5. Conclusion

és de l'outil de calcul sont beaucoup plus vastes que ne
ser les quelques résultats que nous venons de présenter.
alement :
té de comparer presque simultanément le fonctionnement dy-
3 systèmes de chauffages différents (air pulsé, radiateur et
uffant).
compte du couplage vrai "bâtiment-systèmes de chauffage",
le plancher du plancher chauffant.
té de définir différentes stratégies de fonctionnement des
chauffage.

ice de tel outil au niveau de la conception permettra de dé-
ds choix du système thermique à utiliser. Par contre lors
jet on peut affirmer que l'on pourra estimer précisément
es, les paramètres de dimensionnement sur le fonctionnement
système de chauffage et par conséquent le confort thermique
âtiment et la consommation d'énergie.

es de développement à moyen terme sont évidentes ; une pri-
lu caractère multizone des bâtiments avec une stratégie de
pre à chacune des zones est actuellement à l'étude. Les
ncontrées sont alors plus liées à la saisie des données re-
lescription du réseau de chauffages (critère de facilité
qu'à la précision de la représentation des phénomènes
sont assez bien connus.

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#6585

ENERGY CONSUMPTION AND POLLUTION OF BUILDING CONSTRUCTION

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1. INTRODUCTION

Energy consumption for heating, cooling and domestic hot water production accounts to 30-50 % of the overall energy consumption in most industrialized countries. The specific consumption values for different types of buildings, the possibilities of reducing this consumption through retrofit and in new buildings are quite well known by now. The energy consumption for producing building materials and components, on site construction and demolition are less well known and there is little knowledge about the pollution produced by constructing and using buildings. The designers are more and more faced with complex optimisation situations where the purely financial constraints are often no more decisive. It is however difficult to introduce other energetical or pollution criteria because of a lack of available and useable data.
The life cycle approach to energy costs for buildings has produced results which show the relevance of construction energy costs for low energy buildings in moderate and cold climates and for all types of buildings in warm climates, above all in the developing countries. (1)

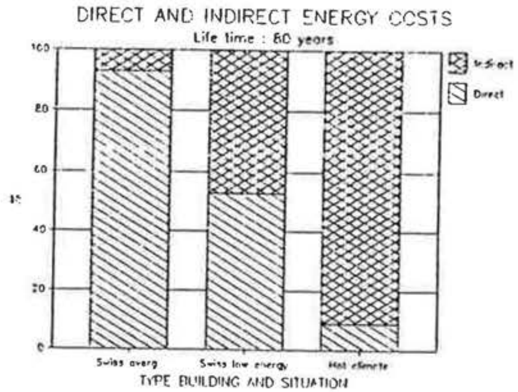

Fig. 1. Relation between direct and indirect energy cost in function of the energy performance and the climat.

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2. Life cycle energy costs.

The indirect energy costs (i.e. building material production, construction, repair during life time and demolition) and the direct energy costs (for heating and hot water) have been established for 30 buildings with an appropriate model (2). This model takes into account two types of energy costs: the direct or operation energy costs and the indirect or construction energy costs. The direct energy costs are calculated with a simplified, heating season, method which takes into account the passive solar and internal gains as well as the efficiency of the heating and warm water production. The indirect costs include the energy for the production and transport of building materials, the energy used on site, the energy costs of all repair and the energy costs for demolition. The feedstock energy is taken into account as well as the benefits from recycling for all the materials. The advantage of the model lies in the possibility to perform parameter studies.
The distribution of indirect energy costs varies for different types of buildings. The relation between direct and indirect energy costs shows that the indirect energy cost become important for low energy buildings (region c on fig.2). They can amount up to 30-40 % of the direct costs during a life time of 80 years.

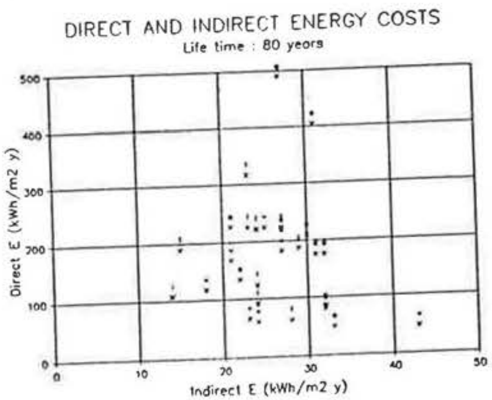


Fig. 2: Direct and indirect annual energy cost for different buildings

A parameter analysis has been performed on the 30 buildings. The sample was statistically far too small to allow reliable conclusions, but it seems that there are no evident correlations between the indirect energy costs and structural materials or particular construction techniques. Only the weight of the construction seems to have an influence, light buildings need much less materials, above all for foundations, and even if the materials are more energy intensive the overall balance is in favour of light buildings.
The anlysis of the energetic improuvement in the design stage or by retrofit for existing buildings shows that the energetic payback time of these mesures is generally very low (weeks or months), and that the principal effort has to be ac-

complished in this field. The fig.3 shows the very small increase of indirect energy costs in the changes during the design of an office building (IAAC-IABB) and through retrofit of an appartement block (ILMDBO-ILES).

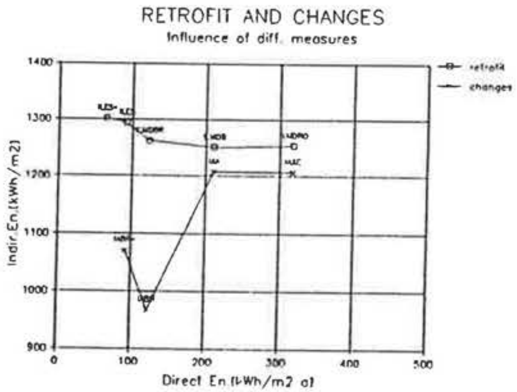


Fig.3 Improuvement through design (lower curve) or retrofit.

3. Pollution caused during life cycle

The interest of establishing the overall energy costs is double:
- the ressources in energy and building materials are limited and if we want to allocate the existing stock in an optimal manner we have to know more about how materials and energy are used
- all industrial and domestic activities use energy in different forms and are therefore a source of pollution. The attempt to reduce the pollution level needs also more detailled knowledge about the importance of pollution of different activities.(4) A part at least of the pollution and the impact on the natural environnement is the result of energy transformations.

It was therefore interesting to try to establish the pollution resulting from the energy consumption during the life cycle of buildings. When using the primary energy costs at a certain uniform level of desagregation it is possible to sum up all energy costs independant of the type of energy. This is not possible for different types of pollution.
The basic energy data are the final consumption for thermal and electrical energy. For the thermal energy a modal split has to be assumed (part of fuel, petrol, wood, coal, gas). These data vary from country to country, in our study swiss data of 1985 have been used. Furthermore the part of imported building materials has to be assumed.
The pollution resulting from building is only part of the impact of building on the environnement. There are other impacts like disturbing the ground water level, destroying vegetation, changing the microclimate by the shape of buildings which are not considered at this stage of the work (3). Of course these impacts are important and have to be quantified in the future.
The pollution associated with energy transformations produces the following quantities in g/kWh (Average Swiss Data)

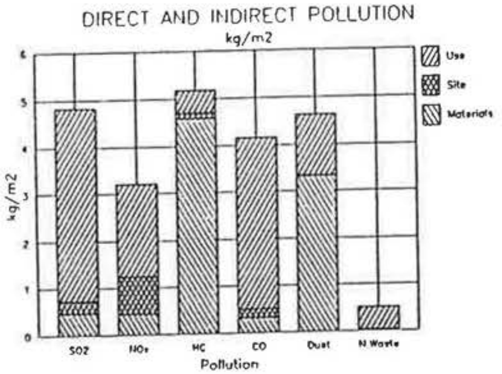


Fig.7: Average pollution rates during the the life time of a building.

3. Optimisation

The design process is very complex and based on many iterations, feedbacks, intuitive shortcuts. Most of the optimisation methodes which are proposed to designers can not be applied because the questions these methods answer never appear in this form in the design process. All energy conservation strategies have to follow as closely as possible the design process and offer answers in the right form at the right moment. Some optimisation models reduce the problem to building materials and components, which is very practical. The analysis of the overall costs shows however that this approach is inappropriate and leads to false conclusions. The models which try to optimise the whole building envelope give already better results, they neglect however the interrelation between the HVAC and Control equipement and the building envelope. The only conclusion which can be drawn from these models, is that there are coherence levels between the thermal quality of the walls and the windows. They show that from a certain quality level on (beyond 12 to 15 cm of insulation) the principal effort has to be put on windows by trying to obtain transmission values under 1 W/m2K and maintain a high solar transmission. The limit of the application of these windows lies in the capacity of the building structure to stock the incoming solar energy and in the control system to adapt the output of the heating system.

4. Optimisation procedure

The optimisation problem can probaly only be solved trough a optimisation procedure. At each stage of important planning decisions the appropriate questions have to raised.

1. Do we need a building ?
This question may seem unnessary, but in certain situations it is possible to solve the problem without a building, for example by treating patients at home instead of constructing a new hospital. The decision to build implies already the largest part of the energy costs and the resulting pollution.

2. Do we need a new building or should we transform an existing building?

From a financial point of view the answer is often in favour of a new building, because transformation is very labour and cost intensive. From the point of view of energy costs there is no single answer. Depending on the energetic performance of the existing building and the possibilies of retrofit the answer might be different. Fig. 8 shows 3 possibilies: A bad building with no retrofit,a complete retrofit and a good new building. In the long run (30 years) the new building is the best.

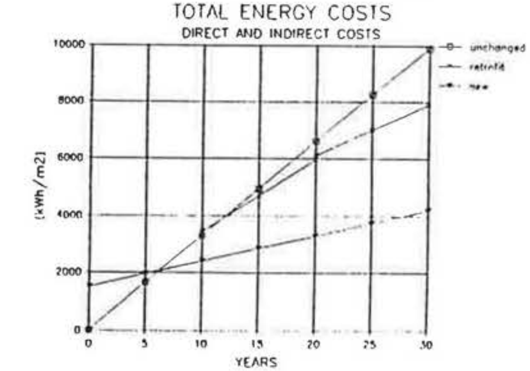


Fig.8: Total energy costs during a period of 30 years for three types of transformation.

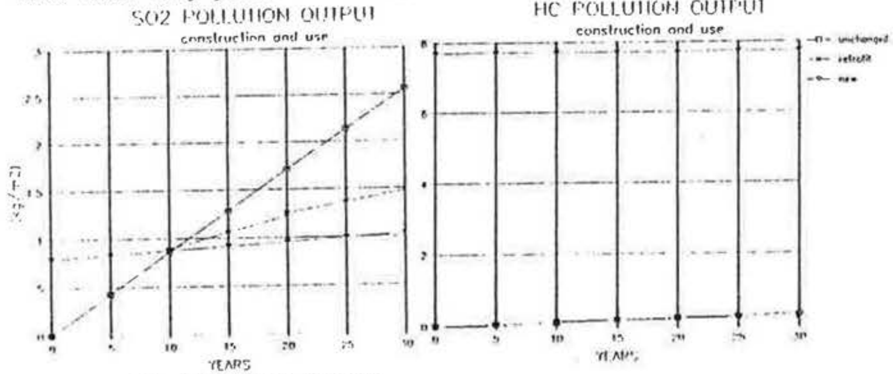
Considering the pollution output the answer is less clear. SO2 results mainly from heating therefore the existing bad building is the worst solution. The hydrocarbure output is highest for a new building, far off all retrofit and existing building. For a minimum of NOx the retrofit version is best. The only answer which we can give is that additional criteria must be used to take a decision. The ambiant pollution level, or other environment criteria like the impact on the vegetation must be taken into account.

3. How far should we go with energy conservation ?

The question is clear from a energy cost point of view: as far as possible. The indirect energy costs will not exceed the direct energy cost in a moderate or cold climate.
Concerning pollution the same answer can be given. The additional pollution resulting from better construction can be neglected.

4. How should we build, which materials should we choose?

From a purely energy cost point of view the question is of secondary importance. There are a great number of materials in a building, many of them can be replaced easily and recycled and if the life time of the building exceeds 50 years the differences are small. From a pollution point of view the question is more interesting but there is no single answer neither even if light buildings seem to produce less pollution during the building process. Each building is situated in an environnement which is already exposed to pollution impacts of different types. If the pollution level of one type is particulary high in a certain place it could be interesting to choose a certain type of building and building materials and use a prefabricated construction to limit the impacts on the site. The production of all building materials, even the most natural ones like wood, is highly industrialized and the resulting pollutions differ mainly by the type of pollution but not by the fact that they pollute or not.



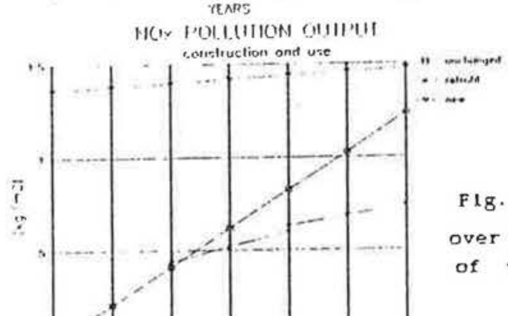


Fig. 9.: Pollution output over 30 years for three types of transformation.

5. Conclusions

There are no single, simple answers to the problems of overall energy costs and pollution of the building process. The only way to get hold of the problem during the design process is to try to reconsider the problems at each design stage. In the future it will probably be possible to integrate energy cost and pollution data in the quantity surveying procedures and to advice the designer through expert systems during the whole process.

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DEVELOPPEMENT ET EXPLOITATION D'UN MODE
DE SIMULATION DES PLANCHERS CHAUFFANTS EN REGIME

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1. Introduction

La technique de chauffage des locaux par le sol préser
particulier parce qu'elle offre la possibilité d'utili
chaleur à basse température. Si le dimensionnement des
fants est bien maitrisé (1), leur comportement en régi
plus difficile à appréhender du fait de la capacité ca
tante des émetteurs.

On s'intéresse ici aux systèmes à "dalle flottante" qu
currence avec les chauffages traditionnels à émetteurs
individuel, et pour lesquels l'inertie est à priori un

L'objectif de l'étude est :

(1) de connaitre la consommation énergétique des systè
riable pour un niveau de confort donné, par comparaiso
traditionnel sans inertie,
(2) de définir les caractéristiques dimensionnelles du
fant, compte tenu des contraintes liées au régime vari
(3) de préciser les conditions optimales d'utilisation
(type d'habitat et mode de régulation - programmation)

2. Développement d'un modèle de simulat

Outre l'inertie de l'émetteur, la spécificité du chauf
est relative au mode d'émission de la chaleur dans le
ment sous forme radiative.

L'étude a nécessité la mise au point d'un modèle de c
mulant le système de chauffage, sa régulation et le lo
il se trouve installé :

2.1. Plancher chauffant :

Les transferts thermiques par conduction dans le planc
par la méthode des facteurs de réponse (2). Ceux-ci s
fois pour toutes avec un programme en différences fini
les pour tenir compte des gradients thermiques horizon