

LCA as a tool to Identify the Advantages of Bioclimatic Architecture

B. Rivela, C. Bedoya
Department of Architectonic Construction and Technology, School of Architecture,
Polytechnic University of Madrid, Spain
brivela@usc.es

Keywords: Life Cycle Assessment (LCA), environmental performance, building, design implications

ABSTRACT

Nowadays, an increasing number of designers, developers and building users is aware of the environmental impact associated to building sector and more environmentally sustainable design and construction strategies are being encouraged. The objective of this paper is to assess the importance of bioclimatic design related to the environmental impact of the entire life cycle of a building. To do so, different exterior walls (envelope) were inventoried, including the production and manufacturing of construction materials involved as well as the process of the envelope construction. Operation phase activities include heating, cooling and ventilating the building. Lighting, water supply and water heating were leaved out according to the principle of excluding identical activities for comparative assessments.

When comparing bioclimatic options with conventional practices of design, the results show a significant improvement in the environmental performance when bioclimatic strategy is applied (65% to 70% for the categories analyzed according to Ecoindicator 99 methodology). This fact is explained in simple terms by the saving of energy consumption during the use of the building.

Introduction

Commercial buildings contribute significantly to resource consumption, as well as to other environmental impacts such as air emissions and solid waste generation [1]. Construction uses more raw materials than any other sector, and the creation and operation of the built environment accounts for an important consumption of natural resources. The "cradle to grave" aspects linked to the creation, use and disposal of built facilities constitute major environmental impacts, accounting for the largest share of greenhouse gas emissions (about 40%) in terms of energy end usage. Therefore, there is a clear challenge for the construction industry if a long-term sustainability is aimed.

Nowadays, an increasing number of designers, developers and building users is aware of the environmental impact associated to building sector and more environmentally sustainable design and construction strategies are being encouraged. Sustainable building strives to minimize the consumption of energy and resources for all phases of buildings life-cycle - from planning and construction through use and renovation to eventual demolition. Life Cycle Assessment (LCA) methodology has proved to be a valuable tool to help in the design of more environmentally responsible buildings by analyzing environmental considerations that need to be part of decision-making process towards sustainability.

Goal and Scope

The objective of this paper is to assess the importance of bioclimatic design related to the environmental impact of the entire life cycle of building. To do so, different exterior walls (envelope) were inventoried, including the production and manufacturing of construction materials involved as well as the process of the envelope construction.

In order to take into account the characteristics of typical private houses in Spain, an average area of 150 m² was

considered for a single-family house [2]. The two scenarios under study were (Figure 1):

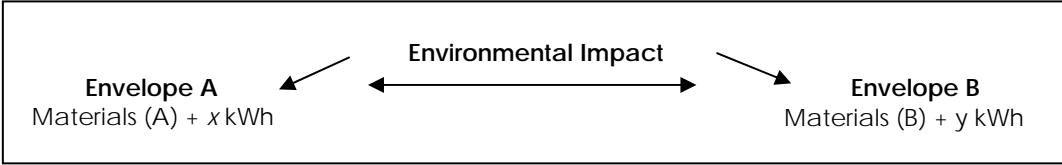


Figure 1: Functional unit of scenarios under study

-Envelope A: production of component materials of the “A” wall (Fig. 2) and construction of the envelope, as well as energy consumption associated to entire life cycle of the building.

-Envelope B: production of component materials of the “B” wall (Fig. 3) and construction of the envelope, as well as energy consumption associated to entire life cycle of the building.

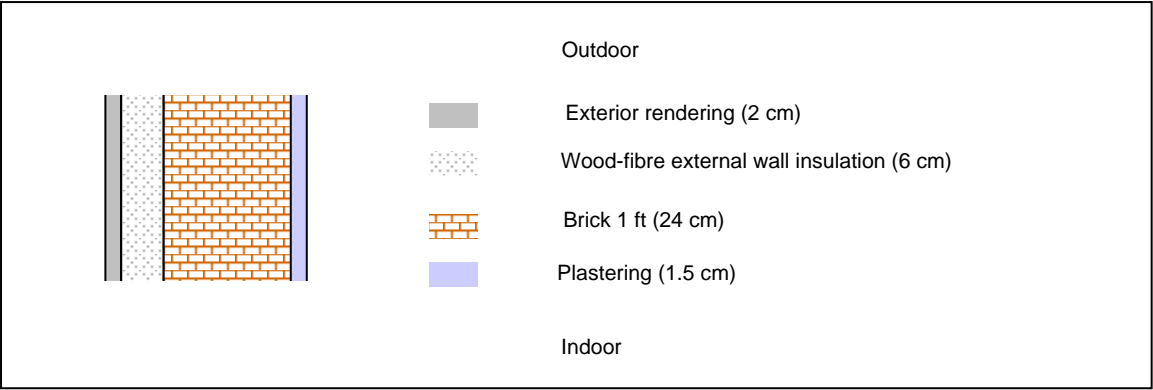


Figure 2: Description of envelope A

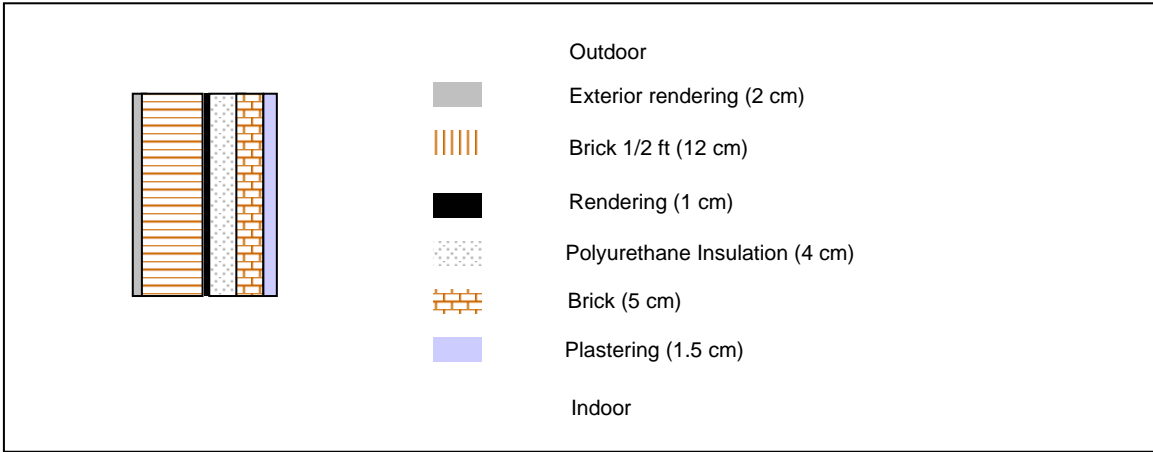


Figure 3: Description of envelope B

Life Cycle Inventory

The exterior walls were inventoried, including the production and manufacturing of construction materials involved as well as the process of the envelope construction. As far as the energy consumption is of concern,

operations phase activities considered include heating, cooling and ventilating the building. Lighting, water supply and water heating were leaved out according to the principle of excluding identical activities for comparative assessments [3].

Table 1 shows the energy consumptions for both scenarios with different locations (Madrid, Seville and San Sebastian) for the life cycle of the corresponding houses (30 years).

Table 1: Energy consumptions during the life cycle (30 years)

Envelope	Winter (kWh)			Summer (kWh)		
	San Sebastian	Madrid	Seville	San Sebastian	Madrid	Seville
A	239,805	226,665	200,385	42,705	45,990	49,275
B	640,575	558,450	440,190	279,225	374,490	436,905

The electricity profile is of major importance as it broadly affects the environmental impacts assigned to the use phase. The electricity generation profile considered in this work has been obtained from the Spanish Government Spanish Institute for Energy Diversification and Saving (IDAE).

Impact Assessment

The impact assessment was performed with the Ecoindicator 99 methodology, a damage oriented method which reflects the state of art in LCA and provides not only characterization (potential impacts of impact categories such as climate change), but also damage assessment for safeguard subjects [4-5].

The characterization step analyses the contribution of the different subsystems to the impact categories, essential to detect the ‘hot spots’. The results for the characterization step and damage assessment exhibit a high contribution of the use phase during the life cycle for both scenarios, with the exception of the categories of Radiation (R), Land Use (LU) and Minerals.(M). Figure 4 shows the relative contribution of the construction and the use phase for envelope A:

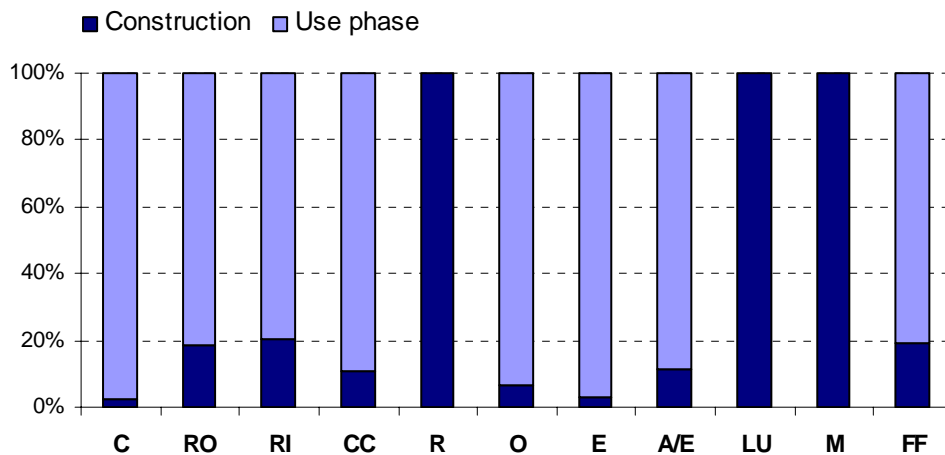


Figure 4: Comparative characterization of Construction versus Use Phase for envelope A. C: Carcinogens (DALY); RO: Respiratory organics (DALY); RI: Respiratory inorganics (DALY); CC: Climate change (DALY); O: Ozone layer (DALY); E: Ecotoxicity (PAFm²yr); A/E: Acidification/Eutrophication (PDFm²yr); M: Minerals (MJsurplus); FF: Fossil fuels (MJsurplus).

When comparing bioclimatic option (envelope A) with the example of conventional practices of design (envelope B), the results show a significant improvement in the environmental performance when bioclimatic strategy is applied. The normalization step, which intends to perceive the relative magnitude for each

environmental indicator under a non-dimensional approach, shows a reduction of the environmental impact from 65% to 70% for the categories analyzed, when envelope A is considered. This fact is explained in simple terms by the saving of energy consumption during the use of the building. Results from the normalization among the damage assessment are briefly presented in Figure 5.

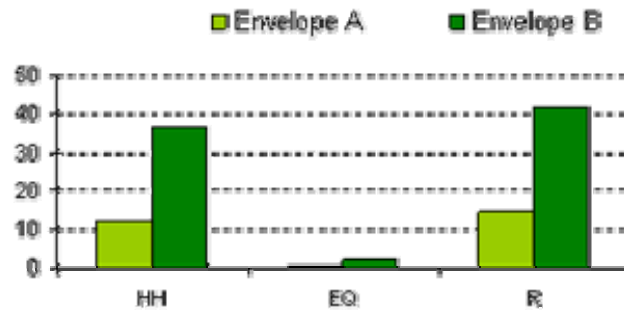


Figure 5: Comparative normalization of Envelope A vs. Envelope B. HH: Human Health; EQ: Ecosystem Quality; R: Resources.

Conclusions

The accomplishment of sustainable technologies by the construction sector depends on the demonstrated reduction of the emission loads with quantifiable economical benefits. Bioclimatic strategies are ease of application with minimum additional investments, and provide not only a large reduction of the environmental impacts but also a reduction of operational costs, which makes more viable their realization. Further research must be done to demonstrate improved environmental performance and the economy of the system when the life cycle is considered.

References

- [1] Scheuer C., Keoleian G.A., Reppe P. (2003), Life cycle energy and environmental performance of a new university building: modeling challenges and design implications, *Energy and Buildings* 35, 1049–1064.
- [2] Personal communication with Pedro Merino, Spanish Ministry of Housing.
- [3] Reynolds M., Fraser R., Checkel D. (2002), The Relative Mass-Energy-Economic (RMEE) Method for System Boundary Selection, *International Journal of Life Cycle Assessment* 5(1), 37-46.
- [4] Itsubo N. (2002), *International Journal of Life Cycle Assessment* 7 (3), 178.
- [5] Goedkoop M., Spriensma R. (2000), The eco-indicator 99 –A damage oriented method for life cycle impact assessment. Methodology report, Pré Consultants BV