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GUIDELINES FOR VENTILATION IN COMMERCIAL BUILDINGS

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RECOMMENDATIONS FOR COMMERCIAL BUILDINGS WITH LOW ENERGY CONSUMPTION

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(1) **Agence de l'Environnement et de la Maîtrise de l'Energie/Agency for Environment and Energy Management.**

(2) **AICVF:**
Association des Ingénieurs en Chauffage, Ventilation et Froid/Association of Engineers for Heating, Ventilating and Air Conditioning

RECOMMENDATIONS FOR COMMERCIAL BUILDINGS WITH LOW ENERGY CONSUMPTION

Summary

Important effort of energy consumption management in the residential sector has been achieved, in France, for almost twenty years, and a regulation device defining *requirements* of a substantial level is set up since the end of the eighties. On the other hand, the sector of buildings for professional use - non residential buildings - is behind the schedule.

It is to improve this situation that the Ademe gave the AICVF the mission of establishing *list of recommendations* for the design, the implementation and the management of the buildings and which meet the three requirements indissociable from now on:

- limitation of the consumptions of the energy expenses,
- better respect of the environment
- increased quality of indoor conditions.

An approach is proposed:

- *by activity sector* (offices, schools, hospitals, hotels, commercial premises, etc.),
- *all energy uses*: for each use all the factors contributing to the energy balance of a building are studied (envelope, air conditioning systems, hot water production, lighting, driving force, kitchen uses, etc.)
- *in global cost*: the technical solutions proposed are analyzed by systematically integrating investment, operating and maintenance costs.

Besides, these works aim at backing a government action whose purpose is to prepare, with the help of the greatest dialogue with the building actors, an evolution of the laws through exemplary operations, then through a possible approval of the new constructions. The result expected is *a global reduction of the energy used by about 25%* as compared to the current standards.

This communication takes stock of the operation launched in 1990 by the AFME[1], working together with the AICVF, and aiming at establishing recommendations for new buildings with low energy consumption in non-residential sectors.

First, we mention the data relative to the existing[2] buildings, to the annual flow of new constructions and to the corresponding energy consumptions, in order to evaluate what is at stake in these sectors in terms of energy global consumption management.

Then we develop the main points of the project of the "sectorial handbooks" for new buildings with low energy consumptions. For four of the eight families considered, we present some of the recommendations proposed as an illustration.

Finally, we conclude by sketching what could be an action program of the Ademe and of its partners, in the years to come, to incite the actors of the construction to create buildings which use less energy, with better respect of the environment, however maintaining a high service level.

1. The energy stakes of non-residential buildings in France

In part thanks to the enquiries and studies made by the CEREN[3], we have now quite reliable information on the number of buildings built and the corresponding energy consumptions.

We are interested by the buildings of the three sectors:

- tertiary,
- industrial,
- agricultural,

and by the following uses:

- heating, ventilating, air conditioning,
- lighting,
- production of hot domestic water,
- and by certain uses such as cooking, food cold storage, driving force or laundry.

So, the only consumptions which remain ouside of our concern are those linked to the conversion processes (industrial ovens, drying, grinding, process, etc.).

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(1) **The AFME (French Agency for Energy Management), after merging with the Agence pour la Qualité de l'Air (AQA)/Agency for the Quality of the Air and the Agence Nationale pour la Récupération et l'Elimination des Déchets (ANRED)/National Agency for the Recovery and the Elimination of Waste became the Ademe at the end of 1991.**

(2) **Residential sector not taken into account.**

(3) **Centre d'Etude et de Recherches Economiques sur l'Energie/Study and Economic Research Center on Energy.**

If we only take account of the tertiary sector, we are used to split it up into families, among which the following:

- the offices,
- the commercial premises,
- the hotel and restaurant premises,
- the educational premises,
- the health care establishments,
- the sports premises.

The table below charts the evolution of that flow during the last five years.

(10^6 m^2 heated area)

1986	1987	1988	1989	1990
9.3	11.8	15.3	14.3	14.6

(Source: CEREN)

In 1990, there were about 20,000 new buildings constructed, for an amount of 70 million francs (that is slightly over 10 million ECUs).

The table below charts, for the 5 main families of non-residential buildings, the heated area constructed in 1990, expressed in million heated square meters.

Offices	Commercial premises	Educational premises	Health premises	Hotels, restaurants
4.4	2.4	2.2	1.5	1.4

(Source: CEREN)

For the same 5 families, the table on next page charts:

- the heated surfaces in million m^2,
- the energy consumption ratios in kWh/m^2.year,
- and two energy indices corresponding to the following ratios:
  - energy used for space heating and hot domestic water as compared with the total consumed energy (SH + HDW)/TOT,
  - electrical energy consumed as compared with the total consumed energy ELEC/TOT.

	Heated area (million m^2)	Total cons. (kWh/m^2.year)	(H + CE)/TOT (%)	ELEC/TOT (%)
OFFICES	122	290	68	65
COMMERCIAL PREMISES	164	230	54	50
EDUCATIONAL PREMISES	134	165	87	14
HEALTH PREMISES	77	280	76	19
HOTELS/ RESTAURANTS	42	355	61	38

(Source: CEREN - 1988 data)

These data should not conceal the difficulty when it comes to accurately know the energy consumption structure in that sector: per family, per use, per energy source, in absolute value and in yearly drift. Yet, these elements are necessary for assessing the medium and long-term impact of an energy management policy on the domestic energy balance.

To illustrate the energy stakes related to that sector, we have estimated the primary energy savings:

- cumulated over 10 years,
- on a yearly basis, in 10 years' time,

depending on whether at year 1, steps to cut down energy consumption by 25% are taken or not.

We have obtained the following results[1]:

- 7.3 million TOEs cumulated over 10 years,
- 1.3 million TOE/year, after 10 years.

These values have but an indicative significance, they result only from the modification of the tertiary equipment due to the constructions each year.

Now, the residential sector experience highlights the leading effect new constructions have on existing ones, which is likely to be intensified by the economic policy of the production sectors (offices, hotel business, trade, etc.). So, the above-mentioned savings should be perhaps multiplied by a ratio of 2 or 3.

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(1) Supporting data appended

2. What is the energy performance level in the non-residential new buildings?

The *thermal* regulation for the non-residential sector was enforced in 1989. In comparison with the requirements resulting from the first regulation of 1976, it induces a decrease in heating consumption of about 25%.

In the same time, the requirements relative to the energy performance of residential buildings resulted in a decrease in the overall energy consumption of about 50%, with an intermediate step proposed as early as 1982.

Moreover, whereas the most accomplished option of the regulation applicable to residential buildings hinges on the comparison between the *estimated energy consumption* of the project and a reference energy consumption depending on the climatic area and the nature of the energy, the set of regulations is far less elaborated as regards commercial buildings.

These regulations mainly deal with checking that the estimated *thermal losses* of the project [$W/m^3.K$] are lower than reference thermal losses, which depend on four parameters:

- building type,
- climatic area,
- energy for space heating,
- type of occupation (intermittent or not).

This concerns the *thermal insulation of the envelope.*

This performance is completed by some requirements about:

- control-command of heating per room and per zone,
- air renewal, integrating occupation and pollution factors,
- air conditioning,
- survey of consumptions.

For all these domains, the point is not to check an energy performance but only to define design principles the implementation of which aims at ruling out buildings that are too much energy-hungry.

Finally, some of the uses that might be critical to some families of commercial buildings, i.e. hot domestic water, lighting, are not taken into account.

These various reasons have led the Ademe, in collaboration with the involved professionals, to think about the overstepping of the energy performance levels induced by the current regulation. This is the scope of the working programme entrusted to the AICVF in mid-1990, the first stage of which, dealing with:

- offices,
- hotels/restaurants,
- educational establishments,
- health care establishments,

will be ending in 1992 as a second stage is being initiated, which concerns:

- commercial premises,
- sport premises,
- industrial buildings,
- farm buildings.

This forms the project called "sectorial handbooks" for energy-efficient new constructions that aims at elaborating, for each activity sector, lists of recommendations intended for the owners and prime contractors.

3. Tertiary sectorial handbooks

The approach implemented is quite pragmatic.

All the consumption surveys highlight the diversity of the results obtained: for each type of building, values increased up to fourfold (typically 100 to 400 kWh/m^2.year) are not unusual, the performance of certain operations being far better than the level required by the regulation.

Thus it was decided to lean on the efficient practises of certain actors and to use this know-how as a ground to draft sectorial handbooks that highlight the technical solutions resulting in reduced energy consumptions.

Practically, the proposed framework is *global*; it is characterized by:

- a preliminary physical analysis of all the *thermal and energy requirements* for each use and as a whole, for each building project,
- an economic analysis of the project based on the *global cost* i.e. integrating both investment and operating costs.

So, all the actors should be *informed*, *made aware* and *proposed solutions* that are both efficient and economically acceptable. This applies first to the owner, who is the main decision-maker and can eventually become the building manager, and to the prime contractor, namely either the architect or the engineering departments involved in the engineering missions.

The structure of these handbooks, as inferred from their contents shows it is necessary to:

- better define the program, i.e. the needs of the owner or the decision-maker as regards:
  - the indoor conditions (temperature, humidity, acoustics, cleanliness of the air, etc.),
  - conditions of use (occupancy scenarios, HDW load shape, premises adaptability etc.),
- control all the terms that are part of the global cost:
  - initial and deferred investments,
  - replacement of part of the equipment,
  - cost of energy -consumption and subscription rates,
  - cost of maintenance,
- have recourse to suitable economic criteria (life cycle cost, gross payback, etc.),
- design an efficient envelope, that is one offering the best compromise between the quality of the indoor atmospheres (acoustics, hygrothermics, lighting, cleanliness of the air) and a low energy consumption; the quality of the envelope is an essential factor for reducing

the heating, lighting and air-conditioning energy requirements,
- design technical items that are efficient and adapted to the requirements and operation as regards:
  - space heating and ventilating,
  - air conditioning,
  - hot domestic water,
  - artificial lighting,
  - elevators,
  - cooking items,
  - linen cleaning and ironing.
- design control-command devices and building management systems always ensuring the best compliance with the requirements especially when these are *intermittent*, as it generally is,
- better know all available design and management tools, especially software ones.

The so-called sectorial handbooks are completed by a methodological handbook dealing with the *forward-looking energy consumption computation for the new commercial buildings*.

4. Forward-looking computation handbook of energy consumptions

The latter proposes the computation methods necessary to the application of the global cost, which is based in particular on a realistic evaluation of the operating costs, among which the costs of the energy used constitute the principal item.

In order to adapt to variable users needs as well as to the precision and to the available data at different progress stages of a project (draft, pre-project, project), 3 types of energy consumption computation methods are proposed:

- **assessment methods**, using approximate assessment, coming from the common practice of the professionals, that can be used rapidly, manually and only requiring a limited number of essential parameters; their role is limited to the feasibility, to the choice of options or to very selective decision assistances;
- energy consumption **computation detailed methods**, which require the help of data processed computation, if necessary by spreadsheet, which use quite an important number of parameters and are able to give an account of the evolution of consumption facing these parameters;
- **dynamic simulation methods** which allow - among many other functions - computing energy consumptions and which are available in the form of "*computation codes*", data processed on microcomputers or work stations.

5. A few outstanding points of the sectorial handbooks

By limiting us to two of the handbooks, we precise a few elements which structure the drawing up.

Offices

The definition of a very precise initial programme is the indispensable condition for being satisfied at the use. Furthermore, the important points are in particular:

- the adaptation of the air conditioning installations and of their management to the intermittent use of those buildings which are occupied only one third of the time;
- the fact that office automation and data processing have to be taken into account and that their electrical powers are now of the same magnitude than those relative to lighting;
- the adaptability of the installations, particularly for not dedicated offices for which flexibility is searched,
- at last, the global management of the building, whose interest is evident and which must keep an evolutive aspect.

The emphasis is put on the performances of the windows which represent 75% of the thermal losses of the envelope; on the treatment of air; on the most adapted air conditioning and heating systems, described with the help of advantage/drawback sheets; on the management of technical equipment; on natural lighting and electrical lighting with high efficiency.

Hotels and restaurants

If the weight of energy in the operating budget of a hotel stays modest - from 4 to 8 % -the competition and the search for the best service offered to the customer at the minimum cost possible, incite the hotel-keepers to be attentive to their energy bills.

Furthermore, the investor in generally the manager, which constitutes a favourable situation to an approach in global cost.

First of all, great care is given to the on-site settling. As far as the enveloppe geometry is concerned, the type of hotel - for leasure or business - plays a very important part. So, in each case, the elements of a performing enveloppe are put forward: positioning, sun protections, thermal qualities of the windows, treatment of the thermal bridges, etc.

The occupation is periodic but also uncertain, which has an important consequence on the heating and air conditioning equipment and particularly on their management. Several "speeds" must be planned, and the concern for energy savings must never thwart the well being of the customer.

The economic analysis of the solutions puts to evidence the essential part of the occupation rate.

Moreover, the analysis of the energy needs shows the importance of thermal needs and in particular of the item "hot domestic water" which is commonly of the same magnitude than that of the space heating.

Numerous energy opportunities are brought out: preheating the HDW by recovery of the smokes condensation heat or of the cold rooms condensers, recovery on the exhausted air, solar hot water, etc.

CONCLUSION

After applying for two years a workprogramme which associated numerous professionals, we are able to present the first balance hereunder:

- the "sectorial" approach seems to be essential to the justification of the proposed solutions: it allows the specificities of each sector to be identified and the establishment of recommendations being both realistic and efficient in terms of energy consumption reduction,
- the "global" approach of the energy dimension, from a conception/operation viewpoint, is an important source of energy savings,
- making the actors of building aware of the global cost processes can and has to be continued, for it is in most cases the necessary way for the promotion of low-energy new technologies.

By the end of 1992, the first four handbooks will be published: they are to become the reference documents of the decision-makers and designers in the coming years. The application of the principles and solutions defined in it are likely to improve the overall quality of the building and of its technical equipment while allowing appreciable savings on the operating expenses. The unformal purpose of a 25% reduction in energy consumption of commercial buildings seems to be from now on realizable.

An incentive device to be defined (demonstrations, labels, trophees) will certainly be installed from 1993 on. The latter will prepare progressively the concerted elaboration of a last step in the energy regulation of non-residential buildings, which could come into being around 1995.

For further information:

- Group of engineers, special edition of "Heating, Ventilating, Air Conditioning" AICVF magazine, "New commercial buildings - Energy performances", 18 articles, 40 pages, February 1992.
- Bibliographical data bank, "Energy in non-residential buildings", available for consultation at the AICVF, 500 references.

APPENDIX

Assessment of the primary energy savings due to a 25% reduction in energy consumption of new commercial buildings in relation to the existing standard (thermal regulation, 1989).

Data and computation assumptions

- Economic perspective: 10 years.
- Yearly building flow supposed regular on the economic perspective: 14 millions m^2/year.
- Average energy consumption taken as a reference: 250 kWh/m^2.year (all commercial buildings families joined).
- Distribution between electricity and other energies (natural gas, fuel, heat networks, coal, etc.):
  - 40% electricity,
  - 60% other energies.
- Energy equivalence convention [kWh/TOE]:
  - 4 000 kWh/TOE, in electricity
  - 11 600 kWh/TOE, for combustible energies.

Computation

- Savings of consumed energy, year 1: $E_1 = 0{,}25 \cdot 14.10^6.250 \left[\frac{0.4}{4\ 000} + \frac{0.6}{11\ 600}\right]$
  hence $E_1 = 133\ 000$ TOE.

- Savings of consumed energy, year 10:
  $E_{10} = 10\ E_1$ hence 1.33 million TOE.

- Savings of consumed energy, cumulated from year 1 to year 10:
  $E_{1.10} = \frac{10.11}{2} \cdot E_1$ hence 7.3 million TOE.