, or water of the heating circuit) are by no means constant, nor are the temperatures of the cold source (outside air, outgoing air, floor or water). The real performance coefficients (which are a function of the difference between these two temperatures) also vary, and at worst the performance coefficient has values of 1, i.e. equivalent to electric heating by Joule effect.

(1) The thermodynamic principle is of course to raise the temperature of the cold source to that of the heat source, by consuming energy.

Then again, heat pumps would seem to need an experienced person to attend to them, so that one must recommend large units serving a large building. Premature enthusiasm for small units has prejudiced the development of these appliances. The development of heat pumps depends on the manufacturing of reliable equipment and the carrying out of precise studies in each individual case.

There are various types of heat pumps, which are named according to the cold and heat sources : air-water, water-water, water-air pumps, etc.

B. Exchangers on the air outlet

The principle of exchangers on the air outlet is to make the outgoing air give up its heat to the new incoming air. The exchangers are rotary, or static with cross-flow or contra-flow exchanger panels.

The efficiency of these exchangers can attain 70 %, with a consequent saving of 0.7 x 0.34 N.V. DH_i. This represents 20 - 25 % of total consumption in buildings constructed before the crisis, and more in well-insulated buildings.

The use of exchangers requires controlled dual-flow mechanical ventilation (with its advantages of control and air changes). The saving is about 20 - 30 kWh/m2 per annum, and increases as the region becomes colder (despite expenditure of defrosting energy, which incidentally is not lost), partly because (unlike heat pumps) its efficiency does not decrease with the outside temperature.

The value of the saving is relatively greater in large communal buildings than in individual houses, because ventilation accounts for the expenditure of more heating energy in the former.

Moreover, the better insulated the building is, the relatively greater the saving.

C. Heat pumps + exchangers

The advantage of this combined solution is that the efficiency of the exchanger increases when that of the heat pump decreases, i.e. when the weather is cold. It is then possible to make savings of 45 - 50 %, and the installation costs are not as much as they might seem because the air intake and extraction circuits are common.

2. Cost - Effectiveness

A. Heat pumps

A calculation (ref. C.S.T.B.*, computer calculation) has shown that in the case of air-air systems (with dual-flow mechanical ventilation) the energy-consumption savings are as follows, as compared with all-electric heating without an exchanger :

- block of flats : 30 - 40 %
- individual houses : 30 - 35 %

In fact the saving varies considerably according to the thermal qualities of the dwellings. These figures are however currently accepted for "well-insulated" dwellings.

*C.S.T.B. - "Centre Scientifique et Technique du bâtiment" France.

The additional cost of installation as compared with an ordinary electric heating system is between 15.000 and 20.000 Francs per dwelling. This means that the installation takes too long to pay for itself (15 or 20 years) to say whether a private individual considers it profitable.

For the time being, the main interest of the solution is for blocks of flats or large buildings : the investment costs per m3 heated decrease as the size of the building increases, and it is possible to ensure good technical servicing (something that seems essential in the present state of the art). Moreover, the large units are currently more reliable than the small ones.

B. Exchangers.

The extra cost of an exchanger is about 5.000 F per dwelling, a large part of which represents the cost of the mechanical air extraction system. Such an installation is unlikely to be profitable in an individual house, but is profitable in blocks of flats or of offices fitted with controlled mechanical ventilation.

When the building must for other reasons be fitted with air conditioning, the only extra charge is the cost of the exchanger. Its use should be compulsory in such cases. The exchanger works just as well during heating and cooling periods.

C. Heat pumps + exchangers.

When it is proposed to install an air-air heat pump; it is generally profitable to add an exchanger. The reason for this is that it is most efficient when the efficiency of the heat pump decreases : during very cold weather. The exchanger also reduces the temperature variations of the cold source, and thus improves the performance. As already mentioned the only extra cost is that of the exchanger, since the air intake system is common to both systems.

The total investment cost is nevertheless high, with the result that these solutions are confined to buildings of a large cubic capacity and to climates where there is a large number of degree-days. Profitability is theoretically possible in individual houses, but disappointing experiences show that no definitive conclusions can be drawn on this subject.

3. Limitations

The installation of heat pumps and/or exchangers does not affect the satisfaction of the user's requirements other than heating, apart from the requirement of an absence of smells in rotary exchangers.

4. Application of the measure to new and existing buildings

The only problem that arises when fitting these installations in new buildings is the cost.

Fitting them in existing buildings poses other problems.

In the first place, heat pumps (like certain air conditioners) which are installed room by room (generally under the window) run the risk of being very ill-adapted to their service conditions, as already mentioned.

Moreover, the installation of a housing heat pump requires a particularly accurate study and also modifications to the installations. The use of an air-air pump requires the installation of dual-flow ventilation.

It is however possible to use as a heat source the hot-water heating circuit of a conventional oil-fired system. An advantage of this solution is that the heat pump can be used for background heating (with a performance coefficient), while the peaks are supplied by the oil-fired heating, thereby avoiding undue expense for electricity.

The installation of an exchanger in an existing building is a costly, major operation (except where dual-flow ventilation already exists) and is thus rarely possible.

5. Current use of the measure in Member States

No European government has yet introduced legislation requiring heat pumps to be installed, or even for facilitating finance for them, since this process is thought too new and its results too uncertain. Numerous research programmes and demonstrations are under way, at the instigation of the electricity supply companies in particular.

They have in fact considered it necessary to respond to criticisms of bad use of primary energy in Joule-effect heating systems, by developing a system that does not waste so much "noble" energy.

Moreover, insofar as future electrical energy will not be based on oil, these heating systems using electrical energy will be perfectly justified.

Europe should be responsive to these last two arguments.

Italy requires exchangers to be fitted in non-residential buildings equipped with controlled mechanical ventilation when the air-change rate and heating period exceed certain values.

6. Industrial and commercial consequences

We have not been able to gather data on European heat-pump construction capacity. If however it is pointed out that they use manufacturing techniques similar to those of refrigeration units, one may expect that in the event of a sharp increase in demand, European industry would be in a position to respond quickly.

There would nevertheless be keen competition between European products and those from elsewhere : it is important that the European currencies saved on oil purchases thanks to investment in pumps or exchangers should remain in Europe.

One might suggest that characteristic international standards be drafted for these appliances. CIB W 67* is currently working on them.

7. Proposals

7a - Proposals for Community action. The Community is already financing a large number of research and demonstration operations. The technical progress of heat pumps does not yet seem such as to allow the proposal of statutory measures, but one might invite the Member States to offer financial incentives.

*CIB - The International Council for Building, Research, Studies and Documentation - Working Group 67 - Energy Conservation in the built environment.

In any case however, the adoption (as recommended variously in this report) of regulations limiting the coefficient C of buildings (where C takes account of the presence of such appliances as heat pumps or exchangers) is an implicit encouragement to use such appliances.

7b - Standardisation proposals. It is very important that European standards should be drafted for the performance of heat pumps : CIB W67 is engaged in providing the pre-standardisation base, and the ISO* seems disposed to produce standards.

7c - Research proposals. The Community has already allowed considerable space for heat pumps in its four-year Research and Demonstration Programme. The use of the results of this research should be coordinated so that they can be followed shortly by standardisation.

It is unfortunate that this research lacks in situ experiments designed to measure real performances otherwise than in laboratory conditions.

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*ISO International Standard Organisation (Geneva).

2.2.5 OPERATION - MAINTENANCE - BOILER REPLACEMENT Memorandum 2.5

1. Background information

Most European central-heating boilers are oil-fired. In France they represented 60 % of boilers in 1977, and were responsible for about 15 % of French oil consumption. It is necessary to see that so long as these boilers exist their efficiency is the best possible.

This calls for attention to be given to the following points :

- the operation of the installations, checking that the temperatures obtained are indeed those required ;
- monitoring the installations, i.e. checking various points of the circuit to see that the installation is functioning properly, and then carrying out the necessary adjustment, balancing and maintenance work ;
- adjustment (in particular of the burners, and of air and fuel throughput) ;
- balancing the heat distribution and emission circuits ;
- minor maintenance, i.e. work not costing much by way of parts and labour, and not requiring the installation to be taken out of use ;
- major maintenance, i.e. larger jobs which may require the installation to be taken out of service, but not requiring the replacement in toto of major equipment ;

- the replacement by new equipment of damaged or worn equipment ;

- replacement of the boiler.

The necessary maintenance, operating and replacement work is specified. In France, the government has approved a number of experts who must be used for certain installations.

What savings can be achieved by these operations if they are properly carried out? It is difficult to answer this question without knowing the current average state of maintenance of boilers in Europe. If these operations are carried out more efficiently, they will generally result in a saving.

The efficiency of an installation can be improved by modifying it so that the time when the boiler is "off" is only a small fraction of the time when it is "on" (1).

This can be done :

- by reducing the operating temperatures of the installation, which involves replacing the radiators by larger ones ;

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(1) Where R_n = nominal efficiency of the boiler
t_a and t_m = "off" and "on" time
q = wall losses as a percentage of nominal rating
The mean efficiency is given by : $R_m = R_n \left(1 - q \frac{ta}{tm}\right)$
For an average boiler, $q = 0.04$.
If $t_a = 4t_m$, then $R_m = 0.84\ R_n$
If $t_m = 6t_a$, then $R_m = 0.995\ R_n$
There is a loss of 16 % of the nominal efficiency in one case, and of 0.5 % in the other.

- by making successive use of several boilers according to how cold the weather is (the second and subsequent boilers would not operate until the previous one was under full load). Such arrangements cannot be contemplated unless the demand for heat is considerable, since the unit cost of low-powered boilers would make it impossible for the investment to pay for itself in individual or small communal buildings. This is an argument in favour of district heating.

The following points should be borne in mind as regards boiler replacement.

- It is always worthwhile to replace oil by another fuel, such as gas or even coal. This change does not always require a replacement boiler.

- It is advisable to put a stop to the frequent practice of overdimensioning boilers : if the efficiency of small boilers (under 10 kW) is improved, the apparent justification for this practice ceases.

- Where saving is concerned, another important point with boilers is the type of operating contract when the boiler is not operated by the occupant of the premises.

Some types of contract do not encourage the operator to save : e.g. a contract which requires repayment of the cost of fuel plus a percentage for operation and minor maintenance.

On the other hand, a contract for maintenance of a given temperature, where payment is a function of the degree-days, encourages the operator to save.

Such a contract may moreover provide for the savings to be shared between the operator and the lessor.

There again it is difficult to tell what fuel saving can be expected by changing the type of contract. Some saving is however certain.

2. Cost - Effectiveness

It is really difficult to calculate the difference in cost between maintenance done properly and maintenance done badly. We have also seen it is very difficult to calculate at national level the saving resulting from improved maintenance. The fact nevertheless remains that since good maintenance produces substantial savings, we should make certain of it.

The adoption of a good operating contract should lead to a reduction in both heating expenditure and energy consumption. Hence this measure is essential.

3. Limitations

Improving the efficiency of an installation by better design, better maintenance and better operation obviously has no effect on the satisfaction of the user's requirements. Hence there is no limitation in the application of the measure.

4. Application of the measure to new and existing buildings

Measures regarding maintenance, operating and boiler renewal apply essentially to existing housing. The remarks regarding the reduction of boiler size, or the installation of several staged boilers, however, apply equally to new buildings.

5. Industrial and commercial consequences

The obligation to inspect and maintain boilers above a certain rating necessitates specialists. This serves as a motive for creating a number of jobs.

6. Current use of the measure in Member States

The use shown below is made in the countries concerned.

Belgium : Compulsory annual cleaning of oil- and coal-fired boilers.

Denmark : Annual inspection of boilers of less than 60 kW obligatory since May 1979.

Germany : Regulations on the efficiency of heating systems and their operation in force since October 1978.

France : Since May 1974 there have been compulsory minimum efficiency ratings for boilers of more than 70 kW ; inspections are compulsory, together with detailed examinations every six years for large boiler rooms (about 250 dwellings). Grants linked to improved efficiency have been introduced and are paid when a burner is replaced, a boiler is renewed, pipes are lagged, etc. Moreover, operating contracts "by the calorie" or the tonne of fuel are prohibited.

Italy : Compulsory installation and efficiency control standards since February 1978. Installation of boilers more powerful than required for heating to 20° is prohibited.

Luxembourg : Compulsory efficiency and periodic maintenance standards for oil-fired boilers.

The Netherlands : No action regarding maintenance, but the minimum efficiency standards for boilers were increased in 1979.

United Kingdom : Legislation on efficiency is scheduled for 1980.

7. Proposals for Community action

In its directive of 13 February 1978, the Community has already laid down minimum efficiency ratings for boilers installed after 1 January 1981. A code of practice has been laid down for monitoring the performance of boilers intended for space heating. The Member States are free to fix minimum efficiency ratings and appoint the organisations that are responsible for monitoring.

This code of practice might be supplemented by a compulsory system of periodic inspections by approved experts of major installations, and by the setting-out of favourable heating operation contracts.

In this context, it is important that contracts "by the calorie" should be banned in countries where this has not already been done, and that the vendor should be given an interest in the quantities of energy supplied.

2.2.6 RECOVERY OF HEAT FROM WASTE HOT WASHING WATER Memorandum 2.6

1. Background information.

The production of hot water for washing purposes represents 10 % of the total consumption of the residential and commercial/services sector, i.e. about 15 % of the heating consumption of buildings.

It would thus be worthwhile to recover a substantial amount of this heat. This has not however been done as yet, probably for the following reasons:

- hot washing water has a low temperature when it goes to the drains ; although the water may leave the water heaters at about 60°C, it is used for washing at about 35°C ;

- part of the heat is dissipated in the rooms where it is used, and incidentally contributes by conduction and evaporation to the heating, in the form of free heat ;

- the heat remaining in the waste water could be recovered by means of an exchanger, but this exchanger would be difficult to maintain because of the quality of the waste water (soap and various kinds of dirt).

Another way of making use of this heat might be to use it as the cold source of a heat pump. This solution has been studied in Sweden. The wide variation in temperature of waste water (between 60° and ambient temperature) is a cause of difficulty. One solution would be to have a storage tank fitted with an automatic valve that would permit waste water to enter only if it was above a certain temperature. (Such valves are used on the storage tanks of active solar water systems.).

It will be seen that there are difficulties in recovering the heat from waste washing water. It seems that heat so recovered could best be used to heat water for washing. When it is used for this purpose, large variations in the heat of the water supplied can be tolerated, and the energy recovered is about the same as the energy consumed.

2. Cost - Effectiveness.

We lack data about this measure, which has rarely been applied.

3. Limitations.

This measure does not affect users' requirements.

4. Application of the measure to new and existing buildings.

The recovery of heat from waste hot washing water requires modification of the plumbing circuits, and this is expensive in existing housing. On the other hand, the measure is a technical (if not an economic) possibility in new buildings.

5. Industrial and commercial consequences.

The implementation of the measure would require the manufacture and marketing of *ad hoc* equipment (exchangers or heat pumps).

6. Current use of the measure in Member States

The experts consulted were unable to give us examples of its use.

7. Research proposals

Recovery of a substantial proportion of the 10 % of domestic energy used for heating washing water justifies creation and development efforts.

2.2.7 DISTRICT HEATING - COMBINED PRODUCTION OF HEAT AND POWER

Memorandum 2.7

1. Background information

A. Urban heating is a system for supplying heat to a large number of dwellings from a single heating station.

The system is justified for a variety of reasons :

- it permits a higher standard of operation and maintenance of the boiler house than is the case with boilers serving separate buildings, or individual boilers ;
- because there are several boilers in the boiler room, it allows only a part of them to be used (but under full load) for most of the time ;
- it allows special fuels to be used : e.g. coal-firing, or the incineration of domestic refuse. It alone allows geothermal energy to be used (cf. 3.3 above). Very large quantities of fuel are supplied (which means a favourable price), and they come in huge consignments. Moreover, the station will often be located at a favourable site : beside a waterway, or at least a railway. This permits bulk supplies.

All in all, heat is produced more efficiently than when heating a large building (at least 5 % better), and is even cheaper. On the other hand, urban heating has the disadvantages of distribution from a central point : there are of necessity transmission losses that seem to cancel out the increase in boiler efficiency. There are also large investments in the distribution system, which are only tolerable when the areas served have a high consumption density.

From the point of view of energy saving, the system has the following characteristic features :

- the centralised operation of the system enables the length of the heating season to be curtailed. Subject to reservations as regards auxiliary heating (cf. memorandum 2.2.) the users will be subjected to these curtailments and the resultant savings ;

- the energy can be taken from lukewarm industrial effluent (cf. annex to this memorandum (AI)) ;

- the energy may be of geothermal origin, or be obtained from burning renewable fuels. Two memoranda deal with these two possibilities (memoranda 3.4 and 3.5).

B. The production of heat can be combined with the production of electrical energy. This process differs from that of recovery from power-station effluent, since here it is to some extent the electricity that is a by-product of heat production. The technical aspects of combined production of heat and power are studied in the annex to this memorandum (AII).

2. Cost - Effectiveness.

In the case of urban heating without production of electricity, the final performance at the point of input to the building is not substantially improved. The energy savings are the result of the regular maintenance and proper operation of the central heating station. However, the main advantage of urban heating is the ease with which fuels other than oil (e.g. gas and coal) can be used. The advantage here is one of energy independence rather than energy saving.

However, it seems to be accepted that the return on investments in an urban heating station will in any case be better in the case of an installation of the heat/power type. What are the criteria for these installations? In an article summarising the (convergent) results of three studies carried out in the Federal Republic of Germany, in Poland and in Canada, the periodical "Entropie" (March/April 1978) gives the following criteria :

- a density of heat requirements of not less than 30 kth/h/km2 (35 MW/km2) ;
- the connection of at least 70 % of buildings with a habitable area of over 900 m2.

In an industrial zone, the first criterion requires a density of 15 dwellings per hectare, which admits of individual dwellings. Moreover, this threshold density will decrease as the price of oil increases. The rate of 70 % may be difficult to achieve without compulsion. The local or central authorities may have to make connection to the urban heating system a zonal obligation.

3. Limitations.

Urban heating systems do not interfere with any of the user's requirements.

4. Application of the measure to new and existing buildings.

The measure is primarily intended for use in new building zones, especially if low-temperature energy (lukewarm waste water) has to be distributed, because low-temperature heating systems are rare in old buildings.

Equipping an area with urban heating is certainly more expensive if the area has already been built, but it may be noted that the existing large urban concentrations offer the greatest densities and are thus most profitable.

In towns where urban heating systems already exist, increasing the number of buildings served by them can certainly be recommended. Connection to the system might be made compulsory more especially when the boiler needs replacing in a large building. Setting up a system in a large town poses the problem of profitability : the difficulty of how to connect sufficient buildings quickly is a classical one. It will nevertheless be recalled that the first urban heating systems were installed in existing towns. Be that as it may, the use of regulations may be considered.

5. Industrial and commercial consequences

The supplying of heat over long distances always calls for major investments (central heating station, piping, connections). These investments involve activity in the trades concerned : heating engineers and public works contractors. They will not however create much employment in the long term, since these installations are automated and require very little manpower.

6. Current use of the measure in Member States

Denmark is the Community country that makes most use of urban heating, since the Danish Heat Plan provides for one third of buildings to receive their heat from combined heat/power production installations in 1990. Subsidies of up to 25 % of the cost of investments are granted.

The other European countries have also taken steps to encourage the system without adopting unduly ambitious programmes.

Denmark : Loans for developing the use of residual heat of power stations. The connection of buildings to an urban heating system may be subsidised by up to 25 % of the cost.

France : Plans include facilities for the combined production of heat and power, including in particular the removal of the difficulties created by EDF's distribution monopoly.

Italy : A law provides that the municipalities and provinces may build and operate combined heat/power production units.

Netherlands : Urban heating is being developed at the instigation of the government.

United Kingdom : Few practical applications are planned, despite the favourable conclusions of the Marshall Report on the combined production of heat and power.

7. Proposals

7a - Community action. The Community has already taken action to encourage the combined production of heat/power and urban heating (Council Recommendation 77/714/EEC on 25 October 1977).

Combined production and urban heating occupy an important place in the programme of financial aid to demonstration projects for energy saving : out of a total of 53 projects chosen, 12 (involving nearly 40 % of the loans made available) concern combined production or urban heating.

In addition to the technical aspects of the problem, it is as well that the legislative and legal aspects should be discussed at Community level, to help resolve the "difficulties and obstacles facing the development of the combined production of heat and power, and of urban heating".

The compulsory connection to existing systems of large buildings whose boilers are being replaced should be discussed in particular.

7b - Standardisation. Not applicable here.

7c - Research and development. The use of lukewarm water for the direct heating of buildings requires special devices which call for further research and development effort, e.g. heating by vertical walls.

ANNEX I

WARM INDUSTRIAL EFFLUENT

1. Industry discards lukewarm water which contributes to the thermal pollution of the environment and represents a loss of energy. We are concerned here with water whose temperature is insufficient to enable itto be used directly in conventional hot-water heating installations, i.e. water chose temperature is less than 80°C.

This is typically the case of waste water from thermo-electric power stations, whose characteristic temperature may be said to be 40°C (1). The importance of this effluent is enormous, because the energy it contains exceeds that supplied by these same power stations in the form of electricity. The total energy exceeds that necessary for heating buildings in each of the countries concerned, and is available at a temperature higher than the heating temperature of buildings.

This heat is wrongly called "free". In fact, the amount of the investments involved makes it expensive, because :

a - its transmission requires investments and involves operating costs ;

b - its temperature being low, it is necessary :

b1) to raise the temperature with a heat pump so that it can be used in ordinary hot-water heating installations ; or

(1) The production of heating water by raising its temperature as it leaves the thermoalternators, is not dealt with here.

b2) to use heating installations employing a low-temperature heat-transmission fluid, which generally differ from those existing in buildings (except in the case of warm-air heating and systems using hot water to transmit heat through the walls).

Moreover, since use of this energy is seasonal, the thermal pollution continues during the warm season.

2. The different points listed below should be studied.

2a - Heating water has already been transmitted over long distances in urban heating systems. It is generally transmitted under pressure at temperatures well above 100°C.

With an initial temperature of 120°C, the temperature loss is 0.4°C per km.

The lower the temperature, the smaller this loss ; but since more water has to be transmitted to supply the same amount of heat, this fact increases the investments and pumping costs.

All in all, low temperatures reduce the profitability of long-distance transmission. Hence they reduce the potential operating range for lukewarm effluent.

2b1 - The temperature can be raised by a heat pump on leaving the power station or at the utilisation point.

Raising it when it leaves the power station is an inappropriate solution, as it is preferable to draw off the water at the required temperature as it leaves the alternators : the total theoretical output is identical and the practical output better.

The same reasoning can be used regarding the point of utilisation, unless there is a local source of electricity other than a thermo-electric power station.

A hydroelectric source might be used to raise the temperature without consuming fuel.

It must however be considered that any new consumption of hydroelectric energy is offset by a thermo-electric contribution, so that the operation loses its interest.

Lastly, the use of water at 40° as a source of hot water of a heat pump for producing water that enters the heating system at between 70 and 90° and leaves it at between 50 and 70° is an operation difficult to conceive.

It would thus appear that the solution of lukewarm water + heat pump should be rejected.

2b2 - Lukewarm water can only be used with emitters operating at between 40° and ambient temperature. These emitters can be :

- radiators or ventilator-convectors which have large heating surfaces (roughly 2 $1/_2$ times the usual size) ;

- heating walls : heating through the ceiling exists, and systems which heat through the floor have been criticised as requiring a floor temperature that is too high to be healthy (a criticism that does not apply to background heating). Heating walls have not (?) been used in Western Europe. They nevertheless have attractions, and appear to have few snags. This might be a very good solution for heating by lukewarm water ;

- warm air : the low temperature of the air results in ducts with large cross-sectional areas, but this is probably not a disqualification.

3. The use of these emitters takes different forms in new and existing buildings.

3a - In new buildings, the use of larger radiators or ventilator-convectors and larger-diameter ducts involves an extra cost of 2.800 F/ dwelling.

On the other hand, the initial cost of heating through the walls is less than that of the other heating systems.

It may be concluded from the foregoing that since the cost of the installation for transmitting the lukewarm water a distance of 30 km is offset by the saving in investment for wall heating systems, and since the water supplied free of charge entails the cost of operating the transmission system, it is possible without extra initial cost to use power-station effluent for wall-heating systems in new buildings within a radius of 30 km.

It will be noted that the use of this lukewarm water at the intake of hot washing water installations halves their energy requirement.

3b - There are in existing buildings installations that function by water at 40° : the existing wall-heating systems.

In France they are grouped into large blocks of several thousands of dwellings, which means that they can be served when they are not far from a power station.

Except in such a favourable case the changeover from a hot-water heating system to lukewarm water requires major modifications that are not always possible : replacement of radiators by larger ones, faster circulation of water in the pipes (thus creating noise). Profitability is possible. These modifications are in any case technically possible, and would be very useful in the event of a serious shortage.

Warm-air supplementary heating can also be envisaged, for although it is virtually impossible to install in blocks of flats it can be installed in office and school buildings by using ducts in corridor ceilings. This solution, which enables the old installation to be kept for auxiliary and emergency heating, requires an investment comparable to that required for the first installation : something that is in any case acceptable when the installation has been paid for.

ANNEX II

COMBINED PRODUCTION OF HEAT AND POWER

1. For the operator of an urban heating station, the production of heat and electrical energy (known as "heat/power") involves combining the production of electricity with that of the heat that he would normally produce by itself for his requirements. This name could also be given to the individual units that simultaneously supply a building with electricity and heat (e.g. the FIAT TOTEM unit). Since however the use and advantages of such units differ fundamentally from the production of heat/power on a town scale, they will not be discussed in this memorandum.

Heat/power should be distinguished from the contrary system of recovering heat from power-station effluent : in this latter case, the heat is taken from the power cycle of a turbine at the temperature compatible with the proposed use of the heat. The result is a fall in production of the electricity supplied by that power station, and this fall occurs when the weather is coldest and the demand for electricity highest. Heat/power on the contrary has the advantage of reducing that demand, albeit only slightly. Moreover, a heat/power installation can be incorporated without difficulty in an urban heating system, because there is a free choice of its size and of the temperature of the water supplied. The same is not true when using power-station effluent : firstly the water temperature is limited, and secondly the very large amounts of heat involved require a very high rate of urban concentration for the equipment to be profitable.

Heat/power stations may use three different types of equipment :

A. Steam turbines

These installations comprise (Figure 2) :

- a steam generator, fired by oil, gas or coal ;
- a turbine coupled with an alternator ;
- a condenser, in which the steam leaving the turbine yields its heat to a hot water circuit whose temperature is that required by the heating circuit, and which may be between 110°C and 190°C.

This temperature greatly affects the efficiency of the power station, and hence its profitability.

The ratio $\frac{\text{electricity supplied}}{\text{heat supplied}}$ varies between 0.25 and 0.3, and the overall efficiency is about 0.9. The investment required for the equipment installed and connected is 300 - 560 F/Kw (investment related to the total heat + electricity power).

B. Gas turbines

These installations comprise (Figure 3) :

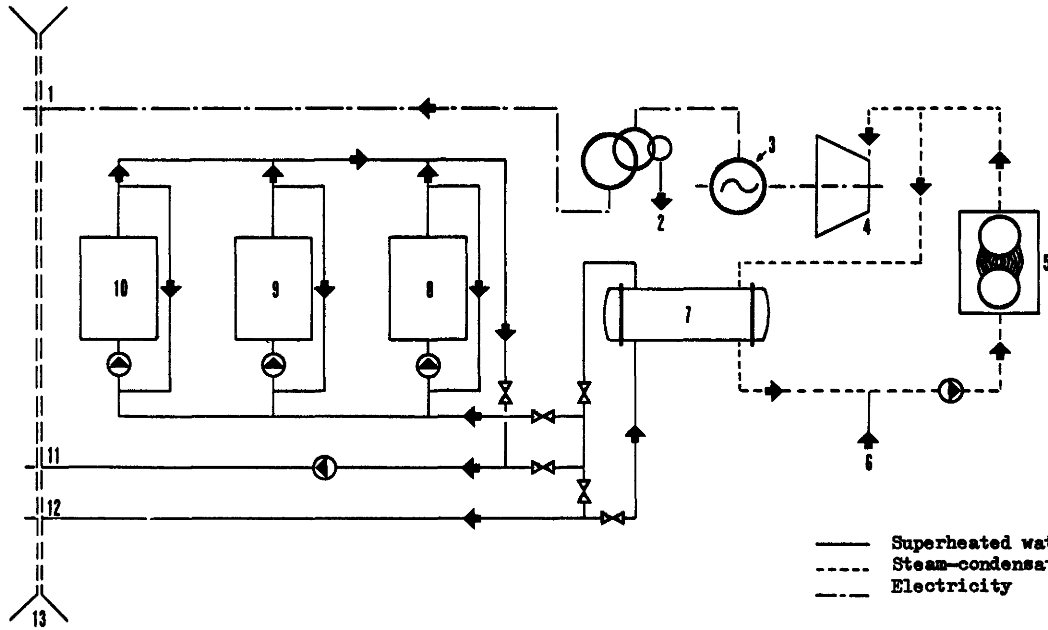
- a turbine which drives a compressor and an alternator. The gases are first compressed, and then expanded in the turbine after combustion ;
- an exhaust-gas heat exchanger.

The ratio $\frac{\text{electricity supplied}}{\text{heat supplied}}$ is between 0.35 and 0.50, and the overall efficiency about 0.80.

Investment varies from 450 to 530 F/Kw of total power.

SKELETON DIAGRAM

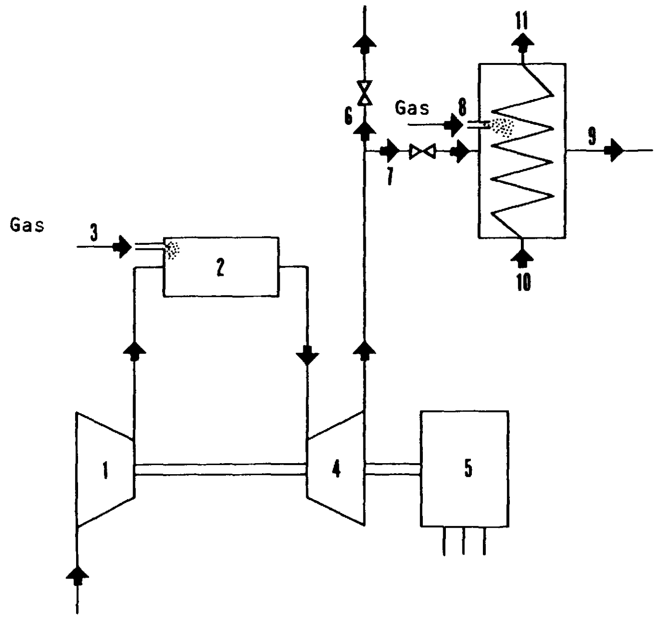
FIGURE 2



Superheated water circuit
Steam-condensation water circuit
Electricity

1. To EDF (electricité de France)
2. 380 W Internal consumption
3. Alternator
4. Turbine
5. Steam boiler
6. Topping-up water
7. Condenser
8.,9.and 10. S.W. Generator
11. Outlet
12. Return
13. Limit of boiler room

Figure 3



1. Compressor
2. Combustion chamber
3. Fuel injection
4. Turbine
5. Alternator
6. Direct exhaust
7. Outlet of hot gases to boiler
8. Additional injection
9. Flue
10. Heating water inlet
11. Hot water or steam outlet

C. Internal combustion engines

A conventional engine, burning oil or gas, drives an alternator. Heat is recovered from the cooling circuit and exhaust gases.

The ratio $\frac{\text{electricity}}{\text{heat}}$ is about 1, and the overall efficiency about 0.75. Investment is between 700 and 1.000 F/Kw of total power. It is higher than for the previous systems.

In systems B and C, there is no trouble in obtaining a water temperature of over 150°C from the exhaust gases.

It will thus be seen that from a technical point of view heat/power can be used in all urban heating areas, whether transmission is at high temperature (output 150°C or even 190°C) or low (output 110°C). Heat/power can in particular be used in all areas built twenty or so years ago in which a superheated water heating station is operating whose boilers now need to be replaced. In areas under construction, we face the classic problem in district heating of profitability during the initial period : since the dwellings are occupied only gradually, the heating station is too large to begin with.

2. When the building of a "heat/power" station is possible from a technical point of view, each particular case must nevertheless be the subject of a financial feasibility study in order to determine :

- the type of equipment to use ;
- the size of the station and the number of units ;
- the percentage of the heating requirements of the area that the station must supply.

This last factor greatly affects the profitability of the installation. To be profitable, such equipment should operate as continuously as possible. It cannot be brought into operation until the heat requirement of the area to be heated is sufficient (a heat/power installation that does not use its heat is only a bad thermo-electric power station). Hence the power of the station should not be designed to cover peak requirements, but a basic portion of them that will be needed during the greater part of the heating period.

However, although the reduction in power results in an increased number of hours of operation per annum, it also increases the investment cost per installed power unit.

A study by a group of experts of the Agence pour les Economies d'Energie concluded that this percentage (called the basic percentage) should be about 30 % of the maximum power for heating requirements.

All the foregoing remarks are made from the point of view of the operator who is seeking maximum profitability. From a national point of view, the greater the basic percentage, the greater will be the advantage of the installations. The governments will thus have to resort to subsidies to encourage the promoters to increase the size of the installations to the extent considered necessary.

3. This measure is applied differently in new and old buildings.

- In new buildings, it is necessary at the planning stage to design an urban heating station and distribution system of the correct size. The problem will be profitability during the initial construction period of the area, where it will be some years before there is full demand.

- In old buildings, these installations can only be used within an existing urban heating system. The replacement of a station with superheated water boilers causes no special difficulties except the problem of the necessary topping-up : the old generators can be used for topping up, or decentralised topping-up facilities can be installed (with the advantage of reducing losses in transmission).

4. In some countries, the application of this measure poses a problem as regards selling the electricity to the electricity companies.

In France, for instance, the operator of a heat/power station cannot sell his electricity direct to the consumers. He is obliged to sell it to Electricité de France* at its official purchasing rate. These rates are fixed according to the quantity of electricity supplied and the reliability of the supply. In spring and autumn the supply is uncertain if the basic percentage is too high.

Hence the general interests of energy saving do not correspond exactly with those of the operators of heat/power stations or those of the electricity generating companies.

The possible courses of action are :

- subsidising installations whose basic percentage exceeds the profitability threshold ;
- using fuels other than oil (gas, and in particular coal), especially in the spheres of influence of sea or river ports.

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*EDF Electricité de France; national company which has the monopoly of electrical power distribution.

2.3 SUBSTITUTE ENERGIES

2.3.1 "PASSIVE" USE OF SOLAR ENERGY Memorandum 3.1

1. Background information.

All buildings receive sunshine. However, depending on the orientation, shape and wall material of a building, its energy requirements for heating in winter are reduced to a greater or lesser extent by the solar energy it receives.

From this point of view, it would be very instructive to classify each building according to its solar efficiency coefficient (ratio of solar energy used to energy received). This can be calculated by means of the formulas cited in annex III to the Introduction.

There is no clear boundary between passive solar heating (sometimes rather curiously called "bioclimatic") and active solar heating. Systems like the Trombe wall are hybrids. Roughly, active solar heating (in the context of present solutions) means heating by panels which use heat-transmission fluids other than the inside air of the building. The distinction has little basic significance.

Passive solar heating uses the following main devices : windows, Trombe walls, and glasshouses.

a - Windows. A room fitted with an ordinary single-glazed window is an excellent collector : the balance of instantaneous radiative exchanges through the window is 85 %. Unfortunately, when the sun is not shining (i.e. at night or when the weather is overcast) this window becomes a thermal weak point which causes great losses by convection.

The energy balance of a south-facing window at latitude 48° is nevertheless positive.

- During a heating season it loses 670 solar MJ by transmission (double glazing k = 2.5 W/m2°K).

- During the same period it receives 1580 MJ, 1000 of which are transmitted to the interior of the room.

The lower the coefficient K of the window, the better its balance ; K can be improved by using multiple glazing or insulating shutters (which improve the mean day-night K).

The solar energy received by the window is subject to sudden variations : when the sun appears and disappears behind neighbouring buildings or the horizon, and when clouds are passing. The "sun inputs" cause overheating if the system of heat emission by the heating installation responds slowly. The occupant often reacts to this overheating by opening the windows, with the result that energy is wasted. Hence it is advisable that there is as little inertia as possible in the control-emission unit of the heating installation.

If on the other hand the energy received when the sun is shining exceeds requirements it should (unless it is to be wasted) be stored for use when the sun is not shining. In the case of the "window collector" the heat is simply stored by the walls of the room, either because the sun's rays strike them directly or because they are heated by the slightly overheated inside air.

If maximum benefit is to be obtained from energy storage in the walls, they should not be insulated (and this poses an acoustic problem for the floor), the inertia of the sunlit parts must be high, and their colour dark.

If however this system enables a substantial part of the solar gains to be recovered in winter, spring and autumn, it may cause discomfort in summer. Solutions (which can be expensive) do exist, such as walls whose inertia is varied by movements of water ; but there are also clever, cheap solutions such as placing the thick walls in the places on which the sun shines in winter (when the sun is low) and which are in the shade in summer (when the sun is high).

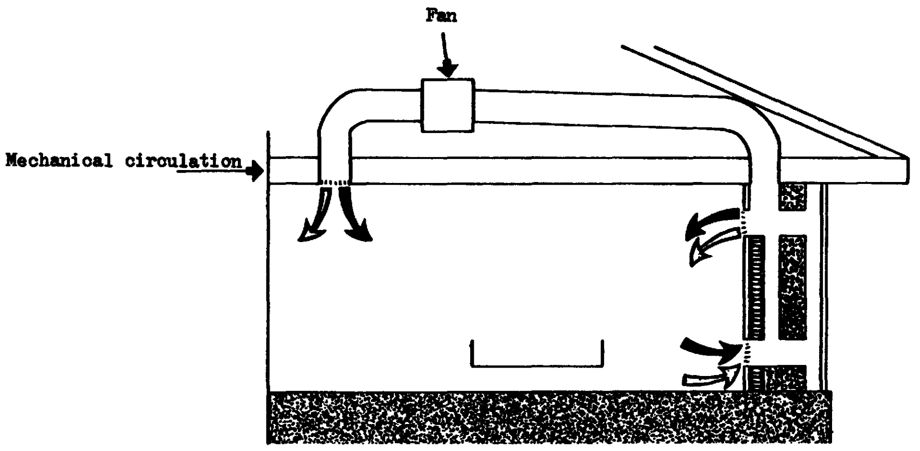
A simple solution is to plant deciduous trees in front of the south wall.

b - The original feature of the Trombe wall (Figure 4) is that it stores heat in a special body (a black wall) on which the sun shines through a window and creates a glasshouse effect. It does not matter if the sunlit side of this wall becomes very warm, because it is insulated at the back. There is a natural air circulation between wall and window, which transmits the heat stored in the wall to the rooms that are to be heated.

Like all collectors, this wall has the major disadvantage of competing with windows for space in south walls, and looking odd from the outside. Its operation by natural draught depends moreover on uncontrolled factors. However, this latter snag can be eliminated with mechanical air circulation.

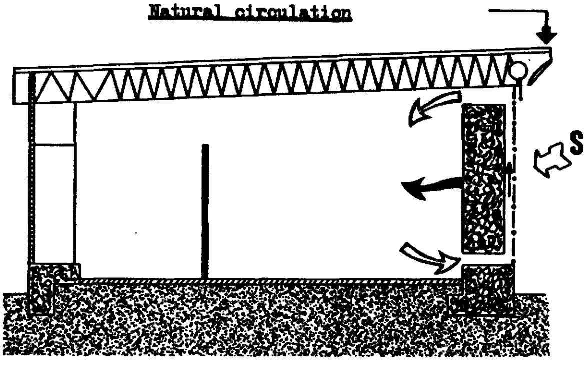
c - The glasshouse. The main advantage of the glasshouse is that its inside is definitely not a habitable space, so that considerable overheating can be tolerated in it, as well as low temperatures. According to the air circulation system adopted, it operates something like a room with windows, or in the opposite way to a Trombe wall. Its disadvantage is that it reduces the quality of contact with the outside ; the rooms are

TROMBE WALL **Figure 4**



Mechanical circulation
Natural convection

Natural circulation



Mechanical circulation
Natural convection

(21)

in fact indirectly lighted. However, the glasshouse itself can be a pleasant place when it is habitable (Figure 5).

In the case of the Trombe wall or the glasshouse,(Figure 6) more highly-developed storage systems store the heat in beds or pebbles under the building. The heat is transferred by mechanical ventilation :

- from one side of the "collector" (Trombe wall or glasshouse) to the storage ;
- from the other side of the storage to the rooms that are to be heated.

Passive solar heating requires particular attention to ensuring comfort in summer.

The attitude to solar energy conservation in buildings is in fact absolutely opposite in summer to what it is in winter (Figure 7). This results in the glasshouses being dismantled in summer or being left wide open all the time, and effective movable (i.e. external) sun screens being fitted to the windows.

Hence these are "variable-geometry" solutions. We have already seen the advantage of movable shutters to protect windows from the cold. This type of solution can be multiplied, and a roof space can become a solar collector if the insulation that is of necessity in it is of a type that can be removed during sunny weather. Water can be used as a means of variable inertia, or even to transfer the heat from a sunny to a cold room (but is this still passive heating?).

2. Effectiveness - Cost.

A good knowledge of the phenomena certainly makes it possible to improve

FIGURE 5

PASSIVE GLASSHOUSE

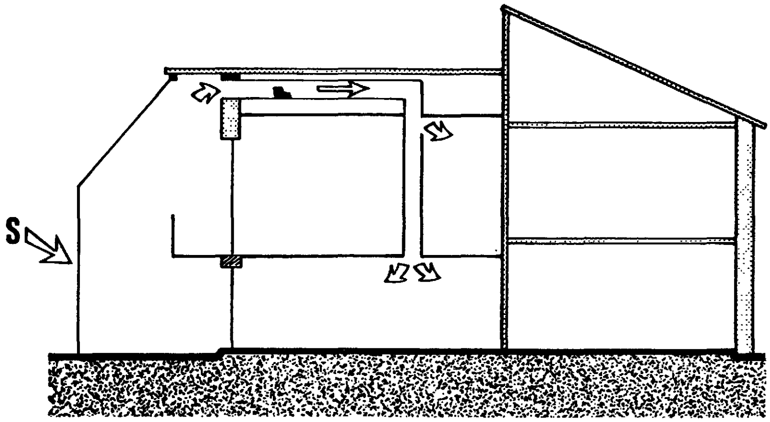


FIGURE 6

TROMBE - GLASSHOUSE SYSTEM

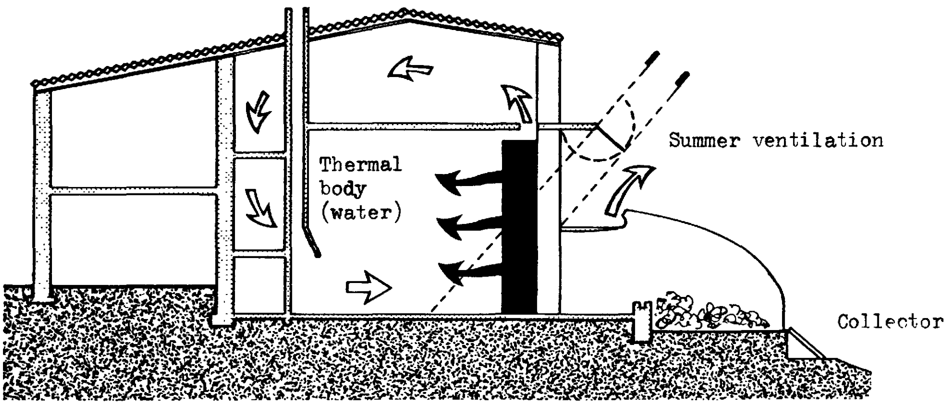
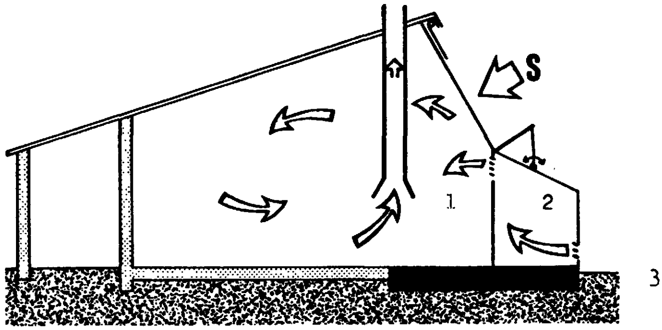


Figure 7

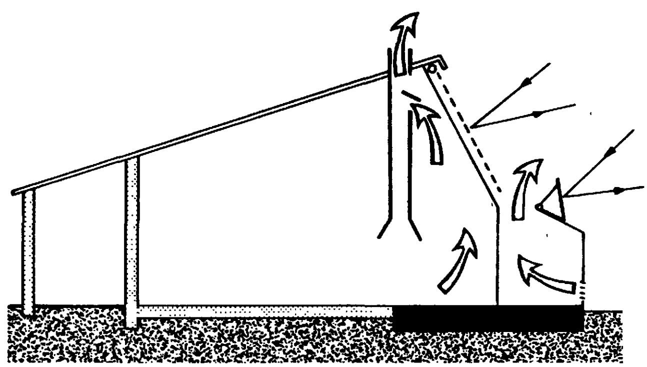
Other Glasshouse

a) Winter



1. Interior Glasshouse
2. Exterior Glasshouse
3. Compacted clay

b) Summer



by between under 10 % and over 20 % the solar efficiency of a building that is entirely conventional in other respects, and thus to reduce heating costs by over 10 %.

This is possible without any extra expenditure. This design improvement might for instance involve regrouping the windows on the south wall (without altering the area), choosing a two-level south wall, with a mono-pitch roof and a wall at ground level only on the north side.

Solutions which use glasshouses or Trombe walls involve extra costs. Experience shows that they may vary between 10.000 and 40.000 F.

It is quite difficult to establish the effectiveness of these devices, because the characteristics of buildings vary considerably : in a super-insulated building that uses a great deal of artificial lighting, the solar gains may be expected to cover a large part of the heating energy requirements proper.

Reasonable figures for possible savings would seem to be 20 % of the consumption of a building (as now insulated) with only collector windows, 30 % with glasshouses, and 40 % with Trombe walls. These percentages will be higher if the insulation is improved, although part of the solar gains will be of no use in mild weather, because the free inside heat will suffice to heat the house. Reducing heating energy consumption by 10 % through improved use of solar gains is a measure that might affect half the stock of buildings in the year 2000, and would thus "weigh" some 10 million TOE.

3. Limitations

If the solar efficiency of buildings is increased by means of windows or glasshouses, the question of satisfying the requirement of comfort in summer arises.

The use of glasshouses, and even more so the use of Trombe walls, makes it more difficult (or even very difficult) to satisfy the requirement of visual contact with the outside world.

This latter point certainly represents a serious limitation of the Trombe wall, just as it limits the use of collectors on outside walls : why should the collectors not be sited somewhere else?

Thus limitations do exist, but it seems difficult to reach conclusions backed by figures.

4. Application of the measure to existing and new buildings

All the solutions cited above apply to new buildings.

It is difficult in existing buildings to move windows to a south-facing wall or to create Trombe systems : but the building's solar efficiency can be improved by :

- improving window insulation by double glazing and insulating shutters;
- improving the control of the heat emitters, especially in sunny rooms (thermostatic valves).

5. Industrial and commercial consequences

The passive use of solar energy will bring a rise in the use of servo-mecanisms and increase the consumption of plain glass (glasshouse, Trombe walls) and of glasses with special coatings.

6. Current use of the measure in Member States

The passive use of solar energy has not been the subject of statutory measures in the Community countries. Encouragement in the forms of grants has been given here and there.

7. Proposals

7a - Community action proposals. A statutory requirement for a minimum "solar efficiency" of buildings might be considered. The best way of doing this however is no doubt to introduce regulations of the kind that limit the coefficient C (whose usefulness we see once again), and which would fix C as a function of a minimum of solar gains.

7b - Standardisation proposals. Nothing to report.

7c - Research proposals. The research programmes and the demonstration projects financed by the EEC put the emphasis as much on active solar systems as on passive ones.

The competition on passive solar architecture organised in 1980 comes within this research aimed at developing an energy-efficient architecture.

A form of research already mentioned might also be carried out : the comparison of methods of calculating solar gains. This is the point that calls for the greatest improvement in current calculation methods, and it cannot be taken for granted that the methods valid for conventional buildings are suitable for buildings that make great use of solar gains. This research is a prior condition for the acceptance of a single calculation method or of harmonised methods.

2.3.2 "ACTIVE" USE OF SOLAR ENERGY — Memorandum 3.2

1. Background information

The active use of solar energy for heating buildings involves the use of collectors which heat a heat-transmission fluid.

The collectors may be flat or of the low-density type ; they are arranged on the walls of a building, or form an independent "solar power station". The heat-transmission fluid is water or air.

The installation has of necessity a heat store with a capacity of one day, several days, several weeks or a season.

Unlike water heaters with flat collectors which are profitable in most climates, it is generally accepted that with present energy costs solar heating installations are not "profitable", i.e. they cannot pay for themselves during their lifetime.

It is however also accepted that solar energy can provide only part of the heating energy needed during the year. This is largely because of the fact that the "solar" houses designed hitherto have in the main had collectors on the walls, and the area of these collectors is limited. If however the walls were no longer to be used for making a solar power station, there is theoretically no limitation area. In actual fact three factors govern the installation and the percentage coverage of heating requirements : the area of the collectors, the storage capacity and the cost. This latter largely depends on the technical solution chosen.

One must compare the advantages of air heating (cheap, long-life collectors, installations which do not require a high fluid temperature) and those of water heating ; compare a solution using collectors with a large area and which has storage for several days (up to two weeks) and a solution with a large and lengthy storage capacity (a season) ; and compare the advantages of various kinds of collectors (flat, low-temperature ; higher-temperature; low-density ; fixed ; tilting ; self-orientating, etc.).

It would seem worthwhile to explore these solutions systematically.

The "solar deposit" (i.e. the solar energy available) has been determined in most of the Community countries.

Lastly, there are calculation methods available for forecasting the performance of an installation.

2. Cost - Effectiveness

Generally costs do not permit guaranteed profitiability. The use of active solar energy saves foreign currency and contributes to self-sufficiency as regards energy requirements.

As stated, cost generally exceeds profitability. The profitability is incidentally better in countries that have a long winter, and reaches its maximum at high altidues.

The prices quoted for an installation often vary.

In France, the cost for a 250 m3 bungalow with flat water collectors (of 20 - 40 m2) and a 3 m3 water storage capacity varies from 30 to 80.000 F. Taking into account the present price of oil and the cost of maintenance, the saving (under 50 %) is 800 F in an area with an Atlantic climate.

The cost for a bungalow on the Mediterranean, with flat air collectors independent of the building, and a 3 m3 pebble storage capacity, is about 25.000 F. The fuel saving also amounts to 800 F.

For a small block of 16 flats (also in the Mediterranean area) with 250 m2 of flat water collectors in the roof and gable, and 15 m3 storage capacity, the cost is 35.000 F per flat. The anticipated 48 % saving amounts to 800 F per flat.

It should be pointed out that the cost is often too high. It would be reduced if solar heating were developed on a large scale. Moreover, the inevitable rise in energy costs will increase the value of the savings made. It would however be unwise to hope for real profitability in the near future.

An energy saving solution should not however bejudged solely in terms of profitability. The threat of a shortage (mentioned in the introduction) should lead to the adoption of other criteria.

Even from a personal point of view, many families who have already paid for their own homes might be led to conclude that it is worth 20 or 30.000 F to be quasi-independent as regards heating energy.

This is of course all the more so from a national point of view.

Solar energy is protected more than any other from the limitations or shortages that may affect all the other forms of energy, except wind power.

3. Limitations

The use of active solar energy for heating interferes with only one of the requirements of the user of a building : when the collectors are sited on the wall they take the place of the windows, and limit the satisfaction of the requirement of contact with the outside world.

This difficulty can be resolved by installing collectors outside the building (or on the flat roof).

Although the visual impact of wall-mounted collectors is not very pleasant at the present time, it is something that people might learn to live with.

Lastly, active solar heating is limited by the necessary collector area.

If we estimate that the minimum collector area is 0.25 m2 per m2 of dwelling to be heated, and that the optimum area is 0.40 (in the absence of a season's storage), there is no difficulty with the solar heating of all the dwellings with a density of 15 dwellings per hectare (600 m2 collector area), but this would appear to be impossible in practice with a density of 60 dwellings per hectare (2.400 m2). In this case however the buildings will necessarily be communal ones with low loss rates, so that the collector area should be smaller, with the result that this solution is not impossible with certain shapes of buildings intended to provide plenty of open space.

4. Application of the measure to new and existing buildings

Studies and demonstrations of solar heating have been carried out in particular (and almost solely) for new buildings. Existing buildings are however the main target for this means of saving as for all the others.

The use of solar heating in existing buildings already fitted with a heating installation encounters certain problems.

In an ordinary hot-water heating installation with water input and output temperatures in the boiler of between 60 and 90°C and 45 and 60°C, it is not possible to use the flat collectors normally supplied nowadays (these collectors were in fact designed for heating washing water).

One solution is to use a heat pump operating between the output water of the collectors (cold source) and the boiler input water (heat source) under difficult conditions. Since this solution needs a dual installation, it is obviously expensive. Operating conditions moreover vary considerably, which makes its efficiency dubious.

Another solution is to use collectors using input and output temperatures of some 60 - 90°C ; this entails specially-insulated collectors (vacuum collectors) and/or low-density collectors.

Since these collectors are not generally flat, it is difficult to install them on the walls of buildings (except on flat roofs). This results in solar boilers "in the garden", or in neighbourhood solar heating stations. This solution moreover has several advantages for both old and new buildings : such an installation (which can be maintained by specialists) can be more sophisticated.

Certain existing heating installations operate with lukewarm water : this system uses solar radiation to heat the ceiling and (less frequently in Western Europe) the walls. These installations can be connected directly to a solar boiler using flat collectors.

Lastly, warm-air heating should not be overlooked. The advantages of flat air-type collectors have already been mentioned. They can be used in a building which has warm-air heating.

A warm-air heating system can also be used as an auxiliary system, at least in some rooms. There have been a number of practical examples and studies of a solar caisson (fitted with air collectors and a pebble storage facility), installed in the garden and heating certain rooms in the building independently of the existing heating system.

It is within the bounds of credibility to imagine that an owner might (so as to be self-sufficient wholly or in part as regards the energy requirements of buildings which have generally paid for themselves) spend several tens of thousands of francs on installing a "solar boiler"* without considering financial profitability as the supreme criterion.

5. Industrial and commercial consequences

The development of solar heating will benefit the European economy by creating a new industry.

6. Current use of the measure in Member States

All Community countries have drawn up solar energy research programmes. They have not gone beyond this stage as regards solar heating.

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* It would doubtless be important to accustom the public to the idea of a "solar boiler", in the same way as the term "solar water heater" is used, in addition to the more restrictive expression "solar house".

7. Proposals

7a - Proposals for Community action. How can the use of solar energy be developed?

It seems possible that States and public authorities might make the use of solar heating compulsory in their buildings.

States in particular would be concerned with questions other than profitability in this respect.

Then again, public buildings often have lower heating requirements than do dwellings (they are not occupied at night, at weekends and during holidays). Moreover, they not infrequently make use of warm-air heating.

Governments do not appear to have taken steps in this direction as yet.

In the case of new private buildings, the use of district solar power stations might be made compulsory in new groups of dwellings. It will doubtless be necessary to await the outcome of experimental applications (especially in Sweden).*

Financial or tax incentives might also be used, of course. At the present time, when practical applications are experimental, Governments have generally provided grants step by step.

They have often undertaken publicity campaigns. Practical applications on a substantial scale have already begun, e.g. the competition in France for 5.000 solar dwellings to be constructed over 3 years.

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* Despite the fact that the lack of winter sunshine in Scandinavia changes the data of the problem considerably, in comparison with lower latitudes.

It will be noted that there seems to be room for considerable improvement in the present sales and installation channels and in after-sales service for solar equipment, and that (as is often the case with a new product) the present profit margins are excessive.

Community action might consist of the following :

- the drafting or acceptance of qualifying European standards for solar collectors and storage systems ;
- encouraging the creation of effective solar collectors working at the usual heating temperatures, by means of research and development grants;
- financing demonstration work and the circulation of information on the subject ;
- encouraging the use of financial and tax incentives to promote the use of solar heating in offices, factories and dwellings ;
- encouraging States and public authorities to use solar heating in their new and existing buildings (by means of a recommendation);
- establishing a policy of aiding or encouraging the use of solar heating in the sunny South European countries (cf. Conclusions III).

During the present stage of experimental applications, the model code might open the door for future requirements as regards standardisation, aid and obligations ;
create the obligations for public buildings ; and
provide for equalisation with other forms of energy.

7b - Standardisation proposals

See the first point of Community action mentioned earlier.

7c - Research proposals

The Commission's research programme in this sphere is very full, both as regards the collection and storage of energy.

1. Background information

The temperature of the earth's crust increases with depth, as is shown by the existence of a heat flux to the outside, whose average value is believed to be 0.05 W/m2 (the solar flux at ground level, perpendicular to the radiation, is 800 W/m2). It is not this flux that is used in "geothermics".

There are underground water-bearing beds which often have external outlets when their temperature is high (geysers, hot springs), but not when it is moderate (under 100°C). Thus for instance the Dogger water-bearing bed in the Paris Basin covers an area of 15.000 km2 at a depth of 1.700 m. Its temperature is 80°C.

"Geothermics" consists of extracting this water from the deep underground hot beds, using it to heat buildings (i.e. cooling it) and reinjecting it into the substratum after cooling. The heat that can be so extracted from the bed is much higher than that of the mean terrestrial flux : the energy so extracted from the substratum is exhausted when the bed is cooled, and will take centuries to renew. It is a non-renewable energy on our time scale : a sort of fossil energy.

The high investment cost means that the maximum amount of heat must be taken from the water extracted, which means returning the water at the lowest possible temperature. This used water is reinjected into the bed, on the one hand because this saline water would pollute the surface water, and on the other hand in order to maintain the pressure of the bed. Reinjection causes the bed to be cooled from the reinjection well, which must be quite a distance from the extraction well. With an output of 200 m3/h the doublet (extraction well and reinjection well) will have a life of 30 years if the distance between the two wells is 1000 m, and 50 years if it is 1500 m (i.e. energy can profitably be extracted during this period).

The water form deep, hot beds is generally saline, and consequently corrosive. This is why it is not used directly in heating installations, but in exchangers. On leaving the exchanger, its temperature will be slightly higher than that of the return water of the urban heating circuit, i.e. 35° in the case of floor heating systems, and higher for others. One is then tempted to use this water as a cold source for heat pumps, and to reinject the water at about 20°C. Of course, this shortens the life of the doublet.

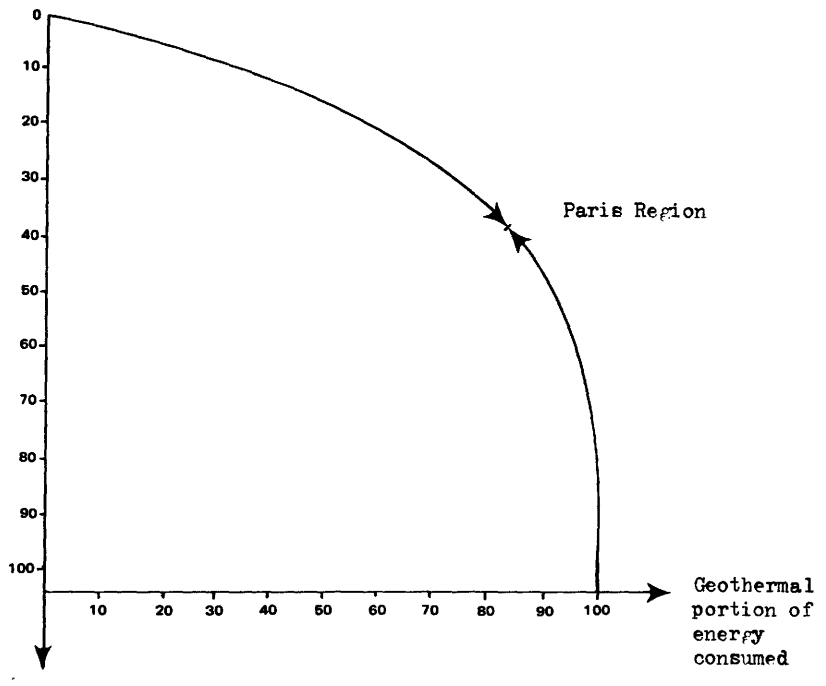
On the other hand, the investment in the installation is (as in the case of boreholes) a function of the maximum water output only. It is thus expedient to "run" the installation at its maximum output for the largest possible number of hours a year.

This maximum is achieved by supplying to a large number of dwellings a quantity of energy that is used during the greater part of the heating period, and which is called "basic heating". The make-up heat will be supplied by central oil-, gas- or coal-fired boilers. (Decentralised supplies of make-up heat are not advisable, because they are uncontrollab- le and interfere with the operation of the geothermal installation).

Examination of the attached curve (see Figure 8) shows that if geothermal energy is used to supply a basic power equal to 40 % of maximum power,

Figure 8

Number of operating hours equivalent to full capacity, and **proportion** of energy produced by a base heat source



Proportion of geothermal energy in the installed **heating** capacity over 85 % of the energy consumed is geothermal.

The installation for supplying the additional heat when the weather is very cold will thus have a capacity of 60 % of the total required capacity, but will supply only 15 % of annual consumption.

A geothermal installation must thus include a conventional heating plant of a capacity comparable to that which the urban heating system would require without geothermal energy. This make-up boiler would not operate much. Hence the characteristics of geothermal energy are as follows : very high additional investment costs, low operating costs, and saving in imported fuels.

2. Cost - Effectiveness

On the basis of the first practical applications in France, the following figures are acceptable :

The cost of the wells, distribution system and exchangers for an installation involving 2.500 dwellings is about 10.000 F/dwelling. The annual fuel saving is about 600 F/dwelling. These figures show that profitability is "touch and go" at present.

Although it may as yet be of little interest to private individuals, it is of interest to governments : it is expected in France to install shortly geothermal heating for 80.000 dwellings per annum, with a saving of 70.000 TOE.*

* TOE, the tonne oil equivalent is an energy unit, its value is 11,6 Mw/h or 42 G.J.

Because of the magnitude of the operations, practical applications take a long time. There are certainly large fuel savings (initial experiments have shown a saving of over 60 %), but they can be applied to a limited number of dwellings only (the proposed 80.000 dwellings per annum in France constitute 18 % of new buildings, or 0.5 % of existing ones). A saving of 1.3 M TOE is expected in the year 2000.

The chances of development of geothermal energy depend on the amount of public money allocated to that technology. Neither the user nor the operator will draw appreciable financial benefits from it. Governments on the other hand will have an opportunity to reduce their fuel imports.

There does not seem to be a general map of geothermal deposits in Europe, and it is thus impossible to evaluate the resource at the level of the Community as a whole.

3. Limitations

Geothermal energy is a substitute for primary energy, and does not affect the other requirements of users of buildings.

4. Application to new or existing buildings

Geothermal energy can be used to heat only large groups of buildings, i.e. when building residential areas with urban heating, or by modifying the central heating plant of an urban heating system. In this latter case, it will be more difficult to achieve profitability in the case of a high-temperature system, as often used in existing heating installations (urban heating systems using pressurised water, or steam).

5. Industrial and commercial consequences

The use of geothermal energy calls for drilling techniques which have been completely mastered in Europe.
It plays a part in the economic growth effort without increasing energy consumption, since the foreign currency saved on fuel goes in the form of investments to European drilling and heating companies.

6. Current use of the measure in Member States

Geothermics has been encouraged by the government in France particularly : the boreholes are financed by loans on very favourable terms (0 to 5 %), repayable only in the event of success. The loan covers up to 75 % of the first boring. It is granted by the Comité Géothermie, which was formed in 1974. The sums allotted to this committee were :

- 7 MF in 1975
- 16.5 MF in 1976
- 20.5 MF in 1977
- 37.5 MF in 1978.

If the first doublet is successful, the remainder of the operation attracts subsidies which cover about 30 % of the cost of the works in the case of low-cost housing.

The French Government's aim is to instigate 10 - 20 operations per annum between 1980 and 1990.

7. Proposals

7a - Proposals for Community action. In Europe, the Community has already taken steps to finance geothermal energy. One can only hope that it will continue to give financial aid similar to that granted to the demonstration projects in December 1978. The Commission granted aid to 12 European projects. This aid takes the form of a loan of 30 % of the cost of the boreholes, and of which only half is repayable. Repayment is not required if the borehole cannot be used commercially. A loan can also be granted for the surface equipment.

Of the 12 projects chosen, 10 were intended for heating and 2 for the production of electricity (in Italy only). The 10 heating projects were distributed as follows :

. Italy	: 1
. Denmark	: 1
. Belgium	: 1
. France	: 5
. Germany	: 1
. Netherlands	: 1

- The Community might recommend Member States to use geothermal energy to heat government buildings : investment does not pose the same problems for a State as for a private individual. As already mentioned, if a government must reasonably encourage unprofitable investments to prevent an oil shortage, the best place to do so is in its own buildings.

- It can also recommend the use of geothermal energy in buildings financially aided by the State ; what we have in mind is low-cost housing for which the investment might be financed by the State, and where there would be a resultant reduction in heating costs for the occupants.

- Finally, it might be suggested to the governments that they encourage the use of geothermal energy by means of financial assistance in places where this is feasible.

1. Background information

All the fossil fuels (oil, gas, coal and even uranium) are doomed to exhaustion. On the contrary wind power, solar energy and the products of photosynthesis are renewable energies (at least for many centuries to come).

Solar energy is the subject of a special memorandum, and wind power will be ignored as being not very suitable for heating except in very special cases.

We shall be concerned here with the combustion of urban waste, otherwise known as refuse, the combustible part of which is of vegetable (and also petrochemical) origin, and with vegetable products.

This renewable energy is not in any event free of charge, because its collection and treatment calls for major investments and equally large operating costs.

A. Urban refuse

T he net calorific value of refuse varies from 6 GJ to 8.5 GJ per kilo (as against 40 GJ/kg for oil). The only way of using it is to burn it in large boiler houses which supply urban heating systems. At present, it is collected and compacted near the heating station.

Being an urban heating installation, a high density of heat utilisation is necessary (cf. memorandum 2.7) to make the installations profitable. This urban density is also necessary to enable refuse to be collected economically.

Hence the combustion of urban refuse can only be contemplated in large urban centres. In France, it is Paris that makes the greatest use of refuse (5.000 tonnes per day). The production of heat is combined with production of electricity (0.1 M TOE and 0.3 M TOE respectively supplied, per annum). The current production of heat for the whole of France is estimated as 0.2 M TOE per annum.

We are unaware of the exact position in the rest of Europe, but the use of urban refuse does not seem to be generalised as yet.

It should be noted that a rational utilisation of refuse assumes the salvaging of paper and plastics, and hence a reduction in the calorific value of the remainder.

B. Vegetable products

All vegetable products are combustible and hence automatically capable of re-use in producing heat. Hitherto, however, only certain varieties of trees have been grown and used for this purpose. The remainder consists essentially of waste up to the present : branches recovered when felling timber, sawdust and chips, cereal straw (over a thousand tonnes of which are burned in France), etc.

Experimentally, attention has been devoted to new species, such as the great reed (canne de Provence) in the South of France.

A useful consideration is the annual yield per hectare per annum : about 10 tonnes for poplars in France (a figure which the chosen species appear to be capable of exceeding substantially).

The production of energy from vegetable products can use the wet process (pyrolysis, methane fermentation) or the dry process (combustion). The purpose of the wet process is gasification of the waste and utilisation of the gas produced for energy purposes (internal combustion engine). It has no direct application to the heating of buildings.

Open fireplaces and woodburning stoves still burn vegetable products for heating. Fear of a fuel shortage has aroused renewed interest in the use of vegetable products, even in central heating installations ; in Europe, this has so far involved burning wood (or by its by-products) for heating. The efficiency of such fuel is low (the calorific value of 3 tonnes of dry material is about 1 TOE), but improvements are possible.

One difficulty of using vegetable products is their light weight, which means that large volumes of products have to be handled, and which also affects boiler size. This can be remedied by compressing the materials (1).

Woodburning central heating is to be recommended in the vicinity of wooded areas, in order to reduce transport. The central heating installations can use brushwood, and this would have the secondary effect of increasing the value of industrial timber and reducing fire risks. Mechanisation of

(1) In central France, for instance, an experimental plant compresses sawdust and chips into briquettes which are used in an automated boiler intended to heat 200 dwellings.

the work of tending coppices will stimulate the use of such wood.

However, the use of vegetable products for other purposes is no doubt to be recommended.

Wood can be distilled to produce xylochemical products (tar and charcoal), and the volatile products can be used to generate mechanical or electrical energy.

2. Cost - Effectiveness

Installations which burn urban refuse have been profitable for a long time now, and the operators of urban heating systems did not wait for the crisis to construct them all over Europe in areas of high urban density. The rise in oil prices should have given a fresh fillip to their profitability and ought to enable them to be used in less dense areas.

The use of vegetable products for heating now seems to be a profitable proposition. However (as in the case of oil and coal), the problem arises of making the best use of chemical materials that it would be barbaric to burn.

The total energy that Europe can expect from wood and the biomass in general is not accurately known.

France consumes about 1 million m3 of commercial firewood and a total of possibly 3.5 million m3 of wood ; it produces 2 M TOE from the wood and 1 M TOE from industrial waste, whereas the resource is estimated at 8 M TOE.

We have no figures for Europe. The resource probably exceeds

20 M TOE.

3. Limitations

In principle, the user's requirements do not limit in any way the use of renewable fuels for heating.

4. Application of the measure to new and existing buildings

The burning of urban refuse can be contemplated in all existing urban heating installations, since it allows conventional heating installations to be used.

Certain heating installations can even be converted to woodburning (wholly or partly).

5. Industrial and commercial consequences

A significant use of the biomass raises the problem of growing more energy crops, probably at the expense of food crops. The economic optimum still has to be determined.

The rational use of vegetable products would also lead to the development of an industry producing furnaces and gasification installations which would contribute to growth without imports.

6. Current use in Member States

Many towns have urban heating installations which burn refuse.

Woodburning heating is still used in the rural areas.

On the other hand, the only large woodburning heating installations are still at the experimental stage.

Government aid has taken the form of research and development loans.

7. Proposals

7a - Proposals for Community action. The use of vegetable products for heating seems unlikely to assume sufficient importance in Europe to require Community measures aimed at developing and pooling resources, i.e. a European biomass policy.

On the other hand, Community financial aid to research (see 7c), invention and development (such as has already been granted in this sphere) is justified and should continue.

7b - Standardisation proposals. Not applicable at present. The standardisation of woodburning central heating boilers might perhaps be hoped for when they become more widespread.

7c - Research proposals. Research should be carried out into the energy potential of the biomass : utilisable energy reserves and possibilities of use. These problems are not however confined to heating, and concern several forms of energy use.

2.4 RECAPITULATION OF THE FINDINGS REGARDING THE FEASIBILITY OF THE MEASURES ENVISAGED

1.1 LIMITATION OF HEATING TEMPERATURE

This measure costs nothing, and has no snags within the limits envisaged (reduction to 17°C by day and to 12°C by night).

It takes effect immediately. Its application can be ordered and easily checked in public premises. In private premises, it can be ordered but its application is impossible to check. Where it has been ordered however, it seems to have been well complied with on the whole. Moreover, many private premises belong to public bodies which heat them, or are heated by contractors, and these bodies and contractors comply with the limitation. It would automatically be respected in the event of fuel rationing on the basis of the coefficient C. (C/Annex III to the introduction) and of the D.J. or D.H.

Demonstration in publicity documents of the advantages of the measure (compulsory or otherwise) is something well worth doing.

The occupants of buildings want intermittent heating and heating that varies from room to room. It is hardly possible to issue instructions to this effect in terms of temperature, but the owners can be compelled to design the new installations (or to modify the old ones) so that intermittent heating and varying temperatures can be obtained without difficulty.

Expressed as a percentage, the (large) saving depends on the difference between inside and outside temperatures, and hence on the severity of the cold season. Theoretically, the relative saving is 11 %/°C in Paris and 8% °C in Copenhagen.

The saving is much less in the case of families who have hitherto limited their heating to a temperature similar to the proposed compulsory maximum temperature.

1.2 LIMITATION OF HEATING PERIOD

This measure (which like the previous one costs nothing) is up to a point more easy to check on. It involves no modifications in buildings or installations. It may however lead to energy consumptions and expenditure on auxiliary heating that would in many cases reduce the effectiveness of the measure considerably.

Moreover, it overlaps with the previous measure to a large extent. Its choice is therefore not proposed.

1.3 LIMITATION OF VENTILATION

The cost of this measure varies considerably : it is virtually nil in buildings with mechanical ventilation, and amounts to the cost of replacing the windows (or simply draughtproofing them) and the installation of controlled ventilation in existing buildings.

Simple measures are profitable.

- Limiting ventilation increases the risk of condensation and insalubrity, but these snags are avoided if an air-change rate of $1/_2$ vol per hour is maintained in rooms with an average rate of occupation, and $2/_3$ in those with a higher rate of occupation.

- In existing buildings, the measure can only be applied gradually; it involves less work than improving insulation. A five-year period might be adopted for improving existing buildings.

The effect is immediate in new buildings, but is confined to a small proportion of new buildings.

- The measure can be made compulsory in new buildings. In existing buildings the chances of application are high thanks to the spur of rising energy costs and the threat of shortage, if people are kept well-informed and financial aid is granted.

- The effect of the measure at European level would be a saving of 2 % (or 5 M TOE) in heating energy as a result of a 10 % reduction in the average ventilation rate.

What would be the real average reduction? Theoretically, there could be a reduction from N = 1 to N = 0.5. In practice, air changes are well below 1 when there is little wind, but are very considerable in buildings of mediocre quality when the wind is strong. The estimated saving resulting from the measure is about 10 M TOE.

1.4 FIXING THE FUEL ALLOWANCE

This measure costs nothing, and its direct effects are similar to those of limiting the heating temperature ; they produce immediate results. Its introduction assumes a knowledge of previous consumption or of the coefficient C of buildings.

However, the indirect socio-economic effects of the measure (black market and discretionary powers of the authorities) mean that this measure should be considered only as a last resort : the measure that all the others are designed to avoid.

Mitigated forms of rationing, accompanied by measures for reducing requirements, have nevertheless not caused difficulties.

1.5 DETERRENT PRICING

This measure costs nothing by way of investment, and yields revenue. It is immediately effective and easy to apply. No accurate figure is available for the probable fuel saving. One of its advantages is to release funds that can be devoted to research and encouragement. This measure has the disadvantage of bearing harder on the poor than on the rich. Possible remedies might consist in relating the higher charges to taxation or wages.

The occupants of heated premises are always displeased by rises in fuel prices, and governments have to take account of this. Present prices nevertheless contain a large tax element. Is one to think that if the public is aware of the amount of such taxes, it would make it more disposed to accept the taxation and its increases? There is no evidence of this. In any case, a widespread public information campaign on the why and wherefore of the taxation might make it more acceptable.

While measure 1.1 is intended to reduce the fuel requirement by modifying the standard of comfort, measures 1.4 and 1.5 are designed to encourage (by price increases or rationing) the occupants of the heated premises to save in all possible ways, whether by using less heating, by taking type 2 measures in their buildings, or using replacement energy.

The artificial raising of the price of certain forms of energy (oil) also has the effect of encouraging the production of replacement energy. Since however the development of such production requires medium- and long-term investments, the policy of charging itself will have to be fixed in the long term in order to produce this effect.

2.1 GEOMETRY OF BUILDINGS

Modifying the geometry of buildings so as to reduce the ratio of the outside area S to the volume V when they are being built, costs nothing and even results in savings.

This ratio can be improved without drawback by 10 or 20 % in a given type of building, and will produce a saving of 5 - 10 % in heating requirements.

The measure can take the form of a compulsory maximum value of S/V. It can be expressed more simply by means of a limitation of the total annual consumption C. This is the third time we have had occasion to see how useful a knowledge of the C of a building is. The possibility should be examined of fixing the same value of C (or of S/V) for all types of buildings, even if this means making individual insulated houses slightly more expensive (a proposal that does not seem acceptable to some Member States).

In any event, the measure is applicable to new buildings only.

2.2 INSULATION IN BUILDINGS

2.2.a - Improving the insulation of existing buildings

This operation is certainly not free of charge. The cost of improvement varies by leaps and bounds for each type of building, if we take first the easiest improvement (e.g. insulation of unventilated roof spaces) and continue with the most expensive ones (multiple glazing).

The list of "profitable" improvements increases with the price of fuel.

Rationing or shortages may however make even unprofitable improvements necessary.

A level of insulation approaching the possible maximum might be considered necessary in new buildings : a coefficient G_1 (1) of about 0.3.

-The disadvantages of the best solution (increased outside insulation) are aesthetic ; other solutions involve humidity, and these latter disadvantages have been wrongly considered to apply generally.

- Because of its magnitude, the measure cannot be applied instantaneously to all existing buildings. The shortest period would seem to be 20 years.

- The chances of success are great because of the spur of rising energy costs and the threat of shortage, if people are sufficiently well informed and financial aid is granted.

- The effect of the measure at European level would be a cumulative saving of 1.5 % per annum for 20 years, or 30 % at the end of 20 years ; this represents about 60 million TOE.

2.2.b - Insulation of new buildings

- This costs less than improving the insulation of existing buildings. The cost may be considered negligible for low requirements (a thermal resistance of about 1 $1/2$ times the old rate of insulation).

(1) G_1 = Losses through opaque and transparent walls, per m3 of housing, in W/m3°C.

More stringent requirements (reducing the G_1 of solid walls to 0.3, and making compulsory the use of multiple glazing) involves an increase in cost of a few percentage points.

The additional cost is offset by the saving in fuel and the reduction in size of the heating installation.

- Its slight disadvantages are aesthetic : when outside walls are heavily insulated, this hampers their design.

- It becomes effective immediately in new buildings, but these amount each year to only about $1/_{50}$ of the existing buildings.

- The operation will be completely successful : all the Community countries can step up their insulation requirements. Experience shows that the G obtained are on average lower than those required, i.e. the insulation is better.

2.3 CONTROL - INDIVIDUAL METERING

- The cost of improving control varies according to the degree of sophistication, but is still moderate (between 500 and 2.500 F per dwelling).

The profitability of the controls seems to be guaranteed in all cases.

The cost of individual metering varies with the quality of the metering installation (from 250 F per annum to 3.000 F). The profitability of this expenditure depends on heating consumption : tentative metering is justified when consumption reaches 2.000 F per annum ; accurate metering is justified when consumption exceeds 3.500 F per annum.

- The measure has no snags.

- All existing buildings can be fitted with controls in 5 years.

- Efficient controls and individual metering can be required in new buildings. The measure can be made compulsory in old buildings. Its use will in any case increase because of the spur of rising energy prices and the threat of shortage, if people are sufficiently well informed and financial aid is granted.

- The effect of the measure on a building can vary from 0 to 20 %.

- At European level, the measure would save about 20 M TOE a year.

2.4 HEAT PUMPS - EXCHANGERS

These measures are not equally expensive.

The installation of an incoming air/outgoing air exchanger in a new dwelling costs 5.000 F. A heat pump costs 20.000 F.

Insufficient use has been made of heat recovery from effluent to permit calculations.

The practical performances of the installations seem to be less than expected, at least in the case of individual installations. The pumps need to be very carefully tended and maintained.

It appears that exchangers and pumps serving a large volume of buildings will provide an economic performance.

- There are no snags in using pumps, exchangers and recuperators.

- Their use is limited to new buildings or, in the case of exchangers, to those fitted with dual-flow mechanical ventilation. Their effectiveness is thus progressive.

- There is no case for action by the authorities on the subject, except to bear in mind the possibility of using pumps and exchangers when calculating consumptions to be used as a basis for other measures. There again, it is information that will encourage development.

- It is not possible to estimate the overall saving to be made from the use of these appliances.

2.5 OPERATION - MAINTENANCE - BOILER REPLACEMENT

Proper operation and regular maintenance of heating installations are measures that do not cost much, whose effect is obviously favourable, but which are very difficult to express in figures.

This measure should be taken, and is never inadvisable.

Advantage should be taken of boiler replacement to change fuel, or to install boilers that will burn more than one fuel ; in some cases, the boilers can be duplicated to obtain greater efficiency.

2.6 RECOVERY OF HEAT FROM WASTE HOT WASHING WATER

Such recovery involves difficulties because the temperature of the waste water varies.

It has not yet been, but should be, the subject of much study.

2.7 DISTRICT HEATING. COMBINED PRODUCTION OF HEAT AND POWER

Supplying heat from urban heating stations makes it possible to use large, well-operated, well-maintained boiler rooms fitted with multiple boilers which can burn different fuels simultaneously and make use of sources that cannot otherwise be used : refuse, geothermal energy, and lukewarm industrial effluent.

Although the measure produces no direct savings, it is indirectly important.

The measure can be used in existing centres of population, but in new areas in particular.

The combined production of heat and power is a response to the wish to use low-temperature sources for heating.

The use of power-station effluent is a very important measure because of the huge amount of energy involved. Used in full, it could supply free of charge 50 % of heating energy.

3.1 PASSIVE USE OF SOLAR ENERGY

The passive use of solar energy involves additional building costs which vary considerably : from a few percentage points for increasing the area of multi-glazed windows fitted with insulating shutters, to increases of over 10.000 FF for glasshouses, and radical design modifications for Trombe walls (additional cost 40.000 FF). Efficiency varies from a possible saving of 10 % in the case of simple solutions, to perhaps 40 % in Trombe-type solutions.

Reducing the heating energy requirement by 10 % as the stock of buildings is gradually replaced will make a saving of 10 M TOE in 20 years.

- Some solutions have disadvantages as regards comfort in summer, and contact with the outer world.

- Solutions such as insulating shutters can be widely used in existing buildings, but their performance is limited (2 - 3 %) and is no different from improved insulation.

- If better use of solar heat is taken into account when determining authorised consumptions, it will be necessary to make use of this measure, which will become more widespread as new building proceeds. This again is a reason for considering the coefficient C.

3.2 ACTIVE USE OF SOLAR ENERGY

It is possible to devise a solar-energy collection and storage installation to supply all the heating energy required by a building. The lower the building's coefficient C, the easier this will be.

In practice, there are projects aimed at supplying 90 %. Most of the practical applications (known as solar houses) scarcely exceed 30 %.

None of these solutions is profitable at present. It is however impossible to set a price on "energy independence".

- The individual solutions, with collectors on building walls, have snags (outside appearance, limitation of contact with the outside world). If the collectors are not installed on the building itself, these snags are avoided.

- Because of the amount of investments involved, this measure can be implemented only gradually. The proposed rates are very low almost everywhere : a percentage of about one or a little more, or new buildings.

- The effect is also very slight : 0.025 % at present.

3.3 GEOTHERMICS

- Using the heat of medium-temperature underground water beds costs about 10.000 F per dwelling, and is economically on the threshold of profitability, assuming that geothermal energy can supply 80 % of the heating energy of the buildings.

- This measure has no snags.

- The measure is applicable both to areas of new buildings and to areas already served by urban heating (in which case it is most often supplemented by heat pumps).

- Its utilisation has a gradual effect, its rate being limited by the magnitude of the investments. In favourable areas it can involve 10 % of new buildings, i.e. 0.25 % of all buildings. Little is known of the potential European capacity.

3.4 RENEWABLE FUELS

Increased use may be made of refuse as a fuel in urban centres : it is profitable where housing density is sufficient. It is a minor contribution to the consumption of energy.

The vegetable products (the basic constituent of the biomass) that have always been used in the form of wood for heating, might supply an interesting contribution : at European level, wood alone would represent 20 M TOE.

Species might be grown for use as fuel (varieties of timber, reeds).

CHAPTER 3

Proposals and conclusions

3.1 Reasons for a Model Code of measures for saving heating energy in buildings

The European Community has put forward a number of measures for the purpose of encouraging the rational use of energy (annex to the Council Resolution of 9 May 1980, OJ C 149 of 18.6.1980).

They are recalled below.

Energy savings in dwellings

- Substantial increase in compulsory minimum performances for new housing and heating systems ;

- regulations providing for individual metering, invoicing and control of heating systems in blocks of multiple dwellings ;

- efficiency standards and monitoring of maintenance of heating systems ;

- publicity campaigns and information centres for saving energy in dwellings ;

- financial grants for the necessary adaptation of existing housing, exemplary programme for housing belonging to the public sector ;

- labelling of domestic appliances to show their energy consumption.

These recommended measures clearly justify the measures proposed in the model code.

3.1.1 What purpose can be served by a Model Code covering the measures for saving heating energy in buildings?

If the Commission of the European Communities agrees to the drafting and publication of a Model Code of measures for saving heating energy in buildings, it may do so for the purpose of using it as a basis for the real harmonisation (reasons justifying which are mentioned in the introduction) of the measures employed in each country, or simply in order to provide Member States with an aide-mémoire and a document containing suggestions and reference material.

It happens that the same style of drafting of the document will do for both purposes. When drafting the annexed document, we have in any case tried to use a style that does not predict what use might be made of such a document.

3.1.2 How stringent should the proposed requirements be made?

Unless a Model Code is to consist solely of vague recommendations and pious hopes, it must quote figures for its recommendations or obligations.

How stringent should these figures be?

Two considerations must be taken into account.

The first is the abundance of national heating energy resources : despite their solidarity with the "energy-poor" countries and their concern to manage their energy capital wisely, the governments of "energy-rich" countries are not necessarily disposed to take such draconian measures as the countries that lack oil, gas and coal.

The second consideration is that of variations in cost and shortage of energy in the course of time.

- Since 1973, the European economy has experienced a continual increase (and will continue to do so) in the price of heating oil, without any real shortage.

- Since then (but especially since 1979) it has been under the threat of a serious shortage that might result from a Middle East oil embargo, or a stoppage of oil production there because of acts of war, for instance. There are of course sources of supply elsewhere, but obviously a reduction of several tens of percentage points in Europe's supply would immediately cause a crisis and rationing, which would obviously affect the use of oil for heating more severely than its use for other purposes.

- On the horizon we see Europe's hopes of energy independence, thanks primarily to nuclear energy from fusion.

The degree of stringency of preventive measures for saving heating energy will vary according to how one assesses the risks of a continual increase in energy costs and of a shortage.

Only a minority of people in the European Community suffered from the heating fuel shortage in the 1939-1945 war. But those who did have certainly not forgotten what it was like. Moreover, there is no comparing the standard of comfort in 1939 with present standards ; and at that time, practically all the sources of heating were local.

The seriousness of the consequences of a shortage undoubtedly calls for more stringent measures than is generally the case.

Moreover, however abundant energy may be in the future, it is an advantage to free oneself of a need and to cease to be dependent, or to reduce that need and dependence.

The best way of preventing a shortage is to show that one is taking the necessary steps to avoid one.

Since in the final analysis none of the measures has an immediate effect (except temperature limitation, which will come of its own accord in case of a shortage) it seems wise to "begin by taking strong action" so as to obtain a substantial result at what might be the right moment, bearing in mind the possibility of relaxing the effort if prospects improve and the effort seems arduous and costly. Not all Community countries adopted this attitude in 1973.

3.1.3 What provisions should a Model Code contain?

There are three possible categories.

A. Provisions whose purpose is to limit consumption by government action (or persuasion) and the behaviour of occupants.

These provisions should be decided in the light of what has been shown to be possible by :

- a knowledge of comfort requirements ;
- technical means of saving (or replacing) fuels.

B. Obligations, and in particular grants and incentives, to improve buildings (i.e. their shell and installations) so that the same energy consumption provides better heating, or the same heating consumes less energy.

These improvements are made by various (quite often complementary) means of achieving the required purpose. Most of them cannot be made compulsory, because choices are possible. The overall result may be made compulsory by means of one of the first group of measures.

C. Obligations, and in particular grants and incentives, to use substitute energy that is independent of extraneous whims, and preferably renewable.

Here (as in the previous group) compulsion is the exception rather than the rule.

3.1.4 The importance of improving heating economy in existing buildings

The statutory regulations introduced by Member States have in the main dealt with new buildings. At least as far as housing is concerned, new buildings replace less than 2 % per annum of the existing stock of buildings. In other words, measures concerning new buildings will be a long time in taking effect.

Action needs to be taken in existing buildings, which consume 200 M TOE per annum by way of heating energy.

It is only in exceptional cases that governments take action regarding existing buildings : for them to do so, the buildings generally have to be unhealthy or in danger of collapse. Governments should change their attitudes, and intervene where major savings are possible.

Statutory means may not be desirable or possible. The essential is however that effective action be taken.

Action in respect of existing buildings is also a long-term matter. For instance, it will take at least 20 years for insulation in the existing stock of buildings to be improved _in toto_. The conclusion to be drawn from this is that a start must be made with partial measures that permit a maximum saving : it is the next few years that are the most worrying for the economic stability of the developed countries.

3.2 Discussion of the provisions of the Model Code

A. An annex to the conclusions contains an example of a possible version of a Model Code based on the foregoing examinations of each measure.

Its contents are discussed here.

Provisions for the purpose of limiting consumption

A1. Limitation of heating temperature

If warmer clothing is used, there is no difficulty in limiting the day temperature to 19° (this has already been done in several countries) and the night temperature to 12° (many occupants already do this).

The day temperature may be reduced to 17° in case of need, although many people consider this too low. If however one considers that (in comparison with the former temperature of 22°) it makes a saving of over 40 % in the temperate countries of Europe, one must admit that if it is necessary (say) to preserve stocks in the event of a threatened shortage, the saving made largely outweighs the disadvantages.

Completely or partly intermittent heating, and the setting of different temperatures in the various rooms, should be possible : it is something that many families and firms already practice of their own accord.

The possibility of including the limitation of temperatures in private premises in a Model Code may be challenged because its application cannot be monitored : such monitoring would require search warrants which, although possible in law (in all Community countries?) are very difficult to apply in practice.

There are however two possible replies to this.

In the first place, the law can lay down obligations without being able to punish non-compliance with them. Some people stress that human nature is such that obligations whose disregard is not punished are seldom complied with. This is after all not altogether true : and honesty exists with or without sanctions.

Moreover, many public or trade operators of heating systems have to comply with any limit that is laid down.

Secondly, however (in particular), if the law can in principle limit temperatures to certain values, the consequences of this can be verified : for example, the limitation of consumption.

A2 - Limitation of annual consumption of heating energy

The Model Code should lay down the principle of limiting the consumption of energy used to heat occupied buildings, in order to draw from that the necessary conclusions. This limit is fixed as a function of a datum - the number of natural D.H. of the period considered - and two parameters :

- the authorised inside heating temperature ;

- the characteristic coefficient C (1) of the building (which as we have seen can be calculated).

It is necessary here to consider the overall coefficient so as to take account of all possibilities of saving energy (and auxiliary energy) from which the builder and operator of a building are entitled to choose.

From this, each government can work out compulsory insulation measures (of group B), expressed in terms of the G of the building (i.e. in W/°C.m3) or the K of the walls (i.e. in W/°C.m2), and any other compulsory saving or replacement measures.

Having already fixed the maximum inside temperature, the C should be fixed.

To do this, we should consider what it is possible to expect from :

- wall insulation. We have seen that a G1 of 0.3 is possible ;

- ventilation. A consumption limited to 0.15 W/°C.m3 is possible ;

- the passive use of solar heat, per m3 and DH : this can average 0.15 W/m3°C.

Disregarding the other measures (in particular intermittent heating, different temperatures in the rooms, use of pumps and exchangers), it will be

(1) It will be recalled that this coefficient C is expressed in W/m3°C. It represents the average heating requirement of the building during a heating season, per degree-hour and m3. It takes account of the average solar energy received by the building in the cold season, of air changes, and if possible of recovery devices and heat pumps.

concluded that it is possible to require buildings to have a coefficient C of less than 0.30 $W°C^{-1}m^{-3}$.

This value seems low in the light of current practice. It does however seem possible at a very moderate additional cost.

The cumulative effect of limiting the temperature to 19°C and improving C reduces energy consumption to 38 % of what it is now, and in the case of 17°C to only 30 %.

The new values of C for new buildings can be made compulsory fairly quickly. Time will have to be allowed to change certain technological habits or to create new equipment. The measure can only be applied equally to buildings on which design work has not yet commenced. These various considerations militate in favour of an application period of two or three years after promulgation of the measure, rather than of application by stages.

On the one hand, such results cannot be expected for old buildings. Initially, one might hope to adapt the natural ventilation and the day-night coefficient of the windows so as to make an average improvement of about 8 %.

By staggering the process, one can aim at an insulation of 0.50 W/m3°C, a ventilation of 0.15 and (assuming a solar utilisation of 0.10 W/m3°C) obtain a C of 0.55 $W/°C^{-1}m^{-3}$.

Work would have to be staggered over a much longer period, because it would involve the entire stock of buildings (nearly 100 million) in Europe. A period of about 20 years for total improvement is admissible ;

buildings will have to be subdivided according to their intended use and technological classes. Meanwhile, partial results will be obtained by encouraging or compelling people to take simple measures : insulation of roof spaces and flat roofs, insulating shutters, and draughtproofing.

We shall not enter into a further discussion at this point of the need to vary the value of C as a function of the climatic zones and the geometry of buildings. This problem should be the subject of discussions independently of those regarding the Model Code (see below : Proposals and Conclusions III) ; their result should subsequently be included in this Code and national codes.

B. Incentives and obligations as regards the thermal quality of buildings and their equipment

Fundamentally, those constructing new buildings and the owners of existing ones have the choice of many ways of achieving the object of limiting consumption mentioned in A2.

Certain measures may however be imposed by governments, either because they appear likely to ensure the success of the limitation, or because they are easy and it would be a pity not to use them in any case.

It is recommended in respect of all the measures :

. to pay grants to owners when profitability in local currency is not guaranteed, or is too low to be a real incentive ;

. to facilitate the financing of studies and the development of new products involved in the various possible measures ;

. to make possible reliable and inexpensive appraisals. This assistance should be graduated in the light of three considerations :

measures that are effective soonest (and which should be encouraged) ;

those that are most likely to be profitable ;

and lastly, those resulting in the use of no resources other than those controlled by the country concerned.

To finance these grants, one naturally thinks of a tax on the fuels whose use one wishes to reduce, i.e. in the main fuels that are imported from countries outside the Community, and oil in particular.

The measures that might be made compulsory include :

a minimum rate of outside wall insulation, per inside m3, or varying according to the nature of the different parts of the wall and related to m2 of wall area ;

generally, the two types of requirement are made to produce almost identical effects by explicit account being taken of building types.

We assert here that the fixing of a limit for heat loss through the outside shell should be contemplated. If this loss is related to m3 of inside volume, it amounts to fixing a limit for G. In relation to the measure of limiting C, this measure as regards G boils down to saying that one will not agree to the required C being obtained by using heat pumps or solar energy. It would not be economical in terms of investment to use such devices without at the same time trying to improve insulation and to reduce uncontrolled air changes. Moreover, the additional supplies of conventional energy would be abnormally high.

Limiting ventilation in both new and existing buildings.

Compulsory installation of regulating systems, operating according to inside temperature and separately by outside walls, if not by rooms ; of selective controls for each outside wall and room, and of separate meters for each occupant.

The effectiveness of the regulation devices is not disputed, and it seems advisable to require a minimum regulation system. This might be room-by-room regulation. The idea of automatic regulation should be linked to the idea of a control for each dwelling, and each room.

The reliability of metering is uncertain, and the possibility of cheating has been noted in particular. Reflection is however necessary before rejecting the idea of requiring individual metering in blocks of flats and of offices. Cheating is regrettable and reprehensible. It does not however render the measure completely ineffective. What we are trying to do is to save energy, not to apportion heating costs fairly. The measure does in fact seem likely to save energy.

The maintenance of boilers and regulation systems, which is known to be reliable, may also be made compulsory. There was no problem in making chimney sweeping compulsory in the past. Maintenance should be entrusted to qualified technicians, who would probably hold a formal qualification.

A timetable should provide for the staggering of these measures [with the same remarks as under A2 (see also D3)].

C. Incentives and obligations regarding the use of substitute energy

Like those proposed for reducing losses, these incentive measures involve financial grants and information campaigns, used mainly to promote increased use of such substitute energies as solar and geothermal energy, fossil fuels that are more plentiful than oil, and renewable fuels.

Compulsion should however also be used in some cases in this respect.

In the first place, a minimum use of solar energy should be made compulsory ; it would doubtless vary according to the use of the building (1).

The installation of multi-fuel boilers, convertible boilers or a number of boilers using different fuels might be made compulsory in new buildings or when replacing boilers. This reduces dependence on scarce fuel.

On the other hand, the use of a certain energy should be made compulsory where local installation measures have been taken or where natural resources exist.

(1) In the case of housing, for instance, this minimum might be fixed at 20 %.

It should thus be possible to make connection to the urban heating system compulsory in areas where this is available. This measure is justified because urban heating produces heat very efficiently (well-regulated, well-operated multiple boilers), but in particular because such a system can change much more easily than individual heating systems or those in multiple-occupation buildings to fuels other than oil, e.g. coal or refuse, and also geothermal energy, whose use (as we have seen) is conceivable only in urban heating systems.

The same applies to the use of heat from the cooling water of electric power stations and the use of the heat produced in installations for the combined production of heat and power.

Lastly, adaptation to heating by natural gas or coal should be made compulsory in areas near production centres.

It will be seen that several of these obligations are linked to the idea of zoning, i.e. creating zones where the use of certain forms of energy will be made compulsory for certain types of building (see D below). It is also clear that a timetable (see D below) will have to be drawn up for converting energy supplies to existing buildings.

The aids to be used to ease the financial burden of the obligations or by way of incentive are the same as for the measures listed under B, and the same method of financing by taxing dependent and non-renewable fuels should be used.

When it is a question of encouraging the use of forms of substitute energy (which as a rule are not yet competitive with imported energy) such aids can be combined with deterrent taxation of the forms of energy to be substituted. To some extent, this necessitates an exercise in equalisation.

This policy of equalisation and taxation is the necessary prerequisite for the industrial developments needed, and should be clearly stated and be continuous. The level of grants and taxation should be fixed so as to make a given form of energy usable. For instance, we propose that active solar energy supplying 90 % of the requirement should be made competitive.

D. Miscellaneous

It is very useful for a government to be able to forecast the effect of energy saving and the investment cost of a given measure involving existing buildings. This would require a census of existing buildings, classified according to characteristics of importance to the proposed measure. From an absolute point of view it can be maintained that a classification that would be of use for all measures is impossible, because it is impossible to imagine all the future measures that would be taken.

In practice we know the most important measures that can be taken, and hence the characteristics of existing buildings of which a knowledge is necessary.

On the other hand, although building techniques are generally regional, there are a limited number of them in each region. Hence it does not seem to be a hopeless task to draw up a classification of existing buildings by construction technology, and consequently by nature of insulation, permeability to air, inertia, and facilities for improving these characteristics.

The Model Code could therefore state this objective.

The previous chapters have noted the need to divide countries into zones, not only for fixing different coefficients such as C, G or K, but also for making the use of special forms of energy compulsory in certain zones. For convenience of use, the various zones would have to be plotted on one and the same map or the same group of maps, so that builders and architects could easily see what their obligations were.

According to the present state of legislation (and even of the Constitutions) of the Member States, it will be necessary for the governments to be given the necessary powers, by means of new laws (or even amendments to the Constitutions), to enforce the measures ; such laws could not normally be incorporated in the national Codes, but should be the subject of a series of laws prior to promulgation of the Code.

Many measures require the government to grant financial aid, either in the form of an incentive or simply because the measure (although useful at national level) is not profitable for individuals. These aids might take the various forms listed in annex II to the Introduction and be financed by a tax on the sale of fuels imported from outside the Community. This point has already been mentioned in II.B and C.

It is generally recognised that the success of an energy-saving policy depends on a public information campaign. This is quite essential if statutory measures are not used. The information campaign might deal with obligations and aids, but also more generally with all the needs and means of saving energy, and in particular with non-renewable energy sources and those that make Europe dependent on certain outside groups. The tax envisaged above might contribute to this campaign of information and awareness, and this use might thus be mentioned in the Code.

According to national customs the information campaign can make use of publicity agencies, non-profit-making associations, or both.

There is one sphere in which governments have very special facilities for action, namely their own buildings. These buildings can be used to demonstrate schemes that are not yet profitable. It is moreover particularly appropriate that the State should maximise savings of scarce fuels in order to leave more for private individuals. Hence it seems that the Model Code could reserve a special place for government buildings, which would also need their own timetable.

While we have so far discussed the aids to using a given type of fuel, we have not discussed the aid that should be given to research into and development of the new appliances and building techniques required by most of the measures.

Grants for research, innovation and development exist in the Member States; and because the need for energy saving is more pressing and many of its aspects are so new that manufacturers hesitate to venture resolutely into this unknown territory, a specific grant might be considered necessary. It could be paid for from the tax on imported fuels.

E. One essential point has not yet been tackled, namely the order and rate of application of the measures : in other words, the timetable.

There would seem to be no financial or material obstacle to applying the measures immediately to new buildings (i.e. all buildings on which planning begins after promulgation of the measures) ; only a limited number of buildings are involved each year, and there are no restrictions because of shortage of labour or materials. The measures recommended are relatively inexpensive when applied at the building stage. It will be recalled that these measures can be reduced to compliance with a given coefficient C.

Existing buildings on the contrary outnumber new buildings by fifty to one, and pose problems of materials and (in particular) of labour when one looks at the whole extent of the problem in the light of the reasonable wish to make all possible savings in a reasonable period of time. We have seen as regards insulation that spending 10.000 F per dwelling over 20 years would mean increasing activity in this building sector by more than 10 %.

Each country will thus have to decide which measures to introduce in the first place and at what rate, according to criteria that are not always objective.

The following points need to be considered :

- the increase in production in certain industries (production of insulating material, meters, regulating devices, etc.) ;

- the admissible increase in building activity over 10 years, 20 years and more ;

- the profitability in local currency of the measures ;

- the profitability in foreign currency, whose limited availability is governed by a forecast of the country's general volume of exports ;

- the risk of shortage, which is essentially a political assessment.

It is impossible within the scope of this report even to take the first steps in analysing these criteria. It is however clearly very important that the Member States should be able to tackle this matter jointly. This would facilitate a subsequent coordination of national policies and the approach to a Community policy.

3.3 Subjects of Community interest suggested for discussion

Analysis of the various possible measures has led to a number of points that cannot be included in the Model Code being noted, especially when they concern the Community rather than individual Member States.

These points are now listed and commented on with a view to their discussion within the Community. They are grouped under three headings :

- Community policy
- Community standardisation action
- Community research and development.

3.3.1 Community policy

3.3.1.1 Ought one to consider that the heating energy used by a family should be independent of the type of dwelling (detached, terraced, small block, large block), or that it should vary according to the type of building and be greater for small than for communal buildings?

This point was tackled in memorandum 2.1. If one considers only energy saving, the reply is that the energy consumed should be independent of the type of building. This penalises individual buildings, in which losses are naturally greater.

If one considers other requirements such as the desire for privacy and individual adjustment, one is induced to take account of the fact that individual dwellings satisfy these requirements better in the view of most people : in other words, one will accept the use of more heating in individual dwellings, even though this has to be offset nationally by greater stringency in communal buildings. It will be recalled that in the 'fifties', the demand for low-cost housing (like that for low heating energy consumption) resulted in the construction of individual houses being sacrificed in several European countries. A discussion of this point would be expedient.

3.3.1.2 How is one to vary the energy normally consumed as a function of the climate? This point was broached in memorandum 2.2.b. It concerns both the Community as a whole and the Community countries whose climates vary (as is the case in all large countries).

There are two competing extreme principles :

- the same consumption for all, which leads to improving insulation and the other economy measures in cold climates. Should there in this case be national - or even Community - cost equalisations?

- the same insulation, i.e. the same investments for fuel saving everywhere. The occupants' own financial interests will always result in more stringent economy measures in cold climates, without going as far as a rigorous inverse proportionality between G and D.H. This is in fact the situation that has been brought about by the regulations introduced since 1973.

Another fact that might be taken into account is that generally speaking the wealth of nations is proportionate to the severity of their climate. Are the richest regions (which are also the coldest) to invest more to save more (something that approaches the idea of the same consumption for all) and so facilitate supplies for the poorer and warmer countries? The choice between these two points is a second matter that might well be discussed by Member States.

Community action : The following points might after discussion be the subject of proposals for Community action.

3.3.1.3 Incentives to use indigenous resources where these are to be found. For instance, solar energy is more abundant in Southern Italy than in Northern Scotland. Community solidarity should provide an incentive for investing in solar heating of domestic hot water in Southern Europe, so as to save all the oil for Northern Europe. If this principle were accepted, its application would require grants for solar equipment in the sunny areas of Southern Europe ; for hydroelectric schemes on small waterfalls in moderately mountainous areas ; for using wind power on the coasts, or even for using the biomass in those climates best suited for the purpose.

The discussion should concern the principle of incentives (which might include financial grants) for equipment for the use of local energy resources.

3.3.1.4 The Community tax. Community incentives and financing might justify ad hoc funding. The funds might come from a tax on oil imported into the Community for heating. The rate of tax would be low, e.g.

0.2 ECU per TOE would yield 50 million ECU, which is a considerable sum. Such a measure is without the dangerous effects of intra-Community compensation. It would without difficulty finance a research, development and demonstration budget. It would enable incentives for developing local resources to be financed. The creation of such a fund is thus worth discussing.

Such a tax must not be confused with the taxes that might be levied by Member States and perhaps the Community to discourage the use of a product or to make it so expensive that substitute resources will become profitable. This second kind of tax (discussed at point II.C) will be levied at a quite different rate : it will be about as much as the price of the product itself, and about 10^2 times the tax mentioned earlier (1).

3.3.1.5 Although the Model Code suggests that Member States draw up a programme of savings with a timetable, the Commission might nevertheless outline a European programme, backed by figures. The programme should be accompanied by a timetable, without which it will not be very convincing. The programme would be supplemented by a European zoning scheme, showing the preferential areas of application of the various measures.

The drafting of the programme is an essential point in the policy for making savings in the sphere concerned. This point was dealt with at the end of the previous chapter II.E. This programme, timetable, zoning scheme and the answers to points A, B, C and D above would form the basis of the

(1) It is this second tax that is implicitly alluded to in § Aii of the guidelines of a basic programme appended to the Council Resolution of 9 June 1980.

Community policy for saving heating energy.

To conclude where the Introduction began, it will be recalled that the existence of such a policy would have at least two results. It would :

- concentrate the efforts of all the countries ;

- show a united front and a resolute attitude to the rest of the world, which would be an advantage when dealing with the energy suppliers.

3.3.2 Community harmonisation of standards

The expediency of harmonising standards for various measures has been noted This applies in particular to :

- the rule for calculating the consumption of a building from the plans ;
- the methods of calculating and measuring the thermal loss coefficients of complex structures and materials ;
- regulating sensors ;
- thermostatic valves ;
- performances of heat pumps ;
- performances of solar collectors ;
- characteristics of woodburning boilers.

After discussion, these requirements might be brought to the notice of the pre-standardisation organisations (primarily the CIB) and the international standardisation organisations ISO and CEN.

Certain products might be the subject of approval directives of the UEAtc (sensors, thermostatic valves).

If these measures proved too slow, the Community might take the initiative by means of measures intended to prevent the creation of obstacles to trade, on the lines of the provisions now being drawn up for building products.

3.3.3 The Community is financing a Community research programme in respect of energy. We have found here research projects that do not yet appear to be included in the financing programmes, and that might be considered useful for the success of the economy programmes. These are :

- research into the air changes necessary in premises used for different purposes ;
- research into present air changes in existing buildings ;
- research into present air changes in buildings used for all purposes, and the improvement that can be expected from this ;
- research into the effect of increasing energy prices on heating consumption ;
- research into the additional cost to small-volume buildings of compliance with the same voluminal loss limits as those of large buildings ;
- research into the technological classification of existing buildings as regards heat losses ;
- research into and determination of the feasible saving potential for each type ;
- research into the creation of materials which have good load-bearing as well as very good insulating qualities ($\lambda \leqslant$ 0.1 W/m°C) ;
- research into the creation of reliable and inexpensive supply meters ;

- research into the *in situ* efficiency of heat pumps ;
- research into heat recovery from waste domestic hot water ;
- research into the creation and development of systems for the direct use of lukewarm industrial effluent ;
- research into the *in situ* efficiency of appliances for passive recovery of solar energy ;
- establishment of methods of calculating the effect of heat pumps and of active solar systems ;
- research into the optimum shape and size of office buildings as regards consumption of heating and air-conditioning energy ;
- studies of the mean annual efficiency of boilers ;
- studies of the use of auxiliary heating.

3.4 CONSEQUENCES OF THE HEATING ECONOMY MEASURES ON INDUSTRY AND COMMERCE

When analysing the measures, we took the opportunity of confirming that the energy-saving measures would result in a substantial amount of sound economic activity as regards the manufacture and installation of materials and equipment.

This activity is very sound because it generally involves a great deal of work for skilled workers, executives and engineers. Production of some of the materials certainly consumes energy (e.g. glass wool and window glass), but the amount used cannot be compared with the saving that will result from their use. Others (like polystyrene) are oil-based. There again, the operation will show a very good profit from the point of view of saving foreign currency.

The materials whose production will increase are essentially insulating materials (mineral wool, macromolecular foam, cellular minerals), multiple glazing material and draughtproofing material.

The constituents will have to adapt themselves to the new insulation requirements. This will only involve a design effort for a limited time, but will result in the reclassification of certain families of solutions.

A very wide range of equipment is involved :

- adjustable air inlets, controlled ventilation equipment of all kinds ;
- regulation (sensors, thermostatic valves) and metering equipment ;
- solar energy collection equipment ;
- equipment for burning and/or gasifying products of the biomass ;
- equipment for heat pumps and exchangers.

These activities will create a large number of jobs :

- for engineers (creating and manufacturing equipment) ;
- for engineers and executives for the same purpose ; but there will also be considerable work in specifying the work to be carried out in existing buildings as regards ventilation, insulation, regulation,and metering. There will also be work to do regarding solar equipment ;
- for highly-skilled and versatile workers, in carrying out this latter work and in maintaining and operating heating installations.

Special studies will be necessary to determine the necessary volume of production and work involved. It can however be said that they will be considerable, and hence of a kind to make a substantial contribution to the national product. As we have seen in the case of insulation, the rate of implementation of many of the measures will depend on the capability to produce the wherewithal.

ANNEX TO CONCLUSIONS

DRAFT MODEL CODE

The best way of demonstrating the feasibility of a Model Code that might be adopted by the European Communities seemed to be to put forward a draft of such a Code.

MODEL CODE OF REQUIREMENTS FOR SAVING HEATING ENERGY IN BUILDINGS

(Draft)

- Preamble -

The purpose of this draft Model Code is to set out the requirements which if submitted to the Member States of the Community might prompt them to adopt harmonised regulations for saving heating energy in buildings, and at the very least serve as an aide mémoire for them when they decide on their energy-saving policies.

General provisions

G1 : It has been decided to use in all matters concerning energy saving and the thermal characteristics of buildings and materials the definitions and expressions standardised by the ISO and CEN ; and as regards the equipment concerned, the definitions, expressions and performances standardised by the ISO, CEI, CEN and CENELEC.

G2 : A census of existing buildings, classified by building technology (and which accordingly contains particulars of insulation, permeability to air, inertia, and the possibility of improving these characteristics) shall be carried out immediately.

G3 : It has been decided to adopt the method of calculation of the coefficient C, i.e. the coefficient of average heating requirement of a building for one season, per degree-hour and per m3 that is to be laid down by the European Communities.

Alternative version : to lay down a method of calculation of the coefficient C that is accurate to within 5 %.

A - Limitation of Consumption of Energy for Heating

Art. A1 : The temperature of premises occupied during daytime shall not exceed 19°C. The temperature of bedrooms shall not exceed 12°C.

When there is a threat of a shortage of heating energy, the temperature of premises used during the day shall be reduced to 17°C.

Installations shall be fitted with means of control and regulation which on the one hand enable these maxima to be complied with, and on the other enable temperatures to be varied daily and from room to room.

Art. A2 For all necessary purposes the maximum quantity of energy that may be used to heat premises is defined as the product of the coefficient C* multiplied by the number of natural degree-days in the heating period and by the volume of the premises.

For every type of use of a building the maximum of the coefficient C shall be Ci for the zone Zi (irrespective of the

* It will be recalled that this coefficient C, expressed in W/m3°C, represents the average heat requirement of the building during one heating season, per degree-hour and per m3. It takes account of the average solar energy received by the building during the cold season, of air changes, and if possible of heat-recovery appliances and heat pumps.

geometry of the building), a zone being defined by the values of a coefficient characteristic of the heating energy requirement, based on the number of natural degree-days and the difference between the mean outside temperature and the heating temperature.

Art. A3 : A tax on imported fuels is introduced for the purpose :

- of providing funds for payment of grants for research into and development of new forms of energy or energy-saving systems and notably :
  - by curbing fuel consumption ;
  - by making competitive sources of energy other than the present sources.

The amount of this tax shall be such as to make competitive the use of solar energy absorbed by collectors and storage facilities under the most favourable conditions.

This tax is also intended to finance public information campaigns in respect of the compulsory measures, of financial aids and of the national importance of saving heating energy.

Art. A4 : Contracts for the operation of heating installations whereby the operator is paid in proportion to the number of calories supplied, are prohibited.

B - Obligations and incentives regarding the quality of buildings and their insulation

Art. B1 : The insulation of the outside wall shall be such that the value of thermal losses per m3 does not exceed :

1a : ...... $W°C^{-1}m^{-3}$ in new housing
1b : ...... $W°C^{-1}m^{-3}$ in old housing
2a : ...... $W°C^{-1}m^{-3}$ in new offices
2b : ...... $W°C^{-1}m^{-3}$ in old offices
3a : ...... $W°C^{-1}m^{-3}$ in new works
3b : ...... $W°C^{-1}m^{-3}$ in old works

etc...

or the value of the heat losses per m2 of the various walls does not exceed the following values under the same headings :

Roofs	Blind walls	Glazed areas
1a :	....	....
1b :	....	....
2a :	....	....
2b :	....	....
3a :	....	....
3b :	....	....

etc...

The measures concerning old buildings shall be applied in the twenty years next following.

Windows must be fitted with insulating shutters : forthwith in the case of new buildings ;

in the five years next following, in the case of existing buildings.

Art. B2 : The rate of change of air by ventilation in living rooms shall not exceed 0.5.
Alternative version : the rates of ventilation in m^3h^{-1} for

the various kinds of premises with different occupation rates are as follows :

.... classrooms

.... offices

etc...

Art. B3 : The heating controls must enable the heating temperature to be varied automatically or manually according to a daily programme.

They must enable different temperatures to be set in different rooms.

The heating must be regulated room by room, or at least by each outside wall.

Art. B4 : Heating energy consumed in communal buildings shall be metered and charged separately for each occupant.

Art. B5 : The maintenance of boilers and regulating devices by qualified technicians shall be compulsory.

Art. B6 : Financial aids in the form of :

low-interest or interest-rebate loans ; and tax relief are granted to owners or occupiers who :

- improve the insulation ;
  the ventilation ;
- install heat pumps ;
  exchangers ;
  recuperators ;
- increase the proportion of solar energy in heating energy;
- improve the regulation or metering system.

These financial facilities are designed to make these energy-saving operations attractive and profitable.

C - Obligations and incentives regarding the use of substitute forms of energy

Art. C1 : In new buildings, a solar gain of .... %* of the heating energy requirement shall be compulsory.

Art. C2 : When boilers are replaced, the installation of multi-fuel boilers shall be compulsory.

The same applies to new buildings.

Art. C3 : Where there is a heating system serving a built-up area (urban or district heating), it shall be compulsory for new buildings to be connected immediately, and existing buildings in accordance with a staggering scheme to be laid down for each zone, to this system.

This shall apply if the heating system uses coal, coal gas, refuse, heat pumps, geothermal energy, power-station cooling water or heat from combined heat/power production installations.

This requirement shall not be compulsory if the heating system burns oil or natural gas.

Art. C4 : The use of coal for heating shall be compulsory in the zones that will be designated.

The same shall apply to heating by natural gas.

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* This percentage is to be fixed by zones.

This requirement shall not however be compulsory for buildings which use more than 60 % of a renewable energy.

Art. C5 : Financial aids in the form of :

low-interest or interest-rebate loans ; and
tax relief

are granted to owners or occupiers who have work done for the purpose of making improved use of solar energy ;

and to operators of urban heating systems who modify their installations to use :

- geothermal energy ;
- lukewarm industrial effluent ;
- renewable fuels.

D - Miscellaneous provisions

Zoning

Art. D1 : The climatic zones contemplated in art. A2, and the zones in which use of a given source of energy is compulsory pursuant to arts. C3 and C4 above,
will be shown in the form of a general map and a list of the administrative districts concerned.

Timetable

Art. D2 : The implementation of the measures contemplated in arts. A2, B1, B3, B4 and C3 shall be staggered according to : their profitability in national currency ;

their effect on the country's balance of trade ; and - the extent to which they safeguard the operation of heating systems by making the countries independent of energy imports.

The staggering arrangements are set out in a general timetable covering a period of 10 years.

Government buildings

Art. D3 : Special compulsory measures, as set out in a special timetable, shall be taken to save heating energy in buildings belonging to the State, to local authorities, to their licensees and to public or subsidised bodies.

Aid to manufacturers creating and developing products useful for saving heating energy in buildings

Art. D4 : Financial aids in the form of research grants or development loans on favourable terms are granted for research into and development of products which help to save energy, either in accordance with the general procedures for research and development, or in a specific form.

ANNEXES TO THE REPORT

ANNEX I

TABLE OF VALUES DRAWN UP BY CIB/W.45
(HUMAN REQUIREMENTS)

New Chapter 14 : The need to restrict energy consumption

14.1 Limiting the amount of energy consumed for heating

The coefficient C is defined as W/m3°C where m3 is the volume of the building and W the energy expended under constant conditions to maintain a difference of 1° between the inside and outside temperatures when the latter is lower.

The coefficient C takes account of the recovery of average solar gains by the building during the cold period and of air renewal (1).

It also takes account of the effect of heat-recovery devices (heat exchangers), heat pumps and building inertia.

Buildings are divided into the following four categories :

Type of building	Habitable volume	Categories
Single-occupancy	Less than 150 m3	A
Single-occupancy	150 m3 or over but less than 300 m3	B
Semi-detached single-occupancy	300 m3 or over	C
Multi-occupancy	Any	D

(1) This and the following classifications are based on those laid down in recent French legislation.

A dwelling is defined as "single-occupancy" if it is not linked to any other dwelling or if it is only linked by one or more unheated rooms or party walls of less than 15 m2 in area.

Climatic zones are defined according to the mean M of monthly minimum temperatures for January for the Northern hemisphere or for July for the Southern hemisphere :

"Zone 1 : M - 25°C
"Zone 2 : M - 18°C
"Zone 3 : M - 13°C
"Zone 4 : M - 9°C
"Zone 5 : M - 5°C
"Zone 6 : M 0°C
"Zone 7 : M 0°C

The C coefficients to be observed for each category of building according to climatic zone are given below :

Category	Coefficient C			
Zone	A	B	C	D
1	1.15	1.00	0.85	0.55
2	1.30	1.15	1.00	0.65
3	1.45	1.30	1.15	0.75
4	1.60	1.45	1.30	0.85
5	1.75	1.60	1.45	0.95
6	2.00	1.90	1.75	1.10
7		No requirement		

These values may be raised for dwellings situated under terraces in or at the ends of blocks of flats.

ANNEX II

DEFINITION OF VALUES

C Coefficient of building's heat requirements (W/m3°K)
This is the energy expended per m3 of building to maintain under constant conditions a difference of 1°K between inside and outside temperatures. Coefficient C takes account of the average free domestic and solar gains, the average air renewal rates, and the effect of heat-recovery devices and heat pumps. In other words, it is the coefficient of a building's average heat requirements over a given period per degree-hour and per m3.

K Coefficient of area transmission (W/m3.°K)
This is the amount of heat transmitted through 1 m2 of wall for a difference of 1°K between the temperature either side of the wall.

K_m Coefficient of average area transmission

$$K_m = \frac{\sum KiSi}{\sum Si}$$

$K_{\text{day/night average}}$: coefficient of area transmission which takes into account the differing configurations of bays, in both day and night conditions.

G_1 Volume coefficient of heat loss by transmission (through walls (W/m3°K))
Heat losses through walls for a 1°K difference between the inside and outside temperatures divided by the interior heated volume.

G_2 Volume coefficient of heat loss through air renewal (W/m3°K)
Loss through air renewal for a 1°K difference between the inside and outside temperature divided by the interior heated volume.

N Rate of air renewal per hour. Dimensionless number.
This is the ratio of air renewed per hour to interior heated volume.

N Number of heating days

λ Heat conductivity (W/m°K)

European Communities — Commission

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The object of this study is to explain the various means which can be used to lessen the need for heating energy.

This report is presented in three series of lists. In each series a means of economy is examined. The three series are as follows:

1. Reduction in the need for heating energy;
2. Measures for buildings and their installations;
3. Energy substitutions.

The following proposals and conclusions include:

(a) the explanation by means of a model code in order to economize heating energy in buildings;
(b) discussions of the model code;
(c) valid Community points of interest to be discussed: in particular Community policy, normalization, research.

And finally, in annex, the proposal for a model code, the value of human requirements and the list of symbols.

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