First International Conference on
Bio-based Building Materials

June 22nd - 24th 2015
Clermont-Ferrand, France

# ENVIRONMENTAL IMPACTS OF AGRO-SOURCED MATERIALS COMPARED TO TRADITIONAL MATERIALS INTO BUILDING

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**Abstract**
Building sector is undergoing a revolution with the development of innovative techniques and materials which significantly improved the performance of buildings. Insulation and concrete based on agro-sourced aggregates have been developed and marketed for several years now, posing as "eco-materials" and judged with less impacts to the environment than their "conventional" counterparts. Many Life Cycle Assessments of these kind of products has been made, showing in many cases, with an equivalent functional unit, an environmental benefit for the agro-sourced materials. This raises the question of the real environmental benefits of using these innovative agro-sourced materials, not more simple comparison with conventional products, but across the full life cycle of the building. Therefore, this article proposes to model a type reference building constructed two radically different ways : one with conventional building products, that is to say materials with mineral and petrochemical base and another one with integrating the maximum agro-sourced materials currently available on the market (insulation, concrete, block, glue, etc.). The objective is to conduct a comparative study analyse and interpreting differences in results between the two models. The findings of this study show significant differences in terms of overall impact on the entire life cycle of buildings. A zoom on the "Products and Equipment" section allows to be aware of the benefits of using these kind of materials. This result suggests also imply, in the case of renovation, the use of agro-based materials is very favourable to environmental assessment as mainly based on the replacement of materials.

**Keywords:**
Life Cycle Assessment, Agro-resourced building materials, Eco-design

## 1 INTRODUCTION

The origin of this study is mainly due to various publications [1-5] on the subject showing that the contributor "Materials and Components" remains the dominant contributor (outside the scope of the movement uses the building) compared to the energy and water consumed in the life cycle of the building or the construction phase and end of life.
This article has absolutely no purpose for the comparison of different software available on the French market. Its main objective is the modelling of a house of 140 sqm² according constructive solutions: one designed and constructed in the traditional manner with materials and traditional building products; and the other with the massive use of agro-sourced products and materials (animal or vegetable and available on the market), which company would achieve the high level of the new " bio-based" label (ie 84 kg of agro-sourced material / sqm² floor).
The scope of the study is a first step all contributors building: components / materials, energy consumption, water consumption, displacement, construction, waste [6-7]. In a second step, we will zoom on the "Components / Materials" contributor to observe the influence of the implementation of agro-sourced in the construction of individual house materials.
Modelization is performed on the French Software of buildind LCA : ELODIE Version 2 which includes nearly 1,200 EPD : Environmental Product Declaration (according to NF P 01-010).
The results will be analysed to identify the impact of the use of such materials in the design of houses.

## 2 MATERIALS AND METHODS

### 2.1 Functional equivalent

The functional equivalent of the two cases studied is the same to conduct an objective and valid comparison: "Construction and Use of a detached house of 140 sqm², according to RT2012 (French Thermal Rules of 2012), which can accommodate a family of 4 people in urban periphery of Amiens, with a lifetime of 50 years".

### 2.2 System boundaries

This is a fictional case study but incorporating elements and actual data on French territory.
The boundaries of the system take into account the home and the garden next to it through various contributors:

- Energy consumptions related to housing ;
- Products, materials and equipment ;
- Construction ;
- Consumption and water discharges ;
- Waste ;
- Transport users.

## 3 VARIANTS EVALUATED

Traditional house of 140 sqm² with a floor, built with materials conventionally used in France, with the following main features:

- Shallow foundations sole kind shooting ;
- Bearing walls of concrete block with horizontal and vertical cross-references ;
- Concrete slab on slab PS ;
- Classic wood timbers with terracotta tile ;
- Inner insulation panels of glass wool ;
- Scratch coat ;
- Parking and asphalt roads ;
- Aluminium joinery ;
- Concrete floor ;
- Partitions interior 13 mm Wallboard with mineral acoustic insulation.

House of 140 sqm² with a floor built with agro- based materials marketed and readily available in DIY market, with the main features:

- Shallow foundations sole kind shooting ;
- Roof terrace;
- Wood floor ;
- Roof insulation panels Excelsior ;
- Isolation o bulk cellulose;
- Timber framing spruce ;
- Raw wood cladding ;
- Wood joinery ;
- Partitions interior 13 mm Wallboard with acoustic insulation linen ;
- Parking lanes and agro- based materials.

| Indicator | Unité | Traditionnal house | Agro-resourced house |
|---|---|---|---|
| **Consumption of total primary energy resources** | (kWh / m²) | 3,72E+04 | 3,23E+04 |
| **Consumption of non renewable energy resources** | (kWh / m²) | 3,54E+04 | 3,04E+04 |
| **Climate change** | (kg équivalent CO2 / m²) | 2,82E+03 | 1,98E+03 |
| **Water consumption** | (L / m²) | 1,68E+05 | 1,61E+05 |
| **Hazardous waste** | (kg / m²) | 4,29E+01 | 3,26E+01 |
| **Non hazardous waste** | (kg / m²) | 2,33E+03 | 1,72E+03 |
| **Radioactive waste** | (kg / m²) | 1,48E+00 | 1,42E+00 |
| **Atmospheric acidification** | (kg équivalent SO2 / m²) | 1,24E+01 | 7,84E+00 |
| **Formation of photochemical ozone** | (kg équivalent éthylène / m²) | 5,74E+00 | 7,43E-01 |

*Figure 1 : Absolute comparison of the environmental impacts.*

## 4 RESULTS

Figure 1 clearly shows significant differences (that is to say at least 15 to 20 % difference) between the two kinds of house.
The most significant results concern the indicators :

- Climate change: 30 % difference less for agro-sourced home, a drop of nearly 1,200 tons of CO2 over 50 years. Which is not less than 5.5 million kilometres travelled by a French car average guy.
  This difference may be partly explained by taking into account the storage of CO2 by plants during their growth and before their transformation into agro-sourced materials.
- Atmospheric Acidification: 34 % difference less for agro-sourced home, a decrease of 640 kg SO2 equivalent of 50 years so a significant decrease in the amounts of acidic substances in the atmosphere.
  This difference is not directly quantifiable in terms of reduction of forest dieback or acid rain but it helps.
- Formation of photochemical ozone: 87 % difference in the house for less agro-sourced, a decrease of 700 kg ethylene equivalent in the atmosphere.
  With this indicator, the difference in impact is not quantifiable but photochemical ozone is causing ozone pollution that occurs very frequently in large cities.

*Note that the indicators do not show significant differences (differences less than 20 %) are still in favour of agro-sourced house.*
These preliminary results can advance without the risk of major errors the house agro-sourced have positive effects in terms of environmental impacts since they are reduced between 20 and 80 % according to the indicators, compared to a conventional home.
Then, zooms were also conducted on the contributor “Materials and Component” on different indicators for well aware of the differences between the two models.
The conclusion is clear: in the case of the traditional house, the "Products and building materials" are the major contributor in three cases : Climate Change, Waste, photochemical ozone formation and the second for the "Total Primary Energy ". While for the agro-sourced home, "Products and Building materials»

come twice in second position and also once in fourth position. Clearly, the contributor "Products and Construction Materials" takes less pregnant place in the case of agro-sourced as traditional house home, even energy and water consumption and waste. A study has been realized on building LCA contributors to evaluate where the main impacts are.

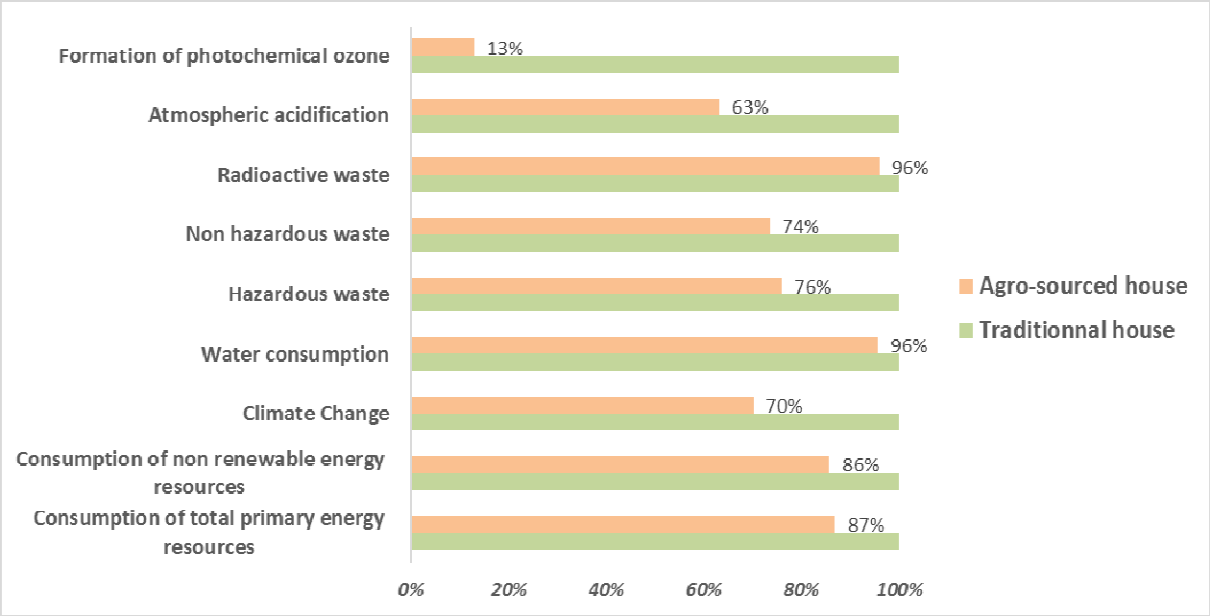


*Figure 2 : Relative comparison of the environmental impacts*

As we can see in these figures, we can conclude:

- Traditional house : “Construction materials” are the major contributor in three cases : Climate Change, Waste, photochemical ozone formation and the second for the "Total Primary Energy".
- Agro-sourced house : "Construction materials" comes twice in second position and also once in fourth.

Clearly, the contributor "Products and Construction Materials" takes up less pregnant in the case of agro-sourced as traditional house home, even energy and water consumption and waste.
Then, a focus has been made on technical batches to identify where come from the environmental impacts.

The distribution of impacts depending on the type of house is very different :

- Traditional house, predominant categories:
  - Superstructure masonry with all bearing walls and concrete slabs for the home;
  - Cover Sealing Frame Zinguerie with framing and insulation;
  - Partitioning Suspended Ceiling Lining Interior woodwork.

These three categories weigh on the set of indicators used in Figure 3 to about 80% of total impacts contributor.

- House agro-sourced, predominant categories :
  - Roads and Utility Services
  - Foundations and infrastructure
  - Superstructure Masonry
  - Facades and exterior woodwork with wood siding.

These four categories weigh on the set of indicators used in Figure 3 between 70 and 80% of total impacts contributor.

## 5 CONCLUSIONS

This study is a first positive step for the use of agro-sourced products across the building materials since demonstrated by the Life Cycle Assessments, the use of such materials may be an asset for reducing environmental impacts throughout the life cycle of the building.
Note that the processes of agro-based materials are still young for some and should be optimized in the future and reduce their energy consumption and achieve better returns.
However, the use of agro-based materials is not always necessarily mean reductions of environmental impacts of a building. In fact, each project is unique, it must be ensured through the implementation of a Life Cycle Analysis Building for example, that constructive solutions and selected materials actually have benefits in terms of environmental impacts. Each case is unique and it is difficult to translate the technical responses to a project to another, especially when it is not located in the same territory. In all cases, the consistency of a project must always be in response to a need expressed by users to present coherent functions with their requirements.

Furthermore, the use of agro- based materials is not the only opportunity to allow to reduce the impacts of a building. Implementation of materials which manufacturers have integrated in their thinking the establishment of an economy regionalised approach with functionality , among other eco-design of their products throughout their lifecycle : from supply of raw materials to their management at end of life : maintenance / repair should be thoughtful, extended lifetime warranty with original performances and finally , recovery facilitated via a deconstruction and die early termination of life is the solution to reduce their environmental burden.

Finally, the environmental argument cannot be the only one used for the development and proliferation of agro-sourced in the market for individual materials. Other criteria may also be considered, including the development of social indicators and the development of social LCA among others that must be entered as a tool for decision support as well as technical performance criteria and environmental


*Figure 3 : Main contributors to environmental impacts in both cases*

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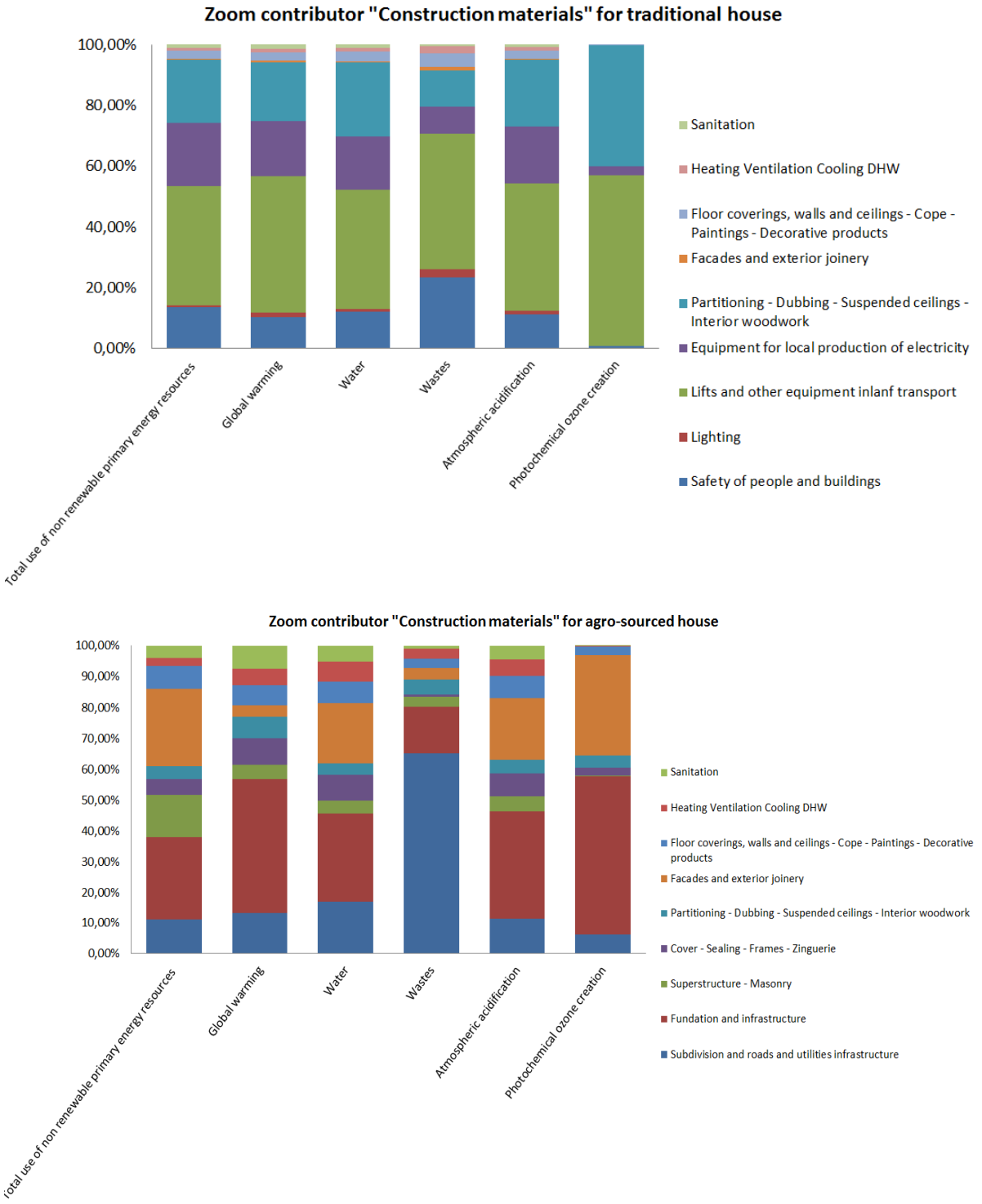


*Figure 4: Comparing relative value of environmental impacts of products contributor and building materials of traditional and agro-sourced houses*