UNIVERSITAT POLITÈCNICA DE VALÈNCIA

PhD THESIS

THE DEVELOPMENT OF GREEN-BUILDING PROJECTS:

OPTIMIZATION OF THE PROJECT-MANAGEMENT PROCESSES THROUGH THE LEAN APPROACH.

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It has been a while since I started my educational path and it looks like this will be the last step. Some say that "you never stop learning", which I guess is true, but at least from a formal point of view this should be it. So at this point I would like to give my warmest thanks to all those who have supported me during all these years, and by saying "support" I mean all the people that shared any kind of life-experience, time or knowledge with me not only during the course of my PhD but also during the previous years. I firmly believe that each of us is what he, or she, experiences. Every person we meet and every experience we have in our lifetime can teach us something, either good or bad, significant or superficial, but something. And it is up to us being able to figure out the lesson and making good use of it. Without willing to be a philosopher, at least not until my defense will be over, I just want to tell the audience that if I am what I am today it is because of them, in both positive and negative ways. I would not play any instrument if somebody would not have made me fall in love with music, I would not speak other languages if nobody would have supported me in my experiences abroad and I would not be so incompetent in other things if I have had the chance to meet different people or experience other things. But one never stops learning, right? So I guess that you will still have to suffer me for the next years to come. This idea goes from the more pragmatic hands-on skills to the less perceptible but nevertheless important emotional aptitudes. The ability to laugh with some friends, to be serious when needed, to create and maintain friendships, to make mistakes and recover… in one word, the ability to be happy and enjoy life in all its good and bad bits, was a gift that I received during all these years by all of you who are now reading this document. And that is why I really want to thank you. Of course different people had different weights, my family who basically believed in me since the first time we met, played a big role during the first years. My close friends and partners also had a big influence but all of you, even the ones who offended or fooled me, brought a little piece to what I am now. I never had the chance to thank you for this and I think that this document may be the right opportunity to do it.

Speaking about this thesis and, more generally, about my PhD experience, the concept is the same. I would not have gained interest in this field if I did not find the right support by family, friends,

colleagues and professors. About eight years ago I was asked if I wanted to start a PhD and I refused, then my perspective changed and when I found the right people to work with I changed my mind. So once again thank you, this time for making me retracing my steps.

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THESIS ABSTRACT

Thesis summary – English.

As the world becomes aware of its limited resources it is increasingly important to consider the development of buildings which could respond to the requirements of sustainability. During the last decades the development of the so-called green buildings has been gaining momentum through the implementation of appropriate reference standards, new technologies, innovative design strategies and processes. Such changes introduced new challenges for all subjects involved and, most of all, the need of working with new technologies and services through fully-integrated processes. Designers are also affected by such issue and, within this scope, project management plays a key role for the optimization of the design-project development. This research analyzes the design process of four case-study projects from the project management perspective taking into consideration all sustainability-related tasks and activities that negatively affected the project design development. A new methodology was created in order to analyze the design process and evaluate the effect of detected project-management issues under three main independent variables related to costs, time and sustainability. The research makes full use of the Lean approach to classify the issues, or wastes, experienced during the different design processes and to identify possible solutions for the process optimization. The four case studies are referred to four real projects developed in different European countries under the LEED and BREEAM reference standards. More specifically the four projects are:

- One nursing-home located Northern Italy certified under the LEED reference standard.
- One school-complex located in Northern Italy certified under the LEED reference standard.
- One office building located in Barcelona (Spain) certified under the LEED reference standard.
- One office building located in South-East of Spain certified under the BREEAM reference standard.

The final scope of the research is to develop a methodology for the analysis of the green-building design processes from the project management perspective in order to identify the problems occurred, optimize the process and provide a tool to prevent unnecessary wastes of money, time and sustainability features.

Resumen de tesis – Castellano.

Cada vez mas el mundo toma consciencia de que la disponibilidad de recursos naturales es limitada y el desarrollo de edificios sostenibles se está convirtiendo en una necesidad. Durante las últimas decadas el desarrollo de edificios sostenibles ha sido impulsada por el desarrollo de protocolos especificos, nuevas tecnologias, diseños y procesos inovadores. Dichos cambios han implicado nuevos retos para todos los sujetos involucrados y, sobretodo, la necesidad de operar con nuevas technologías y servicios a través de procesos integrados. Los proyectistas también quedan afectados por dichos cambios y el project management juega un papel imprescindible de cara a la optimización de procesos de diseño integrados. Esta investigación analiza el proceso de diseño de cuatro casos de studio desde el punto de vista del project management enfocando la atención en las actividades relacionadas con la sostenibilidad que afectaron negativamente el desarrollo de los procesos. Se desarrolla una nueva metodología para analizar el proceso de diseño y evaluar los efectos de eventuales fallos experimentados durante los procesos de project management desde la perspectiva de tres variables independientes relacionadas con: costes, tiempos y sostenibilidad. La investigación implementa los conceptos de la metodología Lean para la clasificación de los fallos, o desperdicios, occurridos durante el desarrollo de los varios procesos y para identificar posibles soluciones de cara a la optimización del proceso. Los cuatro casos de estudio están relacionados a cuatro proyectos reales desarrollados en diferentes estados Europeos a través de los protocolos LEED y BREEAM. Mas en detalle los proyectos son

- Una residencia para mayores ubicada en Italia del Norte y certificada a través del protocolo LEED.
- Un complejo escolar ubicado en Italia del Norte y certificado a través del protocolo LEED.
- Un edificio para oficinas ubicado en Barcelona (España) y certificado a través del protocolo LEED.
- Un edificio para oficinas ubicado en el Sureste de España y certificado a través del protocolo BREEAM.

El objetivo final de la presente investigación es el desarrollo de una nueva metodología para el análisis de los procesos de diseño para edificios sostenibles desde el punto de vista del project management para identificar los problemas occurridos, optimizar el proceso y proporcionar una herramienta a los futuros técnicos para prevenir el desperdicio de dinero, tiempo y caracteristicas de sostenibilidad.

Resum de tesis – Valencià.

Cada vegada més el món té una major consciència que la disponibilitat de recursos naturals és limitada i el desenvolupament d'edificis sostenibles s'està convertint en una necessitat. Durant les últimes dècades el desenvolupament d'edificis sostenibles ha estat impulsat pel desenvolupament de protocols específics, noves tecnologies, dissenys i processos innovadors. Aquests canvis han implicat nous reptes per a tots els subjectes involucrats i, sobretot, la necessitat d'operar amb noves tecnologies i serveis a través de processos integrats. Els projectistes també queden afectats per aquests canvis i el project management juga un paper imprescindible de cara a l'optimització de processos de disseny integrats. Esta investigació analitza el procés de disseny de quatre casos d' estudi des del punt de vista del project management fixant l'atenció en les activitats relacionades amb la sostenibilitat que van afectar negativament el desenvolupament dels processos. Es va a desenvolupar una nova metodologia per analitzar el procés de disseny i avaluar els efectes d'eventuals errors experimentats durant els processos de project management des de la perspectiva de tres variables independents relacionades como son: costos, temps i sostenibilitat. La investigació implementa els conceptes de la metodologia Lean per a la classificació dels errors, o deixalles, aparegudes durant el desenvolupament dels diversos processos, per identificar possibles solucions de cara a l'optimització dels processos. Els quatre casos d'estudi estan relacionats a quatre projectes reals desenvolupats en diferents estats Europeus a través dels protocols LEED i BREEAM:

- Una residència per a gent major situada a Itàlia del Nord i certificada mitjançant el protocol LEED.
- Un complex escolar situat a Itàlia del Nord i certificat a través del protocol LEED.
- Un edifici per a oficines situat a Barcelona (Espanya) i certificat a través del protocol LEED.
- Un edifici per a oficines situat en el Sud Este d'Espanya i certificat a través del protocol BREEAM.

L'objectiu final de la present investigació és el desenvolupament d'una nova metodologia per a l'anàlisi dels processos de disseny en edificis sostenibles des del punt de vista del project management, per identificar els problemes possibles, optimitzar els processos i proporcionar una eina als futurs tècnics per prevenir el malbaratament de diners, temps i característiques de sostenibilitat.

CHAPTER 1

Introduction

1.1. Problem Statement.

As the green building sector is gaining momentum within the global construction industry "…an increased emphasis must be placed on the processes and competencies required to deliver high-performance buildings" (Horman et al., 2006; p. 01). Emerging research and education programs are focused on understanding all aspects of delivering high-performance (or green-building) projects, in order to minimize waste, maximize value, and reduce cost (Riley et al., 2007). During the last years several research studies analyzed different project management issues related to green-building developments. Their main goal was to optimize the project management process for developing green-building projects focusing on different aspects, such as counterfactual analysis (Klotz et al., 2009), Lean processes (Lapinski et al., 2006), and piloting evaluation metrics (Korkmaz et al., 2010).

As highlighted by a recent research study "…providing support resources that allow designers to iteratively improve and re-evaluate designs, reduces the impact of the building design from initial to final design" (Russel-Smith et al., 2015; p. 08). With this study, researchers want to develop a practical approach to rationally analyze the design-stage project management process and a set of guidelines applicable by future technicians in real green-building projects.

During the last decade, sustainability has become a key aspect of the construction field (Enache et al., 2009) and this includes also the project management aspects. However, despite their demonstrated benefits, green buildings are not yet perceived as attractive projects because most builders associate green features with expensive technologies that add cost (Castro-Lacouture et al., 2009). Sustainability is a broad concept that has been standardized worldwide through the implementation of different tools and protocols but the majority of the research studies have been developed on the basis of general project management processes that refer to the United States construction industry (Lopez & Sánchez, 2010).

One of the main pillars for the development of high-performance buildings and green-building projects is the process integration (Hormann et al., 2006) to identify the managing, planning, design, construction, and operation steps of the facility life-cycle. This high performance project delivery model, proposed by Hormann (2006), is based on the Integrated Building Process Model (IBPM) (Sanvido, 1990).

Hormann (2006) recognized the Lean methodology as a possible tool to optimize project management processes for sustainable-project delivery (Lapinski et al., 2006). Following the same idea and using the IBPM model as a reference point, in this work researchers focus on delivering a tool to help technicians avoiding all issues, or wastes as defined by the Lean philosophy, that could affect the design-stage project development.

The area of interest for the present research was narrowed down to projects developed within the European Union. Evidence of existing research studies take into consideration projects developed within the Anglo-American construction process, which is radically different from the one implemented within the European Union; in this scenario, more subjects are involved and local laws as well as European regulations establish new hierarchies within the whole construction and project development procedure leading to very fragmented processes (Guy & Moore, 2004). Within the US construction and project delivery process for design-bid-built projects each subject works almost independently following a two-party contract, only lately with the implementation of the new contract forms A201-2007 (General Conditions of the Contract for Construction) and 232-2009 (General Conditions of the Contract for Construction, Construction Manager as Adviser Edition) owner, contractor and designer have to sign a common document that binds each other. However, the United States design-bid-built process still follows a pyramid organization compared to the European one. Figure 1.1 shows the different layouts representing the contractual linear dependencies between subjects involved within a design-bid-built common process. Whether in the US the owner hires the designer and then separately the contractor using a resident engineer as supervisor, in Europe there are four different figures interacting in the process at the same time, each of them directly dependent from the owner and therefore at the same hierarchic level. Beyond the designer and the general contractor, in Europe the owner must hire a security chief manager and the so-called “director of works” which acts in behalf of the owner during the construction phase and both of them have full powers on all the construction site operations in parallel with the general contractor and the designer. Within the European system these four different parties have to coexist at the same time and occasionally each of them take over certain project management tasks. Such circumstances make the whole project management process more complex and more difficult to analyze. Therefore, the relationship between process integration and green-building design development may be a key-aspect for enhancing the efficiency of green-building design especially in conditions under which processes are very fragmented like the European Design-Bid-Build system.

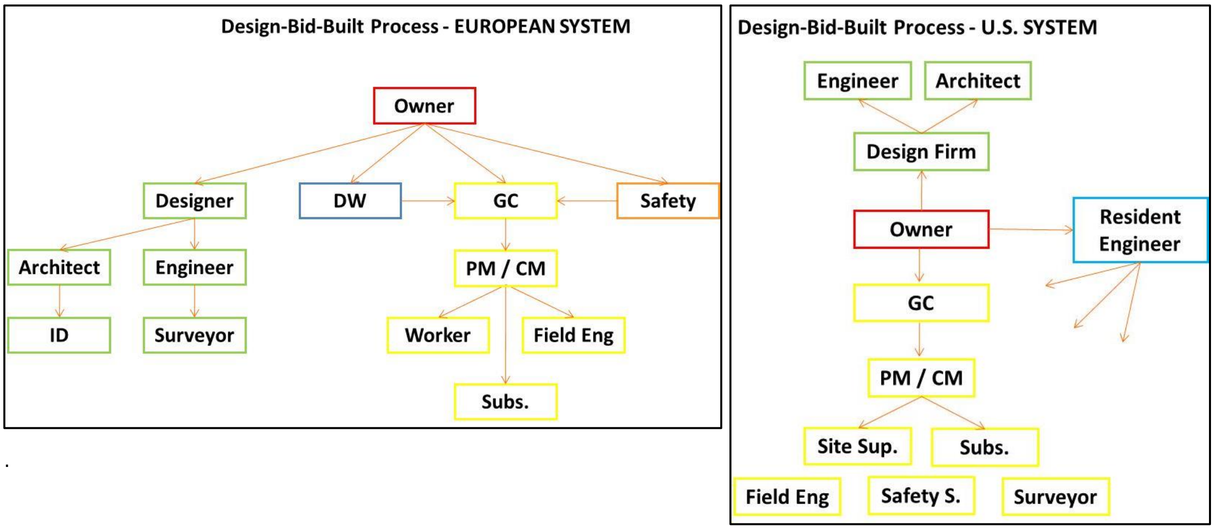


Figure 1.1: Representation of the contractual dependencies between subjects involved in the Design-Bid-Built European and U.S. construction process.

1.2. Research Goals and Objectives.

This study aims to analyze the project management issues occurred during the design process of different green building projects. The specific goal of the research is to find and test a new methodology to identify and quantify the practical problems affecting the development of green building design processes within the European Community regulations and context.

The objectives of the present research can be summarized as follow.

1. Identify a specific gap within the current research and knowledge environment.

2. Define a feasible and adequate methodology in order to complete the present research conducted on the gap mentioned above.
3. Identify and analyze a satisfactory number of case studies in order to develop the research.
4. Categorize the project-management issues affecting the green-building design process.
5. Identify the impact of each problem category on the green-building design process.
6. Highlight the positive relationship between process integration and green-building design development.
7. Develop guidelines for professionals and optimization of future green-building design processes.

The work is based on different real case-study projects all of which, briefly listed below, were developed independently:

1. New Nursing Home Complex located in Volano (TN – Northern Italy), certified under LEED for Healthcare 2009, with a total budget of approximately 11 Million € and a total gross footprint of 5,965 square meters.
2. New School Complex located in Trento (Northern Italy), certified under the LEED for School 2007 protocol, with a total budget of approximately 13,2 Million € and a total gross footprint of 6.000 square meter.
3. New Office Building located in Barcelona (Spain), certified under the LEED Protocol with a total budget of approximately 7.5 Million € and a total gross square footprint of 3.000 square meter.
4. New Office Building located in Alicante (Spain), certified under the BREEAM Protocol with a total budget of approximately 14 Million € and a total gross square footprint of 5.885 square meter.

The choice of the case-study projects was made on the basis of the following statements:

- Direct access to project information and contact with all the managers and technicians that worked on the project and access to first-hand information proceeding from subjects directly involved in the process.
- Simultaneous research and design-project development from which researchers could directly access project data and live-exchange information with the subjects involved while the process was developed.
- Certification of all projects under different green-building protocols which were implemented by researchers as international benchmarks for the rational evaluation of the level of sustainability of each project.
- Project similarity: all projects involved in the present research study have similar features in terms of budget and footprint and were all developed for tertiary-sector activities.

1.3. Methodology.

The present research work was carried out following seven main steps summarized in figure 1.2. Each step implemented for the research is briefly described in the paragraphs below.

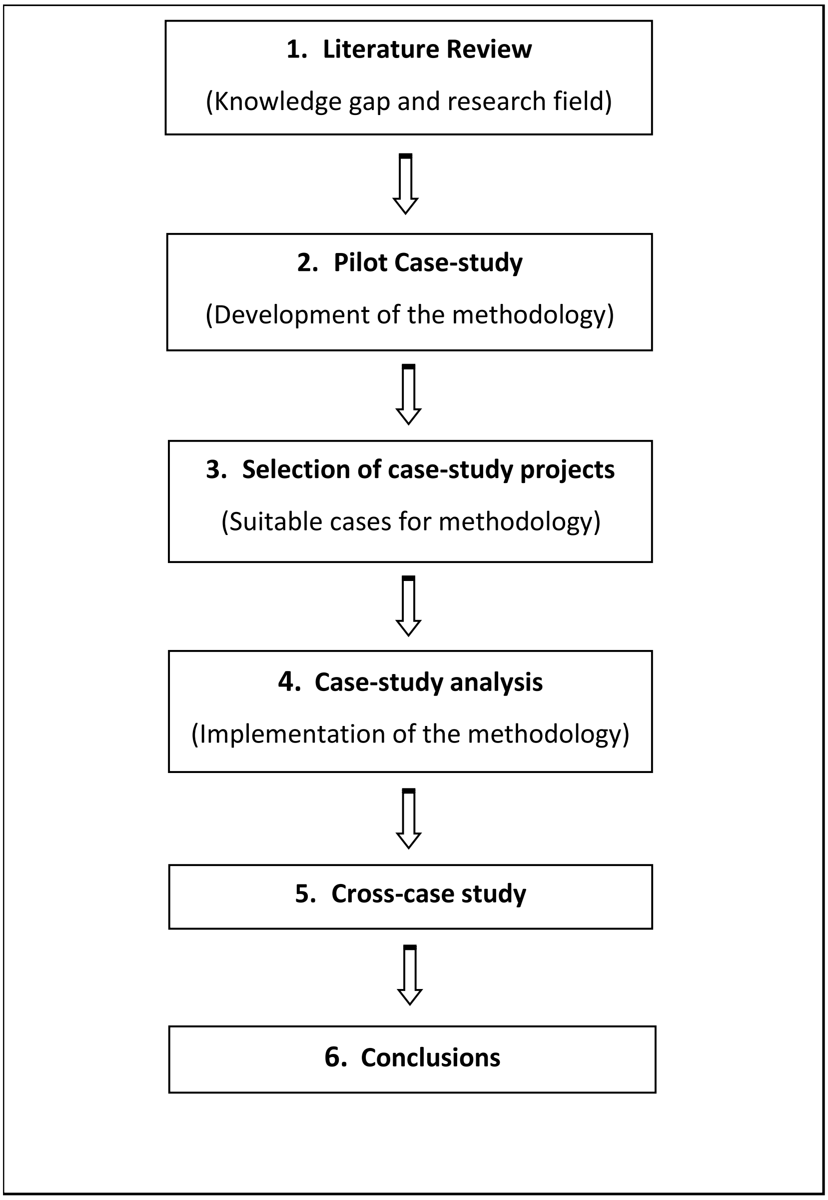


Figure 1.2: brief representation of the main research phases implemented for the purpose of the present study.

1.3.1. Brief literature review.

The first step for the development of the present research work was understanding the current state of the art of research field within the field of green-buildings and project management. On the basis of the professional experience and being involved within the academic world related to these topics the research team had a preliminary idea of which could be the knowledge gaps. However, that idea was not well defined and therefore it had to be sharpened and supported by strong evidence.

Researcher started analyzing the literature review related to the main research topics, green-buildings and project management, independently. The green-building field was examined from a broad perspective, taking into consideration international definitions of sustainability and related reference standards. On the other side, for the Project Management perspective the analysis focused on deep-understanding the European reality with an eye toward the US construction world. The previous experiences and research developed within the Construction Management field at Michigan State University (Orsi A., Mrozowski T., 2009) gave me solid basis for the understanding of the Anglo-Saxon construction management procedures and therefore for the scope of the present work I focused mainly on its implementation within the European Union. The sustainability field was first identified as the one represented by the green-building reference standards currently available worldwide. However, as described in the literature review, being the current reference-standard market very fragmented and dispersive researchers had to narrow down the field of the present study by identifying some major green-building protocols or milestones. On the basis of the research articles and other documents founded during the literature review researchers decided to focus on two green-building reference standard: LEED and BREEAM. This decision proceeded from the fact that, according to the latest survey and research articles (see literature review), LEED and BREEAM are the two most-used green-building reference standards worldwide in terms of number of certified buildings and geographical areas in which they are implemented.

The project management field turned out to be a quite fuzzy concept especially when considering international project developments. The analysis of the current construction market situation demonstrated that different countries apply different laws and procedures for the development of the construction projects (EU, nº 305/2011). This led to a complete re-definition of the project management tasks and concepts for every different country considered. Therefore, aiming toward a fixed and rational definition of the project-management roles, researchers narrowed down the research field to the American and European construction procedures. Within the European Community the research field was narrowed down even further to the countries in which researchers thought they could work with. In other words, countries with potential case-study projects to use for the purpose of the present research. Such countries are Italy, Spain and Germany and each of theirs construction process was analyzed in order to define the role and the tasks related to the project-management field. See the literature review for further information related to each country's construction market and reality. By the end of the literature review the project-management realities taken into account were the ones of Italy, Spain, Germany and USA in relationship with the two main types of public-project procedures: Design-Bid-Build and Design-Build.

Finally the literature review gave researchers a suggestion about the implementation of the Lean methodology. Similar studies were developed in relationship with the present field especially in the US. To the eyes of researchers the ones that provided the best solutions in terms of project optimization were the ones related to Lean implementation. For example, the Lean and Green initiative developed at the Penn State University was taken as a reference for the development of a similar pilot-methodology.

1.3.2. Pilot Case-study.

This research is carried out using a qualitative research approach, taking into account the pilot case-study project as the main research method. This exploratory approach is appropriate for investigating a phenomenon in its current scenario (Yin, 2009).

The main goal of the research is to develop a new methodology for the optimization of green-building processes and therefore researchers needed a rational and solid basis. Thus, they decided to develop the methodology on the basis of a hands-on experience by choosing a pilot case-study project and shaping the first draft of the research methods on the results obtained. The pilot project was chosen also depending on the availability of information and the scenario required for the development of the research. Using the first project as a pilot case-study researchers aimed to take into consideration the major possible number of variables. Thus, the methodology developed and adjusted on the basis of the results of the pilot case-study would have been valid also for other case-studies in which not all variables would have appeared. The pilot case-study had to be a sort of worst-case scenario for the development of a methodology that could be valid for the major number of case studies similar to the original one. Since the present research focuses on integrated project delivery the worst case scenario to be analyzed had to be a fragmented process developed in one of the geographical areas identified above using one of the two reference standards cited before. The project of a new school-complex in Italy certified under the LEED for Schools 2007 reference standard was chosen as pilot case-study project. The project presented a very fragmented design process developed by different subjects through a Design-Bid-Build procedure. The pilot case study defined the three independent variables of the research: cost, time and sustainability.

The process implemented for developing the pilot case-study was sorted out by activities referred to specific project-related tasks or events. Occasionally, researchers identified one of more problems associated with some of these activities. Problems were identified on the basis of the concept of “waste” as defined by the Lean approach (Liker – 2004): any type of activity performed during the process that in spite of consuming resources does not bring added value to the final product. Out of the seven types of waste identified for an industrial Lean process (Liker – 2004) for the purpose of this research only five types of them were considered: (1) waiting (delays in the process); (2) transportation (unnecessary movement of people or materials); (3) extra-processing (re-manufacturing and activity reiteration); (4) costs (unforeseen expenses for project-related activities); (5) defects (intended as project weaknesses that did not allow the team to reach the expected level of sustainability within the LEED certification). Only those directly associable with project management were considered for the current analysis.

Waste-related issues, were the symptoms of the structural project management problems the authors were interested in. Therefore, the ones initially identified during the case study were labelled and gathered together in several “categories of issues” which represent the real project management problems the authors wanted to analyze. Such categories of issues identified determined the dependent variables of the present research and are listed below:

1. Lack integration between technicians involved;
2. Misunderstanding of Commissioning Authority's tasks and process;
3. Lack of appropriate clauses in bid documentation;
4. Systematic cuts to budget due to change-orders and delays;
5. Misunderstanding of the energy modelling role and process.

From now on in the paper the word "problem" will be referred to the categories of issues, or dependent variables, mentioned above if not differently specified. Following the definition of Whelton and Ballard (2002), only well-defined and structured problems were taken into consideration for the purpose of this research. Problems could be related to single or multiple activities. For each independent variable, the total impact "I" of all "i" problems on the whole project completion was estimated as the sum of the impact of that specific dependent variable on all the activities considered.

$$I_d = \sum_{1}^{n} i_{An(d)} + \sum_{1}^{n} i_{Bn(d)} + \sum_{1}^{n} i_{Cn(d)} + \sum_{1}^{n} i_{Dn(d)} + \sum_{1}^{n} i_{En(d)}$$
$$I_€ = \sum_{1}^{n} i_{An(€)} + \sum_{1}^{n} i_{Bn(€)} + \sum_{1}^{n} i_{Cn(€)} + \sum_{1}^{n} i_{Dn(€)} + \sum_{1}^{n} i_{En(€)}$$
$$I_S = \sum_{1}^{n} i_{An(S)} + \sum_{1}^{n} i_{Bn(S)} + \sum_{1}^{n} i_{Cn(S)} + \sum_{1}^{n} i_{Dn(S)} + \sum_{1}^{n} i_{En(S)}$$

Where "I" represents the impact of all different "i" problems interfering in different "n" activities of each "A" to "E" problem category for dimensions of time "d", costs "€" and sustainability "S".

The development of a research methodology though a pilot case-study resulted to be a reiterative process. For each project-related decision, such as, selection of variables, data collection, researchers would first decide a method, the implement it on the field, correct possible mistakes or errors and re-implement the new method until obtaining acceptable results. With the term "acceptable" researchers intended a result upon which all subjects involved would agree on. For example, for the data-collection process researchers collected the first round of information, cross-checked them between different sources, summarized them into one single output and countercheck them with the same subjects involved. If some data, information or number would notbe approved by all subjects the process was adjusted and re-proposed. Following this reiterative procedure always concluded with the unanimous approval of all subjects involved all aspects of the research methodology described below were defined and settled:

- Research variables;
- Source of data and information;
- Types of projects to be analyzed;
- Methods for collecting the information (interviews, docs analysis, etc.);
- Information storage and handling procedures.

1.3.3. Selection of other case-studies and data collection.

On the basis of the information collected during the pilot case-study project researcher focused on getting more projects in order to perform a cross-case analysis following the Yin's approach as described in the literature review. Case-studies had to comply with the outcomes of literature review, knowledge gap and the methodology factors determined through the pilot case-study analysis. Therefore, projects selected had to comply with the following parameters:

- Project which information had to be available to researchers without major restrictions.
- Direct access to first-hand information and direct contact with subjects involved in the project development process.
- Projects which design process was developed in a recent period in order to have direct contact with subjects involved in each activity.
- Projects developed following the European laws either in Spain, Italy or Germany.
- Projects with a budget ranging between 5 and 15 million Euros.

- Projects already registered or certified under LEED or BREEAM protocols.
- Projects which design processes could be tracked and well defined from three different points of view: cost, time and level of sustainability.
- Projects which activities could be directly linked to each of the three aspects cited above and specifically to: direct and indirect costs (as defined in the pilot-case methodology), time and design-activity-related delays, sustainability points achieved and lost during the design process.

On the basis of these parameters researchers searched and selected other three case-study projects which were then analyzed through the methodology developed during the pilot case-study project. Data collection was made through document examination and personal interviews to subjects involved which had been standardized during the pilot-case analysis. Data collection was divided from the early project stage between the three variables identified during the pilot-case methodology: costs, time and level of sustainability.

The methodology developed during the pilot case-study project was verified by researchers through two different methods: interviews and publications. Interview help with the subjects directly involved in the process demonstrated unanimously the validity of the results. All interviewees agreed upon the plausibility of the results both from a qualitative and quantitative points of view. Qualitatively because they agreed on the types of issues and on the causes that determined them, quantitatively because the research results in terms of numbers coincided in order of size, with their expectations. One article focused on the methodology developed for the pilot case-study project was published in the Brazilian journal “Mix Sustentável” in 2016.

1.3.4. Case-study analysis

Processes and activities implemented for project data collection were standardized during the development of the pilot case-study methodology. Variables to be analyzed for the scope of the present research work were also defined during the pilot case study. Therefore, information collected during the different phases of each other case-study project were catalogued and aligned toward the variable's needs.

Information proceeded from two main sources: documentation and interviews. For both cases the extrapolation of the required information followed a standardized process which was determined and verified during the pilot case-study project.

After collecting information all case studies went through a process of output levelling. Each group of information related to the different variables was compared between the different case-study projects through a cross-case process.

Specific software and project-management approach were implemented to obtain results related to costs and time aspects. Both methods were standardized through the implementation of scheduling and estimating techniques which allowed researchers to repeat the process for each case-study project. Sustainability-related information and results were calculated on the basis of the green-building reference standards used for each building certification process.

Results proceeding from the qualitative analysis could be identified under three different categories: dependent variables, independent variables, project outcomes. Dependent variables identify the different fields investigated within the research project and were: costs, time, sustainability. Independent variables are referred to activities marked throughout the process that caused a negative effect. The project outcomes are the results of the correlation between independent and dependent variables.

The final results of the present research study were summarized in four different matrixes, one for each case-study project. Each matrix would report the values for overall project issues divided by groups of dependent variables.

The numbers resulting from the calculations of the different variable-related activities were then turned into percentages related to the total of each category: cost, time, sustainability.

1.3.5. Cross-case analysis.

Once the case-study analysis was completed and results were reported on a case-by-case set of tables, researchers focused on comparing the results obtained from each case-study. The process was developed separately for each independent variable focusing on the main causes and events that determined the consequences measured through the analysis. The process implemented for the cross-case analysis can be briefly described as follow:

- Collect all information and results proceeding from different case-study analysis.
- Organize the collected information in different groups, each of them related to one independent variable.
- Identify the causes that determined the different problems through the problem categorization previously developed (dependent variables) and Lean methodology (Lean wastes).
- Compare the results obtained for each independent variable identifying the causes that generated the project issues (dependent variables) and Lean wastes.
- Develop general considerations in relationship with the global case-study comparison.

1.3.6. Conclusions.

The development of this chapter was based on the following milestones:

- Overall analysis of the results obtained;

- Comparison between results and initial research expectations;
- Evaluation of the obtained results in relationship with research limitations;
- Proposals for the development of future research works.

The result analysis was performed on the basis of the methodology key-concepts: case-study analysis, cross-case analysis, dependent and independent variables. Results from case-study and cross-case analysis compared with optimum situation previously estimated during the collection of project-related information.

Dependent and independent variables were linked together with the overall project expectations in order to identify the impact of each variable on the overall project development. Researchers then focused on isolating each variable’s impact on the overall project results.

The research project presents several limitations in relationship with the conditions under which each phase of the work was performed and the researcher’s capabilities. Such limitations defined the field of legitimacy of the present work.

On the basis of the analysis of the results, the work limitations and the proposals proceeding from the literature review, researchers drafted a list of proposals for the development of future works in relationship with the present research.

1.4. Outputs and potential benefits.

Always focusing on the objectives described above in this chapter, the present research has five main outputs.

- Identify the relationship between project management and project sustainability.
- Highlight and corroborate the importance of process integration for the development of green-building projects.

- Provide some key-concept for the choice of the procedure for the optimum development of green-building projects.
- Implement the Lean approach for optimizing green-building-design processes.
- Develop practical guidelines for technicians and professionals toward the optimization of real project-management process in green-building design.

The first four points are directly related to the present work and arises from the results obtained through the case-study and cross-case analysis reported in chapter 5 of the present manuscript. The last output listed above is intended to establish a set of practical recommendation for optimizing the real management process of future green-building projects and is reported in chapter 6 of the present manuscript.

Starting from Hormann's idea who considers the process integration as one of the main pillars for the development of high-performance buildings and green-building projects (Horman et al., 2006) researchers focused on the events, activities and unforeseen issues that could hinder the process development. During the preliminary phases of this study researchers collected several information related to the state-of-the-art of the research goal. BREEAM ES is the entity responsible for the launch, development and certification of green-building projects certified under the BREEAM protocol within the Iberian peninsula and, according to Oscar Martinez, director of BREEAM ES: "… problems related to the lack of process integration of sustainability-related activities are responsible for the majority of project delays and over-budget costs during the design phase. However, such problems are only known by the green-building specialists which generally play secondary roles within the project development process and can´t prevent their effects without the basis of a rational study" (O. Martinez, personal interview, 11th of September 2012).

Another important statement proceeding from the different interviews and projects analyzed throughout the study is the role of sustainability-related activities which are perceived and treated as secondary-importance activities but that can have a key-role in terms of the design-process improvement. This aspect is described more in detail in chapters 3 and 5 but, at a glance, sustainability is applied to special circumstances which take into consideration specific building features and characteristics such as, energy, wind, water, commissioning service and others. Such activities are so specific and rarely demanded that are provided in the vast majority of cases as punctual consulting services disconnected from the core development of the design team. This causes a fragmentation of the design process in which each sustainability-related activity is detached from the whole process avoiding an integration between subjects involved. These concepts led the road for the development of the present study which aims to create a rational basis for the knowledge and improvement of the design-development processes in relationship with sustainability-related activities and protocols. Identify the possible problems and evaluate their effects from a rational perspective and through a tested methodology point of view in order to avoid their repetition in future design processes.

So far, research studies encountered focus on developing general management principles to analyze the design and construction processes. In this case, following the idea of Hormann (2006) of building process model, more than on "what" task has to be provided, researchers focus on the critical steps of "how" the tasks is performed and "who" has to deliver the job within the process (Hormann et al., 2006). Therefore, the research aims to highlight "why" a specific activity caused problems, "how" that specific activity has to be performed in order to avoid such problems, "who" has to perform the prevention tasks, and "when" they have to be performed.

From a broader perspective, as already cited above and explained more in detail in chapters 6, with this work researchers would like to develop a tool for future professionals and researchers working within the green-building field following the steps cited below:

1. Development of a practical methodology to rationally identify and evaluate unforeseen problems related to green-building services that could compromise the performance of the project management process for the design phase of the building. Through the analysis of the different case-study projects this research develops a methodology to rationally identify and evaluate all events, activities and unforeseen bugs of the project that could weaken the

project-management process. This methodology, being based on rational and practical project features, could be implemented for future projects and set one well-defined benchmark for the evaluation of the impact of green-building activities on the whole project design completion.

2. Awareness and prevention of the potential problems that sustainability-related activities could create during the design-phase development of a building project. Following the idea of Martinez y" (O. Martinez, personal interview, 11th of September 2012), this research aims to create an awareness of the problem existence to the eyes of the subjects involved in the construction business. In fact, as reported later in chapters 4 and 5, one of the main issues that researchers encountered during the data-collection phase was that construction companies, design companies and project owners did not even know that the problems existed. Accessing project information in order to identify and evaluate the problems was denied because, to the eyes of all responsible subjects, there wasn't any problem in their project management process. Therefore, another important goals to which aims this research is to make people aware that problems are there even before explaining how to identify and evaluate them.
3. Evaluation of the potential benefits proceeding from the integration of project tasks and activities. Following the idea of M. Hormann (2006) this study aims to increase the importance of integrated-project delivery processes for the development of green buildings. Researchers want to demonstrate that integration between project activities and subjects is a key factor for the optimization of the project management process.
4. New definition of green-building projects in which sustainability doesn´t refer to a punctual external services but participate to the core-development of the project through an integrated process. With this study researchers aim to emphasize the idea of sustainability as a core-project subject through an integrated process integration that require all green-building services to be considered throughout the whole design development.

1.5. Limitations.

This study aims to investigate a new research perspective analyzing a very small fraction of the whole construction environment and therefore it brings along several limitations related to project conditions, quantitative and qualitative analysis development, data collection and socioeconomic environment of each case-study project. Such restrictions are better explained in chapter 4 of the manuscript however, here researchers want to give a general understanding of the limitation that readers have to keep in mind while evaluating the present research study.

First, due to timing necessities, the research study and all case-study projects were developed simultaneously. Each research project had many stakeholders involved and no global coordination; the lack of a common protocol for the collection and storage of research-related data established prior to the project start determined a certain level of uncertainty. Estimating the delay of single activities resulted sometimes difficult and ambiguous because it depended on other activities. By matching data coming from interviews and project documentation, the authors determined the duration, floats, predecessors and successors of each activity. However, in some cases, the bureaucratic and management processes were so complicated that none of the stakeholders involved knew what activity depended on what. This resulted, as commented above, from the lack of integration and coordination of the process. 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.

As specified above over-budget activities were calculated from two different perspectives defined as direct and indirect costs. Indirect costs were also difficult to estimate because they were not related to any written document nor any specific activity or event of the project. Furthermore, data related to indirect costs were collected through interviews to all subjects involved, which, in some cases, were not able to identify project management wastes. Some technicians claimed that re-defining the project design several times during the process is normal because “it’s the way it goes”. However, in project management terms this is called product re-manufacturing and reflects one of the Lean definitions of waste.

This issue resulted in another limitation; the authors only analyzed the cost of the problems they had related information of; there might have been other extra costs that could not be estimated because nobody appointed them as problems, and so the research team did not even know of their existence. Researchers could not estimate the cost of not using the budget allocated for the project during a medium-long period of time. The case-study refers to a public healthcare project funded by the public authority; these funds have to be listed and approved along with the public county budget still during the project design stage, and they remain locked in the public budget until the construction phase. Delays in design phase completion and, consequently, the start of the construction phase represent a loss for the founding entity which cannot use nor invest the money allocated for the entire project. The authors also believe that indirect costs, in spite of being difficult to estimate, are not less important and maybe even more significant than the direct costs. Unforeseen indirect costs could be one of the main reasons why public bids developed within the construction management process tend to be completed way over budget and behind schedule.

Regarding the sustainability analysis, for the purpose of the present study, the authors took into consideration only a single green-building protocol, LEED. Within the context of a single case-study, the need of reducing the number of variables imposed the selection of a single protocol, which is currently the most used at an international level regarding the number of certified buildings. However, 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 highlight 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. The authors do not have evidence that such waste can be fully avoided. In order to validate this thesis, other projects should be analyzed where appropriate means and resources are implemented in order to prevent these wastes. This, along with other ideas listed below, represents one possible field for the development of future research works.

1.6. Deliverables.

With this study researchers aim to develop several tools, either practical and theoretical, for the optimization of the green-building design processes. Such deliverables follow the definition of objectives listed above and can be described as follow:

- <u>*Develop a new methodology to analyze design-development processes for green-buildings and create the basis for future more sophisticated methodologies overcoming the current limitations.*</u>

As specified above in chapter 1.3 this study focuses on developing a new methodology for analyze and assess the efficiency of green-building design processes. Researchers believe that this will lead to the establishment of a new benchmark for the evaluation of design processes which will be evaluated as another project feature. During the data collection process researchers identified, for the majority of subjects involved, a lack of understanding of the most basic concept that define the efficiency of a certain process. Productivity, total float, free float, time crushing and sequence of activities for example, were concepts not understood by most of the interviewees. This highlighted a deeper problem related to the design process; not only the process was carried out with non-optimum solutions and efficiency problems but the subjects in charge to run the process did not even know what are the parameters to measure the efficiency of a process. In other words, they did not know what efficiency is. On the basis of these considerations researchers developed the present study to develop a benchmark-evaluation methodology to evaluate from the qualitative and quantitative point of view the efficiency of a building design process.

- *Application of the Lean methodology for categorizing the potential issues affecting the green-building design process.*

Following the experience of the Penn State University's with the "Lean and Green" Research Initiative, this study aims to develop a first hands-on application of the Lean methodology to the European design process for green-buildings. As briefly explained above in chapter 1.1, the European design and construction process is substantially different from the US one and in Europe more subjects are involved in a decision-making process which is not pyramidal and more articulated. The Lean methodology was firstly developed by Toyota in Japan (Liker, 2004) and then applied to the American design and construction process through different initiatives. Without copying precisely the methodology applied to machinery and chain-production processes, researchers aim to grasp some of the principles used for the experiences in USA and implement them to practical recommendations for the building design process optimization within the EU reality.

- *Identify and quantify potential losses related to project-management issues on green-building design and rationally allocate the amount of resources to prevent them.*

Identification of problems related to management processes is just the first step for avoiding the potential waste of resources within a project management process. In order to develop a rational prevention strategy is important to quantify the magnitude of problems in order to allocate the right amount of resources for their prevention. Researchers aim to develop a study that could give quantitative indicators related to each problem category encountered within the design process. This will give a double contribution to the prevention strategy: results will provide a rational method to identify the importance and magnitude of each problem which will also be quantified in terms of economic losses; then, subjects involved could evaluate the need of preventing one specific problem and, in that case, with how many economic resources. In fact, results of the present research are expected to provide the readers with general information in order to have an overall understanding of the problem magnitude, but also detailed information related to each waste or problem category.

- *Establish a rational correlation between sustainability and integrated design process.*

As reported in the “Business Case for Green-Building” released in 20013 by the World Green Building Council, the green-building design is currently considered as a normal-building design with some special features attached to it (World GBC, 2013). Other research studies demonstrate that integration is a key-aspect for the process optimization and delivery (Hormann et al., 2006). This study aims to demonstrate that green-building services and sustainability-related activities deeply influence the whole design process development and therefore they should be considered as marginal aspects of the project but as core-features to be planed, developed and carried out throughout the whole process. With the eyes pointed toward future projects, researchers focus on arising awareness about the importance of green-building activities within the design process, avoiding the lack of knowledge and understanding that can generate waste of time, money and green-building features. Following the idea of Ángel Teso, responsible manager for energy efficiency and sustainability of Everis, a big company with an European headquarted but with offices all-around the World, sustainability for building development is not an option and if the whole society has to move toward this goal we, as professionals should help by identifying the right methods and ways to achieve it (A. Teso, 2013) . With this study researchers aim to develop a tool for this scope and to demonstrate one possible way to improve the efficiency of “how” we could reach sustainability.

- *Create a basis for future research projects and extend the research to other phases.*

Guidelines and results proceeding from the present research study could be used in the future for other academic studies and research. With this work researchers focused on a very specific market segment of the construction industry and case studies analyzed represent an infinite fraction of the potential global database. Therefore, it is desirable that further research studies will implement the present work as a baseline case and focus on other aspects, such as, different parameters for the evaluation of project management processes during design, implementation of the methodology to other phases like construction or maintenance. From this perspective, with the present study researchers aim to create a basis and a reference methodology for the development of future research works. For this specific purpose conclusions of the present research are reported in chapter 5 in a brief, clear and precise way, in order to provide the readers with a rational and easy-applicable interpretation of calculations and results obtained.

- *Practical guidelines for professionals.*

What expressed in the paragraphs above will determine the first approach to the development of practical guidelines for technicians and managers. Once the team will have settled the basis for the rational analysis, qualification and quantification of problem categories information will be used to draw a global scheme for practical problem prevention through the implementation of the Lean approach. The scheme will serve as a sort of checklist for project-management related problems giving a general understanding of each problem magnitude taking into considerations all the variables analyzed in the present research but without entering in the details of the calculations laying behind the results. A sort of brief-evaluation checklist to understand the origin of the problems, their importance, the options to prevent them and the costs, in terms of resources, to prevent them. Such guidelines could also serve as a basis for future research studies developed four-hands between academicals and professionals. The goals of the researchers is to create a practical hands-on tool developed by researchers but implementable by professionals, technicians and other subjects involved within the normal project management process.

1.7. Chapter summary.

Green-building design development is becoming a key-sector for the construction industry, new technologies, materials and strategies are evolving and being implemented at international scale. From the project management perspective more attention is being dedicated to the development of green-building projects and the optimization of such processes is a key-factor to guarantee the success of projects itself. However, the development of green-building projects at international scale requires the implementation of protocols, services and activity that are not commonly used in most of building developments. The addition to such non-usual activities can create unexpected consequences throughout the whole project management process and consequently resource losses in terms of time, cost and sustainability features. A rational methodology to analyze, evaluate and optimize the project-management processes during the design phase of green-building project design is needed. The present research focuses on developing such methodology and testing it on several case-studies, all of them developed within an international environment. Case study projects for the purpose of this research have been selected on the basis of their features, in terms of magnitude, level of internationality and sustainability aspects. The development of this methodology will create a basis for the future development of more expended and detailed studies as well as a reference guideline for professionals to recognize potential problem in advance, evaluate them and, when possible, allocate the right amount of resources to prevent them. The process of identification and evaluation of the non-foreseen activities hereby called “problems” was made on the basis of the Lean methodology, taking into consideration some of the main Lean principles along with its definition of “waste”.

CHAPTER 2

Literature review

2.1 Introduction.

The purpose of the literature review is to identify the existing published work related to green-building project management processes and to discover previous work that could either be helpful to this research.

As previously described in Section One, the main focus of this research work is the optimization of the project management processes for green-building design through the development, test and implementation of a rational methodology.

Practical application of project management principles to building design processes is based on theoretical background and calculated through the implementation of algorithms, software and decision-making processes. Some discussion of these background principles and standards was included as a reference level in considering measurement approaches, tests and result-analysis situations. Therefore, the following literature material literature was examined.

2.2 Background on green building development.

This section focuses on the main concepts that define, for the purposes of the present study, the notion of green building. Following the results of a recent survey related to the construction market development, green-building is gaining momentum growing faster than expectations and green-building certifications are the reference for the market development. Quoting the same report,"… the percentage of firms expecting to have more than 60% of their projects certified green is anticipated to more than double from 18% currently to 37% by 2018" (Smart Market Report, 2016). However, during these last years, due to this fast-growing green-building trend, sustainability has become a complex reality that embeds more and more concepts, areas of interest and definitions and for the future trends seem to aim to even higher goals (Prakash et al. – 2014). This emphasis on green-building developments and sustainability in general generated new market sectors along with products, methodology and new strategies that affected deeply the whole building construction market (Prakash et al., 2014). For the purpose of this research is important to identify whether the concept of sustainability is applied to a specific measurable building feature or to a business-related aspect of the building. On the other side, is important also to define the importance of each green-building aspect in a way that readers and researchers could give priority to the aspects that most affects the building development.

One of the most important concepts that are generally misinterpreted within the green-building field, is the dependency between building sustainability and energy efficiency. As cited above, sustainability is a field that embeds different concepts and energy efficiency is only one of them. However, how demonstrated by recent studies, most readers especially between non-professional, identify sustainability with the concept of building energy efficiency (Dahlmann & Veal – 2016). The idea of sustainability applied to the building sector is a much bigger concept, which embeds all possible aspects of construction practices, processes and resources implemented. The understanding and the perception of sustainability and its different aspects depend on different factors which are related to the cultural background, the technical knowledge and even to the personal character of a single person (Chekima et al., 2016).

During these past years these wide-range concepts have been developed and analyzed throughout the work of several research entities and technicians. In each field new studies were developed in order to bring evidence of the importance of sustainability for a specific purpose or asset. Different methodologies, such as, life-cycle assessment, resource planning, green-building reference standards, building information modelling and others have been developed in relationship with, but not limited to, building sustainability (Dahlmann & Veal – 2016). Social surveys and even anthropologic studies have been conducted within the field of sustainability in order to demonstrate the consequences and the best-practice methodologies to achieve the goals. However, the concepts of sustainability and green-building are too wide to be taken into consideration for the present research and, in our opinion, they are also useless if not analyzed without a reference benchmark. The concept of green-building alone would be useless if not referred to a specific field or scope.

Therefore, for the purpose of the present work researchers aim to analyze a well-defined concept of sustainability in relationship with a single aspect of the construction industry in which such concept are regularly implemented. In order to develop the work in a rationally and systematic way researchers took the green-building reference standard as benchmark for the case study evaluation.

2.3 Green-building standards.

As described above, the concept of sustainability could potentially affect any aspect of the building, from the cost of each material and activity if considering a sustainable economic development down to the building performance, material life-cycle, use of resources and others. In order to rationally define, organize and represent all the aspects that could be affected by sustainability during the past years different green-building reference standards were created, each of them with a different range of magnitude.

On the other side, the importance of green-building certification institutes is also rising and reference standards, such as LEED, start to be implemented as international benchmark for the definition of common quality standards for buildings (M.N. Cotton, 2012). According to recent studies, the number of green-building protocols and reference standards is rising, each of them bringing different definitions, either qualitative and quantitative, for the concepts of sustainability (Say & Wood, 2008). All green-building rating system surveyed show variation in their point system which reflect their geographic and cultural singularity, yet with few variations to allow for climate and cultural differences within each specific system. Therefore is essential, for the purpose of the present research, to narrow down the range of green-building category and identify a common definition of building sustainability.

According to the World Green Building Council, currently LEED and BREEAM are the most implemented green-building rating systems worldwide in terms of number of certified buildings and total certified projects area (USGBC Statistics, 2016). The LEED rating system, created in the United

States with the US Green Building Council, is responsible for the certification of more than 170,000 gross square meters per day with a total of 80.100 certified projects worldwide (USGBC Statistics, 2016). On the other side BREEAM, funded in the U.K. in 1990, has been used to certify more than 250,000 projects in 50 different countries (Vierra, 2011).

2.3.1 The LEED Protocol.

The Leadership in Energy and Environmental Design (LEED™) green building rating system represents the U.S. Green Building Council's effort to provide a national standard for what constitutes a "green building." Through its use as a design guideline and third-party certification tool, it aims to improve occupant well-being, environmental performance and economic returns of buildings using established and innovative practices, standards and technologies. The US Green Building Council (USGBC) was established in 1993 as a non-profit organization. The council is made up of construction industry stakeholders including owners, contractors, architects, engineers, product manufacturers and environmental groups. The USGBC established LEED in 1998 under a pilot version to transform the way building and communities are designed, built and operated. By being environmentally and socially responsible LEED enables a healthy and prosperous environment that improves quality of life (Say & Wood, 2008).

LEED is a voluntary certification that may be sought by building owners for new or existing commercial, institutional, or high-rise-residential buildings. LEED accreditation is currently being developed for housing and neighborhood development, as well. Different elements of a building's design, construction and materials earn credits towards a possible total of 100 points.

Depending on the type of building and its final use different LEED reference standards can be applied, such as, Building Design & Construction (LEED BD+C), Existing Building Operational & Maintenance (LEED EBO+M), Hospitals (LEED for Healthcare) and others. The categories and criteria are extensive and divided in chapters each of the related to a specific aspect of sustainable development. Site Selection, Water Management, Building Energy Performance, Use of Materials, Indoor Environmental Quality and Innovation in Design are just the most common chapters repeated through the manuals. Each manual is a collection of different credits, each of them addressing a specific building feature within the field of one single chapter. Credits are divided into pre-requisite, which are mandatory for achieving the final building certification and account approximately for the 7 – 10 % of the total credits, and normal credits, each of them is weighted with a certain number of points. Depending on how many credit requirements the building project will be able to fulfill, given that all pre-requisite will be achieved, the project will earn a certain number of points and consequently a specific level of certification (USGBC, 2016). There are 4 levels of LEED certification based on the amount of credits a building earns:

- Platinum
- Gold
- Silver
- Bronze

As a result, the level of certification achieved by using LEED represents a global score of the building project obtained by considering only the sustainability related to the chapters cited above: Site, Water, Energy, Indoor Environment, Materials, Innovation. However, is important to highlight that such chapters are listed, catalogued and considered through the implementation of rules, laws and standards proceeding from the United States reality. All standards, protocols and criteria listed in LEED manuals are taken from different American's entities and institution, such as, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) or the US Environmental Protection Agency (EPA), and others.

The LEED certification process requires the intervention of three special figures within the design, construction and development process respectively known as: LEED Accredited Professional, Commissioning Authority and Energy Modeler.

LEED AP credential holders possess a deep understanding of all the details, prerequisites, credits, definitions, and rules of the certification process and a particular specialty track within the LEED green building rating system (LEED AP with specialty). The LEED Accredited Professional assists the project team for design, construction, operation and maintenance of the building project.The LEED AP credential signifies an advanced depth of knowledge in green building practices; it also reflects the ability to specialize in a particular LEED Rating System. The LEED AP exam is divided into two parts. The first part is the LEED Green Associate exam, which demonstrates general knowledge of green building practices. The second part is a specialty exam based on one of the LEED Reference Guides called LEED AP exam. Currently the LEED AP specialties are:

- LEED AP Building Design + Construction
- LEED AP Homes
- LEED AP Interior Design + Construction
- LEED AP Neighborhood Development
- LEED AP Operations + Maintenance

The eligibility requirements for the LEED AP exams are to have documented professional experience on a LEED project, within the last 3 years, with verification through LEED Online or employer attestation. Candidates are also required to agree to the Disciplinary and Exam Appeals Policy and Credential Maintenance Program and submit to an application audit.

The Commissioning Authority is a specialist that develops the service of Commissioning for the mechanical equipment and final building performance. Commissioning is the process that ensures a facility and its systems are designed, installed, tested, operated, and maintained to perform as the design intended. This is achieved by implementing and documenting a series of live tests to confirm proper system operation. Commissioning provides written documentation of the owner's expectations and a process for ensuring they are fulfilled, while also avoiding inevitable operational problems. Most of the green building protocols we are currently dealing with consider the commissioning service as a pre-requisite for the achievement of the final certification. In other words, in order to obtain a green building the team will have to provide a commissioning service that could be “regular” if done only during the construction and post-occupancy phases, or “enhanced” if provided during the design, the construction and post-occupancy phases of the building.

The energy modeler is the technician in charge of developing an overall energy model of the project in order to simulate the building energy performance during each time of the year. The model is created using specific software commonly used at global scale, however it has to be configured and developed following the specific protocol rules and reference standards. The LEED protocol takes the American standards, such as, ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers) and EPA (Environmental Protection Agency) as reference for the energy modeling and this details makes it difficult for the European professionals to fulfil this task and therefore the Energy Modeler has to be considered a special service for the purpose of LEED certification.

As a conclusion of this brief LEED analysis researchers identify the LEED reference standard as a protocol that addresses some sustainability-related issues in relationship with the American processes from the procedural, bureaucratic and regulatory point of view. As a result, this reference standard results to follow a partial definition of sustainability addressing a limited number of sustainability-related issues, either in terms of contents as well as scopes. These issues, within the scope of the protocol, are implemented worldwide with very little variations and constitute a quality benchmark for international project developments.

2.3.2 The BREEAM Protocol.

BREEAM (Building Research Establishment Environmental Assessment Method) was created by BRE (Building Research Institute) of Watford, England, in 1988 and the first version for assessing new office buildings was launched in 1990. BREEAM was created as a cost-effective means of bringing sustainable value to development. Its main goal was to help investors, developers, design and construction teams and occupiers to use natural resources more efficiently. Using independent, licensed assessors, BREEAM assesses scientifically based criteria covering a range of issues in categories that evaluate energy and water use, health and wellbeing, pollution, transport, materials, waste, ecology and management processes. Buildings are rated and certified under the following scale depending on the number of credits and thus of the percentage of points achieved: acceptable (> 10%); pass (> 25%); good (>40%); very good (>55%); excellent (> 70%); outstanding (> 85%).

- Acceptable (> 10%);
- Pass (> 25%);
- Good (>40%);
- Very Good (>55%);
- Excellent (> 70%);
- Outstanding (> 85%).

By setting sustainability benchmarks and targets that tend to stay ahead of regulatory requirements – and by encouraging the use of innovative means of achieving these targets – BREEAM drives greater sustainability and innovation in the built environment.

Likewise LEED, the BREEAM protocol addresses several building-related parameters and features collected in nine standard sections: Energy Efficiency; Water Use; Sustainability of Materials; Transportation; Waste Management; Pollution Minimization; Health & Wellbeing; Management Process Optimization; Land Use & Ecology. Each section contains several points, each of them related to a specific building or construction-process feature, classified as credits and pre-requisite. Pre-requisites are mandatory for obtaining the final certification whether the fulfillment of credits determine the assignation of the BREEAM certification points.

The BREEAM certification process is divided into design and construction stage and developed by professional subjects working in partnership with the design team and the general contractor. Two are the main subjects involved into the certification process, the BREEAM Accredited Professional (BREEAM AP) and the BREEAM Assessor. The BREEAM AP has the role of giving assistance to the design team and construction company during the design and construction phases. He would give support to all technicians and professional involved into the project development process explaining which activities should be performed, what and how things should be done in order to fulfill the BREEAM requirements. The BREEAM Assessor has the role of supervising the whole certification process controlling the procedures and documentation produced by technicians following the advices of the BREEAM AP.

In relationship to the BREEAM certification process researchers want to highlight a major incongruence between theory and practice. All BREEAM projects examined for the purpose of the present research had only one subject responsible for the certification process, the BREEAM Assessor. The BREEAM AP would not even be considered for the design process nor for the construction phase. After analyzing the certification procedure followed by project developers researchers found that all projects would have a role overlapping because they would be developed, assessed and addressed by the same person, the BREEAM Assessor, which turned out to be the supervisor and the supervised entity at the same time. In order to clarify this process incongruence researchers investigated the issue in collaboration with the BRE personnel and were reported that, even if inappropriate, the role overlapping of the BREEAM Assessor and BREEAM AP is a common practice outside the UK and it’s a problem that the certification institute BRE is trying to solve (Cinquemani, 2011).

Likewise LEED, a part for the Accredited Professional and Assessor roles the BREEAM certification process requires the participation of two other subjects typically not considered for the development of normal construction projects: the Commissioning Authority and the Energy Modeler.

For the purpose of BREEAM certification the Energy Modeler can be considered differently from the LEED process. In fact the BREEAM certification institute has grown internationally creating different national chapters, each of them responsible for the development of local certification processes. Within this specific asset the energy models are developed following the national laws and standards. This makes it easier for local professional to understand and fulfil the energy-modeling requirement and therefore this task is generally not considered a special service for the purpose of the final certification.

2.3.3 Comparison between LEED and BREEAM Protocols.

A major difference between the two sustainability-protocols in exam is their approach to their international growth and development. The BREEAM certification institute has grown internationally creating different national sections or chapters. Whether LEED is managed by a unique central entity, the US GBC, promoting international standards the BREEAM protocol has been developed nationally in UK by the British Research Institute (BRE) and locally, in other countries, as detached segments of BRE. This caused the creation of BREEAM Sweden (BREEAM SE), BREEAM Germany (BREEAM DE) and others between whom BREEAM Spain (BREEAM ES). This approach to a whole BREEAM asset development determined the simplification of many aspects of the certification process in comparison to LEED because all subjects involved would have to face local reference standards instead of foreign standards and the whole certification process would be carried out by local professionals without having to interact with foreign institutions responding to different laws, rules and principles.

Referring to the LEED protocol currently in use known as LEED v.3 for new construction buildings researchers founded always reference to American's protocols and standards, such as, ASHRAE and EPA (LEED v.3, 2016). However, as recently demonstrated by the Italian committee for LEED Italia, requirements related to American's standards are likely to be less severe that the European ones. During the past years the Italian Green Building Council (GBC Italia) was created along with an Italian version of LEED v.3 known as LEED Italia (LEED Italia, 2011). In order to create a twin-version of the American LEED v.3 one of the key-works of the whole LEED-Italia commission was the comparison between American and Italian standards on a single-credit basis. Out of a total number of credits of one hundred, only 10 turned out to have American standards more restrictive that the local Italian ones in use at the time of the comparison (LEED Italia, 2011). Italian laws and standards are written on the basis of European rules, such as, the Eurocodes, this doesn't automatically extend the proportions made up for Italy to the whole European community however it gives a good understanding of how some sustainability-reference standards such as LEED could be less severe that the reality in which they are implemented (Frattari et al., 2013).

On the other hand BREEAM has spread out in different countries through the creation of several national chapters, each of them related to the national standards in use. This makes it easier to technicians and subjects involved to blend in the certification process requirements with the regular project development process. Either from the technical point of view considering specific requirements for each building features, and from the project management point of view in relationship with time scheduling, cost control and activity sequencing the implementation of local-protocol standards turns out to be easier than the international ones. Subjects involved for the certification achievement are often related to local proficiencies and their coordination within the whole design and construction process is already determined by national laws and technicians are aware of it prior to project start. A practical example is the implementation of BREEAM ES (BREEAM chapter Spain) which is linked to the national law for building design, development and construction (Código Técnico Español) (Saint Gobain, 2012). All services, requirements and reference standards listed within the BREEAM ES manual already exist within the normal Spanish procedure, some roles are extended or given slightly different tasks to perform but the process followed to develop the building is substantially the same. On the other hand, the implementation of LEED always requires the participation of a non-standardized process because subjects and professional tasks involved are related to the American building development process.

The implementation process of BREEAM does not have to be confused with the real contents of the protocol. In fact, in spite of being adapted for each national chapter, the BREEAM reference standard maintain the same requirements in terms of contents. All sections related with water, materials, management, site, transportation remain the same for all national chapters and even building energy performance requirements always stay the same. Plus, as well as LEED, BREEAM has a non-absolute measurement procedure for building performance which always depend on the comparison between Baseline and Design case scenarios (BREEAM Commercial, 2013). In other words, researchers did not find evidence of fixed pre-determined values on which evaluating the final building performance but only standard values for materials implemented in the building design. This creates, as well as LEED, a problem of result relativity for measuring building performance because the optimization of the building design case is always done in relationship with the benchmark set by the baseline case and doesn't take into consideration important aspects such as architectural shape, exposure, orientation of the building but only the materials used to build it. From this point of view researchers concluded that the BREEAM protocol measures only relative-values of building performance, it does not give absolute values for measuring their effectiveness and therefore building performance assessed under BREEAM protocol are not comparable to other building's performance because the benchmark set for the baseline case is different for each project.

Finally a brief analysis of both LEED and BREEAM protocols showed researchers that:

- LEED as well as BREEAM are two limited protocol working on a limited number of sustainability-related issues associated to a limited number of topics which are substantially the same for every geographical area in which they are implemented.
- Both protocols address a limited number of topics that changes depending on the type of building considered but remain always the same in different geographical areas of the planet. This, as described in the previous chapters, represents a severe limitation for the definition of sustainability which depends of many other aspects, each of them related to different cultural, geographical and morphological aspects. So both LEED and BREEAM provide a certification for a limited definition of sustainability.

- The BREEAM is habitually implemented through the use of national chapters that are already linked with national regulations and standards whether LEED refers to American standards no matter where it is implemented. In other words the BREEAM protocol is implemented within a process that's already been standardized and regulated by national laws whether the implementation of the LEED protocol always requires a prototype process of adaptation between the national regulations and the requirements set by the American reference standard.
- LEED and BREEAM protocols are used internationally as reference standard for sustainability but also for building quality certification. The development of building projects at international scale requires internationally known benchmarks which can´t be identified with local or national laws. In spite of their lack of absolute-value measurement for building performance both LEED and BREEAM protocols have grown internationally creating a well-known benchmark from the commercial point of view. This converts them into a powerful tool for project quality evaluation at international level and therefore we cannot ignore their importance for international project developments (Pearson, 2010).

2.3.4 Other important sustainability reference standards.

As briefly described in the previous chapters sustainability and green-building developments have been gaining momentum at international scale. Therefore the construction market experienced the growth and expansion of several green-building reference standards first established at a national scale and then implemented internationally. Here researchers aim to briefly describe some of the most-used reference standards at international level in terms of certified projects and market a part from the already cited LEED and BREEAM in order to have a more complete picture of the current situation that drives the implementation of green-building standards. This is not the focus on the present research however we believe that the understanding of how green-building market evolves and is being considered worldwide from different perspectives is a key point to appreciate the results of this research work. In fact, using the words of the United Nation's Agenda: "Every country and reality is aiming toward sustainability, each of them using their own means, criteria and methods. We all have the same goal and we'll reach it using different streets." (United Nations, 2016).

2.3.4.1 The Passive House Protocol.

Sustainability and green-building development depends on different factors; cultural background and construction typology among others. As described in the previous chapter, green-building reference standards tend to address only a limited number of issues. In case of the Passive House reference standard two key factors are considered above the others, energy performance and thermal comfort of the final users . In fact, this protocol originally created in a cold-climate country like Germany and then implemented at international scale, only considers the energy consumption of the building from a rational perspective and the parameters to optimize the thermal comfort of the final building users. It is, in short words, a protocol that certifies the energy performance of the building and the thermal comfort of the interior spaces. This is achieved by considering also the economic feasibility of the building

The Passive House Institute (PHI) was founded in 1996 as independent research organization to promote and control the Passive House standard and has played a crucial role in the development of the Passive House concept. During these last 20 years the Passive House standard has evolved and today has become a worldwide phenomenon and a generic term for a low energy building: although energy efficiency was initially a by-product of the original concept, which was to find a long-term, sustainable construction solution offering unparalleled comfort to occupants. As of 2014, there are now an estimated 40,000 buildings certified to the Passive House standard with thousands more low energy developments inspired by the model (Webster, 2016).

Passive House is a building standard that evaluates energy efficiency, comfort and affordability of the project. According to the Passive House Institute's co-founder Dr. Wolfgang Feist, the main key-aspects of this reference standard can be described as follow (Feist, 2016):

- Passive Houses allow for space heating and cooling related energy savings of up to 90% compared with typical building stock and over 75% compared to average new builds. Passive Houses use less than 1.5 l of oil or 1.5 m3 of gas to heat one square meter of living space for a year – substantially less than common "low-energy" buildings. Vast energy savings have been demonstrated in warm climates where typical buildings also require active cooling.
- Passive Houses make efficient use of the sun, internal heat sources and heat recovery, rendering conventional heating systems unnecessary throughout even the coldest of winters. During warmer months, Passive Houses make use of passive cooling techniques such as strategic shading to keep comfortably cool.
- Passive Houses are praised for the high level of comfort they offer. Internal surface temperatures vary little from indoor air temperatures, even in the face of extreme outdoor temperatures. Special windows and a building envelope consisting of a highly insulated roof and floor slab as well as highly insulated exterior walls keep the desired warmth in the house – or undesirable heat out.
- A ventilation system imperceptibly supplies constant fresh air, making for superior air quality without unpleasant draughts. A highly efficient heat recovery unit allows for the heat contained in the exhaust air to be re-used.

2.3.4.2 The DGBN Protocol.

The acronym DGNB stands for "Deutsche Gesellschaft fü Nachhaltige Bauen" which means "German Society for Sustainable Buildings". The DGNB system assesses buildings and urban districts which demonstrate an outstanding commitment to meeting sustainability objectives. The sustainability concept of the DGNB System is broadly based and goes beyond the well-known three-pillar model. The DGNB System covers all of the key aspects of sustainable building: environmental, economic, sociocultural and functional aspects, technology, processes and site. The first four quality sections have equal weight in the assessment. This means that the DGNB System is the only one that gives as much importance to the economic aspect of sustainable building as it does to the ecological criteria.

The assessments are always based on the entire life cycle of a building. Of course the focus is always also on the wellbeing of the user. It is crucial to understand that the DGNB does not assess individual measures but instead the overall performance of a building or urban district.

The DGNB Protocol provides an objective description and assessment of the sustainability of buildings and urban districts. Quality is assessed comprehensively over the entire life cycle of the building. The DGNB Certification System can be applied internationally. Due to its flexibility it can be tailored precisely to various uses of a building and even to meet country-specific requirements. The outstanding fulfilment of up to 50 sustainability criteria from the quality sections ecology, economy, socio-cultural aspects, technology, process work flows and site are certified. The system is based on voluntarily outperforming the concepts that are common or usual today. If a performance requirement is met, the DGNB awards the DGNB certificate in bronze, silver, gold and platinum. In addition, there is the option of simple pre-certification in the planning phase.

Buildings' overall performance in terms of sustainability is assessed on the basis of around 40 different criteria, e.g. thermal comfort, design for all and sound insulation. The DGNB schemes for districts include a separate criteria set which addresses issues such as changing urban microclimate, biodiversity and interlinking habitats, and the social and functional mix.

Projects achieve a certificate/pre-certificate in platinum, gold or silver depending on the degree to which the relevant scheme criteria are met.

The DGNB system comprises a variety of certification schemes for different building uses. All international applications of the DGNB system for buildings are based on the core criteria catalogue, referred to as Core 14. These core criteria are used in combination with scheme sheets which provide detailed information for the relevant scheme in question.

2.4 Project Management Processes.

For the scope of this work, in order to provide a clear definition of Project Management, researchers focused on the concepts given by the Project Management Book Guide (PM Book Guide, 2013) and the Project Management Work Book (Kerzen & Saladis, 2013).

Following the notions expressed in the sources above a first definition of “project” can be given as a temporary event that has a well-defined beginning and end in time with a well-defined scope and through the use of limited resources. Moreover, a project is not a routine procedure, but a specific set of operations designed to accomplish a well-defined goal. The project as hereby defined is performed by a group of people, defined as project team, which often includes subjects who do not usually work together – sometimes from different organizations and across multiple geographies.

2.4.1 A brief definition of Project Management.

On the basis of the definitions reported above, researchers classified project management as the discipline of initiating, planning, executing, controlling, and closing the work of a team to achieve pre-determined goals and meet specific success criteria. One of the key-concepts for the development of the present research is the idea of “project” as an effort designed to produce a unique product, service or result with a defined beginning and end undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value (PM Book Guide, 2013). The temporary nature of projects stands in contrast with the typical business standards which collect repetitive, permanent, or semi-permanent functional activities to produce products or services. Therefore, the management of these two systems is often quite different, and as such requires the development of distinct technical skills and management strategies (T. T. Kidd – 2009). With the development of the present work, researchers aim to find a methodology to merge these two different fields within the scope of the green-building construction industry.

On the other side, project management, is considered to be the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. The Guide to the Project Management Body of Knowledge (PM Book Guide, 2013) identifies its recurring elements which can be divided into five groups:

- Initiating
- Planning
- Executing
- Monitoring and Controlling
- Closing

For each group of elements the primary challenge of project management is to achieve all of the project goals within the given constraints. This information is usually described in a user or project manual, which is created at the beginning of the development process. The primary constraints are considered to be scope, time, quality and budget. The secondary — and more ambitious — challenge is to optimize the allocation of necessary inputs and integrate them to meet pre-defined objectives (Kerzen & Saladis, 2013). A graphical representation of the concepts described above is the so-called “iron triangle”, developed by the project management community and re-proposed by Roger Atkinson for the composition of the research article “Project management: cost, time and quality, two best guesses and a phenomenon, it’s time to accept other success criteria” (Atkinson, 1999). The illustration symbolizes three of the primary constraints as the edges of the triangle and sets the fourth, the quality of the final product, as the driving-concept to balance the other three. Depending on the use of each constraint, resources could be implemented in different ways by managers and parties responsible for the project completion, however, the key-factor of the whole process is the focus on the final product quality.

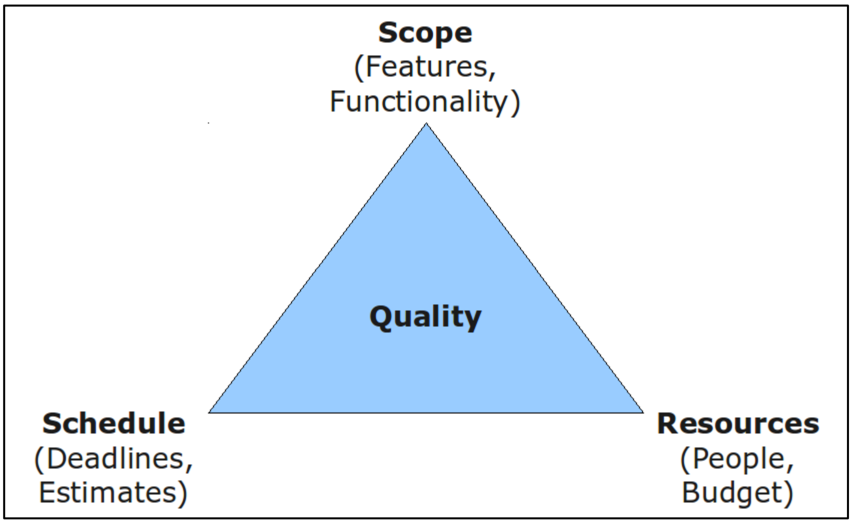


Figure 2.1: graphical representation of the "iron triangle" (Atkinson – 1999).

For scope of this work researchers had to focus on the definition of quality which, as reported by the PM Book Guide, at its most basic level means meeting the needs of customers. This idea is also known as the "fit for use" concept. However, there can be several definitions for the concept of quality, each proceeding from different sources and supported by different explanations. For the purpose of this work researchers focused on the definition of quality in relationship with the construction field and market. A recent study reviewing the related-literature on this aspect of construction defines the concept of "quality" as meeting the owner's requirements or compliance with the set standards and specifications (Al-Ani & Al-Adhmawi, 2011). However, such concept are still susceptible of interpretation and doesn't give a final, rational and un-changeable definition of quality. Therefore, researchers focused on the PM Book approach that defines quality through the use of different concepts. The reference guide identifies three key quality management concepts that allow professionals delivering a high quality project.

- Customer Satisfaction
- Prevention over Inspection
- Continuous Improvement

Each of these concepts can be described separately as reported below.

Customer satisfaction is a key-factor for measuring the quality of a project. However, the idea of project quality can be considered as the customer satisfaction for both the product of the project and the management of the project. For the purpose of this work researchers considered only the first case but with some special conditions explained in the following paragraphs of this chapter. In practical terms, if the customer doesn't feel the product produced by the project meets their needs or if the way the project was run did not meet their expectations, then the customer is very likely to consider the project quality as poor, regardless of what the project manager or team thinks.As a result, not only is it important to make sure the project requirements are met, managing customer expectations is also a critical activity that you need to handle well for your project to succeed (PM Book Guide, 2013).

Prevention over inspections can be qualified as a branch of the project-control process. Such tasks can be performed through the implementation of different tools, such as, cost control, human resources leveling, scheduling, project re-engineering and others. The Cost of Quality (COQ) includes money spent during the project to avoid failures and money spent during and after the project because of failures. These are known as the cost of conformance and the cost of non-conformance or, as a research work recently defined them, costs of quality and costs of non-quality (Rosenfeld, 2009).

Costs of conformance include:

- Prevention costs for training, document processes, equipment and time to perform the tasks;
- Appraisal costs for testing, destructive testing loss and inspections;

Costs of nonconformance include:

- Internal failure costs for tasks re-work and scrap;
- External failure costs for liabilities, warranty work and loss of potential business.

The literature reviewed by researchers for the purpose of this work unanimously indicates that for the vast majority of case-scenarios the cost of preventing mistakes is usually much less than the cost of correcting them. This is the key-concept that sets the basis for the present research, develop a methodology that allow professionals and subjects involved to address the resources toward the most-effective actions for the prevention of project-management-related issues.

Continuous improvement is a concept that exists in all of the major quality management approaches such as Six Sigma and Total Quality Management (Pyzdek & Keller, 2014). It can described as the ongoing effort to improve your products, services, or processes over time. These improvements can be small, progressive changes or major, breakthrough-type changes. From a project perspective, this concept can be applied by analyzing the issues that were encountered during the project for any lessons learned that you can apply to paragraph above “prevention over inspection”. The concept of continuous improvement will be discussed later on in this chapter in relationship with the key-aspects of Lean methodology.

2.4.2 Construction Project Management processes in USA and Europe.

Contrarily from industrial project management processes, construction projects can be very unpredictable and management needs to be able to cope with daily changes (Gould & Joyce, 2009). They need to adapt to the flow of the project, the weather, the mood of the project team and other variables that are not always predictable. A construction project goes through the different phases described above and has therefore a continuously changing workflow and different cultural settings. Management needs to adapt to these changes and at the same time keep the home office updated with the progress of the project.

The development of a project management process related to a construction project is performed through the implementation of a different set of rules and requirements which certainly depends from the asset of resources available but is based on two main pillars: time and costs (Baker, 1991).

This has become a physiological need of private companies such as General Contractors which split their staff and internal organization mainly between scheduling and estimating departments (Bowen et al.,2014). For what concerns the real construction field, once the owner specifies a certain goal through project drawings, specs and documentation, a certain time to achieve the goal and a maximum amount of money to spend the project management process within the company focuses on managing the aspects related to times and costs through the best-possible allocation of available resources.

The scheduling focuses on planning the different project activities in order to obtain the pre-determined goal with the minimum depletion of resources. The whole scheduling process is based on different mathematical algorithms and methods to rationally calculate the best combinations of activity sequences in order to achieve the project completion (Harris, 1978). Success of the planning operation depends on the knowledge of available procedures and the ability of choosing the method that will lead to the maximum benefit. However, whichever the chosen methods, the decision process will involve gathering as much information as possible in relationship with the following categories: materials, machinery, manpower, money and time (Harris, 1978). Since the present research focuses only on building design processes and not construction researchers considered those same items but in relationship with the design process. Following a definition of schedule hierarchy given by R. Harris the scheduling process can be divided into three phases related to basic schedule, bar chart and project control. The basic schedule aims toward a general overview of the project activities, can be developed starting from the concept of Activities-On-Node network and gives a general understanding about when could be approximately located in time the different milestones of the process. The bar chart, developed at the same time with a more detailed AON network is a more hands-on tool that gives technicians a specific terms in time for activity start, ending, floats and critical path. The project control is the last process, developed during the execution of works and not in advance for supervising that the terms of resource allocation expected coincide with the ones really put in place during the project execution. For the purpose of the present work researchers considered only the first two phases of project planning techniques.

The cost estimation models, which in the early stage estimate the construction costs with minimum project information, are useful in the preliminary design stage of a construction project. Improved cost estimation techniques, which are available to project managers, facilitate more executive control of time and costs in construction projects (Dell'Isola, 2003). Despite the great importance of the task of cost estimation, it is neither simple nor straightforward because of the lack of information in the early stages of the project. There is always a discrepancy between cost bidding and cost estimating and this is mainly caused by the level of detail used to perform each of the two tasks (M. Dell'Isola, 2003). During a bid competition companies do not have the time to go through every single feature of all the tasks that have to be perform, this level of detail is achieved through years of experience by technicians and subcontractors that work hands-on within a specific field. Therefore, there is always a gap between a project bid and the real and correct estimate for delivering a specific task or product.

Case studies, interviews and data collection used for the majority of the accessed research articles focuses on the Anglo-American construction process, originally developed within the United States and then implemented in other regions of the planet. However, within the European Union the construction and project management process is substantially different. More subjects are involved and local laws establish new hierarchies within the whole construction and project development process [12] (Guy & Moore, 2005).

Within the US construction and project delivery process for design-bid-built projects each subject works almost independently following a two-party contract, only lately with the implementation of the new contract forms A201-2007 (AIA, 2007) and 232-2009 (General Conditions of the Contract for Construction, Construction Manager as Adviser Edition) owner, contractor and designer have to sign a common document that binds each other. However, the United States design-bid-built process still follows a pyramid organization compared to the European one. Whether in the US the owner hires the designer and then separately the contractor using a resident engineer as supervisor, in Europe there are four different figures interacting in the process at the same time, each of them directly dependent from the owner and therefore at the same hierarchic level. Beyond the designer and the general contractor, in Europe the owner must hire a security chief manager and the so-called "director of works" which acts in behalf of the owner during the construction phase and both of them have full powers on all the construction site operations in parallel with the general contractor and the designer. Within the European system these four different parties have to coexist at the same time and occasionally each of them take over certain project management tasks. Such circumstances make the whole project management process more complex and more difficult to analyze. In figure 1.2 are shown the schemes representing the contractual linear dependencies between subjects involved within a design-bid-built common process.

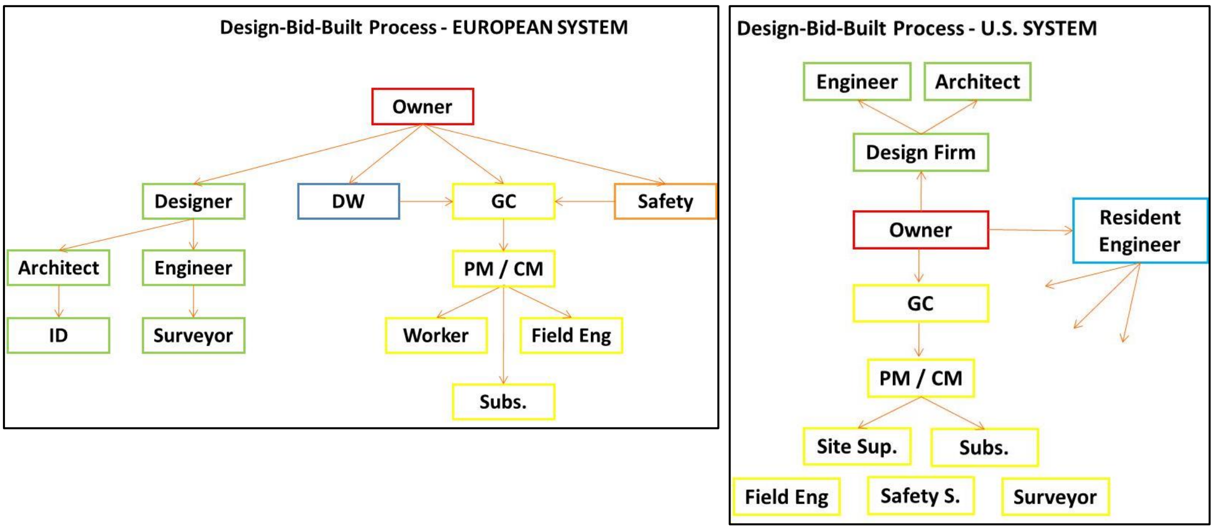


Figure 2.2: Representation of the contractual dependencies between subjects involved in the Design-Bid-Built European and U.S. construction process.

The European Union is substantially different from the USA, each country of the Union has its own laws and is not ruled by a federal set of laws. However, several studies conducted recently show the differences between the two continents from the public-process efficiency point of view as an average value between the main countries that are part of the EU. More specifically, a research promoted and published by the English newspaper “The Telegraph” gives us and idea of how complex and slow could be the European construction-related processes in comparison with the American ones (Quilty-Harper, 2011). *Figures 2.3 and 2.4* below give us an idea of the magnitude of the problem. For example, according to the study, in 2011 obtaining a construction permit in USA would have taken in average 26 days versus the 258 of Italy or the 182 of Spain and France. Enforcing a contract in USA would have taken 300 days, 1210 in Italy and 515 in Spain. For the purpose of this work researchers focused also on the diagram reported in *Figure 2.5* below showing the average periods of time required in each European country to get construction permits, electricity connected, contracts enforced and goods exported. The differences between the two realities are clear, especially when focusing on the extreme points of the diagrams. According to the study, processes in Italy are more than 4 times slower than in the USA and in the majority of the other countries such as Spain, Greece, Ireland and Portugal at least twice as slow. Inevitably the slowness and delay of public-related bureaucratic processes in Europe affects the organization of all design and construction related activities as well as the Project Management area. As a result the importance of some project-management events is modified because activities related to the slowest processes inevitably end up to be part of a critical path (Harris, 1978). However, whether in USA such activities can be generally related to operational needs, such as, steel structure order and supply, in Europe chances are that such activities are related to public sector entities that do not follow a pyramidal decisional system.

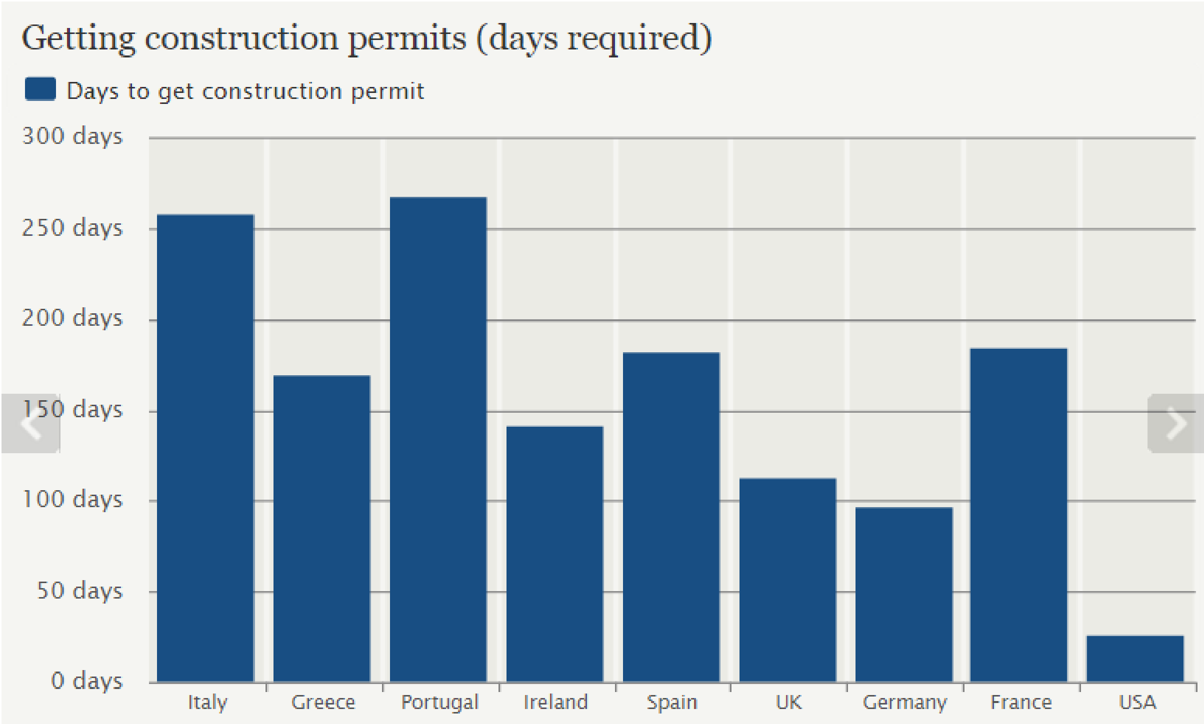


Figure 2.3: snapshot of the graphic diagram reported by "The Telegraph" showing the number of days required to get construction permits within EU and USA (Quilty-Harper, 2011).

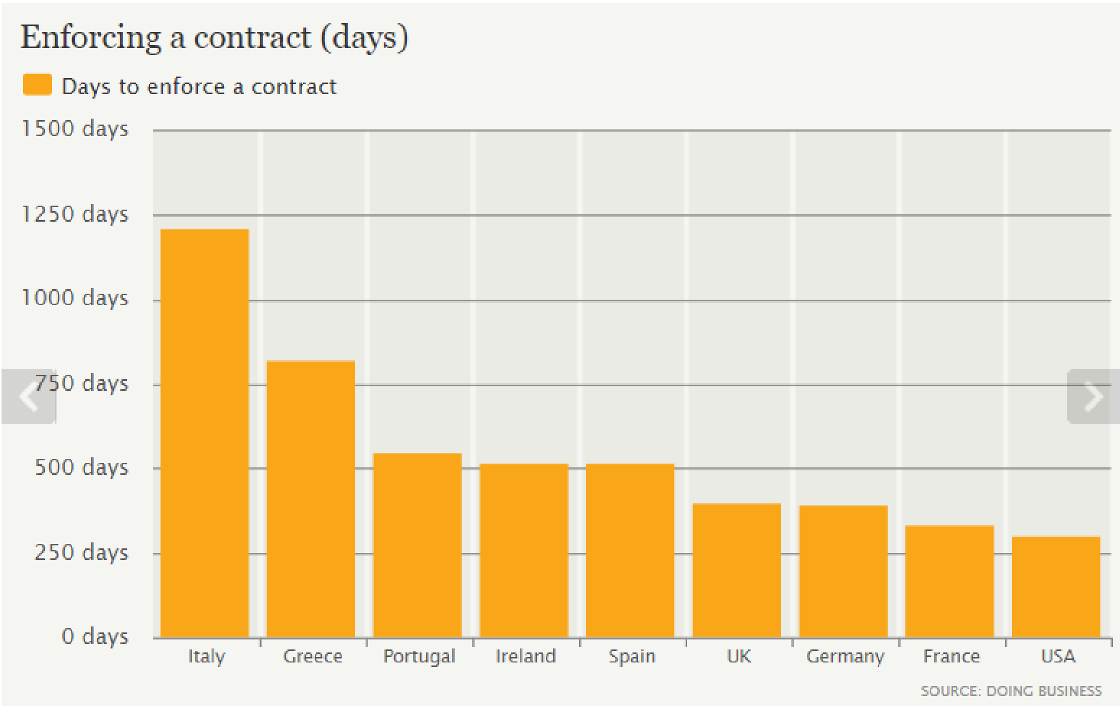


Figure 2.4: snapshot of the graphic diagram reported by "The Telegraph" showing the number of days required to enforce a contract within the major EU countries and the USA (Quilty-Harper, 2011).

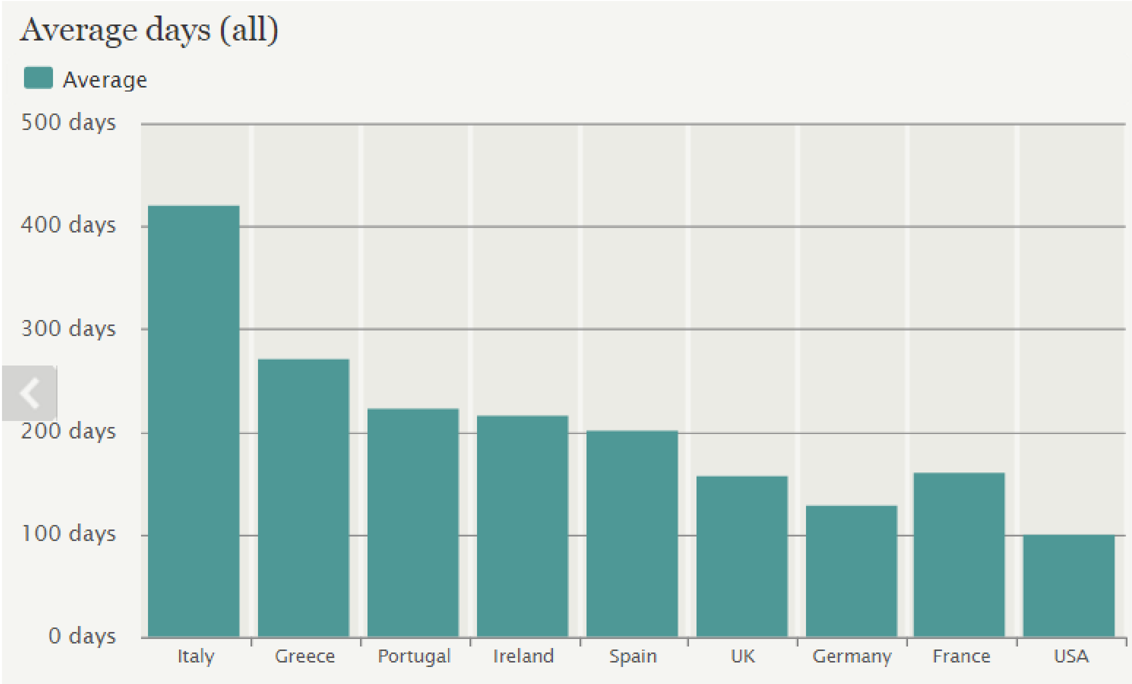


Figure 2.5: snapshot of the graphic diagram reported by "The Telegraph" showing the average number of days required to get construction permits, electricity connected, contracts enforced and goods exported within the major EU countries and the USA (Quilty-Harper, 2011).

According to a recent research study, European public administrative system do not always have rigid classification schemes nor methodologies to manage internal process from a rational and schematic point of view (Passas & Tsekos, 2011). Often decisions and liabilities are taken within an environment in which meritocracy doesn't barely exist because the worker's retribution doesn't depend on the final results obtained. In other words, European public systems are in a certain way exempt from the concept of efficiency and therefore is difficult to manage a high-efficiency demanding process like project design and construction that has to deal with a system in which efficiency is barely considered. Moreover, as highlighted by Christopher Hood in his book "The Blame Game" in Europe bureaucracy is used as a tool to shift responsibilities to other parties and blame avoidance pervades government and public organizations at every level (Hood, 2011). The bureaucracy is then used not as a tool for standardizing processes but as a mean to shift responsibility toward other subjects or entities. Within this never-ending finger-pointing cycle the focus on time and costs is often lost and so all activities related to public-administration decision cannot be taken into account for project and process management purposes.

Therefore, for the purpose of the present work researchers considered this lack of efficiency throughout the public administration system and focused only on the activities that can be managed on the basis of rational and well-defined calculations and processes which excluded, in the majority of the cases, the activities and decision-making processes related to the public administration.

2.5 The Lean approach.

Around the half of the XX century the car manufacturer Toyota started the development of a new approach for the optimization of manufacturing processes. This approach, later identified with the word "Lean" consists in a systematic method for the elimination of any type of waste within a manufacturing system.

Lean methodology is renowned for its focus on the reduction of the original seven types of waste identified by Toyota in order to improve overall customer value, but there are varying perspectives on how this is best achieved. However, from another perspective Lean can be seen as a set of project management and decision-making tools that assist in the identification and steady elimination of waste. As waste is eliminated quality improves while production time and cost are reduced and the terms "waste" identifies all activities that requires any type of resource to be performed but that do not bring an added value to the final product (Liker, 2003).

At the end of 1990s the Lean approach started to be implemented within the construction field for project and construction management purposes. Principles that had been implemented before only for the manufacturing industry started to be transposed and adapted to construction processes. In 1997 the Lean Construction Institute was funded with the goal of developing and using an operating system centered on a common language, fundamental principles, and basic practices.

Within the construction environment, the Lean approach consists in a combination of operational research and practical development in design and construction with the implementation of some of the Lean manufacturing principles. However, construction and manufacturing are two different fields. Construction is a project-based production process in which the project is, most of the times, the first and last of its kind and therefore a prototype whether manufacturing production is a more standardized process. Lean construction focuses on the achievement of concurrent and continuous improvements in all dimensions of the built and natural environment: design, construction, activation, maintenance, salvaging, and recycling (Abdelhamid et al., 2008). From another perspective the Lean approach is seen as the management and optimization method for construction processes with minimum cost and maximum value intended as the best option in response to customer needs (Koskela et al., 2002). The term "construction" associated with the Lean approach refers to the entire industry and not the phase during which construction takes place. Therefore, Lean Construction approach affects and applies to the whole project-development process including owners, architects, designers, engineering, constructors, suppliers and final users.

2.5.1. The basis of Lean.

According to the book "The Toyota Way", published by Dr. Jeffrey Liker in 2004, the Lean approach focuses on the implementation of 14 management principles that can be divided in 4 sections:

- Long-Term Philosophy
- The Right Process Will Produce the Right Results
- Add Value to the Organization by Developing Your People
- Continuously Solving Root Problems Drives Organizational Learning

All principles are based on the ideas of continuous improvement and respect for people which includes different approaches for building respect and teamwork .The continuous-improvement philosophy focuses on establishing a long-term vision, working on challenges, continual innovation, and going to the source of the issue or problem. The four sections cited above, along with the implementation of the related principles, are briefly described below.

Section 1: Long-Term Philosophy:

1. *Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals* (Liker, 2003).

This principle establishes a general mind-setting for most of Lean-related management processes encouraging people to focus on the big-picture situation. Moreover, it pushes technicians and managers to have a global understanding of the environment they are living in without distinction nor discrimination between company, customers, workers and society. This helps building trust within the process and having each party aware of his rights and duties.

Section 2: The Right Process Will Produce the Right Results:

2. *Create a continuous process flow to bring problems to the surface* (Liker, 2003).

One of the key-aspects of Lean approach is the minimization of the waste , or muda in Japanese, Work through the process of continuous improvement. Lean method identifies seven types of muda which can be summarized as follow:

- Overproduction
- Waiting
- Unnecessary transport or conveyance
- Overprocessing or incorrect processing
- Excess inventory
- Motion
- Defects

These types of waste can be seen in several process activities and be analyzed from different perspectives. However, they are all related to the same definition of “waste”: any activity, tasks or event that consumes any type of resource and doesn’t bring any added value beyond capability to the final product (Liker, 2003). Following the idea of J. Liker, when engineers or designers transform an idea into a real design they do not realize that much of the time and effort they spend doesn't directly affect the final product so very little of their work is truly "value added".

The implementation of this principle goes through different ways, for example, the creation of work cells grouped by product and not by process; the use of a sort of "rhythm of demand" to module and segment each production step; the focus on a one-piece flow instead of a massive-production flow.

3. *Use pull systems to avoid overproduction.*

The main concept of this principle is the production leveling throughout the whole process with a method where a process signals its predecessor when more material is needed. The pull system produces only the required material after the subsequent operation asks for it and it focuses on avoiding overproduction and other consequent problems. Overproduction causes generally the growth of inventory which, according to prof. Liker, is responsible for hiding several other problems from the vision of managers and process technicians. Therefore, avoiding overproduction would mean avoiding the growth of inventory, ease the process and clear it from other possible "wastes".

4. *Level out the workload.*

The same principle applied to production is hereby applied to the workload perspective. This helps the minimization of waste by not overburdening people or the equipment, and not creating uneven production levels which, sooner or later, could cause batches throughout the process.

5. *Build a culture of stopping to fix problems, to get quality right the first time.*

The core-concept of this principle is the importance of quality which takes precedence over any other aspect of the process. In order to better explain it we mention a practical example related to the Toyota Production System in which any employee has the authority to stop the process to signal a quality issue. From this perspective all other aspect of the production process, such as, delays, costs, transportation etc. become secondary and serve the main purpose of the production process, deliver a quality product at the first time.

6. *Standardized tasks and processes are the foundation for continuous improvement and employee empowerment.*

Standardized work should be a cooperative effort between the foreman and the worker (Huntzinger, 2002). A common mistake is thinking that standardize means finding the optimum way to perform a task and then freezing it within the process. However, following the Lean approach enables those doing the work to design and build-in quality by writing the standardized procedures themselves which have to be simple and practical to be used on a daily basis by people doing the work (Liker, 2003). In other words, the process allows continuous improvement from the people affected by the system and empowers employees to aid in the growth and improvement of the company or institution they are working for.

7. *Use visual control so no problems are hidden.*

This principle focuses on clearing up the process and every task that compose it in a way to make everything visual and visible. The information should be visible to everybody involved in the process and not seen, and managed, only by one single person. The main idea is to provide a tool that could tell us at a glance if the process or the production segment is deviating from the pre-determined standard. Included in this principle is the so-called "5 S Program" which identifies the steps used to make all work spaces efficient and productive, help people share work stations, reduce time looking for needed tools and improve the work environment. These five steps are summarized here below:

- Sort: Sort out items not needed;
- Straighten: Have a place for every useful tool ;
- Shine: Keep the working area clean and clear;
- Standardize: Create rules and standard operating procedures;
- Sustain: Maintain the system and keep on improving it.

8. *Use only reliable, thoroughly tested technology that serves your people and processes.*

The main idea is to use technology as a tool which has to support the people and the process and this tool cannot be implemented until it hasn’t been understood and testes by all people doing the job. From the Lean perspective personal contact makes the difference and therefore often is better to implement old-time technologies that are better known and appreciated by workers rather than new cutting-edge solutions.

This comes as a result of the process adaptability which cannot suffer massive changes within its development. For example, if the time to perform a certain activity is reduced by 50 % the whole system will not probably be ready to support such massive change because preceding and successive activities would still have to deal with the old timing. Therefore any process change or modification should be done smoothly after the new technology or method has been accepted and recognized by all parties involved. In other words, from the Lean perspective technology is pulled by manufacturing for a smooth and slowly process modification and it is not, as often happens, pushed (or forced) to manufactory.

Section 3: Add Value to the Organization by Developing Your People:

9. *Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.*

With the same focus as the precedent principle but from the human-resources perspective Lean approach encourages the “implementation” of workforce that has been built and grew with the process. Employees must be educated and trained: they have to maintain a learning organization which has its own basis on the people themselves. From this point on view, as well as for the technology implementation, the addition of an external subject with a totally different mind setting could destabilize the system. The Lean approach sees the production experience as a practical teaching tool for employees and people who deal with the system. A teaching tool that flows with the market demand and has to be continuously adapter by and for the employees. A teaching tool made of people for the people.

10. *Develop exceptional people and teams who follow your company's philosophy.*

The Lean approach focuses on the team work rather than the capabilities of the individual. Success is based on the team, not the individual, and teams should consist of no more than 4-5 people and numerous management levels. This idea highlights the importance of management within the Lean philosophy and the need of working in well-organized groups of people. An idea that has to be built and refreshed between the people performing the job on the basis of the previous principle.

An important idea promoted by the implementation of this and the previous principles within the construction field is the bottom-to-top concept. In their book “Construction Project Management” Gould and Joyce say that communication is not a one-way street but needs to be both delivered and received (Gould & Joyce – 2009). This means that the person who wants to communicate information needs to pay attention to the receiver. Therefore a leader needs to carefully choose the time to, for example, critique somebody or give orders. First he should experience and analyze the situation first-hand in order to know what is really going on and then decide what to do.

11. *Respect your extended network of partners and suppliers by challenging them and helping them improve.*

The key-concept of this principle is the development of trust between partners within the production network. The work conditions of employees, as well as suppliers and other subjects collaborating in the process ensures a mutual relationship between partners. Orders and activities are not imposed but firstly discussed together and then implemented with the consensus of the whole production chain.

Lean approach pushes toward challenging suppliers to do better and helping them to achieve it. Moreover, the company implementing Lean should provide cross functional teams to help suppliers discover and fix problems so that they can become a stronger, better supplier and create a team-work process with every partner engaged in the other production stages.

Section 4: Continuously Solving Root Problems Drives Organizational Learning.

12. *Go and see for yourself to thoroughly understand the situation.*

Lean managers are expected to "go-and-see" operations. Without experiencing the situation firsthand, managers cannot have an understanding of how it can be improved. Furthermore, for this purpose Lean managers use ten management principles as a guideline:

- Always keep the final target in mind.
- Clearly assign tasks to yourself and others.
- Think and speak on verified, proven information and data.

- Take full advantage of the wisdom and experiences of others to send, gather or discuss information.
- Share information with others in a timely fashion.
- Always report, inform and consult in a timely manner.
- Analyze and understand shortcomings in your capabilities in a measurable way.
- Relentlessly strive to conduct improvement activities (*kaizen*)
- Think "outside the box," or beyond common sense and standard rules.
- Always be mindful of protecting your safety and health.

13. *Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.*

As already cited above Lean approach focuses on implementing non-radical changes within the production process throughout a consensus-based procedure. However, efficiency on implementing the selected solution is a key aspect for its success. In order to achieve that the following points have to be considered:

- Find what is really going on (go-and-see) to test
- Determine the underlying cause
- Consider a broad range of alternatives
- Build consensus on the resolution
- Use efficient communication tools

14. *Become a learning organization through relentless reflection and continuous improvement.*

Implement the things that you learned to teach hands-on concepts to others, become an organization through the education and the sharing of those principles you have learned during the process. Becoming a learning organization involves criticizing every aspect of what one does and the general problem-solving technique to determine the root cause of a problem includes:

- Initial problem perception
- Clarify the problem
- Locate area/point of cause
- Countermeasure
- Investigate root-causes
- Evaluate
- Standardize

2.5.2. The Lean and Green Initiative.

On the basis of the concepts explained above during the last years several initiatives took place all over the world. Such imitative involved several kinds of entities proceeding from different areas, from the public to the private sectors, which had in common the idea of process optimization through the implementation of new technologies and methodologies.

For the development of the present work researchers focused on the so-called "Lean & Green Initiative" developed through a private-&-public partnership at Penn State University in the US. This asset was originally founded by Penn State faculty members through a collaborative partnership with Toyota for the transposition of Lean methodology toward the construction management field. Following the words of its founders, the focus of Lean & Green Initiative is the implementation of Lean methodology to high-performance building developments which require higher detail definition as well as more complex management processes. Quoting the words of the Lean & Green representatives this initiative "uses scientific method to first understand the process issues facing high performance delivery systems, and then to test strategies to strip process waste and streamline the provision of high-value buildings" (Lean & Green, 2013). This project has been developed and implemented through the partnership with Toyota Motors Corporation and several research studies were conducted taking Toyota's building as real case-study projects. As highlighted by Michael Horman, one of the co-founders of Lean & Green Initiative, high-performance projects require intense interdisciplinary collaboration. Therefore, task development and scheduling can no longer take place in sequential manner but has to be completed using integrated processes and advanced simulation tools that allow all subjects involved to understand and optimize the process (Horman et al., 2006). For the purpose of this work researchers focused on a few concepts implemented by and through the Lean and Green Initiative which are briefly summarized below.

1. *Improvement of building sustainability intended as "building value" and reduction of delivery costs achieved through efficient and functional delivery processes.*

One key-concept used for the development of Lean and Green projects is the definition of a hierarchy of values to be taken into account for the process development. As cited above the Lean approach focuses on minimizing all types of "wastes" intended as activities or events that do not bring added value to the final product. However, depending on the type of project to be developed, researchers have to define what "value" means for the purpose of the project delivery. In this case sustainability becomes a major building value, it is defined as a prime-element of the project-value hierarchy and therefore any activity, event or action that could improve the level of sustainability has to be taken into account and implemented whenever possible.

2. *Alignment of sustainability and constructability through a continuous value enhancement process.*

This aspect of Lean & Green Initiative was developed in partnership with the Pentagon renovation and construction program. The main focus is the development of a type of building that could be sustainable from both environmental and economical point of view (Pulaski et al., 2005). During the development of this work researchers focused on developing, implementing and validating a process that enables project teams to identify sustainable solutions that also improve project constructability. Such improvements which can be identified throughout the whole design and construction stage are then translated into cost savings, time crushing and therefore into the optimization of the whole process. The represent, from another point of view, the integration between processes and information flows between construction and design stages keeping the focus on sustainability and affordability.

3. *Understanding the building pre-design phase and highlight high-performance green-building factors.*

Bringing in more resources during the early design phases of the building and shifting ahead the decision-making process helps minimizing project change orders and modifications which could cost money and time to be fixed in later project stages. This concept is applied to green-building developments having sustainability as a core-value for the whole project duration. Having selected "sustainability" as a key-value for the project development the whole team focuses on preventing problems rather than fixing them. This causes an advanced allocation of resources to be implemented during the early design-stages of the building but smooths out the process for later design and construction stages. This concept is the basis on which the ultimate design technologies, such as, Building Information Modelling (BIM) have been and are being developed. With the representation of the so-called "effort curve" showed below Patrick MacLeamy described how this concept can deeply influence the process optimization (MacLeamy, 2004).

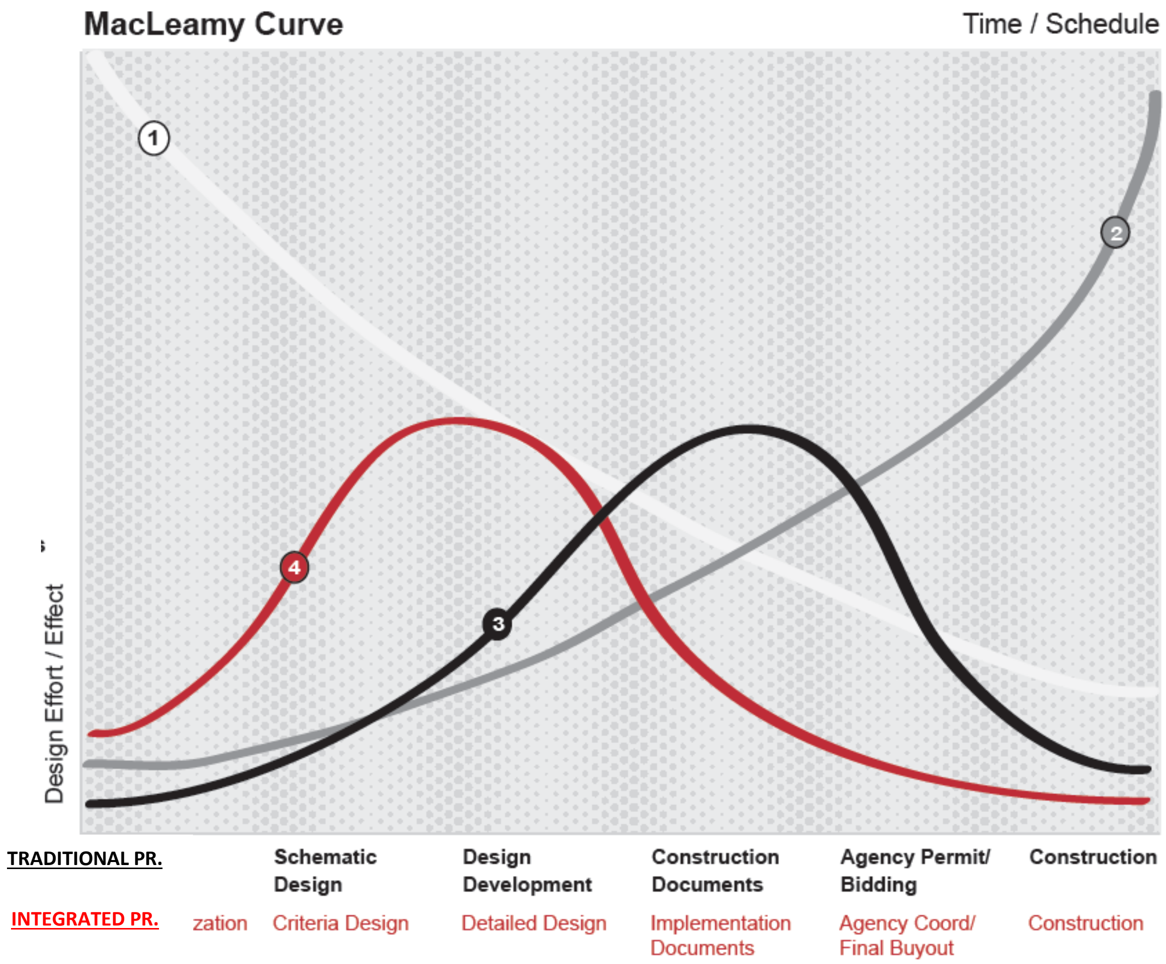


Figure 2.6: representation of the Macleany curve showing the difference between traditional and integrated process from work management point of view. Within the representation readers can see: 1. Ability to impact costs and functional capabilities; 2. Cost of design changes; 3. Traditional design process; 4. Integrated project delivery process (Source: MSA Project Delivery) (Macleamy, 2004).

4. *Relationship between high-performance building, project efficiency and level of sustainability.*

The key-concept is to study the relationship between project delivery, project efficiency, and levels of sustainability to develop a delivery method decision-making tool for green building industry. Sustainability and high-performance buildings are two concepts tight together and aiming for sustainable buildings means aiming toward non-standards performance. Therefore, also project efficiency has to guarantee higher levels in order to manage more complex processes. The relationship between these three concepts gave researchers the basis for identifying the key-factors to be analyzed during the present work.

2.6 Research gap.

The present research focus on three major fields; green-buildings, project management and Lean approach. Within such fields researchers identifies a research gap that can be summarized as follow:

- Different green-building protocols have been established during the last years and the main ones are LEED and BREEAM.
- Several studies related with green-building project management processes have been developed but most of all in relationship with the American design and construction process.
- European design and construction processes are substantially different from the U.S. ones due to procedural, bureaucratic and cultural reasons.
- Implementation of Anglo-Saxon-based protocols such as LEED and BREEAM within the European procedural reality may cause issues at project-management level.
- A deeper understanding on how these issues could affect project design completion is needed.
- One major tool that have been and it's being developed for process optimization is Lean methodology along with an integrated project development approach.
- For the development of the present work researchers focus on investigating the development of green-building design processes through the implementation of Anglo-Saxon protocols using Lean and integrated project delivery approaches as benchmark standards for possible process optimization.

2.7 Chapter summary.

The present chapter defines the state-of-art of research and academic articles related to the field of the present work. It defines the basis on which researchers grounded their work for the purpose of the present research. The main focuses of this research are three: green-building, project management and Lean approach. Each of these three fields has been studied and examined for the purpose of this study. The result of the researcher’s effort in analyzing the state-of-the-art of these three areas of interest has been summarized in this chapter.

CHAPTER 3

Research method

3.1 Introduction.

This Section lays out the main steps of the methodology implemented by researchers for developing the present work and is divided into the following subsections: 3.2 Introduction to the case-study method (Framework of study); 3.3 Stage one: plan (Exploratory case-study approach, Unit of analysis, Qualitative and quantitative research); 3.4 Stage two: design (Identification and selection of case-study projects, Case-study approach); 3.5 Stage three: prepare (The pilot case-study project); 3.6 Stage four: collect (Data source, Dependent and independent variables); 3.7 Stage five: analyze (Explanation building, Cross-case analysis, Data coding, Scheduling and time-related calculations, Cost calculation, Sustainability-related calculations); 3.8 Stage six: share (Verification of methodology, Published research article, Interviews with subjects involved); 3.9 Chapter summary.

3.2 Introduction to the case-study method.

This chapter focuses on defining the core-aspects of the research method. A case-study methodology was implemented for the present research and here are described the main aspects that defined the case-study approach.

Where quantitative research is mainly concerned with the testing of hypotheses and statistical generalizations (Jackson, 2008), qualitative research does not usually employ statistical procedures or other means of quantification, focusing instead on understanding the nature of the research problem rather than on the quantity of observed characteristics (Strauss & Corbin, 1994). Given that qualitative researchers generally assume that social reality is a human creation, they interpret and contextualize meanings from people's beliefs and practices (Denzin & Lincoln, 2011). Case study research involves "intensive study of a single unit for the purpose of understanding a larger class of (similar) units … observed at a single point in time or over some delimited period of time" (Gerring, 2004, p. 342). As such, case studies provide an opportunity for the researcher to gain a deep holistic view of the research problem, and may facilitate describing, understanding and explaining a research problem or situation (Baxter & Jack, 2008). This study adopts Yin's (2009) six-stage case study process; plan, design, prepare, share, collect, analyze. Which is described in chapters below.

3.2.1 Framework of study.

In order to have an overall view of the research matter and better understand the scope of the work researchers created a framework of study. The framework has been developed and refined throughout the whole research process and gives a general understanding of the activities and tasks that have been performed by researchers throughout the whole process. As schematically shown in figure 3.1, the framework is divided in several frames:

- Yin's process stages on the left;
- The different milestones of the research method in the center;
- The practical tasks performed for each process milestone on the right.

This last group represents the hands-on activities performed by the researcher in relationship to the development of the thesis, such as, the collection of information and identification of case-study projects. Therefore, the framework of study was developed for the following main reasons:

- Clarify the research project milestones and visualize them graphically;
- Identify the groups of activities researchers would be directly responsible for;
- Organize the whole research development from the scheduling and resource-allocation point of view;
- Give readers a preliminary at-a-glance overview for understanding the research work methodology.

The following subsections of the chapter describe the framework in detail.

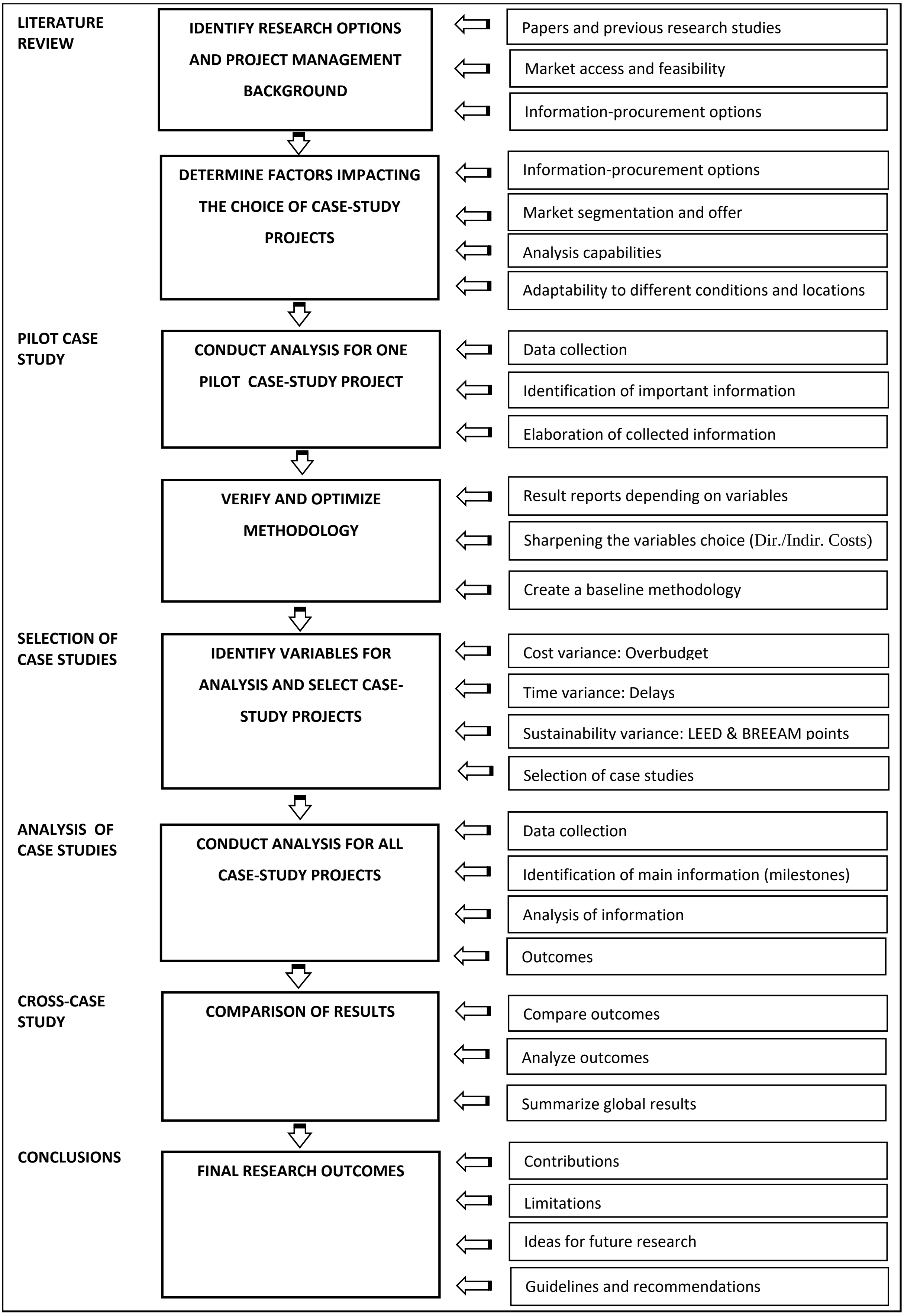


Figure 3.1: framework summarizing the methodology milestones for the present research project.

3.3 Stage one: plan.

The planning stage focused on identifying the research questions or other rationale for doing a case study, deciding to use the case study method (compared with other methods), and understanding its strengths and limitations (Yin, 2009). Clearly defining the research problem was probably the most important step in the entire research project. As such, the case study should began with a comprehensive literature review and a careful consideration of the research questions and study objectives (Ravitch & Riggan, 2011). A comprehensive literature review, which enhances the face validity of the study (Dooley, 2002), identified relevant gaps in the literature and relate them to the research questions (Darke et al., 1998).

Another key point of the planning stage was to ensure that no mismatch exists between the research questions and the case study method (GAO, 1990). The choice of the research method was determined by several factors: the type of research question, the control of the researcher over actual behavioral events, the focus on contemporary as opposed to historical phenomena (Yin, 2013). While the case study method has traditionally been classed as soft research, the properties described above actually make case studies particularly difficult to execute well (Yin, 2009). Nevertheless, they are particularly suitable when research sponsors define the research questions (GAO, 1990). Additionally, while experiments usually control the context in an artificial environment and have many more data points than variables of interest, case studies usually have “many more variables of interest than data points” and rely “on multiple sources of evidence, with data needing to converge in a triangulating fashion” (Yin, 2009, p. 18). For the purpose of this work researchers identified and classified several variables in two main groups, dependent and independent, which will be clarified below. On the other hand in this instance case studies were used for confirmatory (deductive) as well as explanatory (inductive) findings (Yin, 2009), on the basis of multiple cases, and included qualitative and/or quantitative data (Gerring, 2004). Researchers implemented two types of case-studies: exploratory and explanatory, respectively in relationship with the first pilot case-study and with the others developed later on the basis of the first one. While case studies do not aim to generalize to populations (statistical generalization), similar to experiments, they aim to generalize to theories (analytical generalization; Yin, 2009). Thus, according to Yin, replication may be claimed "if two or more cases are shown to support the same theory" (Yin, 2009, p. 38). Following this idea, for the purpose of the present study, researchers picked four different case-study projects in order to support the same theory related to project management optimization.

GAO (1990) provides a detailed classification, differentiating between six types of case studies: • illustrative—this case study is descriptive in character and intended to add realism and in-depth examples to other information about a program or policy; • exploratory—this is also a descriptive case study but is aimed at generating hypotheses for later investigation rather than for illustrating; • critical instance—this examines a single instance of unique interest or serves as a critical test of an assertion about a program, problem, or strategy; • program implementation—this case study investigates operations, often at several sites, and often normatively; • program effects—this application uses the case study to examine causality and usually involves multi-site, multi-method assessments; and • cumulative—this brings together findings from many case studies to answer an evaluation question, whether descriptive, normative, or cause-and-effect.

Using the classification cited above provided by GAO the case-study projects used for the present research can be defined as exploratory for the instance of the pilot case-study and cumulative for the other ones.

3.3.1 Exploratory case-study approach.

Following Yin's guidelines for case-study research (R. Yin, 2013) the present work was developed considering the so-called cross-case analysis approach based on the implementation of a specific theory. The theory was used by researchers to establish a well-defined area of interest within the range of possible case-studies related to a specific cause-effect relationship. The theory that formed the roots of the research was shaped by researchers on the basis on an exploratory case-study research.

Since all research is based on theory, the theoretical foundations of the study should be clearly articulated (Flynn et al., 1990). This includes differentiating between theory building (Eisenhardt, 1989) and theory testing approaches. The exploratory case-study is represented by a single green-building project developed by researchers in partnership with other professional entities. The specific case-study project will be described later in chapter 3.5 however, in this context is important to highlight some elements that emerged from the literature review during the development of the exploratory case-study and which cleared the path for the development of the work theory. The project development helped researchers developing the following core-concepts for the development of the research:

- The implementation of specific protocols, such as, green-building protocols within a building design process brings additional restrictions to the process development.
- Such restrictions cause a constriction of the margin of maneuver of each subject involved in the process.
- The whole process management and organization has to be refined in order to meet the new task restrictions.

Literature review defines and characterizes European and Anglo-Saxon design and construction processes highlighting their discrepancies and rules. As already cited in chapter two, the differences between construction processes affects projects developed at international scale. The most-used green-building protocols implemented world-wide proceed from the Anglo-Saxon reality and were built on the basis on their specific construction process. On the other hand, Europe has an almost unique construction system that varies from country to country but it is consistently different from the Anglo-Saxon one.

3.3.2 Unit of analysis.

According to Yin (2009) the unit of analysis defines what a "case" is in a case study, as a general guide, the definition of the unit of analysis (and therefore of the case) is related to the way the initial research questions have been defined. In other words, what unit of analysis to use generally depends on the primary research questions and it can be a decision, a social program, a process and others. Once defined, the unit of analysis can be changed if desired, on the basis of the results and findings obtained by the research. Yin also points out that operationally defining the unit of analysis assists with replication and efforts at case comparison. Therefore, in order to compare results with previous studies and to allow others to compare results with ours, researchers selected a unit of analysis that is or can be used by others.

The unit of analysis selected for the purpose of this research is a process and, more specifically, the process that coincides with the design-development phase of a green-building project.

Each unit of analysis requires a different research design and data collection strategy and in this case both of them were redefined and sharpened through the implementation of the pilot case-study project. Following the idea of Yin (2009), the comparative process of case studies implemented for this research followed a replication logic under which each case had to be selected so that it predicts similar results. This, paired with the standardization of the data collection strategy for all case studies, allowed researchers to implement a single unit of analysis for all case studies analyzed.

The choice of the variables for the development of the present work was done on two different level. The independent variables defining specific aspects of the unit of analysis that are common to all case-studies. Independent variables that assess the impact of a specific issue on a specific case-study and are not necessarily common throughout the whole project sampling. For the purpose of defining the unit of analysis researchers focused on the dependent variables which can be described as follows:

- Time deviation:
- Cost deviation:

- Sustainability deviation:

The concept of time deviation is 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. In order to measure this delay researchers implemented the scheduling and project-management concepts (Harris, 1978) to calculate the free-float and total-float of each activity of the project design phase. Also the critical path was calculate for the activities performed during the design phase using the information available at the early design stage and this gave the researchers a benchmark of how thing would have been in terms of scheduling and timing if no problem had interfered with the design development. Researchers managed to measure, for all such activities, the delay caused by project-management issues in terms of total float and/or critical path extension. The duration of all sustainability-related problems included on the project critical path were accounted for the total project delay. The duration of all sustainability-related problems of the whole project bar chart were accounted for the total loss of time. The first independent variable takes into consideration the total project delay suffered by sustainability-related activities due to project-management issues and its unit of measure is the work-day.

With the term cost deviation researchers identify all additional costs caused by project-management issues for the development of sustainability-related activities. For the purpose of the study, researchers divided the costs in two different categories: direct costs and indirect costs. With the term “direct costs” researchers identified all expenses, caused by the sustainability-related problems cited above, that the owner had to bear in addition to the original project budget in order to complete the design process. With the term “indirect costs” researchers identified two types of expenses:

1. All additional costs caused by the sustainability-related problems cited above that technicians involved in the project had to bear with no additional compensation to their professional fee, in order to develop the originally expected product.

2. All additional costs caused by the effects of the sustainability-related problems which affected third parties and later project development phases.

In the final results direct and indirect costs are reported separately however, they both refer to the same unit of measure, the Euro.

With the term sustainability deviation researchers identify the loss of certification points, under the LEED or BREEAM reference standard, caused by project-management issues for the development of sustainability-related activities. For each case-study at the beginning of the design phase the team draw a map of how many points would be achieved by the end of the certification process for the design phase. Taking the whole possible score identified at the beginning of the project as a reference, researchers focused on all LEED and BREEAM points that finally could not be achieved due to project management issues related with sustainability. The loss of these certification points was considered as the sustainability deviation for the purpose of this work and its unit of measure was either the LEED or the BREEAM certification credits.

3.3.3 Qualitative and quantitative research.

The present research has been developed through a qualitative and quantitative approach throughout the whole process of data collection, elaboration and outputs delivery.

The collection of all significant information related to the case-study was performed using two methods: analysis of case-study official documentation and interviews with subjects directly involved in each project. For both sources researchers identified separate quantitative and qualitative phases in which different types of information were collected toward the purpose of the research.

The analysis of official project documentation was performed in three steps which can be summarized as follows:

- Collection of all official documentation related to each case-study project. In this phase researchers rounded up all the official documentation available for each project asking directly to each authority and/or entity responsible for the project completion which could be either owner, public administration office, permit-granting authorities, etc. For this process researchers had to deal with different types of subjects depending on the type of project selected. As described more in detail in chapter 4 different case-study projects presented different bureaucratic and managerial organization and therefore also the process of data collection had to be adapted to each single process analyzed. The more fragmented the process the more subjects involved and the more documentation researchers had to collect. In this initial phase researchers tried to collect all the documentation available for each case-study project.

- Identification of significant documents within all the material collected. This process was performed using a qualitative approach by a mere "yes and no" selection. All documents that could contain useful information related to the research project were selected and kept on the side, all the other ones discarded.

- Identification of useful information within the documentation selected previously. Researchers re-analyzed the selected documentation and extracted from it the information which could be useful to the scope of this research. This process was performed at once for each case-study project considering though two types of information, qualitative and quantitative. For each project researchers created a two-column table with the description of qualitative problems on the left and quantitative issues detected on the right. The left column described the entity of the problem identified and the right column reported all the evidence encountered for that specific problem in terms of specific activities or events.

In relationship with the data-collection process researchers conducted several interviews with subjects involved at multiple stages. Likewise the collection of information through official documentation also interviews were structured considering a first qualitative “yes & no” step in which interviewees were asked to answer, for each project phase, the following question: “Do you think there have been any problems occurring during the development of the design process?”. Prior to expose interviewees to this question researchers explained them the details of the interviews sending previously the interview layouts and clarifying key-ideas, such as, the concept of “problem” on the basis of the Lean approach as described in the previous chapters. After this first qualitative step interviewees were asked to define more in detail each activity event or process phase in which they previously recognized the existence of one or more problems. This led researchers to have a double qualitative and qualitative outputs from each interview that was organized, likewise the information proceeding from official documentation, in a double-column table with qualitative aspects on the left and more detailed quantitative features on the right. This second phase of the interview was developed through a standardized checklist sent in advance to interviewees.

The merge of the two quantitative and qualitative tables obtained through documentation analysis and direct interviews with subjects involved created the core of data collected for the scope of the present research. Table 3.1 below gives an example of how qualitative and quantitative information were collected and classified. Quantities indicated on each problem were extrapolated directly from documentation and interviews.

Qualitative analysis: problem identification	Quantitative analysis: problem quantification
- *Problem 1:* Lack of planning for owner's activities before preliminary design start.	- Need to ask for fund extension and re-present grant proposal – 3 weeks - No topographic survey in place – survey assigned with urgency – 3 weeks and 5.000 Euros extra costs.
- *Problem 2:* No clear decision-making process in place at preliminary design stage.	- Extra meetings and documentation re-processing. - Lead time increases – 3 weeks.
- Others…	- Others…

Table 3.1: example of qualitative and quantitative classification of problems identified during the process.

On the basis of different parameters defined in the following chapters all information collected were then elaborated and classified in three qualitative categories related to: costs; time and sustainability. These categories were later identified by researchers as independent variables for the scope of the present study. Then, the analysis of information was performed from both qualitative and quantitative point of view for each single category. The process of analysis embraced at first the overall situation of each case-study project in order to select and classify information and then developed each category in detail using quantitative approaches. Whether during the collection of information the qualitative process was used to answer the question "Was a problem detected with a specific process or a specific process phase?" during the analysis of information the quantitative process was used to answer the following question: "If a problem occurred during the process or during a process phase, how much did this problem affect the overall process development?". The answer to this question is explained in detail in the following chapters and takes into consideration different analytical processes for each of the three categories cited above: costs, time and sustainability.

Following the same approach implemented for the elaboration of information researchers classified each case-study output information under a qualitative and quantitative scheme. Different case-study projects had different conditions and inevitably led to different types of output. In order to get an overall picture of the situation researchers had to homogenize the output information using a qualitative process of classification. On the basis of the information acquired during the study, researchers identified different problem categories under which several issues encountered during the analytical process could be grouped up. This process of homogenization described more accurately below was based on a qualitative classification of output information and allowed researchers to establish common categories of problems for different case-study projects. The main idea that led the creation of these problem categories was the cause of the problem. Each process had, inevitably, several problems or issues related to cost, time and sustainability which, at first sight, would be independent one from another. However researchers identified the cause of each of the problem and recognized different categories which could describe the groups of problem causes through all four case-study projects. Five categories were identified by researchers using this qualitative method and they represent the root-causes of all problems encountered throughout the four case-study projects.

For each category a quantitative estimation of the problems causes was developed as a sum of all problematic events that raised as consequences from each specific cause. Problems identified by all subjects were reported on a global problem list and then grouped up depending on the activities they affected. However, "problems" identified by interviewees following the Lean concepts were the symptoms of the structural project management issues researchers were interested in. Therefore, problems initially identified by subjects were labelled and gathered together in several "categories of issues" which represent the real project management problems researchers wanted to analyze. The categories of issues identified for the purpose of the present research are listed below and are described more in detail in chapter 5:

A. Lack of integration between technicians involved and consequently bad timing for green-building tasks;

B. Misunderstanding of Commissioning Authority's tasks and process;

C. Lack of appropriate clauses in bid documentation;

D. Systematic cuts to budget due to change-orders and delays;

E. Misunderstanding of the energy modelling role and process;

Problems could be related to single or multiple activities. The total impact "I" of all "i" problems on the whole project completion was estimated as the sum of the impact of that specific problem on all the activities it affected in the three dimensions of time, costs and sustainability as follows:

$$\mathrm{I_d} = \sum_{1}^{n} \mathrm{i_{An(d)}} + \sum_{1}^{n} \mathrm{i_{Bn(d)}} + \sum_{1}^{n} \mathrm{i_{Cn(d)}} + \sum_{1}^{n} \mathrm{i_{Dn(d)}} + \sum_{1}^{n} \mathrm{i_{En(d)}}$$

$$\mathrm{I_{€}} = \sum_{1}^{n} \mathrm{i_{An(€)}} + \sum_{1}^{n} \mathrm{i_{Bn(€)}} + \sum_{1}^{n} \mathrm{i_{Cn(€)}} + \sum_{1}^{n} \mathrm{i_{Dn(€)}} + \sum_{1}^{n} \mathrm{i_{En(€)}}$$

$$\mathrm{I_S} = \sum_{1}^{n} \mathrm{i_{An(S)}} + \sum_{1}^{n} \mathrm{i_{Bn(S)}} + \sum_{1}^{n} \mathrm{i_{Cn(S)}} + \sum_{1}^{n} \mathrm{i_{Dn(S)}} + \sum_{1}^{n} \mathrm{i_{En(S)}}$$

Where "I" represents the impact of all different "i" problems interfering in different "n" activities of each "A" to "E" problem category for dimensions of time "d", costs "€" and sustainability "S".

Finally, for cost-related aspects, researchers created different tables using the results obtained from both qualitative and quantitative estimations. Different tables, each of them specifically developed for one specific field of interest, were created for each case-study project and combine the qualitative analysis and evaluation of problems with specific quantitative estimates developed as described above. One axis reports all the different problem categories identified, the other the specific activities that caused the problems and the quantification of the impact of each problem activity in terms of costs was then reported numerically within the table. The definition, estimate, analysis and representation of cost-related aspects of the project will be described more specifically in the following paragraphs of this chapter.

3.4 Stage two: design.

The design stage focuses on defining the unit of analysis and the likely cases to be studied, developing theory/propositions and identifying issues underlying the anticipated study, identifying the case study design (single, multiple, holistic, embedded), and developing procedures to maintain case study quality (Yin, 2009). Research design logically links the research questions to the research conclusions through the steps undertaken during data collection and data analysis. For the scope of this study the research design, developed also through the pilot case-study project, can be seen as a "blueprint" for the research project and addresses the research questions, relevant propositions/hypotheses, the unit of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings. The criteria for interpreting the findings include the most relevant rival theories/explanations so that relevant data can be collected during the data collection stage of other case-study project. The unit of analysis defines what the case is—for example, an event, a process, an individual, a group, or an organization (GAO, 1990; Yin, 2009). A recent review of qualitative case studies in operations management recently found that 83% of articles did not clearly state their unit of analysis (Barratt et al., 2011). Similarly, most case studies published in the information systems literature fail to identify the unit of analysis (Dubé & Paré, 2003). For the purpose of this study, the researcher implemented a system of dependent and independent variables which defined the units of analysis as cited above in chapter 3.3.2. During the case-study design phase the researcher focused on three independent variables which brought later to the definition of the dependent ones.

As studies may have multiple stakeholders, it is also important to either clearly differentiate between, or align, expected practical and theoretical contributions (Darke et al. - 1998). Potential practical benefits to the case study organization include benchmarking against best-practices and other organizations, and rich descriptions of the phenomenon under investigation. Interviewees may also benefit by gaining a better understanding of the research problem (Onwuegbuzie, 2012). It has been shown that many published case studies fail to identify the rationale for case selection (Dubé & Paré - 2003). According to Yin (2009), reasons for justifying single-case studies include studying a critical case, an extreme case, a representative or typical case, a revelatory case (involving a novel situation), and a longitudinal case. That is why, following Yin's idea, the researcher chose a pilot case-study that would represent a worst-case scenario, or in other words an extreme case, for the purpose of this study.

Always according to Yin (2009), in multi-case studies, each case should be selected so that it either predicts similar results (literal replication), or predicts contrasting results but for anticipatable reasons (theoretical replication). If multiple cases lead to contradictory results, the preliminary theory should be revised and tested with another set of cases (Yin, 2009). Both single and multiple designs can be either holistic (one unit of analysis per case) or embedded (multiple units of analysis per case). For the purpose of this case, as already cited above, researchers identified several dependent and independent variables which were investigated through the different case-study scenarios.

While there is no ideal number of cases, depending on the nature of the research question, the available resources, the study timeframe, and case availability, either breadth (across multiple cases) or depth (within case) may take precedence (Darke et al. - 1998). Nevertheless, multiple cases typically lead to more robust outcomes than single-case research, especially in the context of inductive theory building (Eisenhardt & Graebner, 2007). As gaining access to suitable case study organizations is perhaps the most challenging step in the entire process (Walsham, 2006), some argue that it may be more pragmatic to tailor any theoretical contribution based on case study accessibility (Pan & Tan, 2011). In other words, that searching for, and gaining access to, relevant cases should come prior to the identification of research questions.

3.4.1 Identification and selection of case-study projects.

The selection of appropriate case-study projects for the scope of the present research was developed in two main steps:

1) Identification of an optimum range of projects to be analyzed;

2) Selection of the case-study projects based on the availability of information for each project.

The selection of an appropriate set of parameters was the core concept for the identification of the optimum range of case-study projects. Such parameters were selected on the basis of objective considerations supported by real data and information and subjective considerations supported by the researcher's experience. Objective parameters are briefly described below along with the reasons that led researched to choose them:

- *Project location and process organization*. The present research focuses on projects developed on the basis of the European bidding, design and construction process. Therefore all case-study projects had to be geographically limited to the European Union area.
- *Building project records, impact of the research study*. By developing the present work, researchers wanted to develop some guidelines to optimize design processes for green-building developments. Such guidelines should be applicable to a wide range of projects and therefore case-studies selected should have matched, in terms of size and budget, to the majority of projects developed within Europe. Based on several statistic studies developed by private companies (Rabobank, 2014) and public entities (Eurostat, 2013), researchers found that the core-business for new-built construction projects in the EU during the last years is represented by average-small projects with a budget range between 5 and 25 million Euros.
- *Accessibility of information in terms of time frame and location*. All case-study projects had to be analyzed first-hand by researchers and subjects involved had to be directly interviewed without intermediary third-parties. Therefore all projects had to be developed, at least for the design stage, in a time-frame contiguous to the period of time used to develop the present work.

- *Type of projects.* In order to embrace a wide portion of the construction market, researchers discarded all types of non-common building projects that may be developed under special circumstances such as high budget, cutting-hedge technical features or others which could offer a misinterpretation of the common design process reality. Therefore for the scope of this work researchers focused on tertiary-sector and school building projects.

On the other side, subjective parameters used to identify the optimum project range were:

- Manageability of collected information. In order to have a certain work accuracy, researchers focused on the manageability of all project-related information. According to Frese (2003) the bigger the project the more difficult is to handle information due to the potential loss of information, analysis inaccuracies and other possible factors and therefore researchers focused on medium-small building projects that could have been handled accurately by the research team.
- Probability to interact with subjects directly involved in the project. For the scope of the present research, the accessibility to project information depended on their availability and on the researcher's capability of capturing them. In fact, as better described in the following paragraph, companies, public institution and other entities were generally reluctant to share detailed project information with an academic reality. Therefore, the selection of case-study projects was determined by the interaction between the research team members and the subjects involved in each project.

The second phase of appropriate case-study projects was mainly determined by the availability of information. Once researchers identified the range of possible projects in terms of budget, size, location, implemented process and accessibility of information the specific case-study projects were selected depending on the availability of information. The ultimate scope of the present research is to optimize process development by looking at previous real processes and find their weak spots. According to the interviews, communications and documents exchanged between the research team and all entities involved in the projects, from the owner's point of view the present research could represent a problem because it could potentially point out all the weakness of each process in place to the eyes of other subjects involved. Even under the guarantee of confidentiality-clauses and other binding agreements the vast majority of private and public entities refused to provide researchers with any project-related information. Out of twelve projects selected as potential case-study projects, only four accepted to provide the researchers with the information needed for the present work. All entities involved in the four projects had previously worked with the research team or with one of the team's member and this was, according to the researcher's opinion, the key factor that allowed the research to be developed. The opposition of all the private and public entities called by the researchers for the development of this study reflects a structural problem of the relationship between research and construction-related business. A bond which seems to be more formal than functional. The "lack of trust" detected through the many contacts with the companies highlights, from one side, the mental stiffness of companies that struggle to change their ways of working scarifying the process optimization rules to the comfortability of the routine. On the other side it also sets a warning light for a market which could hide many more issues than what are publicly visible. These concepts, along with the full description of the approach to each case-study will be explained more in detail in chapter four of the present document.

3.4.2 Case-study approach.

For the scope of the present work researchers had to analyze different case-study projects, each of them characterized by a specific development process. As highlighted during the last years by the European Commission (EU, 2011) and recently remarked in the last article released by their Joint Research Center (Dimova et al. – 2015), the level of standardization for construction-related processes within the European Community still presents several gaps. Case-study projects analyzed for this project do not represent an exception and researchers had to face different types of design-development processes which diverged in terms of subject involved, organization of project phases, schedule, costs and design features.

All factors and variables researchers had to deal with are described in detail in the following chapter 4 and could not completely been predicted before the project start. Therefore, researchers relied on two different sets of variables, independent and dependent. The dependent variables were considered as the ones whose definition could vary in relationship with the project analyzed as case-study. In other words, the dependent variables were deduced by the parameters affecting the projects under the scope of the present research. On the other side the independent variables coincided with the key-factors (or concepts) that researchers wanted to investigate: cost, time and sustainability. These were analyzed, evaluated and finally expressed as parametrized values which were valid for all case-study projects taken into consideration for the purpose of this study. In order to optimize the choice of dependent variables researchers first identified one single case-study project which served as pilot case-study for the development of the research methodology. During the case-study analysis researchers conducted a continuous process adaptation and re-calibration for data collection and analysis in relationship with project boundary conditions. The development of the methodology resulted from a reiterative process of methodology development that was then validated by several means as described below.

3.5 Stage three: prepare.

The preparation of the case-study approach focuses on developing skills as a researcher, understanding the environment of a specific case study, creating a precise protocol, develop a pilot study, and gather all relevant approvals (Yin, 2009). Preparation should also aim to identify any relevant issues in the case study design, attempt to address any such issues before starting the data collection stage and select case studies that avoid such issues. Even though critical, it has been observed that this step is frequently omitted in published accounts of case studies (Dubé & Paré – 2003).

According to Yin (2009), in order to select one or multiple case-study project(s) the researchers should be sufficiently familiar with the study domain as to understand the main concepts and theoretical issues relevant to the study. They should know why the study is being done, what evidence is being pursued, what empirical variations can be anticipated, and what constitutes supportive (or contrary) evidence. In this case, specific preparations for data collection activities included reviewing the original case study proposal, case study protocol and sample reports proceeding from real-project developments. In addition to being familiar with the study domain, case study investigators should also be able to interpret the information in real-time and adjust their data collection activities accordingly to suit the case study (Yin, 2009). Hence, the importance of being directly-connected with the project environments being studied was a key-concept for the selection of case studies. Such connection, as clarified below, is related to access to information, direct contact with subjects involved and data source triangulation. Any pilot case-study should be paired with a pilot report which should reflect on the lessons identified and, as appropriate, provide avenues for the implementation of lessons into the next iteration (Yin, 2009). Nevertheless, it has been shown that most case studies published in the information systems literature fail to mention any pilots (Dubé & Paré, 2003). Any subsequent changes to, or deviations from, the case study protocol should be completely and accurately documented (Dooley, 2002). On the basis of these statements researchers developed a pilot protocol for the first case-study project which was then refined before being implemented on the other case studies. However, the selection of both pilot and other case studies had to consider such parameters in order to make the most out of the pilot case study and develop a protocol which could have been used for other cases as well. Therefore, as explained below more in detail, researchers aimed to choose a worst-case scenario project for the pilot case-study.

Before proceeding further, the investigators should also reach an agreement with the case study organization and participants regarding any limitations on the disclosure of data, identities, and findings (Darke et al., 1998). Potential participants should also be informed about the research timeframe, the proposed nature of their involvement, and the expected practical outcomes. Therefore, one of the main concepts implemented for the selection of case-study projects was the direct relationship with subjects involved in the process, as well as, the continuous connection between research institution and case-study owners.

3.5.1 The pilot case-study project.

From the very beginning of the research, the difference between type of processes followed for the development of the whole project, from early design to construction completion, appeared to be a key-aspect to be taken into consideration. Therefore researchers had to distinguish between Design/Bid/Build (DBB) and Design/Build (DB) processes which are already been briefly described in chapter 1. As recently pointed out by a study developed by American construction companies: “no one project delivery method is best for all projects. Both of the delivery methods examined may have merit for certain types of projects and some public entities may be required by law to use DBB” (Beck, 2015). However, comparing the two delivery methods the study concludes that: “the overwhelming results of research efforts by numerous organizations indicate that DB projects outperform their DBB counterparts in terms of cost and schedule performance, quality outcomes, reduced owner risk, change orders and the ability to respond to evolving facility needs” (Beck, 2015). Moreover, studies also confirms a higher fragmentation for DBB delivery processes rising their complexity and number of subjects involved (Carpenter, 2014). Researchers, focusing on developing a rational methodology which could be applied to the majority of project-delivery processes chose a pilot project that could represent a sort of “worst-case-scenario” in terms of complexity, fragmentation and number of subjects involved. The development of the research methodology for a complex case-study would have taken into consideration many variables that may have been even not necessary in more simple projects (Baskarada, 2014). Therefore, for the choice of the pilot case-study project, researchers focused not only on the criteria listed above in chapter 3.3 but also on projects developed with the DBB approach with a fragmented delivery process.

The project selected as pilot case-study is a new middle-school complex located in Trento, Northern Italy, certified under the LEED for Schools 2007, with a total budget of approximately 13,2 Million Euros and a total gross square footprint of 6.000 square meters. The choice of this project as single-case study project was made on the basis of the following statements:

- Direct access to project information and contact with all technicians involved in the project;
- Time-simultaneity between research and project design development;
- Project sustainability referring to LEED credits as benchmark for evaluation;
- Implementation of DBB as project-delivery method with high-level of process fragmentation.

The detailed description of each case-study project including the pilot case-study is reported in chapter 4. However, in order to give an overall picture of the case, the pilot project was a public-owned project which had been developed during between 2007 and 2014 in different disconnected phases by different independent subjects through a DBB delivery process. Design development required the participation of several parties, both from the private and public sectors, which increased the complexity of the management scenario. As anticipated before, the research methodology was modelled on the basis of the pilot case-study experience through a continuous reiterative process of collecting, selecting, analyzing data and eventually discarding non-useful information.

3.6 Stage four: collect.

The collection stage involves the development of the case study protocol, using multiple sources of evidence, creating a case study database, and maintaining a chain of evidence (Yin, 2009).

According to Yin, one of the main differences between survey-based studies and case studies is that surveys capture perceptions and attitudes about events and behaviors, whereas case studies collect direct evidence. In case studies, data are analyzed as they become available, and the emerging results are used to shape the next set of observations (GAO, 1990). This idea was fully implemented for the development of the present study where researchers also used the information available during the pilot case-study in order to shape the next, and more detailed, set of observations.
Theoretical samples, which were implemented for the scope of this research and which differs from statistical samples, are based on the development of grounded theory (Glaser & Strauss, 1967). The goal of theoretical sampling is not to undertake representative capture of all possible variations, but to gain a deeper understanding of the cases in order to facilitate the development of theories. Theoretical sampling implies that the researchers guide their data collection activities on the basis of theoretical ideas which have to be considered provisional (Boeije, 2002). Thus, it enables answering of questions that have arisen from the analysis of and reflection on previous data, since each piece of analyzed data provides indications about where to look next. Such questions and provisional theories were identified by researchers through the literature review and sharpened later through the development of the pilot case-study. Not all theories turned out to be properly addressed and were withdrawn but this is part of the theoretical sampling process (Boeije, 2002).

Relevant data may be collected through documents, archival records, interviews, direct observations, and physical artefacts (Yin, 2009). According to Yin, when reviewing documents, researchers should be aware that they may not always be able to accurately reflect reality. Archival records are arguably more reliable, as they are usually used for record keeping purposes. Thus, for the scope of this work, researchers selected the case studies with the highest possible level of reliability which, as explained more in detail in chapter 4 below, depended on several factors. Among them we cite: the availability of first-hand information provided by subjects directly involved in the projects; the temporal conjunction between research and case-study development which allowed a real-time check for the validity of information; the physical presence and involvement of the researchers in the projects which expanded their knowledge about the whole process. For further details about the selection process implemented for each case-study please see chapter 4 below.

According to Yin, interviews are guided conversations that are usually one of the most important sources of case study evidence. However, “they should only be used to obtain information that cannot be obtained in any other way” (Darke et al., 1998, p. 283). Thus, for the scope of this work, researchers implemented the information proceeding from interviews as integrations for the ones collected through the analysis of project-related documentation.

Interviews can be structured, semi-structured, or unstructured (Yin, 2009). Structured interviews which involve asking pre-defined questions, with a limited set of response categories. The responses are coded by the interviewer based on an already established coding scheme (Miles & Huberman, 1994), thus being somewhat similar to written surveys. Semi-structured interviews which can be more flexible and allow the researcher to better understand the perspective of the interviewees (Daymon & Holloway, 2002). In semi-structured interviews, a researcher is able to refocus the questions, or prompt for more information, if something interesting or novel emerges. In this case researchers implemented two sets of interviews: one first round of structured interviews and a second round of semi-structured interviews. Further details are explained in the following paragraphs of this chapter. However, as a quick overview, the process can be described as follows. The first round of structured interviews focused on a simple “yes” and “no” questionnaire in order to select the right source of information. The second round highlighted which information was to be considered within each specific source through an open-answer questionnaire which was previously anticipated to interviewees.

The appropriate number of interviews depends on the size of the unit of analysis (e.g., organization or department), the phenomenon under investigation, the scope of the study, and the timeframe available (Pan & Tan, 2011). Moreover, it has been observed that asking “why” questions may create defensiveness on the part of the interviewees, and that "how" questions are usually a better choice (Yin, 2009).

Additionally, as interviewees may be biased, have poor recall, or poor articulation, it is usually necessary to corroborate such data with information from other sources. For instance, Yin argues that interviewing people with different perspectives can be a valuable approach. On the basis of such ideas researchers developed the method for collecting information through interviews. From one side they focused on different perspectives for each case-study project, interviewing several subjects which belonged to a different section of the project-development process. For instance, 3 technicians of the engineering firm providing mechanical design and calculations, 4 architects proceeding from the architectural design firm, and so on. On the other side, as explained more in detail in section 8 of the present chapter, information proceeding from interviews were verified through a triangulation process.

Interviewers should use eye contact and a confident manner to set the tone for the interview and help establish rapport with the respondent (Kasunic, 2010). That is why researchers chose only projects for which they could have a direct connection with subjects involved in order to collect first-hand information. On the other side this approach allowed the interviewers to review the interview transcript, annotate it as needed (e.g., abbreviations, incomplete thoughts, etc.) and ask for clarification in case of unclear spots (Kasunic, 2010).

According to Sim (1998) the ideal number of participants for interviews ranges from eight to twelve for each case-study. For the scope of this work researchers met the lowest number requirement and in some cases they exceeded it.

3.6.1 Data source.

The design phase of the project taken as pilot case-study was developed by several subjects, each of them in charge of a different task or service package. Plus, the ownership itself depended from local governmental agencies and therefore the process fragmentation characterized both the decision-making side, represented by public administration, governmental agencies and other institutions, and the execution side, represent by all subjects and technicians involved in the design development. Data collection was carried out using two different methods: project documentation analysis and personal interviews. The data collection started with the late design phase of the project which allowed researchers to acquire information first-hand from personal interviews with technicians and public entities. Researchers waited for the last building design phase, called "executive design", to acquire all project information in order to have a global view of the process and better evaluating the effect of each issue on the design process development.

<u>Data source n. 1: Project Documentation.</u>

Project documentation such as technical reports and drawings was provided by the project owner and included all information related to each step, activity and event affecting the project design phase from the early preliminary design stages until the approval of the executive design. For the scope of this work researchers focused on two types of documentation:

1. Formal documentation required by law proceeding from bureaucratic processes such as, technical drawings, official meeting report, public resolutions, change orders and others;
2. Non-formal documentation proceeding from each subject involved in the process such as, informal meeting reports, emails, calculations and others.

As a public project, each step of the process had to be formally documented by law and the project owner, the Public Administration of Volano, had a complete record of all formal activities occurred during the design development. Therefore researchers used the archives on the Volano Public Administration as formal-documentation main source which includes, but is not limited to:

- Deliberations of municipality for public contracts & partnerships;
- Public administration complete budget related to the school project;
- Contractual documentation with costs and schedule for all activities related to the project;

- Memorandum of each municipality council in which project-related decisions were taken;
- Formal agreements and mail with other governmental agencies;
- Contractual documentation, formal communications and meeting reports for each technical subject (architects, engineers, consultants and others) involved in the design process;
- Formal documentation related to the project funding, economical frameworks and related modifications occurred before, during and after the design-development phase;
- Project-related permits, legislation and other bureaucratic documentation.

The information collected through the analysis of formal documents listed above was a key-factor for the calculation of the so-called “direct costs” which will be explained more in detail in the following chapters of the present work.

On the other side researchers collected data through the analysis of off-the-record documentation which had been developed for unofficial purposes nevertheless included significant information for the purpose of the present work. Unofficial documentation proceeds different subject involved in the process and includes:

- Mail and communication between technicians involved in the process;
- Unofficial documentation between technicians and the owner;
- Meeting reports of unofficial meetings organized to arrange specific technical problems of the process;
- Invoices of expenses not directly connected with the project development;
- Communication between researchers, technicians and public entities involved in the process.

Following the same process implemented for the analysis of formal documentation, researchers first identified the relevant documents by a simple “yes” and “no” selection process. By answering the question: “is this document relevant to the scope of the research” they decided whether to keep it or not. Afterwards all documents identified as "relevant" were deeply analyzed and useful information were extrapolated and added to the ones proceeding from the analysis of the formal documentation. The information collected through the analysis of formal documents listed above was a key-factor for the calculation of the so-called "indirect costs" which will be explained more in detail in the following chapters of the present work.

<u>Data source n. 2: Interviews.</u>

Researchers collected information also through personal interviews with different subjects involved in the process which required the development of a structured interviewing process in order to obtain a standardizes Q&A model. For the scope of the present work a semi-structured interview model was chosen by researchers as defined by Barriball (1994). In fact, the amount of potential information to be analyzed and the vast range of topics to be discussed made impossible for researchers to establish a well-defined set of questions prior to the beginning of the work. Therefore the interviewing process was organized in two steps:

1. Qualitative interview: with the scope of identifying if and when the process development suffered any problems, as defined above in chapter two following the Lean approach;
2. Quantitative interview: always supported by written documentation, with the scope of quantifying all problems that may had been detected with the previous round of qualitative interviews.

The development of qualitative interviews followed a preliminary work on the official and unofficial documentation cited above. On the basis of such documents researchers created a list of milestones that summarized all the principal steps of the process and arranged them into a time sequence. The tasks were performed as follows:

- Analyze all formal documentation provided by the owner;
- Identify all activities, events or deadline related with the development of the project design;

- Out of this first list, highlight all elements related with any green-building feature of the project design;
- List the elements in a new table following the time sequence of the project.

Unfortunately the majority of the interviewees could not speak English so all the original documentation related to interviews had to be provided in Italian. Table 3.2 below shows an example of how such table was structured and developed. After completing the list of green-building-related tasks qualitative interviews were held with all different subjects involved. First, researchers explained to each interviewee the concept of "issue" following the Lean approach as described above and then asked interviewees only two questions that can be described as follows:

1. "Considering the definition of "waste" given through the Lean approach, do you recognize, within the following list, any process step that met any waste before, during or after its development?".
2. "If yes, what were the issues that occurred and why?".

DATE	**EVENT**
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009
10/2008	LEED taken as reference standard for school project
12/2008	Municipality deliberates 550,000 € for design project development
12/2008	Public bid for the development of project design
10/2009	Design bid won by "Gruppo Marche"
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan.
…	…

Table 3.2: example of the list of events developed for the first step of the qualitative interview.

As demonstrated by Liker (2003) Lean approach takes into consideration the minimization of the so-called process waste (or *muda* in technical lexicon) intended as every possible activities, events or operation developed within the process that, in spite of consuming any kind of resource, does not provide any added value to the product's final user. In order to establish the identity of a process waste for the pilot case-study, researchers had to establish the concept of "added value" for the considered product, that is, the school building. For the scope of this task, researchers focused on the work "Lean Processes for Sustainable Project Delivery" (Lapinski et al., 2006). The article identifies the owner's priorities as main parameters for defining the value of the product in addition to the concept of sustainability. In other words, sustainability is considered as main value for the final product following the already cited definition of the "Lean & Green" (Lean & Green, 2013) ideas which identified the improvement of building sustainability as a building value.

According to the interview held with the Volano Public Administration, owner of the project, their main priorities for the school development were time and costs. Time intended as the total time frame in which the project design is being developed and cost intended as the total amount of money for which the project design is being built. Following these ideas, researchers identified three parameters for the definition of project value: time, costs and sustainability. As a result, interviewees were asked to report only information that could have a relationship only with those parameters.

Researchers repeated the interview for all subjects involved in the process and developed a new list with the previous project tasks and the issues identified for each task. Table 3.3 below shows an example of how the original interview table was structured:

DATE	**EVENT**
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009
10/2008	LEED taken as reference standard for school project by governmental agency. 1. *Public owner does not speak English and does not know how LEED works.*

DATE	EVENT
12/2008	Municipality deliberates 550,000 € for design project development. 2. *LEED Costs not included in the design bid.* 3. *LEED-time not included in the deliberation.*
12/2008	Public bid for the development of project design. 4. *The jury had no idea about green-building features.* 5. *No reference to evaluate LEED offer for the project.*
10/2009	Design bid won by "Gruppo Marche".
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan. 6. *Problem for LEED SS Credit 1.* 7. *Owner did not plan his activities so impossible to develop a decent schedule.*
…	…

Table 3.3: example of the list of events and related issues developed for the second step of the qualitative interview.

After performing the first round of qualitative interviews researchers obtained a full map of all the potential issues occurred during the design development. However, such map turned out to be very fragmented because it showed the symptoms of the issues occurred but not the causes that generated them. The complete list of issues highlighted by interviewees exceeded the two hundred units which were, at least in part, independent one to another. This would have made unfeasible a rational analysis that could quantify the impact of each issue on the global process development. In fact, analytical and managerial procedures such as, for example, the Lean approach, apply to standard models that admit a certain level of variance and independency between each tasks but are not applicable to random model in which the standardization is the exception and the singularity represents the routine (Kanso et al., 2013). Projects considered for the scope of the present research represent prototype-products in which all activities and event are almost unique to the circumstances of that specific project. Thus, also problems resulting from such activities are unique to the circumstances in which they happen and incomparable to other problems occurred in other project. Therefore, researchers implemented the information retrieved from the interviews to determine the causes of each issue diagnosed before and succeeded in combine them into five groups. Problems initially identified by subjects were labelled and gathered together in several "categories of issues" which represent the root of the project management problems researchers wanted to analyze. From now on in the present work the word "issue" will be referred to the issue categories mentioned above if not differently specified. The categories of issues identified for the purpose of the present research are listed below:

A. Lack integration between technicians involved and bad timing for green-building tasks;
B. Misunderstanding of Commissioning Authority's tasks and process;
C. Lack of appropriate clauses in bid documentation;
D. Systematic cuts to budget due to change-orders and delays;
E. Misunderstanding of the energy modelling role and process;

Issues could be related to single or multiple activities. The total impact "I" of all "i" issues on the whole project completion was estimated as the sum of the impact of that specific problem on all the activities it affected as follows:

$$I = \sum_{1}^{n} i_{An} + \sum_{1}^{n} i_{Bn} + \sum_{1}^{n} i_{Cn} + \sum_{1}^{n} i_{Dn} + \sum_{1}^{n} i_{En}$$

Where "I" represents the impact of all different "i" problems interfering in different "n" activities of each "A" to "E" problem category. This first qualitative analysis process resulted into a new re-ordered list of project activities and related tasks organized by groups or, as cited above, categories of issues. Figure 3.2 below shows how researchers listed all activities and related problems encountered during the process.

P 02 Problem with Commissioning. Disaster between information exchange and coordination between parties.

- Need to modify the “executive project” – “capitolato special d’appalto and computo metrico” in order to meet the Commissioning needs. Information much more detailed than normal (ex. Functioning of CO_2 sensors). Need to implement commissioning at an early design stage (before executive)
  Verify before filling up final executive estimate
  Verify before executive project completion
- Obstructionism done by the architect, he wants to receive mails not the mechanical engineer… this drives the CxA crazy because the architect does not understand. (too strict organization of the office)
  Communication between technicians – better meetings in person
  Delays in executive project completion
- There was not a kick-off meeting with architect and CxA, no human relations, only professionals, each party goes on his own.
  Kick-off meeting architect – CxA before executive design starts
- Problem of commissioning: the CxA need all the details of every single element but the executive project only gives the main characteristics, the exact products will be selected by the GC afterward. So need to draft a list of element for which you cannot tell the exact details delegating all the choices and CxA activities related to those elements to the installing companies.
- Communication problem: use of colours for individuating things in simple ways within the projects (zone terminche con colori diversi per esempio).
  Delay in executive project development
- Functional test problem: need to measure everything (example of Gucci that wanted funky air in the interior spaces)
  Delay in executive project development

Figure 3.2: snapshot of the final list summarizing all categories of issues identified with related activities and issues.

After defining a global scheme for qualitative representation of project issues, quantitative interviews were held with the subjects involved in all problematic activities identified before. The scope of such interviews was not to directly quantify the impact of each issue, or category of issues, on the project but to support the quantitative analysis of project documentation. Project-related quantities taken into consideration by researchers had to be documented objectively and all information obtain through personal interviews to subject involved had to be supported by real documentation, either formal or informal. Therefore researchers conducted another round of interviews to problematic-activity-related subjects to retrieve the documentation that could support the quantification of each issue.

3.6.2 Dependent and independent variables.

As described above, based on the information collected by interviews and literature review, researchers focused their work on three independent variables: time, costs and sustainability. However, at this point researchers found themselves facing different aspects of the same problems and had to split the qualitative and quantitative analysis of information. The process was developed by re-handling the information acquired through documentation, qualitative and quantitative interviews and separate them into the different areas of interest. The development of a research methodology through a pilot case-study generally implies a continuous progression to refine the data collection process (Yin, 2009). This case was no exception and researchers had to re-adapt the data collection procedure throughout the whole case-study analysis.

The first step of the process was a qualitative analysis. Researchers had to link each problem identified before with one or more areas of interest. A simple checklist was developed on the basis of information already collected; a list of all problems of the left and the three areas of interest on the right. Another round of qualitative interviews was held with the subjects involved which were asked to match each problem detected before with the related areas of interest. Table 3.4 below shows an example of checklist developed for the scope of this work.

Cost (Euros)	Time (Working days)	LEED or BREEAM Credits	GENERAL PROBLEMS
x	x		Technicians don't have a sense of what IS a problem
x	x		Problem with COMMISSIONING.
x		x	Bidding Problem.
x	x	x	LEED change-order risks.
x	x	x	Blower Door Test Problem.
	x	x	Problem for sustainability solutions & Estimate.
x	x	x	Problem with Energy Modelling.
		x	Problem for Luminotechnic Simulation and Acoustical Simulation
	x		Problem with reference standard – USGBC Review
	x	x	Problem with the process to create LEED docs and LEEDONLINE interface.
	x	x	Problem of subcontracting
		x	Problem of Protocol Standards
Cost (Euros)	**Time (Working days)**	**LEED or BREEAM Credits**	**DETAILED PROBLEMS**
x	x		Re-manufacturing process for each project step (definitive project start– executive project start)
	x		Delays in project start
	x	x	Verify before filling up final executive estimate
	x	x	Verify before executive project completion
	x	x	Communication between technicians – better meetings in person
	x		Delays in executive project completion
x	x		Kick-off meeting architect – CxA before executive design starts
	x		Delay in executive project development
		x	LEED Project registration
x	x		Architect contract
	x		GC company bidding contract
x		x	LEED Documentation Development
	x	x	Project construction – Core & Shell
	x	x	Project Construction - Finishing
x		x	Defining LEED Goals
	x	x	Project estimate – Definitive Design late stage
	x	x	Project estimate – Executive Design late stage
x		x	Final LEED Goals (Achievable)
	x	x	Define requirements for running energy modelling
x		x	Contract Energy Modelling Specialist
	x	x	Definitive project design – Final stage
		x	First energy modelling – Definitive design
x		x	Executive design development – early stage – changes on the basis of first energy modelling
x		x	Executive design development – final stage – development on basis of energy modelling & costs
		x	Final energy modelling
		x	Not considering the protocol "special features" at the beginning turned out in loosing those credits.
	x	x	Choice of LEED protocol to adopt
		x	Individuation of "high risk credits"
	x	x	Definitive design development
	x	x	Executive design development
		x	LEED documentation development
		x	LEED documentation finished
		x	USGBC Review
x	x		Work re-manufacturing
x	x	x	Kick-off meeting
		x	First checklist draft
	x	x	LEED documentation development
x			LEED Documentation development

Table 3.4: Portion of the checklist developed for the second round of qualitative-interview analysis.

On the basis of the second-round qualitative outputs also the quantitative analysis was refined. Problems listed above were grouped up into the five "categories of issues" defined in the previous chapter and each of them had three dimension of symptoms value: time, costs and sustainability. We remind the reader that the five categories of issue identified before were the following:

A. Lack integration between technicians involved and consequently bad timing for green-building tasks;
B. Misunderstanding of Commissioning Authority's tasks and process;
C. Lack of appropriate clauses in bid documentation;
D. Systematic cuts to budget due to change-orders and delays;
E. Misunderstanding of the energy modelling role and process;

Having the original five categories of issues as reference points and the qualitative partition of their impact in three dimensions, researchers implemented the quantitative-analysis procedure described above to each of the three dimensions. Therefore, the total impact "I" of all "i" problems on the whole project completion was estimated as the sum of the impact of that specific problem on all the activities it affected in the three dimensions of time, costs and sustainability as follows:

$$I_d = \sum_1^n i_{An(d)} + \sum_1^n i_{Bn(d)} + \sum_1^n i_{Cn(d)} + \sum_1^n i_{Dn(d)} + \sum_1^n i_{En(d)}$$

$$I_€ = \sum_1^n i_{An(€)} + \sum_1^n i_{Bn(€)} + \sum_1^n i_{Cn(€)} + \sum_1^n i_{Dn(€)} + \sum_1^n i_{En(€)}$$

$$I_S = \sum_1^n i_{An(S)} + \sum_1^n i_{Bn(S)} + \sum_1^n i_{Cn(S)} + \sum_1^n i_{Dn(S)} + \sum_1^n i_{En(S)}$$

Where "I" represents the impact of all different "i" problems interfering in different "n" activities of each "A" to "E" problem category for dimensions of time "d", costs "€" and sustainability "S".

3.7 Stage five: analyze.

The analysis of qualitative processes has been described in the past as both the most difficult and the least codified part of the case study process (Eisenhardt, 1989) and, according to Yin (2009), this stage relies on theoretical propositions and other strategies such as analytic techniques, rival explanations, and considering facts apart from interpretations.

As already discussed, qualitative research aims towards analytical generalization, as opposed to statistical generalization usually aimed at in quantitative studies. Analytical generalization involves the extraction of abstract concepts from each unit of analysis (Yin, 2013). These concepts should be related to the theoretical grounds and be potentially applicable to other cases. Analytical generalization implements previously developed theory with which empirical case study results are compared (Yin, 2009). Therefore, analytical generalization focus on theory and not on population; the theory can be further reinforced by developing cross-case comparisons (Yin, 2009). Moreover, evidence proves that case studies that implements both direct-case and cross-case analysis are more effective at generating theoretical frameworks and formal propositions than studies only using one of the two approaches (Barratt et al., 2011). On the basis of these concepts, researchers focused on developing a first direct approach through the use of one pilot case-study and corroborating it afterwards using the cross-case analysis with the other case-study projects. Analyzing case study data in parallel with data collection activities allows the researchers to make quick adjustments to study design as required (GAO, 1990). However, failing to explore rival explanations, inconsistently applying analytic techniques, only using a subset of data, and inadequately relating findings a cross cases can lead to unjustified conclusions. Therefore, for the purpose of this work, researchers had a continuous relationship with subjects involved using a continuous flow of information that settled a reiterative process of analysis and data verification. As already cited above, data were collected from different sources and then cross-checked with each other. In case a gap or inconsistency was detected, researchers would implement a rectification process with subject involved checking the accuracy and the validity of the information.

Comparison, the main tool implemented in qualitative analysis, is used to identify hypotheses, group them into themes and find positive or negative evidence (Tesch, 1990). As such, the main focus of qualitative analysis is to identify conceptual similarities or differences and to determine classes, sequences, processes, patterns that associate one with another (Jorgensen, 1989). This approach was also implemented by researchers who firstly identified the different issues related with each process and then grouped them up into different categories of issues. Computer-based tools can be implemented to support researchers with the coding and categorizing of large amounts of information that may have been collected through interviews or obtained as documentary evidence (Yin, 2009). An important point to make is that these tools can only assist an investigator with data analysis, and that much of their functionality is not automated, but analyst-driven, and does not negate the need for subject matter expertise (Walsham, 2006). In this case, the main researcher personally implemented the computer-based tools in order to analyze the amount of collected information. Plus, it was used only for a partial data analysis, the one related to delays which will be explained more in detail below in this chapter. According to Yin (2009), the most important strategy is to follow the theoretical propositions or hypotheses that led to the case study. In other words, such propositions can help the analyst plan and focus on the most relevant data, organize the entire case study and define alternative explanations. In the absence of any propositions/hypotheses, an alternative is to develop a descriptive framework (e.g., a draft table of contents) for organizing the case study, while not pre-empting outcomes before the data has been fully analyzed. Such a framework, which for the purpose of this work is reported at the beginning of the manuscript, helped the analyst organizing the data and developing a research timeline (Yin, 2009).

3.7.1. Explanation building.

In addition to the general strategies described above, two other techniques were also implemented to analyze the case-study evidence: explanation building and cross-case analysis (Yin, 2009).

Explanation building is a special type of pattern matching which aims to analyze the case study data by building an explanation about the case (Yin, 2009). In this context, researchers focused on developing a set of causal links about how or why something happened (Miles & Huberman, 1994). The process was iterative and involved the use of initial predictions, and their comparison against the case study evidence. Then, based on any variances, the initial predictions were revised and compared against additional evidence and/or cases. This process was repeated until a satisfactory match was obtained for different aspects of the present research. The definition of "satisfactory" is explained in detail in chapter 5 along with the results and outputs. However, as a general rule, the process was considered to be satisfactory when all subjects involved (interviewees, researchers and others) unanimously agreed upon the results obtained. According to Yin, compared to surveys, "the ability to trace changes over time is a major strength of case studies" (Yin, 2009, p. 145). The identification of the dependent variables, or categories of issues, and the matching process between types of Lean wastes and problems occurred during the design process were the main fields in which the explanation building method was implemented.

3.7.2. Cross-case analysis.

Cross-case analysis applies to multiple cases and can involve any of the techniques described above. According to GAO (1990), during and after observations, the researchers should think about the meanings of information collected in terms of what it may imply. This thinking leads to ideas about new types of information required in order to confirm existing interpretations. After implementing this approach, during the test phase the researcher collected additional information which led to revisions of initial interpretations. In some cases such revisions required another test phase leading toward the reiterative process. This process was stopped when a plausible explanation had been developed, there are no outlier or unexplained data, no further interpretations are possible, or it is obvious that any additional data will not lead to new information (GAO, 1990). For the scope of the present work researchers stopped the reiterative process when all available information converged to the same data or, for other cases, when all interviewees unanimously agreed upon the result obtained. The reiterations were developed only in case of inconsistencies between data collected, the process focused on cross-checking the information in order to avoid the gaps. Once these gaps were covered researchers decided to interrupt the reiterative process.

3.7.3. Data coding.

In qualitative analysis, coding represents a key-step for the development of the process. Generally speaking, data have to be broken up into manageable pieces, which the researcher then reassemble to reflect back a view of reality (Beekhuyzen et al., 2010). For the purpose of this research coding played a very important role because it allowed researchers to gather together different types of information and group them up in several categories of issues already described above. The coding procedure related to the data management and handling was performed through different steps. First researchers examined the interview transcripts, notes, and any other relevant documents either formal or informal, which lead to the development of preliminary notes or memos that can then be used to formulate initial categories, themes and relationships. Memos are research notes that may contain interpretations of patterns found in the data which can be coded in a similar way to interview transcripts. An example of memo implemented for the purpose of this research is shown in chapter 3.6.1 above. In this case researchers implemented the so-called "analytical coding" which, according to Morse and Richards (2002), focuses on arranging the coded data into a more abstract framework with categories that are generally more abstract than words in interview transcripts. In this case the analytical coding was first developed through the pilot case-study project and later refined through the development of the other case studies.

3.7.4. Scheduling and time-related calculations.

Total amount of delays caused by sustainability-related problems cited above were estimated on the basis of the bar-chart results developed using Microsoft Project. For the development of the bar chart, sustainability-related problem previously identified by researchers 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. However, due to the excessive quantity of project-related information available researchers could not develop a bar-chart with all activities performed during the whole design development. Therefore, research team implemented a selection process for the sustainability-related activities that had a real impact on project delays. The selection process was developed on the basis of the project management and scheduling principles (Schwindt & Zimmermann, 2013) using the Work Breakdown Structure (WBS) as a tool for operating the selection of activities.

For the purpose of the present work the development of the scheduling procedure and related diagrams was made using an unconventional procedure. Generally, as described by Harris (1978) and Baldwin (2014) the typical scheduling for a construction-related project is based on the time sequencing of single or multiple project activities that progressively define the project milestones. For the purpose of this study the researcher at first followed such procedure by looking at the single-activity duration, recreate the sequence followed during the process development and finally determine the deadline of each project milestone. However, due to the imprecision and inconsistency of some single-activity information, proceeding from informal documentation and interviews, the project milestones determined through the sequencing procedure did not always match the real milestone deadlines documented by formal documentation. Therefore the researcher decided to give priority to information proceeding from formal documentation and recreating the scheduling procedure backwards, going from the big milestone deadlines down to the single-activity duration through the support of information proceeding from informal documentation and interviews. In practical terms the researcher created first a big-picture scheduling which included only the project milestones documented by formal documentation. Then researchers determined which activities were needed for each milestone and re-created a more detailed scheduling which included the activity duration, predecessors and successors. Finally the researcher highlighted the issues that had an impact on each activity and re-creating a third scheduling diagram with activity duration, sequencing, issues duration and dependencies and project milestones. The process followed for developing the final schedule is described below more in detail.

1. *Identification of project milestones:* as explained earlier in chapter 2, researchers had to identify, out of the complete list of potential project activities, which were the ones important for the scope of the research and which were not. Information collected through documentation analysis and interviews allowed researchers to draw a complete list of activities which were represented as a complete Work Breakdown Structure (WBS) of the design process based on the process scheduling. Each element of the WBS matched with a different design-process milestone which means a different time frame of the project (Figure 3.3 A).
2. *Identification of project's main activities:* researchers identified all the elements of the WBS diagram containing one or more activities that had been affected by any time-related problem previously detected through the analysis of project documentation and/or interviews. For the purpose of this work researchers considered all problems as they occurred in the process and not only the "problem categories" cited above. Each WBS element (or milestone) identified was then highlighted with a different color (Figure 3.3 B)

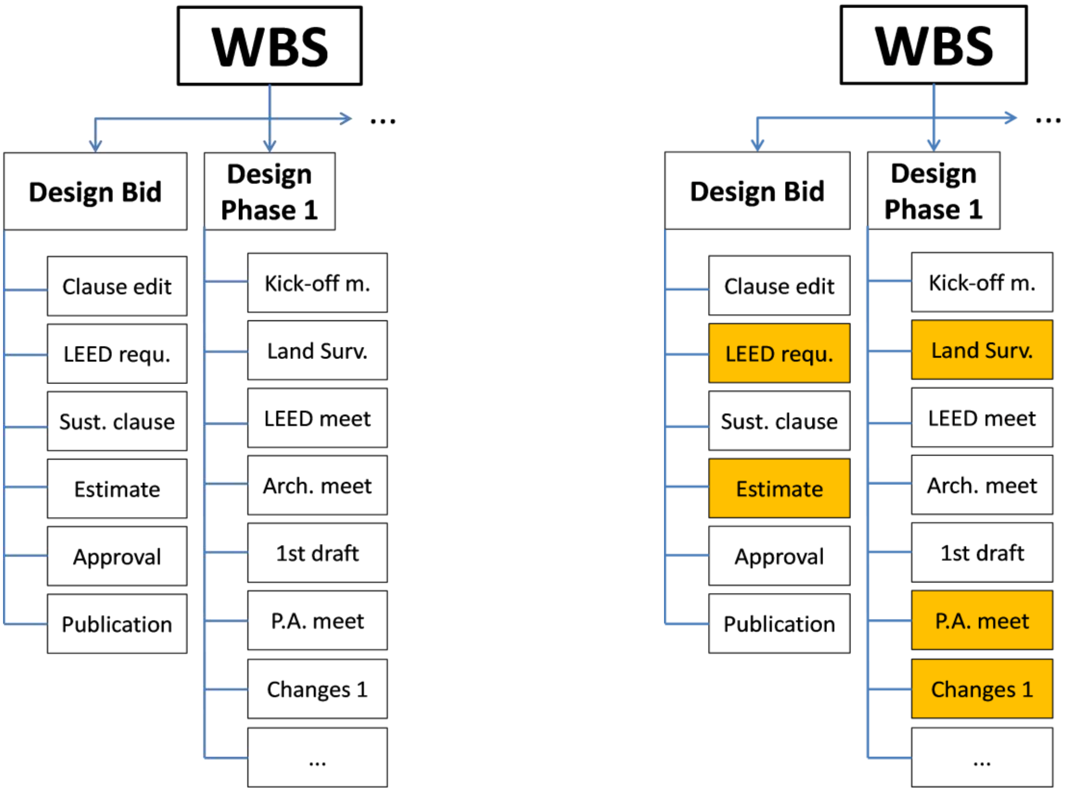


Figure 3.3 A (on the left): snapshot of the initial WBS scheme developed for the scope of the scheduling chapter.

Figure 3.3 B (on the right): milestones affected by green-building issues (delays).

3. *WBS breakdown:* researchers broke down only the highlighted WBS milestones to the level of the activities that suffered the time-related problems (Figure 3.5 C).
4. *Identification of Activity-On-Node (AON) elements:* using the broken-down WBS as a basis, researchers identified all the elements required for the development of an AON network which would have been the ground for the bar-chart development (Figure 3.5 D). It is important to notice that different elements included in the AON network would not have the same magnitude in terms of duration. However, this allowed researchers to reduce the number of activities on the bar-chart without losing the focus of the research: estimate the impact of green-building issues on the total project duration.

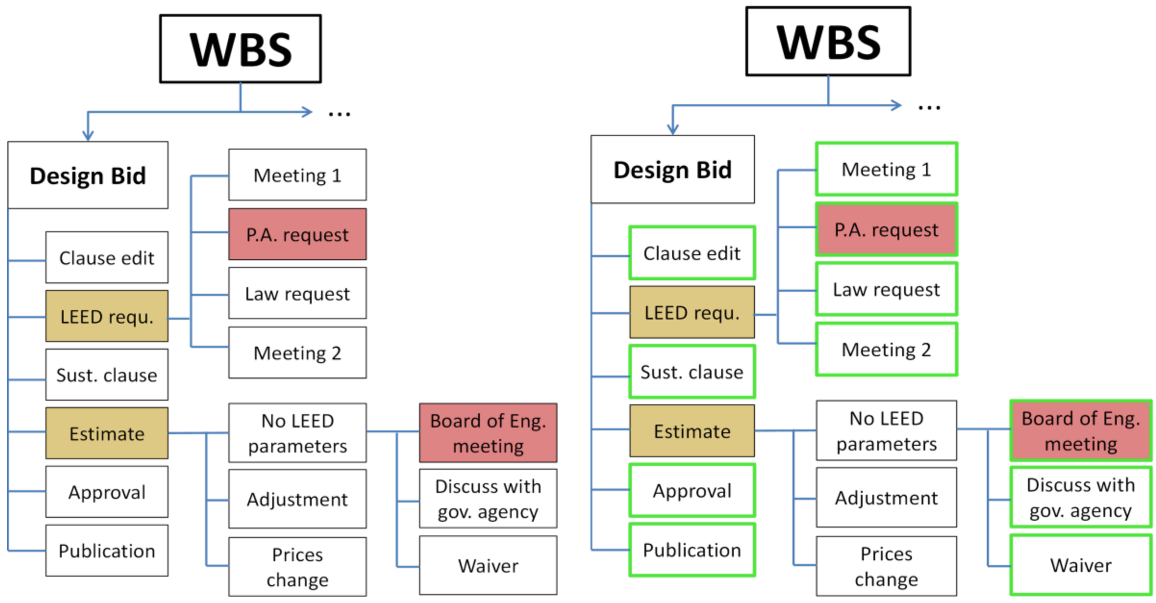


Figure 3.3 C (on the left): snapshot of the WBS-diagram breakdown to the detail of the problems that affected the process schedule.

Figure 3.3 D (on the right): identification of the WBS key-elements (in green color) that were used for the development of the AON network.

After completing the WBS-based selection of activities researchers started to create the AON network which served as a basis for the real bar-chart diagram. Critical path was then calculated on the basis of the scheduling concepts (Harris, 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 project delay. The duration of all sustainability-related problems of the whole project bar-chart, including not only the ones on the critical path, were accounted for the total loss of time.

Figure 3.4 below represents a snapshot of the bar chart developed for the scope of this work. Sustainability-related activities are highlighted in green whether sustainability-related problems and consequent delays in red and orange.

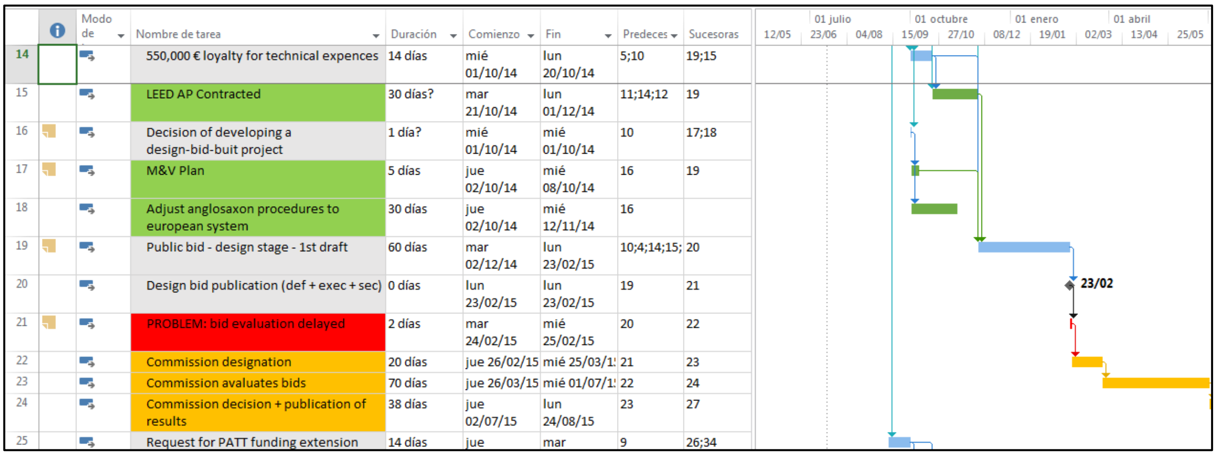


Figure 3.4: snapshot of the project Gantt diagram showing problems (red), problem-related activities (orange), sustainability-related activities (green).

It is important to notice how activities shown on the final bar-chart belong to different order of magnitudes depending on their relationship with the problems identified for the project delay. In fat, the AON network was developed by selecting different elements of the WBS which had different scale of detail. Therefore the elements of the final bar-chart are either single activities, if responsible for any delay-related issue, or project milestones (or macro activities) if not connected to any delay-related issue.

3.7.5. Cost calculation.

Cost analysis was divided in two different categories: direct costs and indirect costs. With the term "direct costs" researchers identified all expenses, caused by the sustainability-related problems cited above, that the owner had to bear in addition to the original project budget in order to complete the design process. With the term "indirect costs" researchers identified two types of expenses:

1. All additional costs caused by the sustainability-related problems cited above that technicians involved in the project had to bear with no additional compensation to their professional fee, in order to develop the originally expected product.
2. All additional costs caused by the effects of the sustainability-related problems which affected third parties and later project development phases.

Being the pilot case-study based on a public project all expenses had to be documented and monitored by law. Therefore the computation of the total direct costs, as defined above, was based on the formal documentation provided by the owner. After recognizing all activities that were impacted by sustainability-related problems, researchers examined if such activities suffered direct cost increase through a cross-check analysis between interview information and formal documentation. Once such activities and related extra costs were spotted researchers grouped them following the "category of issue" method described in the previous chapter. Finally, for every group, the extra costs of all activities were summed up and so researchers found the cost of every category of issue identified for the scope of this work. That is, the direct cost of each macro-cause of sustainability-related problems observed within the pilot case-study project.

Considering all five categories of issue researchers identified six major types of direct extra-costs:

1. <u>Bid re-formulation:</u> extra costs related to bid re-formulation were mainly caused by management inaccuracies for the development of the bid documentation. In fact, this tasks was performed almost independently by the owner's legal consultants without taking into consideration possible interferences with other specialties, such as, the LEED protocol. In more than one occasion professionals were contracted by the owner only after the bid was written and all clauses fixed in a single document. However, after being hired each professional would eventually inform the owner about potential contractual issues if specific clauses would not be added to the bid documentation. This led to multiple re-definition of the bid clauses in order to adjust the final document following each professional's advice.
2. <u>LEED documentation:</u> as demonstrated by Horman (2006), the development of a green-building project, such as LEED, should imbed the concepts of sustainability through an integrated design process and related documentation should be considered a part of the project design. In fact, the original bid for the case-study design had specific clauses binding such aspects with the complete development of the design phase. However, LEED-related services are not included in the national table for the calculation of the professional fees and

should be considered aside from the costs of engineers, architects, geologists and other technical roles defined by law. In the first draft of the bid the owner included LEED-related services within the global design cost without giving them a specific item-line on the budget. The regional board of engineers and architects sent then a letter to the owner claiming the non-compliance of the design bid clauses. As a result, the owner deleted all the LEED-related clauses without notifying anything to the LEED AP before the draft of the second and final version of the bid document. LEED-related clauses for integrated process development were also excluded and then during the design the joint-venture of companies that won the bid claimed additional costs for the development of the activities that should have been developed within the original cost of the design.

3. <u>Changes orders in future construction phases due to lack of design detail:</u> as already demonstrated by the literature review (Horman et al. – 2006) the European and Anglo-Saxon construction process are substantially different. This gap increases even more when considering the Anglo-Saxon and Italian processes. One direct consequence is that in the Italian DBB system final technical design and shop drawings are developed by the designer and not by the general contractor. This leads to several problems for the implementation of project features that within the Anglo-Saxon system implemented by LEED should be developed during the construction phase whether in Italy have to be well-defined before the end of the design phase. In the Italian process every single aspect of the project has to be defined before the final design approval. Just to give an example, every single torque of every single bolt of every single node of the structure has to be defined during the design phase and every modification of the initial conditions requires a change order during construction. Therefore, in relationship with the LEED process designers have to foresee and plan even the activities related to the construction-phase credits of the standard. This aspect was not well understood by designers which left some gaps in the building design. Those gaps had to filled up by the construction company, as a result change orders were put in place and the total cost of the building increased considerably.

4. Commissioning Authority extra costs: as demonstrated by Xiao and Wang (2009) problems generated by construction process discrepancies affected also the role of the Commissioning Authority (CxA). In fact, as described in the previous chapter, within the Italian process the CxA role and activities had to be planned earlier during the design stage even if CxA is a service mainly focused on the building construction phase. The CxA-related pre-requisite require the implementation of a so-called "basic Commissioning Authority" which only interferes with the development of the construction-phase activities. Therefore, within a normal LEED certification process the CxA would be contracted by the general contractor and develop his work after the beginning of the construction. However, for the Italian project, all CxA-related activities and requirements had to be pre-defined during the design stage avoiding discrepancies between the CxA needs and the construction of the real building. Some of the CxA needs were not addressed during the design phase and this led to extra costs in the later project phases. An example of what described above is related to the installation and setup of the Building Management System (BMS). Within the building features designers considered the implementation of a BMS for optimizing the building consumption and management. However, in the project specs attached to the final design documentation they did not include all details about how the BMS would operate. There was a brief description of the BMS type and main features but there wasn't a full description of, for example, how every sensor would operate, where they should be located, what type of signal each sensor would send and how they would be received by the central control panel, what tolerance the system had to have and other specifications that were needed by the CxA. These gaps led to change orders during the construction phase because the project design was lacking some basic features for the development of the CxA service.

   Another problem arisen from the implementation of the CxA service is the development of the CxA pre-assessment document, the so-called "Owner Project Requirements" (OPR) and "Basis Of Design" (BOD). Both documents should be written four-hands by the owner and the CxA before the approval of the final design stage. In fact, these documents should list all the requirement and functional features that the building should have after the construction completion. However, the CxA was contracted after the design completion and such documents had to be drafted by the CxA backward. In other words, it was not the owner telling the CxA how he wanted the building features to be and writing the documents but it was the CxA retrieving information from the already approved design documentation and modelling both OPR and BOD on the features of the design. This extra work developed by the CxA had to be paid by the owner on top of the CxA regular fee.

5. Personnel outsourcing: the development of the LEED certification process, as well as, the development of a green-building project requires a wide range of competences and specific skills to address high-technical tasks (Horman et al. – 2006). Some of the companies participating in the design team did not have such competencies in-house and did not realize the complexity of the process until the certification process did not begin. One example is represented by the language barrier, the small architectural firm did not have anybody in-house speaking a fluent English and they had to hire one extra person for the translation and the development of all the documentation. A similar thing happened for the development of the energy model of the building for which mechanical engineers had to contract an external engineer for the job. The extra-personnel costs caused by the sporadic lack of skills generated project wastes in terms of delays, loss of sustainability point and also indirect costs for the design team members.

6. Project re-manufacturing: this has probably been the most common problem throughout the whole design process. Often it was a side-effects of the other issues cited above but almost every design activity, suffered this kind of issue before the end of the design phase. Re-manufacturing tasks included, but were not limited to, project re-engineering due to new technical standards entered into force, change orders caused by delays and consequent needs of budget re-arrangement, designer's mistake or misinterpretation of the project requirements, lack of coordination between technicians. This issue had massive consequences for the project development process in terms of costs, delays and

sustainability. However, being so consistent and spread out through the whole process it was also the most difficult to detect. In fact, many times such issue wasn't even detected by the people performing the job. For example the architect, when asked about the project re-manufacturing process, answered that it was part of the game and it was so normal to re-do one thing several times before it was commonly accepted and approved by all responsible parties that it could not be considered a problem. Researchers believe that this aspect interferes a lot with the indirect-cost calculation. Indirect costs are often not documented by official papers and their estimate relies on each professional's declaration. This declaration can be considered subjective because depends on each professional's perception of what a "waste" is. Researchers explained the concept of waste through the implementation of the Lean approach but it is possible that part of the waste-related issues had been felt behind due to the lack of awareness of the subjects involved.

As already cited above, indirect costs were more complicated to identify. In fact, no official documentation was ever produced for documenting them and even the unofficial documentation covered only a fraction of the indirect costs observed in the process. Therefore researchers had to rely on personal interviews with subject involved following the qualitative and quantitative progression described in the chapter above.

Indirect extra costs were caused mainly by extra-personnel activities and project re-manufacturing tasks. On the top of that researchers considered all side-effect activities related to such problems, such as, unexpected travel expenses, costs for attending extra-meetings and errors in the design-development process. Different aspect of each point were analyzed for the scope of the work and each of them was calculated using objective or subjective approaches. For example, the cost of the man-hours for attending the extra-meetings was calculated on the basis of a national salary average as described in the literature review (Il Sole 24 Ore, 2015) following an objective and rational process. Other costs, such as, the travel expenses for attending the extra-meetings were declared by all subjects involved following a subjective procedure. However, for the purpose of this work, researchers believe that possible errors proceeding from the approximation of such indirect cost can be considered not relevant to draw the final conclusions mainly because the order of magnitude of these costs is 10 to 100 times smaller than the other costs considered.

3.7.6. Sustainability-related calculations.

All sustainability issues related to the present research work were considered in relationship with the LEED protocol. More precisely the version implemented for the certification process of the building was the LEED for Schools 2007 reference standard and this gave researchers a standardized start point for the objective evaluation of building sustainability. However, the impact of each problem was estimated on the basis of the technician's experience. Prior to project start the design team performed a kick-off meeting with all subjects involved in the project design and filled up a LEED checklist where all credits considered achievable were listed taking the whole LEED credit list as an optimum reference. Such credits were considered to be achievable under a normal case scenario. And during the design development some credits were not achieved due to the project management issues cited above. Researchers focused on those credits the project could not obtain. Structural problems identified at the beginning of the research were taken as reference for the purpose of this chapter. Each of the problems was related to one specific field (energy, materials, site, etc.) and to one or more LEED credits.

The LEED reference standard consist in a list of standards, gathered together in different chapters, each of whom is related to a different construction field or chapters. The individual standards, also called "credits", address one or more building features in order to comply with a certain reference-standard specification. The whole of the LEED credits is divided in two main groups: design phase and construction phase. Each group addresses issues that are related to the design or construction phase of the building and, as seen during the development of the research methodology, several problems derived from the fact that what is considered "design phase" in Italy has to be considered “construction phase” by LEED and vice versa. This depends on the fact that Italian projects follow the European construction process and LEED the Anglo-American one. However, for the purpose of the school design bid, LEED-related tasks addressed by the design team were identified as the ones listed in the LEED design-phase credits. Therefore, for the purpose of the present work researchers considered only the LEED credits related to the LEED design stage.

The design-team kick-off meeting cited above served as a tool for evaluating the LEED score that the project could have achieved. Each LEED credit related to the design stage was analyzed by technicians and evaluated on the basis of objective information retrieved ether from existing project conditions, such as, project site, total area and urban surrounding, or from personal experience of each technician involved. This last point in particular required researchers to face the problem from a subjective perspective. In fact, the evaluation of the project potentials to achieve certain technical credits was made on the basis of the sole technician’s opinion and related calculation which were not refined. For example, the amount of decibel that a certain curtain wall or type of window could reduce was not calculated exactly but was estimated on the basis of the professional’s experience.

At the end of the kick-off meeting the team developed a project checklist indicating all credits that were achievable, potentially achievable and not achievable. Then, at the end of the design phase when the project design was developed and the related LEED-documentation was in place, another checklist was filled out listing all credits that had been actually achieved. The comparison between both checklists determined the number of sustainability points lost during the design process. The new list of unachieved credits was then used by researchers as a baseline scenario for the evaluation of the impact of project-management-related issues on the project design. Following the qualitative interview process already described above researchers asked to each of the subjects involved the causes of each loss of LEED points. The ones caused by one of the categories of issues listed above were considered for the purpose of the present work. Figure 3.5 below reports a snapshot of the preliminary checklist developed after the kick-off meeting of the design team. Note that only credits identified as "achievable", on the left column of the check-list, were considered for the final credit comparison.

LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
6	1	0	**Water Efficiency**		7 Points
1	0	0	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1	0	0	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
1	0	0	Credit 2	**Innovative Wastewater Technologies**	1
3	0	0	Credit 3	**Water Use Reduction**	1 to 3
			Credit 3.1	20% Reduction	1
			Credit 3.2	30% Reduction	2
		-->	Credit 3.3	40% Reduction	3
0	1	0	Credit 4	**Process Water Use Reduction**, 20% Reduction	1

Yes	?	No			
13	2	0	**Energy & Atmosphere**		17 Points
Yes			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 2	**Minimum Energy Performance**	Required
Yes			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1:** All LEED for Schools projects registered after June 26, 2007 are required to achieve at least two (2) points.

Yes	?	No			
10	0	0	Credit 1	**Optimize Energy Performance**	2 to 10
			Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3

Figure 3.5: snapshot of part of the project checklist developed after the first kick-off meeting with the design team.

3.8 Stage six: share.

The quality of any empirical studies, including case studies, depends on construct validity, internal validity, external validity, and reliability (Edmonds & Kennedy, 2012). Construct validity, which is especially challenging in case study research, deals with the concept of operationalization. Operationalization is the process of defining a concept through a set of attributes/variables in order to make it measurable through empirical observations (Loseke, 2012). Numerous threats to construct validity have been identified, including inadequate explication of constructs, construct confounding, mono-operation bias, mono-method bias, confounding constructs with levels of constructs, treatment sensitive factorial structure, reactive self-report changes, reactivity to the experimental situation, experimenter expectancies, novelty and disruption effects, compensatory equalization, compensatory rivalry, resentful demoralization, and treatment diffusion. According to Yin (2009), three strategies for improving construct validity include using multiple sources of evidence, having key informants review the case study report, and maintaining a chain of evidence. Employing multiple sources of evidence can contribute to construct validity by providing multiple measures of the same phenomenon. Therefore, for the purpose of the present study the researcher implemented two different sources of information toward the validation of the research. The first one proceeds from the field and can be considered a direct source of evidence because subjects directly involved in the process were asked, through proper interviews, to "validate" the process and the results obtained on the basis of their experience. In other words, they agreed on both the type of process followed and the magnitude of the results obtained. The second source of evidence was indirect and was developed through a research publication.

On the other hand, designing the case study so that the chain of evidence is maintained allowed reviewers to trace from conclusions back to the initial research questions, or from questions to the conclusions (Sarker & Lee, 1998). The corrections made through reviews by interviewees and editors enhanced the accuracy of the case study as well as identify a range of competing perspectives.

The use of methodological and data source triangulation (including cross-case comparisons) can lead to increased internal validity (GAO, 1990). Therefore the research team decided to pick multiple case-study projects in order to enhance the validity of the results obtained. Other types of triangulation include investigator triangulation and theory triangulation (Denzin, 1978) which were not taken into consideration by researchers. For the purpose of this study researchers performed a theory and data source triangulation between researchers, subjects involved in the case-study projects and results of the different case-study projects.

During the development of the present study researchers faced the problem of the reliability of information. Reliability is concerned with demonstrating that same results can be obtained by repeating the data collection procedure. In other words, other investigators should in principle be able to follow the same procedures and arrive at the same results. From this point of view researchers implemented two strategies for ensuring reliability of case studies: the creation of the case study protocol, and the development of a case study database (Yin, 2009). The case study protocol contributes to the reliability by standardizing the investigation. Researchers created, during the development of the pilot case-study research, a set of standardized field procedures, guiding questions, and a report outline that established how, what and when about the collection of information. On the other side, researchers developed a standardized data-collection system which identified a range of relevant data quality dimensions, including accuracy, objectivity, believability, reputation, interpretability, ease of understanding, concise and consistent representation, relevancy, value-added, timeliness, completeness, amount and accessibility of information which contributed to rise the quality level of the collected information (Wang & Strong, 1996).

3.8.1 Verification of methodology.

One of the main concepts of the present research work is the development of a new methodology for the optimization of green-building project developments under the project management point of view. In chapters above researchers described how this new methodology was developed and improved throughout the case-study analysis. However, in order to have rational elements endorsing its accuracy, researchers needed to validate it or, more properly, go through a validation process.

The validation of the project research methodology was developed using two different approaches, each of them related to the academic and professional environment, and described below:

1. Composition and publication of a proper research article focused on the methodology of the pilot case-study;
2. Interviews with subjects involved in the process to highlight eventual problems, black-spots or defects of the methodology.

3.8.1.1 Published research article.

The prototype research methodology applied to the pilot case-study project was analyzed and described for the composition of a research article which was presented at the ENSUS conference in April 2016, in Florianopolis, Brazil. The ENSUS conference is an event organized by the Federal University of Santa Catarina which collects experts from all around the world. The word ENSUS stands for “Encuentro de Sustentabilidade em Projeto” (Meeting for Project Sustainability) and the main focus of the conference is green-building intended as a broad concept. The event embraces different fields, all related with the development of sustainable buildings. The concept of sustainability is also broad, since does not concentrate the attention on one certification or project delivery system but stretches between all potential meaning of the word sustainability, including design, construction, raw-material supply, affordability, and others. The article presented by researchers was accepted, reviewed by the conference committee which included experts from all around the world and adjusted on the basis of the committee’s requests. The article was then published on the journal “Mix Sustentavel” in the third edition of 2016 (Orsi & Guillamón, 2016).

The process of refining the article and the observations of the committee served as guideline for the improvement of the research method and most of all for the validation procedure. Observations and suggestions made by the committee helped researchers in re-defining the structure of interviews for validation purposes. Such interviews were held again with subjects involved in the process after the conference and results are summarized in chapter below.

3.8.1.2 Interviews with subjects involved.

After the completion of the first research process and the publication of the related article researchers got in contact again with the subjects involved in the original project and held a new round of interviews to validate the research methodology. Interviews were organized on three different levels, all of them developed through a qualitative approach.

The first step included the analysis of the methodology's results by each of the subjects involved which had to express their opinions in relationship with their technical points of view. As described in the chapters above the owner, the public administration and other subjects of the design team contributed to the preliminary definition of the research strategy and development of the methodology. However, their contribution was useful to guide researchers in establishing a well-defined methodology but it was never used to check its accuracy. For example, the establishment of certain dates as reference points for the scheduling part was not always rationally and univocally clear and it required the interpretation of source-information in order to fix a certain date within a wider range of possibilities. On the other side, the calculation of indirect costs, which were almost never documented officially, required also an interpretation of the data acquired in order to double-check the truthfulness of the numbers. For this type of activities, which involved more operative tasks related to the methodology, researchers implemented the qualitative interview with all subjects involved. Therefore, after completing the first draft of the methodology, researchers asked the interviewees if their calculations could be considered correct. All subjects interviewed agreed on the qualitative aspects of the methodology and just in a few occasions they rectified some quantitative data like the ones cited above: identification of an activity start date, evaluation of a certain indirect cost analysis, and others.

The second step was developed on the basis of the so-called cross-check validation approach in which each subject was asked to check each other's results and aspects of the methodology (Minyoung et al., 2006). Along with the first validation step described above, researchers asked all interviewees to evaluate also the methodology and related information for each other's activity.

From this point of view subjects involved could provide only a qualitative analysis of the methodology because they were not aware of each other's quantities and activities. However, this approach helped researchers in finding new perspectives for each problem. New details were highlighted and therefore new problems were pointed out. For several tasks considered in the process.

The third step was a continuous reiterative process of optimization developed throughout the whole methodology-definition progression. The assumption of considerations proceeding from each interview, the evaluation of the feasibility of each consideration and the implementation of the appropriate modifications to the methodology shaped the core of the final validation step. The process ended with the completion of all validation interviews in which each subject and technician involved gave their contribution to the optimization of the methodology.

3.9 Chapter summary.

The present chapter described how researchers approached the case-study project from the early data-collection phase to the information analysis and output arrangement. The methodology was developed following the six-stages process developed by Yin (2009) and the structure of the chapter reflects the organization of this process. The approach to the pilot case-study was developed following a reiterative refining process between researchers, collected information and subjects involved in the process. The different steps implemented throughout the process are also describes from the qualitative and quantitative point of view. The chapter then summarizes the parameters used for collecting and process information during the project analysis and research-related calculations. Furthermore, Researchers describe the basis of the research work validation which was developed through the implementation of direct interviews to subjects involved and the publication of a formal research article. Finally the chapter proposes a set of recommendation for the development of future researches following the methodology used by researchers for the scope of the present work.

CHAPTER 4

Case-study projects

4.1 The school project.

This case-study, briefly described above in chapter 3, was implemented as pilot project for the development, testing and validation of the research methodology. The project refers to a new school complex located within the Province of Trento in Northern Italy currently undergoing the LEED for Schools 2009 certification procedure. The project has a total budget of approximately 13,2 Million Euros and a total gross square footprint of 6.000 square meters. The building ownership is public and represented by two main institutions, the local Municipality which formally has the property of the building and the regional government which funds the development. Due to this double ownership, all decision-making processes related to building design and development have to be taken first by the local Municipality and then approved by the different departments of the Province.

The development of the project followed the Design-Bid-Built procedure as defined by the Italian law "Decreto Legislativo 12 Aprile 2006" which was in force at the time of the project beginning. The law considers three different phases for the design development, each of them related to a different level of detail and estimate (D. Lgs. – 2006). Each phase has to comply with the requirements of the laws in terms of drawing, details, reports and other documentation including detailed estimate of the project costs and overall scheduling for the project completion.

The first phase is called "Progetto Preliminare" (Preliminary Design), is comparable to a concept-design phase and represents a general analysis of the project overall feasibility from different points of view. This design stage focuses on introducing the operation within the surrounding area from the urban point of view outlining a possible shape of the building, volumes, indoor and outdoor areas. This phase also aims to evaluate the economic feasibility of the project developing a parametric estimate of the project based on local information and historical database which is normally provided as Euro-per-square-meter value for each part of the building. Finally the preliminary design sets the instructions and main guidelines for the development of the next design phases.

The second design phase is called “Progetto Definitivo” (Definitive Project) and can be considered as the first real design phase where the vast majority of the building features have to be set and planed from the architectural, economical and scheduling point of view. The details of the building have to be defined not only qualitatively but also quantitatively. The materials of which the building will be composed have to be identified as well as the installation components. The estimate of the building is developed through an analytical process involving the computation of each element and can have a maximum percentage of variance below the 10%. Reports developed during this design phase shall consider all major aspects of the building including qualitative structural design, fulfillment of the fireproof regulations and others.

The last design phase is called “Progetto Esecutivo” (Executive Project) and represents the as-built design of the building. All documentation that the General Contractor would develop following the Anglo-Saxon procedure right before the assembly of the building is provided with this design phase. As-built and shop drawings of every bolt of each column, as well as, technical details and performance of each mechanical equipment have to be determined and sealed by the designer before the end of the design phase. Reports related to each area of interest of the building have to be developed by each specialist, such as, fireproofing experts, structural and production engineers, façade specialists and others.

The bidding procedure followed for this project considered all stages cited above but grouped up in two main segments. First the owner designated one design firm for the development of the first design stage (preliminary design) which was finalized by the end 2007. Then, having the first design draft as a baseline for the future design stages, both public entities owning and funding the project published the official bid for the development of all the following design phases. For the scope of the present work researchers analyzed the development of the second and third design stage. In fact, such phases represent the core of the design development in terms of costs, time and resources spent. The first design phase was developed through a direct designation of the design firm, without public bid and was carried out in a few months. The other two phases, due to their higher level of detail and other bureaucracy-related issues that will be described below, took several years to be completed.

4.1.1 Brief project history.

The contract for the preliminary design project was assigned directly to a private firm during the summer of 2006 and it was completed by the end of September 2009. The delay caused by the bureaucratic process impeded the joint design process in collaboration with the local public entity called “Comprensorio C10” and therefore the public administration decided to go for the Design-Bid-Built procedure. Before the end of 2006 the preliminary design phase was finally approved by the local municipality for a comprehensive total project cost of 9.800.000 €. This estimate was based on a parametric calculation provided along with the preliminary design and therefore was characterized by a certain level of tolerance. In April of 2007 the Province of Trento, published the list of operations that would be admitted to public funding and the school project was included in the list. Therefore, in September 2009 the municipality of Volano presented the proposal for having access of the funds cited above and the Province of Trento admitted them to a global funding of 9.761.153 Euros in March 2008. On April 2008 the LEED protocol was recognized by the Province of Trento as a reference standard for the development of all public projects in the region. Also the school building had to comply with the regulations and therefore the LEED Accredited Professional was hired by the municipality in order to manage and develop the whole design in accordance with the reference standard. Between the beginning of December 2008 and the end of February 2009 the public administration developed the bid documentation for the design competition that would include, as cited above, the definitive and the executive design phases. The bid procedure finalized on October 2009 and was won by the design firm Gruppo Marche. Technicians began to work from both architectural, engineering and sustainability point of view. However, they soon recognized the need of modifying the “Piano Generale di Utilizzo delle Acque Pubbliche” (PGUAP) which corresponds to the general plan for the use of public water and includes all the areas that were subject to flood. In fact, the project site was identified within the previous urban planning program as a building-development zone and was not included in the flood-risk areas. However, years later, the improvement of the PGUAP included the area in the list of areas with potential flood risk with a risk factor of R4 upon a scale of 4. The gap between the area codification within the local urban plan and the global water-management plan had to be covered. In order to solve the problem, between February and June of 2010 several meetings were held between the Municipality, technicians involved and the Department of Public-Water Management ("Bacini Montani") of the Province of Trento. The solution was determined from the qualitative perspective by rising the whole project site area and providing infrastructures and entryways to the building above the maximum flood-risk level. However this had to be quantified and arranged through a specific project in order to be approved by the Department and accepted within the PGUAP. The task of developing a project for solving the flood-related problems was assumed by the design firm Grisotto on August of 2010. After this inconvenient related to the flood risk Gruppo Marche signed the contract to start the next design phase, the definitive design, which continued until November of 2010 when technicians notified the lack of a proper survey of the area to the public administration. The survey available at that time was in fact not precise and the final one had to be provided to allow technicians to finalize the project. The survey was carried out using the procedure of urgency by a land-surveying company and the project was then finalized and ready to be presented by the end of 2010. However, in order to officially present the project to the municipality technicians had to rely on the geological project developed by Grisotto which hadn't been approved by the Department of Water Management. The final approval came on May of 2011, automatically followed by the modification of the PGUAP and the official reclamation of the site. In the meantime the public municipality had to face other problems:

- The original contract signed with Gruppo Marche had deadlines that could not be maintained and therefore it had to be suspended.

- The project funding proceeding from the Province of Trento had already been extended 3 times and the extension of March 2011 expiring on March 2012 could not have been extended any longer.
- The project presented by Gruppo Marche, at its “definitive stage” exceeded the original budget by more than 3 million Euros. This was caused by decisions of the public administration that changed the original design during the development of the second design phase. The final total cost of the project presented by Gruppo Marche to the Municipality was 13.220.000 Euros.

At this point the public administration decided to brake the design-approval-process in two lots, one for the academic portion of the building and one for the rest of the site. This move was based on the following reasons:

- The original funding for the school was expiring in March of 2012;
- The project, as it was and for decision of the public administration, was over budget;
- New funding had to be found for the approval of the whole project but it was not possible to find them before having the old ones expiring.
- In order to have the funding for buildings which construction costs rise above the 5 million Euros each project at its “definitive design” had to be approved by the Technical Committee of the Province of Trento (CTA).

By breaking the project in two lots the Municipality could have had the first lot, which was above the 5 million Euros, reviewed and approved by the CTA before March 2012 and therefore have access to the original funds. The new funds would have been granted for the second lot, which was below the 5 Million Euros and therefore it had no need to be approved by the CTA. Therefore, the contract with the design company Gruppo Marche was rectified by inserting the two-lots clause. Then other minor technical issues occurred during the development of the design phase due to bureaucracy and lack of proper documentation but eventually the project was broken down in two lots by the design firms.

The first lot was presented and approved by the Province CTA in February of 2012 and the first original funding was granted in March 2012. Right after the approval of the fund the Municipality signed the contract with Gruppo Marche for the development of the last design phase, the executive project which still considered two separated lots. In March 2012 technicians started with the Executive-Design phase however, soon after the beginning, designers noticed a problem with the infrastructural plan of the Province. In fact, such plan expected a road to be built right on the project site and, before achieving the authorization for the Executive design approval, the plan had to be modified. A special meeting was organized on July 2012 with the representative subjects of all infrastructures and entities involved and the problem was solved by September 2012. On the same month the new fund was granted for the development of the second lot for a total amount of 3.440.000 Euros. In October of 2012 the Definitive-design phase of both lots was approved for a total amount of 12.649.400 Euros and then the Gruppo Marche was contracted for the process of merging the two lots in one final project at the executive-design stage. In fact, the project break-down was a bureaucratic stratagem to have the funds granted but the final design phase had to be developed at once. The final design stage was finished and delivered on March 2013 with a total budget of 13.200.000 Euros and right after the process for the construction bid started. As a final note researchers highlight that currently, in January 2017, the construction of the school complex has not started yet. In the bullet-point list below are summarized the main project stages cited above:

- 07/2006: private firm directly designated for the development of the Preliminary Design Stage.
- 09/2006: presentation and approval of the Preliminary Design Stage by the public administration with a total budget of 9.800.000 €
- 04/2007: the Province of Trento publishes the list of projects eligible for public funding.
- 09/2007: public-funding request presented by the Municipality to the Province of Trento.
- 03/ 2008: funding granted for a maximum of 9.761.1 53 € - Funds expiring on March 2009
- 10/2008: LEED acquired as reference standard for the school project.

- 12/2008: public bid for the development of the Definitive and Executive Design Stages – first draft.
- 02/2009: public bid for the development of the Definitive and Executive Design Stages – final version – and official publication.
- 10/2009: Gruppo Marche wins the bid.
- 11/2009: technicians highlight the need of modifying the PGUAP and PRG.
- 02/2010 – 06/2010: meeting with the Department of Water Management looking for possible solutions.
- 08/2010: the Dep. Of Water Management finds the solution and the Public administration appoints the firm Grisotto for the development of practical means to implement it (soil embankment).
- 11/2010: urgent survey of the project are is needed. The Municipality directly appoints a private firm.
- 02/2011: contract between the Municipality and Gruppo Marche suspended due to the excess of delay.
- 02/2011: analysis developed by Grisotto is approved by the Province of Trento.
- 03/2011: presentation of the Definitive Design Stage in front of the Municipality – Total budget of 13,200,000 € - and decision to break the project in two lots.
- 05/2011: request for a second funding to the Province of Trento.
- 05/2011: General Plan for Water Management (PGUAP) modified by the Province of Trento.
- 02/2012: first project lot presented to the Technical Committee of the Province (above the 5 million Euros).
- 03/2012: approval of the first project funding.
- 03/2012: Gruppo Marche appointed for the development of the Executive Design Stage of the first lot plus the second in case the second funding would have been granted.

- 07/2012: problem for planned infrastructures colliding with the school project. Meetings and procedures between public entities to define the solution.
- 09/2012: second funding related to the second project lot approved. No need to go through the Technical Committee because the budget is 3,438,847 €.
- 10/2012: final approval of the Definitive Design Stage (lot 1 + lot 2).
- 10/2012: contract with Gruppo Marche re-arranged and firm in charge to merge the design again during the last Executive Design Stage.
- 03/2013: Executive Design Stage completed and delivered to the Municipality (Total Budget of 13,200,000 €)
- 03/2013: convention with the Province of Trento for starting the construction bidding procedure.

4.1.2 Why choosing this case-study project.

As already cited in the previous chapter, the choice of this case study project was made on the basis of the following statements:

- Direct access to project information and contact with all technicians involved in the project;
- Time-simultaneity between research and project design development;
- Project sustainability referring to LEED credits as benchmark for evaluation;
- Implementation of DBB as project-delivery method with high-level of process fragmentation.

Before selecting this as a pilot case-study researchers took into account other projects. All of them presented similar features in terms of budget, timeline and resources however they had big gaps in term of access to information. For the vast majority of the cases researchers were not given the access to information even under the clause of using them only for academic-related purposes. Out of more than ten projects considered for the scope of this work almost none of them would give us access to information related to extra-costs, delays and other issues occurred. Researchers felt the aversion of owners, design firms and other technicians involved toward highlighting the issues of the different projects which, in spite of being public and having all procedures verbalized and published, had clearly something to hide. However, for the school project as well for the nursing-home project described below, both owners and technicians allowed the direct access to project a design information without any limitation.

The school project was also chosen for the highly fragmented process followed for the design-phase development. For the scope of this work researchers focused on picking one pilot-case study project that could contain the vastest number of possible variables. In other words, researchers looked for the worst-case scenario on which they could develop and test the methodology and then implement it to analyze the other cases. This project followed the most complicated and fragmented procedure we saw between all other eligible projects and therefore it represented a good benchmark for the development of the methodology.

4.2 The nursing-home project.

This case-study refers to a nursing-home project located in Northern Italy which includes the development of a brand-new building within an empty urban site. The project is currently undergoing the LEED for Healthcare 2009 reference standard, and was conceived to be a sort of nursing & healthcare facility with special treatment areas for Alzheimer inpatients and other degenerative diseases. The project total budget was 11,5 Million Euros and a gross area of 5.965 square meters. The owner of the project was a public company owned and funded by the local public healthcare system. Therefore, for the development of the project, as for the case of the school complex, the decision-making process counts on a formal CEO of the company, supervised by the company's council, which decisions have to be approved by the local healthcare public system called "Azienda Provinciale per I Servizi Sanitari" (APSS). The CEO is in charge to take decisions for the most "operative" actions related to the day-a-day function of the nursing-home, the council meets once-a-month and is responsible, with the president, for the broad-vision and political assessments. The

APSS intervenes only sporadically when major cost-related or welfare-related decisions have to be taken, such as, the approval of the building design stages or the annual balance sheet. Following the same procedure of the school complex, the development of the project implemented the Design-Bid-Built procedure as defined by the Italian law “Decreto Legislativo 12 Aprile 2006” which was in force at the time of the project start. After a preliminary design phase developed by a local private company directly appointed by the company’s council the APSS decided to develop a design competition for the development of the other design stages. The competition was more like a bid because the jury had to evaluate the quality of the project and the cost for the completion of the remaining design tasks. The best-scoring project, which was deduced using a mathematical average between design and economical scores, would have won the competition. For the purpose of the bid the public entity considered the remaining design phases, the “definitive” and “executive” design and other two tasks which are related to the construction phase of the building and are mandatory under the Italian law: the director of works and the safety superintendent.

The director of works is considered as the delegate of the owner during the construction phase of the building. He represents the owner and his interests for all the activities related to the construction development, such as, technical control, payments to the GC, cost controls, scheduling, disputes between subs and other activities. Moreover, the director of works is also responsible for all tasks, activities equipment and persons on the project site. In other words he is responsible for everything happening within the project site and his main goal is to bring the project construction to completion in accordance with the project drawings, schedule and budget. The responsibility of the director of works is shared by the safety superintendent (or “safety coordinator”) for the safety aspects of the project construction. His role is to verify the project compliance with all safety measures required by law during the final design stage and to control that the project construction fulfills al safety standards for each activity, equipment and material implemented in the site. Both director of words and safety superintendent have to periodically supervise the project site and, in case of need, have the power to stop the construction process at any time.

Both services cited above were included in the original design bid which would cover a timeframe from the definitive design stage until the construction completion of the building. Therefore the participant to the design competition were all joint ventures formed by different companies, each of them specialized in one single aspect of the bid, such as, mechanical engineering, structural engineering, safety, healthcare architecture, etc. The design process started with the finalization of the design bid in 2012 and the final approval of the last design phase, the executive design, three years afterwards. Here below researchers reported a brief summary of the design process followed for the nursing-home development.

4.2.1 Brief project history.

The bidding procedure followed for this project considered all stages cited above for the school pilot project but grouped up in two main segments. First the owner designated one design firm for the development of the first design stage (preliminary design) which was finalized by the end of 2010. Then, having the first design draft as a baseline for the future design stages, both public entities owning and funding the project published the official bid for the development of all the following tasks:

- Definitive Design Stage;
- Executive Design Stage;
- Director of Works during construction;
- Coordinator of Safety and Health during construction.

The terms “Coordinator for health and safety” identifies a role which includes the indication of safety and health measures during the design phase and the coordination and supervision of all health and safety measures during the project execution. For the scope of the present work researchers analyzed the development of the second and third design stage. In fact, such phases represent the core of the design development in terms of costs, time and resources spent. The first design phase was developed through a direct designation of the design firm, without public bid and was carried out in a few months. The other two phases, due to their higher level of detail and other bureaucracy-related issues, were carried out in several years.

The project is owned by Opera Romani, a public entity which already owns and manages an existing nursing home, which in turn is controlled by another public agency, the local healthcare society. Therefore the project funds proceed from two main lines, both of them public. As cited above the project followed a typical DBB European process in which all design phases come before the general contractor and are performed by different subjects. Specifically in this case subject involved for the design development were:

- Architect: represented by a small architectural studio located in Ravenna (central-northern Italy) which had also the tasks of supervising the work during construction;
- Structural Engineers: represented by a large company of engineering located in Venice (western Italy);
- Mechanical Engineers: represented by a medium engineering firm specialized in mechanical equipment and located in Rome (central Italy);
- Assistant Project Manager: represented by a single professional located in Rome (central Italy);
- LEED Accredited Professional: represented by a single subject located in Trento (northern Italy);
- Energy modeler: represented by a mechanical engineer subcontracted by mechanical engineers and located in Mississippi (USA);
- Commissioning Authority: represented by a small company of mechanical engineers located in Brescia (northern Italy);
- Project owner: represented by the public society cited above and located in Trento (northern Italy).

The procedure followed for the development of the project design stage was similar to the one implemented for the school pilot case-study. One private design firm, Baldessari Engineering, was directly appointed for the development of the first stage called “preliminary design”. This phase was developed following a linear process having the owner and the engineering firm as main and almost unique parties involved. The preliminary project was completed by the end of 2010 and then the public owner, supervised by the local Healthcare Department, decided to go for a public bid containing the tasks to be performed for the other two design phases, the director of work and the safety superintendent. During 2011 both public entities developed the bid documentation which was completed by august 2011. At that time the Province of Trento, from which depends the Department of Healthcare, had already chosen the LEED protocol as reference standard for all new public buildings and therefore this had also to comply. The bid documentation was developed with the support of the technician who would have become the LEED AP of the project and proper clauses were written in order to comply with the LEED reference standard and process. The total bid budget was about 1 Million Euros and was determined on the basis of the law in force at that time, each design phase, task and job is estimate by law as a percentage of the total construction cost. However, the bid was asking for a LEED building with specific requirements to professionals involved without considering the costs of such services within the budget. A formal letter was written by the board of engineers to the public owner which, from one side could not modify the budget without going through the approval process of the Healthcare Department and from the other side could not consider extra-services for the project budget. Therefore the owner decided to withdraw all LEED-related clauses already considered in the bid without notifying anything to the LEED AP. In fact, the LEED AP was hired and informed only later on January 2012 and the design competition had already been published. The design bid was eventually won by the joint venture leaded by the company H.C. on February 2012 and soon after the project was registered under the LEED 2009 for Healthcare standard under the GBCI portal in March 2012. The following month the first kick-off meeting between all technicians was held and soon emerged the flood-risk problem which was affecting the project site. The procedure for solving the problem would have been similar to the one implemented for the school project however, the LEED AP who was involved in both projects managed to merge the first bureaucratic process with the second one having the flood-risk problem solved for the RSA by the end of September 2012. The solution for avoiding the flood-risk was, likely the school project case, raising the ground level about 2 meters above the maximum flood-risk level. However, for this case due to the special condition of the nursing-home project, the Department of Water Management allowed one underground floor provided that the entrance door was water-sealing. During the summer of 2012 technicians and designers stared developing the project waiting for the flood-risk problem to be solved. At the beginning of August the architect met with the LEED AP and together they started the preliminary LEED-architectural development which was completed by October 2012. The same process was followed between LEED AP and mechanical engineers and it also came to an end at the end of October 2012. Meanwhile, the owner developed, published and concluded a public bid for the hydraulic redevelopment of the site. The soil-raising operations required a first step of 6-months sedimentation to prevent the ground structural failures. That operation had to be done before the beginning of the building construction and therefore it was contracted through a separate bid in December 2012. During this flood-risk and soil- raising time designers stood-by due to economical reason. In fact the total budget of the project was fixed and they could not know how much the project would have cost without knowing the expenses for the other operations. So the real “definitive” design phase started in January 2013 and soon emerged the lack of experience of designers with LEED. The meetings held before had to be done again and the designers claimed the owner for the cost of LEED-related documentation which they did not know they had to provide. Plus, some of the designers had to hire new technicians due to their lack of capabilities related with LEED (for example nobody within the architectural firm could speak English at all). The design development continued parallel to the LEED-related procedure and came to a substantial completion by July 2013. However, a modification was imposed by the local Department of Landscape (“Tutela del Paesaggio”) and part of the project had to be re-done. The project modification, along with the unforeseen expenses caused problems within the project budget and by the end of the definitive design phase the project estimate was over-budget. Cuts had to be made to the project and, since the architectural part had already been approved by all the Departments of the Province (Water, Landscape and others) the cuts were made on the mechanical design part. Project cuts involved also building features related to LEED but the mechanical engineers did not notify such changes to the LEED AP which continued uploading the documentation developed before. This produced several gaps and problems in further project phases. The “definitive” design phase was approved by the Technical Committee of the Province at the end of December 2013. The final design phase called “executive phase” started then in January and was characterized by a lack of information flow between technicians, mainly architectural and mechanical. Architectural and mechanical engineering parts were developed separately and the problems emerged toward the end when the team had to merge both project estimate. With the new year prices of all materials had raised whether the project budget had not. The project had to go through a cost-cutting process again and the results for the LEED-related issues were similar to the ones had in the previous design phase. At the same time, toward the end of the executive design phase, the mechanical engineers that had took on the energy-modelling task realized that they were not able to develop it due to software-exchange problems. At that point they had to find an energy modeler but the design phase had to be approved soon after or the owner would have lost the public fund for the project. The executive design was officially presented and approved by the Technical Committee on the 14th of May 2014 and the energy modelling was developed only afterward. This led to several issues because, in spite of having the energy model highlighting thermal bridges and design gaps the project design had already been approved and could not be modified. Another major issue was caused by the Commissioning Authority activity, or better said, by the lack of it. The Commissioning Authority service was given to a consulting company called Estia before the end of the executive design phase. The LEED AP repeatedly suggested Estia to have their CxA reviewing the executive project before the approval because, either if in the Anglo-Saxon system is required only during construction, in Europe all clauses, tasks and project features have to be included within the executive design. In fact, in the Anglo-Saxon system the detailed estimate is performed by the General Contractor but within the European system is has to be performed by the designers during the final design phase. The owner has to pay extra for everything that is not included in the detailed project estimate and the CxA tasks are part of it. However, Estia never had the Commissioning Authority reviewing the project design and this caused issues on the following construction phase. In the bullet-point list below are summarized the main project stages described above.

- 12/2010: preliminary design stage completed.
- 04/2011: decision of going with a public design-bid-built procedure.
- 05/2011: beginning of the development of the bid contractual documentation.
- 09/2011: official letter of the board of engineers to the project's owner and withdrawal of the LEED-related clauses.
- 10/2011: publication of the public bid for definitive design, executive design, director of works and safety superintendent.
- 01/2012: LEED AP hired by the public owner.
- 02/2012: design competition won by the joint-venture HC, OTHE, F&M.
- 03/2012: LEED Project registration
- 04/2012: kick-off meeting with all team members.
- 05/2012: problem with the Department of Water Management because the flood risk of the project site.
- 07/2012: hydraulic problem solved, preliminary project to raise the ground.
- 08/2012: LEED Preliminary Development – Architectural.
- 08/2012: documentation approved by the Department of Landscape.
- 10/2012: LEED Preliminary Development – Mechanical.
- 10/2012: hydraulic design bid - preliminary phase.
- 11/2012: hydraulic design approved.

- 12/2012: hydraulic bid end.
- 01/2013: verification of the project economy.
- 01/2013: definitive design stage start.
- 02/2013: technicians do not know LEED; issues related to LEED-documentation development.
- 03/2013: soil loading procedure.
- 05/2013: architectural design for definitive project ready – first draft.
- 06/2013: design approval process by the Department of Landscape (Tutela del Paesaggio).
- 06/2013: mechanical design for definitive project ready – first draft.
- 10/2013: the Department of Landscape demands some design changes.
- 11/2013: changes demanded are put in place and definitive design stage ready.
- 11/2013: take-off analysis procedure and first cost adjustments.
- 12/2013: definitive project approved by the Province Technical Committee (CTA).
- 01/2014: executive design stage – first phase.
- 03/2014: project re-engineering and cost adjustments due to new prices.
- 04/2014: energy modelling first draft – unable to develop the model.
- 05/2014 executive design phase approved.
- 06/2014: development of the energy modelling.

4.2.2 Why choosing this case-study project.

Like the school project the driving factor for the choice of this case study was the accessibility to project information. In fact, this was one of the few projects in which researchers were granted access to all necessary information, including some confidential ones. The relationship that connected the owner, all technicians and some of the researchers involved in the project from both professional and academic sides granted a continuous flow of information which was essential for the scope of the present research.

Researchers did not pick this case as a pilot case-study due to its lower level of complexity however, it still present some similarities with the school-complex case. First of all, it was developed in the same country, which means, within the same legal and bureaucratic boundaries. The time-frame was also very close with the school project which guarantees the application of the same laws and rules for both projects. The project budget was in the same range of the school-project and represented a common average-small project size. The research team had direct access to information and to all subjects involved in the project due to their proximity in terms of geography, time-frame and goals. In fact, during his staying abroad one of the researchers could physically interact with the project team having all questions and doubts solved instantly and on-demand. This aspect was very important because it allows researchers to see and analyze things how they really happen without necessarily going through a formal set of Q&A. Having the full picture of the project development process was a key-aspect for choosing this as a case-study project.

The nursing home project was chosen also for the development process that the owner decided to follow. In fact, as for the school case-study, this project was developed through a Design-Bid-Built procedure having the design phase completely separated from the construction stage. Since the focus of the researchers was to identify issues proceeding from the implementation of fragmented processes, such as, the DBB, this case-study along with the school-complex one created a good database for the scope of the present research.

4.3 The office-building project in Barcelona.

This case-study analyzes a public-owned project located in downtown Barcelona (Spain). The project referrers to a building originally built at the beginning of the 20th century and completely renovated following the LEED 2009 BD+C reference standard with the addition of another adjacent building. The protocol is the same implemented for the nursing home project and is generally used for the development of the new buildings. However, it can be also applied to major-renovation buildings and undergoes the same certification procedure as the new building projects. In this case, the project includes two buildings:

- A small building with an approximate footprint of 200 square meters with two floors and the attic which was completely renovated for the scope of this project;
- A bigger brand-new building with an approximate footprint of 500 square meters and a total height of 6 floors.

Both buildings were built within the same site in downtown Barcelona and therefore had to withstand specific requirements and restrictions imposed by the local city laws. Such restrictions would range from the most common urban parameters to the detailed requirements for historical building conservation and the design team had to face a quite severe process of constant project re-shaping and approval by the local authority. This induced several re-engineering tasks throughout the whole process but, for the purpose of this work, researchers focused only on the sustainability-related issues generated by such procedure, not all of them. As for the other projects already described above for the purpose of this building development the process had to go through different design steps. In fact, the Spanish design process is very similar to the Italian one. Both have three different design phases representing different steps of the design in terms of level of detail and definition of the building features. In both systems the design has to be developed entirely by the design firm which, in this case, was the architectural firm including shop drawings and as-built drawings. The general contractor focuses only on building the project but all the previous work including project estimate, work scheduling, payment planning and others have to be managed and settled by the design firm. Each design phase is complemented by a set of documents related to different project characteristics, such as, construction costs, project related-service costs, sums for unexpected events, expected construction time, project-related law requirements, safety measures etc. Each design phase is related to a different level of detail and, in the case of Spain, the design phases are named:

- "Anteproyecto" which is similar to the Italian "preliminary project";
- "Proyecto Básico" which is similar to the Italian "definitive project";
- "Proyecto de Ejecución" which is exactly the same as the Italian "executive project".

Moreover, the type of complementary documentation attached to each of the design phases are very similar between the two systems. Therefore we can assume that both Italian and Spanish design processes are very similar, almost identical.

One important detail about the development of the design process in all processes analyzed for the purpose of this work is the total lack of the project manager figure. In spite of the vast range of fields that design firms have to face, the entire work is coordinated by the senior designer, either architect or engineer, which doesn't have a proper project-management background and makes decisions on the basis of his own experience but without implementing rational and well-defined management tolls. This concept has been noticed for all projects analyzed and will be re-proposed toward the end of this work. However, at the moment is important to keep it in mind in order to understand the process followed for the development of the project in Barcelona.

4.3.1 Brief project history.

The project started to be developed by a public local entity of Barcelona in year 2014. However, the early phase which lasted several months consisted mainly in preliminary surveys, bureaucratic processes and activities that are not related with the scope of this research. The real design phase started with the public bid related to the project design and construction.

The owner's main idea was to develop an old building within the city center in order to take advantage of a public law and increment the zoning index of the adjacent piece of land. So the whole project included the renovation of the small old building and the construction of a bigger brand new one. Plus, due to personal reasons, the owner wanted a LEED-certified building and therefore the LEED reference standard was taken as a reference for the entire project. Like the Italian projects analyzed for the previous case-studies this project followed the so-called Design-Bid-Built procedure where the owner first publishes a design competition for the development of all design phases and then a separate bid for the building construction. The design competition was published asking for the development of the two final design stages which, in Spain, correspond to the "basico" and "ejecución" phases and was won by a local architectural firm. The firm declared the achievement of a LEED Gold standard for the project completion, in fact, within the documentation that designers have to prepare for the final "executive" phase they can insert the clauses and criteria for the construction development and, on the basis of the check-list calculations, such clauses would have guaranteed the achievement of the Gold certification level. However, from what seen afterwards, such requirements would have been obligatory anyway because all parameters imposed by the municipality of Barcelona and other local institutions were more demanding than the ones required by LEED.

Simultaneously the owner published a bid for all the LEED-related services which originally included: development of LEED-related documentation, management of the USGBC webpage, consulting services for shaping the design following the LEED requirements and commissioning service during the construction phase. However, during the bid the energy simulation was taken out of the bid because the architectural firm claimed the role of energy modeler as well. In this case the process followed to develop and carry out the energy modelling was much better than the ones implemented for the Italian projects at least from the integration point of view. Having the majority of technicians designing the building and the energy modeler in-house allowed the design firm to perform a quite sophisticated energy simulation. In fact, it was developed on several stages, adjusting the active and passive building solutions to the model's results throughout the whole design process. Again, this process was also made in order to comply with the local laws under which the design, approval and development of a geothermal energy source can be approved only after a preliminary energy simulation is run for the whole building consumption. It is not clear whether the design team conducted a multi-level simulation in order to optimize the energy and LEED scoring or only to fulfill the local laws but at the end the design process turned out to grow with the energy modelling. Even though, still one energy-simulation point was lost due to project-management-related issues. Like the RSA project in Italy, in this case the project was approved before the energy modeler could shape the simulation with all the real information and the lighting systems were modelled only afterward. This caused the loss of one point out of 19 for the energy simulation under the LEED EA 1 Credit. After the executive design was completed and the LEED-related services for the design phase were performed the public owner published the bid for the construction. At this point other subjects stepped into the project-development process which now started counting on four key-roles developed by five different subjects:

- Two directors of works, one for the structural/architectural and one for the mechanical part of the project;
- One project manager;
- On general contractor;
- One consulting firm for LEED consulting during construction phase and commissioning services.

At this point, according the information retrieved by subjects involved, the process started to desegregate due to two main factors:

- The increase of the number of subjects acting independently directly hired by the owner made the information flow more complex and problematic. On the other side, the increase of the number of subjects created some uncertainty related to each subject's tasks. In other words, not all tasks were sorted out and addressed properly and the information system to communicate was not clear;
- Except for the consulting firm all the other subjects did not have a clear idea of what LEED was nor how to implement it.

On top of this the project suffered a sensible increase of LEED-related requirements. In fact, the construction bid was won by a general contractor that declared the achievement of the highest LEED certification level, the platinum, through the implementation of the following strategies:

- Use of recycled materials or recycled-content materials;
- Use of regional materials;
- Use of rapidly-renewable materials;
- Restore the local habitat for the project site;
- Use of materials which comply with the VOC-related LEED requirements.

A total number of eight extra points were estimated on the basis of the general contractor's declarations which brought the expectations for the LEED certification on the lower platinum level. At the end some of them were not achieved like, for example, the ones related to habitat and recycled materials. The project was carried out facing several problems related to process desegregation, extra costs and delays in operations but finally the building was completed and achieved the LEED certification.

4.3.2 Why choosing this case-study project.

There are several reasons why researchers chose this project as a reference case-study for the scope of this research. Some of them were determined by limitations, like the ones occurred with the Italian project described above. The lack of available information, the accessibility of available information, the level of reliability of the sources and the time frame in which the process was developed are just some of the reasons that determined the choice of this project. However, the main concept for which this project was chosen as one of the case-study projects is because, from the researcher's point of view, it represents an ideal combination of integrated and non-integrated process. One of the main fields of the present research is the optimization of project management processes through the implementation of integrated procedures. So from one perspective the researcher’s goal is to identify what doesn’t work with the implementation of non-integrated process. On the other side, as we will see later in the next paragraph, it is important to highlight what does work for projects implementing integrated processes. This case-study, in spite of being based on the European Design-Bid-Built process, which as we already saw can be described as non-integrated, has several elements that make it similar to a Design-Build project. For example, the fact of having a design firm responsible for the whole design development and the energy modelling, the consulting company providing both LEED-related and commissioning services, the presence of a project manager coordinating the construction phase. These are the main elements on which researchers focused at the time of choosing the case-study project. In fact, from their perspective, these features could be assimilated as attempts to reach an integrated process in spite of having a process based on a non-integrated Design-Bid-Built procedure. The final goal for researcher is to demonstrate the impact of process integration on green-building project developments. In order to do that different types of procedure have to be analyzed, non-integrated, integrated and hybrid. This project represent, for the scope of the present research, a hybrid for process integration.

4.4 The office building project in Southern Spain.

This case-study refers to a new-construction office building developed in the South of Spain. Unfortunately, due to the confidential nature of all project-related information, researchers are not authorized to give any reference of any kind about the project. Therefore, I will describe the process with the highest possible number of details compatibly with their level of confidentiality. The project ownership belongs to a public entity operating at international level. Therefore, for the development of this building, it implemented a standardized process which is compatible with both European and Anglo-Saxon realities. The bid was developed following the so-called “integrated project” procedure or Design-Build process. In Europe the key-factor of this type of process is that the owner publishes one single bid for the development of both design and construction phases. In order to participate to this type bid each general contractors have to join forces with a design firm or, in case of big general contractor firms, possess an internal technical design department. The main characteristic of this type of bid that attracted researcher's attention is the similarity with the Anglo Saxon construction system. In fact, whether in the typical Design-Bid-Built process followed for the Italian projects the design firm develops all the levels of design including scheduling and take-offs, with the Design-Build process the final design stages, and in some cases also the earliest ones, are developed by the company that wins the bid. Whether this company is a single general contractor or a joint venture between GCs and design firms doesn't matter. The main idea is that within the European Design-Bid-Built process there is a clear separation between design and construction phases, also from the point of view of whom is performing the job. On the contrary, on a Design-Build process this gap is narrowed down because both design and construction services depend on one single private entity.

Within this type of procedure the owner identified and hired, already from the early preliminary stage, a project manager which could follow the development of both design and construction phases. Is important to highlight how this case-study is the only one in which the PM figure is brought in the process since the early stages. Another major difference between this and the previous case-studies is that this project was undergoing the BREEAM certification, from which descends the LEED reference standard. This element did not matter to the researchers because they considered the two protocols very similar and almost identical in terms of project-management organization. Moreover, having studied both reference standards and being aware of their implementation's procedure (see chapters 2.3.1 and 2.3.2 above) researchers considered the BREEAM protocol more demanding than the LEED one. Comparing each other's requirement, even for similar fields, the English protocol has much higher requests to be fulfilled with respect to the American one. This gap between the two was also considered during the result-analysis operations which are described below in chapter 5 of the present manuscript.

4.4.1 Brief project history.

The project was started to be developed between 2014 and 2015 with a double public bid. One related to building design and construction, the other one for project-management consulting tasks. A local general contractor won the first bid and a Spanish consulting company won the second one. The GC had already experience in international projects and hired two design firms for the development of the project design. One foreign design firm which was in charge of the concept design and a local design firm in charge of the project adaptation to local laws and the development of the as-built drawings. Is important to highlight that both design companies had experience in BREEAM and LEED buildings and that they were in charge of the energy modelling at once with the project-design development. The other company won the bid for the consulting services which included: project management, BREEAM-related services and commissioning authority. The company had a little experience in BREEAM projects but, being quite big, could count on a large pond of in-house professionals to solve all kinds of problems without external help.

Unlikely the case-study projects analyzed before, in this case the subjects involved in the process and directly hired by the owner were only two: the general contractor from which depended the design and construction; the consulting company from which depended all the other services and tasks. Therefore, a key-concept highlighted by researchers is the simplicity of this process organization caused by the low number of subjects involved.The whole project included the construction of two brand-new office buildings for a total project cost of 14 million Euros. Both buildings, opposed one to the other on the plans, have four floors, two above and two below the ground level for a total gross area of 14.000 square meters. The general contractors were given 35 days to develop the bid offer which included project design, construction and BREEAM certification. After the bid was assigned the designers hired by the general contractor had, by contractual clauses, 4 months to develop the two design stages named “basico” and “ejecución”. The total cost for the development of both design stages was 515.000 Euros which were divided between the two design firms. At that stage the BREEAM certification process was also assessed for the design stage and at that point the total score guaranteed was 73,25. It is important to notice how the whole BREEAM service package was included in the bid with the other consulting services and the whole bidding package was closed fixing the final BREEAM score that both GC and consulting companies had to guarantee.

However, after the construction had started the owner decided to go for the highest BREEAM certification level which included a change order in all three activities: design, construction and consulting services. In fact, from an original score of 73,25 the team agreed to achieve another 13 points bringing the certification scoring up to 86,41 point. By the end of the project the tam found out that another 4 point considered “not achievable” were then assigned by the certification institute and therefore the final BREEAM score turned out to be 90 instead of the 73,25 established at the beginning. This unforeseen modification brought substantial changed in some building design features, construction activities sharpening also the certification process. All parties involved worked together to come to a solution and finally the cost of the change order was 115.000 Euros. Out of this lump sum 50.000 Euros were spent for the technical-office tasks, such as design re-engineering and certification process adaptation, the other 65.000 Euros covered the growth of the new construction materials determined by the change order. The detailed information related to the BREEAM certification process for this project are reported in appendix 4.

No additional time was asked for the BREEAM-related change order and the project was completed on-time following the original construction schedule.

4.4.2 Why choosing this case-study project.

With this project researchers identified the reference case-study for which activities were developed within a European environment but following an integrated process. In spite of withstanding the local law, bureaucracy and public-owned processes the project was developed in similar way to the typical Anglo-Saxon design and construction process. From a quick initial overview researchers detected that for this projects the vast majority of parameters had been fulfilled in terms of schedule, costs and sustainability features. Therefore it was identified as reference project for the cross-case approach described in the methodology. Besides, this project had other features that made it appealable for the scope of the present research. The total project budget, for example, was similar to the ones of the other case-study projects. The time-frame in which it was developed was very close to the one used for the research development and therefore the researcher could have direct access to fresh information with the capability of verifying potential uncertainties and unclear information.

But again, as already described for the previous case-studies, one of the main reasons for choosing the present project was the availability of information. Several companies were contacted by the team of researchers but only a few of them accepted the conditions of sharing the real project information. Out of this small group of entities this was the only project developed using an integrated process as described above.

4.5 Chapter summary.

This chapter describes the case-study project implemented for the purpose of this work. Each case study is described from different points of view, from the practical project details to the project history down to the selection criteria implemented for each case. The whole chapter was developed as an appendix of both chapters 3 and 5 in order to support the methodology and the results with some practical information related to each project.

CHAPTER 5

Results

5.1 Introduction.

Results proceeding from the qualitative and quantitative analysis were identified under three different categories: dependent variables, independent variables, project outputs. Dependent variables identify the different categories of issues classified during the research process. Independent variables are referred to the parameters analyzed during the research: costs, time, sustainability. The project outcomes are the results of the correlation between independent and dependent variables.

5.2 Interviews.

Interviews we implemented, in the same way as formal and informal documentation, as a key-source of information for the purpose of the present research. Therefore is important to characterize how the interviews were developed, who participated and how information were collected and catalogued. As previously described in chapter 3, two different rounds of interviews were developed for each case study: one first qualitative interview followed by a quantitative estimate developed on the basis of the results previously obtained in the first round.

5.2.1. Categorization of interviewees.

For the purpose of this work researchers implemented different sources of information. Among them, interviews played a key-role for both qualitative and quantitative estimate of the important information. Therefore, in order to understand the source of the information is important to define who were the interviewees and the subjects involved in the present research. All interviews were addressed to subjects directly involved in the project; technicians, owners, professionals, public clerks, council members and others. Table 5.1 below summarizes the role of the interviewees consulted for each case-study.

Project / Subjects	School-complex project	Nursing-home project	Barcelona office project	Southern-Spain office project
Owner	X	X		
Owner's Employee	X	X	X	
Council Member	X			
Senior Architect	X	X		
Assistant Architect	X		X	X
Senior Mechanical Engineer	X	X		
Junior Mechanical Engineer		X	X	
Structural Engineer	X	X		
Project Manager				X
Assistant Project Manager				X
LEED AP	X	X	X	X
Commissioning Authority	X	X	X	
Energy Modeller	X		X	X
Owner's Consultant		X	X	X
General Contractor				X
Site Engineer				X

Table 5.1: summary of the interviewees categorization for each case-study project.

The process of qualitative interviews was developed for each of the subjects listed above. From the quantitative point of view interviews were used only as a supplement and integration of information retrieved from formal and informal documentation of each project. The process is described with more detail the following chapters however, for the purpose of this study is important to define the role of each interviewee.

- *Nursing-home project.*
  - Owner: Luigi Ferrari, CEO of Opera Romani, owner of the project;
  - Owner's employee: Renato Pedrotti, consultant of Opera Romani and responsible for the relationship with the Province of Trento (Trento – Italy);
  - Senior architect: Tassinari Silvano, chief architect of the firm Studio Othe (Ravenna – Italy) for the nursing-home project;
  - Senior mechanical engineer: Alessandro Coraccio, chief engineer of the firm Futura Technologies (Rome – Italy) for the nursing-home project;
  - Assistant mechanical engineer: Marco della Tommasina, mechanical engineer of the firm Hospital Consulting (Florence – Italy);
  - Structural engineer: Tommaso Tassi, structural engineer of the design firm Favero & Milan (Venice – Italy) in charge of the structural design of the nursing-home building;
  - LEED AP: Alessandro Orsi, LEED Accredited Professional for the Volano school project;
  - Commissioning authority: Giampaolo Perini, owner of the firm Technoprogetti (Brescia – Italy) and CxA for the Volano school project.
  - Energy modeler: Ryan Williams, employee of the firm Sinergy Consulting (Tennessee – USA) in charge of the energy-modelling of the project.

- *School-complex project.*
  - Owner: the mayor of the Municipality of Volano which had the formal ownership of the project;
  - Owner's employee: the vice-secretary of the Municipality of Volano;

- Council member: the vice-mayor of the Municipality which was also the council member for public construction projects;
- Senior architect: Alessandro Castelli, project chief of the Gruppo Marche design firm (Macerata – Italy) for the Volano school project;
- Assistant architect: Patrizia Cercone, assistant architect of the Gruppo Marche design firm;
- Senior mechanical engineer: Alessio Trapé, mechanical engineer of the Gruppo Marche design firm;
- Building/structural engineer: Michele Paccaloni, building engineer of the Gruppo Marche design firm;
- LEED AP: Alessandro Orsi, LEED Accredited Professional for the Volano school project;
- Commissioning authority: Giampaolo Perini, owner of the firm Technoprogetti (Brescia – Italy) and CxA for the Volano school project.
- Energy modeler: Alberto Lodi, senior engineer of the firm ICMQ (Milan – Italy) which was in charge of developing the energy model for the school project.

- *Office building in Barcelona.*
    - Owner: Eurostone Barcelona, private fund & investment company that owned the project;
    - Assistant architect: Jordi Serra, employee of Sumo-Architects (Barcelona – Spain) which developed the design for the office building project;
    - Junior mechanical engineer:
    - LEED AP: Héctor Martinez, employee of the company Exeleria (Madrid – Spain) in charge of the whole LEED-certification process;
    - Commissioning authority:
    - Energy modeler:

- Owner's consultant: Angel Teso, chief engineer of the company Exeleria (Madrid – Spain)

- *Office building in Southern Spain.*

Unfortunately, due to the confidentiality of the information related to this project researchers cannot publish the details of the interviewees in terms of reference, company names and specific roles. All researchers are allow to report hereby is that all interviewees proceeded from 3 different companies plus the owner's representative. The three companies involved were respectively the architectural firm, the project management firm and the general contractor, the owner was an international entity which had a representative subject working on-site and he was the target of researcher's interviews.

5.2.2. Qualitative interviews.

The development of qualitative interviews followed a preliminary work analyzing the documentation described in chapter 3 and the subsequent creation of a list of milestones which summarized, for each case study, all the principal steps of the process and arranged them into a time sequence. This process has already been described in chapter 3 and here below in table 5.2 is reported an example of how the scheme of milestones was developed.

DATE	**EVENT**
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009
10/2008	LEED taken as reference standard for school project
12/2008	Municipality deliberates 550,000 € for design project development
12/2008	Public bid for the development of project design

DATE	EVENT
10/2009	Design bid won by “Gruppo Marche”
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan.
…	…

Table 5.2: example of the list of milestones developed for the first step of the qualitative interview.

After completing the list of green-building-related tasks qualitative interviews were held with all different subjects involved. First, researchers explained to each interviewee the concept of “waste” following the Lean approach as described above and then asked interviewees only two questions that can be described as follows:

1. “Considering the definition of “waste” given through the Lean approach, do you recognize, within the following list, any process step that met any waste before, during or after its development?”.
2. “If yes, what were the issues that occurred and why?”.

From this third phase of the qualitative interview round researchers collected the information as qualitative description for each problematic milestone identified before. Table 5.3 below describes this phase for one specific milestone of the school-complex project.

BIDDING PROBLEMS **General Problem:** You can't impose a protocol that doesn't exist. If you try to certify the building under a certain protocol you have to consider that it may vary during the project so FIRST REGISTER IT then develop the project. **Detailed Problems:** - Too much democracy: too many meetings with everybody, changing opinions and delay in taking decisions. Interference of non-technical people with technicians. - Flood problem: owner not prepared to manage such solution. Problem of pulling decisions; everybody has to go and ask to the other party (Municipality → Province→ Water Protection Dept. → Province → Landscape Protection Dept. → Province → Back to Water Protection → etc.). No kick-off meetings → everybody goes alone by himself without a strategy. - Poor decision-making effort of the owner, again it's not a push system where the owner goes ahead of the problems but it's a pull system (LEAN), driven by deadlines which are also not respected by the Province. (Financing deadline of the Province of Trento was shifted ahead twice, 2 years in total). - Cultural diversity, guys of the Municipality were really laid-back (public employees) while Architect was extremely serious, almost rude but efficient → Frictions between the Secretary of the City and the Architect.

Table 5.3: example of the problem listing for one single milestone developed through the qualitative interview phase.

The qualitative outputs collected through the process described above were then analyzed from the project management perspective and categorized. Researchers focused on the causes of the issues identified above and tried to identify the practical tasks upon which issues depended. Table 5.4 below shows an example of how such results were categorized for each milestone identified above. This phase of the analysis focused on determining "what" happened for each project milestone and standardize the results into a normalized grid as shown in table 5.4 below. The identification and categorization of problems during this step generated the "categories of issues" (or dependent variables) cited in chapter 3 and described in detail below in this chapter.

Each of the steps described here and below were verified by subjects involved, as described in chapter 3 for the explanatory-building method the process was reiterated until all interviewees unanimously agreed upon the output of each step.

DATE	EVENT – PM ISSUES
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009 - ***Lack of Project Management*** Funding has a deadline but nobody has a scheduling program with activities required to get it.
10/2008	LEED taken as reference standard for school project by governmental agency. - ***Lack of knowledge*** *Public administration does not speak English and do not know how LEED works.*
12/2008	Municipality deliberates 550,000 € for design project development. - ***Lack of knowledge – lack of integration with LEED AP.*** *LEED Costs not included in the design bid.* *LEED-schedule not included in the deliberation.*
12/2008	Public bid for the development of project design. - ***Lack of knowledge:*** *The jury had no idea about green-building features.* *No reference to evaluate LEED offer for the project.*
10/2009	Design bid won by "Gruppo Marche".
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan. - ***Lack of Project Management and Integration:*** *Owner did not plan his activities so impossible to develop a decent schedule.* *Province Depts. do not respond to any deadline.* *Province Depts. do not talk to each other and communicate with the owner independently.*
…	…

Table 5.4: example of the list of events and related issues developed for the second step of the qualitative interview.

A key-aspect of the interview-development process was the categorization of problematic activities following the Lean approach. Whether the previous tasks-standardization phase focused on determining "what" happened through a normalized scheme, here researchers implement the Lean principles to determine "why" such issues happened (Yin, 2009). The process was developed in three steps:

- Identification of the project management issues: defining "what" happened for each project milestone.

- Identification of the types of Lean waste related to the causes of the different issues previously identified;
- Association of the project-management issues with the types of Lean waste.

The project management issues were identified following the process described above in this chapter by determining "what" happened for each milestone. The types of Lean waste were identified on the basis of the literature review with the method described in chapter 3. Seven types of Lean waste were considered for the purpose of this study: re-manufacturing; hidden problems; incorrect processing; no process flow; no stop to fix problems; visual control; workload not levelled.

The association between project-management issues and Lean wastes was developed as another step of the qualitative interviews with all subjects involved. For each case-study researchers developed a schematic table with project milestones and related project-management issues on the left and types of Lean wastes on the right. Interviewees were then asked to link ones to the others as shown in table 5.5 below.

DATE	EVENT – PM ISSUES	Lean WASTE
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009 - ***Lack of Project Management***	-
10/2008	LEED taken as reference standard for school project by governmental agency. - ***Lack of knowledge***	-
12/2008	Municipality deliberates 550,000 € for design project development. - ***Lack of knowledge*** - ***Lack of integration with LEED AP.***	-
12/2008	Public bid for the development of project design. - ***Lack of knowledge:***	No stop to fix problems Re-manufacturing
10/2009	Design bid won by "Gruppo Marche"	-

DATE	EVENT – PM ISSUES
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan. - ***Lack of Project Management.*** - ***Lack of integration.***

Lean WASTE
No process flow Hidden problems Workload not leveled

Table 5.5: table showing an example of the process implemented to related project-management issues with types of Lean waste.

At his point researchers were able to catalogue each project milestone in relationship with the presence of some kind of Lean waste as reported in table 5.6 below. This allowed researchers to interact with the independent variables of the project and implementing all the other information proceeding from documentation and quantitative interviews in order to analyze the whole process. In fact, most of the available information related to costs and schedule was related to project milestones and not to single activities. This operation performed as explained so far allowed researchers to equalize the magnitude of all problems having the milestones as a reference point for all scheduling, estimating, Lean, project management and sustainability issues.

DATE	EVENT	Lean "WASTE"
03/2008	Local Governmental Funding Agency approves funding of 9,761,153 € - Deadline 03/2009	N
10/2008	LEED taken as reference standard for school project	N
12/2008	Municipality deliberates 550,000 € for design project development	N
12/2008	Public bid for the development of project design	Y
10/2009	Design bid won by "Gruppo Marche"	N
11/2009	Formal request to modify the Flood-Danger Section on the Urban Development Plan.	Y
…	…	…

Table 5.6: identification of project milestones affected by Lean waste.

This step concluded the phase of qualitative interviews. Further interviews were implemented for quantitative estimate of the impact of the categories of issues (or dependent variables) on the project independent variables. However, for such information interviews were used for supporting and integrated the data retrieved from the formal and informal project documentation. This process is described in the following chapter.

5.3 Dependent variables.

Within the research process researchers focused on all activities and tasks which could be considered as issues for the development of the design process from a project management perspective. The recognition of all issues proceeded from the codification process defined in chapter 3 of the present manuscript applied to all activities and tasks which responded to the definition of "waste" following the Lean approach and already described in chapter 2. This was the result of an iterative process developed throughout the whole research, from the early pilot-case study until the last phases of the other case-studies. All activities recognized for each case-study development were firstly gathered together and then put through a coding process used for categorizing of large amounts of information that had been collected through interviews and document analysis (Yin – 2009). Also the parameters implemented for the identification of the issues, based on the application of the Lean approach, were determined through the same reiterative process described in chapter 3.

The purpose of this chapter is to describe the categories of issues identified by technicians throughout the research which became the dependent variables of the study following the process described in chapter 3:

A. Lack integration between technicians involved and green-building tasks;
B. Misunderstanding of the Commissioning Authority's tasks and process;
C. Lack of appropriate clauses in bid documentation;

D. Systematic cuts to budget due to change-orders and delays;

E. Misunderstanding of the energy modelling role and process;

5.3.1 Lack of integration between technicians and green-building tasks.

In many case-studies analyzed researchers detected that the project design team was formed by veteran technicians used to develop project separately following the typical project development process ruled by the local legislation, the architect for the architectural design, mechanical engineer for HVACs and so on. The whole design process had a poor level of integration and each professional would look at his only duties without paying much attention to the other ones. This was also caused by a lack of interdisciplinary knowledge of each technician which would not want to interact with the other one's field for two main reasons:

- *Unawareness and inexperience related to different technical sectors.*

as cited above, each technician would act like an independent party and connect with the other subjects involved only sporadically during comprehensive meetings and brain-storming sessions.

- *Avoidance of potential liability for something said or done in relationship to unknown fields.*

Being each subject focused in one very specific field, such as, nursing-home architecture, mechanical engineering and bureaucratic funding procedures they did not feel comfortable to propose modifications to each other's part of the project. On the other side, each subject appeared to be quite protective about their own knowledge, being quite reluctant to share their personal information with others and providing only the bottom-line results of every activity.

- *Lack of remuneration and legislative reference for integrated project delivery.*

The payment of each professional is ruled by national legislation which indicates, following a parametric approach, each professional's fee (D. Lgs. 50 – 2016; BOE - 2017). However, at least for the geographical regions analyzed in this study, no specific fee nor legislative binding supports the design process integration. The design process is defined by law and each professional has specific tasks to perform and to be paid for. However, such tasks do not expect integrated-project-delivery actions that may be required for processes that fall outside the normal bureaucratic procedure, such as, LEED and BREEAM buildings for example. Therefore, especially for Design-Bid-Build projects each technician tended to develop his own work without addressing the others not even for process integration purposes only. Whereas in the Anglo-Saxon environment, where green-building standards such as LEED and BREEAM were conceived, the law sets specific requirements for integrated project delivery like the 300-series of consensus document for Multi-Party Integrated Project Delivery (IPD) (Kenig et al. – 2010).

The introduction of sustainability through the LEED protocol imposed the integration of project tasks and duties within a process that, in some cases, was not integrated at all. This caused several problems between technicians because everyone had to participate in each other's portion of the project. This fact along with other misunderstandings generated frictions between subjects involved slowing down the whole design process and threatening the achievement of the LEED credits. Several potential LEED points were lost in this case due to missed achievement of the Credit related to internal light and views. Moneywise the process integration caused only indirect proceeding from extra meetings, travels, product re-manufacturing and project management tasks which varied from case to case.

5.3.2 Misunderstanding of Commissioning Authority's (CxA) tasks and process.

As already explained in chapter 2, the differences between European and the Anglo-Saxon design/construction processes are substantially different. One key-aspect of the European Design-Bid-Build process is the full development of all design features before the entrance of the general contractor. Therefore, some activities that within the Anglo-Saxon system are conceived and developed only during the construction stage, for the European system have to be prepared and addressed already during the design stage. In some of the case-studies analyzed for the purpose of this research, in spite of the suggestion of the LEED AP, the owner did not bring in the Commissioning Authority until the very last phases of the design. As a result the final design presented some lacks which had to be covered through change orders and project adaptations during the construction phase. The main reasons of the late enrollment of the commissioning authority are several and can be described as follow:

- In the nursing-home project, developed through the Design-Bid-Build process, the Commissioning Authority (CxA) did not start working on the project until the start of construction phase. Convinced of having a CxA but in reality having only a technician with experience in CxA, the project leader did not exposed the project to the analysis of a proper Commissioning Authority until the end of the design, where all shop drawings, estimates, bid specification and related documents were already approved and closed. From the LEED point of view this led to the loss of the Enhance Commissioning Authority credit which would have brought an additional point and, if done in advance with the right timing, would have been performed without any additional fees.
- For the case of the school project the design team involved the Commissioning Authority during the design-phase development but after taking some key-decisions related to mechanical equipment design. The CxA analyzed the design before having it approved by the owner and avoiding potential change orders during the construction phase. However, the gaps highlighted by the CxA in relationship with the mechanical design led to some re-manufacturing activities and project re-engineering tasks which were then developed by the design team before the final project approval.

Researchers believe that, for the European Design-Bid-Build system, since project estimate and related documentation are developed by designers and not by general contractors, in order to avoid change orders during the construction stage, CxA should always be hired during the early design phase. This did not happened for the projects in question and therefore the CxA could not insert in the documentation the proper clauses for the activities that would have to be performed during the construction stage and this caused extra costs due to change orders and project re-manufacturing activities. The impact of such change orders on later construction stage budget was estimated to be several ten-thousands Euros. On the other side, in cases when the CxA entered too late in the process, he had to develop tasks that were meant to be performed earlier in the process. For instance, the development of the documents “Owner’s Preliminary Requisite” (OPR) and “Basis Of Design” (BOD) according to the reference standard procedure (LEED – 2012) should be performed during the early design stage and not during construction. In some cases the Commissioning Authority had to develop such documents backwards taking the design details as basis of design because they had not been developed earlier. All of these issues and unforeseen events had a substantial costs on the project final development from both money, time and sustainability points of view. The quantification of these costs are described below in this chapter.

5.3.3 No appropriate clauses in bid documentation.

In some cases the first draft of the public bid for the design stage development was written with specific clauses to address the process and the potential issues arising from the development of green-building design. As already cited in the present manuscript, the Anglo-Saxon environment in which green-building standards, such as LEED and BREEAM, have been developed is different from the one in which they may be implemented, such as Italy and Spain. The need of developing integrated and interdisciplinary processes and decision-making tasks was already explained above and represent an example of such gaps that should be addressed with specific bid clauses before the beginning of the design stage. The lack or imprecision of clauses written within the bid documentation were related to different aspects of the design process. More specifically the can be summarized as follow:

- *No specific clauses for the production of the documents associated with the implementation of the green-building standard.*

For the nursing-home project, no specific clauses focused on imposing the winning design company to develop all LEED-related credit documentation for the design stage. However, after receiving a formal letter by the board of engineers claiming that LEED clauses should not be included in the bid the owner decided to withdraw all clauses written earlier on. The only clause left said that the design company had to develop a LEED building offering all services required for the achievement of such goal without citing the documentation. After bid opening the winning design firm claimed that the LEED-documentation clause was not in the original bid and therefore the owner had to pay additional 30.000 Euros for the development of the LEED documentation. In order to re-define and re-present the bid documentation the owner had to spent additional 5000 Euros in consulting services for lawyers and bureaucracy.

- *No specific clauses addressing the integration of activities and multidisciplinary tasks required for the development of several sustainability-related issues.*

In many cases researchers highlighted the lack of clauses and project activities addressing the project integration. For both the nursing-home project, the school complex and the office building in Barcelona the bid was developed as a European competition for design and construction. This attracted different project groups from all around the country and the design team ended up being composed by professionals from different cities which, for all the cases cited above, never worked together before. The most clear example is the nursing home project whose design team was composed by: the owner (Trento), architect (Ravenna), structural engineer (Venice), mechanical engineer (Rome), Assessor (Rome), LEED Consultant (Trento). None of these subjects had worked together before because the team was constituted on the basis of the bid requirements and there was none addressing the process integration issue. According to the interviews the problem, even if this is not object of the present research, was detected also during the construction stage of the projects and this highlights a systematic lack of care for integration procedures within the whole project development process. During the design phase this lack of integration was one of the main causes of indirect costs due to project re-manufacturing activities, resources spent for extra-meetings, travels and other unforeseen managing tasks.

- *No clauses addressing the project-management and green-building aspects of the design process.*

For the nursing-home and school projects developed through the Design-Bid-Build process the project-management tasks were not taken into proper consideration, especially if considered in relationship with the new procedures imposed by the implementation of the green-building reference standards. In fact, for each project there was a subject which could be identified as the project manager but it would be in charge of managing not the project activities but the project bureaucracy. The project-management goals were not the optimization of the project process and productivity but the correct sequencing of bureaucracy-related tasks in which time did not appear as a key-aspect to be considered. In fact, all bureaucratic-related activities had to be developed in collaboration with public-administration offices which, apparently, did not follow any schedule nor productivity-organization. A clear example related to both projects cited above is the authorization-document from the office for water-basins protection of the local Province. The approval of the same document for the exact same conditions (one project is adjacent to the other) took the team 3 months in the first instance, almost 18 in the second. Therefore the project manager selected for the development of these projects was in charge of optimizing a procedure in which time, considered otherwise a key-parameter, was not manageable. This happened also for the sustainability-related activities in which the project manager did not have experience. The sustainability part was supposed to be carried on by an external consultant which did not have to power nor the liability to manage the whole process and would always have to refer to the project manager or to the owner to change something in the project.

As a result, on one side the whole process became very fragmented having the project manager not addressing the sustainability-related problems properly, on the other side some key-aspects of the projects such as time were not addressed properly due to the lack of project management capability.

- *No reference to specific liability of each subject toward the achievement of the standard credits.*

For all the three projects developed through the Design-Bid-Build system but especially for the nursing-home project subjects involved were not assigned to specific liability toward the achievement of the final goal from the green-building standard perspective. In relationship with what mentioned above for the lack of clauses in the bid document, the projects suffered also the absence of specific clauses for the development of the sustainability-related part. From what comprehended by interviews, sustainability is perceived as a detached part of the project which has to be addressed by one single subject which was, for all the case studies analyzed, an external consultant entity. However, as already demonstrated in the literature review and remarked by this same research, the development of a green-building project requires an integrated development process in which all subjects involved have to work together toward a common goal. This means also that all subjects involved have to have some prior experience in green-building developments and actively participate in the process of finding and implementing the best solutions available. However, in these cases sustainability was almost entirely delegated to an external consultant which would tell everybody what to do too achieve a certain goal without having proposals coming from the other side. According to the Lean philosophy this condition is commonly called “Top-To-Bottom” in which unidirectional orders are being given from one subjects to many others without having constructing feedback on the other way around. Plus, none of the subjects involved would be willing to actively participating in the liability-sharing process and therefore the sustainability part would be developed by a subject that has only part of the expertise of the team. According to the data collected this led to a loss of sustainability points due to the lack of knowledge of the single subject toward the implementation of potential green-building technologies. No major costs nor delays were detected for this instance in particular.

5.3.4 Systematic cuts to budget due to change-orders and delays.

All projects developed through the Design-Bid-Build process suffered, during the design phase, some delays which were at least partially related to green-building issues. In two case-studies, the magnitude of the delays was so great that it ended up affecting heavily not only the project completion schedule but the project itself. For example, the whole design phase of the school project took more than 5 years. During a period of time of such magnitude several things can happen in relationship with the project environment. The main one detected by researchers were:

- *Systematic upgrade of the construction prices database.*

Within the Design-Bid-Build process the design phase is divided in different stages, each of which has to be developed and approved through several procedures. The project design includes also all project estimate and take-off calculation related to materials, labor, equipment and expenses for the completion of the final building, including all correlated consulting services. The idea is to develop a building with a total overall cost lower than the original project budget for each design stage. However, the estimate have to be performed on the basis of the most recent database available which changes on a yearly basis. For these projects the delays were so big that different design phases were developed using different databases. In current economic realities like the European countries, prices of materials increase from year to year due to inflation rate on the products, cost of services increase due to new laws and requirements that rise the cost of some activity and globally the cost of the same building increases as the time goes by. However, the budget for the building development is fixed and this created a continuously increasing gap that can be filled only by cutting some of the building features.

- *Change orders imposed by new laws affecting one or more project features.*

In all countries where case studies were located the development of buildings is ruled by codes and standards which are upgraded on a constant basis. In some case the standard upgrade can involve some project feature that has to be modified prior to the final design approval. Generally such force-majeure events are planned and estimated during the design however, if the delay of the design approval becomes too big eventually the money allocated for the force-majeure events will run out and the design team will have to cut some project features in order to fulfill the original budget requirements.

- *Design change orders chosen by the owner.*

In some cases the design modification were imposed by the owner or by the entities funding the project. With delays of such magnitude between the early design phase and the final design approval new technologies appeared in the market offering the design team multiple options to improve the building performance, especially from the mechanical and energetic points of view. One clear example is represented by the mechanical system of the nursing home project which was designed at first with one co-generating boiler running on pellets and then during the final design stage the owner decided to switch it with a gas co-generator. The reasons why the owner decided to switch from one energy source to another are multiple: the availability of a new gas co-generator with increased efficiency; the interruption of a local public funding for all new installations running on pellets; the lack of renewable resources available in terms of pellets because of the growth of the demand with a stable offer. The choice of a new energy source had a great impact on mechanical installation and, as a result, on the sustainability-related performance of the building. The additional costs and delays arisen from this types of change orders were not considered by researchers for the purpose of the present research. However, they did consider the impact on the sustainability-related aspects of the project, such as, energy performance, use of renewable resources and regional materials.

The three circumstances described above led each design phase to run systematically over budget. Therefore, having the budget fixed and imposed by force-major entities, the only way to re-enter in the budget was to cut on mechanical equipment and sustainability-related issues. In fact, the different approvals collected for all the design stages are mainly related to architectural and safety features. The different commissions evaluating the legitimacy of the project design look at all dimensions, fireproofing systems, exit paths, landscape features but at very few mechanical requirements and almost none sustainability parameters. As a result, in some cases the design team had to but some building features in order to meet the budget requirements without touching all the features that had already been approved. Therefore, the design team had to cut on the sustainability-related features and on the mechanical equipment which is highly related to sustainability itself. This caused a loss of several points under the reference standard point of view.

The more the design advances the more the costs of material, labor and equipment increases and consequently the shorter the budget becomes. As a result, at each design step the project team had to apply cuts and re-define the original design which affected also the green-building points of the project. Four LEED points were lost in this case, each of them related to the following credits: water use reduction, water & energy metering, outdoor air monitoring, controllability of systems. A total sum of 9.400 Euros between direct and indirect costs were borne to re-define the project design between architectural, mechanical and management subjects.

5.3.5 Misunderstanding of the energy modelling role and process.

As for the case of the Commissioning Authority, for the development of some projects technicians involved in the process did not quite understand the role and the development process of the energy modelling until the final design phases of the project. For all projects developed through the Design-Bid-Build process the energy modelling wasn't taken into consideration until the final design stages of the project. More specifically, for the school and nursing home projects no references to the energy modelling were put in the initial bid clauses due to a decision of the owner so nobody was formally appointed as Energy Modeler at the moment of signing the contract. In both cases, mechanical engineers took over the task during the design phase after the LEED AP brought the problem to the attention of the team but they did not have experience in developing energy modeling for LEED. The energy model started to be developed toward the end of the final design stage and rapidly technicians realized they were not able to do it. An external professional energy modeler was then contracted by the engineering firm for a substantial amount of money which were then considered by researchers as indirect costs added to the project for the purpose of this study. However, by the time the simulation was ready the final design had already been approved along with the last project estimate and the construction bid had already been published. Therefore, at that point even if needed the design team did not have margin to modify any feature of the project. At last, energy simulation did not match the expected results but no changes could be made since the project had already been approved and bid out to the construction firm. The energy modeling problem, apart from generating extra costs for both projects during the design process, avoided the achievement of numerous points under the EA Credit 1 – Optimize Energy Performance. In fact, technicians identified several possible improvements in order to optimize the building energy performance and obtaining all the energy LEED credits but in both cases it was too late to implement them in practice.

Other types of problems always related to energy-modelling performance were faced by the design team while developing the office building in Barcelona. In this case however, the energy issue was addressed early on during the design stage but only by the consulting firm that, as already explained above, was considered as the only responsible party for all sustainability-related activities. The other subjects involved did not understand the importance of the issue until the last phases of the design and therefore the problem was not fully addressed by all subjects involved. The consulting firm in-charge of the green-building certification notified in multiple occasions the actions that needed to be taken in order to avoid the problem to both architectural and mechanical professionals but without having a good response. As a result, some major energy-modelling enhancing activities were developed but not all points were addressed correctly. More specifically, the energy modelling was developed in two steps, one preliminary energy model to address the macroscopic factors affecting the building energy performance and a second model to simulate the exact conditions under which the building would run. This multiple-step approach avoided major surprises during the later design phases in which, as already described in the literature review, change orders and modifications have a much higher cost in comparison with the early design phases. This point is also confirmed by the data collected from the other project in southern Spain, developed through the Design-Build process. In this case the project did not suffer any major problem related to costs, time and money and, according to the interviewees, from the energy modelling perspective the key-factor was the development of a multi-step model in which technicians could reflect the performance of the building and apply rectifications if needed. However, for the case of the office building in Barcelona, the energy-modelling process was divided only in two steps and not all the recommendations were put in place afterwards due to lack of money and discrepancies between the opinions of the subjects involved. Actions suggested by technicians would not be always taken into consideration by the owner and by the architect. As a result, to sustainability-related points were lost for this project due to problems related with energy-modelling.

5.4 Lean project wastes.

In the previous chapter researchers described the project independent variables or, as explained in the methodology, the problem categories resulting from several project issue occurred during the design-phase development. Such issue were prior identified through a well-defined methodology, the Lean approach, which allowed researchers to highlight all the activities, events and occurrences that caused the so-called project wastes. Drawing fully from the Lean literature researchers already highlighted the concepts of “waste” from the Lean perspective. However, for the purpose of this study, each activity generating some kind of waste had to be conjugated with the Lean principles referred to this waste production. Therefore researchers identified seven types of project waste in relationship with the definition of the Lean approach. These nine project wastes summarize in a schematic way all the activities and events described in the previous chapter which led to the creation of some kind of issue categories or, as defined above, dependent variables. The project wastes identified for the purpose of this research are described below:

- Re-manufacturing tasks for bid re-formulation.

Within the project-development processes researchers identified several issues in relationship with the production of the bidding documentation. Such issues can be conjugated as different expressions of the same type of waste. With the term “re-manufacturing” researchers identify all tasks and events implying a repetition or reiteration of activities, processes or part of them with no added value to the final product. For the case of the bidding documentation this definition includes all documents produced in multiple version after the approval of each final draft. For the scope of this study, researchers did not consider the normal process of developing a formal document which requires a certain number of drafts and adjustments but only the extra work required to re-develop a formal document that was already been approved.

- Hidden problems in the process: development of LEED and BREEAM documentation.

Also for the development of the green-building-standard documentation researchers identified several Lean-related wastes. In the majority of the cases they were caused by an unclear process developed through a non-integrated systems where problem would be shifted ahead and could not be seen and solved rapidly. For example, the development of the bidding documentation was managed by a singular subject who did not share all relevant information with the other parties involved. This led to a bidding document that lacked of clauses in relationship with the production of the LEED documentation but this problem came to the surface almost one year later during the project design phase. In other cases the same process led to the development of a bidding document not addressing all clauses related to BREEAM documentation and this had to be rectified later on during the process.

- <u>Incorrect processing: change orders in design and construction phases.</u>

In relationship with the CxA, the incorrect process followed during the design phase led to change orders during construction. The late integration of the CxA in the design process did not allow him to properly review the documentation and add the required features in the budget for the building construction. Such features were needed by the CxA in order to perform his job during the later construction stage and the fact of not having considered them into the design led to change orders during the construction stage. For example, some sensors required by the CxA in order to measure different parameters of the air-conditioning system were not included in the design, as well as, the related wiring works. They were added only later during the construction phase with a sensible increment of costs due to change order procedures. This misleading process organization affected other sustainability-related elements, such as water tanks, choice of optimum materials and development of the so-called M&V plan (Measurements and Verifications).

- <u>No continuous process flow: role of the CxA and development of the OPR and BOD.</u>

The lack of process planning and organization caused several problems and wastes during both design and construction phases. More specifically, for specialized services such as, the commissioning authority (CxA), the lack of knowledge of subjects involved led to a misinterpretation of the project scheduling and, as a result, to change orders and re-arrangements afterwards. For example, for the case of CxA, in spite of the multiple instructions given by the LEED AP, the owner did not give instructions for the development of documents “Basis Of Design” and “Owner’s Preliminary Requirements” until the late design phase which was when the CxA entered in the process. In theory, such documents should serve as a baseline for technicians to develop the building design in accordance with the owner's will. However, since they were developed only during the late design stage when the vast majority of building features were already established, the CxA had to go backward and help the owner developing such documents the other way around. Therefore it was not the owner telling the designers what to do but the designers telling the owner what it had to be. In fact, by then the final design stage had already been approved along with the project budget and therefore no major changes to the project were allowed anymore. In this case the process logic was flipped upside-down and this affected several activities during both design and construction stages.

- No stop to fix problems at first round: extra personnel costs.

In several cases the problems identified during the process were not properly addressed by the team. In more than one case designers tried to develop the model one first time, they identified some discrepancies early in the process but did not stop to fix them and so such discrepancies became later problems to be solved. For example, the energy modelling procedure suffered this problem in two different case-studies. In both instances the architect thought to be able to develop the model and meet the protocol requirement however, after one first layout of the simulation they saw that there were some problem interfacing their software with the ones allowed by the green-building protocol. Then, instead of highlighting the problem and look for a solution with the other subjects they left the problem laying on one side pulling it out only during the late design phase. This made the initial inconvenient become an urgent problem which had a sensible cost in terms of money, time and sustainability. In fact, a specialist energy modeler had to be hired, the energy model was developed with delay aside from the design with no integration with the other fields.

- Re-manufacturing during project design and use of visual control.

Results showed that all case-study projects developed through the Design-Bid-Build system were subject to re-manufacturing during the different design phases. Even if in some cases this was caused by force majeure events like, as explained above, the modification of a building law or requirement, the lack of a correct project management procedure contributed to enlarge the problem also for the sustainability-related tasks. According to information retrieved from case studies, the main cause of project re-manufacturing is the fragmentation of the process implemented. This concept, already cited and clarified earlier in the manuscript, has to be seen here as a broader notion which includes lack of both spatial and temporal integration.

Spatial integration has already been defined in the previous chapter and is related to the physical location of all subjects involved in the process. For instance, the nursing home project in Trento was developed by the architect located in Ravenna, the structural engineer in Venice and the mechanical engineer in Rome. In this case the lack of a continuous physical connection led the team to meet and share information only sporadically having each subject working on his own without knowing in detail what the other ones were doing. For the case of the nursing home for example, the team would meet once a month or every two months depending on the design phase. Between each meeting few communication would happen between the different subjects involved and by the time the team had the next meeting some of the work developed by one subject would interfere with the one of somebody else generating re-manufacturing issues. This problem is strongly related to the lack of implementation of another Lean principle: the culture of stopping to fix problems in order to get quality right the first time (Liker – 2004). However, as found out by researchers, for the majority of the cases was more the lack of knowledge about when to stop rather than the lack of willing to stop. In other words, professionals would not stop only because each of them was thinking that what they were doing were right and therefore the main issue remains the lack of spatial integration rather than the lack of culture of stopping and ask.

Temporal fragmentation is related to the fact that the design process as to be developed, discussed and approved through different phases in which the same elements can be subject to modifications. For example, as explained in chapter 2 of the manuscript in Italy within the Design-Bid-Build process the design is divided in three steps. The first step is related to broad architectural concepts, shapes and parametric estimate. The second step requires a substantial definition of all architectural details, a broad definition of mechanical equipment and structures and a detailed take-off estimate. The last step involves all the details of the building, structure, mechanical and estimates of each piece of the building. However, according to the information collected, the features defined in the first steps can be still changed during the last one and, as described above in chapter 5.2.4, systematic change orders are made due to projects cuts in order to stay in the budget. Therefore, some aspects of the projects can be re-defined up to three times after they are approved. This generated a great amount of re-manufacturing issues which are also related to green-building features.

- Workload not levelled.

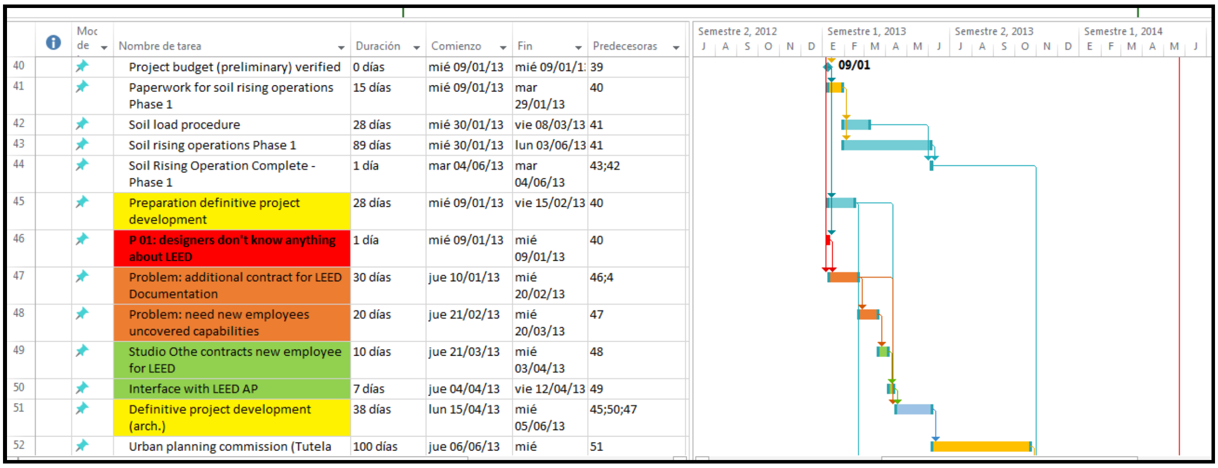
The last type of waste identified by researchers through the Lean approach was the lack of levelled workload. According to the information collected this issue did not have major impact on the different processes but it was constantly present in all projects developed through the Design-Bid-Build. The main cause of this work-levelling problem was, according to the results, the lack of a tight and firm planning procedure for the different design phases. The projects that suffered the most for this instance were the school complex and the nursing home which also account for the major number of delays. According to interviewees the two concepts are related to each other because the delays imposed to one project by external reasons, like the force-majeure events, negatively impact the productivity of the other subjects involved in the process which are not directly responsible for the delay. From the perspective of professional and design firms involved, having a precise schedule benefits them because they know that a certain job has to be done and that the payment for that job will come as planned. However, if the deadline are heavily shifted ahead like for the case of the school complex with the permit granted by the dept. of Water Basins Protection Agency, professionals and design firms leave the work aside and start working on other projects. In some case studies this led to a desegregation of the original scheduling and by the time the permit was granted each subject had to start over again sub estimating the effort and having then workload problems.

5.5 Independent variables

As already cited above, for the purpose of this research the independent variables were divided into three groups respectively related to three types of waste: time, money and sustainability points. In fact, according to the Lean & Green program (2013), the construction industry and especially project management technicians tend to focus on costs and time scheduling for the purpose of a project delivery. However, in case of green-building developments we should consider sustainability as a key concept that has to be considered equally to money and time.

5.5.1 Time.

Total amount of time lost due to sustainability-related problems cited above were estimated on the basis of the bar-chart results developed through a software. In this case the software implemented was Microsoft Project. Within the bar chart, sustainability-related problem previously identified by researchers were accounted as normal activities with predecessors and successors and their duration was estimated on the basis of the data previously collected through project documentation and interviews. Different colors were used to classify normal activities, sustainability-related activities, sustainability-related problem activities and project-management-related activities. Not all project activities were taken into consideration for the purpose of the present research, the bar chart represents only sustainability-related activities and project milestones. The critical path was then calculated on the basis of the scheduling and project-management concepts (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 project delay. The duration of all sustainability-related problems of the whole project bar chart were accounted for the total loss of time. Results of this double accountant operation are listed on table 5.1 below which represents on the X axis the type of problem and on the Y axis the results obtained: total project delay and total loss of time.



		Moc de	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
40			Project budget (preliminary) verified	0 días	mié 09/01/13	mié 09/01/1:	39
41			Paperwork for soil rising operations Phase 1	15 días	mié 09/01/13	mar 29/01/13	40
42			Soil load procedure	28 días	mié 30/01/13	vie 08/03/13	41
43			Soil rising operations Phase 1	89 días	mié 30/01/13	lun 03/06/13	41
44			Soil Rising Operation Complete - Phase 1	1 día	mar 04/06/13	mar 04/06/13	43;42
45			Preparation definitive project development	28 días	mié 09/01/13	vie 15/02/13	40
46			P 01: designers don't know anything about LEED	1 día	mié 09/01/13	mié 09/01/13	40
47			Problem: additional contract for LEED Documentation	30 días	jue 10/01/13	mié 20/02/13	46;4
48			Problem: need new employees uncovered capabilities	20 días	jue 21/02/13	mié 20/03/13	47
49			Studio Othe contracts new employee for LEED	10 días	jue 21/03/13	mié 03/04/13	48
50			Interface with LEED AP	7 días	jue 04/04/13	vie 12/04/13	49
51			Definitive project development (arch.)	38 días	lun 15/04/13	mié 05/06/13	45;50;47
52			Urban planning commission (Tutela	100 días	jue 06/06/13	mié	51

Figure 5.1: snapshot of the project Gantt diagram showing problems (red), problem-related activities (orange), sustainability-related activities (green) and project-management-related activities (yellow).

5.5.2 Costs.

Cost-related analysis was developed as described above in chapter 3 of the present manuscript. However, for the purpose of the study, researchers divided the costs in two different categories: direct costs and indirect costs. With the term "direct costs" researchers identified all expenses, caused by the sustainability-related problems cited above, that the owner had to bear in addition to the original project budget in order to complete the design process. With the term "indirect costs" researchers identified two types of expenses:

- All additional costs caused by the sustainability-related problems cited above that technicians involved in the project had to bear with no additional compensation to their professional fee, in order to develop the originally expected product.
- All additional costs caused by the effects of the sustainability-related problems which affected third parties and later project development phases.

This division of the types of costs in two main categories was caused by the coding process described in chapter 3. Data resulting from different sources, such as, interviews, documentation and others, had to be codified in order to have a structured system to manage (Miles & Huberman – 1994).

Direct costs resulted from the linear sum of all numbers highlighted as direct costs by each subject involved through evidence of interviews and/or formal documentation.

On the other side, indirect costs were extrapolated from all kinds of documents available as well as interviews. However, the estimate process for determining the indirect cost of the different project-management issues was not linear. Indirect costs turned out to be not easy to detect mainly because their recognition depended mainly on the outputs provided by interviewees who often could not indicate the existence of an issue. Researchers exposed all interviewees to the Lean concepts of waste and the other notions described in chapter 2 of the present manuscript. However, in this case more than the one related to direct costs, they had to implement the reiterative process related to cross-case analysis (GAO – 1990) in a much higher level. Discrepancies between acquired information and cross-case analysis of other case-studies often led to revisions of initial interpretations. The reiteration procedure was repeated for each variable on every case-study project because each new case study highlighted new aspects of the same category of issue increasing the impact of such variable on the total amount of indirect costs. Finally, after analyzing all four case-studies and re-reviewing multiple times the process implemented for cost calculation researchers verified that no substantial change would have risen by other sets of reiterations and the process was stopped. However, from the overall research point of view, this fact indicates the potential field for new studies in the future. In fact, researchers think that in this case the estimate of indirect costs was interrupted by lack of further evidence but, this may be caused only by the lack of consciousness of subjects involved. Other aspects of the indirect costs not considered in this instance may be highlighted in further research analyzing a larger number of cases in which subjects involved have the perception of what the term “waste” means from the Lean perspective.

At the end of the cost-calculation procedure researchers gathered together the results in two different tables for each case-study; one related to direct costs and the other related to indirect costs. On each table the horizontal axis summarizes the dependent variables or, as explained above, each problem category; the vertical axis describes the problem-related activities. Finally, for each interaction between the X and Y elements, researchers listed the numbers representing the cost in Euros that each specific activity had in order to solve each specific problem.

All costs were documented either through interviews or project documentation and were summarized in two tables, one for the direct costs and one for the indirect costs. The table reports the research outputs, in this case in Euros, as a function of dependent variables (on the horizontal axis) and Lean wastes (on the vertical axis).

COST ANALYSIS (Direct Costs)						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)	€	€	€	€	€	
Hidden problems (E.g. LEED/BREEAM Docs)	€	€	€	€	€	
Incorrect processing (E.g. Change orders)	€	€	€	€	€	
No process flow (E.g. CxA,OPR & BOD)	€	€	€	€	€	
No stop to fix problems (E.g. Extra personnel)	€	€	€	€	€	
Visual control (E.g. Project re-manufacturing)	€	€	€	€	€	
Workload not levelled	€	€	€	€	€	
Total	...	...	...	...	...	...
COST ANALYSIS (Indirect Costs)						
Visual control (E.g. Project re-manufacturing)	€	€	€	€	€	
No stop to fix problems (E.g. Extra personnel)	€	€	€	€	€	
Workload not levelled	€	€	€	€	€	
Total	...	...	...	...	...	...

Table 5.7: table summarizing the direct and indirect costs generated by all problem categories.

5.5.3 Sustainability.

Results for sustainability-related points were estimated on the basis of the LEED and BREEAM protocol. Taking the whole possible score identified at the beginning of the project as a reference, researchers focused on all LEED and BREEAM points that finally could not be achieved due to project management issues related with sustainability (which are included in the problem category list cited above). Before starting the design stage the project team estimated a possible score filling up a preliminary checklist including design and construction stage. During the design stage the project team realized that not all credits could be fulfilled, some of them due to the proper project features, others due to project-management related issues. It is important to highlight that not all the points were taken into consideration but only the ones which were potentially from the beginning of the design phase. In theory, following Horman's idea (2006) of having sustainability as a key-objective for the design development researchers should have considered all LEED and BREEAM credits. However, the some of them would not be feasible due to project physiological features. For example, the re-use of the building structure for building the new one was not even considered because not possible. Therefore researchers picked as reference only the number of credits considered achievable from the beginning by the design team. This process was developed as such following the philosophy of the LEED and BREEAM reference standards. For each of its chapters in fact, each protocol provides a relative definition of sustainability which measure the difference between the so-called baseline-case and design-case (LEED BD+C – 2012; BREEAM - 2012). Therefore the definition of sustainability through this protocol is not absolute and unconditional but is calculated from a differential between what the building performances could be and what the performances really are.

Further details about time, costs and sustainability-related calculations were already describer in chapter 3 of the present manuscript.

5.6 Research outputs.

This chapter summarizes all the practical outputs obtained from the research project described above. All information collected, interviews, calculations and data analysis conveyed to different sets of numbers that represents the research results proceeding from the interaction between dependent and independent variables. For each case study, the dependent variables were calculated in relationship with the independent ones having different sets of results for each independent variable of each case-study. The representation of each set of results considers also the impact of all types of Lean waste described above on the total output describing each independent variable.

In other words, for each case study researchers developed three sets of results, or tables, one for each independent variable considered: time, cost, sustainability. In each table the unit of measurement related to the independent variable is expressed in function of the dependent variables and the types of Lean wastes that had an impact on that case-study project. The final output is expressed with three numbers for each case-study, each number is related to one of the independent variables.

For the scope of this research, the definition of the independent variable "costs" was divided in direct and indirect costs as already described above in chapter 3. Therefore, also the table of outputs related with that variable was split in two parts.

5.6.1. Case-study 1: the nursing-home complex.

The tables shown here below summarize the research output for each case-study divided in three categories. Each category is referred to one of the three independent variables already described above: cost, time, sustainability.

Table 5.8 below summarize the research outputs for the cost-related analysis in relationship with the nursing-home project. The first table, as explained in the previous paragraph, is divided in two sections, one for direct costs and the other for indirect costs.

PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
COST ANALYSIS (Direct Costs)						
Re-manufacturing (E.g. Bid & early stage)			5000			
Hidden problems (E.g. LEED/BREEAM Docs)			30000			
Incorrect processing (E.g. Change orders)		30000				
No process flow (E.g. CxA, OPR & BOD)		8000				
No stop to fix problems (E.g. Extra personnel)						
Visual control (E.g. Project re-manufacturing)				5000		
TOTAL	0	38000	35000	5000	0	**78000**
COST ANALYSIS (Indirect Costs)						
Visual control (E.g. Project re-manufacturing)	3230			3400		
No stop to fix problems (E.g. Extra personnel)			1200		10000	
Workload not levelled	2500	500	500	1000	500	
TOTAL	5730	500	1700	4400	10500	**22830**

Table 5.8: results proceeding from the analysis of project costs divided in direct and indirect costs values of the nursing-home project.

The total extra costs, direct and indirect, for the case of the nursing home project was 100.830 Euros. The total budget originally approved for the development of the design phase was 275.572 Euros respectively divided in: definitive design (112.884 €); executive design (115.910 €); safety project design (46.777 €). As a result, the total amount of sustainability-related extra costs proceeding for the development of the design phase was the 36,6 % of the total costs for the design development. Table 5.9 below summarizes the time-related variance detected for the school project case.

TIME ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)			18			18
Hidden problems (E.g. LEED/BREEAM Docs)	16			8	7	31
Incorrect processing (E.g. Change orders)		7		21		28
No process flow (E.g. CxA, OPR & BOD)		16				16
No stop to fix problems (E.g. Extra personnel)	5	14			30	49
Visual control (E.g. Project re-manufacturing)	12			11		23
Workload not levelled	4	2			4	10
TOTAL	37	39	18	40	41	**175**

Table 5.9: results proceeding from the analysis of project-related delays for the design-development period.

The table above shows the total amount of delays caused by sustainability-related activities during the design-development period of the process. A total of 175 days were lost for the development of such activities considering the activity floats as defined in the literature review. The main cause of delays in this case was determined by severe change orders and project modifications which influenced also the sustainability features. The most important one was the modification of the main power unit, firstly considered as a biomass co-generating boiler and then replaced with a gas co-generating boiler.

Originally the design phase had to be developed in 600 days and the 175-days delay meant a time variance of 29,2 %.

Table 5.10 below summarizes the results for the sustainability-related issues detected during the design process and the related reference-standard points lost. In this case, being the reference standard the LEED protocol, 14 points were lost on a total potential score of 86 as estimated during the early project stage in November 2013.

SUSTAINABILITY ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)						0
Hidden problems (E.g. LEED/BREEAM Docs)						0
Incorrect processing (E.g. Change orders)	1			2	3	6
No process flow (E.g. CxA, OPR & BOD)		1				1
No stop to fix problems (E.g. Extra personnel)				1	4	5
Visual control (E.g. Project re-manufacturing)	1			1		2
Workload not levelled						0
TOTAL	2	1	0	4	7	14

Table 5.10: results proceeding from the analysis of project-related delays for the design-development period.

Tables 5.11-A and 5.11-B below reports the original LEED project checklist summarizing the score initially estimated by researchers for the whole project certification on the basis of which the team calculated the sustainability-related variance.

LEEDS 2009 for Healthcare:

New Construction and Major Renovations

NUOVA RSA OPERA ROMANI - Project Checklist

Date: 18th November 2013

Construction Stage Credits

Design Stage Credits

Y	?	N			
16	0	2	**Sustainable Sites**	Possible Points:	**18**
C			Prereq 1	Construction Activity Pollution Prevention	
Y			Prereq 2	Environmental Site Assessment	
1			Credit 1	Site Selection	1
1			Credit 2	Development Density and Community Connectivity	1
		1	Credit 3	Brownfield Redevelopment	1
3			Credit 4.1	Alternative Transportation—Public Transportation Access	3
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Room	1
1			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vel	1
1			Credit 4.4	Alternative Transportation—Parking Capacity	1
1			Credit 5.1	Site Development—Protect or Restore Habitat	1
		1	Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
1			Credit 8	Light Pollution Reduction	1
1			Credit 9.1	Connection to the Natural World—Places of Respite	1
1			Credit 9.2	Connection to the Natural World—Direct Exterior Access for Patie	1
5	1	3	**Water Efficiency**	Possible Points:	**9**
Y			Prereq 1	Water Use Reduction—20% Reduction	
Y			Prereq 2	Minimize Potable Water Use for Medical Equipment Cooling	
1			Credit 1	Water Efficient Landscaping—No Potable Water Use or No Irrig	1
2			Credit 2	Water Use Reduction: Measurement & Verification	1 to 2
1	1	1	Credit 3	Water Use Reduction	1 to 3
		1	Credit 4.1	Water Use Reduction—Building Equipment	1
1			Credit 4.2	Water Use Reduction—Cooling Towers	1
		1	Credit 4.3	Water Use Reduction— Food Waste Systems	1
23	8	8	**Energy and Atmosphere**	Possible Points:	**39**
C			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
15	5	4	Credit 1	Optimize Energy Performance	1 to 24
4	2	2	Credit 2	On-Site Renewable Energy	1 to 8
		2	Credit 3	Enhanced Commissioning	1 to 2
1			Credit 4	Enhanced Refrigerant Management	1
1	1		Credit 5	Measurement and Verification	2
1			Credit 6	Green Power	1
1			Credit 7	Community Contaminant Prevention—Airborne Releases	1

Table 5.11-A: snapshot of the first half of the LEED checklist implemented for the nursing-home project.

Y	?	N			
6	1	9	**Materials and Resources**	**Possible Points:**	**16**
Y	?	N			
Y			Prereq 1	Storage and Collection of Recyclables	
Y			Prereq 2	PBT Source Reduction—Mercury	
		3	Credit 11	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 12	Building Reuse—Maintain Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
2		2	Credit 3	Sustainably Sourced Materials and Products	1 to 4
1	0		Credit 4.1	PBT Source Reduction—Mercury in Lamps	1
	1	1	Credit 4.2	PBT Source Reduction—Lead, Cadmium, and Copper	2
		2	Credit 5	Furniture and Medical Furnishings	1 to 2
1			Credit 6	Resource Use—Design for Flexibility	1
14	3	1	**Indoor Environmental Quality**	**Possible Points:**	**18**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
C			Prereq 3	Hazardous Material Removal or Encapsulation	
1			Credit 1	Outdoor Air Delivery Monitoring	1
1		1	Credit 2	Acoustic Environment	1 to 2
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
2	2		Credit 4	Low-Emitting Materials	1 to 4
1			Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7	Thermal Comfort—Design and Verification	1
2			Credit 8.1	Daylight and Views—Daylight	2
2	1		Credit 8.2	Daylight and Views—Views	1 to 3
2	4	0	**Innovation in Design**	**Possible Points:**	**6**
Y			Prereq 1	Integrated Project Planning and Design	
	1		Credit 11	Innovation in Design: Specific Title	1
	1		Credit 12	Innovation in Design: Specific Title	1
	1		Credit 13	Innovation in Design: Specific Title	1
	1		Credit 14	Innovation in Design: Specific Title	1
1			Credit 2	LEED Accredited Professional	1
1			Credit 3	Integrated Project Planning and Design	1
2	1	1	**Regional Priority Credits**	**Possible Points:**	**4**
1			Credit 11	Regional Priority: Specific Credit	1
1			Credit 12	Regional Priority: Specific Credit	1
		1	Credit 13	Regional Priority: Specific Credit	1
	1		Credit 14	Regional Priority: Specific Credit	1
68	18	24	**Total**	**Possible Points:**	**110**

Table 5.11-B: snapshot of the second half of the LEED checklist implemented for the nursing-home project.

As shown in table 5.11 above the original score for sustainability-related certification was fixed at 86 points; 68 certain and 18 probable. Researchers found that, due to project-management issues, 14 of these points were lost on the way which, in general terms, means the 16,3 %. As a final sets of research outputs for the present case-study researchers developed the following table 5.12 which summarizes all the major values for each dependent and independent variable.

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
Additional Time (Working Days)	37	39	18	40	41	**175**
Indirect Additional Costs (€)	5730	500	1700	4400	10500	**22830**
Direct Additional Costs (€)	0	38000	35000	5000	0	**78000**
Green Value (LEED points)	2	1	0	4	7	**14**

Table 5.12: final table summarizing all information obtained from the analysis of the present case-study project

5.6.2. Case-study 2: the school complex.

As defined for the nursing-home project also for the school complex the results were collected and summarized in different sets of tables which are reported below. Table 5.13 below summarize the research outputs for the cost-related analysis in relationship with the school-complex project.

COST ANALYSIS (Direct Costs)						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)						
Hidden problems (E.g. LEED/BREEAM Docs)	4000					
Incorrect processing (E.g. Change orders)						
No process flow (E.g. CxA,OPR & BOD)						
No stop to fix problems (E.g. Extra personnel)		14000	10000		8000	
Visual control (E.g. Project re-manufacturing)	4000		8000	6000		
Workload not levelled						
Total	8000	14000	18000	6000	8000	**54000**
COST ANALYSIS (Indirect Costs)						
Visual control (E.g. Project re-manufacturing)				3500	4000	
No stop to fix problems (E.g. Extra personnel)			0			
Workload not levelled	500		500	1000	500	
Total	500	0	500	4500	4500	**10000**

Table 5.13: results proceeding from the analysis of project costs divided in direct and indirect costs values of the school-complex project.

The total cost for which the professional services for the building design development were contracted were 240.767 €. This lump sum consider all services related with definitive, executive and safety design activities as considered for the previous case-study. In this case the total amount of direct and indirect costs proceeding from the research result is 64.000 € which is the 26,6 % of the total cost of the design services. Table 5.14 below summarizes the outputs related to the time variance detected by researchers for the school-complex project.

TIME ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)						0
Hidden problems (E.g. LEED/BREEAM Docs)		5				5
Incorrect processing (E.g. Change orders)	6		90	16		112
No process flow (E.g. CxA,OPR & BOD)						0
No stop to fix problems (E.g. Extra personnel)						0
Visual control (E.g. Project re-manufacturing)			38	7		45
Workload not levelled						0
TOTAL	6	5	128	23	0	**162**

Table 5.14: results of the time-related analysis applied to the school-complex case study.

For this case-study, the research team could not calculate the whole amount of delays occurred during the design process for all activities because their magnitude exceeded the team's capability. The project design phase started in 2009 and finished in 2014. During that period the process was interrupted, modified, re-scheduled and the team could not find evidence of all the activities occurred. Therefore, it is not possible to have a percentage comparison between the time variance and the total amount of time required to complete the job. However, from the initial contract the design team had 520 days to complete the design and, compared to this number, the time variance calculated accounts for the 30,5 %.

The magnitude of the delay is comparable with the one calculated for the nursing-home project. However, it is important to highlight that in this case the majority of the delay was caused by a major change order of the project imposed by bureaucratic obligations. The Municipality had to use the funding of the Province before an upcoming deadline, the project was over budget and the funding could not cover all the expenses. Therefore the owner decided to split the project design in two parts, approving and funding the first one with the existing fund, in the meantime looking for other funds and merge the design back together at the end of the process. This caused a delay of 102 days only for the sustainability-related activities. For the nursing home project the delays were spread out through all the activities which highlights a consistent problem for all sustainability-related activities.

Also for the school project the team defined, during the early design stage, a reference checklist which was implemented by researchers as a benchmark for calculating the sustainability-related variance. The original LEED score estimated for the school project was 67: 61 of which certain and 6 potentially available, out of a total of 79 possible points. Table 5.15 below summarizes how many LEED points were lost due to project-management issues.

SUSTAINABILITY ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)						0
Hidden problems (E.g. LEED/BREEAM Docs)						0
Incorrect processing (E.g. Change orders)	1	1		2		4
No process flow (E.g. CxA,OPR & BOD)						0
No stop to fix problems (E.g. Extra personnel)					5	5
Visual control (E.g. Project re-manufacturing)				1		1
Workload not levelled						0
TOTAL	1	1	0	3	5	**10**

Table 5.15: results of the sustainability-related analysis applied to the school-complex case study.

Out of the 67 LEED points originally estimated, 10 were lost along the way which accounts for a 11,8 % of the total. All results cited above are summarized in table 5.16 below.

RESEARCH SUMMARY TABLE						
PROBLEM CATEGORIES / DETECTED WASTES	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
Additional Time (Working Days)	9	5	128	23	0	**165**
Indirect Additional Costs (€)	500	0	500	4500	4500	**10000**
Direct Additional Costs (€)	8000	14000	18000	6000	8000	**54000**
Green Value (LEED points)	1	1	0	3	5	**10**

Table 5.16: final table summarizing all information obtained from the analysis of the school-complex case study.

5.6.3. Case-study 3: the office building project in Barcelona.

As previously described in chapter 4, this project was developed through a process which resulted to be more integrated than the ones used for the school and nursing-home projects. This fact is also reflected in the research outputs listed below. As for the other cases, the first table 5.17 summarizes the results of the direct and indirect cost analysis.

COST ANALYSIS (Direct Costs)						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (Bid & early stage)						
Hidden problems (LEED/BREEAM Docs)	7500			1500	1500	
Incorrect processing (Change orders)			1500			
No process flow (CxA,OPR & BOD)		2500				
No stop to fix problems (Extra personnel)						
Visual control (Project re-manufacturing)				7500	3600	
Workload not levelled						
Total	7500	2500	1500	9000	5100	**25600**
COST ANALYSIS (Indirect Costs)						
Visual control (Project re-manufacturing)						
No stop to fix problems (Extra personnel)	2000					
Workload not levelled	300	600		300		
Total	2300	600	0	300	0	**3200**

Table 5.17: results proceeding from the analysis of project costs divided in direct and indirect costs values of the office-building project in Barcelona.

The design phase was assigned to the original design team for a lump sum of 47.889 Euros. As shown above the cost variance of sustainability-related activities accounted for 28.800 Euros which represents the 60,1 % of the original total cost. If compared with the previous projects, the cost variance appears to be much higher in terms of percentages but is, in fact, much smaller in terms of absolute costs. Table 5.18 below reports the time variance calculated for the office building in Barcelona.

TIME ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (Bid & early stage)						0
Hidden problems (LEED/BREEAM Docs)	1			1	2	4
Incorrect processing (Change orders)						0
No process flow (CxA,OPR & BOD)		6				6
No stop to fix problems (Extra personnel)						0
Visual control (Project re-manufacturing)				5	8	13
Workload not levelled						0
TOTAL	1	6	0	6	10	23

Table 5.18: results of the time-related analysis applied to the office building case.

A total of 23 working days were lost due to project-management issues for sustainability-related activities. The total period originally estimated for the design phase development was 670 days which account for 470 working days. Therefore the time variance for this case study resulted to be the 4,9 % of the original time period. Table 5.19 below summarize the outputs of the research for the sustainability-related variance.

SUSTAINABILITY ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (Bid & early stage)						0
Hidden problems (LEED/BREEAM Docs)					1	1
Incorrect processing (Change orders)			1			1
No process flow (CxA,OPR & BOD)						0
No stop to fix problems (Extra personnel)						0
Visual control (Project re-manufacturing)					1	1
Workload not levelled						0
TOTAL	0	0	1	0	2	3

Table 5.19: results of the sustainability-related analysis applied to the office building case located in Barcelona.

A total of 84 LEED points were originally estimated to be achievable by the design team and 3 of these were lost due to project-management issues which means, in global terms, a variance of the 3,57 %. Finally, the following table 5.20 summarizes all the major values for each dependent and independent variable calculated under the present case-study.

RESEARCH SUMMARY TABLE						
PROBLEM CATEGORIES / DETECTED WASTES	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
Additional Time (Days)	1	6	0	6	10	**23**
Indirect Additional Costs (€)	2300	600	0	300	0	**3200**
Direct Additional Costs (€)	7500	2500	1500	9000	5100	**25600**
Green Value (LEED points)	0	0	1	0	2	**3**

Table 5.20: final table summarizing all information obtained from the analysis of the office-building case in Barcelona.

5.6.4. Case-study 4: the office building project in Southern Spain.

Opposite to the school and nursing-home projects that were developed through a traditional Design-Bid-Build process, this last case-study was developed through a complete integrated Design-Build process. The outputs resulting from researcher's analysis are also very different from the previous ones and are summarized here below. Table 5.21 reports the results obtained for the cost-related calculations.

PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
COST ANALYSIS (Direct Costs)						
Re-manufacturing (E.g. Bid & early stage)	**0**	**0**	**0**	**0**	**0**	
Hidden problems (E.g. LEED/BREEAM Docs)	0	0	0	0	0	
Incorrect processing (E.g. Change orders)	**0**	**0**	**0**	**0**	**0**	
No process flow (E.g. CxA,OPR & BOD)	**0**	**0**	**0**	**0**	**0**	
No stop to fix problems (E.g. Extra personnel)	0	0	0	0	0	
Visual control (E.g. Project re-manufacturing)	0	0	0	0	0	
Workload not levelled	**0**	**0**	**0**	**0**	**0**	
Total	0	0	0	0	0	**0**
COST ANALYSIS (Indirect Costs)						
Visual control (E.g. Project re-manufacturing)	0	0	0	0	0	
No stop to fix problems (E.g. Extra personnel)	0	0	0	0	0	
Workload not levelled	**0**	**0**	**0**	**0**	**0**	
Total	0	0	0	0	0	**0**

Table 5.21: results proceeding from the analysis of project costs divided in direct and indirect costs values of the office-building project in Barcelona.

No additional costs were registered for the completion of any sustainability-related activities due to project-management issues. Table 5.22 reports the results obtained for the time-related calculations.

PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
TIME ANALYSIS						
Re-manufacturing (E.g. Bid & early stage)	**0**	**0**	**0**	**0**	**0**	0
Hidden problems (E.g. LEED/BREEAM Docs)	0	0	0	0	0	0
Incorrect processing (E.g. Change orders)	**0**	**0**	**0**	**0**	**0**	0
No process flow (E.g. CxA,OPR & BOD)	**0**	**0**	**0**	**0**	**0**	0
No stop to fix problems (E.g. Extra personnel)	0	0	0	0	0	0
Visual control (E.g. Project re-manufacturing)	0	0	0	0	0	0
Workload not levelled	**0**	**0**	**0**	**0**	**0**	0
TOTAL	0	0	0	0	0	**0**

Table 5.22: results of the time-related analysis applied to the office building case of Southern Spain.

As well as for the costs, no delays were registered for the completion of sustainable-related activities in this project. Table 5.23 below summarizes the results obtained for the sustainability-related problems identified during the design phase of this project.

SUSTAINABILITY ANALYSIS						
PROBLEM CATEGORIES / DETECTED WASTES (LEAN)	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
Re-manufacturing (E.g. Bid & early stage)	**0**	**0**	**0**	**0**	**0**	0
Hidden problems (E.g. LEED/BREEAM Docs)	0	0	0	0	0	0
Incorrect processing (E.g. Change orders)	**0**	**0**	**0**	**0**	**0**	0
No process flow (E.g. CxA,OPR & BOD)	**0**	**0**	**0**	**0**	**0**	0
No stop to fix problems (E.g. Extra personnel)	0	0	0	0	0	0
Visual control (E.g. Project re-manufacturing)	0	0	0	0	0	0
Workload not levelled	**0**	**0**	**0**	**0**	**0**	0
TOTAL	0	0	0	0	0	**0**

Table 5.23: results of the sustainability-related analysis applied to the office building case of Southern Spain.

No loss of BREEAM points caused by any of the problem categories was detected by researchers. On the contrary, the final score appeared to be higher than the one originally contracted. In fact, originally the design team agreed upon achieving 86 BREEAM points but, by the end of the design-certification phase, they achieved 90 without additional costs. If compared with the results obtained for the previous cases this results identifies a negative variance of 4,7 % on the total BREEAM score. This result is reported in the following table 5.24 which summarizes all the major outputs for this specific case-study project.

RESEARCH SUMMARY TABLE						
PROBLEM CATEGORIES / DETECTED WASTES	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
Additional Time (Working Days)	0	0	0	0	0	**0**
Indirect Additional Costs (€)	0	0	0	0	0	**0**
Direct Additional Costs (€)	0	0	0	0	0	**0**
Green Value (BREEAM points)	0	0	0	0	0	**-4**

Table 5.24: final table summarizing all information obtained from the analysis of the office-building case located in Southern Spain.

5.6.5. Output summary.

This last chapter summarizes all the outputs obtained from the present research for all the case-study projects analyzed. Table 5.25 below reports all the values in relationship with the dependent and independent variables.

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	VARIANCE (%)
THE NURSING-HOME PROJECT							
Additional Time (Working Days)	37	39	18	40	41	**175**	**29,2**
Additional Total Costs (€)	5730	38500	36700	9400	10500	**100830**	**36,6**
Green Value (LEED points)	2	1	0	4	7	**14**	**16,3**
THE SCHOOL-COMPLEX PROJECT							
Additional Time (Working Days)	9	5	128	23	0	**165**	**30,5**
Additional Total Costs (€)	8500	14000	18500	10500	12500	**64000**	**26,6**
Green Value (LEED points)	1	1	0	3	5	**10**	**11,8**
THE OFFICE BUILDING PROJECT IN BARCELONA							
Additional Time (Working Days)	1	6	0	6	10	**23**	**4,9**
Additional Total Costs (€)	9800	3100	1500	9300	5100	**28800**	**60,1**
Green Value (LEED points)	0	0	1	0	2	**3**	**3,57**
THE OFFICE BUILDING PROJECT INS SOUTHERN SPAIN							
Additional Time (Working Days)	0	0	0	0	0	**0**	**0**
Additional Total Costs (€)	0	0	0	0	0	**0**	**0**
Green Value (BREEAM points)	0	0	0	0	0	**−4**	**−4,7**

Table 5.25: final table summarizing all information obtained for all case studies.

5.7 Case-study comparison and cross-case analysis.

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

- *First independent variable: time.*

From the time-variance perspective there is a substantial difference between the first two case-studies and the other ones. Whether the school project and nursing-home project suffered a delay of almost a 30%, both office buildings were completed with a delay of less than 5%. According to the results and information retrieved through the interviews and document analysis the cause of this problem was the process fragmentation as defined under the Lean approach (Liker, 2003). For the purpose of this research this fragmentation that has to be considered from a broader point of view; spatial, temporal and procedural. According to the information collected, there were several reasons why technicians and subjects involved could not interact on a continuous basis with each other, sometimes it depended on the distant locations, sometimes on the agenda incompatibility, sometimes on the misunderstanding of technical issues. As already mentioned above, for the first cases most of the subjects involved would operate separately from the others responding to the requirements imposed by national regulations which would not consider the integrate process as a mandatory prerequisite. As a result, each subject would interact with the other ones just once in a while on a random-schedule basis when a problem occurred. Therefore the process integration was done on the basis of a interventionist and not preventionist procedure. The scheduling developed at the beginning of the work by technicians involved and validated by the owner was not accurate nor detailed. As shown in the original Gantt diagram developed for the nursing home project and reported in the appendix 2 of the present manuscript, no activity floats were considered, the dates and deadlines were established on the basis of brief scheduling estimate which considered only the process milestones. As a result, the planning tasks related to several activities remained uncovered, the process that appeared to be fluent presented several gaps which remained hidden during the whole design phase. Thus, such problems which may be solved without difficulties became hidden problems which would eventually came to the surface by the time they needed to be solved turning activities from important to urgent (Riley et al., 2007). This would drain resources on a suddenly basis with little or no prior notification and a consequent impact on the whole scheduling.

One key-difference between the first two case studies and the other ones is the perception of the importance of time. According to the information retrieved during the case analysis, in different case studies the subjects involved and the owner gave different importance to the time variable. Out of the three independent variables identified by researchers not all of them had the same importance throughout the process. In many cases the managing entity had to solve problem by managing money, time and sustainability. For the first two cases, the school complex and the nursing home project which were both public funded, the time and the sustainability variables were often sacrificed to the benefit of the cost variable. Moreover, in such cases often the time variable appeared to be considered as the least important of the three. In more than one occasion during the school and nursing home project the decision process was made following the process described below:

- Problem 1: missing a sustainability-related activity/service: can be solved by:
    A. Add more money (time-crushing);
    B. Avoid the sustainability-related benefit;
    C. Provide the missing service and delaying other activities;
    ➔ Most of the times the option C was chosen.

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. Each of them experienced a delay between 165 and 175 working days only for sustainability-related activities. This fact alone highlights the propensity of project owners to sacrifice the time variable toward the optimization of the one related to sustainability. This highlights a specific hierarchy for the first two public-owned projects in which the project budget cannot be varied and therefore remains the first priority, sustainability may be varied but if the problem can be solved by adding time the owner would rather wait. So the hierarchy of independent variables of the first two projects is the following:

Cost – Sustainability – Time.

On the contrary, according to the information retrieved, for the other two projects analyzed 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.

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. The first two projects registered a delay ranging between 165 and 175 working days which, in terms of variance, means 29,2 and 30,5 percent. The private-owned projects suffered a delay ranging from 0 to 4,9 percent.

- *Second independent variable: costs.*

The cost-variance also registered substantial differences from case to case. However, for this instance the groups are not defined the same was as they were for the time variance. Here the only project that suffered a sensibly lower cost increment was the one developed in southern Spain through the Design-Build procedure. The other three cases registered an increment of cost ranging between 26 and 60 percent with the highest value (60,1 %) affecting the office-building project which, in theory, had a higher level of process integration. However, the researcher believe that these data have to be contextualized. In fact, whether in terms of variance the highest value was registered for the office-building project, in absolute terms this project had an increment of the costs (28.800 Euros) which was less than the half of the school project (64.000 Euros) and less than a third of the nursing home one (100.830 Euros). On the other side, being the initial project budget much lower, even if the final cost variance resulted lower in terms of absolute values, in terms of percentages it had a great impact on the project budget. This can be explained looking at the causes of the problems and the way they occurred during the process. Most of the problems registered for the scope of this study often had a fixed part and a variable part. For example, the process to adjust and re-run the energy model for a building project is more or less the same even if the total project budget is different. The cost of creating the model is different but the cost of adjusting it following the latest change orders was almost the same for all case studies. Therefore this cost has to be considered fixed and not linearly dependent on the total project budget. The same thing happened for the commissioning-authority service, where, according to the project documentation, the second revision of the project costed the same for all three cases. Therefore, due to this lack of linearity between the magnitude of the cost-variance and the magnitude of the project budget, the researcher highlights the lack of linearity between level of integration and cost variance. In other words, the study does not indicate that a better level of integration within the Design-Bid-Build system necessarily leads to a lower cost-variance in terms of percentages. It does contribute in terms of absolute values.

A different perspective has to be implemented for the Design-Build process in which the cost variance resulted to be zero. The project developed in Southern Spain is the only one which was completed on time and under budget. Therefore researchers for the cost independent variable concluded what follows:

- The level of integration within a Design-Bid-Build process affects the cost variance of the design-phase from a non-linear perspective;
- For a Design-Bid-Build process the cost variance results lower in terms of absolute values for projects implementing a higher level of integration;
- For a Design-Bid-Build process the cost variance results higher in terms of percentages for small projects even if implementing a higher level of integration;
- For a Design-Build process the cost variance resulted to be zero.

The researcher highlights the fact that, in terms of absolute values, the projects that suffered the greatest cost variance were 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 and school projects 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. This fact is demonstrated by the document reported in appendix 3 related to the approval act of the nursing-home project. However, these projects 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 developed under the Design-Bid-Build process the project sustainability was never considered as the priority. Even if in multiple interviews owners and technicians declared themselves totally committed to the sustainability this aspect was often left aside when cost-related problem arose. Out of these three, 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. As already cited in chapter two, according to Horman (2006) a key-aspect for the delivery of high-performance and sustainable building is the process integration and the focus of sustainability as a primary requirement second to no others. This aspect was fulfilled only for the third project and, according to the information collected, it may depend on a different perception of the project. In fact, the third project developed through the Design-Build procedure suffered a major change order which was not accounted as a problem because if was caused by the will of the owner. After the design start the owner, which was an international entity, decided to go for a higher certification level by adding some BREEAM-related features to the project. This was not accounted as an issue because it was not unforeseen, it was simply decided by the owner which decided to pay an extra service for the project. The initial clause called for a certification level of at least 73,25 points, the owner decided to pay some extra money and give some extra time for the upgrade which had an initial agreement of 86 points and reached, by the time the project was completed, a total of 90 points, 4 more than the ones initially estimated. All projects analyzed for the purpose of this study had, at a certain point, the need of adjusting the procedure to the new project conditions or requirements which could be determined by different factors. However, the researcher noticed a substantial difference between the way this procedure was developed in the last project and in the other ones. For the BREEAM-score upgrade the design team implemented the so-called "time-crushing" practice (Johansson, 2012) under which, having a greater amount of work with a fixed deadline the company decides to put more money in the project and accelerate the process where possible. However, in the other project, the system was more a push system where the completion of activities was scheduled at the time they were needed. Researchers found some clear evidence of that for the case of the project school for which the owner would wait for the response of the Water Dept. of the Province before scheduling the other activities. No major scheduling plan was implemented and, also for the sustainability, there was no effort to prevent problems but to solve them as they came. This highlights the lack of a project management entity supervising the process and having clear what steps have to be fulfilled for the achievement of a certain level of sustainability. If the owner aims to develop a sustainable building, then he would also have to embrace sustainability as a key-aspect of the project and address it in all the different aspects of the process including the project management part. The results obtained highlight the strong relationship between project management and project sustainability. Not only the sustainability-related activities have a substantial impact on the project management process but also the way the project management process is performed deeply affects the final sustainability features of the project. In other words, a poorly-planned process for the achievement of the different green-building features of the project would cause an impact on the project costs and schedule but, on the other side, a poorly managed project would negatively impact its green-building features.

- *Cross-case analysis: general considerations.*

From a broader perspective the analysis of the case-study project and the results of the present work led researchers to the following conclusions:

- Design-Bid-Build (DBB) projects affected by processes not levelled and lack of integration.

  All the case studies analyzed for the purpose of this research that suffered the most severe issues for all three independent variables were developed through the DBB process and presented, as main problem causes, the lack of integration between technicians and the poor organization of the process-leveling activities. The only project developed through the Design-Build procedure did not suffer any of the problems experienced in the other case studies. This confirms one of the key-concepts developed during the literature review, the potential improvement of the process integration through the implementation of the Design-Build procedure.

- Importance of the role of project manager as manager of the all project activities including the ones related to sustainability;

According to the interviewees a lot of potential issues of the projects analyzed were prevented by the correct behavior of the project manager who could manage both technical and sustainability-related activities. This highlights the importance of the integration not only from the point of view of physical work spaces and/or procedures but also from the knowledge perspective. According to the information retrieved by interviewees the success of delivering an integrate design process depended also on the capability of preventing mistakes and, being each subject specialized in one particular construction field, sometimes each subject does not realize the presence of a mistake until the other technician comes in. The presence of one subject supervising the process with a multi-disciplinary knowledge avoided, according to interviewees, many potential project issues.

- Correlation between Lean project wastes and process integration.

According to the documentation acquired for estimating the magnitude of indirect costs, the lack of visual control and the absence of a culture of stopping to solve problems as they appear was caused by the lack of constant relationship and integration between subjects involved. The large bustle of documentation re-developed multiple times during the process was caused by the misunderstanding between technicians and other subjects involved. In some cases this could be caused by the lack of a common integrated knowledge as cited in the paragraph above however, in other occasion it was also caused by a lack of constant relationship between subjects involved. In several occasions technicians would group all questions directed to other members and wait for the next meeting to ask them clarifications. Such meetings however, would occur every one or two months and, as a result, the production time spent in between them may have had some gaps or mistakes and therefore it had to be submitted again for re-manufacturing tasks. On the other side a proper visual control on the whole project development was not always possible because in some cases, like for the nursing-home project, each technician would be working independently in a different location hundreds of miles away from the other ones. According to interviewees these three factors cited above: lack of physical integration, lack of cultural integration and the excessive time length between meeting, were the main causes of the lack of process integration. The Lean approach provides specific suggestions and countermeasures for avoiding such problems and, if analyzed from a different approach the Lean methodology could serve not only as a tool to detect project issues, or wastes, but also as a method to find the possible countermeasures. If we analyze the case studies considered for the present research not from the problem categories point of view (dependent variables) but from the Lean-wastes perspective we could draw a map of the Lean wastes occurred for each independent variable. Table 5.26 below shows an example of how this procedure could be applied to the cost-variance. On the horizontal axis are described all the case studies analyzed whether on the vertical axis are reported all the Lean-wastes identified in the present research. The table summarizes what impact had a specific Lean waste on each case study in terms of cost and, by adding them together, the total amount shows the impact of each Lean waste on the whole research sample for the cost-variance perspective. Therefore, researchers could tell which Lean wastes create the greatest amount of issues for all the case-studies and, as a result, calculate which countermeasures should be implemented to prevent such issues. This technique has been used by researchers to draw the guidelines for professionals reported in the next chapter 6.

LEAN WASTES - Costs (Direct + Indirect)					
CASE-STUDY PROJECTS / DETECTED WASTES (LEAN)	School Project	Nursing Home	Office Building in Barcelona	Office Building in Southern Spain	TOTAL
Re-manufacturing (E.g. Bid & early stage)	0	5000	0	0	**5000**
Hidden problems (E.g. LEED/BREEAM Docs)	4000	30000	10500	0	**44500**
Incorrect processing (E.g. Change orders)	0	30000	1500	0	**31500**
No process flow (E.g. CxA,OPR & BOD)	0	8000	2500	0	**10500**
No stop to fix problems (E.g. Extra personnel)	32000	11200	2000	0	**45200**
Visual control (E.g. Project re-manufacturing)	25500	11630	11100	0	**48230**
Workload not levelled	2500	5000	1200	0	**8700**
Total	64000	100830	28800	0	**193630**

Table 5.26: impact of the types of Lean-waste on the direct and indirect cost variance of each case study.

5.8 Practical guidelines for professionals.

On the basis of the experience acquired during the development of the present work researchers created a set of practical guidelines for professionals who would be willing to implement the outcomes of this research in the real green-building field. Such guidelines are related to different aspects of the research and are reported in the list below.

A. *Define specific project priorities from the beginning of the design phase and keep them throughout the whole process.*

One of the main causes of project change orders and therefore wastes, was the habit of not keeping a tight hierarchy of priorities. As already cited in chapter 5 in fact, often the owners of the projects that suffered the greatest amount of issues change the order of project priorities, keeping the costs as first, sustainability second and schedule as third and the last one. However, these three variables which for the purpose of this study were considered independent, have in fact a strong relationship between each other. The project delays affect the costs which affect the speed of the process, the green-building features and finally the costs themselves. None of these three variables can be considered, for the purpose of the project completion, totally independent from each other and therefore is important that the owner keeps the focus of the project on all three of them. If a problem occurs a feasible solution would be to act on one of the variables favoring the others but only temporarily to solve the problem as occurred, for example, for the sustainability-score of the case-study project in Southern Spain. After the problem is solved the priority of all three variables should be equalized again.

B. *Hire a project manager with the knowledge and ability of managing also the green-building features of the project.*

The results of the present study demonstrated the existence of a positive relationship between level of process integration and green-building design development. In order to support the integrated process development the project manager should be capable of embracing all the building features including the sustainability-related ones. Moreover, the projects that suffered the greatest amount of wastes had a project manager who was in charge of the bureaucratic process but not of the technical one. This can potentially create a gap between what should be done (bureaucratic side) and what can be done (technical side). Therefore, the researcher believe that the project manager appointed for green-building design developments should comply with the following statements:

- Have the knowledge and capability for managing practical technical activities and not only the bureaucratic process of the building development;
- Being in charge by the owner of managing the practical aspects of the project and not only the bureaucratic part;
- Have experience in green-building developments and, if possible, merge the project-management role with the one of the accredited professional for each reference standard implemented;
- Implement a bottom-to-top decision-making procedure following the Lean approach in order to manage activities on the basis of a hands-on knowledge.

C. Re-define the organization of the project budget and schedule for Design-Bid-Build design processes.

Researchers can claim that all case-study project developed through the Design-Bid-Build procedure analyzed for the purpose of the present study experienced some kind of project issues related to cost and time variance in relationship with the green-building features of the project. As demonstrated by the analysis many of these problems were caused by change orders that could not then be covered appropriately by the budget and schedule at disposal. Currently, the Design-Bid-Build project budget considers a specific amount of money for unforeseen problems that could potentially occur during the late phases of the project. On the contrary it does not consider a supplementary schedule duration for such problems to be fixed. It also does not consider the problems that may be caused by sustainability-related activities. One example could be the adaptation of the building performance on the basis of the energy-model outputs: if such outputs would highlight one or more poor energy performance due to lack of insulation or other design gaps the team could no longer modify the project if the budget had already been approved and the project schedule does not allow further delays in order to comply with the deadlines of the funding entities. This problem occurred in both school and nursing-home projects. Therefore, the researcher suggest that in case of green-building developments, the owner or the project manager considers a specific amount of additional costs and time to solve potential sustainability-related issues that may occur during the late phases of the design.

D. Address the resources to solve the problems following the Lean approach.

The last but maybe most important suggestion to professionals provided by this research work is the practical implementation of the Lean approach as a tool for addressing the green-building-design process issues. In fact, using the Lean categorization of project issues developed through the methodology and implementing the tables of results reported in chapter 4, professionals could get a sense of which categories of issues had a bigger impact on the design process. In fact, by analyzing the tables following the horizontal axis, the researchers can categorize the problems following the Lean approach and, as a result, categorize the causes that provoked them. This gives an idea of which could be the most dangerous aspects of the process for which professionals may want to addressed and prevent first. Tables 5.27, 5.28 and 5.29 below summarize the results of each independent variable from the Lean-waste perspective, grouping together the results of all case-studies for each Lean-waste category.

LEAN WASTES - Costs (Direct + Indirect)					
CASE-STUDY PROJECTS / DETECTED WASTES (LEAN)	School Project	Nursing Home	Office Building in Barcelona	Office Building in Southern Spain	TOTAL
Re-manufacturing (E.g. Bid & early stage)	0	5000	0	0	**5000**
Hidden problems (E.g. LEED/BREEAM Docs)	4000	30000	10500	0	**44500**
Incorrect processing (E.g. Change orders)	0	30000	1500	0	**31500**
No process flow (E.g. CxA,OPR & BOD)	0	8000	2500	0	**10500**
No stop to fix problems (E.g. Extra personnel)	32000	11200	2000	0	**45200**
Visual control (E.g. Project re-manufacturing)	25500	11630	11100	0	**48230**
Workload not levelled	2500	5000	1200	0	**8700**
Total	64000	100830	28800	0	**193630**

Table 5.27: impact of the types of Lean-waste on the direct and indirect cost variance of each case study.

From the cost-variance perspective the results show how the Lean-wastes related to visual control, stopping to fix problems and the presence of hidden problems were the main causes of extra costs during the project design phase. Therefore technicians, owners and project managers may want to address those activities before others in order to optimize the project budget.

TIME ANALYSIS					
CASE-STUDY PROJECTS / DETECTED WASTES (LEAN)	School Project	Nursing Home	Office Building in Barcelona	Office Building in Southern Spain	TOTAL
Re-manufacturing (E.g. Bid & early stage)	0	18	0	0	**18**
Hidden problems (E.g. LEED/BREEAM Docs)	5	31	4	0	**40**
Incorrect processing (E.g. Change orders)	112	28	0	0	**140**
No process flow (E.g. CxA,OPR & BOD)	0	16	6	0	**22**
No stop to fix problems (E.g. Extra personnel)	0	49	0	0	**49**
Visual control (E.g. Project re-manufacturing)	45	23	13	0	**81**
Workload not levelled	0	10	0	0	**10**
TOTAL	162	175	23	0	**360**

Table 5.28: impact of the types of Lean-waste on the time variance of each case study.

On the other side from the time-variance perspective the results show how the waste related to incorrect processing had a greater impact than the other types of waste. Therefore, in case the primary need of the project was to comply with the project deadlines the project manager may want to address resources toward those activities in order to make sure that the process is executed correctly from the beginning until the end.

SUSTAINABILITY ANALYSIS					
CASE-STUDY PROJECTS / DETECTED WASTES (LEAN)	School Project	Nursing Home	Office Building in Barcelona	Office Building in Southern Spain	TOTAL
Re-manufacturing (E.g. Bid & early stage)	0	0	0	0	0
Hidden problems (E.g. LEED/BREEAM Docs)	0	0	1	0	1
Incorrect processing (E.g. Change orders)	4	6	1	0	11
No process flow (E.g. CxA,OPR & BOD)	0	1	0	0	1
No stop to fix problems (E.g. Extra personnel)	0	5	0	0	5
Visual control (E.g. Project re-manufacturing)	1	2	1	0	4
Workload not levelled	0	0	0	0	0
TOTAL	5	14	3	0	**22**

Table 5.29: impact of the types of Lean-waste on the time variance of each case study.

Also if the project priority was the achievement of the highest possible level of sustainability the owner may want to address all the activities related to the correct development of the process before others. In fact, according to the results, the incorrect processing was responsible for the major loss of green-building points for all case-studies analyzed.

5.9 Chapter summary.

This chapter describes the results obtained during the whole research process from both qualitative and quantitative points of view. Qualitative results are expressed as specific tasks and problematic activities related to both dependent variables and independent variables. Quantitative results are conveyed as research outputs through specific tables identifying the impact of each dependent variable (or problem category) on each independent variable standardized through the Lean approach. In fact, the chapter also sets the basis for the development of the professional's guidelines, which will be explained in the next chapter. Using the Lean methodology to standardize the representation of the research outputs, researchers identified the key-factors in order to avoid the replication of the detected problems. This procedure establishes the basis for the development of practical guidelines and rules for professionals in order to avoid the replication of the detected issues in real-project situations.

CHAPTER 6

Conclusions

6.1. Achievement of the research objectives.

Table 6.1 summarizes the research objectives anticipated in chapter 1 indicating if, how and where in the manuscript they were achieved.

Research objective	If and how it was achieved	Where in the text
1. Identify a specific gap within the current research and knowledge environment;	Yes. A specific process of literature review was developed focusing on the main research fields and objectives.	Chapter 2
2. Define a feasible and adequate methodology in order to complete the present research conducted on the research gap;	Yes. On the basis of the information collected through the literature review researchers developed a methodology supported by appropriate evidence and other research works.	Chapter 3
3. Identify and analyze a satisfactory number of case studies in order to develop the research;	Yes. Four appropriate case-study projects were identified and analyzed for the purpose of the present research.	Chapter 4
4. Categorize the project-management issues affecting the green-building design process;	Yes. A specific categorization of project-management issues was developed through the identification of dependent and independent variables and the implementation of the Lean approach.	Chapter 5
5. Identify the impact of each problem category on the green-building design process;	Yes. The impact of each problem category was estimated from a qualitative and quantitative point of view through the use of interviews and project documentation.	Chapter 5
6. Highlight the positive relationship between process integration and green-building design development;	Yes. The final results of the study highlight a positive correlation between the two aspects of the project.	Chapter 5
7. Develop guidelines for professionals and optimization of future green-building design processes.	Yes. On the basis of the results obtained, the researcher draw a set of guidelines also implementing some of the Lean concepts.	Chapter 6

Table 6.1: summary of the research objectives achieved with the present study.

6.2. Contributions.

A. *Relationship between project management and project sustainability.*

In chapter 5 the researcher demonstrate the existence of a relationship between the fields of project management and sustainability for the development of green-building projects. The cross-case analysis showed that both fields are mutually linked and that the efficiency of one can impact the success of the other and vice versa. This relationship leads to a new concept which combines sustainability with affordability. Project management is, as defined in chapter two, the application of a whole set of skills, tools, knowledge and techniques to meet the project requirements by using the minimum amount of resources. On the other side sustainability can be defined by several definitions but all of the ones analyzed for the scope of this project focused on the optimization of the use of resources to build one or more buildings. The relationship between project management and green-building development confirmed hereby 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 first contribution of the present study: the relationship between project management and green-building projects which also supports the relationship between sustainability and affordability.

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

The analysis of the results highlighted the importance of the process integration for the development of green-building projects which has to be perceived from a broad perspective. Integration has to be intended as physical integration, in which each component can physically interact mutually during the development of the design phase and see first-hand the problems that are occurring or may be occurring in the process. It also has to be intended as timely integration for which subjects involved have to interact on a frequent basis with each other and not only once in a while when problems occur. Promoting this broad concept of integration in relationship with the development of green-building projects has a great potential impact on the business. In fact, as explained in chapter two, as the building developments become more and more international, the green-building reference standards are being taken as a global benchmark for establishing the quality of the buildings. Having the funding subject, the architect, engineer and general contractor hailing from several different countries is not uncommon. For such international projects this study demonstrates the importance of process integration which could possibly prevents some major problems that may occur if conditions similar to the case studies are replicated.

Therefore, the second contribution of this study can be described as follow: the relationship between process integration and optimization of sustainability features in green-building developments which serves as a advice for international projects developed through a highly-fragmented process.

C. *Choice of the procedure for the optimum development of green-building projects.*

The case-study analysis focuses on the comparison of projects developed through the two main procedures currently available in Europe, the Design-Bid-Build (DBB) and the Design-Build (DB). As reported in chapter 2 several studies already demonstrated the benefits of the DB approach versus the DBB for general project-management purposes due to its higher level of integration. This work focuses also on demonstrating the positive relationship between process integration and green-building design development. Therefore, on the basis of the literature review and of the results obtained, this research also demonstrate that the DB approach is a more suitable procedure for green-building developments. This idea may open a dispute in the future of the construction business. In fact, recently some regulations of the countries in which case-studies were located banned the development of public project through the implementation of the DB approach leaving the DBB one as the only option. For example the Italian Government in October 2016 introduced the new law for public construction and developments (Dgls. 50, 2016) which bans the use of the Design-Build procedure except for some rare cases and vicissitudes. This study shows that such approach, which may be banned for other reasons, in reality is the optimum currently available for the development of green-building projects.

Therefore, the third contribution of this study is to show the capability of the Design-Build procedure from the project management perspective and the potential advantages of its implementation for the development of green-building projects.

D. *Implementation of the Lean approach for optimizing green-building-design processes.*

The study focused on the categorization of project management problems making full use of the Lean approach. On one side this helped the standardization of the definitions of issue in relationship with the concept of waste promoted by Lean. On the other side, this allowed researchers to look at the optimization process from the perspective of the Lean methodology for which, as demonstrated in the literature review, researchers and professionals already developed several guidelines and approaches to optimize the process efficiency. With this study researchers aimed to provide some practical guidelines for the optimization of green-building design processes. However, the main goal was not to develop such guidelines from scratch but to make full use of other existing techniques. The Lean approach differentiates the so-called process "waste" into different problem categories each of which is related to practical problems occurring during the process and to the practical causes that generated them. By identifying such problems and therefore the related Lean-associated causes, researchers indirectly also identified the potential methods to avoid them because, as already shown in the literature review, several methods to avoid and/or minimize them have already been developed and categorized. In the table of results reported in chapter 5 the horizontal axis indicates the general categories of problems detected and the vertical axis the types of Lean waste. If we read the result cumulatively, the bottom line of the problem categories shows how many resources the team lost in relationship with one independent variable for that specific issue in that project (E.g. How many Euros wasted for activities related to the commissioning service in the school project). However, the horizontal bottom line shows how many resources were lost in relationship with that specific Lean waste (E.g. How many Euros were wasted due to lack of process flow in the school project). From the project manager's perspective this allows the owner to direct project resources where most needed, addressing the Lean wastes that caused more issues for each independent variable.

Therefore, the fourth contribution of this study is the development of a methodology to implement the Lean approach toward the optimization of the green-building-design processes.

6.3. Limitations.

The present research present several limitations that, for a better understanding, have been divided into three groups in relationship with the three independent variables measured and analyzed.

A. *Limitations related to time-variance analysis.*

The research project involved many subjects and often information were collected after the work had been performed. Even if researchers selected on purpose case studies developed almost simultaneously with the present research, the lack of a common protocol for the collection and storage of research-related data established prior to the project start determined a quantitative level of uncertainty. This was experienced most of all for the time-related analysis because, whether for costs and sustainability researchers relied on written documentation, timing and scheduling data of single activities were collected mainly through interviews which were subjective.

Estimating the delay of single activities resulted sometimes difficult and ambiguous because it relied on other activities which dependency could not be calculated. By matching data proceeding from interviews and project documentation, researchers determined the duration, floats, predecessors and successors of each activity. However, in some cases the bureaucratic and management process was so complicated that none of the subjects involved knew what depended on what. This resulted, as cited above, from the lack of integration and coordination of the process. 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.

B. *Limitations related to cost-variance analysis.*

Indirect costs resulted to be difficult to estimate because were not related to any written document nor any formal activity or event of the project. Furthermore, data related to indirect costs were collected through interviews to all subjects involved which, in some cases, weren't able to identify project management wastes. For example, some technicians claimed that re-defining the project design several times during the process is normal because "it is the way it goes". However, in project management terms this is called product re-manufacturing and reflects one of the Lean definitions of waste. This issue resulted in another limitation point. Researchers only analyzed the cost of the problems they had related information of, there might have been other extra costs that could not be estimate because nobody appointed them as problems and so researchers did not even know the existence of.

Researchers could not estimate the cost of not using the money allocated for the project during a medium-large period of time. The case-study refers to a public healthcare project funded by the public authority, in this case the Province of Trento. Funds for the project construction have to be listed and approved along with the public county budget still during the project design stage and remain locked in the public budget until the construction phase. Delays in design phase completion and consequently construction phase start represent a loss for the founding entity which cannot use nor invest the money allocated for the entire project.

As a general limitation related to this variable, researchers believe that indirect costs, in spite of being difficult to estimate, are not less important and maybe even more significant than the direct costs. Researchers believe that unforeseen indirect costs could be one of the main reasons why public bids developed within this construction management process tend to be completed way over budget and behind schedule.

C. *Limitations related to sustainability-variance analysis.*

For the purpose of the present work researchers took into consideration only two green-building protocols, LEED and BREEAM. Within the context of a this case-study analysis, the need of reducing the number of variables imposed the selection of two protocols which are currently the most used at an international level for number of certified buildings and square meters. However, these protocols represents only a fraction of the green-building construction market and therefore results of the present research have to be considered partially valid.

D. *General limitations of the research study.*

Out of four case-study projects analyzed for this work, three were developed through the Design-Bid-Build procedure and only one through the Design-Build method. Even if different projects presented different levels of process integration which were then reflected in the results, one single case-study is not to be considered sufficient to make valid assumption of all Design-Build projects. The results appoint toward the positive relationship between process integration, Design-Build processes and sustainability but in order to verify and validate this idea further studies through a higher number of samples are needed.

All case-study projects analyzed for the purpose of this research were similar in terms of building type, budget and, more generally, business segment. It is not clear if the values obtained for each of the independent variables would not vary in case of different projects in terms of use, dimensions and budget. The modification of one or more of these variables could modify the whole results, an example of this appears for the case of the office building in Barcelona which had half the project budget of the other ones. This, together with the fixed costs of some project issues, made the cost variance rise considerably from the percentage perspective even if in terms of absolute values the total cost of the issues was much lower. Therefore, further investigation of different types of building may be needed in order to validate the results of this work.

The idea of 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.

6.4. Ideas for future researches.

This paragraph proposes several suggestions to the researchers that will want to expand the present work using the methodology described above. The present work was developed on the basis of a four case-studies and presents several limitations. The researcher hereby focuses on highlighting such gaps to the eyes of the future researchers in order to help them optimizing the methodology and suggest some ideas for future research studies. These ideas can be described as follow:

- *Extend the research to a larger building sample:* in order to verify, correct or even prove wrong the validity of the results the research should be extended to different types of building projects in terms of budget, magnitude, location and use.

- *Extend the research to a larger protocol sample*: the present research implemented the LEED and BREEAM protocols for defining the concept of sustainability. Different protocols having different parameters of sustainability may have a different impact on the project management processes. Therefore, the methodology proposed hereby should be tested for other protocols as well.

- *Extend the research to a larger location sample*: the conclusions associated with the type of procedure of Design-Bid-Build and Design-Build were related to the European regulations and, more specifically, to the reality of public works developed in Italy and Spain. Other countries may have dissimilar regulations and bureaucratic procedures affecting the project management process in different ways and therefore further studies in this direction are needed to verify the validity of the results at an international level.

- *Upgrade the magnitude of the research sample to a proper survey.*

The combination of all three concepts described above would create a more powerful essay to verify and possibly validate the methodology developed with this study. If such study was developed and results would be consistently confirmed throughout the essay of a large number of case-studies researchers could draw the first common guidelines for developing green-building projects at international level. This could constitute a form of integrated tool for the development of green-building projects worldwide.

- *Integrate the current methodology for better indirect-cost estimate:* future research studies may include more detailed analysis for estimate indirect costs which involve each subject's perspective as described above. For the purpose of this work all information related to indirect costs were retrieved directly by each subject that experienced them and then cross-checked with other entities involved. However, the analysis of the cost of each elements could not be always done in detail because information were not always available. In some cases indirect costs were estimated by each subject on the basis of personal perspective. Researchers believe that indirect costs could account for the majority of the total extra expenses, or wastes, occurred during the process. However, in order to accurately estimate such indirect costs an integration of the current methodology is needed.

6.5. Chapter Summary.

The present chapter summarizes all the conclusions established by researchers on the basis of the analysis of the results developed during the research process. Such conclusions take into consideration both positive and negative aspects of this work. Positive aspects are defined through the description of the research outputs, achievement of the predetermined objectives and contribution of the present work for future research and professionals. Negative aspects include the limitations of the research which, however, could be filled up by future researches and studies.

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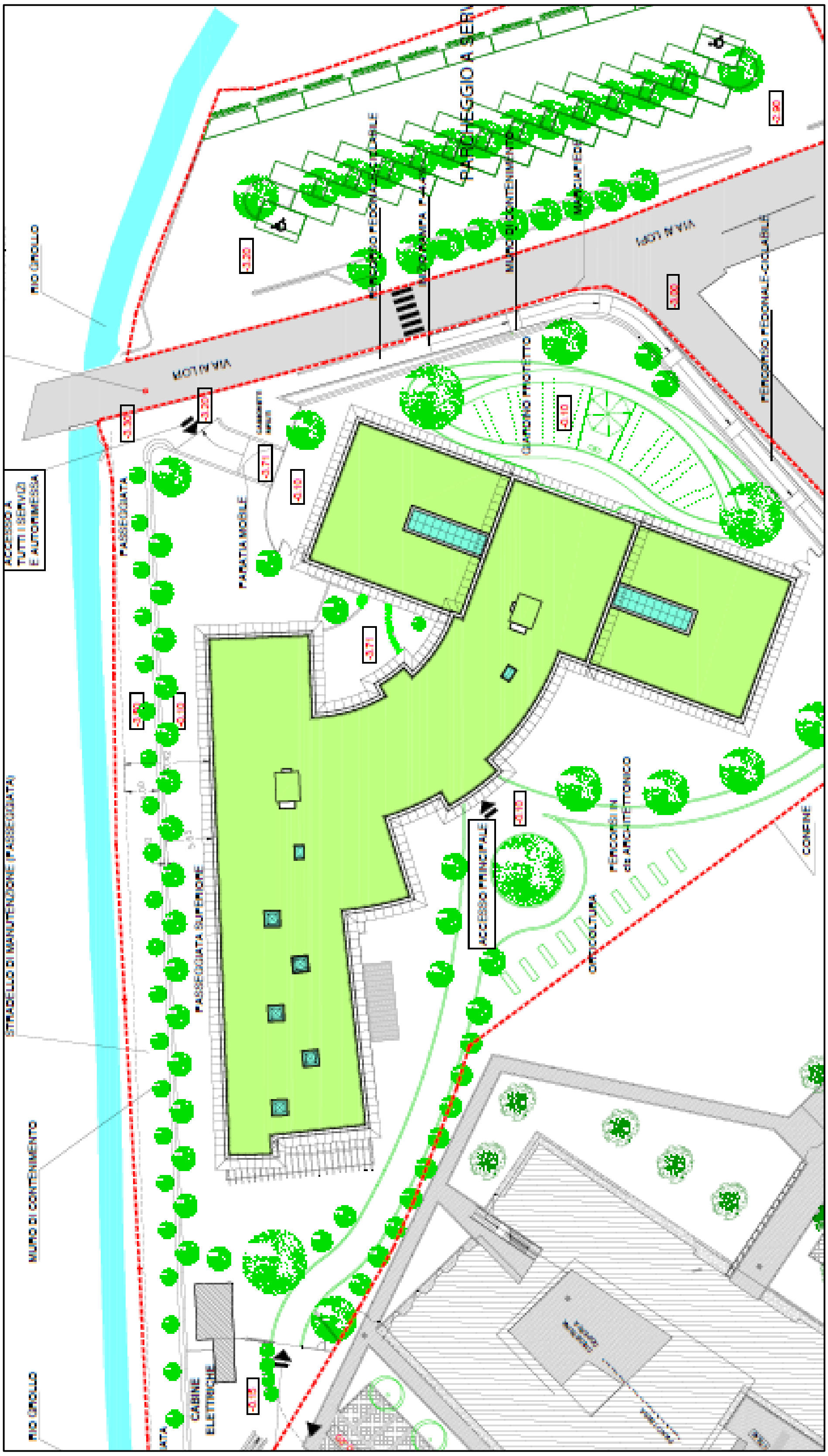
APPENDIX 1

Case-study projects: graphic documentation

1. THE NURSING-HOME PROJECT.



General plan of the building. *Source & Copyright: Studio Othe.*

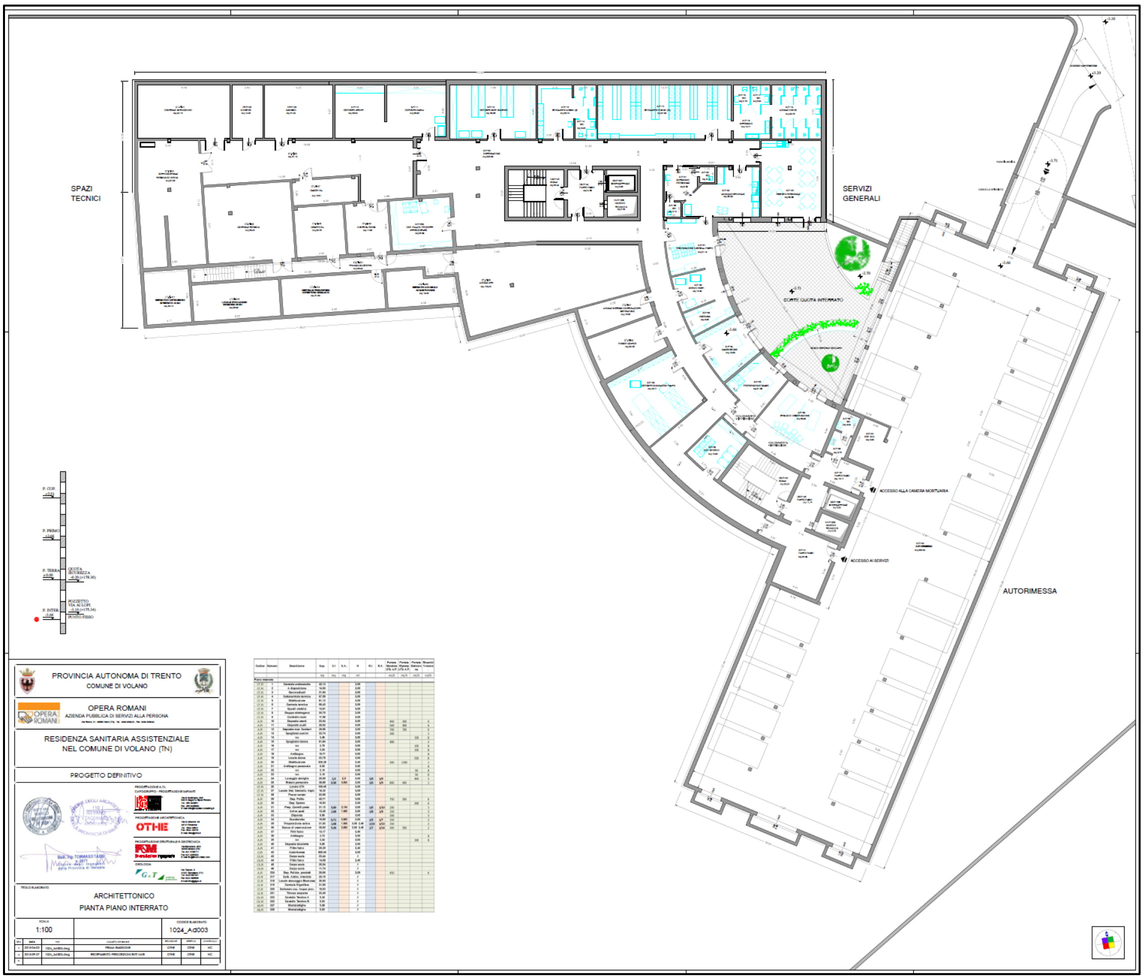
Rendering view of the school complex. *Source & Copyright: Studio Othe.*

Rendering view of the building entrance. *Source & Copyright: Studio Othe.*

Rendering view of the norther side of the building project. *Source & Copyright: Studio Othe.*

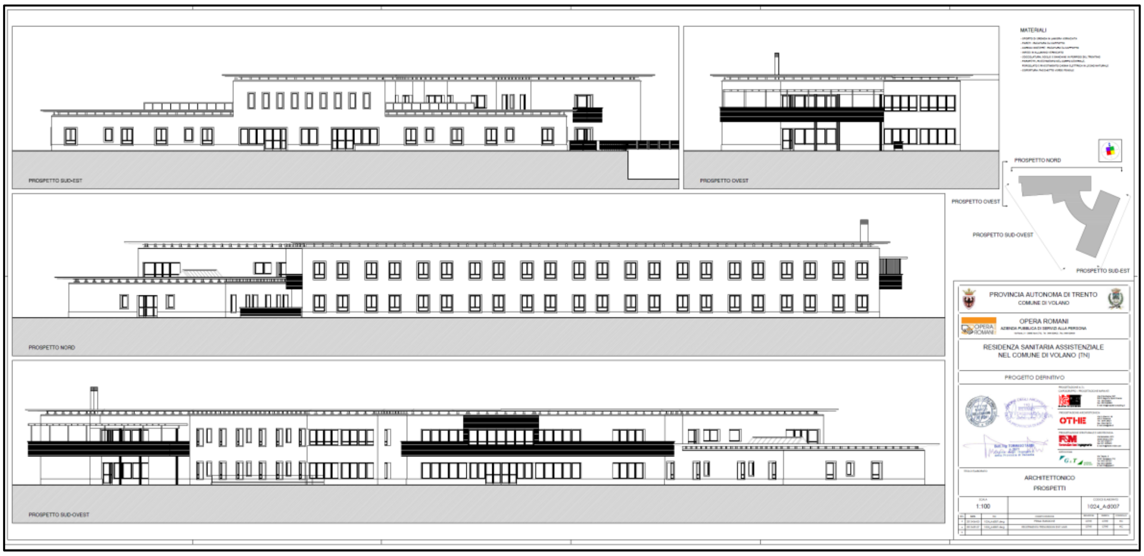
Rendering view of the norther entrance of the building. *Source & Copyright: Studio Othe.*

Rendering view of the project from the east perspective. *Source & Copyright: Studio Othe.*

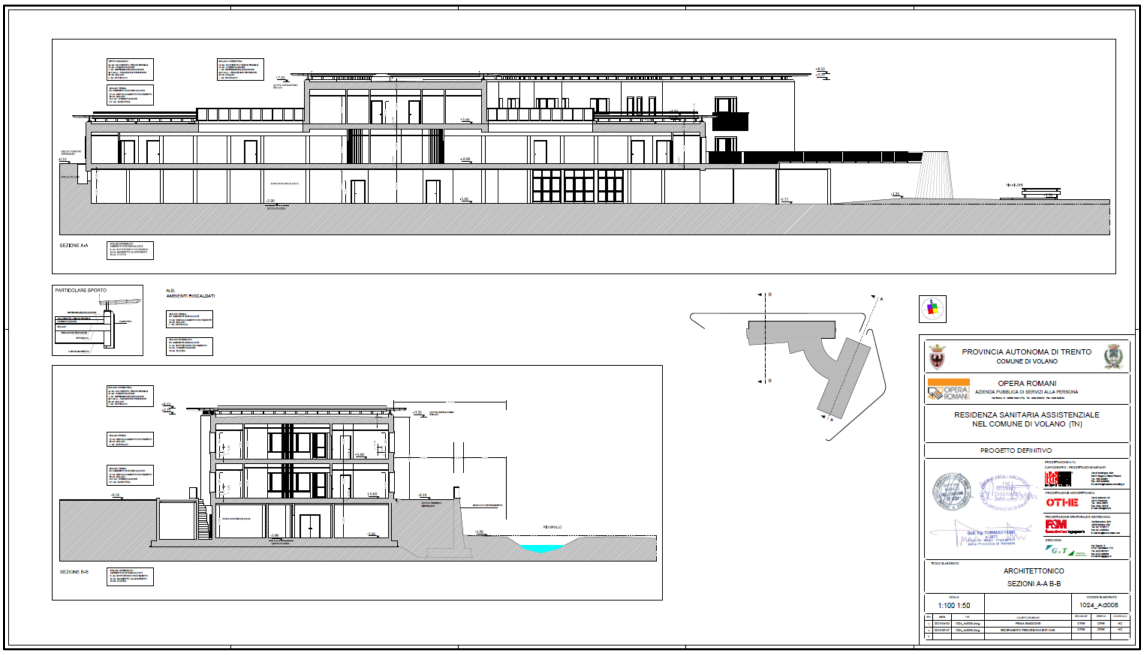


General plan of the building underground floor. *Source & Copyright: Studio Othe.*

General plan of the building ground floor. *Source & Copyright: Studio Othe.*



Building elevations. *Source & Copyright: Studio Othe.*



General plan of the building sections 1-1, 2-2. *Source & Copyright: Studio Othe.*

General plan of the building sections 3-3, 4-4, 5-5. *Source & Copyright: Studio Othe.*

2. THE SCHOOL-COMPLEX PROJECT.

Project global overview. *Source & Copyright: Gruppo Marche.*

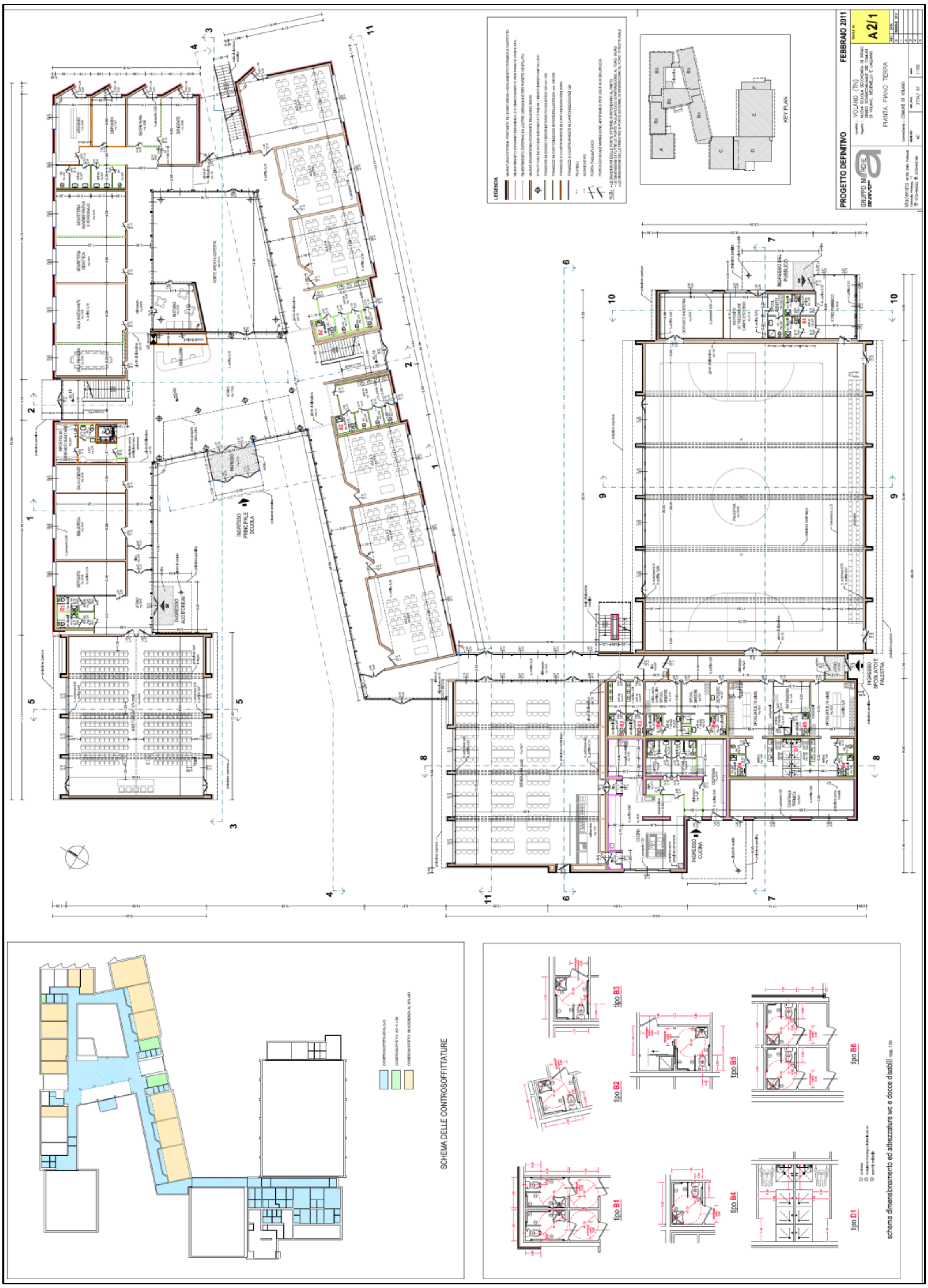
Rendering view of the school complex. *Source & Copyright: Gruppo Marche.*

Rendering view of the building complex from the street. *Source & Copyright: Gruppo Marche.*

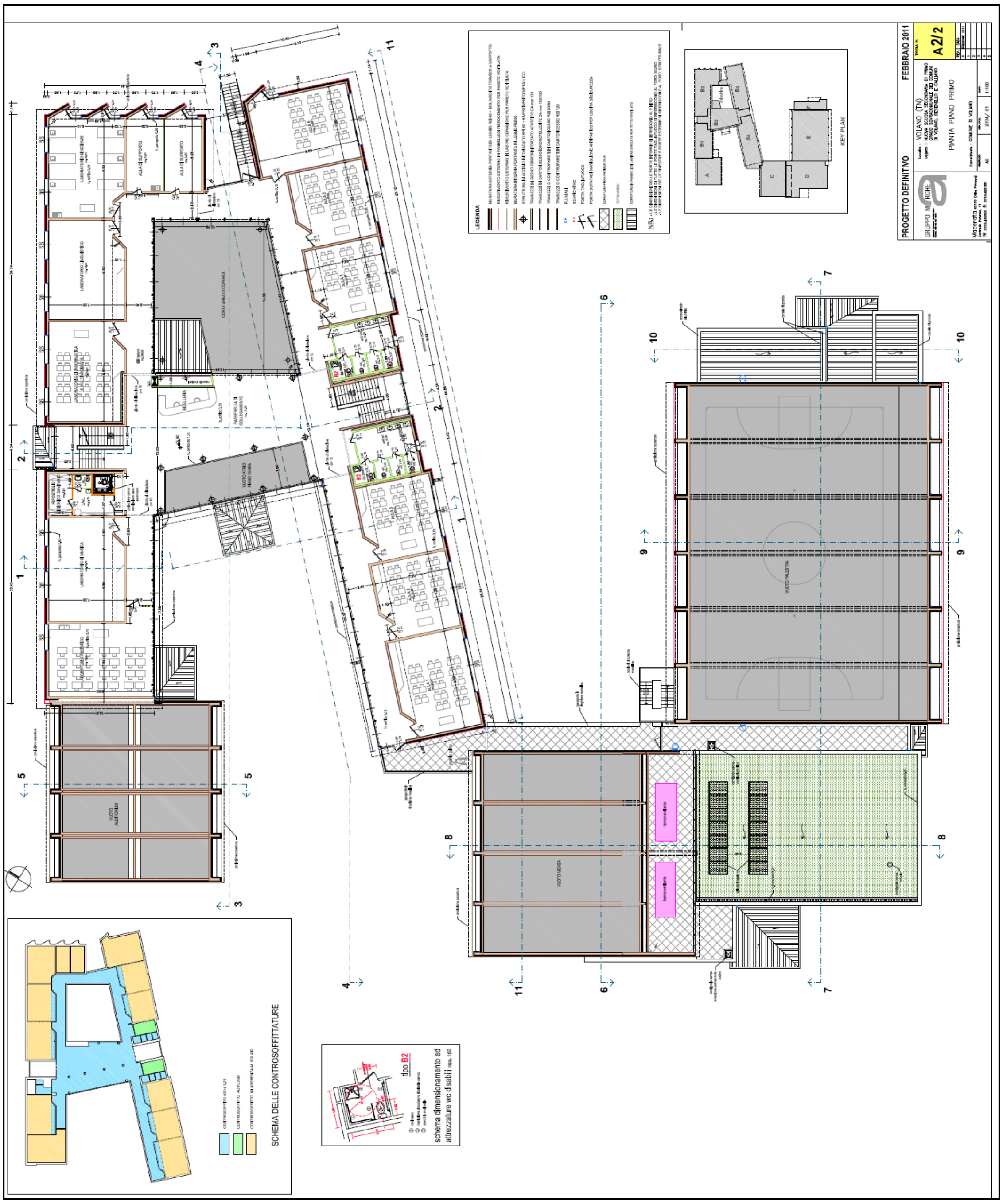
Rendering view of the building entrance. *Source & Copyright: Gruppo Marche.*

Rendering view of the building main court. *Source & Copyright: Gruppo Marche.*

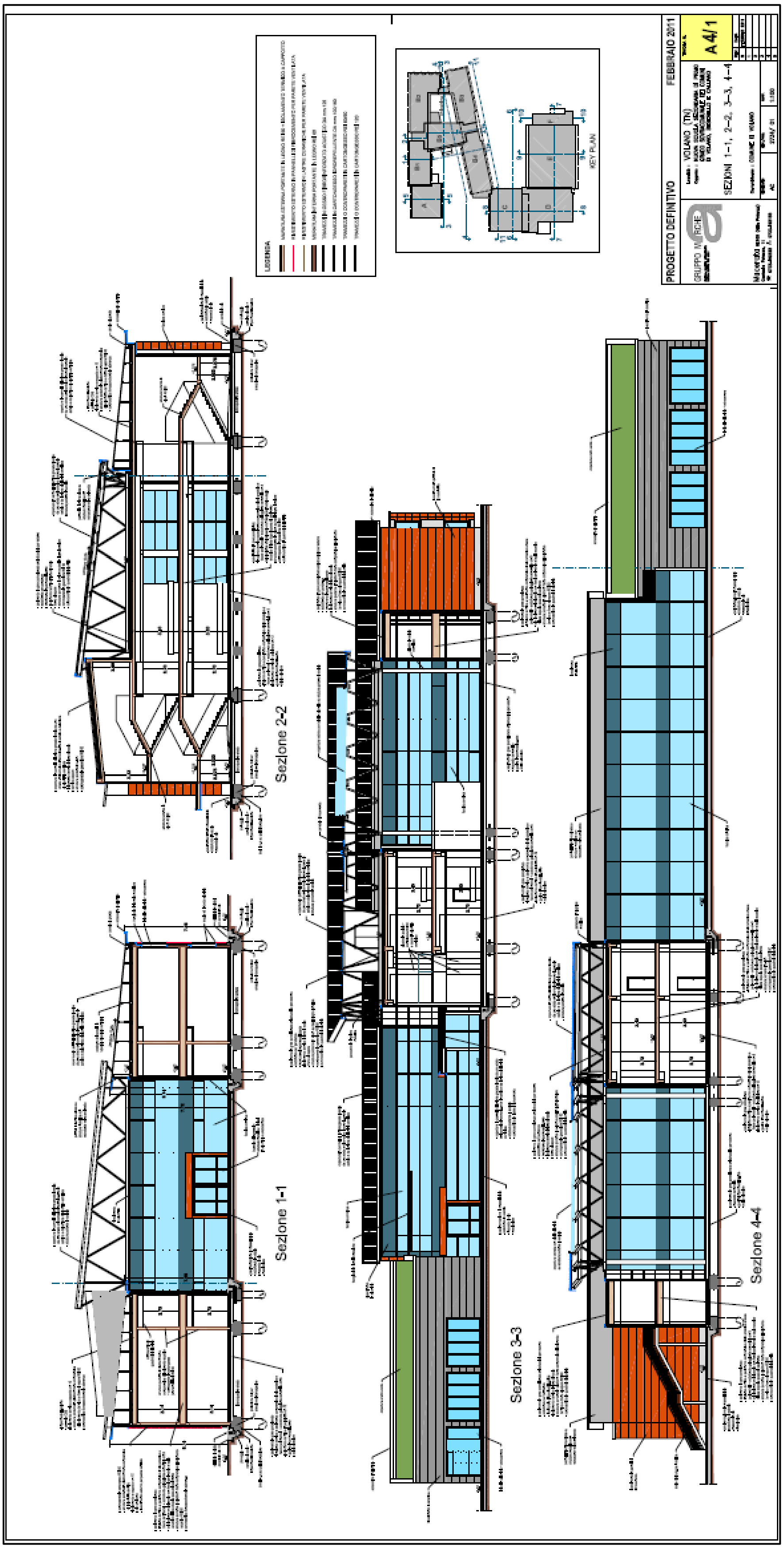
Rendering view of the building from the parking lot. *Source & Copyright: Gruppo Marche.*



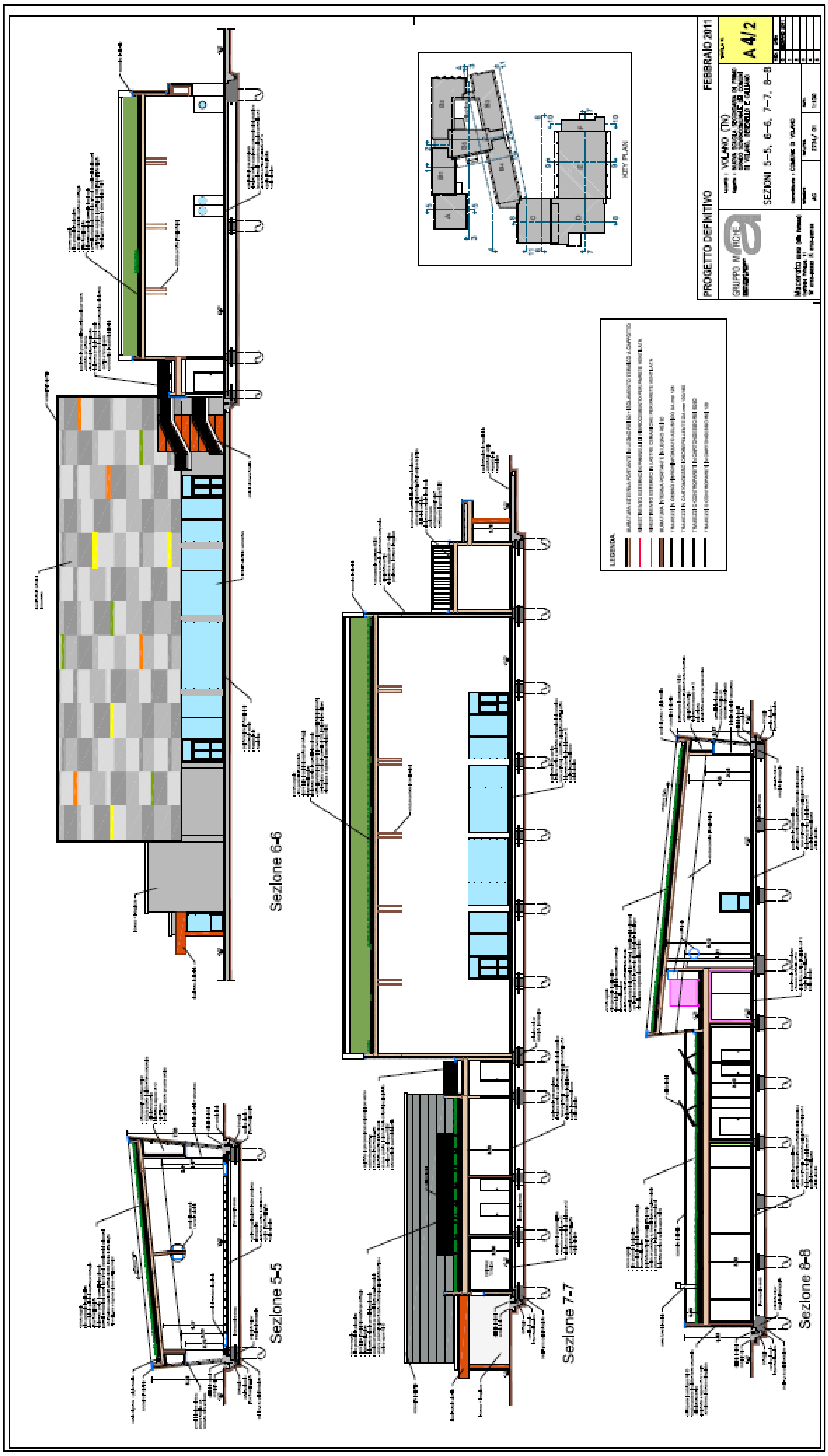
General plan of the building ground floor. *Source & Copyright: Gruppo Marche.*



General plan of the building first floor. *Source & Copyright: Gruppo Marche.*



General plan of the building sections 1-1, 2-2, 3-3. *Source & Copyright: Gruppo Marche.*

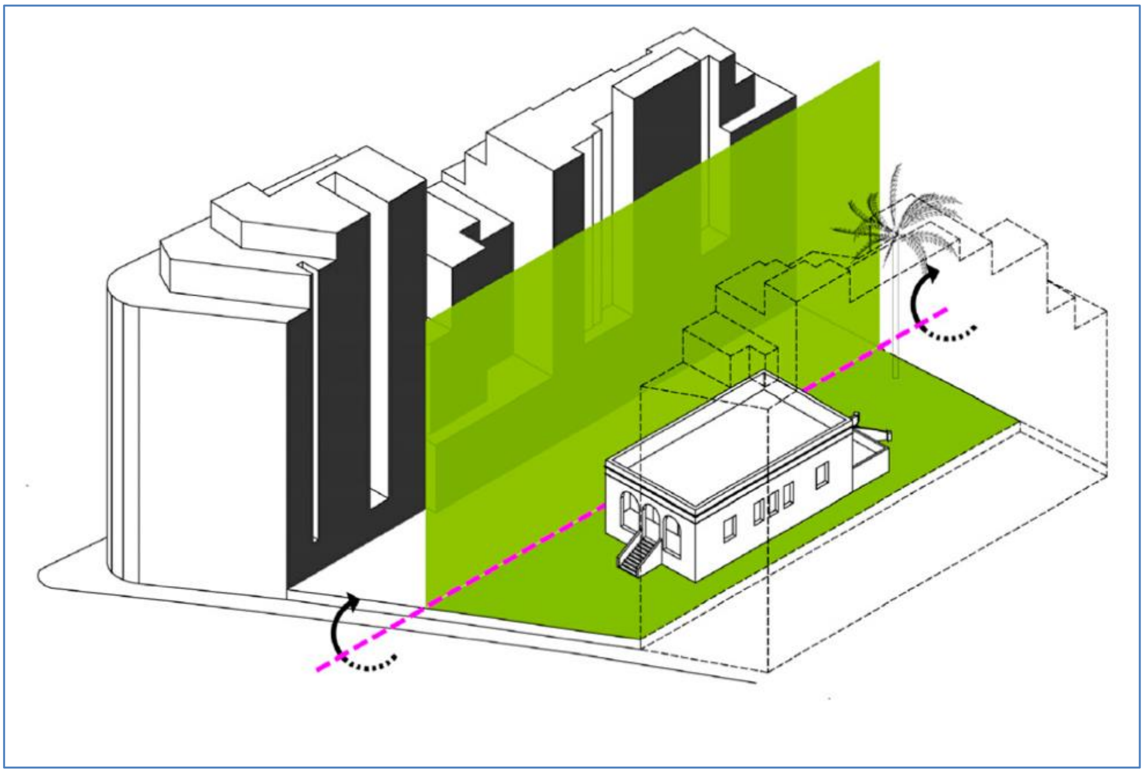


General plan of the building sections 4-4, 5-5, 6-6. *Source & Copyright: Gruppo Marche.*

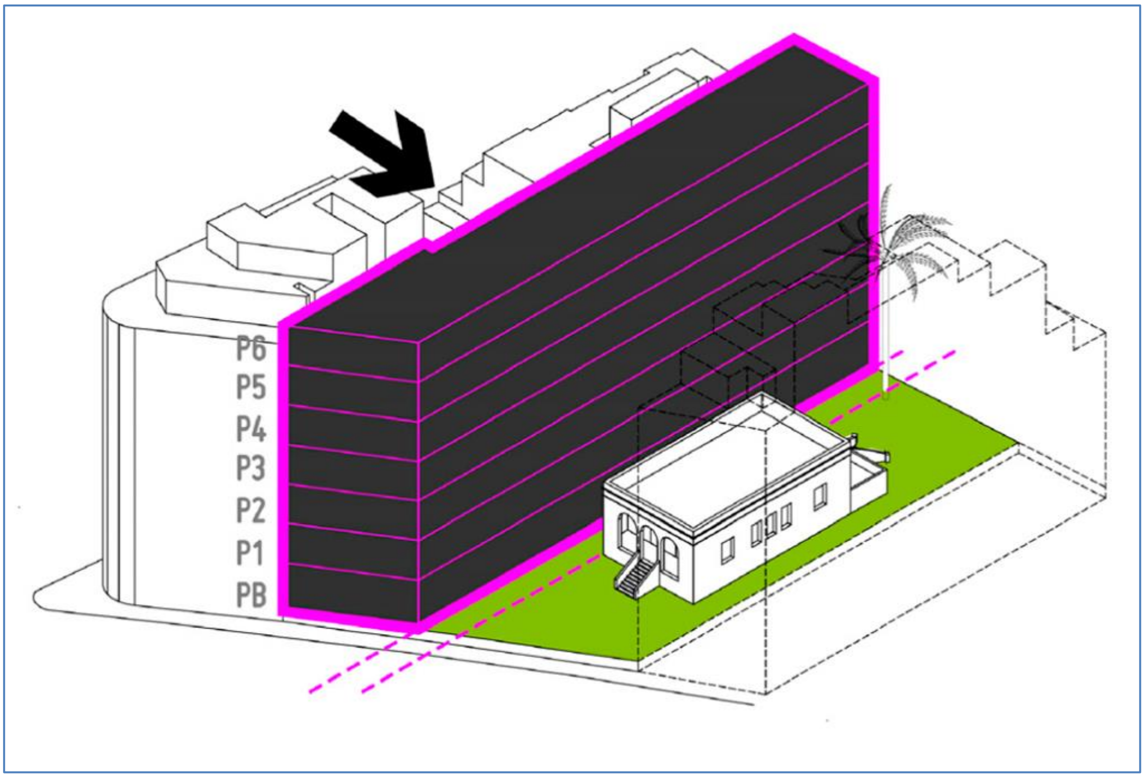
3. THE OFFICE BUILDING PROJECT IN BARCELONA.

The graphic documentation reported below summarizes the project magnitude and its main development phases.

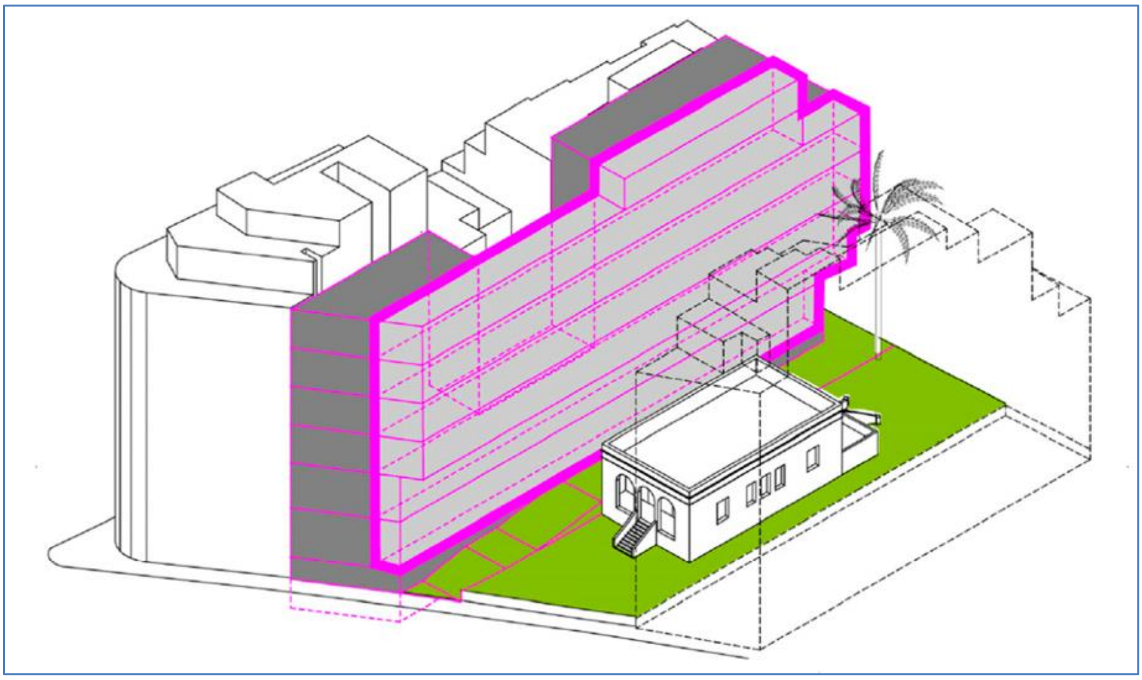
General plan of the building surrounding area. *Source & Copyright: SUMO arquitectos.*



First building-design phase - demolition. *Source & Copyright: SUMO arquitectos.*



Second building-design phase – building renovation and new addition. *Source & Copyright: SUMO arquitectos.*



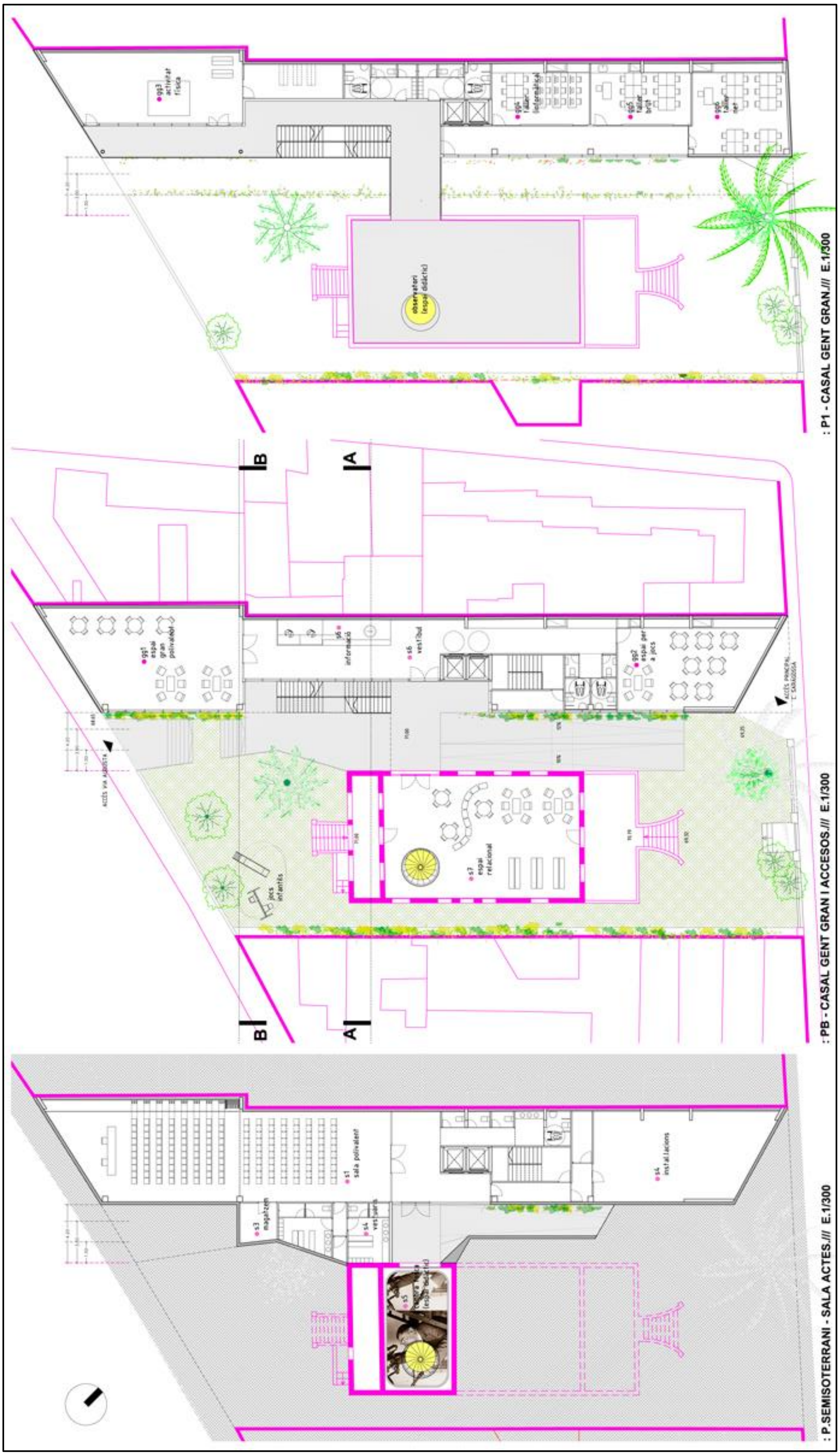
Third building-design phase – internal space and external landscape renovation. *Source & Copyright: SUMO arquitectos.*

Fourth building-design phase – internal and external finishes. *Source & Copyright: SUMO arquitectos.*

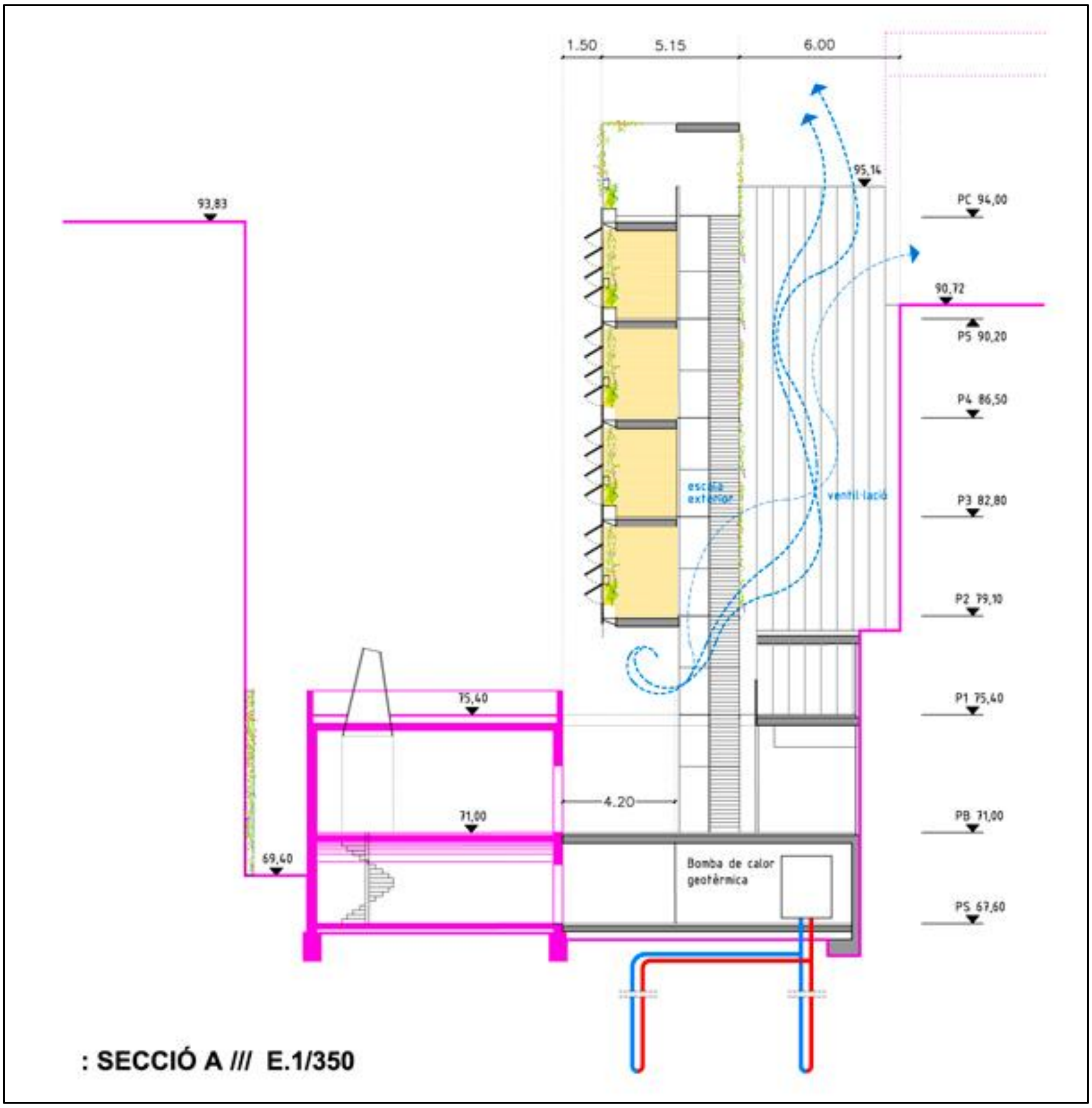
Rendering view of the whole building. *Source & Copyright: SUMO arquitectos.*

Rendering view of the interior corridor of the building. *Source & Copyright: SUMO arquitectos.*

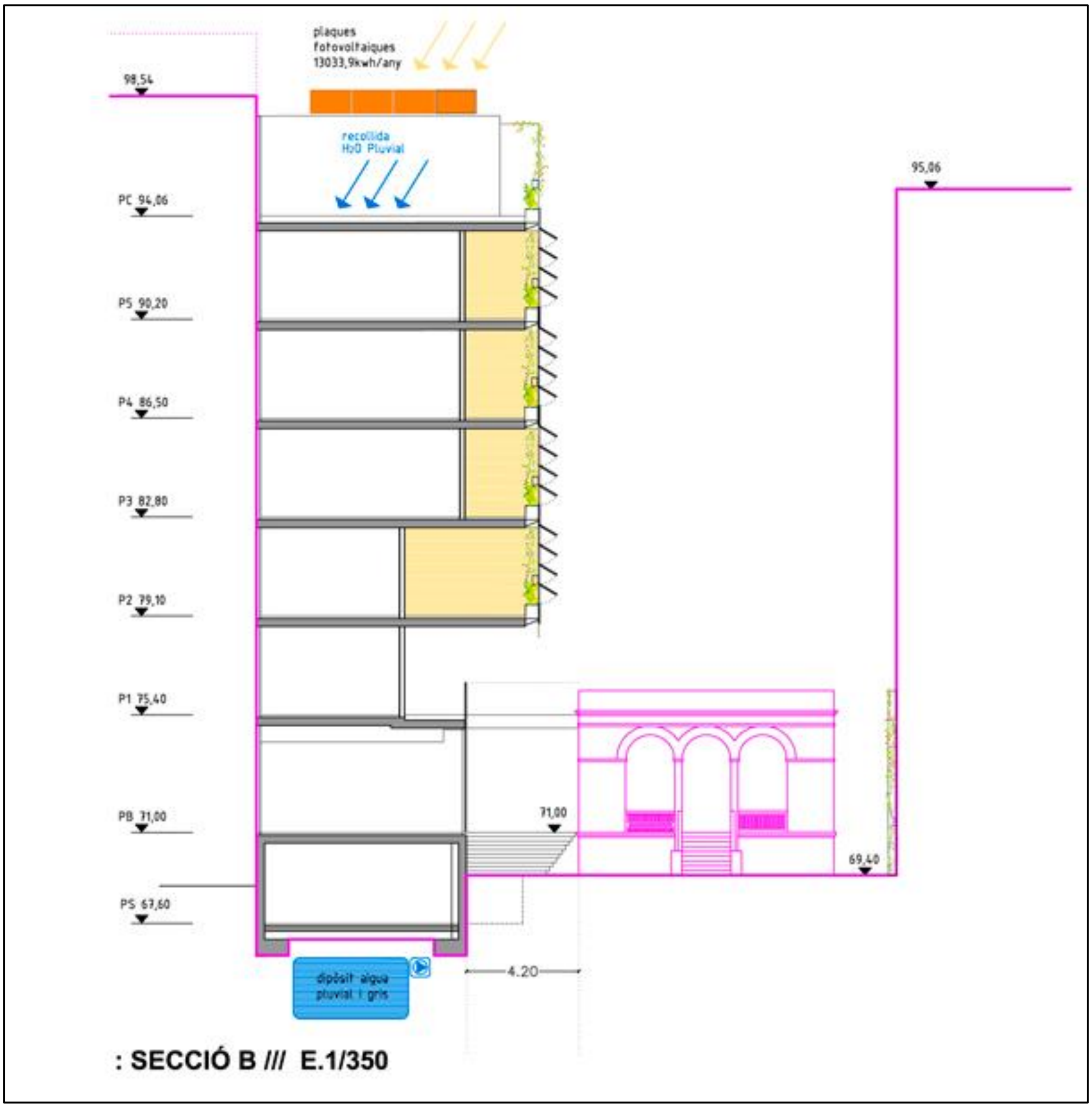
Rendering view of the exterior vegetated façade of the building. *Source & Copyright: SUMO arquitectos.*



Project plans – ground floor. *Source & Copyright: SUMO arquitectos.*



Project drawing – building A-A section. *Source & Copyright: SUMO arquitectos.*



Project drawing – building B-B section. *Source & Copyright: SUMO arquitectos.*

4. THE OFFICE BUILDING IN SOUTHERN SPAIN.

Due to the confidentiality of information involved, the project owner didn't authorize the publication of graphic documentation related to the building nor the surrounding area.

APPENDIX 2

Case-study projects: scheduling documentation

1. THE SCHOOL-COMPLEX PROJECT.

The following document summarizes the design-process milestones considered.

LIST OF ACTIVITIES – DESIGN PROCESS MILESTONES

PREAMBOLO:

Inizio progetto preliminare:

- Urgenza per stesura progetto preliminare dovuta alla scadenza dei contributi
- Contratto redatto in ritardo, lavori di fretta – Affido lavori agosto 2006 – Consegna Settembre 2006
- Delibera per depenalizzazione lavori consegnati in ritardo Dicembre 2006

NB: Richiesta progettazione congiunta con C10 non ascoltata per tempistiche troppo ristrette.

ITER PROGETTAZIONE DEFINITIVA - ESECUTIVA

1. 08/2006: sottoscrizione accordo di programma tra comuni per divisione dei beni – durata 5 anni
2. 09/2006: presentazione ed approvazione progetto preliminare – costo preliminare previsto **13,225,000 €** (Opere + somme a disposizione compreso esproprio)
3. Manifesta necessità di modificare il PRG
   2
4. 10/2006: Riunione organizzativa
   2
5. 04/2007: approvazione elenco interventi ammessi a finanziamento dalla PAT (generale per gruppi di finanziamento)
6. 09/2007: richiesta finanziamento presentata dal comune per scuola alla PAT
   2
7. 03/ 2008: delibera intervento ammissibile fino a 9,761,153 € - Scadenza finanziamento Marzo 2009
   5
8. 04/2008: creazione istituto comprensivo
9. 10/2008: LEED acquisito come protocollo di riferimento dalla PATT
10. 12/2008: impegno di 550,000 € per fronteggiare spese tecniche
    6
11. 12/2008: Bando Gara Scuola progettazione– Raccolta pareri
    9
    Problemi legate alla: valutazione delle offerte, verifica requisiti, difficoltà procedurali previste dalla legge (in estate le commisssioni non si trovano)
12. 02/2009: gara d'appalto progetto def – esec – sicurezza
    10, 11
13. 02/2009: richiesta proroga finanziamento
    6
14. 04/2009: proroga finanziamento al 03/2010 da parte della PAT
    12
15. 10/2009: aggiudicazione Gruppo Marche firmato il 01/2010
    10
16. Manifesta necessità di modificare PGUAP & PRG (ri-sottolineata dai tecnici Orsi e Castelli).
    2
17. 02/2010 – 06/2010 meeting con Bacini Montani + ricerca soluzioni per zona R4
    15
18. Elaborazione dati da parte dei bacini montani
    16

1. 02/2010: richiesta proroga finanziamento (Firma contratto con Gruppo Marche in ritardo)
   14
2. 04/2010: proroga finanziamento al 03/2011 da parte della PAT
   18
3. 08/2010: affidamento a Grisotto dello studio di compatibilità + ricerca soluzioni idro-geologiche per l'area.
   15, 16, 19
4. 11/2010: rilievo urgente dell'area ; il progetto definitivo era stato sviluppato "in aria" e era necessario fare un rilievo di corsa per poter andare in CTA ma in CTA ci siamo andati un anno dopo alla fine per problemi vari (PGUAP, PRG, etc)
   14, 17 (dipende da scadenza finanziamento)
5. 02/2011: richiesta sospensione termine di consegna progetto definitivo a data da destinarsi (non solamente posticipato)
   17 (ritardo dei bacini montani nel consegnare il progetto)
6. 02/2011: studio compatibilità idraulica di Grisotto approvato dalla PAT
   20, 21
7. 03/2011: presentazione progetto definitivo generale dal comune **costo 13,200,000 € - Decisione di spaccarlo in 2 lotti**
   14, 21
8. 05/2011: richiesta integrazione finanziamento
   24
9. 08/2011: conferma sospensione dei termini di scadenza
   22
10. PROBLEMA BACINI MONTANI: Riunioni + Presentato piano di misure di Grisotto + piano sul tavolo del direttore per n mesi + problemi strutture una accanto all'altro (infratrutture tra una e l'altra)
11. 05/2011: modifica PGUAP
    16, 20, 21, 27
12. 09/2011: scadenza accordo di programma sottoscritto dai 3 comuni nel 2006 – richiamo della Provincia e corse per fare il 2° accordo di programma (delibere + giunte + ecc.). Il 2° accordo di programma dura 5 anni ma "comunque fino alla fine dei lavori".
    1
13. 11/2012: altro rilievo + frazionamento dell'area perché era nata la casa di riposo e necessità di separare ed annettere parte del terreno
14. 12/2011: richiesta sospensione alla PAT del termine per consegna progetto 1° lotto (Progetto definitivo pronto ma la PAT non ci inseriva in CTA quindi dovevamo ri-inviare)
15. 02/2012: presentazione e approvazione prog. Definitivo dal CTA provincia – solo 1° lotto perché superiore ai 5 milioni di € - **conferma finanziamento**
    Da tutto ma soprattutto dal 30
16. 03/2012: conferma finanziamento 1° lotto da parte della PAT
    32
17. 03/2012: affidamento 1° lotto al Gruppo Marche per Prog. Esecutivo + 2° lotto eventuale
    33
18. 07/2012: riunione tecnici SCUOLA – RSA promossa da Orsi per definizione urbanistica e infrastrutturale dell'area (strada che passava in mezzo)
    33,
19. 09/2012: approvazione finanziamento 2° lotto per 3,438,847 € **(spesa ammessa = 3,440,000 €)**

25

1. Finanziamento concesso = 95% del secondo lotto, perso tanto tempo per trovare le somme per coprire il buco imprevisto.
2. 10/2012: approvazione in linea tecnica del progetto definitivo + impegno formale della somma = 12,649,400 € di cui 550,600€ già impegnati nel 12/2008
   36, 35, 34, 37
3. 10/2012: Inizio processo di esproprio (previa approvazione tecnica definitivo)
   38
4. 10/2012: approvazione convenzione con Gruppo Marche per riunificare il progetto esecutivo in un unico lotto
   38
5. 03/2013: consegna progetto esecutivo (spesa totale = 13,200,000 €)
   40
6. 04/2013: richiesta di verifica del progetto esecutivo da parte del Gruppo Marche (verifica effettuata e finalizzata entro 1 settimana dalla comunicazione)
7. 03/2013: convenzione con l'APAC di Trento per passare l'appalto alla Provincia

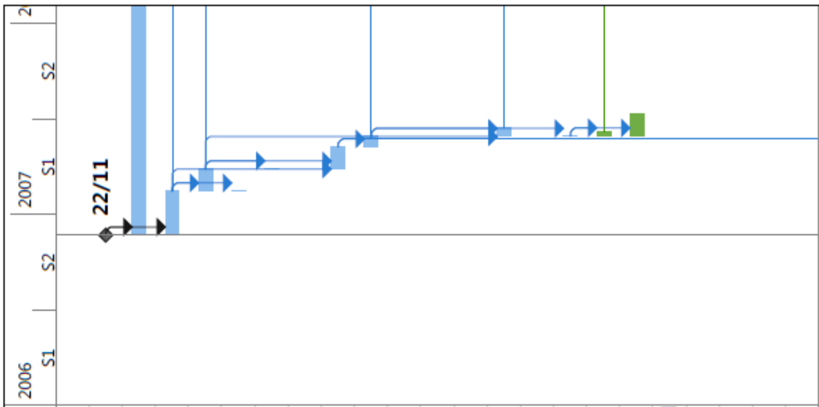
SOLDI EXTRA PER PROGETTAZIONE DEFINITIVA ED ESECUTIVA:

Revisione progetto preliminare (lo hanno rivisto secondo le nuove esigenze) (è passato troppo tempo quindi esigenze nuove)
Smembramento progetto in 2 lotti:

- Progetto Definitivo 1° lotto
- Progetto Esecutivo 1° lotto
- Unificazione progetto alla fine

The following documentation summarizes the procedure followed by the researcher to calculate the time-related issues of the project through the implementation of the software Microsoft Project.

Id	Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
1			1 día?	jue 17/07/14	jue 17/07/14	
2		START	0 días	mié 22/11/06	mié 22/11/06	
3		"Accordo di programma" between	1825 días	mié 22/11/06	mar 19/11/13	2
4		Preliminary Design Developed and Presented	60 días	mié 22/11/06	mar 13/02/07	2
5		Preliminary Design Approved	30 días	mié 14/02/07	mar 27/03/07	4
6		Procedure starts to change PRG	1 día	mié 14/02/07	mié 14/02/07	4
7		"Half" Kick-off meeting	1 día	mié 28/03/07	mié 28/03/07	5
8		PROBLEM - Not attending	1 día?	jue 17/07/14	jue 17/07/14	
9		Funding proposal presented to PATT	30 días	mié 28/03/07	mar 08/05/07	4;5
10		Deliberation of 9,761,153 €	14 días	mié 09/05/07	lun 28/05/07	9
11		LEED acquired as reference protocol by PATT	0 días	jue 01/01/09	jue 01/01/09	
12		P03: organizing LEED activities and LEED-related	21 días	jue 01/01/09	jue 29/01/09	11
13		PROBLEM - LEED activitied and bid protocols	1 día?	jue 17/07/14	jue 17/07/14	
14		550,000 € loyalty for technical expences	14 días	mar 29/05/07	vie 15/06/07	5;10
15		LEED AP Contracted	30 días?	vie 30/01/09	jue 12/03/09	11;14;12
16		Decision of developing a design-bid-buit project	1 día?	mar 29/05/07	mar 29/05/07	10
17		M&V Plan	5 días	mié 30/05/07	mar 05/06/07	16
18		Adjust anglosaxon procedures to european	30 días	mié 30/05/07	mar 10/07/07	16
19		Public bid - design stage - 1st draft	60 días	vie 13/03/09	jue 04/06/09	10;4;14;15;1
20		Design bid publication (def + exec + sec)	0 días	jue 04/06/09	jue 04/06/09	19
21		PROBLEM: bid evaluation delayed	2 días	vie 05/06/09	lun 08/06/09	20
22		Commission designation	20 días	mar 09/06/09	lun 06/07/09	21
23		Commission avaluates bids	70 días	mar 07/07/09	lun 12/10/09	22

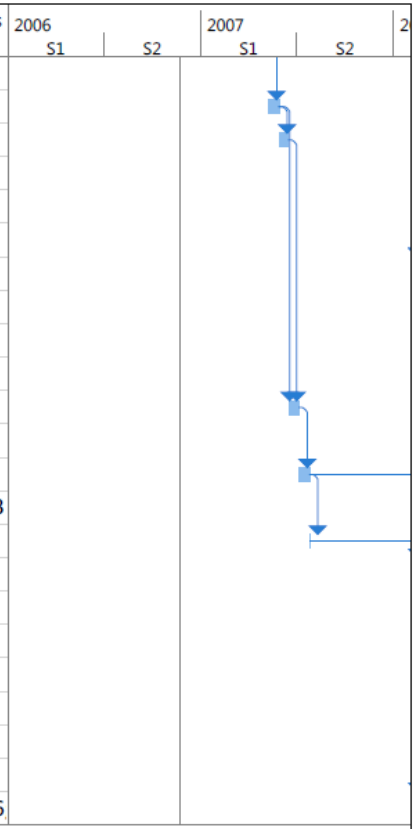


Proyecto: List of activities 2
Fecha: mar 23/05/17

Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	

Página 1

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
24			Commission decision + publication of results	38 días	mar 13/10/09	jue 03/12/09	23
25			Request for PATT funding extension	14 días	mié 09/05/07	lun 28/05/07	9
26			PATT funding extesion granted	14 días	mar 29/05/07	vie 15/06/07	25
27			Gruppo Marche wins the bid	0 días	jue 03/12/09	jue 03/12/09	24
28			"Definitive" design in-charged to Gruppo	150 días	vie 04/12/09	jue 01/07/10	27
29			PROBLEM: flood problem	7 días	vie 02/07/10	lun 12/07/10	28
30			Procedure for modifying PGUAP and PRG	1 día	mar 13/07/10	mar 13/07/10	4;5;29
31			Meeting with "Bacini Montani" and RSA	21 días	mié 14/07/10	mié 11/08/10	30
32			Data analyzed by Bacini Montani	180 días	jue 12/08/10	mié 20/04/11	31
33			PROBLEM: need geological prescription /	14 días	jue 21/04/11	mar 10/05/11	32
34			Request for PATT funding extension	14 días	lun 18/06/07	jue 05/07/07	25;26
35			PROBLEM: contract delay with Gruppo Marche	1 día	vie 04/12/09	vie 04/12/09	27
36			Funding extension granted	14 días	vie 06/07/07	mié 25/07/07	34
37			Grisotto in charge of geotechnical solution	30 días	mié 11/05/11	mar 21/06/11	30;31;32;33
38			PROBLEM: geo-referential survey needed	1 día?	jue 26/07/07	jue 26/07/07	36
39			Need of area geometrical survey	1 día?	vie 02/07/10	vie 02/07/10	28;38
40			Survey granted to Battisti	5 días	lun 05/07/10	vie 09/07/10	39
41			Survey developed by Battisti	14 días	lun 12/07/10	jue 29/07/10	40
42			"Delibera" by municipality	21 días	vie 30/07/10	vie 27/08/10	41
43			Request of suspension due date for project	14 días	mié 22/06/11	lun 11/07/11	37
44			Grisotto develops project solution	90 días	mar 12/07/11	lun 14/11/11	37;43
45			Grisotto's solution approved by PATT	30 días	mar 15/11/11	lun 26/12/11	44
46			Definitive design modified and now ready	30 días	mar 27/12/11	lun 06/02/12	28;41;45;36



Proyecto: List of activities 2
Fecha: mar 23/05/17

Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	

Página 2

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras	2006 S1	S2	2007 S1	S2	2
47			PROBLEM: funding is expiring, not enough	1 día?	mar 07/02/12	mar 07/02/12	46					
48			Decision of breaking project in 2 lots	14 días	jue 17/07/14	mar 05/08/14						
49			Request of funding integration	14 días	mié 06/08/14	lun 25/08/14	48					
50			Due date suspension funding #1 granted	14 días	mar 26/08/14	vie 12/09/14	49					
51			PROBLEM: bacini montani delays the process	1 día?	mié 22/06/11	mié 22/06/11	32;37					
52			PGUAP modified - Problem Bacini Montani Fixed	0 días	lun 06/02/12	lun 06/02/12	46;45					
53			First "accordo di programma" expired	1 día?	mié 20/11/13	mié 20/11/13	3					
54			PROBLEM: quickly doing new "accordo di	1 día?	jue 21/11/13	jue 21/11/13	53					
55			New RSA	1 día?	jue 13/09/12	jue 13/09/12						
56			Exchange of properties, new survey needed	1 día	vie 14/09/12	vie 14/09/12	55					
57			1st lot (definitive) completed by Gruppo Marche	1 día?	jue 11/10/12	jue 11/10/12						
58			Energy Modeling Sample-model developed by	1 día?	vie 12/10/12	vie 12/10/12	57					
59			P01: E.M. software different architect / USGBC	45 días	lun 15/10/12	vie 14/12/12	58					
60			Energy mBid for Energy Modelling and	90 días	lun 17/12/12	vie 19/04/13	59					
61			Energy modelling subcontracted to ICMQ	30 días	lun 22/04/13	vie 31/05/13	60					
62			P01: Energy modelling have to wait until design	120 días	lun 03/06/13	vie 15/11/13	61					
63			P01: Project is developed without sense of	1 día?	lun 18/11/13	lun 18/11/13	62					
64			1st lot (definitive) presented + approved by CTA	90 días	dom	jue 26/12/13	46;52;57;63					
65			Funding for 1st lot approved	1 día?	vie 27/12/13	vie 27/12/13	64					
66			Gruppo Marche in-charge of 1st lot executive	1 día?	lun 30/12/13	lun 30/12/13	65					
67			Commissioning Authority comes in	1 día?	jue 17/07/14	jue 17/07/14						
68			P02: CxA kick-off meeting with designers never	1 día?	jue 17/07/14	jue 17/07/14						
69			Technical meeting School - RSA promoted by	25 días	vie 27/12/13	jue 30/01/14	55;64					

Proyecto: List of activities 2
Fecha: mar 23/05/17

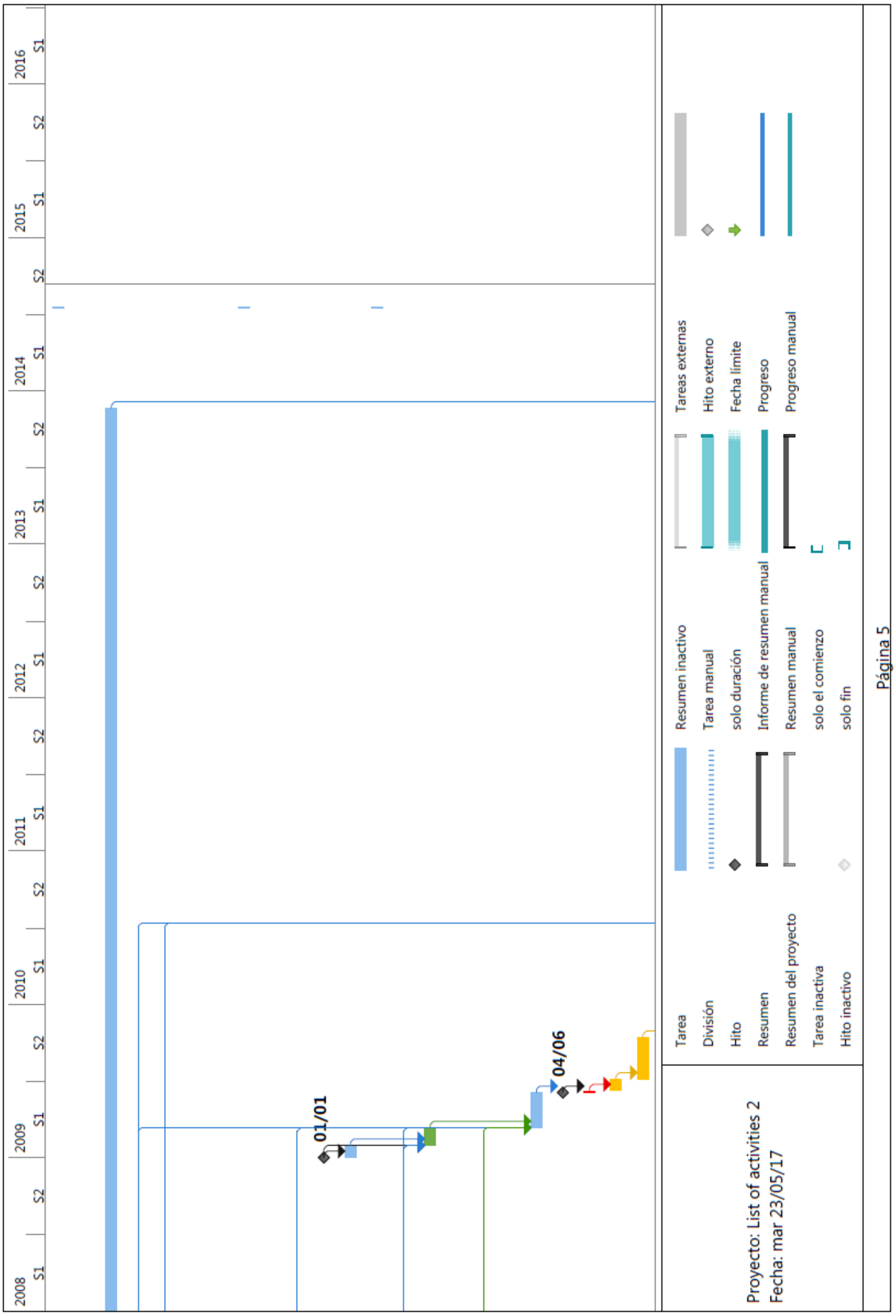
Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	

Página 3

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras	2006 S1	S2	2007 S1	S2
70			Problem with "Bacini Montani" and RSA fixed	1 día?	vie 31/01/14	vie 31/01/14	69				
71			PROBLEM: funding = 95% of 2nd lot, need time	1 día?	jue 17/07/14	jue 17/07/14					
72			Technical approval of definitive design	0 días	vie 31/01/14	vie 31/01/14	70				
73			Expropriation process begins	1 día?	lun 03/02/14	lun 03/02/14	72				
74			Request to Gruppo Marche to merge the 2 lots	1 día?	mar 31/12/13	mar 31/12/13	66				
75			Executive design done (13,200,000 €)	1 día?	mié 01/01/14	mié 01/01/14	74				
76			P01: no time to adjust the project to the E.M.	1 día?	jue 02/01/14	jue 02/01/14	75				
77			Project verified by Gruppo Marche	1 día?	jue 02/01/14	jue 02/01/14	75				
78			P02: CxA review, need to change executive	14 días	vie 18/07/14	mié 06/08/14	68				
79			P02: Designer follows CxA but Can't impose 1	1 día?	jue 07/08/14	jue 07/08/14	78				
80			The executive project is finalized following CxA	1 día?	vie 08/08/14	vie 08/08/14	79				
81			Agreement with APAC for Construction Bid	1 día	lun 11/08/14	lun 11/08/14	77;72;80				
82			Design Phase Ends	0 días	lun 11/08/14	lun 11/08/14	77;81				
83			LEED Documentation Completed	1 día?	mar 12/08/14	mar 12/08/14	82				
84			LEED Review Received	1 día?	mié 13/08/14	mié 13/08/14	83				
85			P05: USGBC uses different standards for Energy	1 día?	jue 14/08/14	jue 14/08/14	84				

Proyecto: List of activities 2
Fecha: mar 23/05/17

Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	


2008
S1
S2
2009
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S1
S2
2011
S1
S2
2012
S1
S2
2013
S1
S2
2014
S1
S2
2015
S1
S2
2016
S1
01/01
04/06
Proyecto: List of activities 2
Fecha: mar 23/05/17
Tarea
División
Hito
Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual
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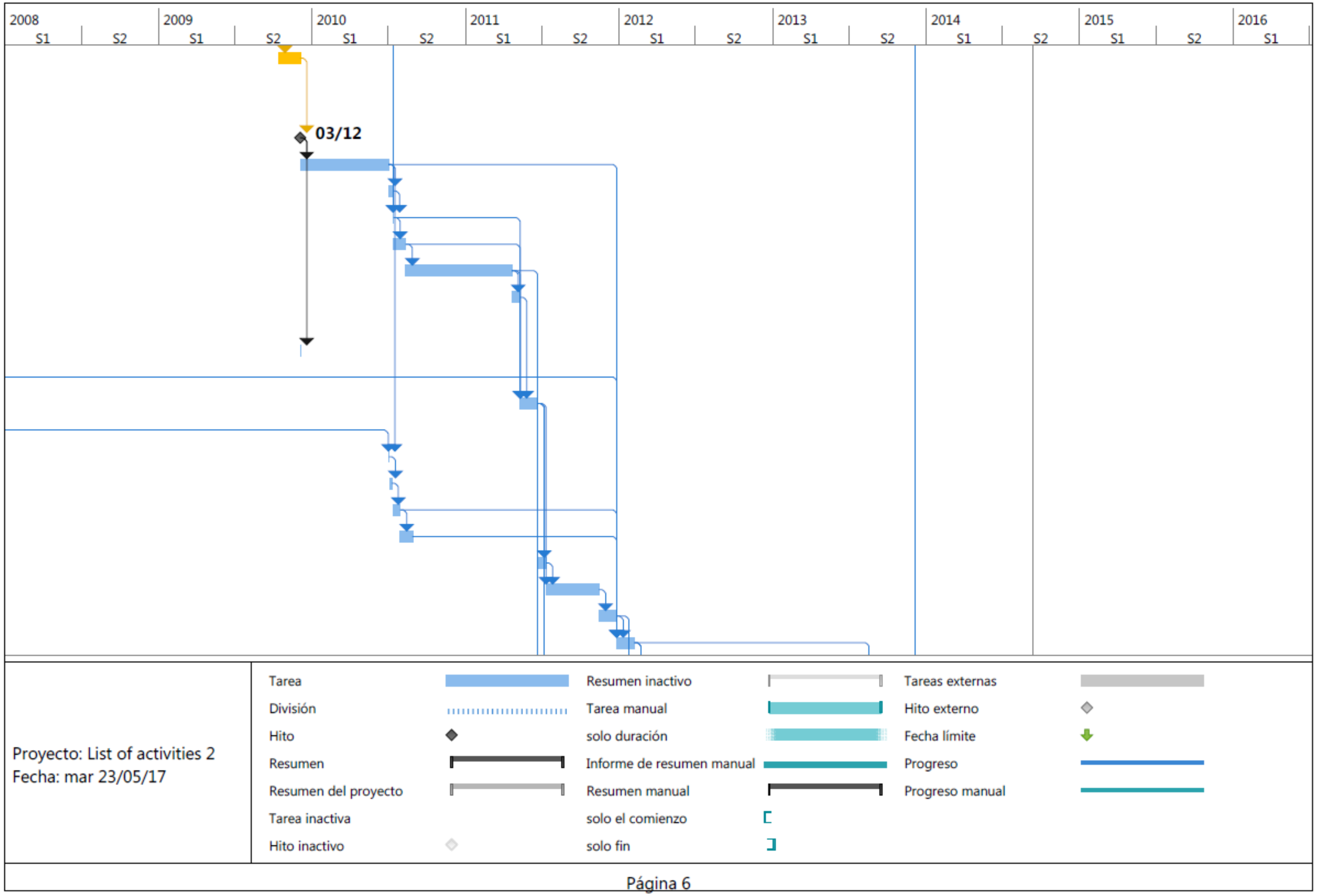
2008
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2014
S1
S2
2015
S1
S2
2016
S1
03/12
Proyecto: List of activities 2
Fecha: mar 23/05/17
Tarea
División
Hito
Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual
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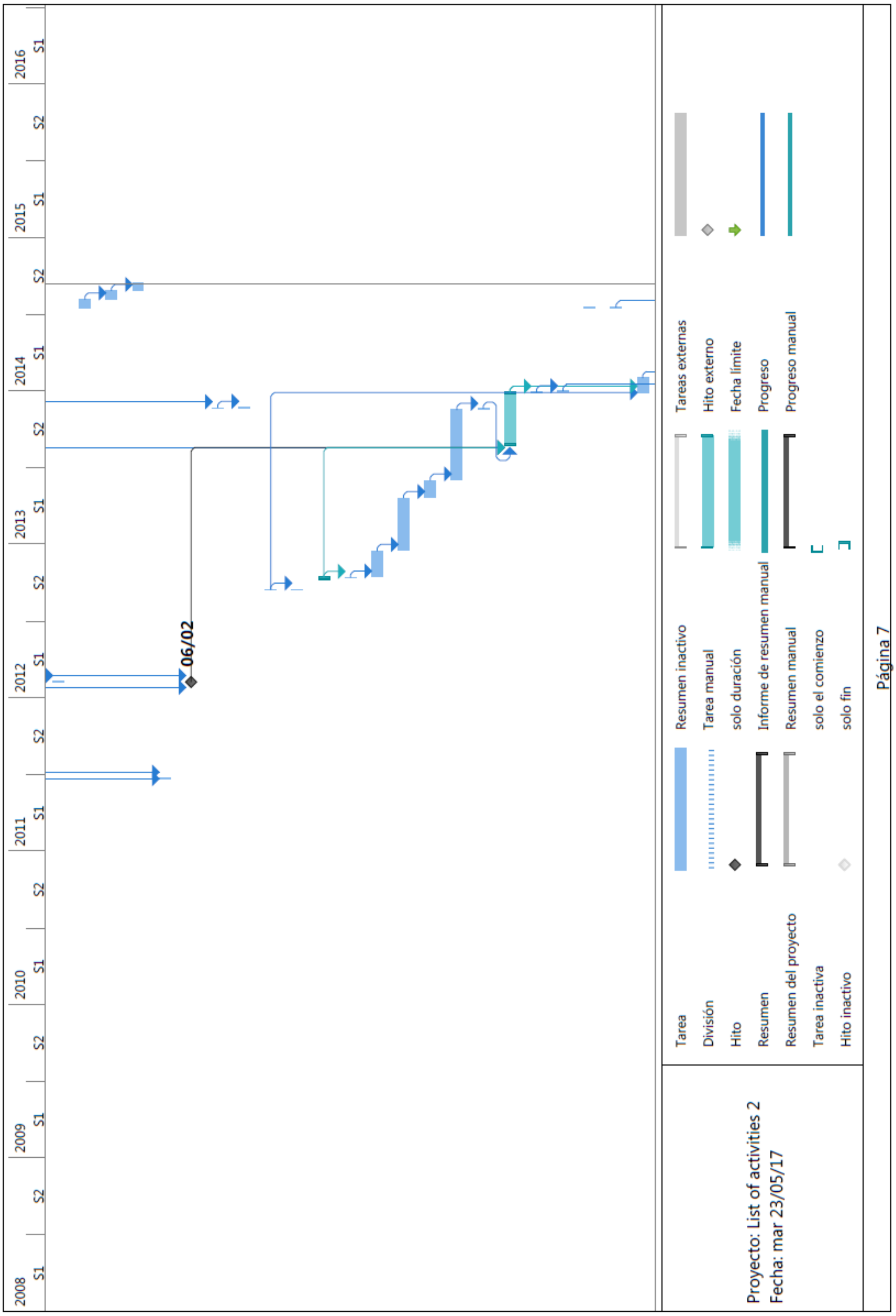
2008 S1 S2
2009 S1 S2
2010 S1 S2
2011 S1 S2
2012 S1 S2
2013 S1 S2
2014 S1 S2
2015 S1 S2
2016 S1
06/02
Proyecto: List of activities 2
Fecha: mar 23/05/17
Tarea
División
Hito
Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual
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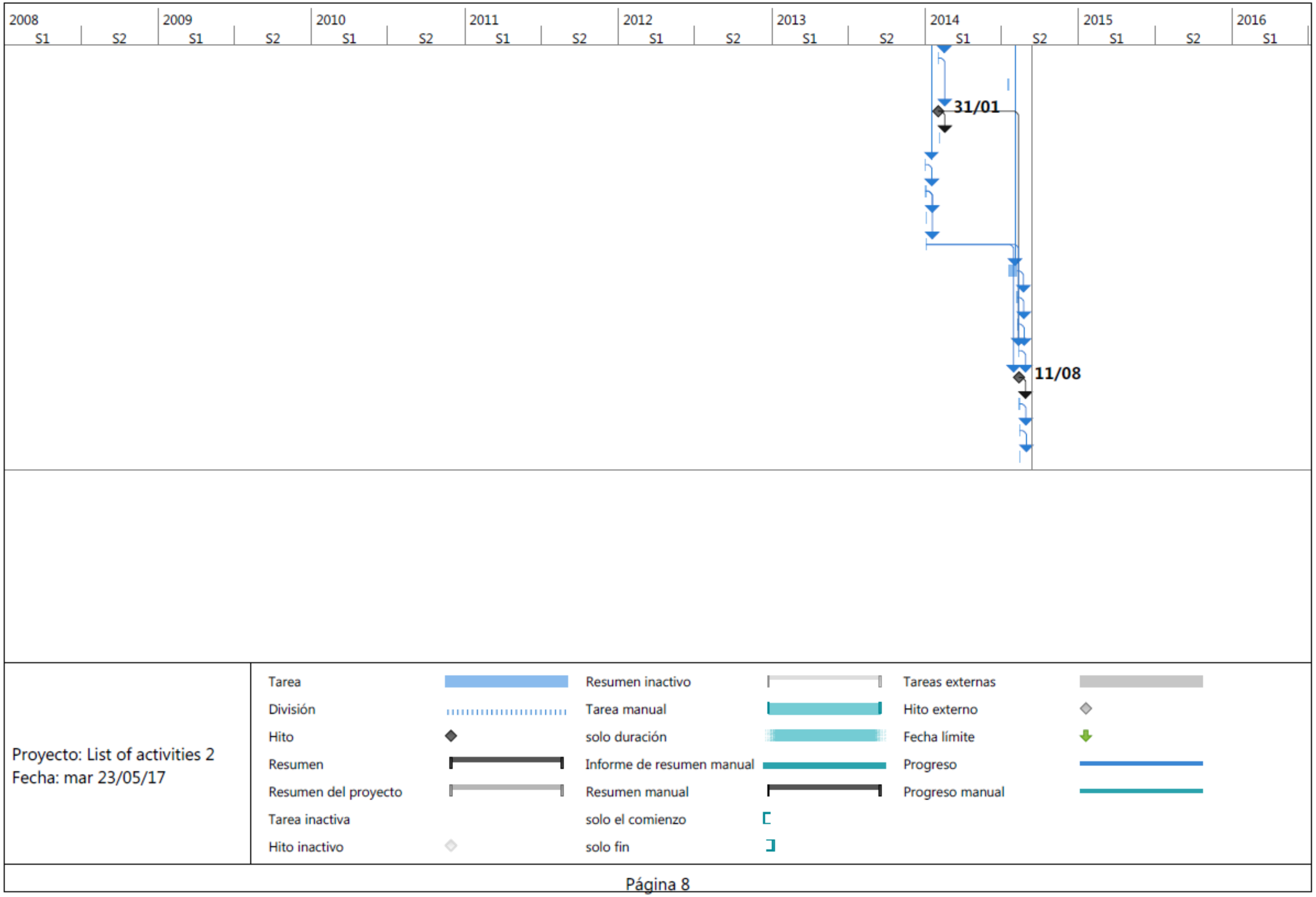

2008
S1
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2013
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S2
2014
S1
S2
2015
S1
S2
2016
S1
31/01
11/08
Proyecto: List of activities 2
Fecha: mar 23/05/17
Tarea
División
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Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual
Página 8

2. THE NURSING-HOME PROJECT.

The following document summarizes the design-process milestones considered.

OGGETTO: **COSTRUZIONE NUOVA R.S.A. DI VOLANO**
DISTINTA PRESTAZIONI PROFESSIONALI (più significative) per assistenza tecnica al responsabile del procedimento (R.U.P.)
PERIODO PRESTAZIONI: dal 15.06.2012 al 31.01.2015

GIUGNO 2012

- fase istruttoria pratica;
- stesura e invio PARERE TECNICO;
- riunioni, colloqui e verifiche c/o Opera Romani: 18.06 - 22.06;
- riunioni/colloqui c/o Comune di Volano: 20.06
- verifica documentazione progettuale;
- colloqui telefonici vari e corrispondenza e-mail con gruppo di progettazione, Comune di Volano, Opera Romani, Ing. Orsi (leed).

LUGLIO 2012

- riunioni, colloqui e verifiche c/o Opera Romani: 02.07 - 18.07 - 30.07;
- riunioni, colloqui e verifiche c/o Comune di Volano: 02.07 - 18.07 -
- riunioni, colloqui e verifiche c/o P.A.T.: 03.07 - 06.07
- istruttoria con geom. Battisti per stesura nuovo tipo di frazionamento: 05.07 - 07.07.
- verifica documentazione progettuale;
- colloqui telefonici vari e corrispondenza e-mail con gruppo di progettazione, Comune di Volano, Opera Romani, Studio Notarile Bonfiglio, Ing. Orsi (leed).

AGOSTO 2012

- riunioni, colloqui e verifiche c/o Opera Romani: 02.08 - 07.08 - 28.08;
- riunioni, colloqui e verifiche c/o Comune di Volano: 07.08 - 21.08 - 23.08
- riunioni, colloqui e verifiche c/o P.A.T. - Tutela Paesaggio: 09.08
- stampa e fascicolazioni documentazione progettuale per messa in sicurezza idraulica , consegna elaborati a Opera Romani e Tutela del Paesaggio;
- verifica documentazione progettuale;
- colloqui telefonici vari e corrispondenza e-mail con gruppo di progettazione, Comune di Volano, Opera Romani, Studio Notarile Bonfiglio, dott. Grisotto, P.A.T. Tutela del Paesaggio, A.P.S.S. Ufficio Rovereto geom. Zeni e Dott.ssa Mastromarino.

SETTEMBRE 2012

- istruttoria pratica per autorizzazione della Commissione per la Pianificazione Territoriale e il Paesaggio - Messa in sicurezza idraulica 1.a fase;
- deposito pratica Tutela Paesaggio;
- riunioni, colloqui e verifiche c/o Opera Romani: 07.09. - 24.09;

- verifica documentazione progettuale - progetto preliminare;
- istruttoria pratica progetto preliminare Dott.ssa Mastromarino e Dott.ssa Buffato dell'A.P.S.S. Rovereto - Servizi Sanitari e Sicurezza Ambienti di Lavoro;
- istruttoria preliminare per indizione gara di appalto - Messa in sicurezza idraulica 1.a fase.
- colloqui telefonici vari e corrispondenza e-mail con gruppo di progettazione, Comune di Volano (Dott.ssa Candotti Luisa, Dott. Nardin, Sindaco), Opera Romani, Tutela Paesaggio;

OTTOBRE 2012
- istruttoria gara d'appalto c/o Opera Romani con Dott. Cadonna;
- corrispondenza varia con Gruppo di progettazione e Enti interessati;
- verifica procedura per nuova normativa Terre e Rocce da Scavo D.M. n° 161/2012;
- riunioni varie c/o Opera Romani;
- partecipazione al Consiglio di Amministrazione c/o Opera Romani;
- pratica estirpazione viti a mezzo incontri con affittuari c/o Opera Romani e c/o terreno a Volano;
- colloqui telefonici vari e corrispondenza e-mail con gruppo di progettazione, Comune di Volano, Opera Romani.

NOVEMBRE 2012
- aggiornamenti pratica Tutela del Paesaggio per autorizzazione Messa in sicurezza idraulica 1.a fase;
- verifica progettuale progetto preliminare con Gruppo di Progettazione (quadro economico, ecc.);
- ritiro documentazione Tutela del Paesaggio e inoltro D.I.A. Comune di Volano;
- incontro c/o Opera Romani con Ing. Scarpone per verifica generale quadro economico progetto preliminare;
- richiesta e ritiro certificato conformità urbanistica del Comune di Volano;
- illustrazioni progetto preliminare alla Commissione incaricata dai tre Comuni;
- verifica preventiva progetto preliminare c/o V.V.F. di Trento: 26.11;
- incontro c/o Comune di Volano con Sindaco e Segretario;
- verifica c/o Ufficio Espropri (geom. Piras);
- verifica c/o P.A.T. Ufficio Acque Pubbliche per presenza pozzo Artesiano;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

DICEMBRE 2012
- riunioni in Comune di Volano per definizione pratica terre e rocce da scavo: 03.12
- corrispondenza per esproprio;
- verifica c/o P.A.T. (Servizio APPA) pratica terre e rocce da scavo: 12.12
- verifiche varie con il gruppo di progettazione;
- pratica pozzo H_2O c/o Servizio Acque Pubbliche Trento: 18.12;
- istruttoria per gara d'appalto: 20.12;
- deposito piano di utilizzo c/o Comune di Volano: 21.12;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

GENNAIO 2013

- sopralluoghi c/o Volano con ditte invitate alla gara per messa in sicurezza 1.a fase (n. 7 sopralluoghi: 07.01 ÷22.01)
- 23.01: incontro c/o il Comune di Volano;
- 25.01: incontro c/o Opera Romani con gruppo progettazione;
- corrispondenza per assegnazione appalto;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

FEBBRAIO 2013

- istruttoria per consegna lavori messa in sicurezza idraulica 1.a fase;
- corrispondenza con Comune di Volano per piano di utilizzo;
- 08.02: ritiro approvazione piano di utilizzo;
- istruttoria per verbale consegna inizio lavori e controllo documentazione;
- 15.02: consegna lavori messa in sicurezza idraulica 1.a fase;
- 18.02: deposito inizio lavori;
- 19.02: - verifica programma con Impresa Marsilli Spa
  - istruttoria progetto definitivo RSA con Arch. Tassinari
- sopralluoghi giornalieri in cantiere;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 al 31 marzo 2013

- sopralluoghi con D.L. : 01.03 - 04.03 - 06.03 - 08.03 - 15.03 - 22.03
- riunioni in Comune di Volano per definizione pratica terre e rocce da scavo: 03.12
- documentazione / ipotesi acquisto terreno Amadori: 08.03 - 12.03
- sopralluogo per prova di carico terreno: 11.03 - 28.03
- verifica c/o Comunità di Valle per variante: 14.03;
- lettera pozzo H2O signor Tovazzi Saverio: 19.03.;
- prelievo analisi con geologo: 28.03
- verifiche varie con il gruppo di progettazione;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 al 30 aprile 2013

- sopralluoghi cantiere;
- riunione con i tecnici aziende erogatrici (Dolomiti Reti, ecc.): 08.04 - 12.04
- 16.04: incontro c/o il Comune di Volano con Sindaco e Dr. Nardin
- prova di carico terreno: 17.04
- 22.04: c/o PAT Bacini Montani;
- istruttoria ricorso, formalizzazione e consegna: 27.04 - 28.04 - 29.04 - 30.04;
- lettera sospensione lavori: 30.04.;
- 25.0: incontro c/o Opera Romani con gruppo progettazione;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

- verifica per spostamento fognatura con Ing. Angiari;
- incontro per 1° S.A.L. con Ing. Moro e Impresa Marsilli;
- istruttoria, domanda VVF e consegna a Trento;
- inoltro pratica per ripresa lavori;
- sopralluoghi giornalieri in cantiere;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.
-

dal 21 al 31 maggio 2013

- sopralluoghi con D.L. : 30.05
- verifiche varie e colloqui per ricorso Tutela Paesaggio e progetto definitivo.
- verifica c/o Comune di Volano per nuova S.C.I.A.
- stesura variante SCIA e invio documentazione a Arch. Tassinari.
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.
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dal 01 al 30 giugno 2013

- 03.06 - 05.06 - 06.06 - 12.06 - 26.06.: riunioni c/o Opera Romani per presentazione progetto definitivo e spiegazioni varie;
- telefonate varie con i tecnici aziende erogatrici (Dolomiti Reti, ecc.);
- 17.06.: incontro c/o il Comune di Volano per variante P.R.G. con Grisotto e Ing. Lorenzi;
- 18.06.: ritiro pratica VVF a Trento
- 26.06.: ritiro parere sanitario e incontro con Dott.ssa Buffato.
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 fino al 31 luglio 2013

- 01.07.: incontro a Trento con geom. Guidi per perizia.
- 01.07. - 04.07 - 17.07 : riunioni/incontri c/o Opera Romani
- 04.07. - 09.07: incontro c/o Ufficio Fognature con geom. Zulietti;
- 10.07.: verifica certificato regolare esecuzione;
- 08.07.: consegna pratica per deroga sanitaria;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 fino al 31 agosto 2013

- 01.08.: incontro c/o Tutela Paesaggio con Arch. Tassinari + Consiglio Comunale a Volano per variante P.R.G.
- 02.08.: incontro a Trento con Geom. Guidi per analisi prezzi;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 fino al 30 settembre 2013

- 01.07.: incontro a Trento con geom. Guidi per perizia.
- 02.09. - 11.09 - 24.09 : riunioni/incontri c/o Opera Romani
- 11.09: incontro con Ing. Orsi;
- 11.09: incontro in Tutela Paesaggio con Arch. Tassinari;

- 24.09: incontro c/o Opera Romani con Dott. Ferrari e PResidente per problema acquisizione aree;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 al 30 ottobre 2013

- 02.10. - 22.10.: riunioni c/o Opera Romani per programmazione e spiegazioni varie;
- 03.10.: riunione c/o Opera con Ing. Orsi;
- 08.10.: incontro a Trento con geom. Guidi;
- 17.10.: consiglio Comunale Volano
- 21.10.: ritiro autorizzazione Tutela Paesaggio;
- verifica generale Progetto Definitivo con Ing. Scarpone, Arch. Tassinari e Sindaco;
- modulistica per concessione edilizia e lettera certificato conformità urbanistica;
- 30.10.: incontro con Ispettori Forestali per spiegazioni messa in sicurezza 1.a fase;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 05 al 30 novembre 2013

- 14.11. - 28.11.: riunioni c/o Opera Romani;
- 05.11.: riunione con Scarpone per gara di appalto;
- 13.11.: consegna certificato regolare esecuzione ad Ispettore Forestale;
- richiesta nuovo C.D.U. Comune di Volano;
- 15.11.: a Trento da geom. Guidi con Tassinari e Dr. Ferrari per consegna progetto;
- 26.11.: a Trento con Dr. Ferrari c/o Ufficio Espropri - Dott. Ing. Rech;
- 27.11.: incontro c/o il Comune di Volano per pratica esproprio con Dott. Nardin;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 02 al 24 dicembre 2013

- 02.12. - 28.11.: riunioni c/o Opera Romani per procedura espropri;
- 09.12. - 18.12:: incontro c/o il Comune di Volano per pratica esproprio con Dott. Nardin e Sindaco;
- 13.12.: consegna a Trento al geom. Guidi documentazione analisi prezzi per CTA;
- 20.12.: incontro con Ing. Rech per pratica esproprio;
- 23.12.: incontro con geom. Guidi per esproprio;
- 24.12.: ritiro e consegna n° 2 copie progetto completo per esproprio.
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 07.01 al 31 gennaio 2014

- 07.01.: ritiro documentazione Bacini Montani;
- 13.01. - 20.01. - 21.01..: riunioni c/o Opera Romani con Direttore e Presidente per programma esproprio;
- 21.01: riunione con Ing. Scarpone per quadro economico - residuati bellici;
- 30.01.: preparazione documentazione da portare in Comune per esproprio;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 03 al 28 febbraio 2014

- 03.02.: consegna documentazione esproprio al Comune di Volano
- 04.02.: sopralluogo beni ex Maule e relazione valori;
- 11.02.: preparazione documentazione per incontro PAT Ing. Decol;
- 12.02: a Trento con Presidente e Direttore per incontro c/o PAT con Ing. Decol;
- 26.02: incontro con Ing. Scarpone per controllo quadri economici - messa in sicurezza 1.a fase e progetto;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 al 31 marzo 2014

- 13.03.: incontro con Ing. Scarpone per quadri economici + P.A.T. per sistema gara IRLER
- 14.03.: riunioni c/o Opera Romani con Ing. Scarpone + Dott. Ferrari + Presidente per programmazione e spiegazioni varie;
- 24.03: incontro a Trento (PAT) da Ing. Rech per valutazioni ex Maule e strada comunale
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 01 al 30 aprile 2014

- 01.04: minuta documentazione per acquisto strada comunale Volano
- 02.04.- 03.04: riunione con Ing. Scarpone e Dott. Ferrari per gara di appalto;
- 07.04: incontro a Trento (PAT) da Ing. Rech per stima acquisto strada comunale
- 08.04: consegna documentazione originale Opera Romani per lettera PAT (valutazione strada comunale)
- 16.04.- 29.04: incontro c/o il Comune di Volano (geom Vieceli) per stima immobili ex Maule
- 16.04. - 17.04.: riunioni c/o Opera Romani per gara appalto;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 02 al 31 maggio 2014

- 02.05.: incontro c/o il Comune di Volano per stima con geom. Vieceli e Sindaco;
- 19.05.: predisposizione documentazione progetto esecutivo per consegna a Trento - P.S.C. e fascicolazioni con Ing. Mario;
- 20.05.: incontro con Ing. Scarpone per progetto esecutivo;
- 20.05.: a Trento per APAC;
- 21.05.: riunione c/o Opera Romani con Ing. Scarpone per definizione gara;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

dal 03.06 al 30 giugno 2014

- 03.06. - 04.06.: pratiche per esproprio con Dott. Nardin e Dott. Ferrari;
- 05.06: controllo documentazione per Ufficio espropri;
- 09.06. - 10.06 : riunioni c/o Opera Romani con Ing. Scarpone + Direttore + Dr. Irler per preparazione bandi di gara - appalto;
- 12.06: controllo delibera Comune Volano con dr. Ferrari;
- 12.06: ritiro e consegna nuovo C.D.U.

- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 02 al 11 luglio 2014</u>

- 02.07.: documentazione presso Ufficio Tavolare per certificato eredità Maule Rita;
- 03.07: controllo esproprio indennizzo Comune di Volano con dr. Ferrari;
- 04.07.: controllo presso Ufficio Tavolare (dott. Castelli) per vincolo testamentario
- 10.07: riunioni c/o Opera Romani con Ing. Scarpone + Direttore per perizia di variante
- 11.07: incontro Comune di Volano con Dr. Nardin per intavolazione frazionamento;
- 11.07: da Notaio Romoli (Riva del Garda) per definire rogito con Comune di Volano;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 15 al 31 luglio 2014</u>

- 14.07: incontro Comune di Volano per atto notarile;
- 15.07: fatto richiesta C.D.U. e consegnato;
- 22.07: 1° sopralluogo obbligatorio e tel. Ing. Brigadoi;
- 31.07: a Trento da Ing. Brigadoi per esproprio;
- 31.07: incontro Opera Romani con Dr. Ferrari per programmazione;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 01 al 31 agosto 2014</u>

- 05.08: a Trento da Ing. Rech per esproprio;
- 27.08: firma decreto tavolare con Amadori - C.V. con Comune di Volano - verifica costi sicurezza per stima - uffici espropri;
- colloqui telefonici con Ing. Rech;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 01 al 30 settembre 2014</u>

- 02.09: controllo documentazione Ing. Scarpone e invio a Ing. Rech;
- colloqui telefonici con Ing. Rech;
- 30.09.: incontro con Ing. Scarpone e Dr. Ferrari per verifica generale;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 02 al 31 ottobre 2014</u>

- 02.10.: incontro con Ing. Lotti (C.T.U.) per esproprio Amadori;
- 22.10.: ritiro documentazione Comune di Volano per esproprio + lettera per P.A.T. Ing. Rech per indennità aggiuntiva;
- 28-29-30-31: colloqui telefonici e corrispondenza per esproprio Amadori - Ing. Scarpone;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

<u>dal 03 al 30 novembre 2014</u>

- 03.11: verifica perizia variante con Ing. Rech e c/o Opera;
- 05.11: verifica quadro variante con Ing. Scarpone e Dr. Ferrari;
- 17.11: a Trento da Ing. Rech;
- 17.11.: c/o Opera per controllo documentazione;
- 18.11: a Trento da Geom. Guidi con Dr. Ferrari;
- 18.11.: c/o Opera per controllo documentazione;
- 19.11.: c/o Opera con Tovazzi Mariano per quota viti;
- 20.11: Comune di Volano con Geom. Vieceli per controllo documentazione concessione edilizia;
- 20.11.: colloqui telefonici per pozzo e quote espianto viti;
- 24.11: c/o Opera Romani per firma e controllo esproprio Amadori con Boschi Carmen e spiegazioni per pozzo;
- 25.11: a Trento da p.i. Graziadei per pratica pozzo, da Dott.ssa Tasin per pratica quote viti;
- 25.11: c/o Opera per spiegazioni incontri a Trento a Dr. Ferrari;
- 27.11: sopralluogo con Galvagni Stefano per estirpazione viti (vedi preventivo);
- 27.11: colloqui telefonici con Ing. Rech e p.i. Graziadei;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

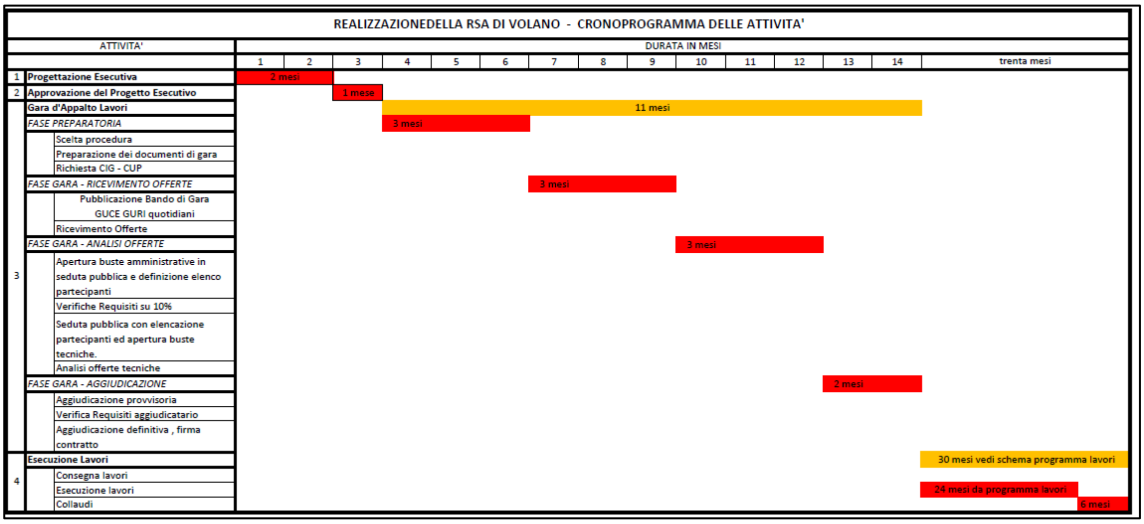
dal 01 al 31 dicembre 2014

- 01.12: verifica determina occupazione anticipata;
- 01.12.: colloqui telefonici con Galvagni Stefano;
- 02.12.: a Trento da p.i. Graziadei per consegna pratica pozzo;
- 03.12: a Trento per ritiro documentazione esproprio;
- 03.12: controllo telefonico con Arch. Tassinari della documentazione per concessione edilizia;
- 05.12: Comune di Volano da geom. Vieceli per controllo richiesta concessione edilizia;
- 09.12: n° 2 sopralluoghi per inizio estirpazione viti;
- 09.12: c/o Opera Romani con Dr. Ferrari per varie;
- 10.12: sopralluogo per estirpazione viti;
- 11.12: sopralluogo per estirpazione viti;
- 12.12: sopralluogo per estirpazione viti - verbale;
- 15.12: consegna documentazione estirpazione viti + lettera PAT per estirpazione viti;
- 16.12: sopralluogo per inizio bonifica bellica;
- 16.12: Comune di Volano da geom. Vieceli per controllo documentazione concessione edilizia;
- 16.12: c/o Opera Romani con Dr. Ferrari e Ing. Scarpone;
- 17.12: sopralluogo per bonifica bellica;
- 18.12: sopralluogo per bonifica bellica;
- 19.12: varie lettere a geom. Vieceli con Ing. Scarpone per bonifica bellica;
- 29-30.12: colloqui telefonici con geom. Vieceli per documentazione concessione edilizia;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.

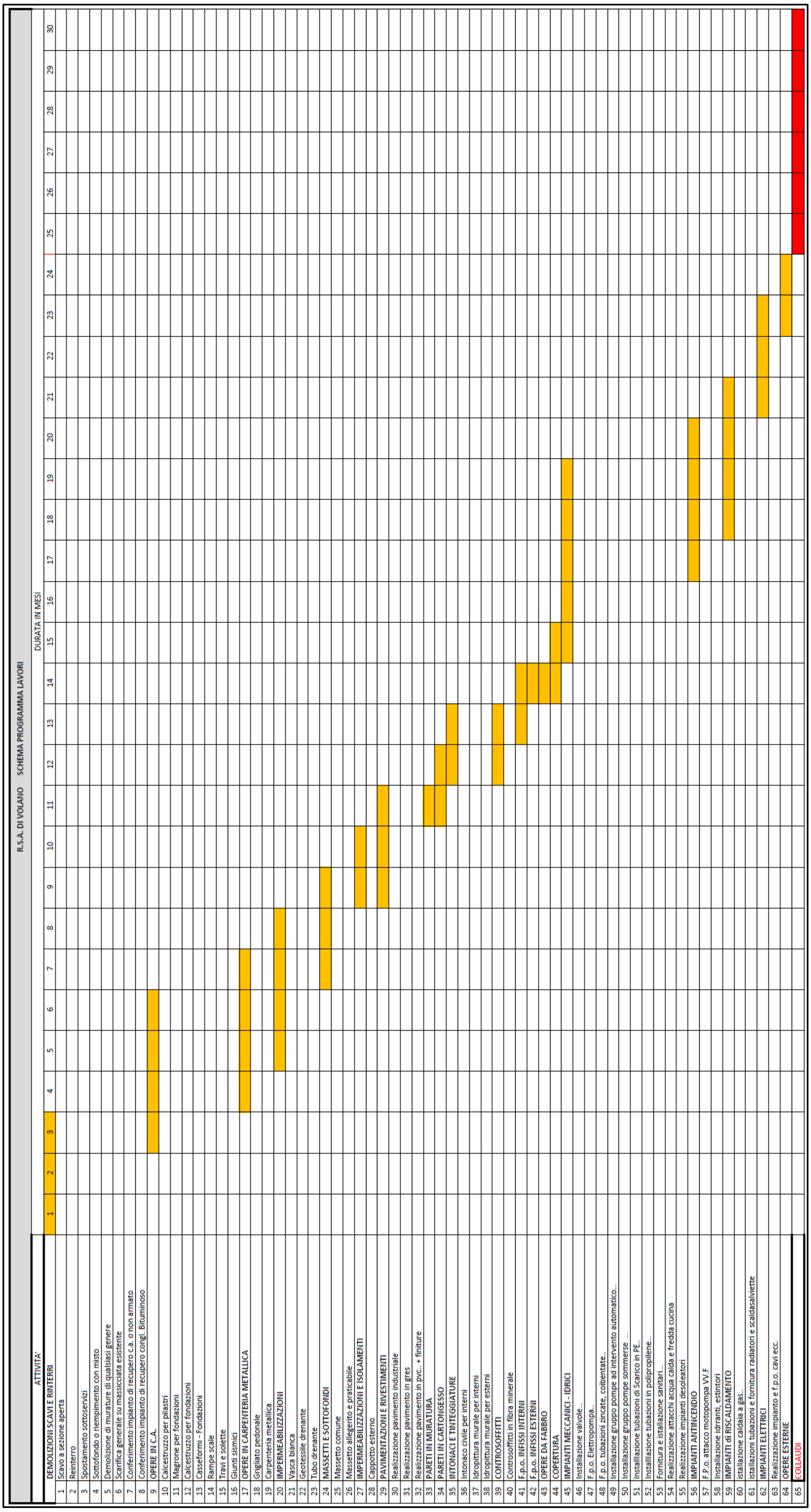
dal 07 al 31 gennaio 2015

- 07.01: colloqui telefonici con geom. Vieceli;

- 14.01: verifica generale concessione edilizia - fine lavori messa in sicurezza 1.a fase - tel. a Arch. Tassinari;
- 15.01: nuovo controllo modulistica concessione edilizia con Arch. Tassinari e tel. geom. Vieceli,
- 16.01: lettera per Ing. Moro + incontro c/o Opera Romani con Dr. Ferrari;
- 20.01: sopralluogo per bonifica bellica - in cantiere non è presente nessuno;
- 22.01: c/o Opera Romani con Dr. Ferrari per varie - lettera a Ing. Rech e Ing. Moro;
- 23.01: c/o Opera Romani con Ing. Scarpone per verifica/analisi documentazioni varie - appalto - verifica contratto per residuati bellici;
- 26.01: sopralluogo per 1° controllo ripresa bonifica bellica - varie telefonate per chiarimenti e cambio metodologia scavo;
- 27.01: sopralluogo per bonifica bellica;
- 28.01: consegna c/o Opera Romani documentazione per firma concessione edilizia;
- 28.01; sopralluogo per bonifica bellica;
- 29.01: sopralluogo per bonifica bellica - conclusa 1^ fase;
- 30.01: consegna Comune di Volano domanda concessione edilizia;
- colloqui telefonici vari e corrispondenza e-mail con Gruppo di progettazione, Comune di Volano, Opera Romani, ecc.



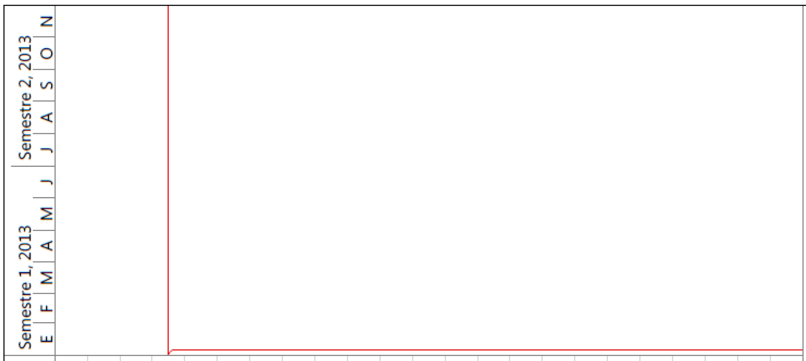
General Gantt diagram for the project design activities. *Source & Copyright: Studio Othe.*



Detailed Gantt diagram for the project design activities. *Source & Copyright: Studio Othe.*

The following documentation summarizes the procedure followed by the researcher to calculate the time-related issues of the project through the implementation of the software Microsoft Project.

Id	Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
1						
2		Project start	5 días	lun 22/08/11	vie 26/08/11	
3		Development of the Design bid	90 días	lun 29/08/11	vie 30/12/11	2
4		**P 03: LEED clauses not included in bid**	1 día	lun 02/01/12	lun 02/01/12	3
5		Appeal of the Board of Engineers	10 días	lun 09/01/12	vie 20/01/12	4
6		Bid text re-formulated	20 días	lun 23/01/12	vie 17/02/12	5
7		LEED AP contracted	20 días	lun 02/01/12	vie 27/01/12	2
8		Public bid for design and C.M. won by H.C.	18 días	lun 20/02/12	mié 14/03/12	6
9		Buraucratic steps	20 días	jue 15/03/12	mié 11/04/12	8
10		LEED Project registration	3 días	jue 15/03/12	lun 19/03/12	7;8
11		**P04: LEED registration timing**	1 día	mar 20/03/12	mar 20/03/12	10
12		LEED meetings with customer	7 días	mar 20/03/12	mié 28/03/12	7;10
13		Kick-off meeting design team	7 días	lun 16/04/12	mar 24/04/12	12;9
14		LEED brainstorming design team	10 días	vie 27/04/12	jue 10/05/12	13
15		Hydraulic problem	1 día	vie 27/04/12	vie 27/04/12	13
16		RUP manages hydraulic paperwork	30 días	lun 30/04/12	vie 08/06/12	15
17		Hydraulic - Infos acknowledgment	45 días	lun 30/04/12	vie 29/06/12	15
18		LEED meeting between technicians	5 días	lun 02/07/12	vie 06/07/12	17
19		Problems hydraulic - LEED - school SOLVED	1 día	lun 09/07/12	lun 09/07/12	14;15;16;17;18
20		Design team meeting	1 día	mar 10/07/12	mar 10/07/12	17;14;16;19
21		Verify project docs	15 días	mié 11/07/12	mar 31/07/12	20
22		Meeting with Volano administration	1 día	mié 01/08/12	mié 01/08/12	21
23		General meeting (technicians, owners, public,	1 día	jue 02/08/12	jue 02/08/12	19;22

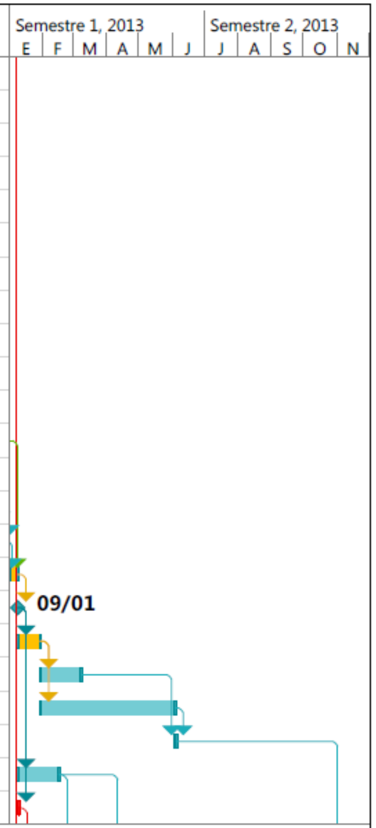


Proyecto: List of activities RSA -
Fecha: mar 23/05/17

Tarea	Resumen inactivo	Tareas externas	
División	Tarea manual	Hito externo	
Hito	solo duración	Fecha límite	
Resumen	Informe de resumen manual	Progreso	
Resumen del proyecto	Resumen manual	Progreso manual	
Tarea inactiva	solo el comienzo		
Hito inactivo	solo fin		

Página 1

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
24			RUP interface with design, owner and public	10 días	vie 03/08/12	jue 16/08/12	23
25			LEED Preliminary Development - Architectural	45 días	vie 03/08/12	jue 04/10/12	23
26			"Hydraulic safety" preliminary project	30 días	mié 11/07/12	mar 21/08/12	20
27			Project docs verification	7 días	mié 22/08/12	jue 30/08/12	26;24
28			LEED Preliminary Development - Mechanical	30 días	vie 05/10/12	jue 15/11/12	25
29			Docs passed and approved by Tutela del	30 días	vie 31/08/12	jue 11/10/12	27
30			Hydraulic Design Bid - preliminary phase	15 días	vie 12/10/12	jue 01/11/12	29
31			RUP organizes phases	15 días	vie 12/10/12	jue 01/11/12	29
32			Hydraulic design approved	1 día	vie 02/11/12	vie 02/11/12	30;31
33			LEED problem meeting: MR - WE - EA - IEQ	2 días	vie 16/11/12	lun 19/11/12	28;31
34			Site pre-occupancy operations	15 días	vie 12/10/12	jue 01/11/12	29
35			LEED Problem solving	30 días	mar 20/11/12	lun 31/12/12	33
36			Hydraulic work bid	30 días	lun 05/11/12	vie 14/12/12	32
37			Hydraulic company surveys	6 días	lun 17/12/12	lun 24/12/12	36
38			Hydraulic bid ends	2 días	mar 25/12/12	mié 26/12/12	37
39			Verifying project economy	6 días	mar 01/01/13	mar 08/01/13	38;35
40			Project budget (preliminary) verified	0 días	mié 09/01/13	mié 09/01/13	39
41			Paperwork for soil rising operations Phase 1	15 días	mié 09/01/13	mar 29/01/13	40
42			Soil load procedure	28 días	mié 30/01/13	vie 08/03/13	41
43			Soil rising operations Phase 1	89 días	mié 30/01/13	lun 03/06/13	41
44			Soil Rising Operation Complete - Phase 1	1 día	mar 04/06/13	mar 04/06/13	43;42
45			Preparation definitive project development	28 días	mié 09/01/13	vie 15/02/13	40
46			P 01: designers don't know anything about	1 día	mié 09/01/13	mié 09/01/13	40

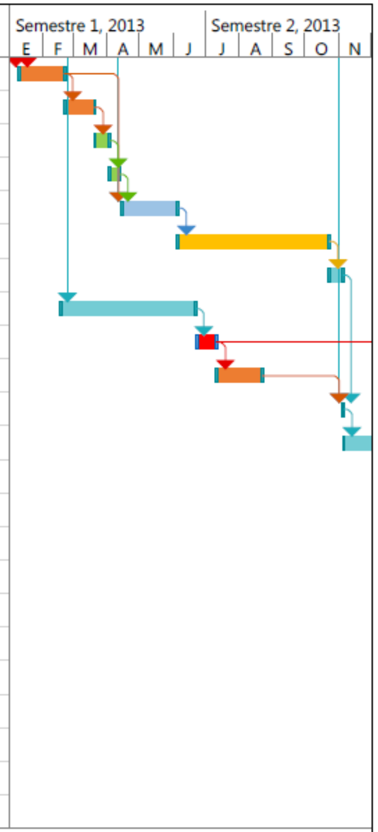


Proyecto: List of activities RSA -
Fecha: mar 23/05/17

Tarea
División
Hito
Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual

Página 2

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras
47			Problem: additional contract for LEED	30 días	jue 10/01/13	mié 20/02/13	46;4
48			Problem: need new employees uncovered	20 días	jue 21/02/13	mié 20/03/13	47
49			Studio Othe contracts new employee for LEED	10 días	jue 21/03/13	mié 03/04/13	48
50			Interface with LEED AP	7 días	jue 04/04/13	vie 12/04/13	49
51			Definitive project development (arch.)	38 días	lun 15/04/13	mié 05/06/13	45;50;47
52			Urban planning commission (Tutela del	100 días	jue 06/06/13	mié 23/10/13	51
53			Project modification with Tutela Paesaggio	8 días	jue 24/10/13	lun 04/11/13	52
54			Definitive Project Development (mech.)	90 días	lun 18/02/13	vie 21/06/13	45
55			**P05 : LEED cuts due to budget**	14 días	lun 24/06/13	jue 11/07/13	54
56			Project Modification based on new	30 días	vie 12/07/13	jue 22/08/13	55
57			Definitive Project General Verification	1 día	mar 05/11/13	mar 05/11/13	53;56;44
58			Take-off analysis procedure for CTA	29 días	mié 06/11/13	lun 16/12/13	57
59			Paperwork preparation for CTA	10 días	mar 17/12/13	lun 30/12/13	58
60			Definitive Project Approved	0 días	mar 31/12/13	mar 31/12/13	59
61			Executive Project Development - First Phase	45 días	mar 31/12/13	lun 03/03/14	60
62			**P01: no comunication between technicians**	1 día	mar 04/03/14	mar 04/03/14	61
63			Re-manufacturing process for design	14 días	mié 05/03/14	lun 24/03/14	62
64			Mistakes / lack of details in final design	7 días	mié 05/03/14	jue 13/03/14	62
65			IRLER bid - Preliminary phase	21 días	mar 31/12/13	mar 28/01/14	60
66			**Problem: variation of original take-off prices**	24 días	mié 29/01/14	lun 03/03/14	65;55
67			Re-manufacturing process for design based	14 días	mar 25/03/14	vie 11/04/14	66;63;64
68			Energy modelling - draft	30 días	mar 04/03/14	lun 14/04/14	61
69			Executive Project Developmet - Final Phase	36 días	mar 25/03/14	mar 13/05/14	61;66



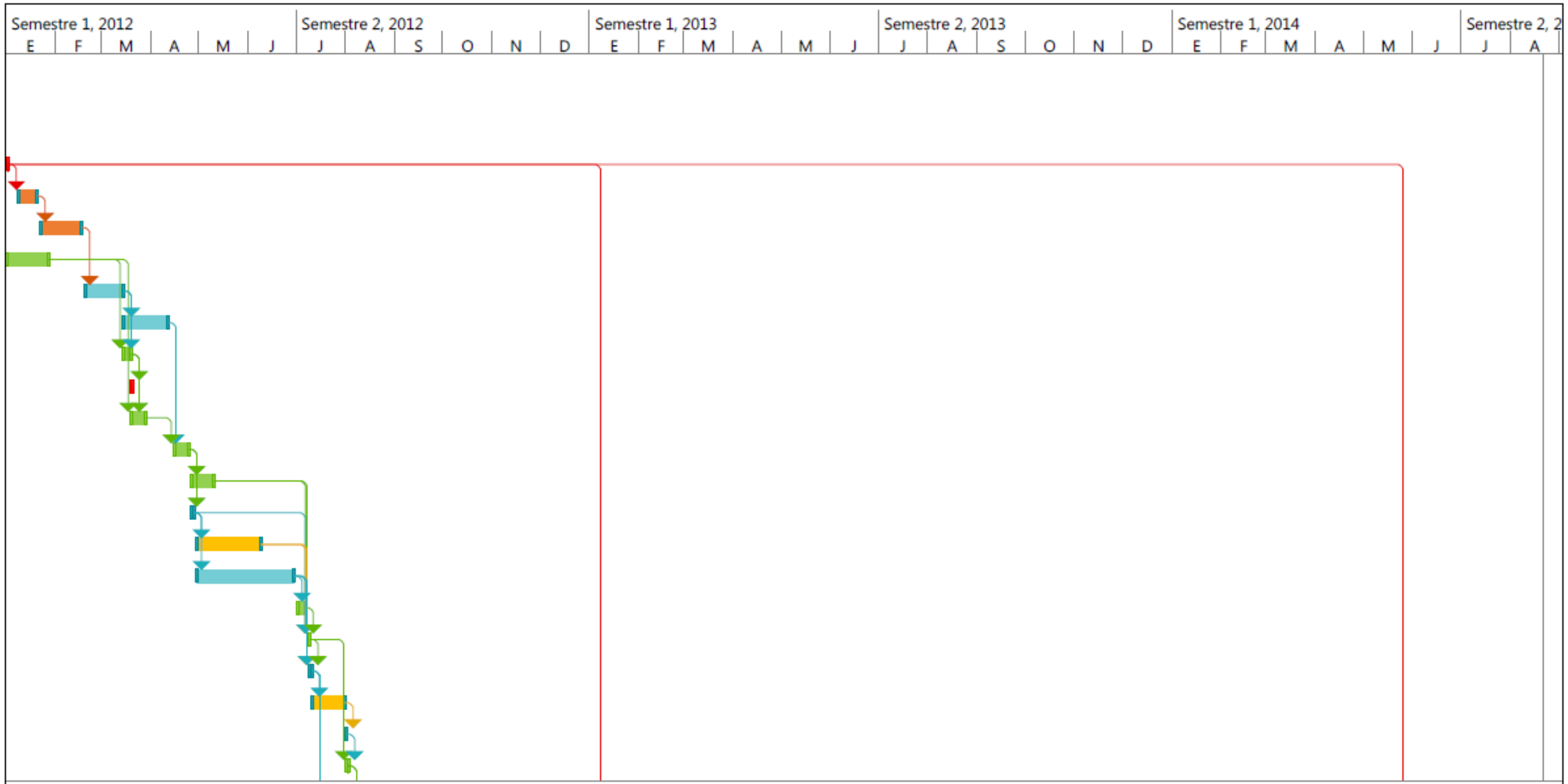
Proyecto: List of activities RSA -
Fecha: mar 23/05/17

Página 3

Id		Modo de tarea	Nombre de tarea	Duración	Comienzo	Fin	Predecesoras	Semestre 1, 2013 E F M A M J	Semestre 2, 2013 J A S O N
70			P 06: unable to develop Energy Modelling	1 día	mar 15/04/14	mar 15/04/14	68		
71			Need to find a Energy modeller	15 días	mié 16/04/14	mar 06/05/14	70		
72			Executive Project Approved	0 días	mié 14/05/14	mié 14/05/14	69;67		
73			Energy Modelling Development	30 días	mié 07/05/14	mar 17/06/14	71		
74			P06: Energy Modelling done, project can't be	1 día	mié 18/06/14	mié 18/06/14	73		
75			Contacts to bring in the CxA	10 días	mié 14/05/14	mar 27/05/14	72		
76			P01: No idea abount CxA	1 día	mié 28/05/14	mié 28/05/14	4;75		
77			P02: Commissioning Authority	1 día	mié 28/05/14	mié 28/05/14	75		
78			Need to find a CxA "on the run"	15 días	jue 29/05/14	mié 18/06/14	77		
79			P02: CxA never met Designer, Mech. Engineer	1 día	jue 19/06/14	jue 19/06/14	78		
80			CxA has to catch-up and re-define the project	45 días	vie 20/06/14	jue 21/08/14	79		

Proyecto: List of activities RSA -
Fecha: mar 23/05/17

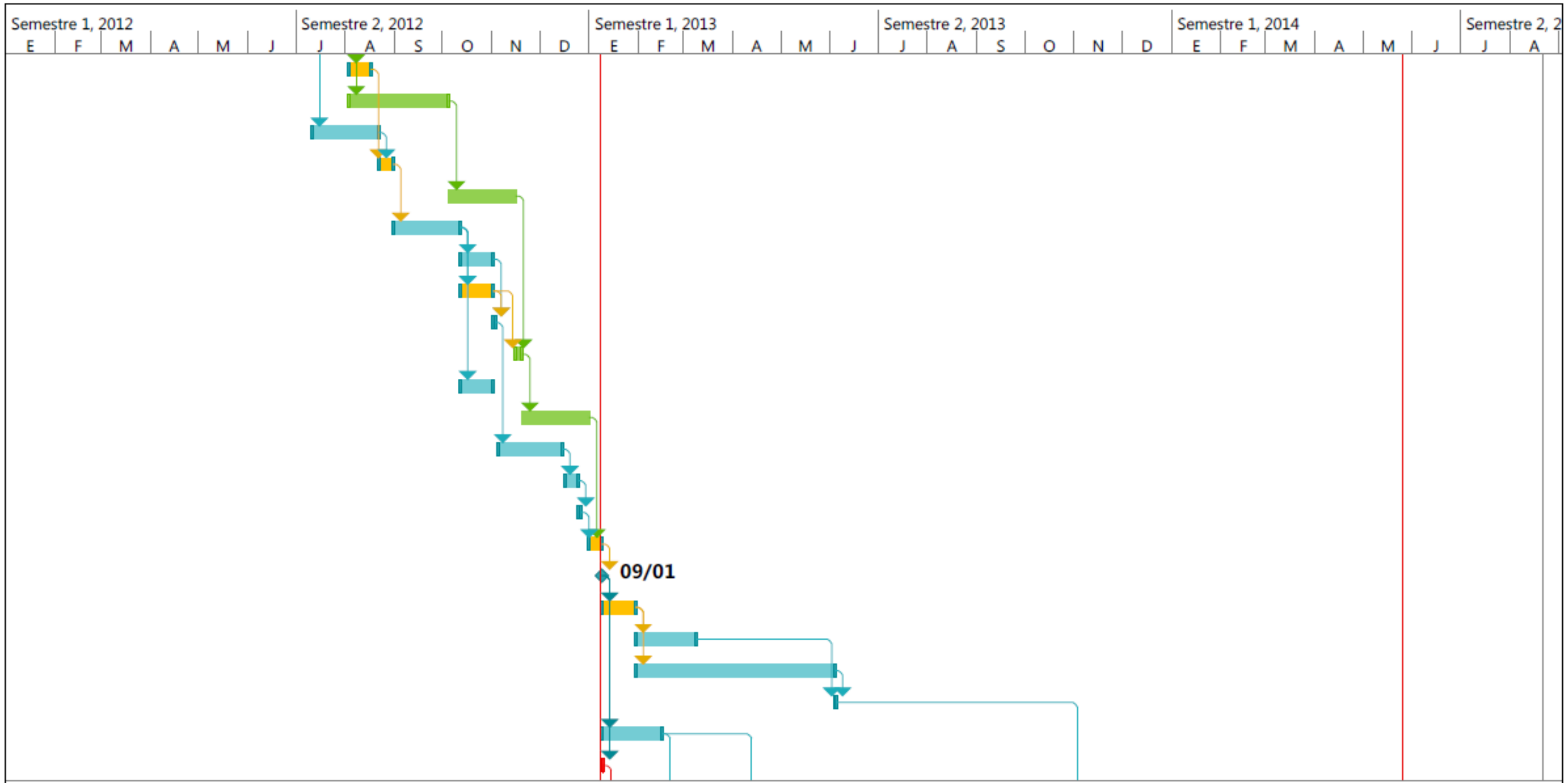
- Tarea
- División
- Hito
- Resumen
- Resumen del proyecto
- Tarea inactiva
- Hito inactivo
- Resumen inactivo
- Tarea manual
- solo duración
- Informe de resumen manual
- Resumen manual
- solo el comienzo
- solo fin
- Tareas externas
- Hito externo
- Fecha límite
- Progreso
- Progreso manual



Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	

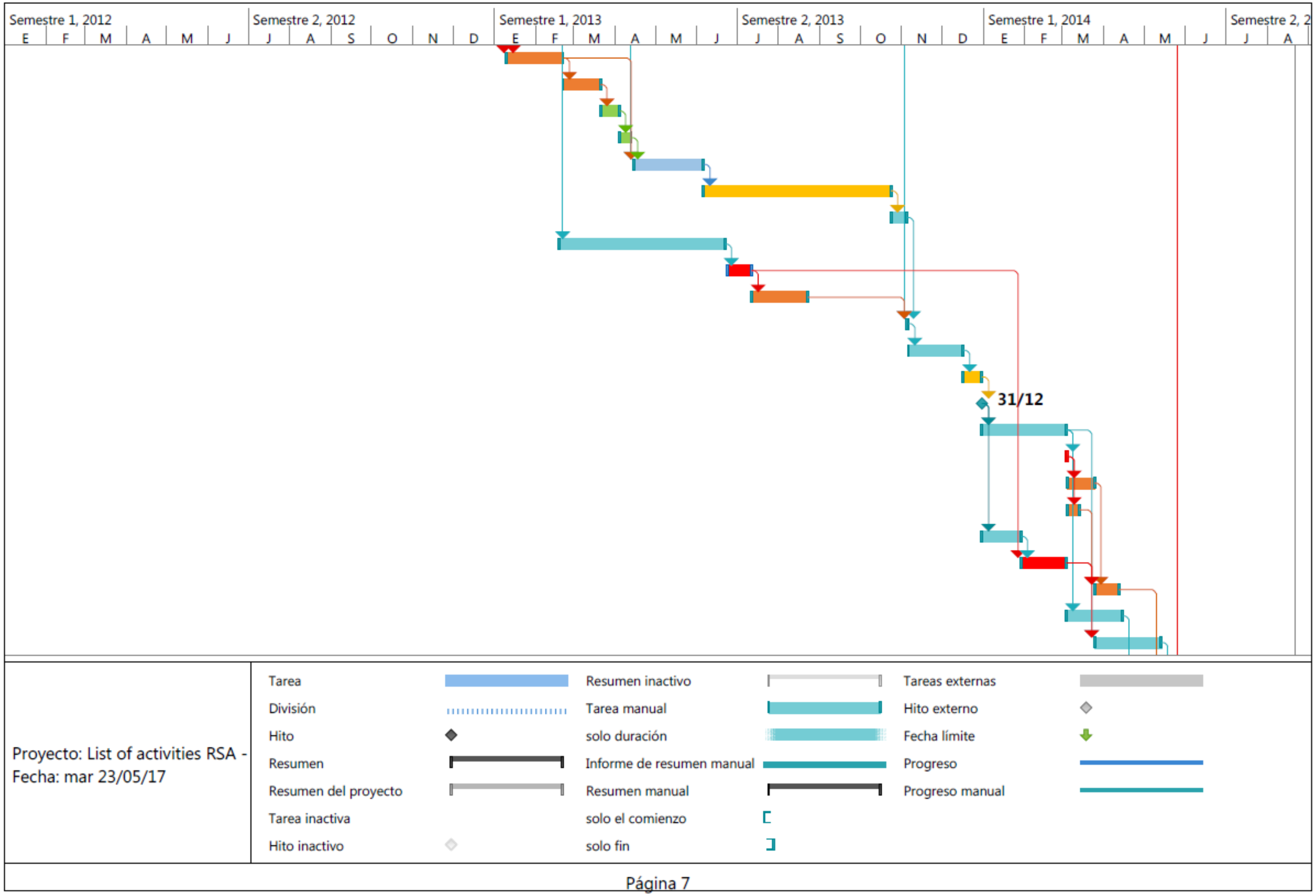
Proyecto: List of activities RSA -
Fecha: mar 23/05/17

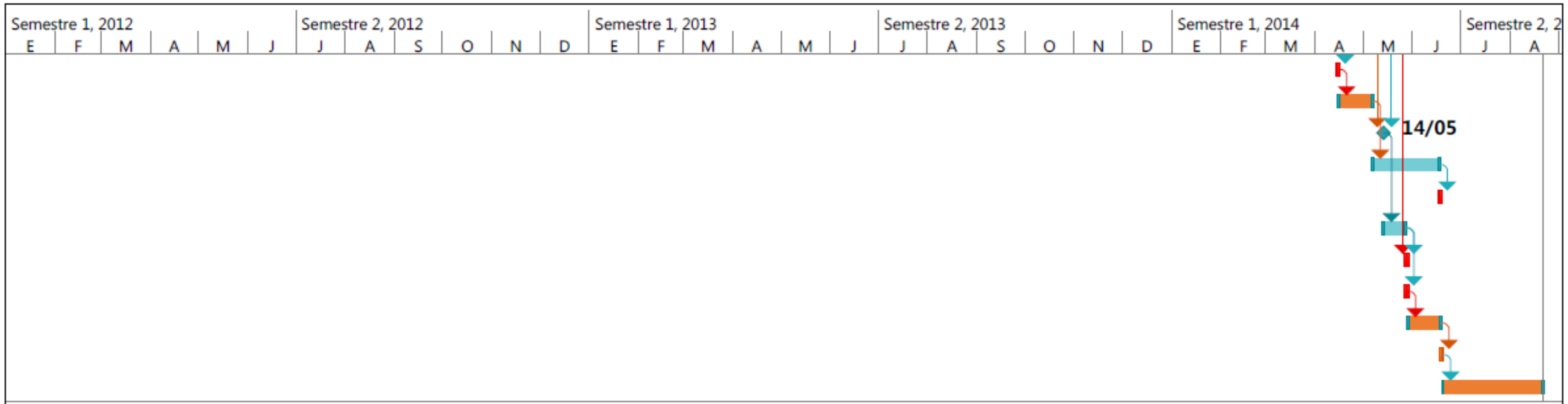
Página 5



Proyecto: List of activities RSA -
Fecha: mar 23/05/17

Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	


Semestre 1, 2012
E F M A M J
Semestre 2, 2012
J A S O N D
Semestre 1, 2013
E F M A M J
Semestre 2, 2013
J A S O N D
Semestre 1, 2014
E F M A M J
Semestre 2, 2
J A
31/12
Proyecto: List of activities RSA -
Fecha: mar 23/05/17
Tarea
División
Hito
Resumen
Resumen del proyecto
Tarea inactiva
Hito inactivo
Resumen inactivo
Tarea manual
solo duración
Informe de resumen manual
Resumen manual
solo el comienzo
solo fin
Tareas externas
Hito externo
Fecha límite
Progreso
Progreso manual
Página 7



Proyecto: List of activities RSA - Fecha: mar 23/05/17		

Tarea	Resumen inactivo	Tareas externas
División	Tarea manual	Hito externo
Hito	solo duración	Fecha límite
Resumen	Informe de resumen manual	Progreso
Resumen del proyecto	Resumen manual	Progreso manual
Tarea inactiva	solo el comienzo	
Hito inactivo	solo fin	

Página 8

3. THE OFFICE BUILDING PROJECT IN BARCELONA.

Due to the confidentiality of information involved, the project owner didn't authorize the publication of scheduling-related documentation for the building project.

4. THE OFFICE BUILDING IN SOUTHERN SPAIN.

Due to the confidentiality of information involved, the project owner didn't authorize the publication of scheduling-related documentation for the building project.

APPENDIX 3

Case-study projects: estimate documentation

1. THE NURSING-HOME PROJECT.

OPERA ROMANI RSA DI VOLANO - QUADRO TECNICO ECONOMICO					
		Descrizioni	Quantità	Riferimento	Importi in €
A. IMPORTI PER LAVORI	A. Importo dei Lavori a base gara				
	A.1	Importo dei lavori a base d'asta soggetto a ribasso			8.683.590,65
	A.2	Oneri per la sicurezza non soggetti a ribasso (3,0% importo lavori)	3,00%	totale A1	260.507,72
	A.3	**Totale A importo dei lavori a base d'asta**			**8.944.098,37**
B. SOMME A DISPOSIZIONE DELL'AMMINISTRAZIONE	B. Somme a disposizione dell'Amministrazione				
	B.1	Lavori in economia			0,00
	B.2	Rilievi iniziali,diagnosi iniziali, accertamenti e indagini			4.160,00
	B.3	Allacciamenti ai pubblici servizi			30.000,00
	B.4	Imprevisti (2,0% importo lavori)	2,00%	totale A	178.881,97
	B.5	Acquisizione aree o immobili e pertinenze indennizzi			0,00
	B.6	Accantonamento di cui all'articolo 133 del D.Lgs.163/2006			0,00
	B.7	Spese di cui agli articoli 90, comma 5, e 92, comma 7-bis del codice			0,00
	B.8	Spese per attività tecnico amministrative connesse alla progettazione, di supporto al responsabile del procedimento, e di verifica e validazione			
	B.8.1	*Progettazione preliminare e ridefinizione progetto preliminare (compreso CNPAIA)*			72.065,50
	B.8.2	*Progettazione definitiva, esecutiva, sicurezza, D.L., misura e contabilità (compreso CNPAIA)*			682.101,57
	B.8.3	*Prestazioni accessorie (verifiche impiantistiche, certificazione energetica, certificato prevenzione incendi, accatastamento, ecc.) compreso CNPAIA*			28.080,00
	B.8.4	*Attività di supporto al RUP (compreso contributo cassa)*			49.920,00
	B.8.5	*Spese per Certificazione LEED per progettazione e costruzione Commissioning ed energing modeling (compreso CNPAIA)*			153.474,00
	B.9	Spese per gare e commissioni giudicatrici compresi supporti legali			
	B.9.1	*Gara per appalto servizi di ingegneria compresi supporti legali*			31.271,36
	B.9.2	*Gara per appalto lavori*			41.600,00
	B.10	Spese per pubblicità e , ove previsto, per opere artistiche			60.000,00
	B.11	Spese per accertamenti di laboratorio e verifiche tecniche previste dal capitolato speciale d'appalto, collaudo tecnico amministrativo, collaudo statico ed altri eventuali collaudi specialistici			30.000,00
	B.12	**Totale B Somme a disposizione dell'Amministrazione (B1+....+B11)**			**1.361.554,40**
C. I.V.A	C. I.V.A.				
	C.1	I.V.A. sui Lavori	10,00%	totale A	894.409,84
	C.2	I.V.A. sulle Somme a disposizione dell'Amministrazione	22,00%	totale B	299.541,97
	C.3	**Totale I.V.A. (C.1+C.2)**			**1.193.951,80**
COSTO COMPLESSIVO DELL'INTERVENTO (A+B+C)					€ 11.499.604,57
				arrotondato a	**€ 11.500.000,00**

General estimate of all project-related activities. *Source & Copyright: Studio Othe.*

2. THE SCHOOL-COMPLEX PROJECT.

QUADRO ECONOMICO GENERALE DELL'INTERVENTO

A)	Lavori a base d'appalto			€	9.648.559,08
B)	Somme a disposizione				
B.1)	Lavori in economia	€	0,00		
B.2)	Rilievi, accertamenti e indagini (compresi in B.7)	€	50.000,00		
B.3)	Allacciamenti ai pubblici servizi	€	40.000,00		
B.4)	Imprevisti	€	410.662,58		
B.5)	Acquisizione aree o immobili	€	2.021.600,00		
B.6)	Accantonamento art. 26, comma 4, della Legge	€	0,00		
B.7)	Spese tecniche	€	600.000,00		
B.8)	Spese per attività di consulenza o di supporto	€	50.000,00		
B.9)	Eventuali spese per commissioni giudicatrici	€	5.000,00		
B.10)	Spese per pubblicità e opere artistiche	€	96.485,00		
B.11)	Spese per accertamenti di laboratorio verifiche tecniche, collaudi	€	60.000,00		
B.12)	Contributi previdenziali	€	24.000,00		
B.13)	I.V.A. ed altre eventuali imposte	€	1.250.722,16		
B.14)	Fondo di incentivazione ex-art.18 L. 109/1994	€	192.971,18		
B.15)	Fondo accordi bonari ex-art. 12 DPR 554/1999		0,00		
B.16)	Acquisto arredi e attrezzature	€	450.000,00		
	Totale somme a disposizione	€	5.251.440,92	€	5.251.440,92
	Totale generale			€	14.900.000,00

General estimate of all project-related activities. *Source & Copyright: Gruppo Marche.*

The following document summarizes the amount of the design bid related to the school project.

OSSERVATORIO OICE/INFORMATEL AL 30/11/2009

3) Bandi di gara italiani per servizi di ingegneria
g) Aggiudicazione gare italiane

ATTENZIONE
La rilevazione delle aggiudicazioni non può considerarsi esaustiva né può escludersi la presenza di errori giacché la maggior
------ Chiunque fosse informato dell'esito di una gara è pregato di darne notizia all'Ufficio Gare dell'Oice ------
ufficio.gare@oice.it

Tabella riassuntiva sui ribassi, tempi e valori medi delle aggiudicazioni

Anno	Media del numero dei giomi dal bando all'aggiudicazione	Media della differenza tra valore di aggiudicazione e valore base d'asta a partire dall'abolizione dei minimi tariffari (agosto 2006)	Importo medio del valore degli affidamenti (in euro)
2003	220		1.060.000
2004	202		697.000
2005	166		1.729.000
2006	205		844.000
2007	196	-30,4%	390.000
2008	170	-34,9%	437.000
2009	132	-35,8%	339.000

N.B.:L'importo medio degli affidamenti si riferisce alle aggiudicazioni rilevate, che sono normalmente quelle più importanti e quindi di maggior valore.

23) Comune di Volano (TN): Servizi tecnici di progettazione definitiva, esecutiva e coordinamento della sicurezza in fase di progettazione dei lavori di realizzazione della nuova scuola secondaria di primo grado sovracomunale dei comuni di Volano, Besenello e Calliano - Provincia di Trento
Data pubblicazione bando: 13/02/2009 Data aggiudicazione: 26/10/2009
Importo a base d'asta euro: 437.758 Importo d'aggiudicazione euro: 240.767 (ribasso -45%)
Aggiudicatario: Studio Tecnico Gruppo Marche

The following document reports the approval act of the Volano Council for the school final approved budget. Readers can see how out of 13.200.200 Euros of total budget, 11.095.000 were funded by the Province of Trento (PAT).

OGGETTO: LAVORI DI REALIZZAZIONE DI UNA NUOVA SCUOLA SECONDARIA DI PRIMO GRADO SOVRACOMUNALE DEI COMUNI DI VOLANO, BESENELLO E CALLIANO: APPROVAZIONE IN LINEA TECNICA E A TUTTI GLI EFFETTI DEL PROGETTO ESECUTIVO.

LA GIUNTA COMUNALE

PREMESSO E RILEVATO CHE:

Con deliberazione della Giunta comunale di Volano n. 254 di data 03.08.2006 è stato affidato all'ing. Michele Trentini, con Studio tecnico a Rovereto l'incarico di redigere il progetto preliminare dell'opera in oggetto e la relativa convenzione è stata sottoscritta in data 10.08.2006;

Il progetto preliminare, redatto dall'ing. Michele Trentini, è stato presentato in data 04.09.2006, prot. n. 6752 è stato approvato in linea tecnica con deliberazione del Consiglio comunale n° 37 di data 13.09.2006 e presentava il seguente quadro economico:

- Importo lavori: Euro 6.968.324,00.=
- Somme a disposizione dell'amministrazione: Euro 6.256.125,00.=
- IMPORTO COMPL. DELL'OPERA ARROTONDATO Euro 13.225.000,00.=;

E' stato quindi richiesto alla P.A.T. Servizio Autonomie Locali un finanziamento a valere sul fondo per gli investimenti comunali di rilevanza provinciale di cui all'art. 16 della L.P. 36/93 e s.m. concesso con deliberazione della Giunta provinciale n° 757 di data 13.04.2007;

Con deliberazione della Giunta comunale di Volano n° 353 di data 18.12.2008 si è provveduto ad impegnare la somma pari ad euro € 550.600,00.= per fare fronte alle spese tecniche relative alla progettazione definitiva ed esecutiva e alla redazione del piano della sicurezza ai sensi del D.Lgs. 81/2008 nonché per fare fronte alle spese per la pubblicazione del bando di gara ed ad eventuali ulteriori spese d'ufficio;

Con deliberazione della Giunta comunale di Volano n° 29 di data 05.02.2009 si è proceduto all'espletamento della procedura di gara, di rilevanza comunitaria, mediante pubblico incanto, con il criterio dell'offerta economicamente più vantaggiosa ai sensi dell'art. 83 del D.Lgs 163/2006 per l'affidamento dei servizi di progettazione definitiva, esecutiva e di coordinatore della sicurezza in fase di progettazione;

In data 26.10.2009 a seguito della procedura di gara mediante la valutazione delle offerte tecniche e delle offerte economiche, è risultata aggiudicataria lo Studio Tecnico Gruppo Marche con sede a Macerata e la relativa convenzione è stata sottoscritta in data 27.01.2010 rep. n° 135/atti privati;

Il progetto preliminare è stato nel frattempo oggetto di analisi approfondita da parte di una commissione formatasi all'interno dell'Istituto Comprensivo Alta Vallagarina con la presenza anche dell'amministrazione comunale e dei progettisti incaricati al fine di addivenire ad una progettazione quanto più consona alle esigenze concrete dell'Istituto comprensivo;

Nel frattempo è nata anche la necessità di predisporre uno studio di compatibilità per inquadrare in modo esaustivo la problematica inerente la pericolosità idrogeologica dell'area in cui è prevista la realizzazione del futuro edificio scolastico, con particolare riferimento ai fenomeni di esondazione connessi alle piene del Fiume Adige, secondo quanto previsto dal Piano Generale di Utilizzazione delle Acque Pubbliche (P.G.U.A.P.) e dalla D.G.P. n. 2759 del 22/12/2006 relativa alle disposizioni tecniche e organizzative per la redazione e l'aggiornamento delle carte delle pericolosità idrogeologica;

Per tale motivo anche a seguito di incontri con il Servizio Bacini Montani della P.A.T., si è provveduto con deliberazione della Giunta comunale di Volano n° 187 di data 05.08.2010, ai sensi dell'art. 20 - comma 3 e 12 - della L.P. n. 26/93 e ss.mm., ad affidare al dott. Silvio Grisotto dello studio tecnico GRS lo studio di compatibilità idraulica citato;

Lo studio di compatibilità idraulica inerente il Programma degli interventi e delle misure di messa in sicurezza è stato approvato con determinazione del Dirigente del Servizio bacini Montani della P.A.T. n° 385 di data 27.05.2011;

Il Gruppo Marche ha presentato al Comune di Volano in data 04.03.2011 prot. n° 1699 il progetto definitivo generale che presentava il seguente quadro economico:

- Lavori a base d’asta euro 9.730.997,45;
- Somme a disposizione dell’amministrazione euro 3.469.002,55;
- Totale dell’intervento euro 13.200.000,00;

Non avendo le tre Amministrazioni la disponibilità economica per l’intero intervento è stato deciso, anche in accordo con il servizio Autonomie Locali della PAT di suddividere l’intervento in due Lotti funzionali a cui procedere con diversi finanziamenti;

Il primo lotto sostanzialmente prevedeva lo scorporo dal progetto del blocco mensa e della palestra ed il relativo progetto definitivo è stato approvato con deliberazione della Giunta comunale n° 34 di data 01.03.2012;

Con nota di data 30.03.2012, ns. prot. n° 2480 si comunicava ufficialmente al Gruppo Marche l'autorizzazione a proseguire nella progettazione esecutiva del I° Lotto della scuola media;

Con nota dell'Assessore agli Enti Locali della PAT di data 18 settembre 2012 veniva comunicato al Comune di Volano che con deliberazione della Giunta Provinciale n° 1920 di data 07.09.2012 il secondo lotto della scuola media sovracomunale era stato ammesso a finanziamento per un importo pari ad euro 3.266.904,65 per una spesa ammessa pari ad euro 3.438.847,00;

A seguito del finanziamento del II° Lotto con nota di data 16.10.2012, ns. prtot. n° 7126 si comunicava al Gruppo Marche la necessità di riunire i due Lotti della Scuola media al fine di addivenire ad un unico appalto dei lavori;

Con deliberazione della Giunta comunale n° 195 di data 30.10.2012 è stato nel frattempo approvato in linea tecnica il progetto definitivo generale dei lavori di cui all'oggetto e con deliberazione della Giunta comunale n° 254 di data 18.12.2012 si è provveduto inoltre ad impegnare formalmente la somma pari ad euro 12.649.400,00 per la realizzazione dei lavori di cui all'oggetto dando atto che la spesa pari ad € 550.600,00.= era già stata impegnata con deliberazione della Giunta comunale di Volano n° 353 di data 18.12.2008;

Tali deliberazioni si sono rese necessarie al fine di avviare le procedure espropriative delle aree coinvolte dai lavori in oggetto;

Con deliberazione della Giunta comunale n° 14 di data 24.01.2013 è stato quindi approvato uno schema di atto aggiuntivo alla convenzione sottoscritta in data 27.01.2010 rep. n° 135/atti privati con il Gruppo Marche per la riunificazione del progetto esecutivo dei lavori di realizzazione della nuova scuola secondaria di primo grado sottoscritto in data 14.02.2013, rep. n° 213;

In data 01.03.2013, ns. prot. n° 1535 il Gruppo Marche ha provveduto a consegnare copia del progetto esecutivo dei lavori di cui all'oggetto successivamente integrato e modificato con nota di data 06.08.2013, ns. prot. n° 5390;

Il progetto esecutivo presenta il seguente quadro economico:

A) LAVORI A BASE D'APPALTO		
A.1) Lavori	€ 9.772.282,61	
A.2) Oneri per la sicurezza	€ 153.918,65	
TOTALE LAVORI A BASE D'APPALTO		€ 9.926.201,26
B) SOMME A DISPOSIZIONE	€ 3.273.798,74	
TOTALE GENERALE	**€ 13.200.000,00**	

Il progetto esecutivo, depositato in atti, si compone degli elaborati di cui all'elenco allegato agli atti;

La spesa complessiva pari ad euro 13.200.000,00 è già stata impegnata per euro 550.600,00 con deliberazione della Giunta comunale n° 353 di data 18.12.2008, mentre la parte rimanente, pari ad euro 12.649.400,00 è stata impegnata con deliberazione della Giunta comunale n° 254 di data 18.12.2012 sarà finanziata con le seguenti modalità:

- euro 11.095.900,00 contributo PAT;
- euro 838.900,00 Comuni di Besenello e Calliano;
- euro 714.600,00 Comune di Volano di cui:
- euro 633.500,00 alienazione beni immobili;
- euro 81.100,00 budget 2011-2015;

Tutto ciò premesso e considerato;

Visto ed esaminato il progetto esecutivo generale elaborato dallo Studio Tecnico Gruppo Marche con sede a Macerata e ritenuto lo stesso meritevole di approvazione;

Dato atto che con nota del Comune di Volano di data 02.04.2013, ns. prot. n° 2172 è stato richiesto al Gruppo Marche ai sensi degli artt. 39 e 40 della D.P.P. 11.05.2012, n° 9-84/Leg di procedere alla verifica del progetto esecutivo che è stata effettuata positivamente dal Gruppo Marche come da verbale di verifica pervenuto in data 09.04.2013, ns. prot. n° 2439;

Precisato che per quanto attiene lo svolgimento della gara, con deliberazione del Consiglio comunale n° 43 di data 16.10.2012 modificata con deliberazione del Consiglio comunale n° 4 di data 05.02.2013 è stato approvato lo schema di convenzione per l'affidamento all'Agenzia Provinciale per gli Appalti e i Contratti delle funzioni di stazione appaltante, servizio di consulenza e funzioni di centrale di committenza;

La relativa convenzione con l'APAC è stata sottoscritta in data 20.03.2013, reps n° 158;

Vista la nota dell'APAC di data 20.06.2013, prot. n° S506/13/346763/1347-12 pervenuta in data 20.06.2013, ns. prot. n° 4320 con la quale l'Agenzia propone al Comune di Volano di gestire attraverso il Servizio appalti lavori pubblici lo svolgimento delle funzioni di stazione appaltante dei lavori in oggetto;

Considerato quindi di affidare ai sensi dell'art. 13 della L.P. 23/90 e ss.mm. all'APAC le funzioni di stazione appaltante per lo svolgimento della gara in oggetto;

Dato atto che la gara verrà svolta con il sistema di cui all'art. 30 comma 5 bis della L.P. 26/93 e ss.mm. e i relativi lavori aggiudicati con il criterio del prezzo più basso da determinarsi mediante il sistema dell'offerta a prezzi unitari ai sensi dell'art. 39 comma 1 lett. a) della L.P. 26/93 e ss.mm.;

Vista a tal proposito la nota dle Dipartimento Lavori Pubblici della P.A.T. prevenuta in data 23.05.2013 ns. prot. n° 3542;

Ricordato che sul progetto definitivo generale dell'opera sono già stati acquisiti i seguenti pareri:
- parere della Commissione edilizia comunale di Volano di conformità urbanistica di data 16.03.2011;
- parere favorevole antincendio del Servizio Antincendi del Corpo permanente dei vigili del fuoco della PAT di data 30.03.2011 n° 32083;
- parere positivo anche dal Comitato Tecnico Amministrativo della P.A.T. di data 20.02.2012, n° 5/12 e pervenuto presso questa Amministrazione in data 23.04.2012, ns. prot. n° 3077;

Considerato che il suddetto progetto soddisfa le esigenze di pubblico interesse che questa Amministrazione intende perseguire con la realizzazione dell'opera pubblica di cui trattasi;

Proposto di confermare la dichiarazione di pubblica utilità, indifferibilità ed urgenza il progetto in oggetto;

Proposto inoltre di dichiarare la presente deliberazione immediatamente esecutiva vista l'urgenza di procedere con le successive fasi dell'appalto;

Visto il D.Leg. 12 aprile 2006, n. 163 ed il relativo regolamento di attuazione;

Vista la L.P. 10 settembre 1993 n. 26 e s.m. nonché il D.P.P. 11.05.2012, n° 9-84/Leg con il quale è stato approvato il relativo regolamento attuativo;

Vista la L.P. n° 6/1993 e ss.mm.;

Vista la L.R. 4 gennaio 1993 n. 1 e successive modifiche;

Dato atto che ai sensi dell'art. 56 comma 1 della L.R. 1/1993 e s.m., sulla proposta di deliberazione è stato espresso parere favorevole in ordine alla regolarità tecnico – amministrativa dal responsabile del servizio e parere favorevole in ordine alla regolarità contabile dal responsabile di ragioneria;

Con voti favorevoli ed unanimi;

D E L I B E R A

1. di approvare, per i motivi indicati in premessa, in linea tecnica e a tutti gli effetti il progetto esecutivo generale dei lavori di realizzazione di una nuova scuola secondaria di primo grado sovracomunale dei comuni di Volano, Besenello e Calliano, redatto dallo Studio Tecnico Gruppo Marche con sede a Macerata, pervenuto in data 01.03.2013, ns. prot. n° 1535 e integrato in data 06.08.2013, ns. prot. n° 5390, depositato in atti che presenta i seguenti importi:
   A) LAVORI A BASE D'APPALTO

A.1) Lavori	€ 9.772.282,61
A.2) Oneri per la sicurezza	€ 153.918,65
TOTALE LAVORI A BASE D'APPALTO	€ 9.926.201,26
B) SOMME A DISPOSIZIONE	€ 3.273.798,74
TOTALE GENERALE	**€ 13.200.000,00**

1. di riconfermare, ai sensi dell'art. 16 e 18 della L.P. 26/93 e ss.mm., l'opera in oggetto di pubblica utilità, e l'indifferibilità ed urgenza dei relativi lavori;

3. di precisare che con il presente provvedimento si affida la funzione di stazione appaltante all'Agenzia provinciale per gli Appalti e contratti della P.A.T, in considerazione della complessità dell'appalto, indicando quale responsabile del procedimento per il Comune di Volano, il Vicesegretario comunale;

4. di prendere atto che la spesa complessiva pari ad euro 13.200.000,00 è già stata impegnata per euro 550.600,00 con deliberazione della Giunta comunale n° 353 di data 18.12.2008, mentre la parte rimanente, pari ad euro 12.649.400,00 è stata impegnata con deliberazione della Giunta comunale n° 254 di data 18.12.2012 e sarà finanziata con le seguenti modalità:
   - euro 11.095.900,00 contributo PAT;
   - euro 838.900,00 Comuni di Besenello e Calliano;
   - euro 714.600,00 Comune di Volano di cui:
   - euro 633.500,00 alienazione beni immobili;
   - euro 81.100,00 budget 2011-2015;

5. di dare atto che la gara verrà svolta con il sistema di cui all'art. 30 comma 5 bis della L.P. 26/93 e ss.mm. e i relativi lavori aggiudicati con il criterio del prezzo più basso da determinarsi mediante il sistema dell'offerta a prezzi unitari ai sensi dell'art. 39 comma 1 lett. a) della L.P. 26/93 e ss.mm.;

6. di dichiarare, per i motivi indicati in premessa, la presente deliberazione immediatamente esecutiva ai sensi e per gli effetti dell'art. 54 comma 3 della L.R. 1/1993 e s.m.;

7. di dare evidenza, ai sensi degli artt. 4 e 37 della L.P. 30 novembre1992 n. 23 e ss.mm., che avverso la presente deliberazione sono ammessi i seguenti ricorsi:
   a. opposizione alla Giunta Comunale da parte di ogni cittadino entro il periodo di pubblicazione ai sensi dell'art. 79 del T.U.LL.RR.O.C. approvato con D.P.Reg. 1 febbraio 2005 n. 3/L;
   b. ricorso giurisdizionale al T.R.G.A. di Trento da parte di chi vi abbia interesse entro 60 giorni, ai sensi della legge 6.12.1971 n. 1034;
   c. in alternativa alla possibilità indicata alla lettera b), ricorso straordinario al Presidente della Repubblica entro 120 giorni, ai sensi dell'art. 8 del D.P.R. 24 novembre 1971 n. 1199.-.

* * * * * * * *

3. THE OFFICE BUILDING PROJECT IN BARCELONA.

Due to the confidentiality of information involved, the project owner didn’t authorize the publication of cost-related documentation for the building project.

4. THE OFFICE BUILDING IN SOUTHERN SPAIN.

Due to the confidentiality of information involved, the project owner didn’t authorize the publication of cost-related documentation for the building project.

APPENDIX 4

Case-study projects: LEED and BREEAM documentation

1. THE NURSING-HOME PROJECT.

The following document summarizes the LEED checklist initially developed for the nursing-home project.

LEED 2009 for Healthcare:

New Construction and Major Renovations

NUOVA RSA OPERA ROMANI - Project Checklist

Date: 18th November 2013

Construction Stage Credits

Design Stage Credits

Y	?	N			Possible Points
16	0	2		**Sustainable Sites**	**Possible Points: 18**
C			Prereq 1	Construction Activity Pollution Prevention	
Y			Prereq 2	Environmental Site Assessment	
1			Credit 1	Site Selection	1
1			Credit 2	Development Density and Community Connectivity	1
		1	Credit 3	Brownfield Redevelopment	1
3			Credit 4.1	Alternative Transportation—Public Transportation Access	3
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Roon	1
1			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vel	1
1			Credit 4.4	Alternative Transportation—Parking Capacity	1
1			Credit 5.1	Site Development—Protect or Restore Habitat	1
		1	Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
1			Credit 8	Light Pollution Reduction	1
1			Credit 9.1	Connection to the Natural World—Places of Respite	1
1			Credit 9.2	Connection to the Natural World—Direct Exterior Access for Patie	1
5	1	3		**Water Efficiency**	**Possible Points: 9**
Y			Prereq 1	Water Use Reduction—20% Reduction	
Y			Prereq 2	Minimize Potable Water Use for Medical Equipment Cooling	
1			Credit 1	Water Efficient Landscaping—No Potable Water Use or No Irrig	1
2			Credit 2	Water Use Reduction: Measurement & Verification	1 to 2
1	1	1	Credit 3	Water Use Reduction	1 to 3
		1	Credit 4.1	Water Use Reduction—Building Equipment	1
1			Credit 4.2	Water Use Reduction—Cooling Towers	1
		1	Credit 4.3	Water Use Reduction— Food Waste Systems	1
23	8	8		**Energy and Atmosphere**	**Possible Points: 39**
C			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
15	5	4	Credit 1	Optimize Energy Performance	1 to 24
4	2	2	Credit 2	On-Site Renewable Energy	1 to 8
		2	Credit 3	Enhanced Commissioning	1 to 2
1			Credit 4	Enhanced Refrigerant Management	1
1	1		Credit 5	Measurement and Verification	2
1			Credit 6	Green Power	1
1			Credit 7	Community Contaminant Prevention—Airborne Releases	1

Y	?	N			
6	1	9	**Materials and Resources**		**Possible Points: 16**
Y	?	N			
Y			Prereq 1	Storage and Collection of Recyclables	
Y			Prereq 2	PBT Source Reduction—Mercury	
		3	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 1.2	Building Reuse—Maintain Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
2		2	Credit 3	Sustainably Sourced Materials and Products	1 to 4
1	0		Credit 4.1	PBT Source Reduction—Mercury in Lamps	1
	1	1	Credit 4.2	PBT Source Reduction—Lead, Cadmium, and Copper	2
		2	Credit 5	Furniture and Medical Furnishings	1 to 2
1			Credit 6	Resource Use—Design for Flexibility	1
14	3	1	**Indoor Environmental Quality**		**Possible Points: 18**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
C			Prereq 3	Hazardous Material Removal or Encapsulation	
1			Credit 1	Outdoor Air Delivery Monitoring	1
1		1	Credit 2	Acoustic Environment	1 to 2
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
2	2		Credit 4	Low-Emitting Materials	1 to 4
1			Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7	Thermal Comfort—Design and Verification	1
2			Credit 8.1	Daylight and Views—Daylight	2
2	1		Credit 8.2	Daylight and Views—Views	1 to 3
2	4	0	**Innovation in Design**		**Possible Points: 6**
Y			Prereq 1	Integrated Project Planning and Design	
	1		Credit 1.1	Innovation in Design: Specific Title	1
	1		Credit 1.2	Innovation in Design: Specific Title	1
	1		Credit 1.3	Innovation in Design: Specific Title	1
	1		Credit 1.4	Innovation in Design: Specific Title	1
1			Credit 2	LEED Accredited Professional	1
1			Credit 3	Integrated Project Planning and Design	1
2	1	1	**Regional Priority Credits**		**Possible Points: 4**
1			Credit 1.1	Regional Priority: Specific Credit	1
1			Credit 1.2	Regional Priority: Specific Credit	1
		1	Credit 1.3	Regional Priority: Specific Credit	1
	1		Credit 1.4	Regional Priority: Specific Credit	1
68	18	24	**Total**		**Possible Points: 110**

2. THE SCHOOL-COMPLEX PROJECT.

The following document summarizes the LEED checklist initially developed for the school project.

LEED for Schools 2007
Registered Project Checklist

Project Name: Nuova Scuola Sovracomunale

Project Address: Volano - TN - Italy

Yes	?	No		
61	6	7	**Project Totals** (Pre-Certification Estimates)	79 Points
	PLATINUM		**Certified**: 29-36 points **Silver**: 37-43 points **Gold**: 44-57 points **Platinum**: 58-79 points	

Yes	?	No			
15	0	1	Sustainable Sites		16 Points
Yes			Prereq 1	**Construction Activity Pollution Prevention**	Required
Yes			Prereq 2	**Environmental Site Assessment**	Required
1	0	0	Credit 1	**Site Selection**	1
1	0	0	Credit 2	**Development Density & Community Connectivity**	1
0	0	1	Credit 3	**Brownfield Redevelopment**	1
1	0	0	Credit 4.1	**Alternative Transportation**, Public Transportation	1
1	0	0	Credit 4.2	**Alternative Transportation**, Bicycle Use	1
1	0	0	Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel Efficient Vehicles	1
1	0	0	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
1	0	0	Credit 5.1	**Site Development**, Protect or Restore Habitat	1
1	0	0	Credit 5.2	**Site Development**, Maximize Open Space	1
1	0	0	Credit 6.1	**Stormwater Design**, Quantity Control	1
1	0	0	Credit 6.2	**Stormwater Design**, Quality Control	1
1	0	0	Credit 7.1	**Heat Island Effect**, Non-Roof	1
1	0	0	Credit 7.2	**Heat Island Effect**, Roof	1
1	0	0	Credit 8	**Light Pollution Reduction**	1
1	0	0	Credit 9	**Site Master Plan**	1
1	0	0	Credit 10	**Joint Use of Facilities**	1

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LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
6	1	0	**Water Efficiency**		7 Points
1	0	0	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1	0	0	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
1	0	0	Credit 2	**Innovative Wastewater Technologies**	1
3	0	0	Credit 3	**Water Use Reduction**	1 to 3
			Credit 3.1	20% Reduction	1
			Credit 3.2	30% Reduction	2
			--> Credit 3.3	40% Reduction	3
0	1	0	Credit 4	**Process Water Use Reduction**, 20% Reduction	1

Yes	?	No			
13	2	0	**Energy & Atmosphere**		17 Points
Yes			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 2	**Minimum Energy Performance**	Required
Yes			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1:** All LEED for Schools projects registered after June 26, 2007 are required to achieve at least two (2) points.

Yes	?	No			
10	0	0	Credit 1	**Optimize Energy Performance**	2 to 10
			Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
			Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
			Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
			Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
			Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
			Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
			Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
			--> Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
1	0	0	Credit 2	**On-Site Renewable Energy**	1 to 3
			--> Credit 2.1	2.5% Renewable Energy	1
			Credit 2.2	7.5% Renewable Energy	2
			Credit 2.3	12.5% Renewable Energy	3
0	1	0	Credit 3	**Enhanced Commissioning**	1
1	0	0	Credit 4	**Enhanced Refrigerant Management**	1
1	0	0	Credit 5	**Measurement & Verification**	1
0	1	0	Credit 6	**Green Power**	1

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LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
5	1	6	**Materials & Resources**		13 Points
Yes			Prereq 1	**Storage & Collection of Recyclables**	Required
0	0	0	Credit 1.1	**Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof	1
0	0	1	Credit 1.2	**Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof	1
0	0	1	Credit 1.3	**Building Reuse,** Maintain 50% of Interior Non-Structural Elements	1
1	0	0	Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
0	0	1	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
0	0	1	Credit 3.1	**Materials Reuse**, 5%	1
0	0	1	Credit 3.2	**Materials Reuse**, 10%	1
1	0	0	Credit 4.1	**Recycled Content**, 10% (post-consumer + 1/2 pre-consumer)	1
1	0	0	Credit 4.2	**Recycled Content**, 20% (post-consumer + 1/2 pre-consumer)	1
1	0	0	Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured	1
1	0	0	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured	1
0	0	1	Credit 6	**Rapidly Renewable Materials**	1
0	1	0	Credit 7	**Certified Wood**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No		Indoor Environmental Quality	20 Points
17	1	0			
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
Yes			Prereq 3	**Minimum Acoustical Performance**	Required
1	0	0	Credit 1	**Outdoor Air Delivery Monitoring**	1
1	0	0	Credit 2	**Increased Ventilation**	1
1	0	0	Credit 3.1	**Construction IAQ Management Plan,** During Construction	1
1	0	0	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1	1	0	Credit 4	**Low-Emiiting Materials**	1 to 4
1	0	0	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1	0	0	Credit 6.1	**Controllability of Systems**, Lighting	1
1	0	0	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1	0	0	Credit 7.1	**Thermal Comfort,** Design	1
1	0	0	Credit 7.2	**Thermal Comfort,** Verification	1
3	0	0	Credit 8.1	**Daylight & Views,** Daylight 75% of Spaces	1 to 3
			-->	75% of classrooms (Required for either points below)	1
				90% of classrooms	2
			-->	75% of other spaces	3
1	0	0	Credit 8.2	**Daylight & Views,** Views for 90% of Spaces	1
1	0	0	Credit 9	**Enhanced Acoustical Performance,** 40 dBA / RC level of 32	1
1	0	0		**Enhanced Acoustical Performance,** 35 dBA / RC level of 27	1
1	0	0	Credit 10	**Mold Prevention**	1

Yes	?	No		Innovation & Design Process	6 Points
5	1	0			
1	0	0	Credit 1.1	**Innovation in Design:** SSc5.2 Exemplary performance	1
1	0	0	Credit 1.2	**Innovation in Design:** MRc5.1-2 Exemplary performance	1
1	0	0	Credit 1.3	**Innovation in Design:** EQc8.2 - Raggiunto 99%	1
0	1	0	Credit 1.4	**Innovation in Design:** Uso di pavimenti fotocatalitici	1
1	0	0	Credit 2	**LEED® Accredited Professional**	1
1	0	0	Credit 3	**School as a Teaching Tool**	1

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3. THE OFFICE BUILDING PROJECT IN BARCELONA.

Due to the confidentiality of information involved, the project owner didn’t authorize the publication of any official documentation related to the LEED certification process of the building project.

4. THE OFFICE BUILDING PROJECT IN SOUTHERN SPAIN.

The following document summarizes the BREEAM checklist of the project for each design phase considering the change order requested by the owner through the EN-PC19 process.

PUNTUACIONES BREEAM EN DISTINTAS FASES DEL PROYECTO			
	FCC LICITACIÓN	PUNTUACIÓN COMPROMETIDA EN PC-19	PUNTUACIÓN OBTENIDA EN FASE DE DISEÑO
GST 1	7	7	7
GST 2	2	2	2
GST 3	5	5	5
GST 4	4	4	4
GST 5	1	3	3
SYB 1	2	2	3
SYB 2	2	3	3
SYB 3	2	2	2
SYB 4	1	1	1
SYB 5	0	0	0
SYB 6	0	1	1
ENE 1	13	13	14
ENE 2	2	2	2
ENE 3	1	1	1
ENE 4	1	2	2
ENE 6	2	2	2
ENE 8	2	2	2
TRA 1	0	1	1
TRA 2	2	2	2
TRA 3	3	3	3
TRA 5	2	2	2
AG 1	4	5	6
AG 2	2	2	2
AG 3	2	2	2
AG 4	1	1	1
MAT 1	1	1	1
MAT 3	1	1	1
MAT 4	1	1	1
MAT 5	0	1	1
RSD 1	4	4	4
RSD 2	0	2	2
RSD 3	1	1	1
RSD 4	1	1	1
USE 1	0	2	3
USE 2	2	2	2
USE 4	2	2	2
USE 5	2	2	2
USE 7	2	2	2
CONT 1	1	1	2
CONT 2	3	3	3
CONT 3	2	5	5
CONT 4	1	1	1
CONT 5	1	1	1
PUNTUACIÓN	**88**	**103**	**108**
TOTAL	**73,25%**	**86,41%**	**90,85%**