

THE INTEGRATION OF GREEN-BUILDING TASKS AND PROJECT-DESIGN PROCESS. - CASE-STUDY COMPARISON -

A INTEGRAÇÃO DAS TAREFAS DE SUSTENTABILIDADE COM O PROCESSO DE DESENHO DO PROJETO. - ESTUDO DE CASOS -

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Key Words

Green-building; Project management; Integrated process; LEAN; Process waste; LEED.

ABSTRACT

The development of a green-building project following a specific reference standard such as LEED, brings new conditions and restrains for all subjects involved in the process. Such changes affect technicians, owners, bureaucracy and also the management tasks either during design or construction phases. Within this scope, the management of sustainability-related activities plays a key role for the optimization of the design-project development. This research analyzes the design process of two different case-study projects undergoing the same green-building certification from the project management perspective. In both project sustainability-related activities were performed throughout the design process however, in one of them such activities were integrated to the building-design development and in the other they were not. The projects selected for the scope of the research is a new nursing home complex located in Northern Italy and an office building project in Barcelona (Spain) currently pursuing the LEED certification. A new methodology was created in order to analyze the project and evaluate the effects of detected project-management issues under three different points of view: costs, time and building sustainability. Such "issues" were identified by researchers on the basis of the LEAN-definition of "waste". The scope of the research is to demonstrate a positive relationship between integration of the process green-building tasks and successful development of green-building projects within the European construction environment. The results showed that integration of green-building tasks through the development of the design process can considerably affect the cost, schedule and sustainability of the project design.

1. INTRODUCTION

The importance of sustainability within the construction business has been increasing dramatically during the last decades [1] (P. Hansford et al. – 2013) and, as some research studies point out, “an increased emphasis must be placed on the processes and competencies required to deliver high-performance buildings” [2] (Horman et al. – 2006). Currently, many researchers focus on understanding different aspects of delivering green-building projects in order to minimize waste, maximize value, and reduce cost. During the last years several research studies analyzed different project management issues related to green-building developments. Their main goal is to optimize the project management process for developing green-building projects focusing on different aspects, such as, counterfactual analysis [3] (Klotz et al. - 2009), LEAN processes [4] (Lapinski et al. – 2006), piloting evaluation metrics [5] (Korkmaz et al. – 2010).

As Lenfle points out in a recent study, “the links between studies devoted to project management and innovation management are complex and marked by a relative lack of communication between the two fields” [6] (Lenfle – 2008). Moreover, during the last years project management practice has evolved into a business process and got detached from the practical aspects of the job tasks [7] (Kerzer – 2013). The scope of this research is to develop a practical comparison between projects with different levels of integration for the development of green-building tasks.

The concept of sustainability has been standardized internationally through the implementation of different protocols but the majority of the research studies have been developed on the basis of common project management processes that refer to the United States construction industry [8] (Lopez & Sánchez – 2010). Recently, sustainability has become a key aspect of the construction field [9] (Enache, Pommer & Horman – 2009) and this includes also project management. However, despite their demonstrated benefits, green buildings are not yet perceived as attractive projects because most people associate green features with expensive technologies that add cost [10] (Castro-Lacouture et al.).

2. SCOPE OF THE RESEARCH

The scope of this research is to analyze the effect of process integration for green-building design delivery within the European Community.

The whole research is based on the comparison of real case-study projects and has been carried out through three different stages:

- Data collection and process illustration;
- Process Analysis and detection of project-management issues;
- Estimate of the impact of project-management issues on project costs, schedule and sustainability.

The projects selected for the case-study is a new nursing-home complex located in Trento, Northern Italy, and an office building located in Barcelona, Spain, both certified under the LEED protocol, with a total budget of approximately 10 Million Euros. The choice of these case-study projects was made on the basis of the following statements:

- Direct access to project information and contact with all technicians involved in the project;
- Simultaneity between research and project design development;
- Project sustainability referring to LEED credits as benchmark for evaluation.

The choice of real case-study projects helped researchers testing a new methodology for the analysis of the project management issues in green-building developments. The intent is to develop, with future research, a deep hands-on analysis where specific problems related to specific activities and circumstances could be identified and, possibly, prevented.

2.1 Deliverables and potential benefits of the research.

The present research has two main outputs:

- The endorsement of the new methodology developed by researchers in previous investigations for analyzing sustainability-related issues within the development of a European green-building design project.
- The evaluation of the impact of process integration for sustainability-related tasks within the design process in terms of costs, time and sustainability features.

3. METHODOLOGY

This study focuses on the practical implementation of a methodology developed during a previous investigation where researchers analyzed a single case-study project and developed a method to estimate the entity of project management problems generated by the lack of process integration [11] (Orsi & Guillamón, 2016).

Following the original scope, researchers focused on identifying project management “problems”, defined on the basis of the “waste” definition of the LEAN philosophy. In simple words, any type of activity performed during the process that in spite of consuming resources doesn’t bring added value to the final product [12] (J. Liker - 2003). Five types of problems were considered for the purpose of this research: waiting (process delays), transportation (unnecessary displacement of people or materials), extra-processing (re-manufacturing and reiteration), costs (unforeseen costs for project-related tasks), defects (project weaknesses that didn’t allow the achievement of the expected LEED certification). Project-related information were collected with two different methods: project documentation analysis and personal interviews. Project owners provided all project documentation such as technical reports and drawings and included all information related to each phase, activity and event affecting the project design phase from the early preliminary design stage until the final executive phase. Interviews were made by researchers personally to technicians and personnel involved in the project. The interview process was standardized by using a common procedure for all interviewees. Each subject recognized all the problems they encountered during the design development and indicated them in the list of project activities developed before.

The results obtained from the data collection process allowed researchers to identify the project priorities or, in other words, the independent variables that had to be considered for the scope of this research. Such independent variables are:

- Time deviation: intended as the delay suffered by all sustainability-related activities of the project impacted by any of the project management issues during the design-phase development.
- Cost deviation: intended as all additional costs caused by project-management issues for the development of sustainability-related activities.
- Sustainability deviation: intended as the loss of certification points, under the LEED reference standard, caused by project-management issues for the development of sustainability-related activities.

Problems, as defined above, were identified by all subjects involved and were gathered together in several “categories of issues” which represent the dependent variables researchers aimed to focus on. The categories of issues identified for the purpose of the present research are listed below:

- Misunderstanding of Commissioning Authority’s (CxA) tasks and process. Project designers and owner didn’t understand the role of the Commissioning Authority and in spite of the suggestions of the LEED consultant the design was carried out without the CxA help until the very last stage.
- No appropriate clauses in bid documentation. No specific clauses were introduced in order to determine how and for which compensation LEED-related services would have been performed. During the later design and construction phases the costs of such services were subject to fluctuation on the basis of the construction cost variation.
- Systematic cuts to budget due to change-orders and delays. The delay of the project design phase brought to price increase and big deficits in the project budget which involved also the sustainability-related aspect.
- Lack of knowledge about energy modelling role and process. The mechanical engineers in charge of the design development developed an energy model that could not be interfaced with the LEED-required software. Another energy modeler had then to be contracted in order to partially or totally redevelop the original model however, the second energy modeler was brought in too late in order to have significant impact on the project because by the time the energy model was finished the final design had already been finished and approved with little or no margin for modification.
- Lack of project manager supervising the whole project. A project manager for sustainability-related and LEED-related issues was contracted from the beginning but no general project manager was overseeing the whole process. This brought to a lack of coordination between subjects involved and consequent fragmentation of the process.

Problems related to project schedule and therefore to time variance were analyzed and evaluated with the use of a project management software, Microsoft Project. The list of activities was used to create a Gantt diagram for the whole project. Problems were accounted as activities and identified with different colors depending on their relationship with time, costs or sustainability. For the purpose of the present research only issues related to green-building activities were taken into consideration. Duration of each activity was defined on the basis of the data collected from the project documentation.

Issues related to project costs and therefore cost variance were estimated using data collected from two different sources, cash-flow volume documented by project files and cost information acquired during the different interviews with technicians. Cost-related information for each problem was provided as Euros amount or as number of extra hours spent to solve the problem. In case of the hourly-based information researchers estimate the corresponding Euros amount multiply the number of hours by the average hourly salary for a middle-range professional technician with a short-term consulting contract in Italy (Il Sole 24 Ore - 2015). The cost analysis was developed for all dependent variables described above. The Gantt diagram was used to link each problem to groups of project tasks, total problem costs were then estimated afterwards using simple Excel sheets.

Sustainability variance was determined on the basis of the LEED protocol score. Prior to each project start the design team performed a kick-off meeting with all subjects involved in the project and filled up a LEED checklist where all credits considered "potentially achievable" were listed taking the whole LEED credit list as an optimum reference. During the project development some of those credits were not achieved because of project management issues and researchers focused on those credits the project could not obtain due to sustainability-related project management issues. The problem representation procedure had to go through a iterative process in order to have a set of results that could be graphically understandable and summarize the results. Different filters were applied in order to eliminate

unnecessary information and bring only the most important to the eyes of the reader.

4. RESULTS

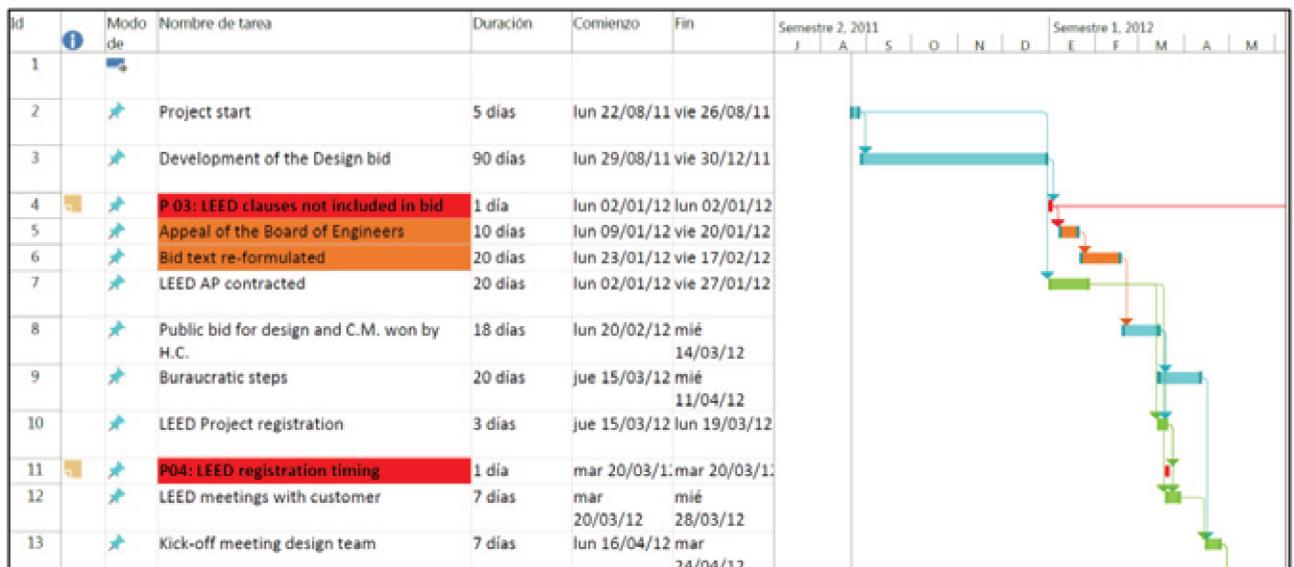
Information resulting from the present research were divided into three groups respectively related to the three independent variables previously identified.

Time variance was estimated on the basis of the bar-chart results developed using Microsoft Project. Within the bar chart, sustainability-related problems were accounted as normal activities with predecessors and successors and their duration was estimated on the basis of the data collected through project documentation and interviews. Critical path was then calculated on the basis of the scheduling concepts [13] (Harris, R.B. - 1978) along with free-float and total-float of each activity. The duration of all sustainability-related problems included on the project critical path were accounted for the total loss of time.

The calculation of cost variance was based on two different types of costs: direct costs and indirect costs. The term "direct costs" refers to all expenses, caused by the sustainability-related problems that the owner had to add to the original budget in order to complete the design process. The term "indirect costs" researchers identified two types of quantities:

- All additional costs caused by the sustainability-related problems that technicians had to bear with no additional compensation to their professional fee.
- All additional costs caused by the effects of the sustainability-related problems which affected third parties and later project development phases.

Figure 1: Snapshot of the project Gantt diagram showing problems (red), problem-related activities (orange), sustainability-related activities (green).



Direct and indirect cost calculations were performed for each dependent variable considered by researchers generating a cost-variance table linking dependent variables (problem categories) with problem-related activities. On each table the horizontal axis represents the dependent variables, the vertical axis the problem-related activities and the numbers represent the cost in Euros that each specific activity had in order to solve each specific problem.

Sustainability variance was estimated on the basis of the LEED protocol. Taking the whole possible score identified at the beginning of the project as a reference, researchers focused on all LEED points that finally couldn't be achieved due to project management issues related with sustainability (which are included in the problem category list cited above). Below are summarized the results of both case-study projects.

and document analysis the cause of this problem was the process fragmentation as defined under the Lean approach (Liker, 2003).

One key-difference between the first and the second case study is the perception of the importance of time. According to the information retrieved, for the first case, time and sustainability were often sacrificed to the benefit of the cost. The lack of importance given to the time variable is demonstrated by the delays suffered during the completion of the first two case-study project. On the contrary, for the other case-study time was a major issue. Subjects interviewed for these cases declared that the schedule deadline was included as a major contractual clause from the beginning of the design phase and therefore any delay would be considered as an exception almost the same way as a contractual breach.

Table 1: Table summarizing all results for dependent and independent variables related to both case-study projects.

RESEARCH SUMMARY TABLE						
DEPENDENT VARIABLES \ INDEPENDENT VARIABLES	Lack of integration between technicians	Commissioning Authority tasks & process	No appropriate clauses in bid documentation	Systematic cuts to project budget	Energy Modelling role and process	TOTAL
THE NURSING-HOME PROJECT						
Additional Time (Working Days)	37	39	18	40	41	175
Additional Total Costs (€)	5730	38500	36700	9400	10500	100830
Green Value (LEED points)	2	1	0	4	7	14
THE OFFICE BUILDING PROJECT IN BARCELONA						
Additional Time (Working Days)	1	6	0	6	10	23
Additional Total Costs (€)	9800	3100	1500	9300	5100	28800
Green Value (LEED points)	0	0	1	0	2	3

5. CASE-STUDY COMPARISON AND CROSS-CASE ANALYSIS

After completing the analysis on the case studies the researcher focused on comparing the results obtained. In order to do that we separated the analysis for each independent variable: time variance, cost variance and sustainability variance.

First independent variable: time.

Whether the nursing-home project suffered a delay of almost a 30%, the office buildings was completed with a delay of less than 5%. According to the results and information retrieved through the interviews

This different perception of the importance of time within the process development, as well as, the different management associated with it, led the projects to have different delays both from the variance perspective as well as in absolute value.

Second independent variable: costs.

The cost-variance also registered substantial differences from case to case. Following the idea cited above about the importance of each variable the researcher highlights that, in terms of absolute values, the projects that suffered the greatest cost variance was the ones having the independent variable "cost" as the most important of the three. As already cited above for the time-variance paragraph, each

project owner had a different order of priorities for each of the three independent variables. For the nursing-home project the most important was always the “cost” variable mainly because, as explained above, it depended on a public funding which had already been approved and could not be changed. However, this project also had “time” as the least important variable and, according to the analysis, these two variables are heavily related one to the other. Most of the issues that generated the cost variance depended on delays which imposed change orders, project remanufacturing tasks and other expensive activities. Therefore, is important to notice that cost variance and time variance depend one from the other or, said in other words, from the project management perspective, also during the design phase of a green-building project, time is money.

Cross-case analysis: sustainability.

For all projects analyzed for the scope of this research sustainability was never considered as the priority. None of the project budgets was ever modified for a sustainability-related problem and this had severe consequences on the final level of sustainability of the project. However, the researcher noticed a substantial difference between the way the LEED procedure was developed in the two projects. For the office building project sustainability was an integrated aspect of the design that was constantly upgraded, modified and adapted to the new schedule and budget needs. For the nursing home project however, sustainability was developed more as an outsider activity which had to be considered just once-in-a-while during comprehensive meetings with all technicians involved. This detachment of green-building activities from the design-development phase caused a growing gap between what should have been done and what could be done leading to a withdraw of many green-building features and tasks.

6. CONCLUSIONS

Importance of process integration for the development of green-building projects.

The analysis of the results highlighted the positive relationship between process integration and development of green-building projects which has to be perceived from a broad perspective. Integration intended as physical integration, in which each component can physically interact with each other, and timely integration where technicians involved interact on a frequent basis with each other. Promoting this broad concept of integration in relationship with the development of green-building projects has a great potential impact on the business especially at

an international scale where subjects involved have different backgrounds, benchmark and procedures.

This leads to the first contribution of the present study: the quality of the project sustainability features could be improved by enhancing the integration between subjects involved in the design process.

Positive relationship between green-building features and project management.

Researcher demonstrate the existence of a relationship between the level of project integration and sustainability for the development of green-building projects. The cross-case analysis showed that both fields are mutually linked and that the efficacy of one can impact the success of the other. Following the literature review researchers focused also on the strong relationship between project management and process integration (Jainendrakumar, 2015). The relationship between project management and green-building development can also be seen as the relationship between two subjects which goal is to optimize the use of available resources. Let these resources be mainly time and costs for project management and water, energy and others for sustainability. Finally, all resources can be spent and both project management and sustainability focus on spending them the best possible way.

This leads to the second contribution of the present study: the relationship between project management and green-building projects which also supports the relationship between sustainability and affordability.

Green-building activities as critical tasks for the scheduling process.

The analysis of different case studies led researchers to identify a parallelism between design activities, (including architectural, mechanical, structural design) and sustainability-related activities. As cited above, for the nursing home project such activities were not integrated in the design process on a frequent basis but were considered only sporadically for global meetings. This didn't happened for the second case study where results were sensibly different. Researchers saw that the schedule developed for design-related tasks did not always coincide with the sustainability-related one and, being the LEED certification a long process with no specific deadlines, these activities were never considered in the global planning procedure and therefore, even if behind schedule, were never considered critical. This was the cause of several problems, such as, the misunderstanding of the CxA role or the lack of use given to the energy model.

Considering sustainability-related tasks as critical activities within the global design planning and goal may prevent future issues for both sustainability features, budget and time spent. This is the third contribution of this study which follows the original idea of Horman related to the priority of sustainability-related tasks (Horman, 2006).

7. LIMITATIONS

Time analysis:

Estimating the delay of single activities resulted sometimes difficult because depended from tasks which dependency could not be calculated. Therefore, for the purpose of this research activities with undefined scheduling features were considered not individually but as part of groups of activities (milestones) whose start and ending point could be determined univocally.

Cost Analysis:

Indirect costs estimate was often ambiguous because could not be linked to written documents nor to any specific project activity. Information related to indirect costs were collected through interviews to subjects who sometimes could not identify project management wastes.

Researchers only analyzed the cost of the problems they had related information of, there might have been other extra costs that couldn't be estimate because nobody appointed them as problems and so researchers didn't even know the existence of.

Sustainability Analysis

For the purpose of the present work researchers took into consideration only a single green-building protocol, LEED. This protocol represents only a fraction of the green-building construction market and therefore results of the present research have to be considered partially valid.

Finally, as a general limitation for the work, researchers specify that avoiding the causes that determined the problems mentioned above is a necessary condition but maybe not sufficient to avoid the waste. The problems listed above have been calculated with reference to an optimum and ideal situation characterized by zero waste in terms of time, costs and sustainability. Researchers do not have evidence that such waste can be fully avoided. In order to validate this thesis, researchers would need to analyze other projects where appropriate means and resources are implemented in order to prevent wastes listed above. This, along with other ideas listed below, represents one possible field for the development of future research works.

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