# ELODIE: A Tool for the Environmental Assessment of Building

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## Abstract

In 2007, the CSTB developed an environmental impacts assessment of buildings tool named ELODIE. Based on a Life Cycle approach, this tool meets the need of construction sector in quantifying the building performances and contributing to the environmental friendly design of buildings. In its first version it allowed to calculate only the products contribution to the environmental impacts of the building. The model uses Environmental Products Declarations (EPD) provided by manufacturers in the INIES database. ELODIE is now a complete building assessment tool integrating contributory elements as energy and water consumptions, transport of users'(in line with NF P01-010 and NF P01-020 methodology). ELODIE can also use the information of the Building Information Model (BIM) to facilitate the calculation of the building's quantity take off. As a result, ELODIE provides an environmental multi criteria profile of the building and will provide at the end of 2009 a complete score of the building that will enable an easier environmental comparison of buildings. ELODIE also provides tools to help designers to identify major environmental improvement solutions. ELODIE has now solid bases to integrate or develop links with new modules

on comfort aspects (acoustic, lightning, thermal comfort') and economic and social aspects to become a more complete tool to assess the environmental sustainability of buildings.

**Keywords:** building impact assessment, life cycle assessment, environmental product declaration, INIES, ELODIE

# 1. Introduction

ELODIE was developed in order to meet the need of construction sector in quantifying the environmental building performances and to use the environmental data produced by manufacturers (EPDs on construction products°. If several LCA-based analysis tools have been developed in the past few years around the world, none is specially adapted to the French context or use a methodology based on the product scale data. FDES is the French equivalent for EPD's, which contains Life Cycle Assessment (LCA) data (made for a French context), together with health and comfort aspects. The tool ELODIE provides assistance for the choice of environmentally friendly constructive solutions. It allows comparing several alternatives for the same building or for the same part of work realized with different components, different materials, and even different constructive modes. Within few years, it will become a complete environmental assessment tool (with environment, but also health and comfort aspects as in HQE approach) and will be developed in coherence with sustainability assessment tools. It will be consistent with standardization basis and SBA work about a core set of indicators shared by number of countries and the French HQE approach. Based on a life cycle approach and on the standard XP P01-020-3, the software can be used to set up models of new buildings or existing ones.

# 2. Scientific model

The model is based on the quantification of the flow's balance. At the building scale, we named these flows contributory elements. The model (illustrated by the following figure) considers the sum of the impacts of various flows as material and products, as energy and water consumptions.

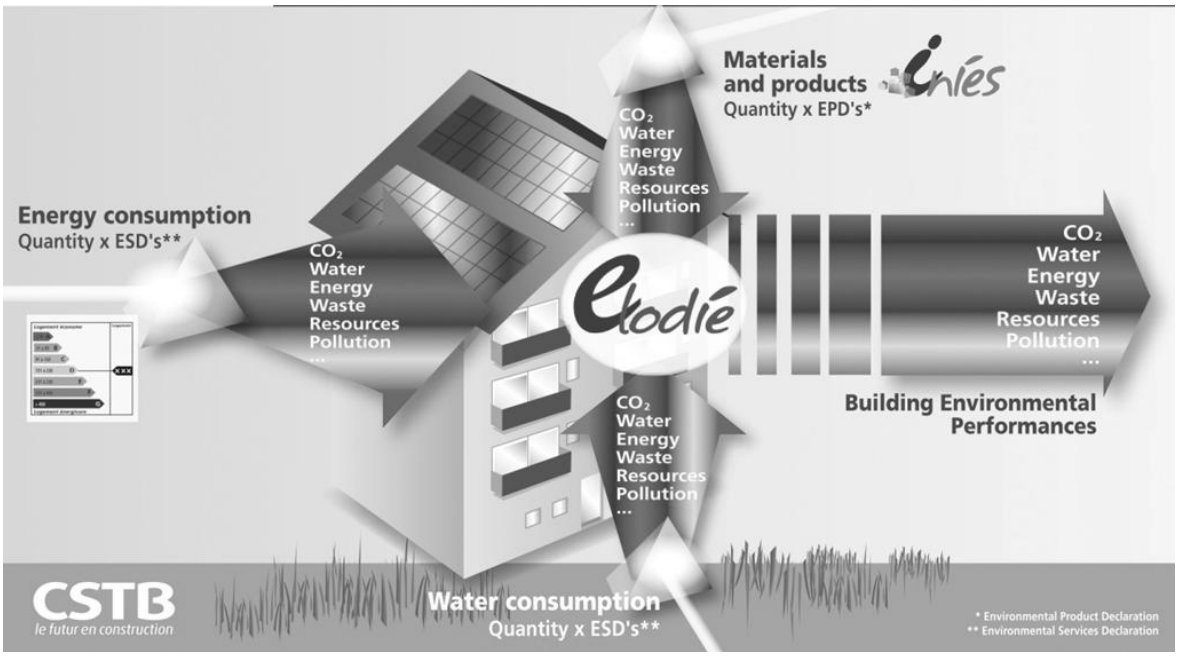

Figure 1: The building environmental performance calculation model

The quantification of the contributory element "product and material" is based on the FDES. French construction sector has decided to develop common rules to establish environmental declarations of construction products (EPDs). This decision led to the development of a standard, (i.e. NF P01-010) issued in 2004. The adopted methodology for the EPDs establishment is based on Life Cycle Assessment (LCA) approach and includes also the health and comfort aspects. In order to improve the dissemination and the accessibility to these type III declarations, the EPDs, a public free access data base has been created in 2004, i.e. INIES database (www.inies.fr). At present, there are about 420 EPDs. The LCA is based on a cradle to grave analysis including packaging, and complementary products.

French EPDs contain 16 environmental indicators to evaluate the environmental impact of one product.

*Table 1:The environmental indicators of French EPDs*

| | Environmental Impact | | Unit |
|---|---|---|---|
| 1 | Energy consumption | Total primary energy | MJ |
| | | Renewable energy | MJ |
| | | non renewable energy | MJ |
| 2 | Ressource depletion (ADP) | | kg Sb eq. |
| 3 | Water consumption | | L |
| 4 | Recovered waste | | kg |
| | Eliminated solid waste | hasardous waste | kg |
| | | non hasardous waste | kg |
| | | inert waste | kg |
| | | radioactive waste | kg |
| 5 | Climate change | | kg CO2 eq. |
| 6 | Atmospheric acidification | | kg SO2 eq. |
| 7 | Air pollution | | m3 of air |
| 8 | Water pollution | | m3 of water |
| 9 | Destruction of the stratospheric ozone layer | | kg CFC eq. |
| 10 | Formation of photochemical ozone | | kg ethylene eq. |

Manufacturers of electric components and equipments (as ventilation, boilers, etc.) had chosen a similar format of environmental data expression: the PEP (Profile Environmental Product).

EPDS and PEP both can be used in the tool. At present, there are about 300 PEP, disseminated on various data database.

## 2.1 The tool's structure

From the quantity survey of a building and EPD's, the tool allows calculate the contribution of products to the environmental impacts at the building scale.

From the quantity of consumed energy and water and ESD's (Environmental Service Declaration), the tool calculates the impacts of the building during its design life.

The ELODIE introductory part collects data about the building and constructs the functional unit of the evaluation. This data record concentrates common data for calculation in different modules and contains information such as: the building design life, the size of a building as measured by its floorspace, the construction period, the location of buildings, operating periods, the number of occupants or workers in a building, etc.

## 2.2 Materials and products contribution

ELODIE calculates the environmental impact of a building from the quantity of each product inserted in this building and their FDES (functional units must be the same). It is also possible to use other sources of environmental data for one product. To calculate the results, the model require an estimated lifetime (DVE) for each product, which is taken as the lifetime of the FDES initially but can be adapted to the project and the service life of the building (DVP). Consequently ELODIE calculate the number of replacement for each product, the quantity to insert, and then the environmental contribution of each product.

| **Number of replacing:** | |
|---|---|
| if DVE≥DVP | There is no replacing: the product is used only one time |
| if DVE<DVP | The number of replacing is $t_r$=ENT(DVP/DVE)+1 |

The sum of the impact of the products is one part of the environmental profile of the building.

## 2.3 Energy consumption contribution

ELODIE allows connecting energy concerns to environmental ones. From the impact of placing energy at disposal (under an ESD), and amount of consumed energy resources during the building service life ELODIE calculates the environmental impacts of the site energy consumption. These impacts are dependants of factors such as: the losses in production, transmission and distribution of energy on the grid scale, generation and distribution efficiency in the building itself, nature of combustible (coal, wood, fuel, etc.), etc. Among the multi criteria results, the amount of primary energy used to provide end users site energy is specified. ELODIE database contains few generic ESD, but the user can create his own ESD.

## 2.4 Water consumption contribution

ELODIE estimates the water consumption of a building using as input data: 1) some building characteristics such as floor area and its geographical location 2) the number of occupants and their behaviour 3) some characteristics of the water distribution network such as the hot water production device and the presence or not of the water pressure regulator 4) the characteristics of the water-using equipments (toilet flush type, shower flow, washing machine type etc.). The user can choose several types of equipment intended for the same use (e.g. a 6L toilet flush and a 6L/3L dual flush toilet) as well as the equipment which he wishes to integrate in total calculation (e.g. to not take into account the consumption of the washing machine or to take into account only the inside uses etc). ELODIE

could also estimate the cost of consumed water and to highlight the equipments whose impact is most important on the total water consumption.

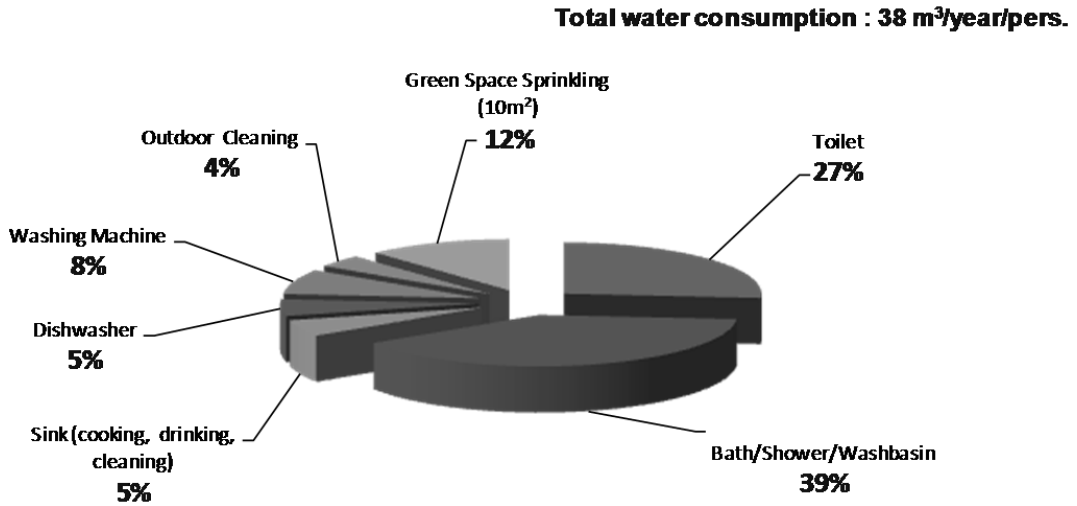

Figure 2: Example of results on water consumption of a housing

# 3. ELODIE and the building information model (BIM)

ELODIE has an internet interface which is connected to the INIES database. ELODIE is compatible with IFC (Industry Foundation Classes) formats, allowing a full integration in building project processes. The quantity of each product already occurs in the numeric description of the building. Those quantities can be easily transferred to the ELODIE software if the IFC format is used. In the best cases ELODIE will only need to ask for the lifetime of the building, and will calculate alone immediately the environmental impact of the building describe in the IFC format. The goal of the compatibility with the IFC format is to avoid having to capture data twice.

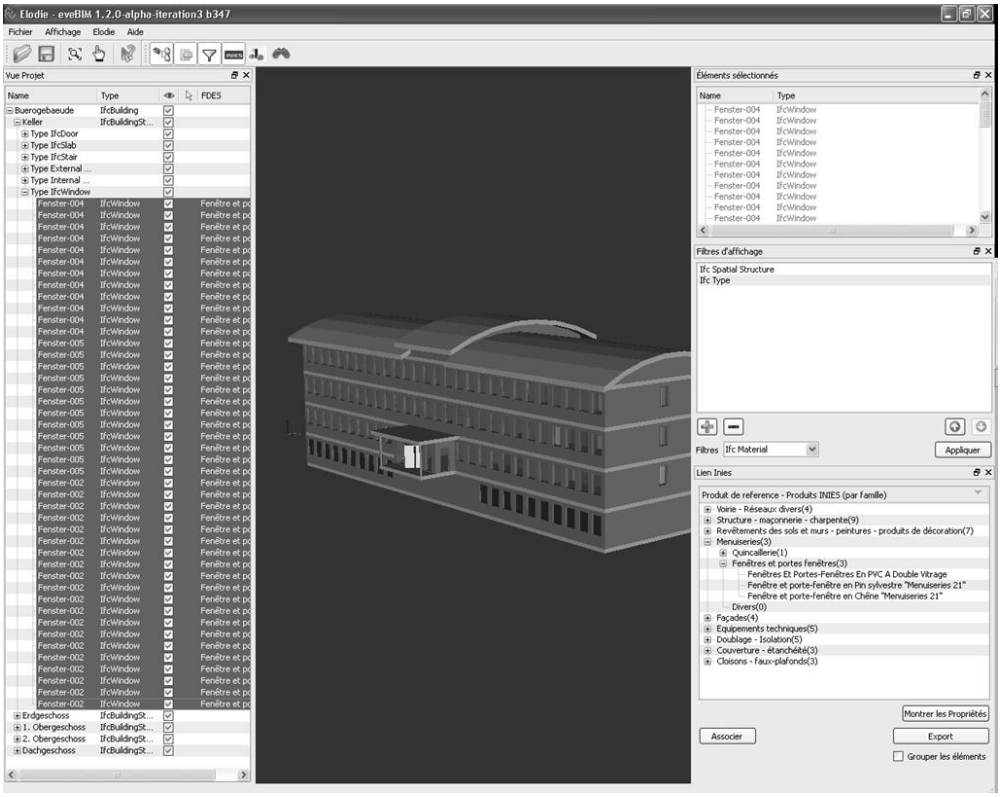

Figure 3 : The Building Information Model is used to connect product to their EPDs

# 4. ELODIE's results

ELODIE provides, as a principal result, an environmental profile of the building, which compiles all the contributions of the various products, the site energy consumption and the water supply. This profile corresponds to the environmental indicators of the NF P01-010 standard, preserving all of them for a better transparency of the results. ELODIE allows considering distinctively the contributories impacts: building products, energy and water supply.

The calculation of the contribution of the construction products gives as results the opportunity for construction sector actors (designers, client, project managers…) to design a building with an environmental friendly approach : it makes possible to compare several alternatives for the same building or for the same part of work realized with different components, different materials, and even different constructive modes.

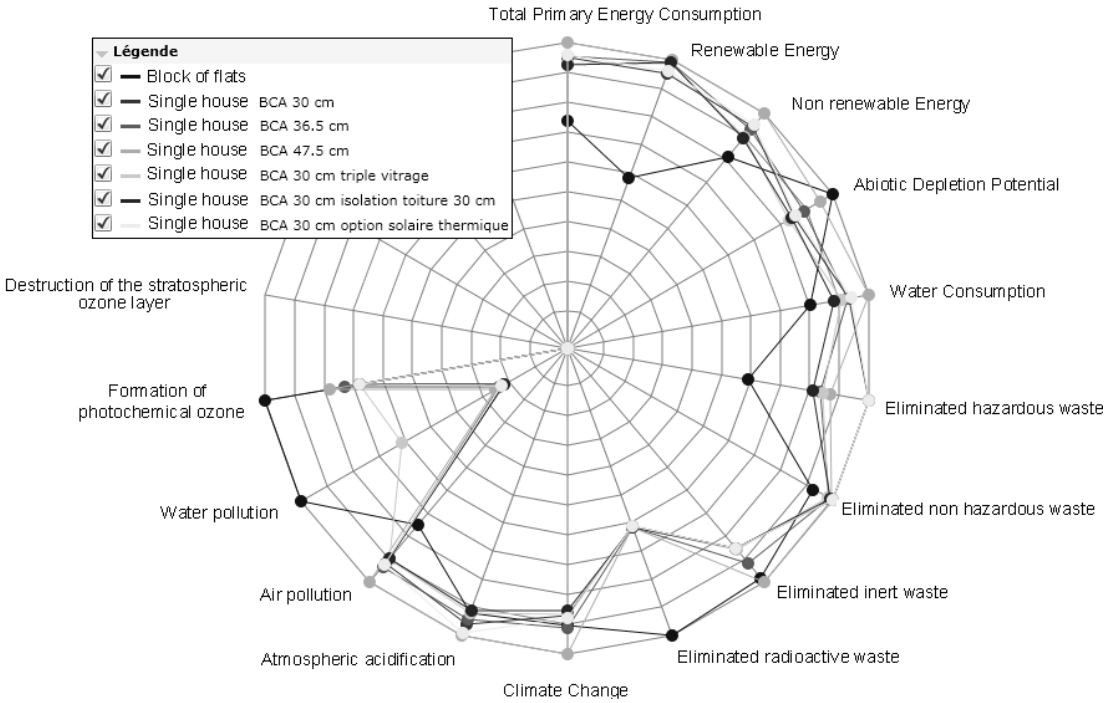


Figure 4: Analysis of results: Comparison of various constructive solutions for a single house, on the environmental impacts of the building.

The results of the product module contribution must be considered with energy and water contribution results in order to consider the whole environmental performance and avoid impacts transfers.

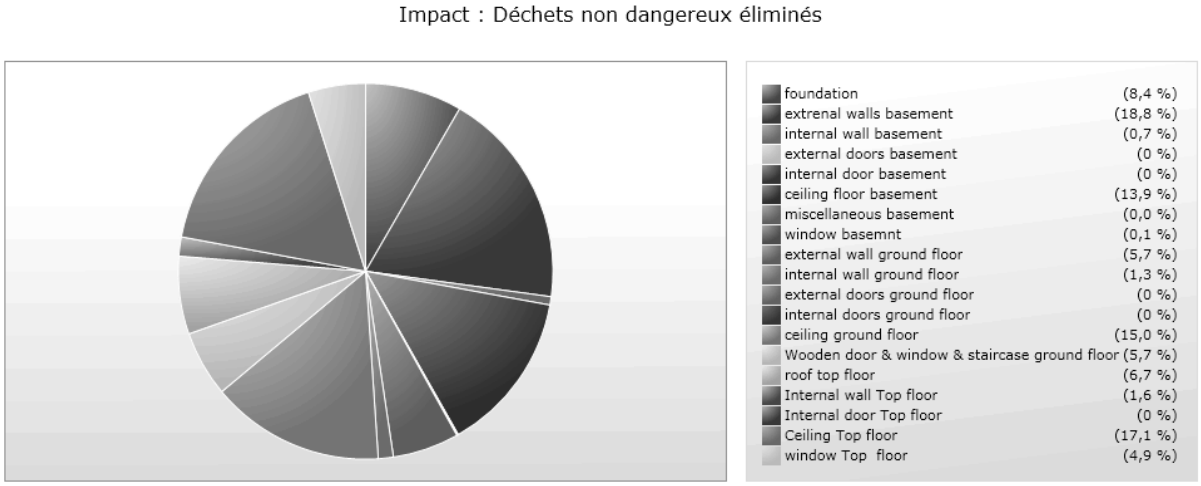


Figure 5: Analysis of results: Example for one impact indicator for a whole building, displaying the main contributors

# 5. Experience feedback:

We worked with manufacturers, designers, association to analyze the impacts of constructive solutions, to identify the contribution of products and operating energy consumption in building environmental performance, etc. For example, we evaluate – on the whole all life cycle environmental - the contribution of few specific products, considering several standard buildings, corresponding to different level of French thermal building rules, different technical solutions, a potential optimum (between environmental and thermal performances), etc.

The used data were the following ones:

- French Environmental Product Declarations (EPDs, according to NF P-01-010 standard ),
- environmental contributions of Operating energy consumption (heating, sanitary hot water, air cooling, air conditioning, lighting) are considered using French environmental Service Declarations (ESDs),
- the service life of building is considered to be 50 years.

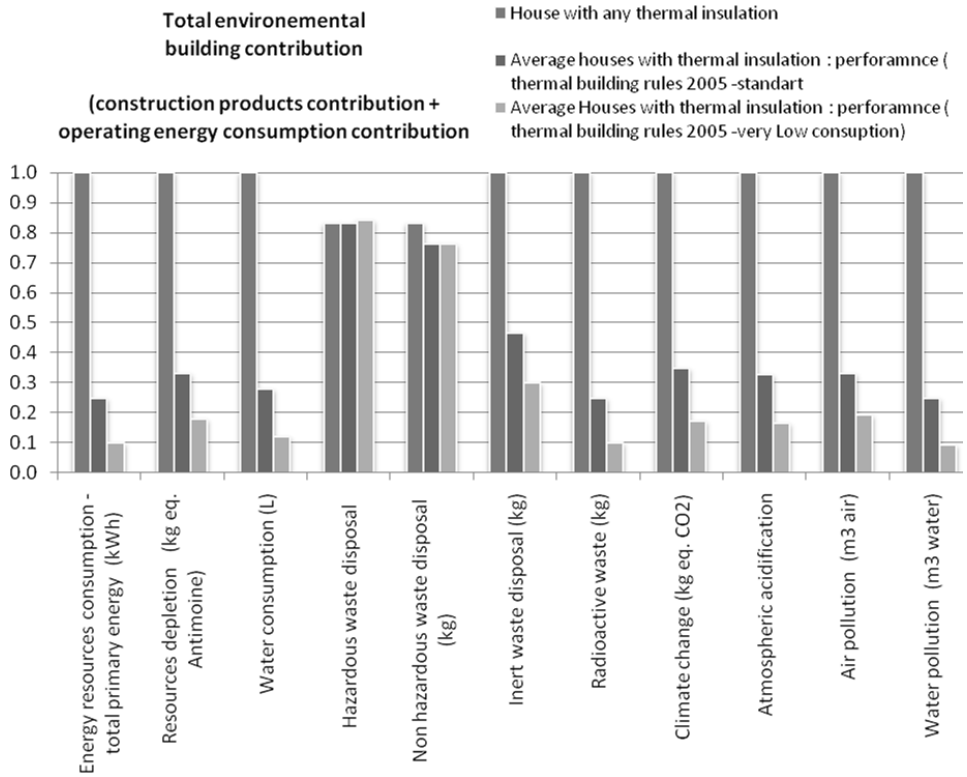


Figure 6 : Example of results: the environmental impacts of thermal insulation for a housing.

A first benchmarking has been done from the first building simulations on ELODIE. Results have been statistically analysed in order to define average data for each element of the building typology (house, tertiary, etc.), maximum and minimum targets. The influence of the structure product

(concrete, wooden, bricks, etc.) as the typology and the level of insulation have been considered. These results have to be consolidated before to be the base of a future regulation.

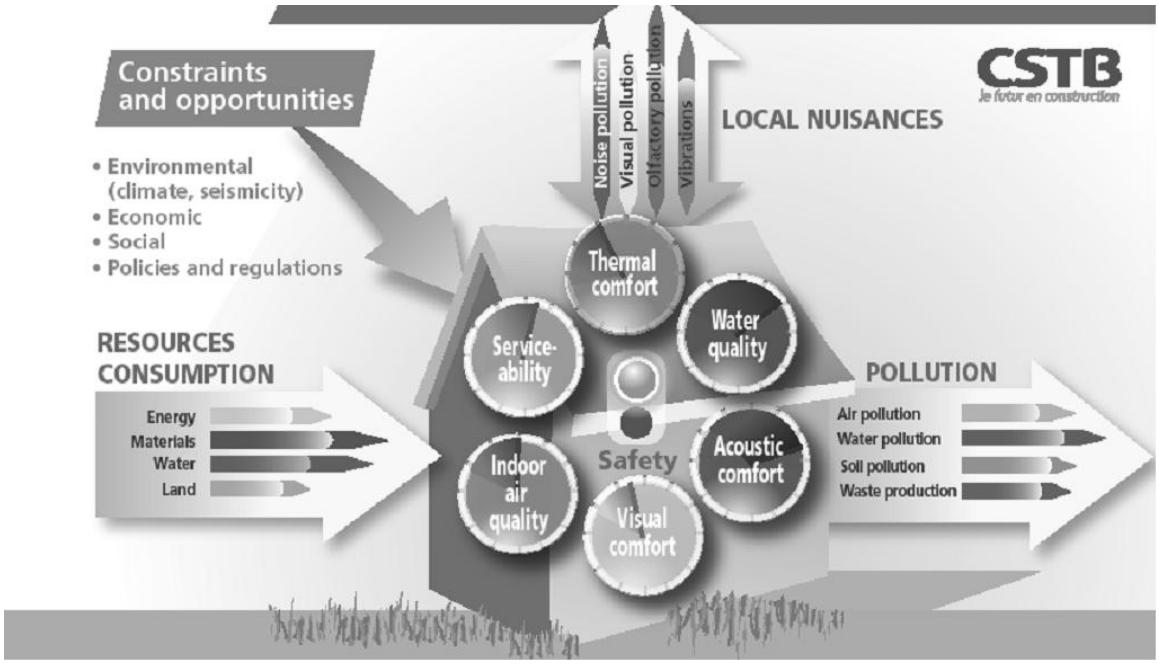

Figure 7: Building environmental Performance

# 6. The tool's perspectives

After one year of testing with stakeholders, (they were about 1200 to be enrolled), ELODIE is diffused to a professional use after one-day training. A free version will still be available for testing and private use. By the middle of 2010, the tool will integrate new aspects (i.e. user's transportation, site waste) in its environmental assessment model. Step by step, ELODIE will integrate health and comfort aspects (hydrothermal, acoustic, visual comfort and olfactory comfort, serviceability, indoor air quality).

Construction sectors actors became more and more aware to environmental aspects at product and building scale. They are asking for a quick dissemination and evolution of environmental assessment tools or models as ELODIE. Moreover, professionals need reference scales to analyse their own results, and methodology guidelines.

Several evolutions are planned to improve the tool, in order to propose a making-decision tools and more analysis elements. One of the next steps will be to propose an evaluation model adapted to every typology and every conception and construction stage, with the objective to simplify of the physical building model.

Endly, this kind of tool will become support for the French energy and environment labels on buildings (HQE certification, energy labels derived from the French energy regulation on buildings…).

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