MILANO | MEXICO CITY | BANGALORE | CAPE TOWN | CURITIBA | BEIJING

3-5 April 2019

DESIGNING SUSTAINABILITY FOR ALL

Edited by Marcelo Ambrosio and Carlo Vezzoli

Proceedings of the

3rd LeNS world distributed conference

VOL. 4

ISBN 978-88-95651-26-2

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With the support of the Erasmus+ Programme of the European Union

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LeNS - the Learning Network on Sustainabilty - is a project funded by LeNSin Erasmus+ Programme of the European Union

the Learning Network on Sustainability

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SUSTAINABLE-ORIENTED CHANGE MANAGEMENT FOR ALL BUILDING DESIGN PRACTICE

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ABSTRACT

Design plays a key role in the transition towards Sustainability for All, especially in building sector demanding a change management to effectively enable the shift in thinking and in process. To this end, an assessment framework was developed to support design practice for integrating life cycle perspective into design process.

Indeed, the application of Life Cycle Thinking and related methodologies represents a turning point, calling for a profound transformation to switch from current to life cycle-oriented practice.

Based on current practice, the framework discloses for each phase of the process the set of life cycle information to be progressively considered and the connected actors in charge, envisioning the information-flow for a life cycle-oriented decision-making.

If the suggested framework is implemented in building design practice, remarkable effects will be visible, allowing practitioners to make aware decisions, avoid shifting problems, gain long-term perspective, optimize design process, lead decision-making and decrease construction impacts.

Key Words: design practice; change management; design process; life cycle perspective.

1. INTRODUCTION

The construction sector is esteem as one of the most incisive and impacting sector at a global scale, due to the high consumption of soil, natural resources and energy and the high emission in air, water and soil. Just to provide an overview, from the environmental point of view, it consumes each year about 3 billion tons of raw materials to manufacture building products worldwide and it is responsible for 40% of solid waste derived from construction and demolition and for 25-40% of the total energy use at global level. From the economical point of view, the construction industry collects total annual revenues of almost $10 trillion, accounting for about 5% of global GDP and employing more than 100 million people worldwide. Furthermore, from social point of view, it constantly shapes our daily life in unique ways, with high impacts on the users health status and well-being (WEF, 2016). On account of these, building sector encompasses not only all the three pillars of sustainability but it also affects them during the whole building life cycle, staring from the construction to the deconstruction/demolition process (Zhao et al., 2019).

In this context, design – as kick off phase of the building process – plays a key role in the transition towards sustainability for all, representing a strategic field of action to address the sustainable and environmental goals of construction sector along the whole life cycle. The hotspot in which to interfere is thus the set of design firms – as main responsible actors of the built environment - involving all the connected practitioners and working out on their way of practice to integrate a life cycle approach from the outset of the building process onward. Nonetheless, actually life cycle perspective is not so far established in current design practice, becoming for the building industry one of the main challenges of the next future (Ramani et al., 2010; Rusu and Popescu, 2018).

Purpose of the paper is therefore to disclose an assessment framework developed to support the design change management required for switching from current to life cycle-oriented practice. Focus is hence the design decision-making in terms of actors engaged, life cycle information considered and information flow suggested along the process.

2. BACKGROUND

Towards sustainability, the integration of Life Cycle Thinking (LCT) and the related methodologies within the design is even more considered as a turning point for the building sector to boost sustainable practice, promote environmentally-friendly innovations and business models (Antink et al., 2014). In fact, understood as a learning process, LCT helps identify where actions are most effective and efficient and thus improve resource efficiency with environmental, social and economic benefits (UN environment, 2017; Miah et al., 2017). However, the assimilation of a life cycle approach in all building design practice represents a demanding task, due to the complexities inherent buildings, the wide range of requirements to be achieved and the plurality of practitioners and disciplines involved. Furthermore, it calls within the practice for a shift both in thinking and in process.

The shift in thinking pertains to the mindset of all the actors involved during the project design, recommending to consider buildings not as objects but rather as unique systems where each individual part affects and is in relationships with the others. Moreover, it commits designers to direct the decision-making of each part and in turn of the building as a whole keeping in mind the entire life cycle and not involving – as traditionally happen – only the construction or use phase. In this way, during design, the set of products/components/systems are evaluated in relation to the proprieties and performance provided as well as, for instance, in relation to the distance between the factory and the site, the maintenance required, the service life declared and the reuse and recycle possibilities.

In addition, to face the complexities of buildings as systems and the amount of information and choices required during the decision-making, a shift in process is needed to change management in the way of design practice. Over the year, designers were trained in the process of optimizing each part of the system in isolation, but today this practice is no more compelling to fit current needs towards life cycle sustainability. Indeed, in the age of specialization, a single actor is not able to address all data and meet all building requirements: miscellaneous competences are engaged, bringing their specific know-how and interacting each other to look at the whole considering the entire life cycle. The integration of LCT into design entails therefore not only the understanding that every building system is in relation with other systems and the surrounding environment, but it also demands a holistic process where everybody integrates their work rather than design in isolated silos.

To this end, the challenge is twofold. On one hand, building need to be designed as systems, where every sub-system and component impact all the others. On the other hand, the design team itself need to function as a system (Boecker et al., 2009), where all design members have to be aware on how the decisions undertaken by each affect the decision made by all other, with the aim to jointly design and achieve sustainable and high-performance buildings. On this purpose, the information flow among the involved actors deserves particular attention for the decision-making process.

3. FRAMEWORK DEVELOPMENT

To support practitioners in the change management required to implement life cycle design, an assessment framework was developed with the aim to integrate LCT in building design practice. In particular, to put into effect LCT, that represents a general mind-set, Life Cycle Assessment (LCA) was taken as reference frame (EN 15978:2011; EPD PCR UN CPC 531:2014), providing an added value since depicts a standardized methodology affirmed at international level. Note that for this reason it refers from the outset to environmental issues but with wider purpose, representing for instance the elementary frame also for economic issues. By contrast, design practice was deepened in relation to the design process, adopting and harmonizing classifications recognized worldwide (AIA, 2014; RIBA, 2013). In this way, the basic matrix of the framework is established, on one hand, by the different stage of life cycle from cradle to grave and, on the other, by the different phase of design process. On this basis, the framework sets out the life cycle information to be gathered along the process and the related actors in charge, disclosing the information flow required in practice for a life cycle-oriented decision-making.

The identification within the basic matrix of the life cycle information and related actors and thus of the resulting information flow along the process was done through three main development steps. The first step identifies them for each life cycle stage and process phase by means of hypothesis based on the sustainability researches available in literature, providing the general concept of the assessment framework. The second step is their mapping based on the design process of real building projects, providing the testing of the assessment framework ex-post the process, not affecting directly the decision-making but giving an overview on how it is actually faced by current design practice. The third step is the adjustment of the supposed life cycle information, actors and information flow based on current practice, providing at the end the assessment framework proposal to implement life cycle-oriented practice.

The methodology adopted for the framework development interrelated therefore the know-how acquired in the field of research about sustainability and life cycle approach with the ethnographic experience conducted within an US architectural and engineering firm affirmed at international level and joined for the deepening of the project case studies. Indeed, ethnography is now emerging as part of the set of techniques used to understand the construction industry (Pink et al., 2013), a sector considered extremely complex and influential but that despite this remains mostly unexplored and under-theorized. The effort was thus to fill the gap, looking into the current state of life cycle integration into design practice to consequently recommend through the assessment framework how to gradually implement and strengthen a life cycle perspective during the decision-making process.

4. FRAMEWORK TO SUPPORT LIFE CYCLE DESIGN

Based on current practice, the framework discloses for each phase of the process the set of life cycle information to be progressively considered and the connected actors in charge and information flow in order to implement a life cycle perspective into design process. In this regard, it is worth mentioning that the framework was tailored to fit the most demanding projects, in particular new building projects with federal mandates and called for LEED certification. In this way, it recommends the most virtuous life cycle-oriented building design practice feasible at current state but that can be overcome in the next future when more life cycle data and database will be available. Moreover, it allows to provide some levels of simplification for its implementation also in less complex projects, depending on how deeply life cycle perspective has to be integrated into the design process in relation to the building project at issue.

Concerning life cycle information, it is important to underline that the framework focuses only on life cycle quantitative data, since they represents the type of information directly demanded to design firms and therefore to bear in mind during the design process. Furthermore, the aim is to support and promote along the process, on one hand, a progressive implementation and, on the other, a progressive detailing of the life cycle information accordingly to the process development. For this purpose, to simulate the progressive definition of the design process in a realistic way, the life cycle information recommended by the framework were established in compliance with the minimum submission requirements defined by federal mandates specifications.

For each advised life cycle information, the design team is expected to integrate within the framework the relative life cycle data according to the design phase in progress. In addition, for boosting the optimization of the process, the whole set of life cycle quantitative data embedded in the framework turns out to be the thresholds to be not exceeded in the following phases of the process, if not expressly justified and proved. This is certainly valid in the transition of one phase to another of the design process as well as in the shifting from the design process to the construction process. Indeed, it is expected that in a life cycle-oriented practice the final life cycle information related to the building projects will be included in the specifications, placing constraints on the selection process of the bidding phase.

The suggested assessment framework intends therefore to support the implementation of LCT into design process, pointing out step by step the life cycle information in relation to the different process phases and showing a growing level of detail and accuracy during the process. With regard to materials selection process, for instance, it endorses an approach by parts, progressively evaluating alternative options for each technological system designed and choosing materials based on life cycle criteria.

4.1. Empowering design disciplines in the accomplishment of life cycle tasks

To support the change management demanded to shift from current to life cycle-oriented design practice, the proposed framework discloses the set of life cycle information to be considered during the design process. However, due to the amount of information required, to put the framework into practice, the life cycle information were broken down for each involved technological elements, explaining thereafter the competences responsible for each technological element related to both construction materials and building systems. In this way, the actors in charge of gathering the recommended life cycle information were identified in order to share the connected roles. Based on the analysis of current practice and on the set of technological elements in question, the involved competences turn out to be the following: architecture, interior design, structural engineering, mechanical engineering, plumbing engineering, electrical engineering, building energy design and environmental design/sustainability.

Envisioning a life cycle-oriented practice, each of these competences is responsible not only for the design of the committed technological elements – as happens nowadays – but also for finding and evaluating along the process the connected life cycle information. To this end, the suggested assessment framework supports the appointed actors in the progressive implementation of life cycle information and data, establishing for each the information required at each phase of the process. Nonetheless, it is important to note that these actors represent the leading competences involved, with the awareness that also the pertaining specializations, if included within the project, may be engaged for the accomplishment of the life cycle tasks. Anyway, to not overburden their assignments, since each competence is entrusted with one or more technological elements and with all the connected life cycle information, the framework endorses a progressive implementation of the information and a growing level of detail and accuracy of the related data over the process. In this way, during the decision-making process each commissioned team of actors has to take into consideration step by step the quantitative data of the designed technological elements and to collect the related life cycle data in compliance with the progressive implementation stated by the framework.

With the aim to encourage the team in adopting a systemic approach for life cycle design, a personal worksheet was inferred from the framework for each competence in charge, explaining the main life cycle topics at issue for each technological element appointed in relation to the design phase. Note that, to allow a gradual integration of the life cycle information and data, only the main life cycle topics are included for each phase of the process, since potentially all could be taken into consideration at the same time.

In this perspective, for instance, along the design process, architecture team is in charge of the development especially of cladding, envelope, walls and floors solutions, being thus entrusted with the connected life cycle information, including them as further criteria for the decision-making process. As an example, concerning only the decision-making for cladding systems, starting from the early phase of the process focused on the definition of building massing, architects have to select the best building scheme including beyond architectural, functional and environmental issues, such as orientation, view and energy consumption, the amount of construction materials as further life cycle-oriented criteria. To this end, due to the preliminary phase and the still no definition of envelope materials, cladding area turns out to be the reference data, since it is indicative of the amount of construction materials and significant for the massing comparison. Going on with the process, the team subdivides the envelope in the glazing and massive parts, evaluating different materials for cladding solutions to be proposed to the clients in order to figure out the overall appearance of the building under design. In this case, in the assessment of different cladding materials, beyond the relative performance metrics and aesthetic features, materials quantity is taken as further criteria as well as the distance from the manufacturing in order to reduce the impacts derived from transport. Going on with the process, architects specify the assigned technological elements, calculating with a progressive level of detail the quantity of construction materials and embracing further life cycle-criteria. For each selected cladding solution, they concern the transport distance from factory to building site, the amount of construction waste, the VOC emissions as well as the materials and related transport required for both maintenance and replacement process. Furthermore, in overall terms, architecture team has to state the expected energy use for installation of products and water use for on-site production, assuming the first as percentage of the construction material and the second on the base of the adopted technological solutions. Finally, in the last design phase, architects update all the previous claimed life-cycle oriented data for cladding, providing additional specifications on the end of life stage, including transport of waste from building site to landfill, waste derived from deconstruction process and potential materials used for reuse, recycling and energy recovery. Thereafter, all details have to be clearly communicated to contractor as minimum requirements for the bidding phase as well as the complete drawings, fully coordinated with the other disciplines.

4.2. Information flow to build up a project-based life cycle database

If according to the framework all the involved design disciplines includes within the decision-making process the committed life cycle criteria, tracking all information in one-single and well-framed record, they progressively build up a life cycle database of the facility, envisioned in line with current trends in a BIM-oriented working environment. Indeed, following the framework recommendations, all the actors in charge and/or allowed contribute information to and extract information from the building virtual model, providing a long-term vision of the building project. In this way, the suggested life cycle BIM database allows the establishment in one-record of the life cycle information and data of the building in question, fostering a systemic vision of the project and representing an added value for the design firm as well as for clients and a continuous build-up of know-how.

In this perspective, contrary to what happens in current practice, the information flow demanded along the process does not involve the single competences in relationship when needed one-to-one for the exchange of information. In a life cycle-oriented design practice, all the responsible actors enter the life cycle data into the BIM model/database of the facility. In this way, all the life cycle data are collected in one single record enabling all the actors to insert their assigned life cycle information but also to use all the other available data to carry out the most varied design studies. Indeed, the whole set of life cycle data or part of it, depending on the cases, represents the input data required to perform the most miscellaneous environmental and life cycle design studies, constituting especially the building inventory phase for Life Cycle Assessment (LCA) but also Life Cycle Costing (LCC) analyses.

For this purpose, to build up the life cycle database of building projects, it is crucial to have the support of all the main competences, committed to considering, retrieving and entering the life cycle information and data of the assigned technological elements. The joint combination of all individual efforts results thereafter in the overall and systemic vision of the designed building, represented by the life cycle BIM database with the connected offered opportunities. However, since the implementation of life cycle practice is a challenging task, demanding a shifting both in thinking and in process, the project management competences have a key role in the transformation, being called for soliciting the involved actors in the accomplishment of the life cycle tasks and for verifying the congruency with the proposed framework. In this context, it is important to note that during the design process the actors in charge for the life cycle information and data remain almost the same: what changes are the life cycle topics and the technological elements to be progressively evaluated.

5. CONCLUSION

The proposed assessment framework was developed to support and enhance the necessary shift in thinking and in process required in practice to integrate LCT into design process. In fact, it points out not only the progressive set of life cycle information to be considered at each design phase, but also the related actors in charge and the resulting information flow demanded during the process. Concerning the recommended life cycle information, two are the key points stressed by the framework. On one hand, the progressive implementation of life cycle information and data to orient starting from the beginning the decision-making process. On the other, the growing level of detail of the data embedded in the resulting life cycle database of the project. Moreover, to put it in practice, it identifies as first the main competences that must be strengthened or implemented from a life cycle perspective. Thereafter, it assigns to each responsible competence the life cycle information and data to be progressively gathered and considered as further design life cycle-oriented criteria during the decision-making of the committed technological elements. Finally, depicting the information flow required during the design process, it provides an overall vision of the life cycle information required by each actor at each phase, pointing out the change management required to turn into life cycle AE(C) practice.

The application of the proposed assessment framework in practice is twofold. From the life cycle perspective, it solicits each responsible actors for the progressive inclusion of life cycle, establishing at the end in one-single record a project-based and well-frame set of data of the facility during the whole life cycle. This factor is crucial for the project decision-making, supporting practitioners to make aware decisions, avoid shifting problems from one phase to another and gain long-term perspective. Moreover, from the design process perspective, it allows the overall monitoring of the process as well as the verification or not of its optimization, since the assessed life cycle data stand for the thresholds to be not exceeded in the following phases of the process. This factor is pivotal to optimize design process, lead decision-making and to support practitioners in decreasing construction impacts. Nevertheless, it should be not underestimated that the implementation in practice of the suggested framework calls for a sharing of roles and responsibility. If on one hand this organizational set-up represents a point of strengths to put LCT in practice, not overburdening their design competences, on the other hand it constitutes a point of weakness, since it involves a wide range of competences that must be trained and successfully managed to embed life cycle perspective in all building design practice.

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