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INTEGRATING LCA-BASED MODELS INTO DESIGN PROCESS FOR BUILDINGS: A STUDY OF THE EXISTING PRACTICES IN FRANCE

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ABSTRACT

Buildings have a significant impact on the environment throughout their life cycle. They are a major responsible for exhausting valuable natural resources and polluting the atmosphere through the emission of greenhouse gases. Nowadays, a high interest is manifested worldwide in constructing green buildings so that to limit the harm caused by human habitations on the ecosystem. In this scope, sustainable design is thus a primary thrust area. However, the development of eco-design tools as well as their implementation by building experts is still limited. In this paper, we investigate the eco-design practices as adopted nowadays by building designers and constructors in France. By using the results of a qualitative survey, we analyze how the environmental issue is considered in the decision-making process. Later on, a proposition of how and which stage eco-design tools could be implemented is discussed.

INTRODUCTION

The building sector is considered as a major responsible for the environmental impacts. In France this sector accounts for about 25 percent of the total CO2 emissions(ADEME, 2013). Consequently, environmental regulations, standardizations and building certifications are implemented so that building sector is forced to meet national commitments towards sustainable environment. Eco-design is being widely used in the development of new environmentally-friendly products. A number of tools, such as Life cycle assessment (LCA), are developed and being deployed since a decade (Haapio & Viitaniemi, 2008).. LCA assesses the environmental performances of a system over its entire life cycle (Bribia, Uson, & Scarpellini, 2009) (Ortiz, Castells, & Sonnemann, 2009) (Sharma, Saxena, Sethi, & Shree, 2011). There is no question about the great interest and the favorable deployment context of LCA in the design process. Some recent works promote LCA as a consistent tool for building's ecodesign (Malmqvist et al., 2010). However, in the French building sector, the use of LCA to support decision-making processes throughout design stages is still limited.

In the scope of capturing actual ecodesign practices and more specifically LCA implementation in building design in France, two studies are performed simultaneously: (i) an

exhaustive analysis of the building design process in France (ii) an investigation about the mechanisms used to integrate the environmental issue in the design process.

METHODOLOGY

The methodology adopted comprises two main steps undertaken through a research-action approach.
First, a comprehensive framework about the design process of buildings in France is established using a systemic approach. The objective is to identify actors involved, their actual needs and the promising stages where the introduction of environmental data can be useful. Design stages, respective inputs and outputs, design choices and engineering estimations and finally decision-makers are identified and characterized along the building project. Needs and constraints are also investigated. Preliminary based on literature review, the process framework was later on validated and refined by building experts.

In a second time, a survey on environmental practices in building's design process is carried out. Twelve semi-directed interviews are conducted on academics in building design, architects, engineers, eco-design experts, and Project Managers. Issues covered are clustered according 3 main topics: environmental approaches and certifications, assumptions usually defined while performing LCA and LCA integration into the design process.

RESULTS

The building's design process – a systemic approach

As depicted in figure 1, the common building's design process starts with client's needs and follows a sequential process: feasibility study, program, design, construction, exploitation, rehabilitation and/or deconstruction. Until design phase, main lines of the building's design, consisting in defining global solutions and performing estimations, are specified.

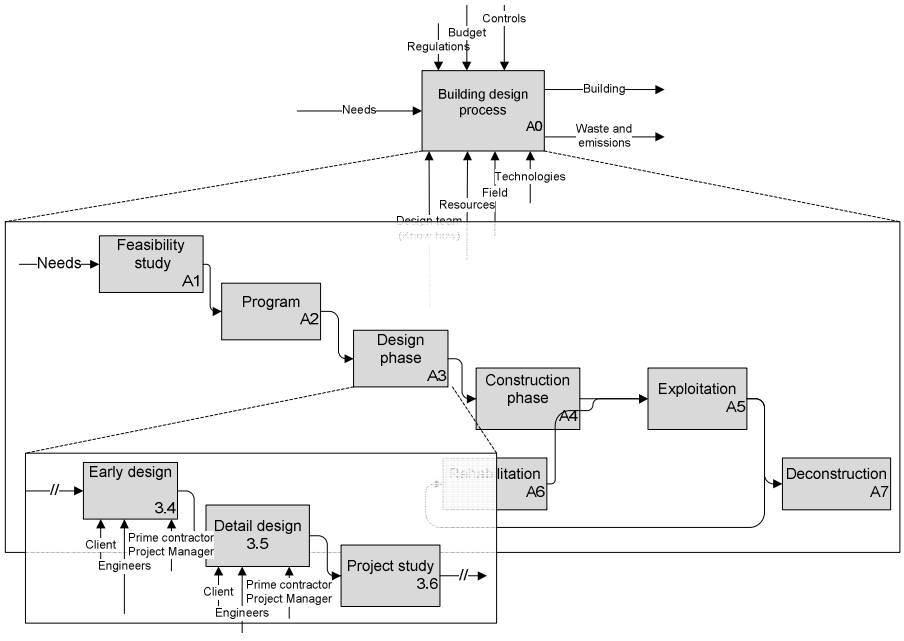

Figure 1: A systemic representation of the building's design process

The decision-maker is the project owner. Once design phase starts, estimations and design choices are progressively formalized. First technical solutions are evaluated and defined at early design stage. From this point, the project manager assisted by economists and engineers is in charge of design choices.

Ecodesign approach requires integrating environmental issues and life cycle thinking as soon as possible. In this context, early design phase appears as a promising step to introduce environmental concerns in design process until first technical solutions require evaluation and comparison. Moreover, even if the building's design process involved a lot of actors, the project manager is still the main decision-maker and has a holistic overview.

Survey on environmental approach and LCA deployment in building's design process

Major highlights from the survey are summarized as follow:

✓ Environmental approaches and certification

- Normative approaches and certifications as Breeam, HQE, LEED and labels for buildings materials are widely used but not systematic. Several limitations are pointed out:
- Certification is essentially performed to obtain competing advantages (not to increase building performances)
- Conflicting situations between environmental, cost and customer's satisfaction are revealed
- Cost is the main parameter the client considers in decision-making, thus trade-off are difficult to define

✓ Assumptions in LCA

- Lifespan is of high interest since it helps defining functional unit of the system under study (material and building). Nevertheless, it is now weakly integrated and theoretical lifespan is commonly used (50 years for building)
- Usage and consumer's behaviors are traditionally averaged when integrated

✓ LCA deployment and integration in decision-making

- LCA is rarely performed and essentially at the end of the design process
- LCA is often performed to feed environmental communication (EPD)
- Main limitations pointed out are: data unavailability, imprecision, the difficulty to deals with big systems as building and complexity
- At present LCA contributes to material choices (costs and user's behaviors are excluded)
- LCA contribution to decision-making is still limited until cost is a dominant criterion.

At present, environmental design is essentially driven by norms and client's requirements. Normative approaches are widely used while LCA is not commonly performed during the design process. Major applications are turned to communication and competing advantages.

DISCUSSION

The first results of this preliminary research suggest an increasing need to integrate environmental dimension in decision-making as soon as technical solutions are selected. Early design stage appears to be a promising step to initiate the dissemination of environmental data. For this sake, actual needs in terms of information have to be refined and

the implementation of simplified approaches of life cycle instead of traditional LCA is suggested. By this, overcoming the difficulty of large amount of data required is possible. In addition considering the importance of investment cost in decision-making process, the definition of the system's boundaries is of high interest. Indeed, building owners and users are often different persons with conflicting expectations. Thus, maximizing cost performance during design phase can lead to high maintenance costs and environmental impact during the use phase. For example, an ongoing study on three competing floor covering solutions highlights that choosing the cheapest solution engages 2 to 7 times more environmental impact and 0.5 to 0.7 more maintenance (preventive and corrective) costs during the use phase. The results reveal that environmental and economic performances are highly sensitive to material lifespan and maintenance cycles. In this context, developing LCA-models which combine environmental issue, life cycle cost and contextual users' behaviors is of high interest. The latter issue is confirmed in the work of (Zaraket, Yannou, Leroy, Minel, & Chapotot, 2013).

CONCLUSIONS AND PERSPECTIVES

In this paper, building's design process is investigated through a systemic approach. Twelve semi-directed interviews were conducted to survey ecodesign practices and LCA's level of deployment. This study reveals that the early phase of an ecodesign process is a promising stage where the environmental dimension can be integrated. At present, the environment issue is traditionally integrated in the decision-making through normative approaches. However, and despite its growing interest, LCA is not commonly used. Once applied, LCA results are used essentially as a mean of communication and competing advantage. Building experts explain this by the limitations of LCA (complexity, data availability), the exclusion of costs and the dominant position of cost in decision-making. Future works will focus on a better employment of LCA as a function of the needs specific to each design stage, as well as on the enrichment of LCA-based models by integrating cost evaluations and user's behaviors.

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