

REPORT 3

**SUSTAINABLE DEVELOPMENT
AND FUTURE OF CONSTRUCTION
IN FRANCE**

LUC BOURDEAU

CSTB
CENTRE SCIENTIFIQUE ET TECHNIQUE DU BÂTIMENT
290 route des Lucioles - BP 290
06904 Sophia Antipolis cedex - FRANCE
Tel : +33 (0)4 93 95 67 00 - Fax : +33 (0)4 93 95 67 33
email : l.bourdeau@cstb.fr

NATIONAL REPORT

CONTENTS

1. INTRODUCTION.....	3
1.1 'Sustainable Development' : a new concept about what?.....	3
1.2 How buildings are concerned ?.....	3
1.3 State of the Art and Specific Issues	4
1.4 The French BâtiVille Club.....	5
2. DEFINITION OF 24 CRITERIA FOR SUSTAINABLE BUILDING DESIGN	6
2.1 Scope and methodology	6
2.2 The 24 sustainability criteria.....	7
3. ANSWER ON MAIN QUESTION AND 5 SUBQUESTIONS.....	9
3.1 Introduction.....	9
3.2 The answers	11
4. MAIN GENERAL CONSEQUENCES FOR THE WHOLE CONSTRUCTION INDUSTRY	18
4.1 Introduction.....	18
4.2 Consequences per phase	19
5. MAIN RECOMMENDATIONS TO THE ACTORS.....	20
5.1 Focus on Important Recognized Aspects.....	20
5.2 Fit Sustainable Development on Four Simple Issues.....	21
5.3 Approach Sustainable Construction through Three Problem Categories	21
5.4 Main Technical Recommendations.....	22
5.5 Do not Wait and Take Action at Once.....	27
6. BEST PRACTICE EXAMPLES	27
6.1 High Environmental Quality Buildings	27
6.2 Les Chantiers Verts ("Green Sites").....	28
6.3 INIES, EQUITY and ESCALE: three examples of assessment tools.....	28
7. REFERENCES	29
8. ACKNOWLEDGMENTS	30
9. APPENDIX 1: MULTI-DIMENSION ANALYSIS MATRIX	31
10. APPENDIX 2: BEST PRACTICE EXAMPLES.....	34

1. INTRODUCTION

1.1 'Sustainable Development' : a new concept about what?

'Sustainable development' is today about to join the 'charts' of spread out phrases such as 'society of consumers', 'zero growth' or 'the thirty happy years', without clear ideas about the real meaning of this concept or the deep changes that will be derived in our day-to-day practices.

This concept was defined in 1987 by Mrs Gro Harlem BRUNTLAND, in her report to the World Committee on Environment and Development, as « a development which meets the present needs without endangering the capacity of the future generations to meet their own needs ».

Another author has proposed to define the sustainable *urban* development as « a process leading to changes in the built environment, which will favour the economic development while preserving resources and saving human, community and ecosystem integrity ».

As a matter of fact, even if the phrase 'sustainable development' carries along a lot of ambiguities and is a source of confusing - particularly in the French building sector where the word 'durabilité', which is close to the translation of 'sustainable development', i.e. 'développement durable', often refers to the life span of a construction or its components -, it is sure however that it is a paramount stake for the future of our world, our society model, and, to a smaller extent of course, the professionals of the building sector.

1.2 How buildings are concerned ?

The concept of 'sustainable development' often refers to the notion of product life cycle. In that sense, since a building must be seen as a product, it is obvious that we have to look at the environmental constraints from an industrial point of view. But, this is not sufficient.

As a matter of fact, the builder of a building, a quarter or a city modifies the *physical*, but also the *socio-economic* tissue on which he operates, not in a lasting way but definitively, without any real possibility to go 'back' to erase the causes of the damages which can appear later. The challenge we are facing today is not only to find the best balance between the present various constraints of the building process - technical, architectural, social or cost constraints -, but also to try to favour 'without regret' decisions and, consequently, to strengthen the importance given to *long term* aspects in the choices that the building process requires permanently.

Moreover, the operation of the built environment has every day, a great influence on the immediate surroundings, and therefore on the global urban life environment.

It can be concluded that the management of the built environment should only be envisaged with a global approach, i.e. integrating the life span of building much further than its production alone and even further than its life cycle. The manoeuvring capabilities in this domain are so far unknown and a priori depend on numerous factors linked to the complexity of relations and the rarity of the 'raw material' which is available and usable on a individual plan.

1.3 State of the Art and Specific Issues

In France, interest on environmental problems appears only in the late 70's which were marked by some major ecological accidents. The Ministry of Environment was created at that time. The Rio Conference, which was given a high media coverage, speeded up this trend. The "contaminated blood" and "mad cow" affairs have, more recently, strongly affected the population, but have also revealed the complexity of an anticipation and a control of the risks in the absence of scientific certainty. At last, the first circulation constraints in Paris were decided last year for air quality.

The practices of the consumers are still not very ecological and, even if one can note a real acceleration of the innovations in the eco-industry, those do not have spectacular effects on consumption. However, the on-going changes in the country are much more important than the changes of the behaviours can show it today. The awakening of the environmental stakes seems right now to have major effects in the society.

In France the concepts of sustainable development, and of "sustainable construction" are quite new. It is only at the end of the 80's that the problem of the links between environment and buildings is really raised. However, the problem of energy savings in buildings has been the topic of a lot of development in France since the oil crisis (and even before). Several energy standards were set up in France since the 70's and the last one in 1989 introduced an advanced approach taking into account all energy consumption factors in the dwelling sector.

The main other environmental preoccupation factors in the construction sector were so far the problems of lead and asbestos, the problem of community wastes, the problem of CFC substitutes in building products and equipments (insulation products and cooling systems), the saving of water in flush systems, and the development of the use of recycled materials for road construction.

However in the early 90's the CSTB initiated a large research program on this topic, and in 1993 the French Equipment Department "Plan Construction et Architecture (PCA)" launched a call for proposals to develop experimental building projects with a High Environmental Quality ("Bâtiments HQE"). Thirteen operations have been launched and supported so far and are being monitored and analyzed by the PCA and the CSTB. The five main aspects considered in these operations are: environmental

quality of the construction products, water management, visual comfort, site integration, and environmental management.

This Departement launched also in 1993 with the "Agence de l'Environnement et de la Maîtrise de l'Energie" of the Industry Department a research and demonstration call for proposals on "Environmentally Friendly Products, Techniques and Methods". The goal of the Program was to reduce the nuisances susceptible to be caused by a building site, while being concerned by keeping the technico-economic profitability of the building sector. A total of 11 specific construction projects were completed. They deal with one or several kinds of nuisances susceptible to be caused by a building site: waste management, acoustic nuisances, traffic and parking problems, ground and water pollution.

Some "ecological" schools were built (Maximilien Perret, Calais) and some others (Limoges) are under construction.

1.4 The French BâtiVille Club

The BâtiVille Club is a future studies group created by the 'Centre Scientifique et Technique du Bâtiment', the 'Agence de l'Environnement et de la Maîtrise de l'Energie' and the 'Centre de Prospective et de Veille Stratégique' (Direction de la Recherche et des Affaires Scientifiques et Techniques - Ministère de l'Equipement) in 1993 to gather actors of the building sector who are interested in carrying out collective studies in the future domain.

After a preliminary future study called "Bâtiment 2030" which allowed to propose four scenarios of the built environment, the club launched in 1995 a subgroup in charge of thinking over the concept of 'bâtiments durables' (sustainable buildings), with the collaboration of the Dumez company.

The objective of the subgroup is to try to define this concept by identifying and listing the elements to be clarified to stabilise the concept. The subgroup also seeks to determine the research orientations needed for the design and the construction of buildings in a view of sustainable development.

This activity is complementary to the scientific and technical analyses of ATEQUE. It is a future study since it looks at what we will build and retrofit by using the findings of the upcoming studies.

2. DEFINITION OF 24 CRITERIA FOR SUSTAINABLE BUILDING DESIGN

2.1 Scope and methodology

The concept ‘to build without regret’ means that the builder has explicitly taken into account the future, i.e. in some way the life cycle of the building which is to evolve during its operation and get value till its destruction. The purpose of the approach is therefore :

- to identify and to precise how short-term, mid-term and long-term interests can converge,
- to see how to integrate into the pre-design phase the know-how, the methods and the experience gained during the other phases of the building life (Figure 1).

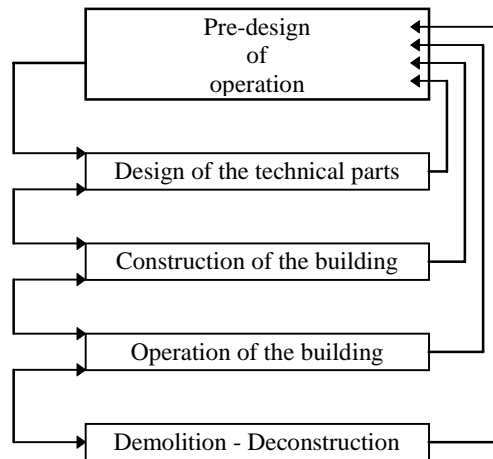


Figure 1 : Two ways principle between the pre-design practice and the life cycle of a building

In order to analyze the whole process, the BâtiVille Club has elaborated a set of 24 criteria which concern the totality of the life cycle of the building from its birth (design stage) to its death (demolition phase). Starting from this set of criteria, it would then be possible:

- to identify appropriate research and development orientations on the entirety of the technical and socio-economic sub-sectors and domains of the building sector,
- to develop pertinent design tools taking account of all the relevant factors.

Different kinds of buildings could be analyzed through the set of criteria. The analysis method which was used is based on a functional analysis, element by element, of all the components of the building, from foundations and substructure to achievement and finishing.

Therefore three steps can be identified in the progress of the study:

- definition of a typology of buildings, based on constructive methods and volumes,
- definition of a functional and time based breaking up of buildings, from the construction phase to the retrofit and demolition phases, leading to a definition of a set of sustainability criteria,
- close examination of each family of buildings through the set of criteria.

The results obtained so far and presented here deal with the second step.

2.2 The 24 sustainability criteria

Following the methodology described above, a list of 24 criteria has been defined. Only two kinds of buildings have been selected : dwellings (diffuse houses, intermediate grouped houses and blocks of flats), and two kinds of buildings of the tertiary sector : office buildings and large commercial buildings. The time based analysis has been carried out from three phases of the life cycle of buildings : construction, operation and retrofit / demolition.

This led to the set of criteria presented in Figure 2.

- The first phase involves the technico-economic optimization of the project, the site activities and the resources subtraction.
- The operation phase also implies the resources subtraction, complemented by the maintaining of the use functions during the life of the building, the management of the interfaces with the surrounding tissue (utilities), and the contribution to the social and urban life (links inside the city, communications, access to the city, security,...).
- At last, the retrofit / demolition phase includes, on one side, retrofit and refurbishment, and, on another side, demolition and deconstruction.

The criteria have been classified in two families: direct criteria and indirect criteria. The direct criteria involve impact factors in terms of physical pollution and have effects on resources depletion, area degradation and pollution growth. The indirect criteria are all the other criteria, expressly those with a socio-economic character. They have only an indirect influence on the life environment and the human relations.

The close examination of a building through the set of criteria is done one element after each other. The notion of 'sustainable development' applied to each element of a building is in fact a dangerous exercise mixing various impacts on the environment, which can be either measured quantitatively or just assessed on a qualitative way. In order to carry out this exercise in a pertinent way, the subgroup has also decided that he could say that he is not able to give a appraisal in the actual state of the art in a given domain. In such a case, it is said that the criterion is either 'without object' or needs additional studies.

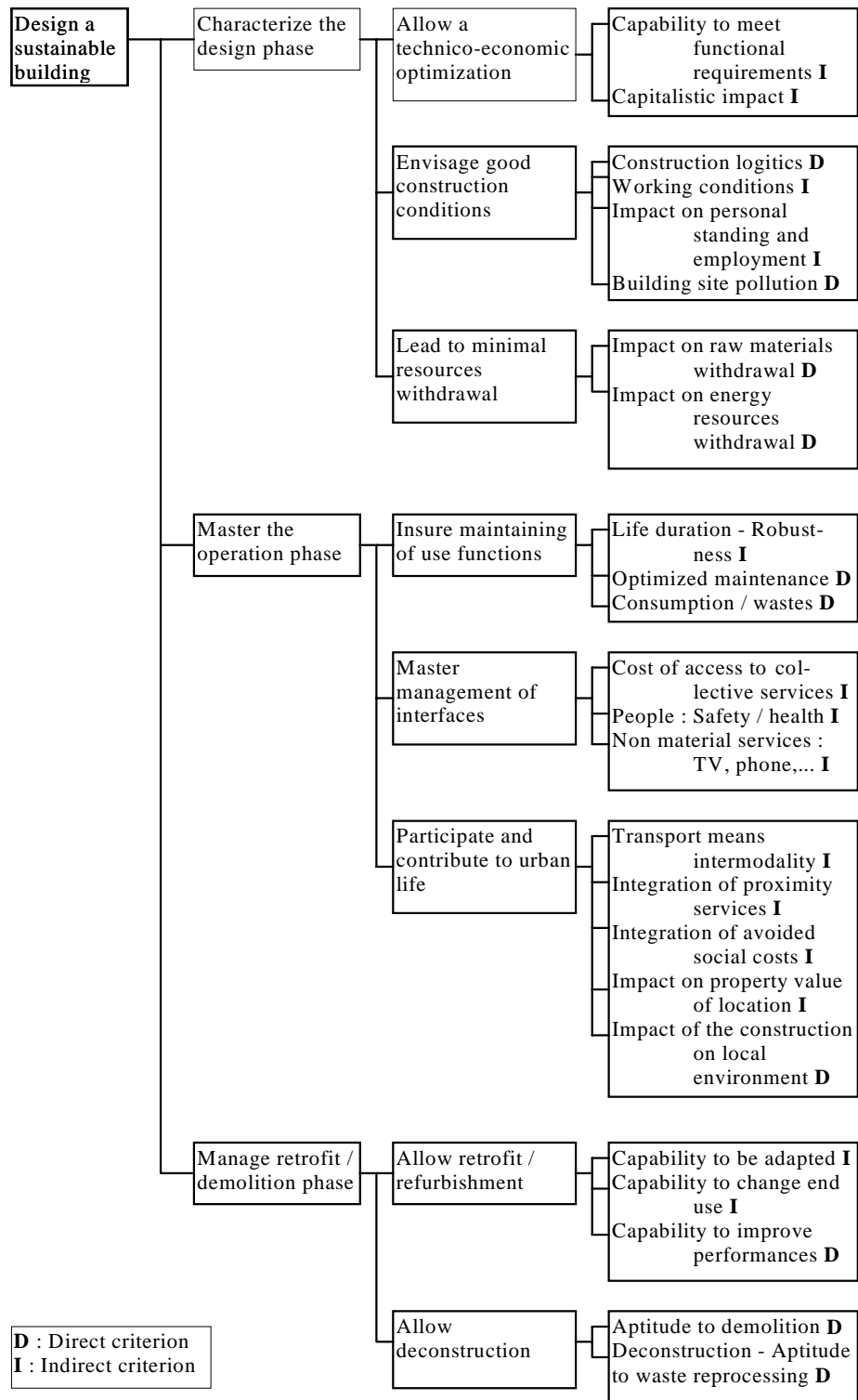


Figure 2 : Treelike outline of the analysis of a sustainable building

3. ANSWER ON MAIN QUESTION AND 5 SUBQUESTIONS

3.1 Introduction

3.1.1 Applied Methodology

The methodology applied in the framework of the French participation to Phase II of the CIB W82 Project was to organise a brainstorming meeting with experts from the building sector in order to collect answers to the five questions defined in the CIB Project.

About fifteen experts¹ from the BâtiVille Club participated in this brainstorming meeting which took place in the CSTB premises in Paris on the morning of 8 February 1996. The five questions were presented "on a wall" to the experts who were free to answer without following any order. The leader of the group was just put in charge to launch again the reflections when he felt that a topic had been enough discussed.

After the meeting, the recording of the discussions was analyzed in order to edit the report with a dispatching of the results into five chapters corresponding to the five questions of the CIB project.

3.1.2 Time Horizon

Taking into account that things are moving rather slowly in the building sector, due to, on one side, the inertia of the built environment which makes any innovation in the new buildings to take a long time before spreading into the built environment, and, on the other side, the large number of actors and the stability of the sector, the group of experts considers that the time horizon which has been chosen (2010) can be seen as a short/mid term horizon. The changes mentioned by the group are to be considered as only a step towards more important changes which could take place later, always if the assumption of a sustainable development occurs.

3.1.3 Reflection Scope

The group has considered that its reflections cannot be reasonably focused only on the concept of environmental quality but have to be enlarged definitely towards the larger notion of "sustainable building", which is supposed to contain in particular the notion of affordable costs. Therefore the purpose is to consider the assumption of a

¹ The author wishes to acknowledge the experts who participated in the brainstorming session organised in the framework of the Club BâtiVille : Messrs Angioletti (Ademe), Blachère (Auxirbat), Blondy (Ateque), Boudjouher (Edf), Collet (Graph), Mrs Coudret (CSTB), Messrs Coulon (Edf), Gobin (Dumez), Henderieckx (CSTC), Lajouanie (Ademe), Lepoivre (CERIB), Moch (Ademe), Mrs Setbon (Ademe), Mr Weckstein (CSTB).

development without compromising the future (develop "without regret"), and not only the assumption of a protection of the environment independently of the general context of the sector.

3.1.4 Macro-economic Context

The group has wished defining some elements of the macro-economic context in which it could put its reflections. As a matter of fact, this context is very important when defining future scenarios (see the study "Building 2030").

The initial framework of the project of CIB W82 does not define this context, excepted for the time horizon (10-15 years) and for the assumption of sustainable development. The other factors are not detailed ; in particular, do we assume a low, moderate or high economic growth ?

Since some of the answers can depend on this context, the group has decided to assume present trends such as : a low demographic context, an economic growth between 0 and 2 %, an unemployment rate rather high, and no large migration flows. The group will give if necessary in its answers some details if some sensitivity to the macro-economic context is identified. The group will also precise if, taking account of these assumptions, the changes it foresees must be seen as heavy trends or if they should show some uncertainties.

3.1.5 Need for a More General Debate

While agreeing on the interest of the five posed questions - which indeed deal with technical aspects - the group wonders, since everybody is in fact convinced that we have to "go towards a sustainable construction", if the question should not be more focused on the need for organizing a debate on the topic "how to go there". Should this CIB action not be widely taken over by the specialized press in order to pose the real questions as those about environment and costs ? Should the changes not be suggested by scientists rather than by professionals, whose immediate interests, in a logical way, do not go generally towards these aspects ?

3.1.6 Need for Reflections about Stakes

Reflections about present and foreseen stakes are also necessary in particular order to push to the birth of a regulation body able to take account, in a neutral and non partial way, of the different aspects of the problem.

3.2 The answers

3.2.1 What Kind of Buildings will be Built in 2010 and How will we Adapt Existing Buildings ?

3.2.1.1 Will an "Environmental Demand" Really Emerge ?

3.2.1.1.1 *The "environmental demand" cannot be disassociated from the other aspects of the demand*

Everything will depend on the **emerging of a demand** : will we build or will we not build any more ? will dwelling get unchanging or modernized ?

3.2.1.1.2 *The demand will be stimulated by a growth of "immaterial" aspects*

We can imagine a decrease of the domination of the offer and a growth of the demand, particularly under the effect of the **influence of information and communication**. When the questions are well defined and the demand well expressed, the offer will get adapted to the demand and not the demand to the offer. This outburst of information will deal of course with the way of living, but also with the quality of life both inside and outside the building. The power of information will be the generator of the power of response.

3.2.1.1.3 *The demand could remain ambiguous*

However this **demand** could prove to be **ambiguous** (demand for quality of life but also for consumption) and ask for making choices.

3.2.1.1.4 *The looming sensitivity of users could be not lasting*

In Some countries, an approach is to set up a **series of rules** which lead to a sustainable dwelling and a **series of concepts** which can be related to them. Some experimental operations are planned following these rules and concepts. How will occupants feel their effects and will the **sensitivity** be still present in 2010.

3.2.1.1.5 *The influence of changes in the desires of users is uncertain*

There will be certainly some **changes in the desires of users**, but they cannot be precisely predicted today (individual houses, houses close to working places,...?) particularly because of the large influence of the economic context.

3.2.1.1.6 *The lack of an economic pushing factor is unfavourable*

The current context is not the same as the context which led to energy savings because of the **lack of an economic pushing factor**. The payback of investment does not exist or practically not here. The slow progress of changes in the new construction sector could lead to a demand coming from the only "ecological people".

3.2.1.1.7 *The influence of external factors can be poorly defined*

A lot of questioning relates to the evolution of **external factors**. However, **some general trends** can be brought out which are mentioned hereafter. As a matter of fact, due to heavy influences for example at the European level, it is likely that several aspects must be evolving.

3.2.1.1.8 *A need for pragmatic design and construction tools*

Following the Netherlands which have developed and diffused about 160 practical rules for environmental design and construction, it is through **pragmatic and didactic tools** developed with professionals that the goal will be favoured ; it is the only way in order that people realize the need for adapting the construction practice to sustainable concepts. These tools should however avoid the pitfall of the "red lists" or putting miraculous materials forward.

3.2.1.2 *New or Retrofit ?*

3.2.1.2.1 *More results in the retrofit sector than in the new buildings sector*

As a matter of fact, the two sectors have to be clearly distinguished. In the **new buildings sector**, 2005/2010 is only a **step**, without a lot of sure results. The assessment of new constructed buildings can be done only after a large period of time. Consequently, results in terms of impacts on the building stock, which can be obtained only after the spreading of technologies firstly tested, then validated, will be observed only after a large period of time. On another hand, in the retrofit sector, in which paradoxically there are today only very few studies and works, but which is already a large demand market, much more results are expected and should be observed.

Operations will be dominated firstly by **retrofit then**, after an upper limit of the number of possible operations (and a change in mind of people which today in some countries do not accept any longer that old buildings are destroyed to build new ones), we should observe a "**come back**" to new construction (after 2010 ?).

3.2.1.2.2 *Experimental operations and criticism in the new construction sector*

A lot of experimental operations will be carried out (pilot operations) and these will lead to **a lot of criticism**. For example, it must be known that the few experimental operations which are carried out today (ecological villages) do not meet the present quality standards, just because this is not possible. It must be feared that these operations may have a negative effect.

3.2.1.3 *Role of Public Authorities*

3.2.1.3.1 *A possible mid/long term program in the construction sector*

There will be possibly a mid/long term program (20 years) in the construction field.

3.2.1.4 *Tertiary Sector and Flexibility*

3.2.1.4.1 *The tertiary sector modified by teleworking*

The tertiary sector will be submitted to the **influence of "teleworking"** and Information Technologies : decrease of areas, office sharing, reallocation of spaces,... (examples of IBM applications). The IT evolution should go faster in the tertiary sector than in the dwelling sector. The link with the decrease of the travelling needs is not obvious, taking into account the demand for meeting that should last in spite of it.

3.2.1.4.2 *Taking account of spaces flexibility*

"Spaces flexibility" will be probably taken into account.

3.2.2 How will we Design and Construct them ?

3.2.2.1 *Other Main Constraints*

3.2.2.1.1 *Importance of the user*

There will have been diffusion of the **importance of the user** from the urban problems towards the building aspects.

3.2.2.1.2 *Importance of the financial aspect*

A major problem will be the problem of the **payback of the investment** necessary to construct sustainable buildings.

3.2.2.1.3 *Resources savings*

Though these aspects are today relatively a little considered in France, unlike some other countries, there will be probably a search for **capitalistic and human resources savings**, together with a **decrease of the part of the costs of non quality**.

3.2.2.1.4 *Possible decrease of costs*

There will be probably a very strong influence of **a search for decreasing building costs** ("affordable housing"). But who or what will have been the driving force : political action, "keys on the door" suppliers,...? As a matter of fact, the problems of construction costs, insolvent demand, overcosts, have been mentioned for several years, without any real evolution. The absence of the final user, who is the only real interested actor, in the construction process explains this fact probably. The development of "keys on the door" process could increase the power of the final user.

3.2.2.2 Major Modifications

3.2.2.2.1 Aspects health/environment

Taking into account the permanent questions asked to industrialists on the **potential impacts** of their products or their manufacturing **on environment and health**, there will be inevitably consideration of these impacts on the various components of buildings.

3.2.2.2.2 Home waste management

There will be **modifications in the building design** due to taking account of the **management of home waste**.

3.2.2.2.3 Emerging of the life duration mastering

There will be an emerging of the concept of "**life duration mastering**".

3.2.2.2.4 Strengthening of energy savings

Energy savings will be strengthened (goal : -25%) : new facade components with a positive energy balance, ventilation management, energy control management,... However, with regards to facade components, it must be kept in mind that their performance will, on one side, strongly depend on building location and use, and, on the other side, have a direct link with the comfort conditions created in the spaces. Consequently, the way these components will be integrated in the buildings will be much more important than their own characteristics.

3.2.3 What Kind of Materials, Services and Components will be Used Then ?

3.2.3.1 What Basic Technologies

3.2.3.1.1 Uncertainty about basic technologies

With **which basic technologies** will buildings be constructed ? Will the "rules" already established in some countries such as the Netherlands have drastically modified technologies or will they have just led to select some of them ?

3.2.3.2 Adapted Materials

3.2.3.2.1 An uncertain emerging of sustainable materials

Sustainable materials will have emerged only if a **real debate** is given rise to.

3.2.3.2.2 *Today materials but adapted*

Will we observed the birth of new materials or a rebirth of forgotten traditional materials ? Will there be a spreading of the application of LCA concepts ? Probably we will observe the **same materials as today but** these materials will have been adapted, with new properties, new performances,... In particular, their environmental harmlessness will have been increased (materials which can be easily separated, materials without toxic fumes,...). On another side, a recycling economy will have been organized, even if the low added value which characterizes building materials, and therefore their high sensitivity to the costs of inputs, will have made difficult the use of recycled products.

3.2.3.2.3 *Asbestos problem will have been solved*

Considering the consequences for health and the scale of the problem in most of European countries, it is almost certain that solutions, of course maybe costly, will have been developed and that the **asbestos problem** will have been **fully solved**.

3.2.3.2.4 *The "black lists" danger*

It must be mentioned the important risk of having - **black scenario** - "**black lists**" of **materials, solutions,...** in case of lack of available training and scientific tools.

3.2.3.2.5 *Regionalization of construction*

It will be probably observed a larger use of **local materials and technologies**.

3.2.3.3 *New Equipment and Components*

3.2.3.3.1 *Facades with a high interface role*

It will be observed an emerging of the concept of **interface facade** at the inside and outside. From an architectural point of view, we could thus have a framework based on the notion of plates and mixed supports (wall-posts) which leaves a high freedom at the facade level. However, the outside facade will be mainly determined by the necessary continuity with the urban environment in which the building will be integrated. Only the inside facade will have more freedom and will enable a high flexibility to be adapted to various internal requirements.

3.2.3.3.2 *Priority to comfort aspects*

The **comfort aspects** will have taken a large importance, but the consequences on buildings can be hardly identified today.

3.2.3.3.3 *Waste and effluent reduction*

The aspects **waste and effluent reduction (including domestic waste)** will have also taken a high importance. However consequences cannot be foreseen today.

3.2.3.3.4 *Environmentally free building sites*

This is the same situation for "**green building sites**".

Particularly with regard to building site waste, we can wonder about what will constitute the driving force which will perpetuate reprocessing. The development of new taxes is a priori today highly unlikely, and the only public pressure on the local authorities with a refusal to have a degradation of environment could maintain the impulse. It must also be noted the non toxic feature of building waste and consequently the low criticality of the reprocessing. Added to the difficulty of carrying out controls and enforcement actions on a very diffuse profession (craft industry), this low criticality could delay the development of the reprocessing of this kind of waste.

3.2.3.3.5 *Equipment for saving water*

The cost of water will have largely increased (an average increase of 10 to 15% per year until 2005 is foreseen today) due to the necessary connecting of the biggest part of the cities and therefore of the population to draining networks, which will lead to strong impacts on the uses and probably to an **unavoidable adapting of buildings and equipment**.

3.2.3.3.6 *Likely development of indoor cooling*

Under the effect of an always higher demand for comfort and under the driving effect of office and car cooling, it is likely that **cooling** will also have been **largely developed in dwellings** (some experts estimate that 20% of the building stock could be equipped within some years). The only design of ventilation, shading protections, facades and thermal inertia will not be able to solve, with passive or hybrid means (see the example of cooling floors), all the summer comfort problems.

3.2.3.3.7 *A ventilation for a high air quality*

We will observe **modifications in ventilation and indoor air quality systems**. The current sensitivity to outdoor air quality will indeed spread to indoor air aspects. This sensitivity will lead to new technical solutions (confining, filtering,...?).

3.2.3.3.8 *From immovable to movable*

We will observe a **decrease of the cabling** and a trend **from immovable to movable objects** (equipment which is taken with him by the user when moving).

3.2.4 What Kind of Skills and Standards will be Required ?

3.2.4.1 *A very weak regulations driving force*

Taking into account the political and economic context in which we are today (deregulation, budget deficit reduction,...), it is likely that we will not observe the evolution which occurred in the context of the French energy savings regulation in buildings, that is to say with a very voluntarist policy, even if it would be desirable to follow the same approach (research, experiments, labels, regulations). This approach can however **be envisaged for aspects** where there is a strong social demand **such as health**.

3.2.4.2 *Technologies in continuous progress*

Technologies are **neither ready nor well defined**, contrary to the situation, generally speaking, after the energy crisis (a comparison could be made with bioclimatic technologies).

3.2.4.3 *New skills*

There will be a development of activities linked to **co-ordination and management of projects** in a view of **performance and inconsistencies management**. This performance management will have been well understood by actors and will have contributed to the emerging of a demand for sustainable performances.

3.2.5 What Kind of Cities and Settlements will we Have Then ?

3.2.5.1 *Less acute suburbs problems*

Urban and social dysfunction will be **decreasing**, as the problem is today emerging and will be the subject of a lot of particular attentions, with, for example, heavy retrofits of buildings and urban quarters.

3.2.5.2 *Lots of unknowns*

But **which town planning ? Which country planning ? Which material and non material networks ?**

3.2.5.3 *No major disruptions*

Towns and villages will have the **same** general features **as today**. Industrial activities will be still concentrated in urban poles, even if it can be envisaged a certain transfer towards middle size towns. The development of a settlement mainly trending towards individual houses in the country side seems therefore very unlikely.

3.2.5.4 No "ecological villages or settlements"

There will **not** be "ecological villages or settlements", excepted in some very particular cases.

3.2.5.5 A regional country planning

It can be envisaged a rather large **country dissemination of activity poles**, in spite of an uncertain economic viability, due to a "political listening" regarding regional "cases", which will be favoured for example by tax breaks. But this would not of course constitute a large percentage of the economic activity of the country.

3.2.5.6 A taking account of urban transport in building design

The possibility of having cities without cars must not be rejected. **Other transport means** (public transports, one-person transports, electric cars,...) could have appeared with some consequences for buildings for example at the levels of parking means, power supply systems or even the building geometry.

4. MAIN GENERAL CONSEQUENCES FOR THE WHOLE CONSTRUCTION INDUSTRY

4.1 Introduction

At the Sophia Antipolis Meeting it was agreed to use a common format to present the various national results. This format is based on a multi-dimension analysis of the problem such as described in the minutes of the meeting. Three dimensions were introduced :

- ecological principles (six principles are defined in the construction field in order to meet the three basic goals of a Sustainable Development: to eliminate resource depletion, to eliminate environmental degradation, and to create a healthy interior and exterior environment),
- resources (four resources are concerned: land, energy, water and materials)
- life-cycle phases of the construction process (five phases are defined: develop and plan, design, construct, operate, deconstruct).

The various aspects introduced in the 24 domain based definition of Sustainable Construction have been dispatched and detailed in five tables which correspond to the five life-cycle phases of the construction process (APPENDIX 1). It can be seen that several aspects cannot be associated to any of the resources and principles defined in this approach. These aspects deal generally with human, social or financial topics. However a global approach of Sustainable Construction cannot be envisaged without taking account of these aspects. Therefore the various aspects of the 24 criteria are presented below through a simple listing.

4.2 Consequences per phase

4.2.1 Development and Planning

- Optimize impacts on property value of the place : image, comfort, vacancy rate,...
- Limit space occupation impacts on green spaces,...
- Protect flora and wildlife (trees, protection areas,...)
- Limit space occupation impacts on ground water and run-off
- Optimize costs of access to collective services : costs of connections (water, gas, electricity, highways, services), costs of evacuation (water, gas, domestic waste), costs of operation
- Master traveling needs : access to transport means (nearness to collective transport means, parking optimization,...), safety of traveling (parking, pedestrian ways, outside spaces,...)
- Accommodate proximity services : meeting room (space and management), services (shops, city representation,...)
- Optimize space design and social costs : stairwells, housing blocks, quarters,...
- Respect residents and surrounding buildings (shading masks, view obstruction, noise,...)
- Calibrate impacts on capital (technical costs, put off costs, housing subsidy costs)

4.2.2 Design

- Choose products with low energy content (local products, reduce transports)
- Reduce component weight
- Use innovative or natural technologies
- Optimize building weight
- Use recycled products
- Insure use functionalities : space, climate, protection, equipments, relation mastering, site integration, sense bearing
- Insure no health risks
- Increase durability
- Increase robustness
- Optimize maintainability (easiness, accessibility, modularity,...)
- Optimize internal flexibility (spaces, indoor climates, equipment connections,...)
- Optimize use changes capabilities (structures, equipments,...)
- Optimize performance improvements capabilities (indoor climates and protections, equipments)
- Optimize abilities to be deconstructed (site accessibility, nuisances,...)

4.2.3 Construct

- Reduce squandering (plan right quantities, re-use offcuts,...)
- Insure flora and wildlife protection
- Increase waste management

- Insure ground water protection
- No air pollution
- No soil pollution
- Building site without noise
- Limit traffic needs
- Decrease task hardness (definition of tasks and operating methods, adapted tools,...)
- Secure tasks
- Pleasure at work (good living conditions at site, site cleanness,...)
- Impact on self-actualization (interest at work, image,...)
- Optimize building site logistics : supplying, delivering, executing, controlling

4.2.4 Operate

- Optimize energy consumption
- Optimize water consumption
- Recycle gray water
- Use rain and run-off
- Master fluid waste
- Master gaseous waste
- Master domestic waste
- Optimize consumptions (in operation loads equivalents)
- Mastery of communications (access to networks)
- Insure no health risks

4.2.5 Deconstruct

- Marking of products to increase selecting abilities
- Collection on building or specialized site
- New assembling methods
- New connections
- Operating manuals
- Waste treatment
- Final waste treatment

5. MAIN RECOMMENDATIONS TO THE ACTORS

5.1 Focus on Important Recognized Aspects

Behind the phrase "sustainable development", which is often today hackneyed and also more and more used as a "suitcase concept" into which a lot of various and diversified questions can be put, it can be distinguished in fact a certain amount of issues that the building sector cannot ignore.

In order to avoid overdiversification in a sector for which innovation is not the main consideration of every day, it seems important to focus attention on some specific but important aspects on which consensus and appropriation could be reached certainly.

These aspects should be clearly linked to the general concept of Sustainable Development. The Bruntland approach has initiated a large concept, but it turns out today that 4 main simple issues can be used to define the concept.

5.2 Fit Sustainable Development on Four Simple Issues

Four main simple issues can be used to define Sustainable Development for non-expert people :

1. SD encompasses the idea of development with an economic growth, but...
2. SD must take place without signing mankind's life away,
3. by taking also account of natural and cultural heritage,
4. and trying to ensure an inter- and intra-generation solidarity.

These four issues are still very large, but can be easily accepted and memorized, even if they can lead to numerous constraints and incompatibilities.

As far as the building sector is concerned, and if the first issue is put apart since followed for many years by the sector, the three last issues give birth to numerous problems which have been detailed above but which, generally speaking, can be classified into three main categories : physical (or "environmental") problems, biological (or "health") problems and sociological problems.

5.3 Approach Sustainable Construction through Three Problem Categories

Three categories of problems can be identified behind the notion of Sustainable Construction. These three categories are the following :

1. Physical problems : these problems come from the issue of taking account of natural heritage, that is to say, on one side, the management of resources shortage (essentially energy and water), and, on another side, the management of damage caused to the earth (essentially greenhouse effect). These problems will lead to recommendations that aim at decreasing the impacts of the building industry and activities on environment.
2. Biological problems : these problems come from the issue of not signing mankind's life away. These problems will lead to recommendations aiming at avoiding any damage which could be caused to the mankind's health, either in the outside environment, or in the inside environment of the buildings.

3. Sociological problems : these problems come from the issue of ensuring an inter- and intra-generation solidarity. These problems have several facets which are sociopolitical, socioeconomic or sociocultural (preservation of cultural heritage for instance) facets.

If the first category seems to encompass very rational problems, the second and above all the third ones introduce some irrationality. As a matter of fact, a lot of uncertainties still remain on the knowledge of the effects on health due to many factors. However, it is sure that these effects cannot be put apart and that these problems must be tackled with the same priority as the problems of the first category. Only the third category could be treated at a different level with a lower priority, at least in the "Sustainable Construction" problematics, as far as the major risks linked to the previous issues are not totally eliminated.

5.4 Main Technical Recommendations

The basic mission of a building has ever been to protect man against natural elements. The main efforts so far have been focused on the improvement of the ways necessary to fulfill this mission, that is to say on the improvements of the global quality of the building and the mastery of the corresponding costs.

Today, the notion of sustainable development introduces an additional constraint which is to fulfill this mission without compromising the possibilities of future generations to meet their needs.

As a matter of fact, a building has an environment impact which goes far beyond the classical notion of investment. On another hand, the internal environment created by a building must satisfy higher and higher requirements linked to indoor climate and health.

The 24 criteria described above lead to a lot of consequences for the building sector, which have been listed in the previous chapter per phase of the building process. To try to define priorities between these different aspects is not possible so far in a scientific way. However the protection of environment and health should be in the hearth of the strategic choices of the actors of the building sector.

After reviewing all the aspects which have been identified in the study and taking account of the prioritisation principles mentioned above, it turns out that the following main recommendations can be made, as far as the French context is considered.

5.4.1 Going on with Energy Savings Policy

A lot of efforts have already been done in the building sector to decrease energy consumptions. Some additional ones can be done at short term for example in the tertiary sector. New thermal standards have to be issued shortly, which will increase

the level of requirements and make uniform the approaches in the domestic and tertiary sectors.

Several new developments have to be looked for in the domains of renewable energy (new materials, cost reduction of solar photovoltaic cells, network connected systems, facade and roof integrated systems, solar active and passive heating and cooling systems), advanced glazing and insulation materials, natural, artificial and mixed lighting, boilers, energy control systems,...

Cooling equipments should be studied in particular since comfort requirements will lead to a heavy development of this kind of systems.

Mastery of electricity demand should also be looked for through the improvement of the knowledge on the electricity demand for each use (at home or in the offices), the energy and environment performance of domestic appliances (such as lighting devices, washing machines or refrigerators), information, and awareness and consciousness-raising campaigns.

5.4.2 Improving Air Quality

The air quality must be ensured inside buildings. The causes of bad quality can come both from the outside environment and from occupants or the building itself.

The improvement of air quality in indoor spaces should be a global objective of research, study and technical evaluation projects. The indoor environments which should be considered are office buildings, dwellings, public or private collective use buildings (nurseries, schools, swimming pools, theaters,...), underground spaces (subways, parking, railway stations,...), as well as transport vehicles (cars, trains,...). Hospitals, workshops and other spaces with specific pollution sources should also be considered.

Some examples of activities which are to be carried out in this domain are the following :

- characterizing pollution sources and air contamination elements,
- optimizing ventilation systems,
- clarifying sociological aspects linked to air quality,
- measuring air contamination elements and assessing exposures,
- developing standardization in the domain.

5.4.3 Decreasing Health Risks

The building and construction sector, as the other industrial sectors directly linked to the collective life, is the subject for a tougher and tougher social demand for risk management. In the domains of health and safety, society gives often the authorities the responsibility of maintaining a certain amount of hazards at a "zero risk" level.

Recent examples in the domain of health (lead in paintings, asbestos) depict this fact very well.

The theme "health and construction" is very vast and asks for various experiences and disciplines. Furthermore, the object is both to treat problems coming from the past and to deal with tomorrow risks, with regard to work design as well as to construction products put on the market.

Recommendations in this domain would be :

- to identify and analyze the current state of the art in this domain in order to anticipate future problems,
- to develop progressively sanitary criteria in the technical evaluation procedures, in accordance with conditions and practices which are still to be invented and in co-operation with health experts,
- to help building professionals to take account of this preoccupation,
- to develop information dissemination on these health problems.

5.4.4 Bettering Waste Management

If a specific attention should be essentially given to ultimate waste problems (what can we do with asbestos taken out from buildings ?), waste management should also be bettered both at the level of the work sites and at the level of the communities.

5.4.4.1 Work Sites

Developments in the domain of the work sites should aim at favoring the changes that this preoccupation implies :

- new organizations of demolition work sites : the objective is to help professionals to develop deconstruction and selection processes which will facilitate material recycling;
- an offer of materials, products and adapted construction methods.

Among the numerous actions which can take here, the following themes can be mentioned :

- the development of administrative and contractual documents (call for proposals, specification documents,...),
- the amendment of technical standards in order to avoid discrimination of products manufactured with secondary raw materials,
- procedures of selecting waste (on work sites or outside work sites) at acceptable economical conditions,
- valorization chains for mineral materials, polymeric materials, wood, heating systems,...
- work site noise reduction.

5.4.4.2 Communities

At the level of the community waste management, improvements should be obtained through :

- R&D on waste characterization (particularly heavy metals in domestic waste), domestic selective precollecting (with new systems in the field of flat buildings), specific materials (aluminium, steel, plastics and glass) in the waste collection process, organic waste management and biological treatments, thermal treatments, temporarily storage, incineration optimizing, new process assessment, ultimate waste, waste site closing or retrofitting, improvement of the energy performance of waste incinerators, domestic waste treatment procedures, specific waste such as commercial waste, hospitals and building site waste.
- Development of a technical and financial support to local communities to elaborate plans for domestic waste management and to select equipment investment depending on a multi-criteria approach.
- Activities (waste studies, research an development, consciousness-raising campaigns and training) in the field of domestic packaging.
- Development of regulation and standards essentially in the domains of waste sites and container collecting.

5.4.5 Foreseeing Fresh Water Shortage

It is clear that hydrological cycle is more and more modified by human activities and it is likely that some "desertification" problems will appear late or soon in the southern part of France. This implies to launch a program for rationalizing the utilization of fresh water including water saving and recycling systems in buildings.

5.4.6 Developing Construction Materials Saving

The main objective here is not using non renewable materials (such as river aggregates) but more and more renewable ones (such as wood). The development and use of recycled materials should also be favoured.

5.4.7 Developing Assessment Methods

To help professionals to take into account this new preoccupation in their actual activities, it is necessary to develop methods and tools which will aims at :

- increasing knowledge on the integration of building products and buildings into the eco-system and on their effects on health,
- clarifying the debate by identifying the real problems and proposing well-established and scientifically argued answers,
- allowing professionals to improve products, processes, construction and deconstruction technologies, together with the global design of buildings, in order to make them more favorable to environment and health,

- looking for innovation which could lead to a revolutionary progress in construction and deconstruction technologies,
- diffusing information towards professionals in real time of evolution.

From a practical point of view, two main objectives must be followed : incorporating ecological criteria into the product technical assessment procedures and developing tools for assessing the environmental quality of buildings.

5.4.7.1 Environmental Assessment of Building Products - Life Cycle Analysis of Products

The aim is to incorporate ecological criteria into technical assessment procedures. Studies should be pursued to develop an assessment method which will allow industrialists to know and to improve the environmental quality of their products and construction process on a highly pertinent ground. Based on an analysis of the different steps of the life cycle of products, this method of assessment of the environmental quality of products is today available. However the basic assumptions of LCA are not all valid when considering the specificity of the products and actors of the building sector. The necessary validation of the method has to be pursued.

5.4.7.2 Environmental Quality of Buildings

All along their life, buildings have a strong impact on environment as well as on health and comfort of occupants. In order to help city planners, decision-makers and professionals to design, construct, maintain and renovate buildings while protecting environment at best, a method is needed for assessing the global environmental quality of buildings.

The requirement of global environmental quality of a construction project which includes together the considered building, its surrounding and the operation of the building, aims at reaching the following objectives : a limited utilization of natural resources (raw materials, energy, water, ground), a reduced pollution of air, water and ground, a reduced production of ultimate waste, a decrease of pollution (noise,...), satisfactory relations of the building with the surrounding environment, a satisfactory indoor quality from the point of view of comfort and health.

These requirements apply to the building all along its life cycle (construction, operation, adaptation, deconstruction) and should take into account the manufacturing of the utilized products and the valorization and elimination of produced waste.

5.4.8 Modulating the "Building-to-Last" Concept

If the main idea is to limit material squandering, it must be kept in mind that several life durations should be considered depending on the various elements of a building. The shell is built to last several decades, since a lot of internal parts must last only some years in order to allow for changes. This will facilitate changes of use of the

buildings and increase flexibility. Numerous technical systems and construction process approaches should be innovated in that goal.

5.5 Do not Wait and Take Action at Once

It turns out today more and more clearly that to take account of environmental constraints will have heavy consequences on the main options of the building process. This will imply to stress on aspects such as the durability and the evolution of buildings, to reject the idea of considering a building as a "consumable to be thrown away" and to reason in global costs.

Protecting the environment includes also the notion of urban environment. The building is supposed to act as a barrier between it and the occupants, without creating other internal aggressions, coming from indoor air, water, materials,... This aspect must not be forgotten, when looking at the environmental constraints.

Therefore even if the concept of "Sustainable Construction" is not yet stabilized and may still appear a little blurred, it is more and more recognized that construction cannot be ignored when talking about Sustainable Development. All the recommendations mentioned above should be taken into consideration at once for at least two reasons.

First of all, to take appropriate measures preventively to be sure that the consequences which have been foreseen for health and mankind will be as much limited as possible.

Second, to prepare the building sector to changes which are needed in the construction process. Three measures seem to be able to contribute to these evolutions towards the good direction :

- to assign external costs to internal/initial costs, that means, as already said, to reason in global costs,
- to develop R&D along the technical recommendations mentioned above,
- to ensure a global information which must be full and sound without any search for sensationalism.

6. BEST PRACTICE EXAMPLES

6.1 High Environmental Quality Buildings

The French Equipment Department 'Plan Construction et Architecture' has launched in 1993 a call for proposals to develop experimental building projects with a High Environmental Quality ('Bâtiments HQE'). Thirteen operations (called REX for "Réalisations EXpérimentales") have been launched and supported so far and are being monitored and analysed by the PCA and the CSTB.

All these REX HQE had to meet 25 environmental requirements grouped in 4 topics :

- eco-construction requirements,
- eco-management requirements,
- comfort requirements,
- health requirements.

Each REX has additionally to focus on one or two specific requirements. The main aspects considered in these operations are :

- environmental quality of the construction products,
- water management,
- visual comfort,
- site integration,
- environmental management.

Four REX HQE are presented in APPENDIX 2.

6.2 Les Chantiers Verts ("Green Sites")

This program was launched in 1993 by the "Plan Construction et Architecture" of the French Equipment Department and the "Agence de l'Environnement et de la Maîtrise de l'Energie" of the Industry Department through a research and demonstration call for proposals on "Environmentally Friendly Products, Techniques and Methods".

The goal of the Program was to reduce the nuisances susceptible to be caused by a building site, while being concerned by keeping the technico-economic profitability of the building sector. The monitoring was ensured by CSTB.

A total of 11 specific construction projects were completed. They deal with one or several kinds of nuisances susceptible to be caused by a building site: waste management, acoustic nuisances, traffic and parking problems, ground and water pollution.

The list of these projects is given in APPENDIX 2.

6.3 INIES, EQuity and ESCALE: three examples of assessment tools

INIES and EQuity are two complementary tools for assessing the environmental quality of building products and ESCALE is a method for assessing the environmental quality of buildings. These three tools developed by CSTB are presented in APPENDIX 2.

7. REFERENCES

ATEQUE: 'Atelier d'évaluation de la qualité environnementale des bâtiments' (building environmental quality assessment workshop), CSTB Magazine no 79, November 1994.

ATEQUE, French working group on assessment of building environmental quality. G. Olive, S. Nibel. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Bâtiment 2030: quels bâtiments pour l'avenir? CSTB, Ademe. Sophia Antipolis, 9-10/12/1992.

Vingt-quatre critères pour concevoir et construire un bâtiment dans une logique de développement durable. R. Angioletti & alii. Cahier du CSTB n°2864, janvier/février 1996.

Twenty-four criteria for designing and constructing buildings on sustainable development principles. R. Angioletti & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Mieux bâtir avec l'environnement. REX HQE. Dossier PCA/CSTB, 1996.

Environmental quality: a new objective for thirteen residential construction operations in France. Ph Duchêne-Marullaz & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Les chantiers verts. Qualité environnementale des opérations de construction. Dossier PCA/DHC, 1997.

European project REGENER, life cycle analysis of buildings. B. Peuportier & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

How to produce useful results with LCA: the EQUITY model for building products. J.F. Le Téo. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

New steps towards the integration of environmental quality into building products technical evaluation. J.L. Chevalier. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Specifying for environmentally friendly construction sites. C. Charlot-Valdieu, H. Chevet. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Life cycle analysis: taking into account of the recycling. C. Buhe & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Incorporating waste into the preparation of concrete: bases for an assessment methodology. S. Rémond & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Waste on new building construction sites: existing situation and proposals for a better management. H. Boileau & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Survey of opinion about the use of rainwater for non-human consumption use in France. C. Skoda-Schmoll & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

About the definition of environmental quality of buildings. G. Olive & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

PAPOOSE: a tool, based on environmental criteria, to assist promoters in decision-making. A. Bornarel. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Environmental assessment method adapted to the iterative process of building design: presentation of the methodology. N. Chatagnon, S. Nibel. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Management of the environmental quality of a building project. D. Bidou & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Ranking environmental impacts; applications to buildings. P. Chemla, E. Labouze. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Assistance to green building projects through the BATIMPACT method. H. Penicaud & alii. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

A geocoded information system for sustainable urban development. L. Adolphe. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

Construction and environment perception by French parties involved in building. M. Weckstein. 2nd CIB Conference on Buildings and the Environment. Paris, 9-12/6/1997.

8. ACKNOWLEDGMENTS

This study was carried out with the financial support of the "Agence De l'Environnement et de la Maîtrise de l'Energie" and the French Department of Equipment.

9. APPENDIX 1: MULTI-DIMENSION ANALYSIS MATRIX

Develop/Plan	Resources			
	Land	Energy	Water	Materials
Principles				
Conserve	- Optimize impacts on property value of the place : image, comfort, vacancy rate,...			
Re-use				
Renewable/ Recycle				
Protect Nature	- Limit space occupation impacts on green spaces, ... - Protect flora and wildlife (trees, protection areas, ...)		- Limit space occupation impacts on ground water and run-off	
Non-Toxic				
Excellent Quality				
Other aspects (human, finance,...)	<ul style="list-style-type: none"> - Optimize costs of access to collective services : costs of connections (water, gas, electricity, highways, services), costs of evacuation (water, gas, domestic waste), costs of operation - Master traveling needs : access to transport means (nearness to collective transport means, parking optimization,...), safety of traveling (parking, pedestrian ways, outside spaces,...) - Accommodate proximity services : meeting room (space and management), services (shops, city representation,...) - Optimize space design and social costs : stairwells, housing blocks, quarters,... - Respect residents and surrounding buildings (shading masks, view obstruction, noise,...) - Calibrate impacts on capital (technical costs, put off costs, housing subsidy costs) 			

Design	Resources			
	Land	Energy	Water	Materials
Principles				
Conserve		<ul style="list-style-type: none"> - Choose products with low energy content (local products, reduce transports) - Reduce component weight - Use innovative or natural technologies 		<ul style="list-style-type: none"> - Optimize building weight
Re-use				
Renewable/ Recycle				<ul style="list-style-type: none"> - Use recycled products
Protect Nature				
Non-Toxic				
Excellent Quality				
Other aspects (human, finance,...)	<ul style="list-style-type: none"> - Insure use functionalities : space, climate, protection, equipments, relation mastering, site integration, sense bearing - Insure no health risks - Increase durability - Increase robustness - Optimize maintainability (easiness, accessibility, modularity,...) - Optimize internal flexibility (spaces, indoor climates, equipment connections,...) - Optimize use changes capabilities (structures, equipments,...) - Optimize performance improvements capabilities (indoor climates and protections, equipments) - Optimize abilities to be deconstructed (site accessibility, nuisances,...) 			

Construct	Resources			
	Land	Energy	Water	Materials
Principles				
Conserve				<ul style="list-style-type: none"> - Reduce squandering (plan right quantities, re-use offcuts,...)
Re-use				
Renewable/ Recycle				
Protect Nature	<ul style="list-style-type: none"> - Insure flora and wildlife protection - Increase waste management 		<ul style="list-style-type: none"> - Insure ground water protection 	
Non-Toxic	<ul style="list-style-type: none"> - No air pollution - No soil pollution 			
Excellent Quality				
Other aspects (human, finance,...)	<ul style="list-style-type: none"> - Building site without noise - Limit traffic needs - Decrease task hardness (definition of tasks and operating methods, adapted tools,...) - Secure tasks - Pleasure at work (good living conditions at site, site cleanness,...) - Impact on self-actualization (interest at work, image,...) - Optimize building site logistics : supplying, delivering, executing, controlling 			

Operate	Resources			
	Land	Energy	Water	Materials
Principles				
Conserve		- Optimize energy consumption	- Optimize water consumption	
Re-use			- Recycle gray water	
Renewable/ Recycle			- Use rain and run-off	
Protect Nature	- Master fluid waste - Master gaseous waste - Master domestic waste			
Non-Toxic				
Excellent Quality				
Other aspects (human, finance,...)	- Optimize consumptions (in operation loads equivalents) - Mastery of communications (access to networks) - Insure no health risks			

Deconstruct	Resources			
	Land	Energy	Water	Materials
Principles				
Conserve				
Re-use				- Marking of products to increase selecting abilities - Collection on building or specialized site
Renewable/ Recycle				- New assembling methods - New connections - Operating manuals - Waste treatment
Protect Nature				
Non-Toxic				- Final waste treatment
Excellent Quality				
Other aspects (human, finance,...)				

10. APPENDIX 2: BEST PRACTICE EXAMPLES

WATER MANAGEMENT

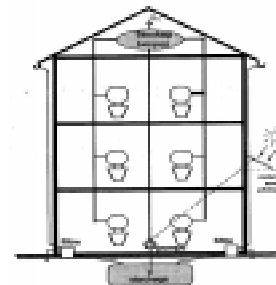
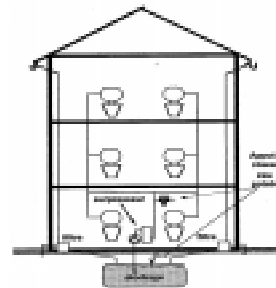
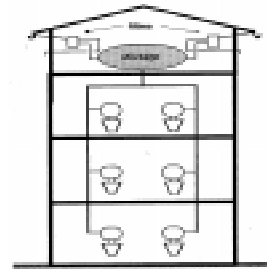
LE PRE DE LA COUR

One 12 flat building and 5 houses
MEILLONAS (Ain- Eastern France)

This REX HQE takes place in a small village of 1000 inhabitants. The owner (OPAC HLM de l'Ain) has looked for decreasing the services charges and has given importance to energy and water saving solutions.

Three technical solutions to collect and store rain water have been envisaged :

1. A total collecting of rain water above the last floor, with a distribution to all toilets by gravity, which implies overraising the roof.
2. A storage under the first floor, which implies a pump and a surpressing device.
3. A solution which is a mix of the two previous ones. This solution allows for an easy collecting and a storage below the first floor, and a distribution by gravity from a buffer storage at the top of the building. A small pump, powered by solar photovoltaïcs cells, ensures the water transfer to the storage. This solution has been chosen, but without the solar cells.



ENVIRONMENTAL QUALITY OF MATERIALS and SITE INTEGRATION

LES JARDINS DE RABAUDY

50 rental houses

CASTANET TOLOSAN (Haute Garonne - West-southern France)

In this REX HQE situated in the hearth of a protected "green zone", a heavy attention has been brought to the integration of the buildings and their neighbourhood into the site. The choice of environmentally friendly materials has been deeply studied.

The following materials have been chosen :

- baked clay (tiles, 20-cm-hollow bricks, facing bricks, window ledges, chimney ducts, life cycle studied with an industrialist),
- wood (skeleton, shutters, garage doors, internal doors, plinths, stairs),
- zinc (gutters),
- traditional coating,
- non toxic glue,
- labelled paints.



SITE INTEGRATION

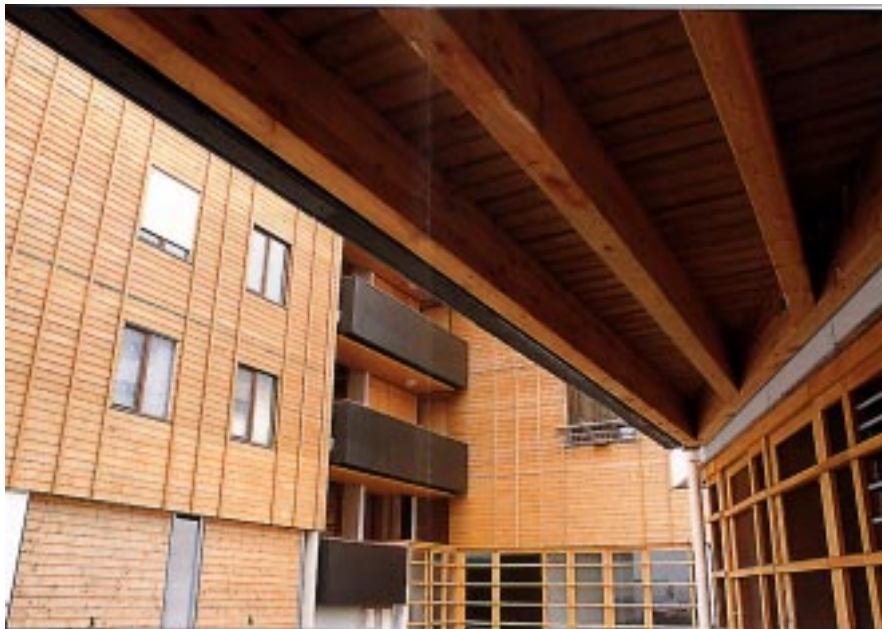
LE CLOS DES VIGNES

56 flats

SAINT MAX (Meurthe et Moselle - Eastern France)

This REX HQE, with 6 flats dedicated to disabled people, has been integrated in a site with specific characteristics from the geographical, cultural and social points of view. Several themes have been considered in this operation, such as the site integration but also water and domestic waste management.

Wood (from the Vosges forests) has been heavily used in this construction, on the façades and inside the common areas. The history and geography of the site have been taken into account for the gardens and surroundings. Various communication actions have also been conducted in order to reach a good appropriation by the inhabitants.



VISUAL COMFORT

PLACE DU VIGNERON

44 flats and stores

UNIEUX (Loire - South-West of Paris)

This REX HQE, with three 5-storeys buildings, takes place in a heavy restructuration of the center of a middle-size town. The problem of visual comfort has been studied in particular. A light shaft, located in the middle of each building, brings "second lighting" to landings, bathrooms and livingrooms.

The natural lighting concept includes also :

- larger glazings in the light shaft at the lowest floors in order to balance the lack of light,
- "transparent" lifts to improve natural lighting of landings and lifts,
- appropriate design of the window frames,
- light-coloured cladding and covering,

All these topics have been deeply studied through modelling/simulation and laboratory testing.



LES CHANTIERS VERTS ("GREEN SITES")

Environmental Quality of Building Sites

This program was launched in 1993 by the "Plan Construction et Architecture" of the French Equipment Department and the "Agence de l'Environnement et de la Maîtrise de l'Energie" of the Industry Department through a research and demonstration call for proposals on "Environmentally Friendly Products, Techniques and Methods".

The goal of the Program was to reduce the nuisances susceptible to be caused by a building site, while being concerned by keeping the technico-economic profitability of the building sector.

The monitoring was ensured by CSTB.

A total of 11 specific construction projects were completed. They deal with one or several kinds of nuisances susceptible to be caused by a building site: waste management, acoustic nuisances, traffic and parking problems, ground and water pollution.

The 11 projects and the main themes dealt with are the following:

- BESANCON: all nuisances, communication with neighbours
- BORDEAUX: site noise, waste
- CHAMBERY: waste reduction and enhanced value
- HELLEMMES: site noise, traffic/parking, communication with neighbours
- LILLE: waste reduction and pre-selection
- MONTPELLIER: waste on a retrofit site : pre-selection and enhanced value
- NEVERS: all nuisances on a retrofit site, communication with tenants
- TOURCOING: ground and water pollution by oils
- VILLEURBANNE: all nuisances, in particular waste and noise
- VOGLANS: waste pre-selection
- WAMBRECHIES: waste reduction and pre-selection.

Despite the great progress which has been made, several points need more improvements:

- on materials, equipments (acoustic interest, dust reduction),
- on waste value enhancement paths to go with on-site selection,
- on construction products, by favouring environmentally friendly products and appropriate packages,
- on logistics and organisation, time necessary for changing methods and training of workers.

In order to integrate environmental management aspects into habits, the construction sector should keep in mind three basic principles:

- to define reasonable and well prepared goals before the site launching; these goals should be coherent with the size of the site, the size of the enterprises, the procurement methods and the local context,
- to stress co-ordination, information and training, which appear to run out of steam in the secondary works,
- to plan a control of the environmental actions all along the site duration.

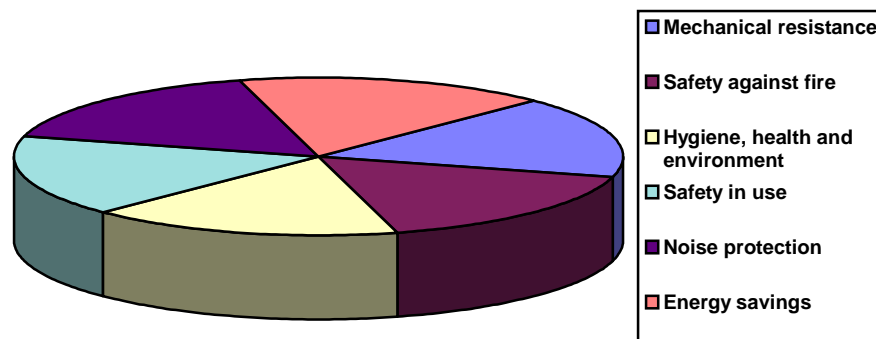
INIES and EQuity Two Complementary Tools for Assessing the Environmental Quality of Building Products

The notion of Environmental Quality includes the aspects of "cleanness" (lowest quantity of pollutants emitted) and "sobriety" (lowest quantity of new materials and energy resources consumed). This notion comes in addition to more common aspects of the quality of building products - functionality, durability, performance - which it is not disconnected from.

It is important to remind that, as there is no technically good products in the absolute - that depends on what you will do with it - there is no "green products" or "eco-products", but only products which are more or less adapted to a given use from the point of view of the Environmental Quality, and which therefore can be improved or better designed through an approach which will integrate the Environmental Quality.

Experience proved that the improvement of technical performances and manufacturing/installing costs can take place in coherence with an approach of Environmental Quality. For this kind of approach, which needs to look for precise answers to precise questions, CSTB has developed a software, called EQuity and based on the Life Cycle Analysis of products.

If the question is more to select products, which have a good equivalent technical quality, on their environmental qualities, it turns out that the results of a Life Cycle Analysis are generally not clear enough to help taking a decision. It is why CSTB has developed a second tool, called INIES (INformation on Sanitary and Environmental Impacts), which consists of a series of forms to collect and organise existing information on the Environmental Quality of a product.



Environmental Quality is a New Compound of Quality

ESCALE

A Method for Assessing the Environmental Quality of Buildings

Due to the emerging of a demand and the development of High Environmental Quality construction projects, it gets necessary to help professionals to design buildings while protecting the environment. In this context, an method for assessing and checking the environmental quality of buildings is under development by CSTB.

The method follows the design phase. It allows to control and to improve a project from the point of view of the environmental quality all along the design phase.

The assessment criteria are purely environmental ones.

For every criteria, two assessment models are defined, adapted to the level of details of the design data

Every result, expressed by an indicator, is placed on a performance scale from -1 to 5. The lowest level is defined by a standard or commonly reached value. The highest value is defined as the optimal value which could be reached.

The final profile, which represents the performances of the project against the various criteria, can be detailed with "sub-profiles" in order to explain the results obtained.

