POLITECNICO DI TORINO

Honors thesis

Course of Master degree in
Architecture for sustainable project

Abstract

Methods and tools for the environmental assessment of buildings. Comparison between conventional and natural building systems for housing

Tutor

Prof. Roberto Giordano

Co-tutors

Arch. Francesca Thiebat

Prof.ssa Valentina Serra

Arch. Tiziana Monterisi

by

Ema Madalina Budau

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The thesis consists in the application to a case study of methods and tools for the environmental assessment of buildings. Specifically, the work is divided into 3 parts:

• In the first part the properties of straw material are investigated, highlighting the possibilities of use in construction

• In the second part the case study is presented, with a description of both the design solution in wood-rice straw and the constructive hypotheses for comparison

• In the third part a comparison between constructive solutions is made based on the environmental impact and the energy efficiency

The thesis is based on some specific objectives that include:

1.The energy-environmental assessment of the wood-rice straw building

2.The comparison between the design solution in wood-rice straw with two constructive hypotheses employing conventional materials, based on the primary energy needs of the building, the environmental impacts associated with its life cycle and the construction time

3. The potential use of tools and results in building design

The object of analysis is a small residence, winner of the 2017^{th} Sustainability Award in the Restoration category, realized by the studio of arch. Monterisi in the municipality of Chamois, at 1,800 m of height. Given the impossibility of access to road vehicles, the transport was partly carried out by means of the helicopter, used for the mobilization of the structural components and window frames from La Magdeleine (a location 4 km away from the construction site).

For the analysis of the case study, analytical and comparative methods were employed: the former aim at calculating the energy and environmental performance of buildings, the latter aim at parametric comparison between buildings with regard to the wooden-straw solution. The study was based on the calculation of 10 energy and environmental indicators, 5 of which are particularly significant as indicators with global effects; these 5 indicators include:

1.Embodied and Operational Energy, related to the primary energy needs of the building

2.Embodied and Operational Carbon, associated with the CO_2 emissions produced by the building during its life cycle

3.The Water Footprint, related to the water needs of the building along its life cycle

As for the tools employed, it is possible to distinguish between softwares and spreadsheets. The former include the etoolLCD and SimaPro applications, aimed at assessing the environmental impact of buildings, while the latter include sheets for calculating the building's energy requirements, dynamic thermal parameters and CO_2 emissions associated with the building life cycle.

For the purposes of the study 2 criterias of comparison were considered: the first related to the constructive system of the building (in wood-rice straw, masonry and wood-rockwool), the second related to the life expectancy of the building: 50, 70 and 100 years. That way it's possible to define 9 comparison scenarios: 3 for each constructive system under examination. Once the study scenarios have been defined, the Building Energy Analysis (BEA) and Building Carbon Analysis (BCA) could be calculated. The BEA, expressed in relation to the m^2 of usable floor area, is given by the sum of the indicators of primary energy needs related to the initial phase (EE_I), the use phase (OE), the maintenance (EE_R) and the end of life of the building (EE_{FD}). The results of the BEA show that the highest

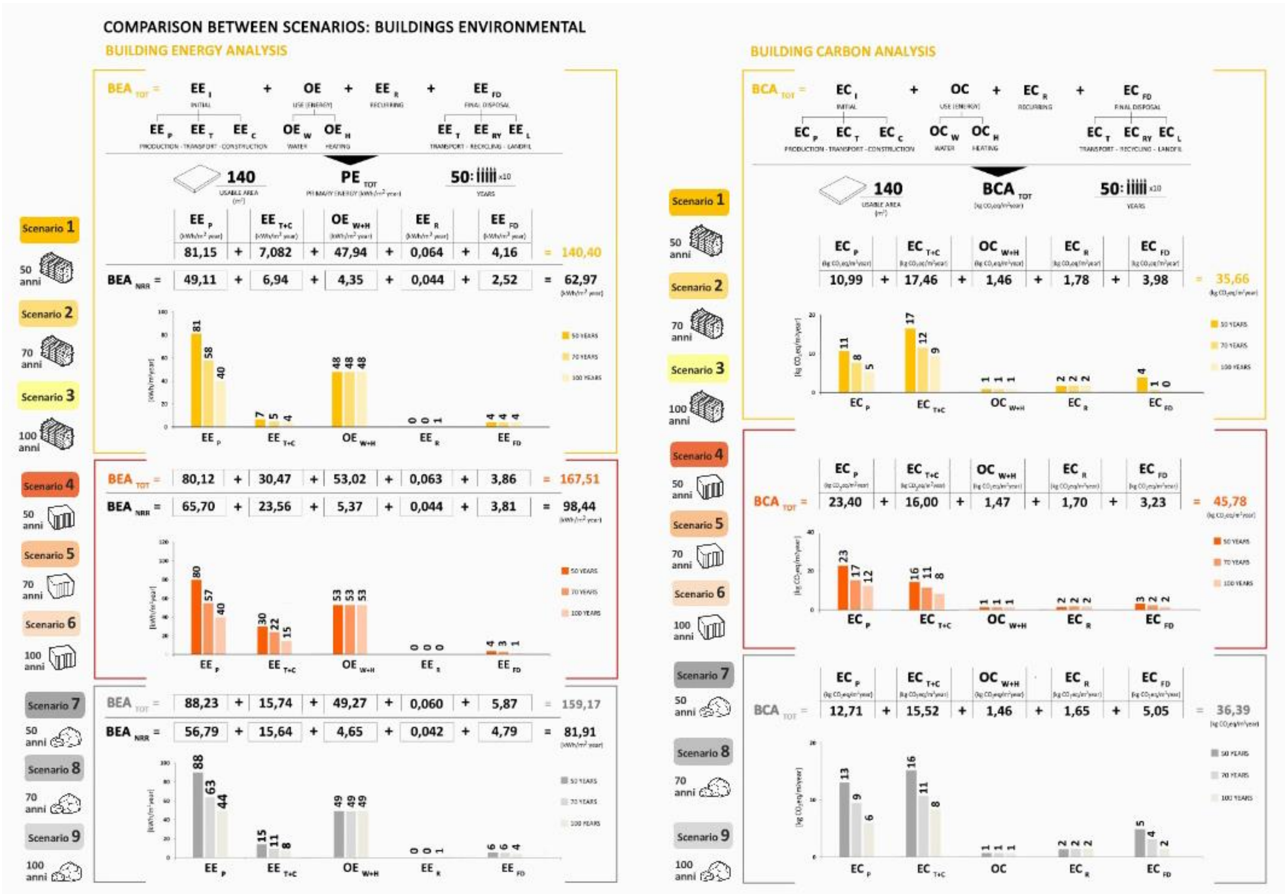
energy needs are associated with the production and use phases, followed by the contributions for the initial transport (specially by helicopter) and the construction phase. Similarly to the BEA, the BCA is given by the sum of the environmental vectors associated with the initial (EC_I), the use (OC), the maintenance phases (EC_R) and the end of life of the building (EC_{FD}) and it's also expressed in relation to the m^2 of usable floor area. In this case, for the wooden constructive solutions the greater environmental impacts are due to transport and construction phases, while for what concerns the masonry building it's the production phase to impact more on the environment.
In conclusion, the results obtained show that the design solution in wood-rice straw is the most sustainable in terms of energy needs, environmental impact and optimization of construction time. Moreover the thesis deals comprehensively with the issue of energy and environmental assessment of buildings thanks to the use of tools such as etoolLCD and SimaPro, which are used to assess the environmental impact of buildings from a life cycle point of view.

THE EXISTING BUILDING

YEAR OF CONSTRUCTION:	**1854**
USABLE FLOOR AREA:	**117 m^2**
GROSS FLOOR AREA:	**176 m^2**
STRUCTURE:	**LOCAL WOOD & STONE**
WINDOWS:	**WOOD & IRON (NO GLASS)**

THE PROJECT BUILDING

YEAR OF CONSTRUCTION:	**2016-2017**
USABLE FLOOR AREA:	**140 m^2**
GROSS FLOOR AREA:	**200 m^2**
STRUCTURE:	**PREFABRICATED WOODEN- STRAW FRAMES, LAMELLAR WOOD PILLARS & BEAMS**
WINDOWS:	**TRIPLE GLAZED WINDOWS & LAMELLAR WOOD FRAMES**



COMPARISON BETWEEN SCENARIOS - 50 YEARS BUILDING LIFE EXPECTANCY

	OE	EE	OC	EC	H_2O_{USE}	$H_2O_{INITIAL+END\ OF\ LIFE}$	$TIME_{CONSTRUCTION}$
Scenario 1 50 anni	47,94 kWh/m²s.u.*anno	92,46 kWh/m²s.u.*anno	1,46 kg CO_2/m²s.u.*anno	34,20 kg CO_2/m²s.u.*anno	0,037 m³/m²s.u.*anno	0,28 m³/m²s.u.*anno	6 mesi
Scenario 4 50 anni	53,02 kWh/m²s.u.*anno	114,49 kWh/m²s.u.*anno	1,47 kg CO_2/m²s.u.*anno	44,31 kg CO_2/m²s.u.*anno	0,037 m³/m²s.u.*anno	0,32 m³/m²s.u.*anno	9 mesi
Scenario 7 50 anni	49,27 kWh/m²s.u.*anno	109,90 kWh/m²s.u.*anno	1,46 kg CO_2/m²s.u.*anno	34,93 kg CO_2/m²s.u.*anno	0,037 m³/m²s.u.*anno	0,29 m³/m²s.u.*anno	7 mesi

LEGENDA

- Operational Energy
- Embodied Energy
- Operational Carbon
- Embodied Carbon
- Fabbisogno d'acqua in fase d'uso edificio
- Fabbisogno d'acqua in fase iniziale e di fine vita
- Tempo di durata dei lavori di cantiere

For further information please contact:
Ema Madalina Budau, emabudau@mail.com