Designing a Bio-Climatic Passiv' Haus

FINAL REPORT
V0.3

Written by	Written by	Approved by
Elia DIAZ Víctor GUIJARRO Cézanne DE HEUS Geordi ZUIDERVELD	Elia DIAZ	Fabien DUCO Date: Philippe FILLATREAU
Date: 12/06/2017	Date: 23/06/2017	Date:

Acknowledgements

We would like to take this opportunity to thank our technical supervisor, Mr. Fabien DUCO, and our management supervisor, Mr. Philippe FILLATREAU, for their help during the project and the given feedback. With their help we have managed to learn a lot during the EPS.

We would also like to take this moment to thank Mrs. Alexandra MARREGOT JOUANET for giving us French lessons, Mrs. Eleanor BENSON for the communication skills classes and Mr. Philippe FILLATREAU for the project management classes. We have learned a lot during these classes and are grateful for the effort the teachers put into them.

And we would like to thank Ms. Sandra MANDON and Ms. Julie FUENTES of the international office for helping us with everything surrounding the EPS and printing our documents when we need them.

Greenit&Co

Tarbes, EPS Spring 2017

Summary

The aim of the final report is to present the methods and show the results of the work done by the team during the EPS (European Project Semester) which consists of four months of work. The project consisted of designing a bio-climatic passive house in Labastide-Chalosse (Landes, France (40700)). It has been carried out by Greenit&Co which is a multicultural as well as a multidisciplinary team consisting of four students, the technical supervisor (Mr. Fabien DUCO) and the management supervisor (Mr. Philippe FILLATREAU).

By designing a bio-climatic passive house the team has had to meet the requirements set by the Passive House Institute which is the official institution that is able to give the Passiv' Haus certificate. These requirements have the aim of being respectful with the environment by using renewable energy, insulating it properly in order to avoid to have thermal bridges and consequently having a minimum consumption from the grid which can be at a maximum 15 kWh/m^2/year.

The passive house concerning this project will be a single-family house with a living space of 115 m^2 and ground floor, the style of the living space must be "American" style, which means that there will be no walls between the kitchen, living room and dining room, this requirement is according to the client preferences.

At the beginning of the project the team must set a planning in order to follow one schedule, taking into account all the probable risks, the deadlines and deliverables. Moreover the team must monitor this schedule to provide a clear overview about the current progress of the project and take the proper decisions.

An extensive study is done by the team about the passive house in order to understand the main concept. The choice of materials to apply in the exterior envelope of the house must be the right one, because this can save cost in the long run by decreasing the heat load. The house systems used, which are systems for power generation, heating, ventilation and lighting, are studied to make sure that the decision taken by the team is the right one and consequently the passive house requirements and city regulations are met.

Once the previously mentioned studies and choices are done a thermal simulation with Clima-Win™ is carried out to check if the team has been capable of designing a passive house by meeting all the requirements. Either those regarding the power consumption or those regarding the heating requirement.

To conclude the project the conclusions are done in order to show how the project has been carried out, the difficulties found, the decisions taken and the final results.

Table of contents

Acknowledgements 1
Summary 2
Figure list 5
Table list 6
1. Introduction 7
1.1 Outline 7
1.2 EPS Context 8
1.3 Stakeholders 8
1.3.1 Team 8
1.3.2 Supervision and Acceptance 9
2. Management 10
2.1 Scope of the Project 10
2.1.1 Needs expression 10
2.1.2 Requirements 11
2.1.3 Deliverables 13
2.1.4 Limitations and Exclusions 14
2.2 Planning 15
2.2.1 Work Breakdown Structure (WBS) 15
2.2.2 List of Tasks 19
2.2.3 Milestones 20
2.2.4 Gantt Chart 21
2.2.5 Risks 26
2.2.6 Quality 28
2.3 Monitoring Tools 31
2.3.1 Logbook 31
2.3.2 Tracking Gantt 32
2.3.3 Milestones 32
2.3.4 Deliverables 33
2.4 Conclusions 34
3. Technical progress 35
3.1 Study 36

3.1.1 Regulations ... 36
3.1.2 House Systems ... 38
3.2 House Design ... 42
3.2.1 Land Visit ... 42
3.2.2 2D House Plans ... 44
3.2.3 3D Cad Model of the House ... 48
3.3 Thermal Simulation ... 50
3.3.1 Materials Choice ... 50
3.3.2 Thermal Results ... 52
3.4 Conclusions ... 54
4. Management II ... 55
4.1 Monitoring ... 55
4.1.1 Actual work ... 55
4.1.2 Tracking Gantt ... 56
4.1.3 Deliverable Status ... 59
4.2 Cost Analysis ... 61
4.2.1 Systems ... 61
4.2.2 Materials ... 61
4.2.3 Miscellaneous ... 63
4.3 Conclusions ... 64
5. Final Conclusions ... 65
Bibliography ... 69
Appendix A: Study Report ... 70
Appendix B: 2D House Plans ... 70
Appendix C: Thermal Simulation Report ... 70
Appendix D: 3D CAD Model of the House ... 70
Appendix E: House Design Report ... 70
Appendix F: Requirements Document ... 70
Appendix G: Planning Documents ... 70
Appendix H: Monitoring Documents ... 70
Appendix I: Meeting Minutes ... 70

Figure list

Figure 1 Spain ... 8
Figure 2 The Netherlands ... 9
Figure 3 Global WBS picture ... 16
Figure 4 First branch: STUDY ... 16
Figure 5 Second branch: HOUSE ... 17
Figure 6 Third category: MANAGEMENT DOC. ... 18
Figure 7 Fourth category: EPS DOC. ... 18
Figure 8 Milestones timeline ... 20
Figure 9 Organization Gantt Chart ... 21
Figure 10 Gantt planning; task and duration ... 22
Figure 11 Gantt Chart ... 23
Figure 12 Passive house pie chart ... 24
Figure 13 Elia Díaz pie chart ... 25
Figure 14 Victor Guijarro pie chart ... 25
Figure 15 Cézanne de Heus pie chart ... 25
Figure 16 Geordi Zuiderveld pie chart ... 25
Figure 17 Main folders ... 29
Figure 18 Document branch folders ... 30
Figure 19.Tracking Gantt ... 32
Figure 20 Project phases ... 35
Figure 21 Architectural style in the village ... 36
Figure 22 Passive House Institute logo ... 37
Figure 23 Solar panel BISOL BMO-300 ... 38
Figure 24 ALTHERMA MURAL 4 TO 8 KW heating system ... 39
Figure 25 GES Energy 1 (Hoirzontal)(Z010339) VHR ... 40
Figure 26 Flow VS External pressure ... 40
Figure 27 LED bulb ... 41
Figure 28 Land plan ... 43
Figure 29 Southern view of the land ... 43
Figure 30 Steps for designing a house ... 44
Figure 31 2D house plan concept 1 ... 46
Figure 32 2D house plan concept 2 ... 47
Figure 33 Final 3D CAD model north ... 48
Figure 34 Final 3D CAD model south ... 49
Figure 35 Final 3D CAD model furnished ... 49
Figure 36 Results of the thermal simulation ... 53
Figure 37 Planned work ... 55
Figure 38 Actual work ... 55
Figure 39 Tracking Gantt of the branch study ... 56
Figure 40 Tracking Gantt of the branch house ... 57
Figure 41 Tracking Gantt of the branch management doc.and EPS doc. ... 58

Table list

Table 1 List of tasks 19
Table 2 Milestones 20
Table 3 Probability and impact matrix [3] 26
Table 4 Risks [4] 27
Table 5 Logbook example 31
Table 6.Status of the deliverables at the intermediate review. 33
Table 7. Structure element selection 52
Table 8 Deliverable status 59
Table 9 Cost analysis of the house systems 61
Table 10 Cost analysis of the materials used in the house 62
Table 11. Cost analysis of the miscellaneous. 63
Table 12 Checklist objetives 66
Table 13 Checklist passive house requirements 66
Table 14 Checklist city regulations 67
Table 15 Checklist requirements of the clients 67

1. Introduction

1.1 Outline

This document concerns the "Designing of a bio-climatic Passiv' Haus" project. In short; for this project the team, Greenit&Co, was asked to design a family house according to the Passiv' Haus concept. Nowadays the fossil fuels (oil, natural gas, coal etc.) are running out, so it is necessary to think about preserving the planet and to use other resources for energy, for example renewable energies. For this reason, Greenit&Co has chosen this project: it is an opportunity to help the land and to build more ecological in this way, and respect the nature. The team is very interested to learn about new building methods for the future.

The completion of the final report is made to present the methods and show the results of the project. This consists of designing a bio-climatic passive house in Labastide-Chalosse (Landes, France (40700)). The main requirement of designing a passive house is to design a house that respects the environment by using renewable energy according to the area where the house will be built, instead of only using energy from the electrical grid (15 kWh/m^2/year). Also the house needs to be affordable, comfortable and ecological.

First of all the participants and the context are introduced: the European Project Semester (EPS), the team and stakeholders. The team for this project, called Greenit&Co, consists of four members. The team is multidisciplinary as well as multicultural. The project has one technical supervisor (Mr. Fabien DUCO) and one management supervisor (Mr. Philippe FILLATREAU).

In the second chapter the management of the project is discussed, shown in Management, this management chapter focuses on the general information about the project. This includes for example why the project is carried out, when the finish date is, and what the different phases for the project are. The requirements and deliverables are also discussed, shown in 2.1.2 Requirements. This chapter also focuses on the planning part of the project. The Work Breakdown Structure (WBS) is explained as well as the Gantt Chart planning, including pie charts to show how the project was divided, shown in 2.2 Planning.

The third chapter focuses on the technical part of the project, shown in Technical progress. In this chapter the studies that have been carried out are discussed as well as the regulations, shown in 3.1.1 Regulations, the house design, shown in 3.2 House Design that has been made by the team, the materials choice and the thermal simulation, shown in 3.3 Thermal Simulation.

The fourth chapter also concerns management, shown in Management II, but this chapter mainly focuses on the monitoring of the project, how this is done and the final status of the deliverables, show in 4.1.3 Deliverable Status.

The report ends with the conclusion, show in Final Conclusions. In addition for more information, appendices have been added to this document.

1.2 EPS Context

The project is developed at the ENIT (École Nationale d'Ingénieurs de Tarbes) during the EPS, this semester is a European program that, in this case, is done in Tarbes, France (65000). During this semester, students from all around Europe are divided in teams to carry out different projects according to their abilities and preferences, but at the same time the students must follow different classes that the university has established for the EPS students. These classes are:

- Communication Skills
- Project Management
- French Language

Every project is supervised by a technical supervisor and a management supervisor to teach the students in the professional work method and to help the students in the stages where they are not able to overcome the difficulties. This way the students will gain new abilities and knowledge thanks to the EPS.

1.3 Stakeholders

1.3.1 Team

The team for this project, called Greenit&Co, consists of four members. The name for the team is composed by two words "green" and "ENIT". The first word, "green", represents the project because it is related to "green energy" and the second, ENIT, is the abbreviation for "École Nationale d'Ingénieurs de Tarbes", where the project is being developed. The team is multidisciplinary as well as multicultural. The team members are as follows (shown in Figure 1 and *Figure 2*):

Elia DIAZ
25 years old
Industrial Engineer

Figure 1 Spain

Victor GUIJARRO
21 years old
Mechanical Engineering student

Cézanne DE HEUS
20 years old
Electrical Engineering student

Geordi ZUIDERVELD
19 years old
Electrical Engineering student

Figure 2 The Netherlands

1.3.2 Supervision and Acceptance

This project has one end client (Mr. Sylvain BROUCA), one representative of said client, who at the same time is the technical supervisor (Mr. Fabien DUCO) and one management supervisor (Mr. Philippe FILLATREAU). The team can only contact Mr. Sylvain BROUCA if it is strictly necessary and contacting Mr. Sylvain BROUCA is only allowed through Mr. Fabien DUCO.

Apart from the project team themselves Mr. Fabien DUCO's collaboration is required for the necessary skills, knowledge, training and communication with the end user, Mr. Sylvain BROUCA. Mr. Philippe FILLATREAU's contribution is required for advice on the different project management aspects.

Mr. Fabien DUCO, Mr. Philippe FILLATREAU and Mr. Sylvain BROUCA's approval is required.

Mr. Fabien DUCO is also in power to oppose or stop the project.

Mr. Fabien DUCO, Mr. Philippe FILLATREAU and Mr. Sylvain BROUCA will all receive progress reports.

Mr. Fabien DUCO and Mr. Philippe FILLATREAU will evaluate the work of the team.

2. Management

The management section of the final report consists of four different chapters: *2.1 Scope of the Project, 2.2 Planning, 2.3 Monitoring Tools, 2.4 Conclusions*. The management aspect of a project is important to make sure the project is finished on time with a satisfactory outcome. When management is done right it is possible to focus on the technical aspects of the project without having to worry about the planning and whether the available time is enough for the tasks that have to be done, because the team takes control of it with the tools explain in section 2.2 and 2.3.

In *2.1 Scope of the Project*, the project and the requirements are described. Then, the team starts with the organization of the project in chapter *2.2 Planning*. In this section the planning process is developed, the team creates the Work Breakdown Structure, and use the Gantt Chart to carry out a general vision of all the project. The quality and the risks are explained as well. Finally, the team presents the different tools to monitor the project in section *2.3 Monitoring Tools*.

2.1 Scope of the Project

In this chapter the scope of the project is described. A description of the project is given, then the requirements consisting of objectives and technical requirements, the deliverables, and finally the limitations and the exclusions are presented.

2.1.1 Needs expression

The needs expression consists of, what the project is, why the project is carried out, when the finish date is and how much the reference budget is.

The project considers the designing of a single-family house according to the Passiv' Haus concept, with a living space of 115 m^2 and one ground floor. The house will be built on the end client's land in Labastide-Chalosse (Landes, France (40700)).The Passiv' Haus concept concerns a house that is for the most part self-sustaining. More information about the passive house requirements can be found in *Appendix A: Study Report.*

The project is created by the end client, who wants an EPS group to design a passive house for him. A design was already made by a professional company, but the end client did not completely like their design. This is why he wants a fresh set of minds on the project to make a new design of the house. The team did not get to see the previously made plans, since the client wanted the team to not be influenced by them.

The finish date of the project is Thursday the 29th of June 2017, the deadline for the final report however is a week earlier on Thursday the 22nd of June 2017.

The budget can only be used as a reference while designing the house, it cannot be spent by the team. The budget is €170.000 and is completely for the construction of the house and the needed house systems.

2.1.2 Requirements

The requirements of the project are the objectives and the technical requirements. In this project, the team has to achieve seven objectives.Most of the technical requirements are the dimensions of the house with some exceptions, for example the amount of floors that the client wishes to have.

2.1.2.1 Objectives

The main objective of designing a Passive House is to design a house that respects the environment by using renewable energy according to the area where the house will be built, instead of only using energy from the electrical grid (15 kWh/m^2/year). Also the house needs to be affordable, comfortable and ecological.

The objectives have been defined by the technical supervisor, the end client and the team. These objectives have to be realised to end the project in a satisfactory manner, with a deadline for the final review on the 29th of June 2017. The passive house that is going to be designed should be a single-family house with a living space of 115 m^2. The land where the house will be built has an area of approximately 2812 m^2 and is located in Labastide-Chalosse (Landes, France (40700)). The objectives are as follows:

R1 - To study:
- City regulations (Labastide-Chalosse (40700)) [1]
- Passive House requirements [2]

R2 - To optimize the orientation of the house

R3 - To draw the 2D plans of the house

R4 - To design the following house systems:
- Power generation
- Heating
- Ventilation
- Lighting

R5 - To calculate the window surface area and placement (16,67% of the total wall area on the south side of the house should be window surface area).

R6 - To choose the adapted insulation (floor, walls, roof base)

R7 - To analyse the cost

To achieve the objectives, the team can count on the support of one technical supervisor (Mr. Fabien DUCO) and one project management supervisor (Mr. Philippe FILLATREAU).

2.1.2.2 Technical Requirements

To make sure the expectations of the end client are met, technical requirements were defined. These technical requirements include the dimensions of the house. These dimensions have a small margin of **±1%.** The technical requirements are as follows:

- The energy consumption cannot exceed 15 kWh/m^2/year.
- The house can have one floor: the ground floor.
- The dimensions for each part of the house:
    - The living space of the house is 115 m^2.
    - The area of the garage is 50 m^2 and it should be linked to the house.
    - 50 m^2 – Kitchen, living room, dining room.
    - 7,2 m^2 – Technical room (should be linked to the kitchen).
    - 24 m^2 – 2 Rooms (12 m^2/Room).
    - 16 m^2 – Parental room.
    - 5 m^2 – Walk-in-closet.
    - 7 m^2 – Bathroom (shower).
    - 3 m^2 – Toilet.
- Present the results of the simulations that can be used for analysis or simulation.

The plans of the land are shown in *3.2.1.1 Plan of the Land.*

2.1.3 Deliverables

The deliverables can be divided into two separate groups; deliverables mainly for EPS supervisors and deliverables for the end client. These deliverables have been established during a meeting with the technical supervisor. With his help the team made a list of deliverables that had to be done during the project.

EPS supervisors

- Study Report (D1.1)
  - Regulation Study Report (D1.1.1)
- 2D House Plans (D2.1)
  - Land Visit Report (D2.1.1)
  - Draft 2D House Plans (D2.1.2)
  - Final 2D House Plan (D2.1.3)
- Thermal Simulation Report (D2.2)
  - Materials Choice Report (D2.2.1)
- 3D CAD Model of the House (D2.3)
- Requirements Document (D3.1)
- Planning Documents (D3.2)
  - WBS (D3.2.1)
  - Gantt Chart (D3.2.2)
- Monitoring Documents (D3.3)
- Intermediate Review (D4.1)
  - Intermediate Report (D4.1.1)
  - Intermediate Presentation (D4.1.2)
- Final Review (D4.2)
  - Final Report (D4.2.1)
  - Final Presentation (D4.2.2)

End client

- 2D House Plans (D2.1)
- Thermal Simulation Report (D2.2)
- 3D CAD Model of the House (D2.3)
- House Design Report (D2.4)
- Requirements Document (D3.1)

2.1.4 Limitations and Exclusions

In this part of the report the limitations and exclusions are described. The limitations consist of tasks that will be done until a certain point (for example the team will decide the materials of the house and estimate the price of each material, however deciding on the provider will not be done) and the exclusions consist of tasks that will not be done and are excluded from the objectives and requirements of this project.

The limitations for this project are as follows:

- Not choosing furniture in detail, this means that only basic furniture will be chosen for simulation purposes so the team will only take care of the dimensions but not the exact model of each piece of furniture.
- Designing dimensions for the house, the dimensions are set by the client during the first technical meeting, which means the team cannot change these. However the dimensions do have a small margin of **±1%**.
- Contacting the providers to ask for an estimation of the cost for some of the materials, without assigning them to the actual project and asking them for a real offer. The contacting will only be done to obtain information concerning the product and a possible cost analysis.

The exclusions of the project are as follows:

- Structural calculations of the house.
- Physical construction of the house, the house will not be constructed by the team on the land itself.
- Connection between the different house systems, which are listed in *2.1.2.1 Objectives* (for example the connection between the heating system and the power generation system), it is not part of the project for the team to research and establish the connections between the house systems.
- Electrical cabling: length, thickness, material of the cables etc. will not be calculated or studied in this project.

2.2 Planning

In this chapter the planning for the project is explained. The objectives and the deliverables are known (described in *2.1.2.1 Objectives* and *2.1.3 Deliverables*) and with these the team has been able to make the Work Breakdown Structure (WBS). The WBS is designed with the XMind 8™ software. As a result, the team has obtained the tasks of the project, assigned the team member responsible for each task as well as the team members that are working on each different task.

The following step to plan the project was to estimate the duration of the tasks. First, the team decided to define the deadlines for the deliverables, which are called milestones. The team created the Gantt Chart to plan the project in the time that is available. The Gantt Chart is designed with the MS Project™ software.

At the end, Greenit&Co identified the risks for the project, using the scope of the project (presented in *2.1 Scope of the Project*), the structure of the project, tasks and milestones, due to all of the aforementioned the team understands where the most dangerous weaknesses lie, that, in this case, were the lack of skills regarding the civil engineering and architectural knowledge. All the risks are shown and rated in *2.2.5 Risks* .

2.2.1 Work Breakdown Structure (WBS)

The WBS is the Work Breakdown Structure that allows converting a list of deliverables into a list of tasks for this project. It is a difficult tool to use because the team has no experience using this tool. At the beginning of the project the team only knew that it should divide the project in four branches. These four branches are the main four groups of the deliverables. The method to make the WBS is grouping the deliverables. The team tries to group the deliverables most related in different ways, this until the most appropriate solution has been found. This was a large process because the team spent a lot of time to decide and discuss, the main and sub deliverables as well as the tasks.

- Global Picture

In this structure the deliverables have been divided into four branches (shown in *Figure 3*), broken down into tasks that lead to meeting the client's requirements and the expected results. Each branch has a different colour and code in order to identify every deliverable. The technical part consists of D1 Study and D2 House, the management part is D3 Management documents and D4 are the EPS documents.

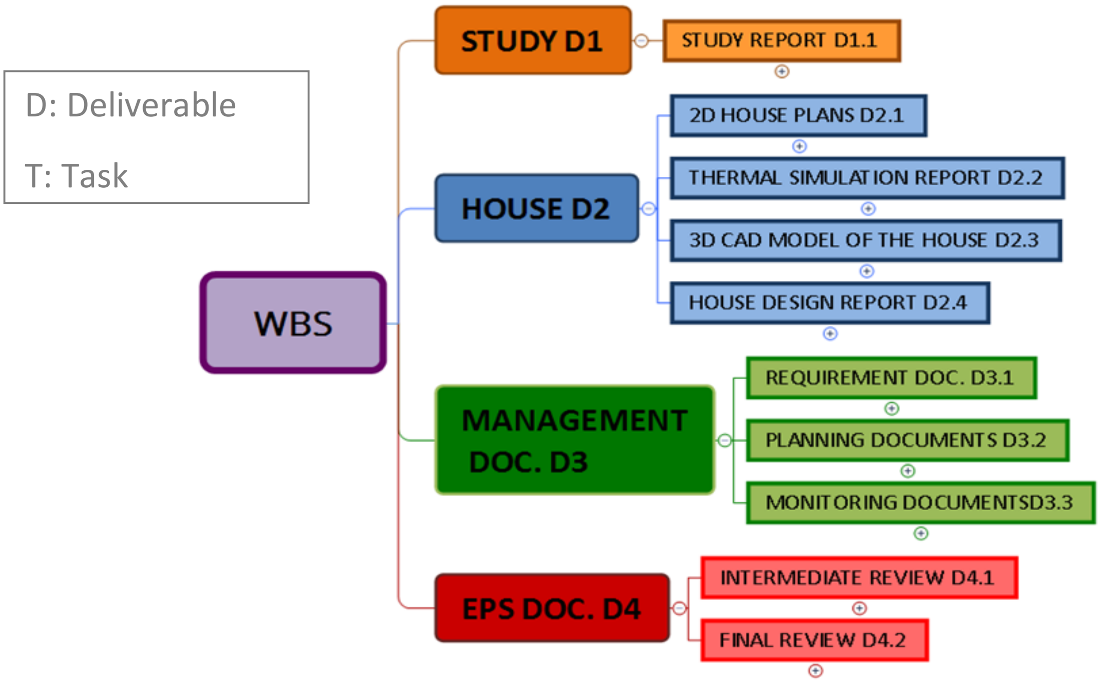


Figure 3 Global WBS picture

- Study

The first branch (shown in *Figure 4*) corresponds to the deliverable, called study report that includes the regulation of the city, the passive house requirements, both are included in the sub deliverable regulation study report, and the systems in the house (power generation, heating, ventilation and lighting systems).

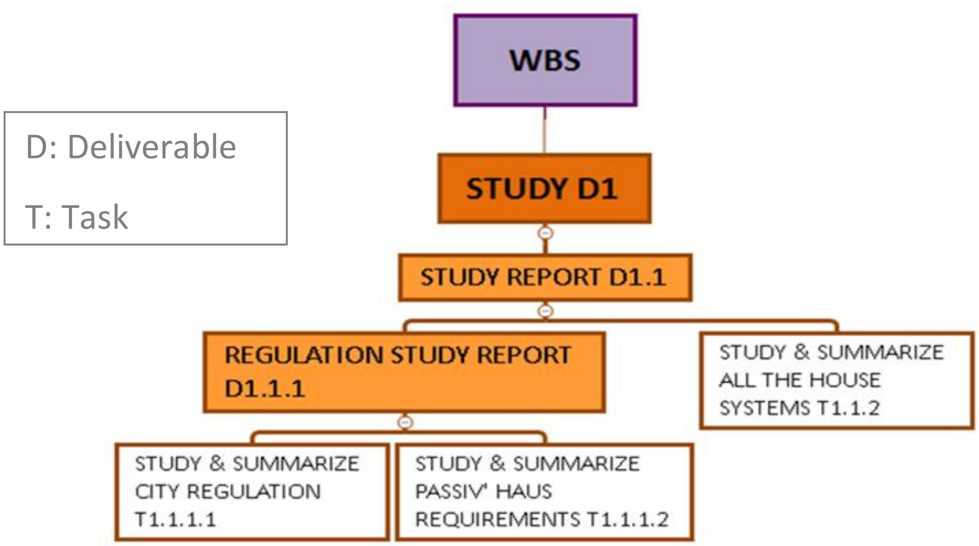


Figure 4 First branch: STUDY

- House

The second branch includes the deliverables: 2D house plans, thermal simulation report, 3D CAD Model of the house and house design report (shown in *Figure 5*). The house branch includes all of the technical parts of this project. The team has to carry out a study of the different house systems and materials choice; the local environment, as well as analyse and simulate them in a thermal software to check all the requirements.

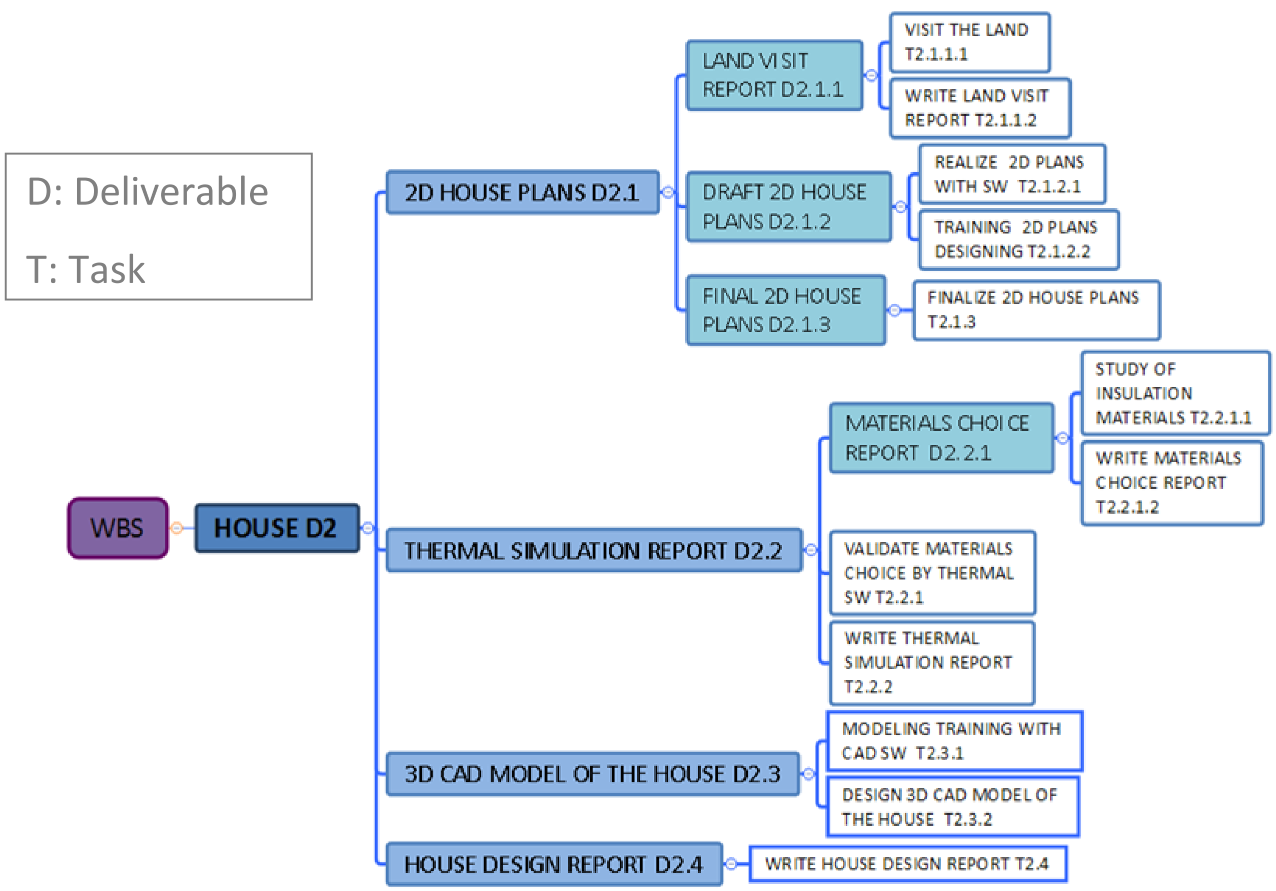


Figure 5 Second branch: HOUSE

- Management Document

The third branch consists of the organisation of the project. The deliverables are the requirements document, the planning documents and the monitoring documents (shown in *Figure 6*). The requirements document consists of all the main requirements and the structure of the project. The planning documents are WBS and Gantt Chart to follow the project and the monitoring documents are used by the team to keep the project updated and under control.

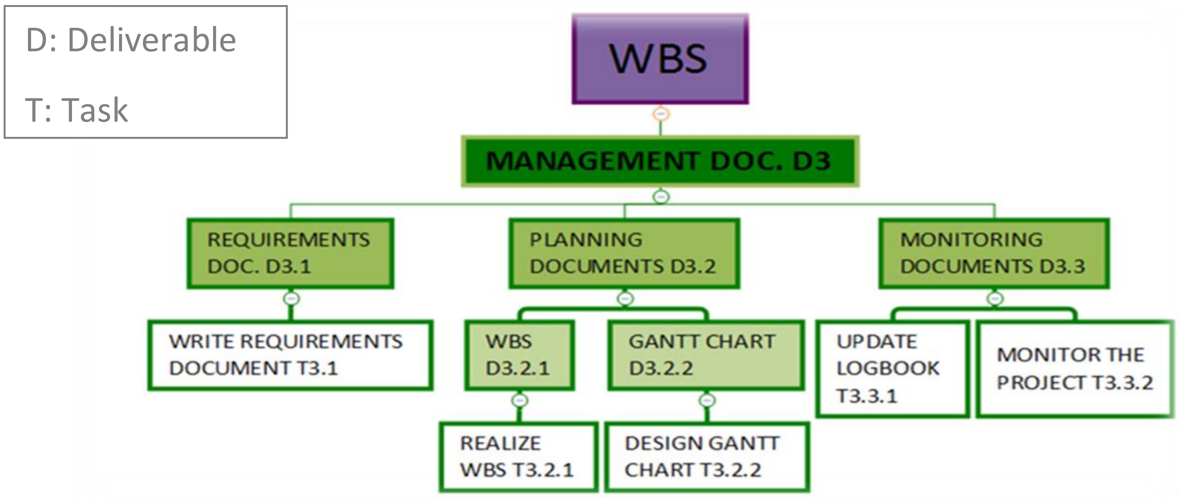


Figure 6 Third category: MANAGEMENT DOC.

- EPS Documents

The last branch contains the intermediate and final reports and presentations (shown in *Figure 7*).

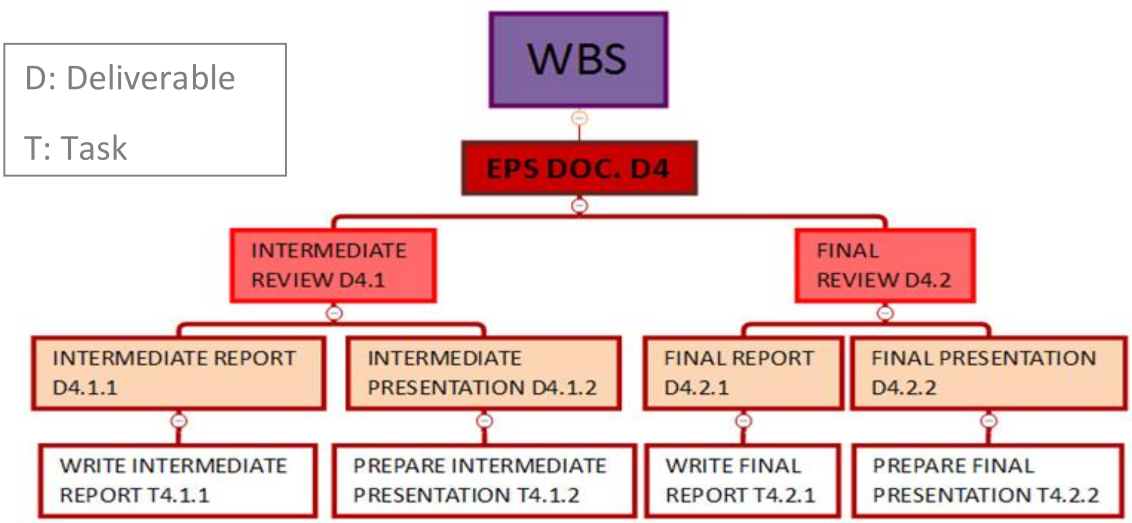


Figure 7 Fourth category: EPS DOC.

2.2.2 List of Tasks

To have an overview of the different tasks within this project, *Table 1* has been made with an overview of the different tasks that can also be found in the WBS.

The letter R correspond to the responsible person for that task and the letter W is for working on that task.

Code	Task	Geordi	Elia	Cezanne	Victor	Wh (H)
T1.1.1.1	Study & summarize city regulation		R W		W	32
T1.1.1.2	Study & summarize passiv' haus requirements	R W		W		32
T1.1.2	Study & summarize all the house systems			W	R W	64
T2.1.1.1	Visit the land	W	W	R W	W	20
T2.1.1.2	Write land visit report		W	R W		24
T2.1.2.1	Realise 2D plans with SW	R W	W	W	W	119
T2.1.2.2	Training 2D plans designing	R W	W	W	W	20
T2.1.3	Finalize 2D house plans	R W	W	W	W	60
T2.2.1.1	Study of insulation materials	W	R W			44
T2.2.1.2	Write material choice report	W	R W			20
T2.2.1	Validate material choice by Thermal SW	W	W	R W	W	52
T2.2.2	Write thermal simulation report	W	RW	W	W	25
T2.3.1	Modeling training with CAD SW	W	W	W	R W	60
T2.3.2	Design 3D CAD model of the house	W	W	W	RW	24
T2.4	Write house design report	W	W	R W	W	44
T3.1	Write requirements document	W	R W	W	W	100
T3.2.1	Realise WBS		W		R W	38
T3.2.2	Design Gantt chart	R W		W		22
T3.3.1	Update logbook			R W		4
T3.3.2	Monitor the project	W		R W		20
T4.1.1	Write intermediate report	W	W	R W	W	60
T4.1.2	Prepare intermediate presentation	W	W	W	R W	40
T4.2.1	Write final report	W	R W	W	W	76
T4.2.2	Prepare final presentation	R W	W	W	W	50

Table 1 List of tasks

2.2.3 Milestones

Milestones are specific points during the project, called deadlines. The team needs these deadlines to plan and organise when it is necessary to finish the deliverable. This task is very difficult because the team doesn't know the real workload for each deliverable.

First the team makes a timeline on the white board to discuss the dates, shown in *Figure 8*.

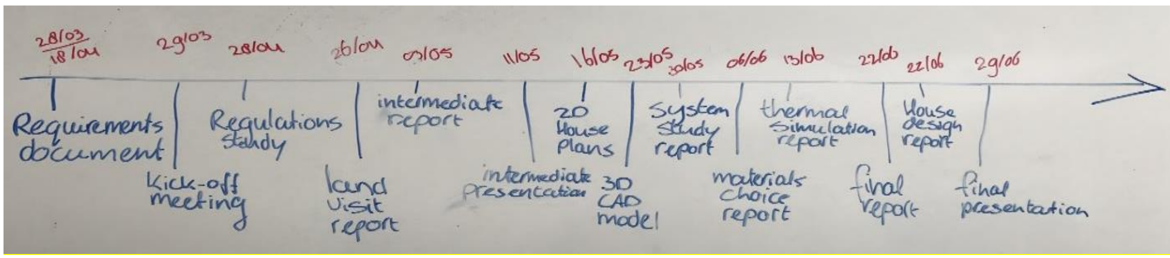


Figure 8 Milestones timeline

The milestones for the biggest part consist of the deliverables that can also be found in the WBS. The milestones can be found in *Table 2*:

N°	DEADLINE	DELIVERABLE
M1	21/04	Requirements Document (D3.1)
M2	24/04	Land Visit Report (D2.1.1)
M3	03/05	Regulation Study Report (D1.1.1)
M4	05/05	Intermediate Report (D4.1.1)
M5	12/05	Intermediate Presentation (D4.1.2)
M6	18/05	Draft 2D House Plans (D2.1.2)
M7	23/05	Study Report (D1.1)
M8	23/05	Materials Choice Report (D2.2.1)
M9	02/06	Thermal Simulation Report (D2.2)
M10	08/06	Final 2D House Plans (D2.1.3)
M11	15/06	3D CAD Model of the House (D2.3)
M12	20/06	Final Report (D4.2.1)
M13	23/06	House Design Report (D2.4)
M14	29/06	Final Presentation (D4.2.2)

Table 2 Milestones

2.2.4 Gantt Chart

To plan the project, the team has made a Gantt Chart to have a clear overview of all the tasks and the duration of said tasks with starting and finishing dates. The tasks are divided as the WBS is defined, meaning the task names in the WBS can also be found in the Gantt Chart, shown in *Figure 9*. In addition, every task has been assigned one or several human resources (1.3.1 Team).

	WBS	Task Name	Duration	Start	Finish
1		Designing a Bio-Climatic Passiv'Haus	0,86 days	Fri 03/03/17	Sat 04/03/17
2	**T1**	+ **STUDY**	**21 days?**	**Wed 19/04/17**	**Thu 25/05/17**
8	**T2**	+ **HOUSE**	**36 days?**	**Fri 21/04/17**	**Fri 23/06/17**
28	**T3**	+ **MANAGEMENT DOC.**	**52,43 days?**	**Tue 14/03/17**	**Tue 27/06/17**
35	**T4**	+ **EPS DOC.**	**59,86 days?**	**Fri 03/03/17**	**Wed 28/06/17**
41					

Figure 9 Organization Gantt Chart

The first task for the planning is to calculate the available hours for the project. First the workdays have been counted in the school-hyperplanning. Since the rule of the EPS is that the team has to work a minimum of 6 hours per day, the days can be multiplied by 6 hours. In total the group has 138 hours of classes, so this number has to be subtracted from the total amount, resulting in hours available per person. This is then multiplied by 4, since the team consists of 4 people, resulting in the total amount of hours available for the complete project. The calculation is done as follows:

69 days in total

138 hours of classes

$$69 \text{ days} \cdot 6 \text{ hours} = 414 \text{ hours}$$

$$414 \text{ hours} - 138 \text{ hours} = 276 \text{ hours per person}$$

$$276 \cdot 4 = 1104 \text{ hours for the whole team}$$

Greenit&Co has taken into account that the team has 1104 hours to spend in total, as a reference. This corresponds to 276 hours per person. In case the team needs more time, it is possible to have longer workdays of for example 10 hours per day. When the available time is clear, the team estimates the needed duration for each of the tasks with the help of the set deadlines for the *milestones.*

With the help of the milestones the duration of the different tasks has been estimated, which then resulted in a start date that could be filled into the Gantt Chart along with the finish date.

To make the Gantt Chart the team started by filling in every taskname, which can also be found in the WBS, and added the milestones, an example is shown in ***Figure 10***. After that the dependencies are added, as well as the deadlines for every task and milestone. With the help of the deadlines of the milestones; the start dates, finish dates and dependencies of the tasks are set. All the tasks were set to fixed duration, this to have the program calculate the workload (shown in *2.2.2 List of Tasks*). When the workload hours appeared to be too much in comparison with the reference hours, these were edited with the unit percentages of the human resources. After the resources were assigned to the different tasks. Since on some tasks the assigned team member would not be working for 100%.

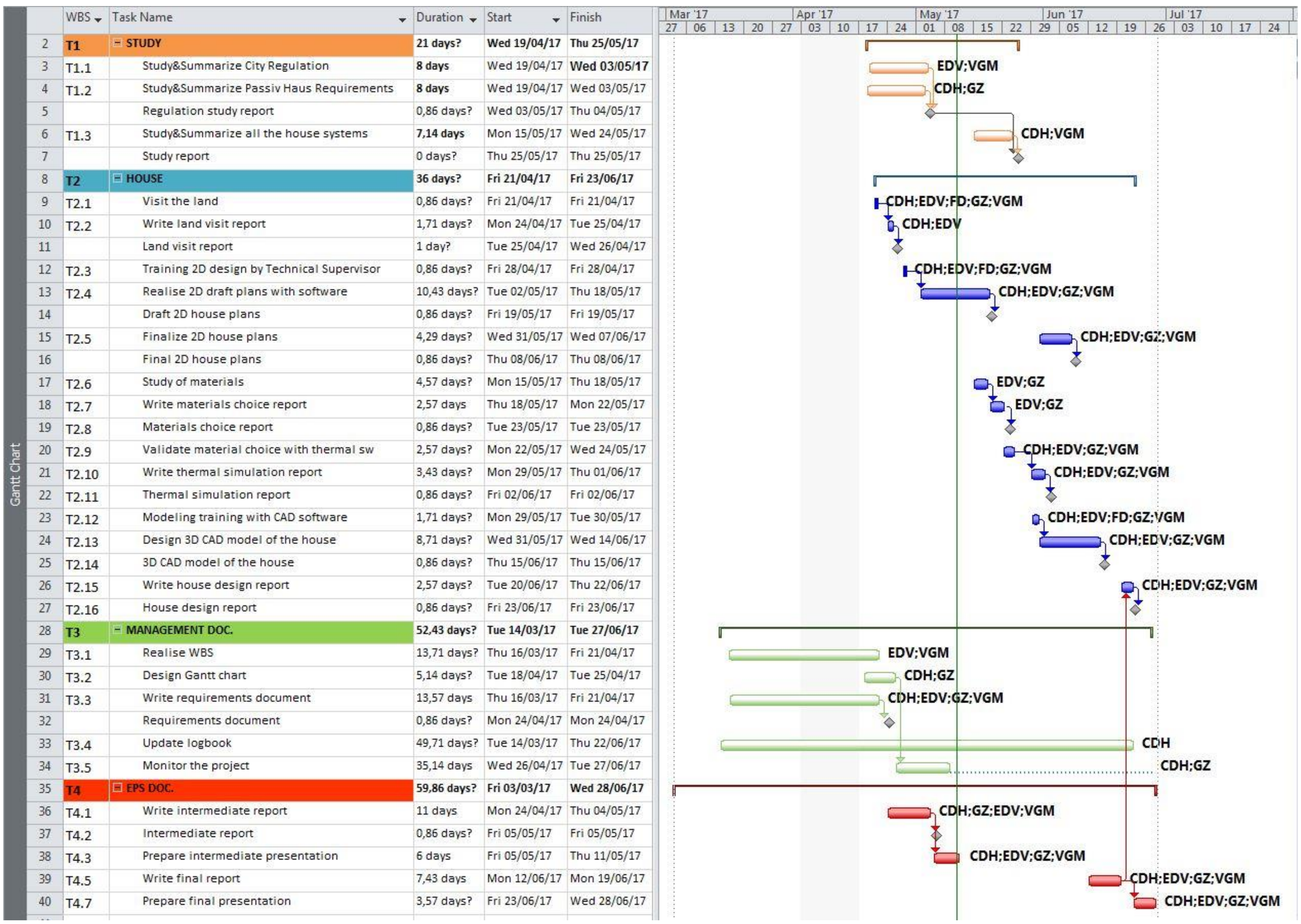
Gantt Chart

	WBS	Task Name	Duratic	Start	Finish
1		Designing a Bio-Climatic Passiv'Haus	0,86 days	Fri 03/03/17	Sat 04/03/17
2	**T1**	**+ STUDY**	**21 days?**	**Wed 19/04/17**	**Thu 25/05/17**
8	**T2**	**− HOUSE**	**36 days?**	**Fri 21/04/17**	**Fri 23/06/17**
9	T2.1	Visit the land	0,86 days	Fri 21/04/17	Fri 21/04/17
10	T2.2	Write land visit report	1,71 days	Mon 24/04/17	Tue 25/04/17
11		Land visit report	1 day?	Tue 25/04/17	Wed 26/04/17
12	T2.3	Training 2D design by Technical Supervisor	0,86 days	Fri 28/04/17	Fri 28/04/17
13	T2.4	Realise 2D draft plans with software	10,43 day	Tue 02/05/17	Thu 18/05/17
14		Draft 2D house plans	0,86 days	Fri 19/05/17	Fri 19/05/17
15	T2.5	Finalize 2D house plans	4,29 days	Wed 31/05/17	Wed 07/06/17
16		Final 2D house plans	0,86 days	Thu 08/06/17	Thu 08/06/17
17	T2.6	Study of materials	4,57 days	Mon 15/05/17	Thu 18/05/17
18	T2.7	Write materials choice report	2,57 days	Thu 18/05/17	Mon 22/05/17
19		Materials choice report	0,86 days	Tue 23/05/17	Tue 23/05/17
20	T2.8	Validate material choice with thermal sw	2,57 days	Mon 22/05/17	Wed 24/05/17
21	T2.9	Write thermal simulation report	3,43 days	Mon 29/05/17	Thu 01/06/17
22		Thermal simulation report	0,86 days	Fri 02/06/17	Fri 02/06/17
23	T2.10	Modeling training with CAD software	1,71 days	Mon 29/05/17	Tue 30/05/17
24	T2.11	Design 3D CAD model of the house	8,71 days	Wed 31/05/17	Wed 14/06/17
25		3D CAD model of the house	0,86 days	Thu 15/06/17	Thu 15/06/17
26	T2.12	Write house design report	2,57 days	Tue 20/06/17	Thu 22/06/17
27		House design report	0,86 days	Fri 23/06/17	Fri 23/06/17
28	**T3**	**+ MANAGEMENT DOC.**	**52,43 days**	**Tue 14/03/17**	**Tue 27/06/17**
35	**T4**	**+ EPS DOC.**	**59,86 days**	**Fri 03/03/17**	**Wed 28/06/17**
41					

Figure 10 Gantt planning; task and duration

The Gantt Chart with the bar-planning can be found in *Figure 11.* The initials of the resources are shown in the bars of the Gantt Chart. The initials correspond with the names of the team members. The initials are as follows:

- EDV: Elia DÍAZ VÁZQUEZ
- VGM: Víctor GUIJARRO MONFORTE
- CDH: Cézanne DE HEUS
- GZ: Geordi ZUIDERVELD



	WBS	Task Name	Duration	Start	Finish
2	T1	STUDY	21 days?	Wed 19/04/17	Thu 25/05/17
3	T1.1	Study&Summarize City Regulation	8 days	Wed 19/04/17	Wed 03/05/17
4	T1.2	Study&Summarize Passiv Haus Requirements	8 days	Wed 19/04/17	Wed 03/05/17
5		Regulation study report	0,86 days?	Wed 03/05/17	Thu 04/05/17
6	T1.3	Study&Summarize all the house systems	7,14 days	Mon 15/05/17	Wed 24/05/17
7		Study report	0 days?	Thu 25/05/17	Thu 25/05/17
8	T2	HOUSE	36 days?	Fri 21/04/17	Fri 23/06/17
9	T2.1	Visit the land	0,86 days?	Fri 21/04/17	Fri 21/04/17
10	T2.2	Write land visit report	1,71 days?	Mon 24/04/17	Tue 25/04/17
11		Land visit report	1 day?	Tue 25/04/17	Wed 26/04/17
12	T2.3	Training 2D design by Technical Supervisor	0,86 days?	Fri 28/04/17	Fri 28/04/17
13	T2.4	Realise 2D draft plans with software	10,43 days?	Tue 02/05/17	Thu 18/05/17
14		Draft 2D house plans	0,86 days?	Fri 19/05/17	Fri 19/05/17
15	T2.5	Finalize 2D house plans	4,29 days?	Wed 31/05/17	Wed 07/06/17
16		Final 2D house plans	0,86 days?	Thu 08/06/17	Thu 08/06/17
17	T2.6	Study of materials	4,57 days?	Mon 15/05/17	Thu 18/05/17
18	T2.7	Write materials choice report	2,57 days	Thu 18/05/17	Mon 22/05/17
19	T2.8	Materials choice report	0,86 days?	Tue 23/05/17	Tue 23/05/17
20	T2.9	Validate material choice with thermal sw	2,57 days?	Mon 22/05/17	Wed 24/05/17
21	T2.10	Write thermal simulation report	3,43 days?	Mon 29/05/17	Thu 01/06/17
22	T2.11	Thermal simulation report	0,86 days?	Fri 02/06/17	Fri 02/06/17
23	T2.12	Modeling training with CAD software	1,71 days?	Mon 29/05/17	Tue 30/05/17
24	T2.13	Design 3D CAD model of the house	8,71 days?	Wed 31/05/17	Wed 14/06/17
25	T2.14	3D CAD model of the house	0,86 days?	Thu 15/06/17	Thu 15/06/17
26	T2.15	Write house design report	2,57 days?	Tue 20/06/17	Thu 22/06/17
27	T2.16	House design report	0,86 days?	Fri 23/06/17	Fri 23/06/17
28	T3	MANAGEMENT DOC.	52,43 days?	Tue 14/03/17	Tue 27/06/17
29	T3.1	Realise WBS	13,71 days?	Thu 16/03/17	Fri 21/04/17
30	T3.2	Design Gantt chart	5,14 days?	Tue 18/04/17	Tue 25/04/17
31	T3.3	Write requirements document	13,57 days	Thu 16/03/17	Fri 21/04/17
32		Requirements document	0,86 days?	Mon 24/04/17	Mon 24/04/17
33	T3.4	Update logbook	49,71 days?	Tue 14/03/17	Thu 22/06/17
34	T3.5	Monitor the project	35,14 days	Wed 26/04/17	Tue 27/06/17
35	T4	EPS DOC.	59,86 days?	Fri 03/03/17	Wed 28/06/17
36	T4.1	Write intermediate report	11 days	Mon 24/04/17	Thu 04/05/17
37	T4.2	Intermediate report	0,86 days?	Fri 05/05/17	Fri 05/05/17
38	T4.3	Prepare intermediate presentation	6 days	Fri 05/05/17	Thu 11/05/17
39	T4.5	Write final report	7,43 days	Mon 12/06/17	Mon 19/06/17
40	T4.7	Prepare final presentation	3,57 days?	Fri 23/06/17	Wed 28/06/17

Figure 11 Gantt Chart

2.2.4.1 Pie Charts

The team has created different pie charts to represent the percentage of hours needed per branch and per person. Each branch, shown in the pie charts, corresponds with the same named branches in the WBS. These branches are study, house, management and EPS, shown in 2.2.1 Work Breakdown Structure (WBS). Another pie chart has been done to represent the percentage of hours needed per branch.

The first result in the pie chart shows (*Figure 12*) the percentage the team needs per branch. For the technical part it is approximately 59%, for EPS documents 21% is needed, and for management documents 20% is necessary.

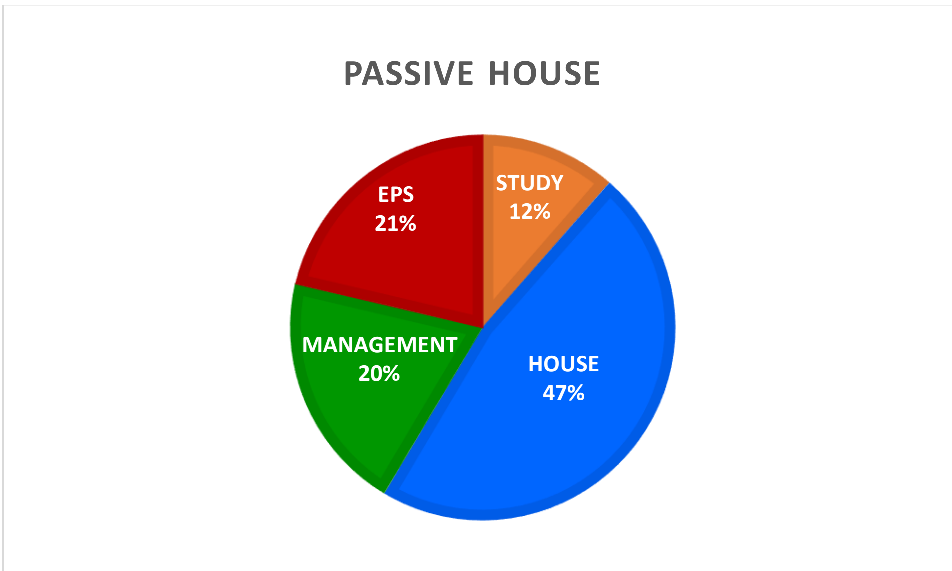


Figure 12 Passive house pie chart

The charts (*Figure 13, Figure 14, Figure 15, Figure 16*) represent the amount of hours that each member of the team is working on the tasks, divided into the four branches. The percentages are for all members approximately the same. This due to the way the tasks are divided and the workload for each of the tasks.

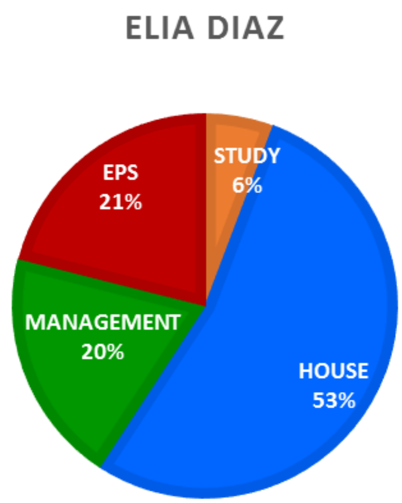


Figure 13 Elia Díaz pie chart

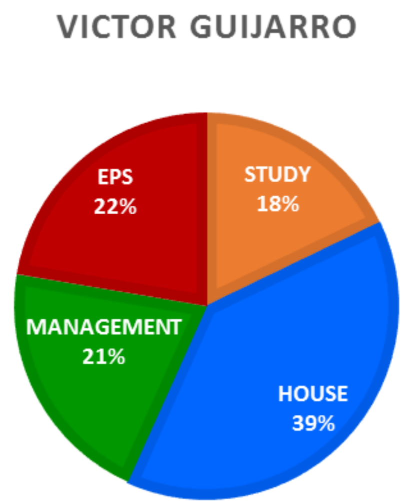


Figure 14 Victor Guijarro pie chart

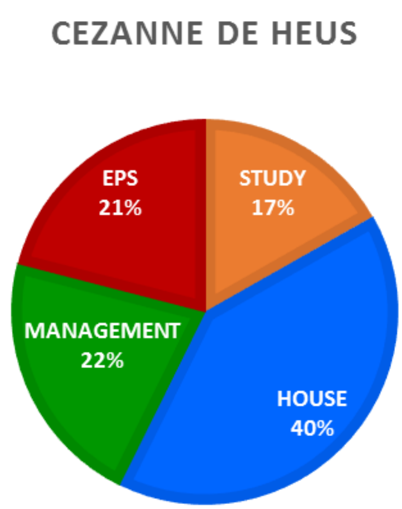


Figure 15 Cézanne de Heus pie chart

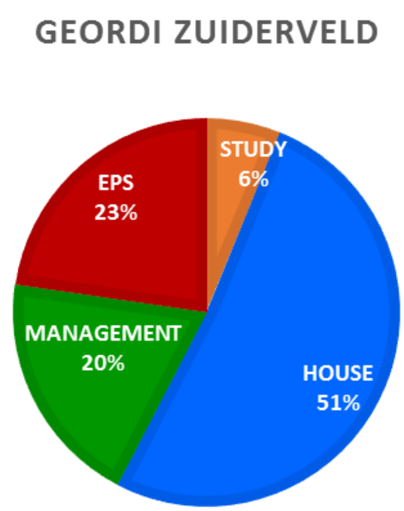


Figure 16 Geordi Zuiderveld pie chart

The tasks have been divided this way so that everyone can learn an equal amount on every subject. Since the experience in most categories are around the same level of the team members, makes this project a good opportunity for them all to gain experience in the different fields.

The major difference in the pie charts is that Víctor GUIJARRO and Cézanne DE HEUS have approximately 10% more in the study branch compared to Elia DIAZ and Geordi ZUIDERVELD (who have approximately 10% more in the house branch). This is due to the fact that Víctor and Cézanne are studying the systems for the house while Elia and Geordi are researching the material choice for the house. These tasks are in two different branches and this choice has been made because the subjects chosen by the four of them are more interesting for that person in comparison to the other subject.

2.2.5 Risks

This chapter describes the risks identified for this project. For every risk there is a probability and an impact. Probability [5] means the likelihood of occurrence of a risk, measured on a scale from 0,1 (very low chance) to 0,9 (very high chance) and the impact [5] is a number that considers how big the damage for the end result of the project is. Should that risk happen, measured on a scale from 0,1 (small effect on the end result) to 0,9 (large effect on the end result). The risk rating can be calculated by multiplying the probability and the impact:

$$Risk\ rating = risk\ probability * risk\ impact\ \ [3]$$

The higher the risk rating the worse the risk will be for the project. Looking at *Table 3* there are different colours which correspond to different levels of risks; Green for minor risks, yellow for medium risks, and red for major risks.

Probability					
0,9	0,09	0,27	0,45	0,63	0,81
0,7	0,07	0,21	0,35	0,49	0,63
0,5	0,05	0,15	0,25	0,35	0,45
0,3	0,03	0,09	0,15	0,21	0,27
0,1	0,01	0,03	0,05	0,07	0,09
Impact	**0,1**	**0,3**	**0,5**	**0,7**	**0,9**

Table 3 Probability and impact matrix [3]

With *Table 3* taken in mind the team has identified certain risks that can be encountered further on in the project. Next is *Table 4* where the following can be found: the description of the risks, with the probability and the impact regarding each risk. These numbers are estimated by using the scope of the project (presented in *2.1 Scope of the Project)*, the structure of the project, tasks and milestones. Due to all of the aforementioned the team realised that the lack of skills regarding civil engineering and architectural knowledge were the most dangerous weaknesses the team had at the beginning of the project and all of the identified risks are listed in the *Table 4* with the solutions provided by the team for each risk.

The team has qualified two risks as major risks. The first risk, *House design does not comply with passive house requirements*, has a risk rating of 0,45, the probability of this risk is 0,5 seeing that this task depends on a lot of parameters set by the Passive House Institute. It is very difficult to know and apply them all in the first drafts because it is the first time for all the team members to design a whole house as well as working according to the passive house requirements. The team will learn from these mistakes and apply feedback given on the first few drafts to improve their qualities. The team will need to iterate through the drafts to reach an acceptable concept. The other risk is *2D plans of the house do notcomply with city regulations,* it has a 0,5 probability because the team does not have the skills to make architectural plans yet and needs to take several constraints into account.

The impact of both of the above mentioned risks is 0,9 because these risks are important objectives in this project, if the team encounters these risks, the project has a higher chance of not achieving the wanted end result. In the following table, *Table 4*, the solutions that the team has planned to apply for each of the different risks can be found.

Risk description	Probability	Impact	Risk rating	Solutions
House design does not comply with passive house requirements	0,5	0,9	0,45	Test or simulate before finalising the design and redesign where necessary, use passive house requirements checklist.
2D plans of the house do not comply with city regulations (Labastide-Chalosse (40700))	0,5	0,9	0,45	Consult specialist before presenting final plans to the client, redesign if necessary
Client changing requirements throughout the project	0,3	0,9	0,27	Implement the new requirement as quickly as possible
Not enough training time for the team	0,3	0,5	0,15	Schedule an extra training session
Spending more time on a task than was planned	0,5	0,7	0,35	Have a plan B ready, reschedule other tasks
Not understanding questions within the team because of language barrier	0,5	0,1	0,05	Explain things differently, find translators to translate struggles
The team does not have the knowledge of the software (for example: simulation programs, text editing programs etc.) used	0,7	0,5	0,35	Schedule training days with the technical supervisor
Software licenses cannot be acquired	0,5	0,5	0,25	Find replacement software
Software (for example: simulation programs, text editing programs etc.) are not installed on the computers	0,1	0,7	0,07	Inspect the computers for missing software, if software is missing alert supervisors
Saved files become corrupted	0,3	0,9	0,27	Keep backup files on different computers, usb-sticks or on Google Drive.
Software (for example: simulation programs, text editing programs etc.) crashes	0,3	0,7	0,21	Save regularly and keep back-ups

Table 4 Risks [4]

2.2.6 Quality

In this chapter the quality will be discussed and how the team is going to achieve a good quality for this project.

2.2.6.1 Project Organization

For the project organization there will be looked at how the project is carried out. The project is carried out by a team of four international students who are supervised on both technical and management aspects of the project by two teachers of the ENIT. The role of the project manager will be carried out by a different person every other week. This way everyone will learn the role of a project manager and will have this responsibility.

The main functions of the project manager in general are to plan, monitor the project and keep a good overview of the current status of the project. For the technical and management meetings one meeting leader and one secretary will be appointed. These roles will be taken on by a different person every meeting. This way all the team members will obtain more experience in both leading a meeting and writing the minutes.

The agendas of the meetings will be mailed to the supervisors two days before the meeting starts and the minutes will be mailed to the supervisors after they are structured. The important documents that the supervisors need will also be mailed to them.

2.2.6.2 Naming of the Documents

The names of the documents are as follows:

“Number_name_version number”

The <u>number</u> is only used for the documents that can be found in the WBS. These numbers correspond with the numbers of the WBS categories. The <u>name</u> is the same as the deliverables.

The first <u>version number</u> shows in what stage the document is, whether the document is in a draft or final stage. The second number explains which version it is. For example if it is version 0.1, this means that the document is the first draft version without any checks from the team. If the document has version number 0.2, this means that the document is still a draft version, but there have been made some bigger changes after a check from the team. The draft version is the very first version of a document without any checks from the supervisors. This means that this version has only been seen and checked within the team.

0 Draft stage

1 After first check supervisor/finished stage

2 After second check supervisor/finished stage

2.2.6.3 Format

To create consistency, a font and size have been chosen for all the documents that are going to be made. When things have to be summed up, dots (see below) and numbers will be used. To have consistency in the use of English, British English will be used by all team members when writing a document.

Text:

- Font: Calibri
- Size: 11

Chapter:

- Heading 1 (grey)
- Font: Calibri Light (Headings)
- Size: 16
- Start:
    - In case of long chapters, the chapter will start on a new page
    - In case of short chapters, two “enters” before starting a new chapter

Subchapter:

- Heading 2 (grey)
- Font: Calibri Light (Headings)
- Size: 14
- One “enter” before starting a new chapter

The team has designed a file format for all the documents establishing the same header style and also the cover page style to maintain an own style.

2.2.6.4 Folder Structure

To have clear overview of what can be found in the shared Google Drive folder this chapter describes the different folders and places where the documents are mainly stored.

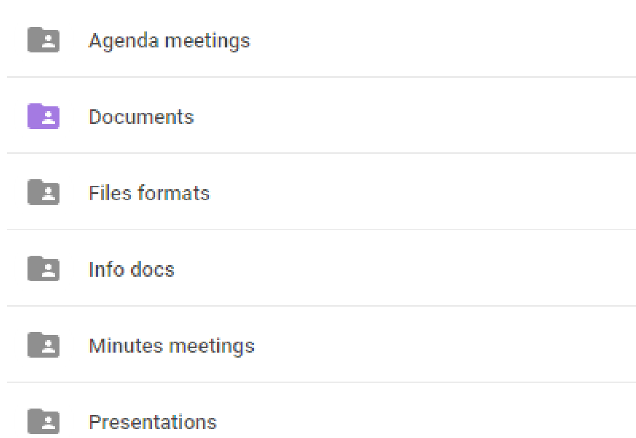


Figure 17 Main folders

In the main folder there are currently six different folders (shown in *Figure 17*) with subfolders:

- Agenda meetings
    - Management meeting
    - Technical meeting
- Documents
    - 1 Study
    - 2 House
    - 3 Management
    - 4 EPS
- Files Formats
- Info docs
    - Examples
- Minutes meetings
    - Management meeting
    - Technical meeting
- Presentations
    - Old versions

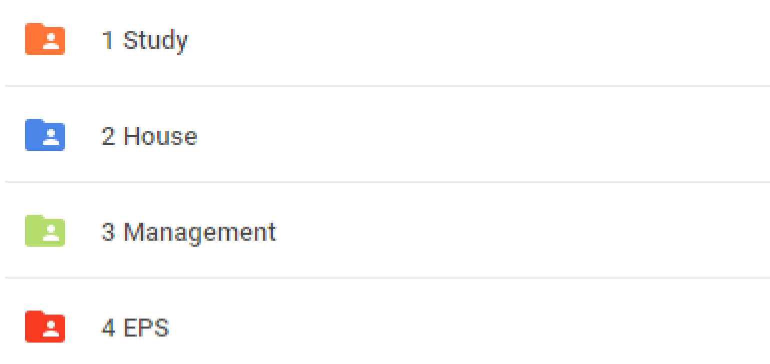


Figure 18 Document branch folders

Most folders speak for themselves, like the "Agenda meetings" folder and "Presentations" folder. The "Documents" folder consists of four subfolders. These subfolders, shown in *Figure 18**Figure 18***, are based on the WBS and will create a better overview of the different documents that will be made. In *2.2.1 Work Breakdown Structure (WBS)* an overview of what documents can be found in these four subfolders is presented.

2.3 Monitoring Tools

The team uses monitoring tools to keep the project updated and under control during the progress of it. It also enables the team to check if the project is on time or if it is necessary to find other solutions. In this chapter*, 2.3.1 Logbook*, *2.3.2 Tracking Gantt*, *2.3.3 Milestones*, and *2.3.4 Deliverables* are presented.

Moreover, Greenit&Co has different meetings during the project with the technical supervisor and the management supervisor to help the project. In these meetings, the team receives feedback from the supervisors and makes choices about the project. All the information about the meetings is written in the minutes of the meetings. In each meeting the team chooses the chairman and the secretary.For more information please refer to *Appendix I: Meeting Minutes.*

2.3.1 Logbook

The logbook has been used since the beginning of the project and has been updated daily during the working hours. The logbook has been made and updated in Excel™. In the logbook every team member has their own column where the task that they had been working on that day is written down, where the task was carried out, when and for how long. This way the team can keep track on the hours spent for each person on the different tasks of the project. As a result, with this tool it will be possible to compare the planning hours with the real hours.

In *Table 5* an example is shown of the hours spent on each task by a member of the team until the date of 20th of April:

What	Where	When	Time (hours)
Write requirements document	Office	20/03/2017	2
Realise WBS	Office	21/03/2017	4,5
Realise WBS	Office	22/03/2017	4,5
Realise WBS + Write requirements document	Office	23/03/2017	5
Write requirements document	Office	24/03/2017	4,5
Write requirements document	Office	27/03/2017	5
Write requirements document	Office	28/03/2017	6
Write requirements document	Office	31/03/2017	5
Design Gantt Chart	School	18/04/2017	4
Write requirements document	Office	18/04/2017	5
Look for Draftsight program+download and look for Microsoft project 2013 software	Office	19/04/2017	3,5
Design Gantt Chart	Office	20/04/2017	4,5

Table 5 Logbook example

2.3.2 Tracking Gantt

However, the logbook is not the only monitoring tool the team used,. The tool of tracking Gantt is a function of the Gantt Chart, which can be found in the MS Project™ software, where it shows the percentage of completeness of the tasks, shown in *Figure 19.*Also, the tool shows when a task is not completed as planned. The team uses this tool to keep track on the completeness of the different tasks and the actual start and finish date. If a task is heading in the direction of not being completed as planned, the team can take actions to reschedule a task or extend the working hours.

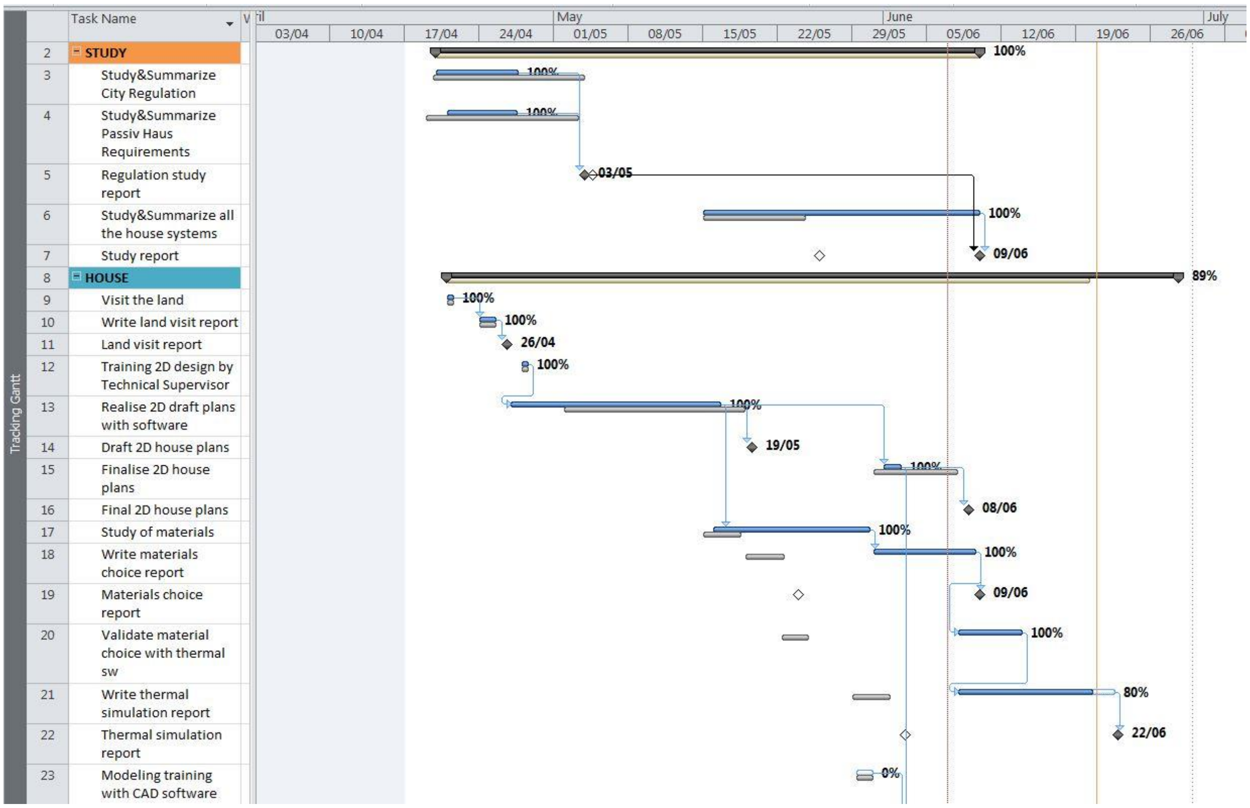


Figure 19.Tracking Gantt

2.3.3 Milestones

The milestones are used as a tool. These are defined in *Table 2*, which can be found in section *2.2.3 Milestones*. In the beginning of each week, the team checks the table and decides the priorities for the week, according to the deadlines of the deliverables.

Also, the team knows this way if the deliverables are delayed or in advance. Thanks to this information the team can follow the project and keep it on track.

2.3.4 Deliverables

The last tool to monitor the project is the deliverables. These can be found in section *2.1.3 Deliverables*, and they are organised in the WBS, which is shown in chapter *2.2.1 Work Breakdown Structure (WBS)*. The team updated the status of the project every week. Greenit&Co are calculating percentage of completeness of the deliverables and then comparing that with the percentage on the Gantt Chart, to know what the status is of the project.

Shown in Table 6 is the status of the deliverables at the intermediate review.

DELIVERABLE	DEADLINE	STATUS
Requirements document (D3.1)	21/04	100%
Land Visiting Report (D2.1.1)	24/04	100%
Regulation study report (D1.1.1)	03/05	100%
Intermediate Report (D4.1.1)	05/05	100%
Intermediate Presentation (D4.1.2)	10/05	30%
Draft 2D House Plans (D2.1.2)	18/05	30%
Study report (D1.1)	23/05	25%
Materials Choice Report (D2.2.1)	23/05	0%
Thermal simulation report (D2.2)	02/06	0%
Final 2D House Plans (D2.1.3)	08/06	0%
3D CAD Model of the house (D2.3)	15/06	0%
Final Report (D4.2.1)	20/06	0%
House Design report (D2.4)	23/06	0%
Final Presentation (D4.2.2)	29/06	0%

Table 6.Status of the deliverables at the intermediate review.

2.4 Conclusions

Once the planning part of the project is finished the team is ready to start with the technical part. Greenit&Co has a lot of tools to be able to plan and monitor the project effectively. The team understands and knows all the requirements and objectives of the project, and the limitations and exclusions as well. This part is the base of the project in order to comply with the requirements.

Also, the team plans the project to help during the whole project. As a result, creating the WBS and the Gantt Chart, the team has a general vision of the project and it is easier to work. Because the team can situate all the tasks in the timeline and, at the same time, they are ready to change the plan if some problems appear.

Finally, the monitoring tools are described to help the team. Greenit&Co uses the logbook every day to have an overview on how much time is spend on each of the tasks. This way the team is able to make sure that the project stays on track.

3. Technical progress

This section is one of the most important parts of the project in order to achieve the objectives set by the team. The technical progress includes the technical part of the WBS, this part consists of the branches D1-Study and D2-House. These branches contain a set of deliverables and these deliverables have tasks attached to them. In the chapters 3.1 Study, 3.2 House Design, and 3.3 Thermal Simulation, the technical progress of the project is shown.

At the beginning of the project five phases have been defined to guide the technical progress. These phases were defined to help the team work in an organised way and to make it possible to finish the project in a satisfactory manner. The phases are shown in *Figure 20*. In phase 3, the team designs two scenarios in case the first scenario does not comply with the requirements in the thermal simulation. In this manner, the team does not have to repeat the process.

The technical progress is build up as follows. First, in section 3.1 Study, comes the different studies performed during the start of the project. Section 3.1.1 Regulations contains the study about the regulations within the city and the passive house requirements, and in section 3.1.2 House Systems the study about the house systems is explained. The house design consists of the sections 3.2.1 Land Visit, 3.2.2 2D House Plans, and 3.2.3 3D Cad Model of the House. Following that is the last part of the technical progress which contains the thermal simulation. In this chapter 3.3.1 Materials Choice which are used within the house are described and in 3.3.2 Thermal Results which are obtained from the simulation performed with these materials and house systems.

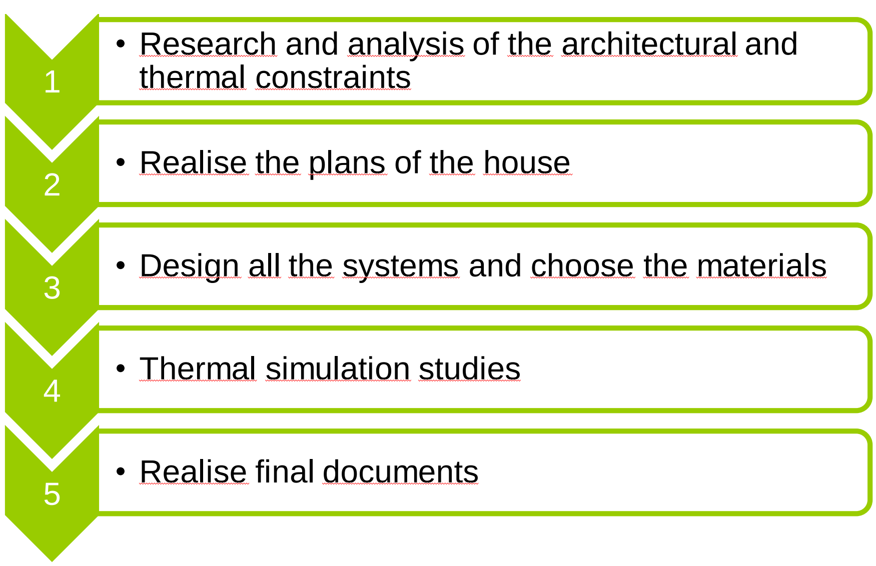


Figure 20 Project phases

3.1 Study

This chapter contains one main deliverable, the study report, in this report are three studies: in section 3.1.1.1 City Regulations, in section 3.1.1.2 Passive House Requirements and in section 3.1.2 House Systems. All of these studies are summarized in this chapter. For more detailed information please refer to *Appendix A: Study Report.*

3.1.1 Regulations

3.1.1.1 City Regulations

The city regulations of Labastide-Chalosse (Landes, France (40700)) [1] explain what is allowed in this village. In *Figure 21* an example is shown of the architectural style in the village. The most important regulations to design the house are described in the following points:

- Architectural Style

- The colours for the walls should be light, between white and orange (shown in *Figure 21*).
- The city regulations allow a maximum height of 7,5 metres for the building.
- It is forbidden to use wood in the house design.

- Roof

- The roof must be covered with tiles, which in French are called “tuile provençale”.
- The slope of the roof has to be 30°.

- Windows

- The height of the window should be bigger than the width.

- House Situation

- It is not allowed to have the beginning of the house between 0 to 3 metres from the road. It is only allowed to build the beginning of the house in line with the road and otherwise 3 metres or further away from the road.

Figure 21 Architectural style in the village

3.1.1.2 Passive House Requirements

To design a passive house, the team first had to study what a passive house is and what the requirements are for a house to be recognized as a passive house. A passive house is a house that is energy efficient, comfortable and affordable. The investment cost may be relatively high but it will return the investment cost in due time because of its energy efficiency and the usage of renewable energy.

Following now are the main requirements which need to be met in order to receive the certificate of “Passiv’ Haus”, for more information please refer to *Appendix A: Study Report:*

1. Heating and cooling
2. Primary Energy Demand
3. Airtightness
4. Thermal comfort

The design of the house must be designed according to these requirements and are validated by an Excel document approved and provided by the PHI (Passive House Institute, whose logo is shown in *Figure 22*). This Excel document [6], called the PHPP (Passive House Planning Package), needs to be filled in by a passive house certifier who can only be trained and certified by the PHI. The result of the PHPP can give an answer to three of the four main requirements, the missing one being the airtightness, the airtightness of the house needs to be tested on-site by an independent company who are not affiliated with the passive house certifier or the designer of the house. For more information please refer to *Appendix A: Study Report:*

Passive House Institute

Figure 22 Passive House Institute logo

3.1.2 House Systems

The house systems include power generation, heating, ventilation and lighting systems. These systems have been studied and chosen.

3.1.2.1 Power Generation

The first thing to do is to calculate how much energy is needed, before it is possible to choose the photovoltaic (PV) solar panel and the quantity of it. This was done through research about how much general electrical systems (for example a washing machine, a dishwasher, a refrigerator, a TV, a computer etc.) on average consumes.

After taking into account all the electrical systems, the power consumption is 13.797,5 W and if the heating system is included this consumption has a total of 14.747,5 W. According to the Passive House Institute 15 kWh/m^2/year can be used from the grid. After the proper calculations (explained in detail in *Appendix A: Study Report*) the amount of energy that can be used from the grid is then subtracted from the calculated power consumption obtaining 4.227,3 W, which must be provided by renewable energy. This renewable energy is going to be provided by PV solar panels, due to the fact that the house will be built in a region with a high solar irradiance.

Figure 23 Solar panel BISOL BMO-300

The team has mainly compared monocrystalline with polycrystalline panels and monocrystalline panels have been chosen, because they are more efficient.

Then, two monocrystalline models (manufactured in Europe) out of four have been compared to decide which one is the better option. The other two models have not been compared for the reason that both are more expensive and are also manufactured in China which would increase the cost. The comparison has been made following the steps shown below:

1. The first step is to calculate the needed surface of panels taking into account the efficiency of each one.
2. Then the number of panels for each model.
3. And to conclude, the comparison, the cost of both models have been evaluated and the cheapest option has been chosen.

Once these steps are done, the Solar panel BISOL BMO-300 has been chosen shown in *Figure 23,* consequently 15 solar panels are going to be located on the south side of the roof where there is more solar irradiance. This helps provide the maximum energy, eventually reaching a cost of €3.285.

3.1.2.2 Heating

Figure 24 ALTHERMA MURAL 4 TO 8 KW heating system

The heating system is going to heat the house as well as the hot domestic water due to the air-water heat pump chosen by the team. This heat pump is the *ALTHERMA MURAL 4 TO 8 KW* heat pump shown in *Figure 24* that has a consumption of 0,87 kW and provides 4,4 kW to the house. The house is going to have a radiant floor which means that hot water passes through some tubes located under the floor, due to the radiant floor the whole house is heated in the same way.

According to the examples read and studied [7] by the team, the heat pump with the lowest power consumption has been chosen due to the fact that the house is going to have minimum heat losses because of the good insulation in the roof, walls and floor. The choice is then checked by the software called Clima-Win™ (further explained in chapter *3.3 Thermal Simulation)* to decide if the choice is in compliance with the requirements.

3.1.2.3 Ventilation

The ventilation system consists of a ventilation heat recovery that allows the house to have a good indoor air quality and also uses the heat in the exhaust air to transfer it to the fresh air going into the house. The chosen ventilation system is GES Energy 1 (Horizontal) (Z010339) shown in *Figure 25.* The consumption of this ventilation is 80 W.

The maximum air flow that the Ventilation Heat Recovery (VHR) must provide is calculated, according to the datasheet of the model, as follows:

$$\text{Max. capacity } \left(\frac{m^3}{h}\right) = \text{living area } (m^2) \cdot \text{room height } (m) \cdot \text{Air exchange}$$

Figure 25 GES Energy 1 (Hoirzontal)(Z010339) VHR

The dimensions of the house and the air changes per hour which are allowed are fixed. This leads to the following calculation for the air flow:

$$\text{Max. capacity } \left(\frac{m^3}{h}\right) = 115\ (\text{m}^2) \cdot 3\ (\text{m}) \cdot 0{,}5\ (\text{h}) = 172\ \left(\frac{m^3}{h}\right)$$

A maximum air flow of 172 $\frac{m^3}{h}$ is the proper one according to the datasheet of the model. I n this datasheet the following graph can be found where the performance of the VHR can be defined as is shown below [9]:

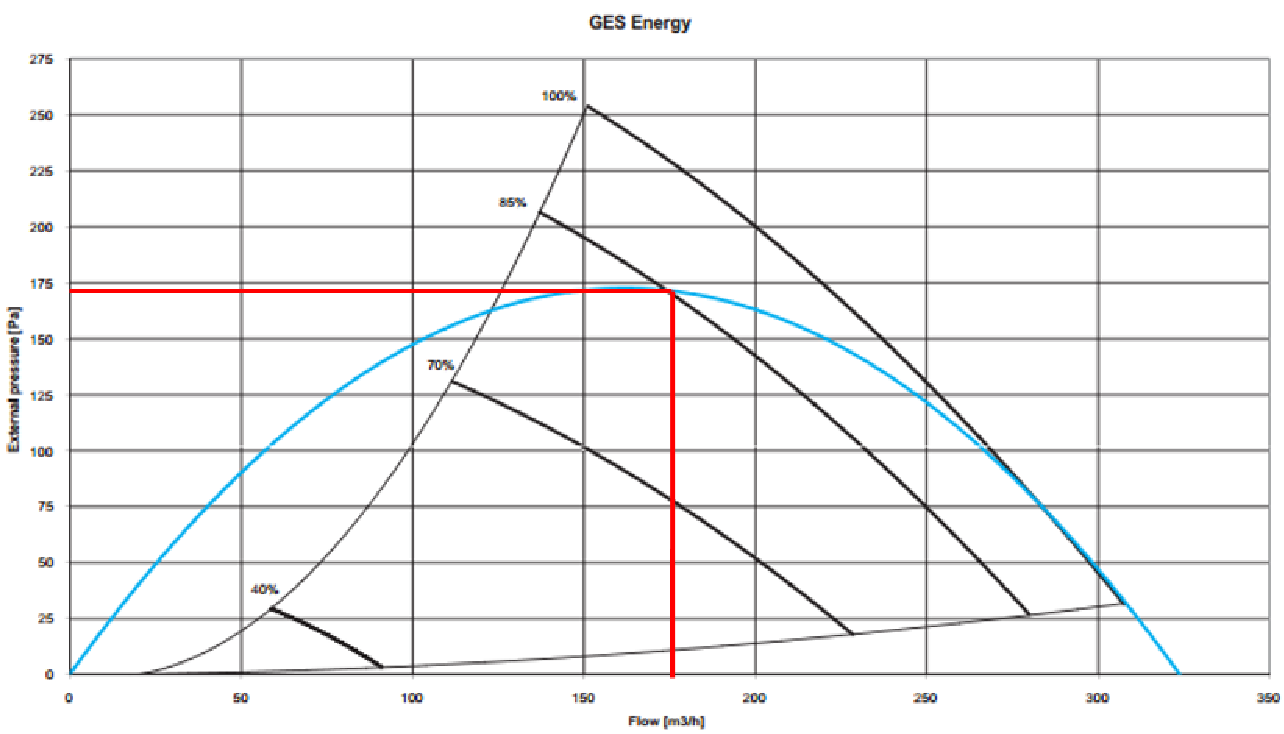


Figure 26 Flow VS External pressure

The blue line shows the consumption of energy for both fans and controller according to passive house requirements, so working with an airflow of 172 $\frac{m^3}{h}$ these requirements are met when the VHR performance is 85% and the external pressure is almost 175 Pa.

For the heating and ventilation system the total price will be €5.611,77.

3.1.2.4 Lighting systems

For the lighting there has been chosen for LED bulbs shown in *Figure 27*, since these are the most efficient, have a long durability and can be switched on and off more often and faster compared to the other studied option; CFL.

The lighting has a cost of around €168. The prices for LED bulbs vary between €8 and €20, a price of €14, has been taken to make the cost calculations. The team took into account that a minimum of 12 lights would be needed to have enough light in the house.

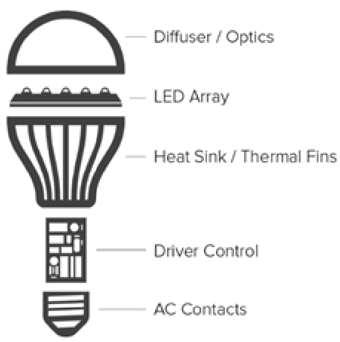


Figure 27 LED bulb

For a complete explanation of the studied house systems and the calculations, please refer to *Appendix A: Study Report.*

3.2 House Design

This chapter contains an important objective of the project in order to achieve the requirements set by the team.

The house design chapter consist of three sections: 3.2.1 Land Visit, 3.2.2 2D House Plans, and 3.2.3 3D Cad Model of the House. The sections 3.2.1 and 3.2.2 compose the main deliverable 2D House Plans. The last section 3.2.3 include the main deliverable 3D CAD Model of the house.

3.2.1 Land Visit

The land visit contains the section 3.2.1.1 Plan of the Land and the section 3.2.1.2 Southern View, both are included in the sub deliverable Land Visit report. The most important part in this sub deliverable is the location of the house. The team was at the land of the client to know the views of the land and the avaible public networks, and with this information take the decision considering where the house would be best located. For more detailed information please refer to *Appendix B: 2D House Plans.*

3.2.1.1 Plan of the Land

The land where the house will be built is shown in *Figure 28,* the house location and the position of the north is also visible in this picture. The land is divided into two parts, the left part is for the client and the right part is for the client's sister. The dimensions of the client's land are 37,5 m in width and 75 m in length

The house would be best located close to the north-west corner next to the road because the electricity pole is situated in that corner and this way the team is saving money since further from the pole means more money is needed to connect the house to the electricity network. This is due to the fact that the first 35 metres from the post costs €1.300. If this connection is longer than 35 metres, then the costs go up substantially.

In *Figure 28* the final 2D house plan can be found located on a map of the client's land.

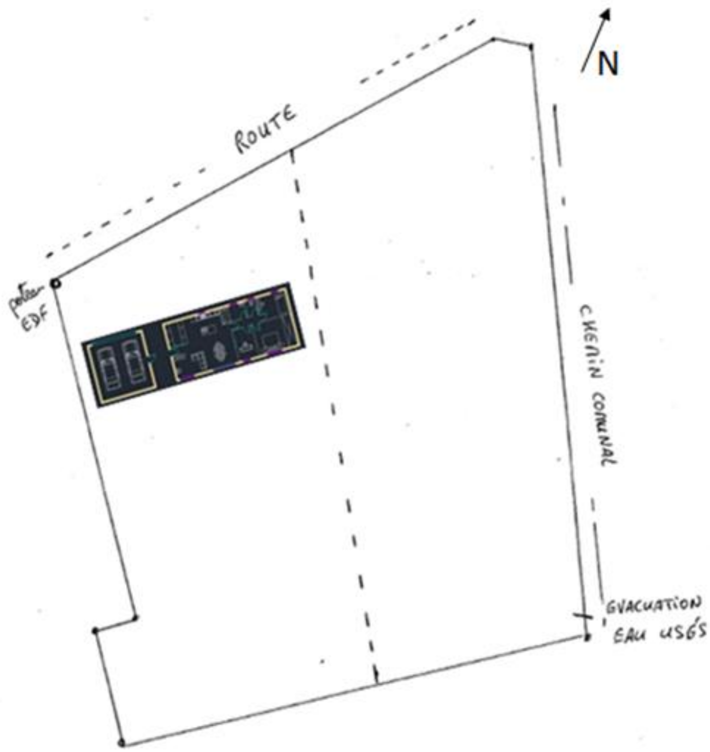


Figure 28 Land plan

3.2.1.2 Southern View

In this chapter a picture from the land looking towards the south is shown (*Figure 29*) because it provides the best view for the living room and master bedroom and has a good orientation for the house considering maximum solar panel efficiency, because the sun is situated in the south for most of the day. This is the perfect situation because the house can have the perfect orientation, generating the best view for the client and the highest efficiency for the solar panels at the same time. And also, to comply with the advice of the Passive House Institute because most of the passive house is oriented to the south view.

Figure 29 Southern view of the land

3.2.2 2D House Plans

The ultimate goal of the project is to deliver the 2D plans of the passive house. The first step is to make draft designs of the 2D house plans in the software AutoCAD™. Then, from the draft designs, the final 2D house plan is chosen and completed. In this section, the sub deliverables; draft 2D house plans and final 2D house plan, are further described.

The house design is a difficult part of the project since the team needs to take several constraints into account: technical requirements, shown in *2.1.2.2 Technical Requirements*, city regulations, shown in *3.1.1.1 City Regulations* and passive house requirements, shown in *3.1.1.2 Passive House Requirements.*

To design the 2D House Plans, first the team need to make different draft designs. Using the draft plans the team has designed it was easier to choose a final 2D plan. The second concept was already in the correct scale and corresponded with the previously mentioned requirements. After a couple of minor changes the team obtained the final plan which could be used in the rest of the project. For example in the 3D CAD model or in the materials choice report.

The draft 2D house plans should contain the limits of the land and the direction of the north, which enables the team to respect the requirements that were given to them. The first step of designing a house is to define the entrance of the house. The next step is to locate the house on the land and the last step is to establish the priorities to situate the different rooms. These steps are shown in *Figure 30*. A more detailed explanation of the different steps to design a house can be found in chapter 3.2.2.1 General design steps.

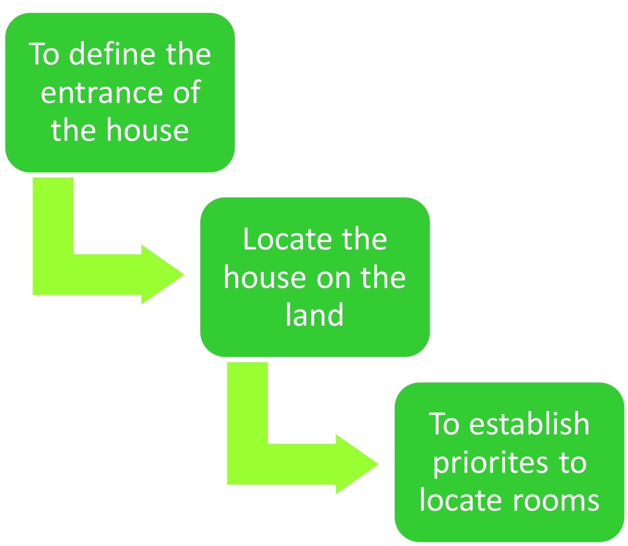


Figure 30 Steps for designing a house

3.2.2.1 General design steps

The first step while designing the house is to look at the technical requirements and make the different rooms with the right dimensions. When that is done the first priority is to locate the entrance of the house with respect to the entrance of the land. This is an important part of the house and also difficult to situate, since it is necessary to think about the way people will navigate the land when walking towards the house.

With the location of the entrance of the house, the location of the garage is then easily determined, since the entrance of the house and the entrance of the garage should be opposite each other. This to create a dry passing in case of bad weather, since the house and the garage are connected by a roof.

The next step is to situate the house on the land. This means looking at how far the house is placed from the road and how close to the neighbouring house.

The third step is to establish priorities to situate each room of the house, for instance the living room needs to have the best view, which means placing it on the south side of the land as well as the master bedroom. It is important to have a nice view from there as well.

The technical room is then placed closest to the electricity pole to reduce the costs on the needed connection. The bathroom and toilet are situated next to each other, this to reduce cost and make it easier to have a connection for the water. The two spare rooms were then moved in a way that the living room, dining room and kitchen would have an open “American” style.

And the last step is to think about what kind of vegetation to put around the house. This step depends on the location of the house.

3.2.2.2 Concept 1

As is previously shown, the house is located in the north of the land, this due to the fact that the costs for the electricity connection will not increase above €1.300,-, since it remains within the 35 metres of the electricity pole ("Poteau EDF").

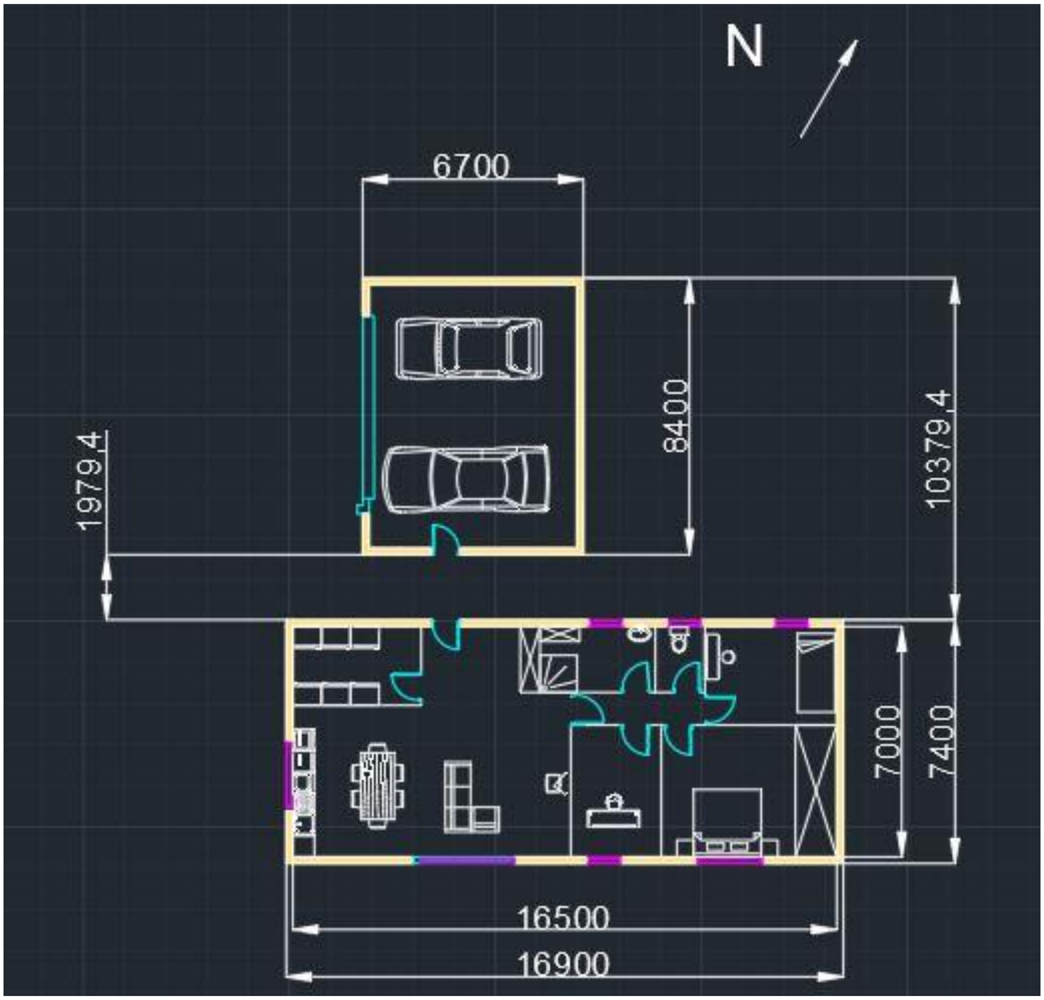


Figure 31 2D house plan concept 1

In this design (*Figure 31*), concept 1 is shown. The garage is located on the north side of the land, between the house and the road. This to have an easy access to the house. The garage is linked to the house by a roof.

However, the way the garage is situated in this concept, it means that there will have to be made use of two different roofs instead of one. This due to the fact that the garage is not located in a straight line with the house. This increases the costs and the budget does not allow the team to design these two separate roofs.

Also, there is an excess of space near the entrance, therefore surface is wasted in the living area.

3.2.2.3 Concept 2

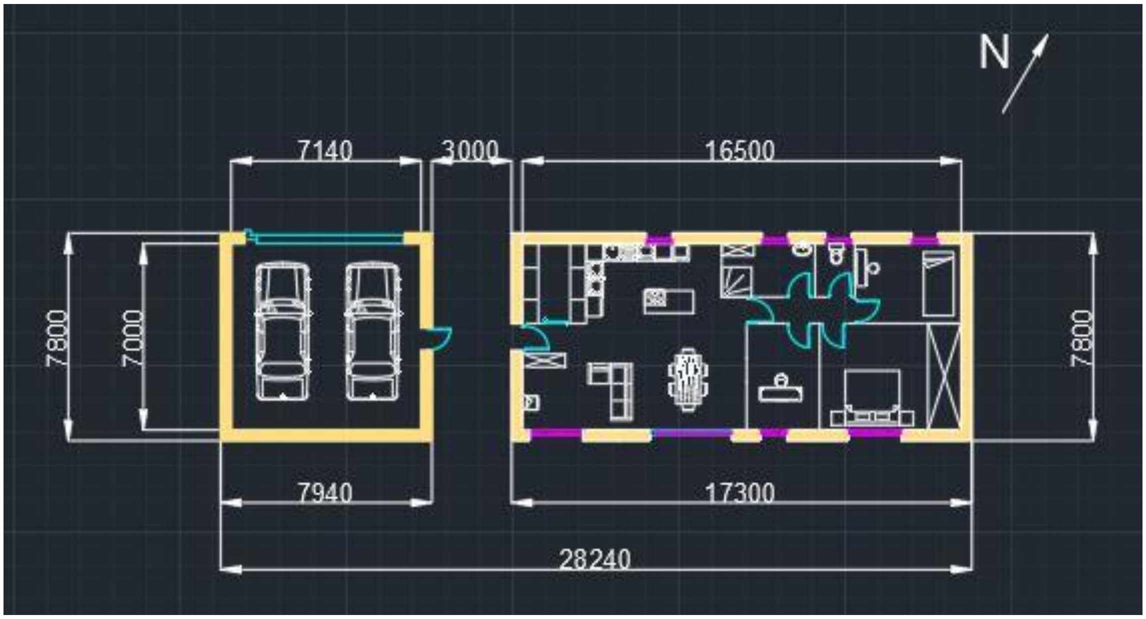


Figure 32 2D house plan concept 2

As is shown in Concept 2 (*Figure 32*), this design has the house and the garage in one line in order to have a single roof covering the house, the garage and the space in between them. This space could be used as a terrace with the garage protecting it from the sun in winter. This is the most economical design because there is only one roof and solar panels can be placed on this roof, oriented to the south, receiving as much sun as possible during the duration of the day.

Due to this location of the garage, the entrance of the house has appropriate dimensions and the living space area has more surface available than in the previous design, so the kitchen, dining room and living room are better situated.

In this design all of the rooms are located in the east, except for the technical room. The dining and living room are towards the south to generate the best view possible in the client's everyday life.

3.2.3 3D Cad Model of the House

After the 2D house plans were finalised, the team was able to start working on the 3D CAD model of the house. The 3D CAD model has been made with SketchUp™, which is a free software to use when designing a building. The program is based on drawing lines and shapes that can be pushed and pulled in order to turn them into 3D forms.

To design the 3D CAD model there was made use of the 2D house plans as a reference, to make sure the rooms were in the correct location and the furniture was placed correctly according to the previously made 2D plans.

The house itself was designed by the team, the placing of the furniture included, but the team did not design the furniture and was able to download it from a site, that can be found in the reference [8] This saved a lot of time and effort, that could be used on other parts of the 3D model and the project itself.

Figure 33 Final 3D CAD model north

The final 3D CAD model can be found in *Figure 33*, in this picture the front of the house can be found. The path from the garage to the edge of the grass is the entrance for the car into the garage and the smaller path is for pedestrians who want to enter the house.

In *Figure 34* the back of the house, that faces the south, can be found. Including the photovoltaic solar panels for the power generation. The slope of the roof is 30^0, creating a good surface for the PV solar panels to catch the sunlight.

Figure 34 Final 3D CAD model south

One of the given requirements is to have at least 1/6th of the south side of the house to consist out of windows, this has been achieved with this design, making it possible to enjoy the beautiful south view of the land as well as having a good amount of natural light coming into the house.

Figure 35 Final 3D CAD model furnished

All the furniture is included in the 3D CAD model of the house, shown in *Figure 35*, to portray how the house could be furnished. This way imagining the life inside is made easier.

For a complete overview of the different steps the team took to eventually come to the final 3D CAD model that is discussed in this chapter, please refer to *Appendix D: 3D CAD Model of the House*.

3.3 Thermal Simulation

The last part of the technical progress of the report consists of the thermal simulations of the chosen design. First of all is the material choice, in section *3.3.1 Materials Choice* because to be able to perform the thermal simulations of the house the materials have to be included within the final design.

After all of the materials are studied the thermal simulations take place in section *3.3.2 Thermal Results*. With the results presented within this simulation it is also possible to see if the heating system and the power consumption are within the boundaries set by the Passive House Institute.

3.3.1 Materials Choice

The exterior envelope of the house is of interest for the team. There are four main structure elements within the envelope of the house. These four elements are: the walls, the roof, the floor and the windows. This means that the garage will be outside the scope of this chapter.

The Passive House Institute has set limits for the U-value which should not be exceeded. These limits ensure that the house has a proper insulation. Together with the final design of the house and the dimensions of the house (show in *3.2.2 2D House Plans* and *Appendix B: 2D House Plans*) the materials used for the envelope of the house can be studied and U-values can be calculated.

3.3.1.1 Properties

The most important criteria for materials is the U-value, also known as the U-factor or heat transfer coefficient. This factor is used to show the heat transfer, whether it is heat gain or loss, through the elements. It is expressed in watts per square metre Kelvin [$W/m^2 \cdot K$]. The lower this number is, the less heat is going to be lost or gained through the material and the better the material can be used as an insulation material.

3.3.1.2 Structures elements

To make a good choice between the different options for all the structure elements some criteria have been selected and these criteria have the following order of priority: U-value, regulations, properties, cost and thickness.

The final choice for the construction methods and materials used within these methods will be made according to these criteria. Following now are the elements of the exterior envelope of the house.

3.3.1.2.1 Walls

First is the construction method for the exterior walls of the house. There has been chosen for a prefabricated porous concrete element. Because the element is prefabricated it will save a lot on labour cost and it will be easier to install it in the house. The exterior walls also need a layer of insulation to keep the heat on the inside of the house to attain a high thermal comfort. The insulation material used within the walls is EPS 100 (Expandable Polystyrene). On this a plastering system is placed, this system can be decorated to suit the client's wishes.

3.3.1.2.2 Roof

The second element is the roof of the house. There are multiple ways to insulate the roof but since the client has no need of living in the attic of the house there has been chosen to use a sprayed insulation to insulate the ceiling of the building. The material which is sprayed on the ceiling is glass wool and is one of the most used materials within France.

The frame of the roof is made of wood, wood is a strong and cheap way to reinforce the roof. The covering of the roof is tile, in France known as “tuile provençale”. This covering has been chosen because it is a mandatory covering within the city. A wind proofing layer is applied between these two layers to decrease the probability of thermal bridges.

3.3.1.2.3 Floor

The foundation of the house is also important because the cold of the ground could infiltrate the house. The chosen solution for this is a swedish design called “Supergrund”. This solution has a very low U-value and insulates the whole slab instead of only the upper- or underside. Using this technique eliminates all the thermal bridges to the ground and protects the structure from moisture.

The materials used in this technique are primarily EPS. Underneath this insulation material there are three moisture protecting layers. The layers from the bottom up are: hardcore, radón barrier and sand binding.

3.3.1.2.4 Windows

The final elements of the envelope are the windows. The design of the windows contains the glass and the frame. The team chooses the double glazed unit because it saves cost and according to the climate it is not necessary to select the triple glazed unit. The configuration of the glass is 4-12-E4 that is with low emissivity coating and argon gas as cavity gas. The chosen frame is made of PVC because of the low heat conduction and its affordability.

Finally, the ultimate goal is to have the U-value as low as possible. That is why these options are chosen (*Table 7*). It costs a little bit more to construct, but in the long run the client will save money from the good insulation. This due to the heating system that is able to perform at a lower rate because it needs to heat the house up less.

Scenarios	Thickness [cm]	Cost [€]	U_{total}-value [W/m²K]
Walls: Porous concrete element using EPS 100	41,30	5084	0,113
Roof: Glass Wool Sprayed Insulation	67,30	8910	0,106
Floor: Supergrund	68	6045	0,068
Windows: Low emissivity coating with argon (4-12-E4)	48	438	0,80

Table 7. Structure element selection

The total cost of scenario A is:

5084+8910+6045+(438·7)=€ 23.105

For any additional information about materials and additional structure elements please refer to *Appendix C: Thermal Simulation Report.*

3.3.2 Thermal Results

With the thermal simulation the team achieved these results using the Clima-Win™ software. The team need to include in the software the data of the location of the city, the thechnical requirements, the house systems and the materials as well.

The results show that the Primary Energy Consumption (CEP) is -1,00 kWh/m²/year. Then, the house are compliant to the passive house requirements, the main requirement of the passive house (15 kWh/m²/year) , even better that the initial objetive The results even show that the house is not a passive house but it is a positive house.

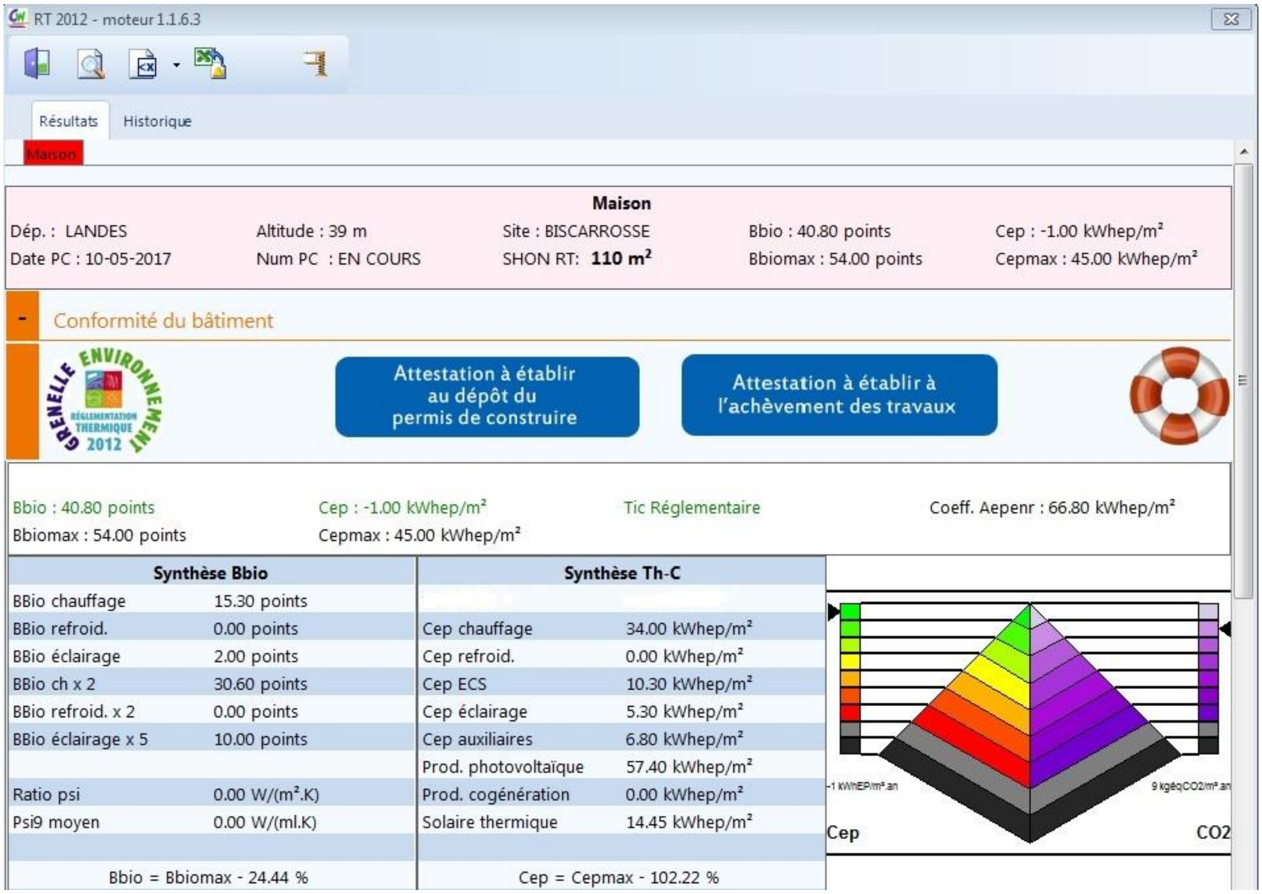


Figure 36 Results of the thermal simulation

In *Figure 36* the consumption of the different house systems are shown. The consumption of the house systems are as follows:

The heating system consumes 34,00 kWh/m^2/year, the "ECS" 10,30 kWh/m^2/year, the "éclairage" 5,30 kWh/ m^2/year and the "auxilaires" 6,80 kWh/ m^2/year.

The total consumption of the house is 56,4 kWh/ m^2/year, but the generated power from the solar panels is 57,4 kWh/ m^2/year. In total it generates 1 kWh/ m^2/year more. Turning the house from a passive house into a positive house. A positive house is a house that generates more energy than it consumes.

3.4 Conclusions

This part of the chapter is to conclude on the technical part of the project. A lot has been studied and designed by the team to finish the project in a satisfactory manner.

First the team understood the three constraints, the regulations of the city, the passive house requirements and the requirements of the client, that have to be taken into account in the designing stage of the project. Once the constraints were clear to the team, they could move on to the designing stage of the project.

Before the designing stage the team visited the land of the client. The team completed the requirements necessary to design the passive house.

The final house design corresponds to all the given requirements. It gives the client the open “American” style kitchen, dining room and living room he asked for, all the rooms are the correct size, the entrance of the house is directly opposite the garage’s entrance, this to create a dry passing for the client in case of bad weather. The costs are reduced due to the fact that the technical room is close to the electricity pole and the bathroom, toilet and kitchen are next to each other, this to create an easier water connection.

The 3D model design also corresponds to the city regulations, for example the exterior wall colour is between white and orange, the windows are in height bigger than their width, wood is not used on the exterior walls of the house, the beginning of the house is 3 metres away from the road, the house has a tile roof covering and the house is not higher than 7,5 metres.

For the materials the ultimate goal is to have the U-value as low as possible. That is why these options are chosen. It costs a little bit more to construct, but in the long run the client will save money from the good insulation. This due to the heating system performing at a lower rate because it needs to heat the house up less.

Regarding the house systems the team has taken decisions about the power generation system, the heating system and the lightning system. The power generation system consists of 15 photovoltaic solar panels providing energy to the house. The heating system consists of one Ventilation Heat Recovery (VHR) to heat up the ventilated air. As well as a air-water heat pump to heat up the house and the domestic hot water. LED bulbs have been chosen for lighting inside the house because of the efficiency and the long durability.

After the studies of the materials and the systems the project team made a decision. Looking at the time remaining for the project and the complexity of the software program Clima-Win™ the technical supervisor offered to make the thermal simulations. The results show that the house the team designed is a positive house which generates 1 kWh more per year than it consumes.

4. Management II

Not only planning a project and executing it is important, but also keeping track on how the project is going. Different tools have been used for monitoring. This due to the fact that at the beginning of the project the Gantt Chart was not available yet and the team wanted to keep track on the hours spent on the project, this to have a good overview later on when the planning was done.

In this chapter the monitoring of the project is explained, including sections 4.1.1 Actual work, 4.1.2 Tracking Gantt, and 4.1.3 Deliverable Status. Also, 4.2 Cost Analysis is included in this chapter, in the cost analysis the costs for the systems, materials and miscellaneous can be found.

Finally, 4.3 Conclusions is concluded in the conclusion.

4.1 Monitoring

4.1.1 Actual work

By monitoring the Gantt Chart it is easy to see how much time was planned for certain tasks and how much time is actually spent on it, hence the name actual work. By using the planned work hours and actual work hours the pie chart shown in *Figure 38* and *Figure 37* has been made.

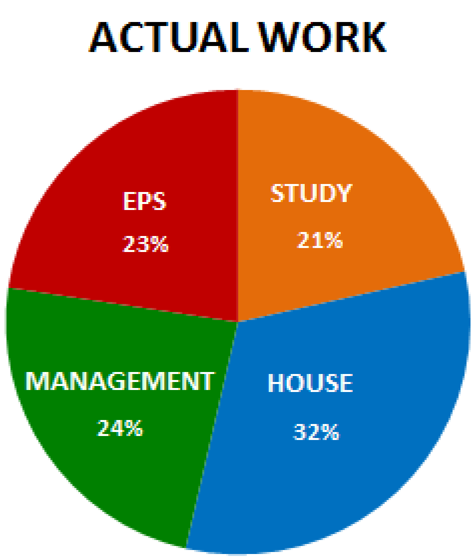


Figure 38 Actual work

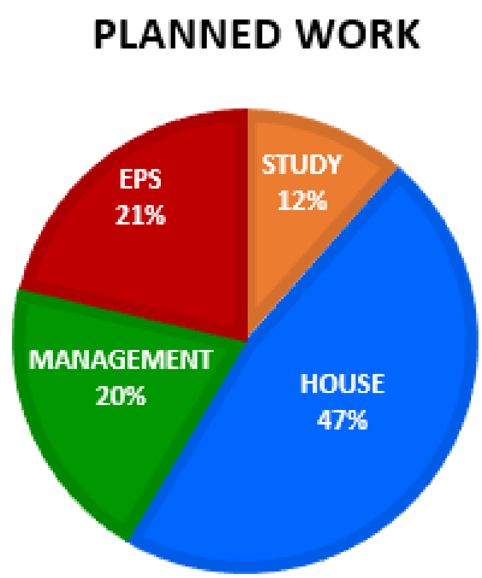


Figure 37 Planned work

As is shown in the pie chart of the actual work, the percentages are a bit different from the planned work. The biggest change is the change in percentages in the study and house branch. This due to the fact that the team spend more time on the system study report than previously anticipated. There was more time needed because finding the right house systems for the different purposes was not as easy as thought at first. Especially when it came down to finding the prices for the different systems. These were often not shown on the sites and the team had to send in a request for quotes to eventually get the prices.

Furthermore, the team spend less time than anticipated in the house branch, this due to the fact that the realising and finalising of the 2D house plans took less time as well as the thermal simulation. According to the success of the project the team has asked for the technical supervisor's help with the thermal simulations. It was a decision of the whole project team.

However, the material choice study took longer than expected, which caused the percentage to still be the largest of the four branches. The material choice report took longer, because there are a lot of materials and it is also important, cost wisely, to find suppliers in France.

4.1.2 Tracking Gantt

The tracking Gantt helped the team to improve the way of carrying out the tasks. This due to the fact that it is possible to know what had to be done at which moment and show how much time the team has to finish the tasks.

This is done manually by using the "Tracking Gantt" view in this software. First the baseline is set, this to be able to see the difference in planned and actual duration. To monitor the different tasks the tool "Update tasks" is used. By using this the actual start and finish date could be filled in as well as the completeness of the tasks.

The completeness of the tasks is determined by the duration that is planned for the tasks. In case a task is late, the finish date is manually moved and therefore the percentage of completeness changes alongside it.

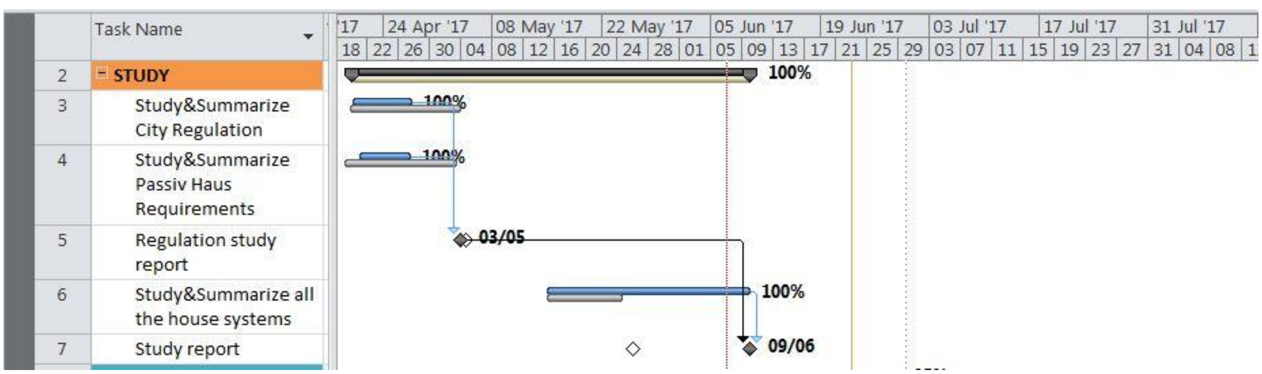


Figure 39 Tracking Gantt of the branch study

In *Figure 39* the monitoring of the branch study can be found. As is shown in the chart, the study and summarizing of the city regulation and passive house requirements took less time than the team had anticipated, this meant that the team could start working on another task earlier. The study and summarizing of the house systems took longer than expected, therefore the milestone of the study report also had a delay.

In the chart a time gap of no work can be found. This does not mean that the team did not work during this time. In the time between study and summarizing the city regulations and passive house requirements and study and summarizing the house systems, the team worked on realising the draft 2D house plans and the intermediate report.

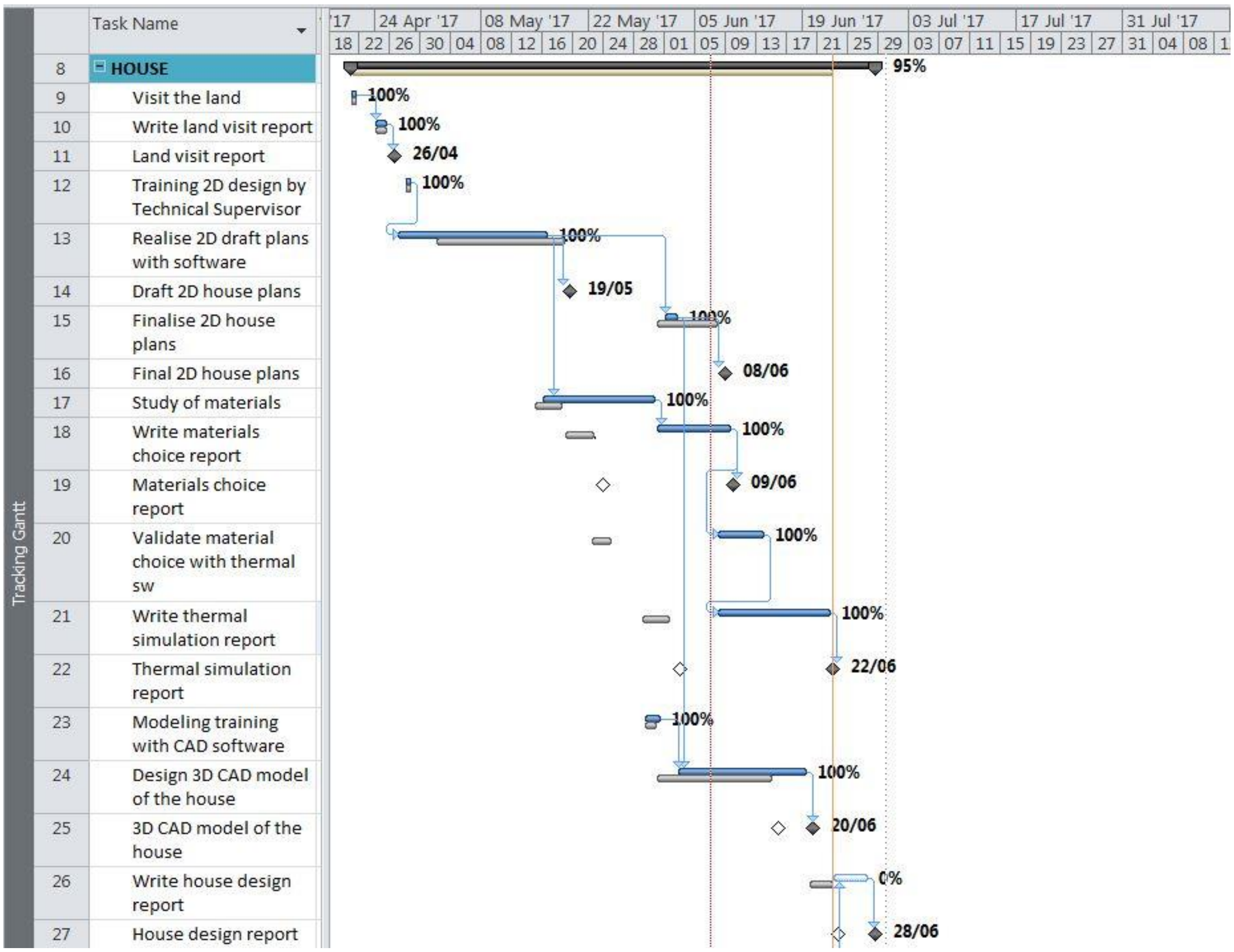


Figure 40 Tracking Gantt of the branch house

As is shown in *Figure 40*, realising the draft 2D house plans was started before the planned date. This due to the fact that there was time for a few of the team members to start working on this task while the others were working on the intermediate report. Since the team wanted to include a draft design, to show their progress on the technical part of the project.

Finalising the 2D house plan took less time, since the team used the draft 2D house plans to obtain the final plan. They only had to apply some minor changes when one of the two concepts was chosen as the final plan.

Most tasks in the house branch were started later than planned, this due to the fact that some tasks took longer than expected. In the end this did not turn out to be a problem, because the team managed to finish all the tasks in the available time for the project.

At this point the team only has to start writing the house design report. In the house design report the client will be able to easily access information that is only important to him, this means the house design report will mostly consist of the technical subjects of the final report. Therefore the final report first has to be finished before the team can start working on the house design report. This will not be a lot of work and can easily be finished within half a day or perhaps less.

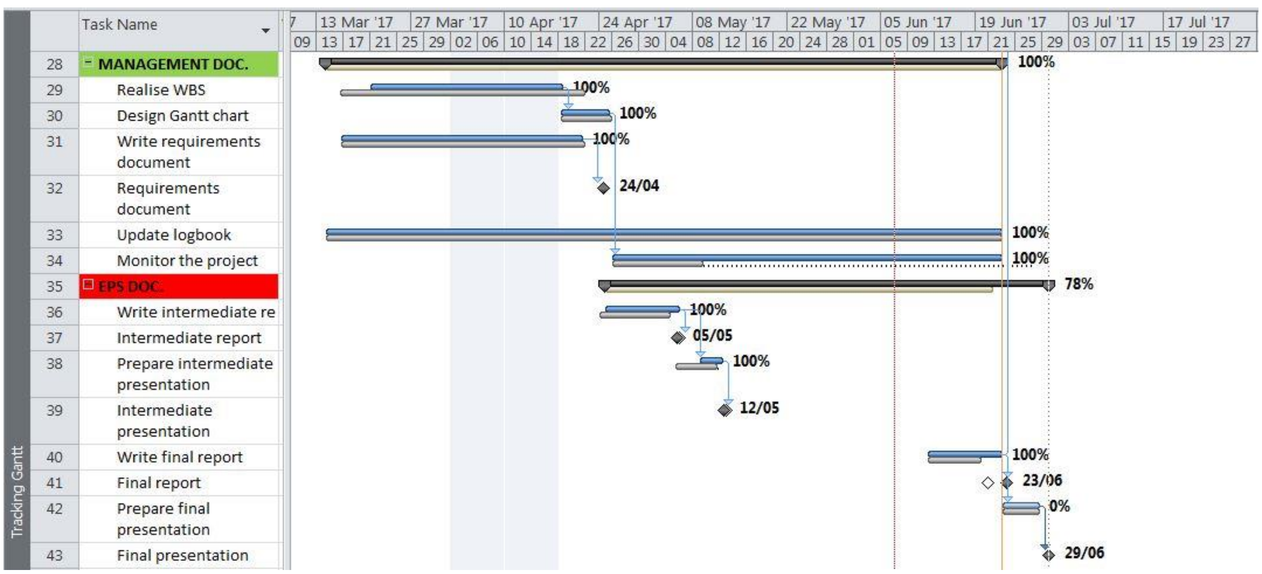


Figure 41 Tracking Gantt of the branch management doc.and EPS doc.

In *Figure 41* the management doc. and EPS doc.branch chart is shown. As can be seen in the chart, realising the WBS started later, but also finished earlier. Less time was needed to carry out this task. Designing the Gantt Chart took the amount of time that the team had planned for it as well as writing the requirements document, updating the logbook and monitoring the project.

Writing the intermediate report, in the EPS doc. branch, started slightly later than the team had planned and therefore, in agreement with the supervisors, the team was allowed to submit the intermediate report one day later than planned. This did cause a slight delay in preparing the intermediate presentation. This was however not a problem, since the team's intermediate presentation date was one day later than previously thought.

Writing the final report started on time, but took longer than previously anticipated, but the team will be able to start working on the final presentation on time, which still has a completeness rate of 0%, since the team has not started working on the final presentation yet and will do this after the final report is finished.

4.1.3 Deliverable Status

Throughout the project the team has kept track on the statuses of the deliverables. This is done in an excel file. In *Table 8* the deliverables along with their planned deadlines, actual deadlines and status is shown:

Milestone Nº	Deliverables	Planned deadline	Actual deadline	Work days late	Status
1	Requirements Document (D3.1)	21/04	24/04	3	100%
2	Land Visit Report (D2.1.1)	24/04	26/04	2	100%
3	Regulation Study Report (D1.1.1)	03/05	03/05	0	100%
4	Intermediate Report (D4.1.1)	05/05	05/05	0	100%
5	Intermediate Presentation (D4.1.2)	12/05	12/05	0	100%
6	Draft 2D House Plans (D2.1.2)	18/05	19/05	1	100%
7	Study Report (D1.1)	23/05	09/06	13	100%
8	Materials Choice Report (D2.2.1)	23/05	09/06	13	100%
9	Thermal Simulation Report (D2.2)	02/06	22/06	14	100%
10	Final 2D House Plan (D2.1.3)	08/06	08/06	0	100%
11	3D CAD Model of the House (D2.3)	15/06	14/06	-1	100%
12	Final Report (D4.2.1)	20/06	23/06	3	100%
13	House Design Report (D2.4)	23/06	23/06	0	100%
14	Final Presentation (D4.2.2)	29/06	26/06	-3	100%

Table 8 Deliverable status

Legend:

- 0 days late
- 1-5 days late
- More than 5 days late

As is shown in the table *Table 8*, a few deadlines are met within the planned time, but others needed more time to finish. This due to the fact that for some tasks the workload has been estimated to be less than it in reality appears to be. Therefore tasks are moved as well as the planned and actually used resources for certain tasks, this to divide the workload more to be able to finish the project in time and in a satisfactory manner. For example the whole team should have worked on the thermal simulation and the 3D CAD model of the house, but due to the fact that they were behind on schedule, the team split up so these two tasks could be carried out parallel to each other.

The materials choice report and the study report have been two of the most delayed deliverables with 13 days of delay for each one. This due to the lack of knowledge that the team possessed at the beginning. For example during the materials choice report the team had to find the prices of every material, which was not an easy task due to the fact that most of the providers do not show the prices on their websites. It was also difficult to exactly understand all the parameters to take into account in order to decide the best option.

The study report also has 13 days of delay because it includes the study of the house systems. The house systems were new for the team at the beginning, the lack of knowledge made the team spend a lot more time on understanding the main concepts, trying to find prices and researching the proper systems for the passive house as well as meeting the passive house requirements regarding the power consumption.

The most delayed deliverable is the thermal simulation with 14 days. After the studies of the materials and the systems the project team made a decision. After looking at the time remaining for the project and the complexity of the software program Clima-Win™ the technical supervisor offered to make the thermal simulations. This to use the time on the other tasks that still had to be finished.

However, even with the fact that a few deliverables were late, the team has been able to finish them all within the time available for the project.

The project is accepted using the status of the deliverables. When the status of the deliverables reaches 100%, the documents are signed by the team. After this has happened, the documents are sent to the supervisors for acceptance. This means that once the supervisors agree with the contents of the document, they sign to approve and accept the document.

4.2 Cost Analysis

In this chapter the cost analysis can be found. These costs include the studied systems, in section 4.2.1 Systems, materials in section 4.2.2 Materials, and miscellaneous costs in section 4.2.3 Miscellaneous, this to have an overview of how much money is estimated to be reserved for these three sections. The construction of the house itself, including the man hours of the workers and the equipment that they will use are not included in this cost analysis.

The costs of the team are also not included in this cost analysis, since the team works on this project for free and the office did not have to be rented either. It would be useless to calculate those hours, since these costs are not made. The software is used, is also available on the computers in the office, so no licensing of these products is required.

4.2.1 Systems

The first part shows the cost of the house systems within the house. These house systems include systems for power generation, heating, ventilation and lighting.

Element	**System**	**Cost**
PV Solar Panels	Solar Panel BISOL BMO-300	€ 3.285,00
Heating system	ALTHERMA MURAL 4 TO 8 KW	€ 2.959,74
Ventilation system	GES Energy 1 (Horizontal) (Z010339)	€ 2.652,13
Lighting system	LED bulbs	€ 168,00
	Total	€ 9064,87

Table 9 Cost analysis of the house systems

The house systems used within the house are presented in *Table 9*. These house systems are compared with viable other options in *Appendix A: Study Report.* After the comparison the cheapest solution, which is also able to provide what is required, has been chosen to apply in the house.

4.2.2 Materials

The second part of this cost analysis shows the cost of the materials which are used within the envelope of the house, shown in *Table 10*.

After the study of the materials, the above mentioned options have been chosen by the team. The team has chosen these options because of the balance between the U-value, cost and thickness. It is not the cheapest solution but this scenario will save cost in the heating system because this system does not need to run that often because of the chosen insulation materials.

Moreover, a meeting with the technical supervisor concluded that the prices indicated by the team were a good representation of the prices in the real world.

Element	Material	Cost
Walls	Porous concrete	€ 64,33
	EPS 100	€ 4655,20
	Plastering system (BA13)	€ 363,95
	Subtotal	€ 5083,48
Roof	Roof covering	€ 450,00
	Cross wood beam	€ 6666,00
	Glass wool sprayed insulation	€ 1506,52
	Plastering system (BA13)	€ 286,64
	Subtotal	€ 8909,16
Floor	Reinforced concrete slab	€ 188,27
	EPS 100	€ 3176,25
	Sand binding	€ 244,62
	Radon barrier	€ 108,57
	Hardcore	€ 376,00
	EPS 300	€ 1292,50
	Reinforced concrete ring beam	€ 658,47
	Subtotal	€ 6044,68
Windows	Double layered glass	€ 120,44
	Window frame	€ 316,92
	Subtotal per window	€ 437,36
	Subtotal all windows	€ 2624,16
	Total	€ 22.661,48

Table 10 Cost analysis of the materials used in the house

4.2.3 Miscellaneous

The last part of the cost analysis are the costs that do not have a category, show in *Table 11.*

Element	Type	Cost
Electricity- phone- and internet connection		€ 1300,00
Garage	Building	€ 24.123,00
	Total	€ 25.423,00

Table 11. Cost analysis of the miscellaneous.

The price of the electricity connection to the house was given by the technical supervisor during the visit of the land. After a small study the cost of the garage was found to be € 24.123,- according to the reference [10]. This price indicates the price of the materials to build a garage.

If all of the costs are added together the total cost for the project is:

$$9064{,}87 + 22.661{,}48 + 25.423{,}00 = € \, 57.149{,}35$$

It has to be reminded that the costs for the designing and the construction of the house are not taken into account in this cost analysis.

4.3 Conclusions

In this chapter management II is concluded. This includes the monitoring of the project and the cost analysis that were previously discussed.

The monitoring of the project has been done by filling in a logbook throughout the duration of the project. This to keep track of the time that is spend on the different tasks. However, the logbook was not the only monitoring tool the team used. The team also used the Gantt Chart to monitor the project. This was done by using the tracking Gantt function in MS project™.

By using the tracking Gantt it is easy to keep track on the completeness of the different tasks. This way it is clear what to move when a certain task finishes earlier than expected or when a task is delayed for example. By filling in the actual start date and finish date of the tasks as well as the completeness of the tasks according to the duration.

In the end, a few tasks were delayed, due to the fact that some took more time than the team had previously anticipated. However, this was not a big problem. All the planned tasks have been done and finished in time, meaning that all the deliverables were also finished before the end of the project.

The cost analysis include the costs of the studied systems, materials and miscellaneous costs, this to have an overview on how much money is estimated to be reserved for these three sections. The construction of the house itself, including the man hours of the workers and the equipment that they will use are not included in this cost analysis.

The costs of the team are also not included in this cost analysis, since the team works on this project for free and the office did not have to be rented either. It would be useless to calculate those hours, since these costs are not made. The software that is used, is also available on the computers in the office, so no licensing of these products is required.

If all of the costs are added together the total cost for the project is:

$$9064{,}87 + 22.661{,}48 + 25.423{,}00 = € \, 57.149{,}35$$

5. Final Conclusions

After four months of working on the project of designing a bio-climatic passive house the Greenit&Co team has been capable of designing not a passive house but a positive house. Which is better than the main objective of the project (to consume less than 15 kWh/m^2/year). This means that the house does not need energy from the public network, because it produces more than the house consumes. In this case the house produces 1 kWh/m^2/year more than what is necessary.

For the first part of this project, the team needs to understand and know all the requirements and objectives. With the objectives the team creates the deliverables to achieve the objectives. To carry out the deliverables, Greenit&Co uses the planning.

The planning is useful in this project because the team uses it to follow the project and to divide the tasks between the members of the team. Also, the milestones are created to know the deadlines of the deliverables. The WBS is a tool that the team uses for the structure in the project. This was a difficult task to carry out, but very useful for the rest of the progress of the project. The Gantt Chart and the most part of the documents follow the structure of the WBS. The result of this tool is very satisfactory because it makes it possible to know during the project where the documents and tasks are situated.

To make sure the technical part is achieved, the team creates different tables to conclude each requirement. In *Table 12* an overview of the objectives can be found with a description of the solution and a checklist of whether the requirement has been achieved yes or no.

N°	Requirement	Solution	Achieved
R1	To study: city regulations (Labastide-Chalosse (40700)) and passive house requirements	The study report contains the studies of the constraints within the project.	Yes
R2	To optimize the orientation of the house	The orientation of the house could be decided during the land visit, and optimized during the 2D plan design.	Yes
R3	To draw the 2D plans of the house	2D draft designing provides the 2D plans of the house and the methods on how these are created.	Yes
R4	To design the house systems: Power generation, heating, ventilation and lighting	In addition to the constraints the study report also includes the house systems.	Yes

R5	To calculate the window surface area and placement	The minimum window surface area and the best place for them are given with the passive house requirements.	Yes
R6	To choose the adapted insulation	Multiple materials are studied within the materials choice report. A comparison and selection are made within this report.	Yes
R7	To analyse the cost	A cost analysis is made in chapter *4.2 Cost Analysis*	Yes

Table 12 Checklist objetives

In *Table 13* the passive house requirements are listed, along with a description of the solution and a checklist concerning whether they have been achieved yes or no:

N°	Requirement	Solution	Achieved
1	The Space Heating Energy Demand is not to exceed 15 kWh/m^2/year	The renewable energy is enough to heat the house due to the number of photovoltaic panels and the proper insulation.	Yes
2	The total energy to be used for all domestic applications must not exceed 60 kWh/m^2/year.	The same explanation as in the requirement above.	Yes
3	In terms of airtightness, a maximum of 0.6 air changes per hour at 50 Pascals pressure.	This requirement has to be verified by an on site pressure test once the house is built, so it has not been possible to test it.	No
4	Thermal comfort must be met for all living areas, with not more than 10% of the hours in a given year over 25 °C	Due to the materials choice a small quantity of energy is needed to heat the house (34 kWh/m^2/year), and the heating system can provide that energy by using renewable energy from the photovoltaic panels	Yes

Table 13 Checklist passive house requirements

In *Table 14* the city regulations are listed the same way the previous two tables were worked out:

N°	Requirement	Solution	Achieved
1	Light wall colours	Light colour for the exterior wall has been chosen as is shown in the 3D model.	Yes
2	Maximum height of 7,5 metre	The height of the house according to the 3D model is 5,60 m	Yes

3	Wood as an exterior building material	The team has not used wood as a construction material.	Yes
4	Tile roof covering	As is shown in the 3D model the roof covering is tile	Yes
5	30 degrees of roof slope	The size of the roof has been designed in order to get this 30 degrees of slope	Yes
6	Bigger height than width of the windows	In all of the windows the height is bigger than the width even the door to access the terrace.	Yes
7	It is forbidden to design the beginning of the house between 0 and 3 metres from the road	The beginning of the house is designed 13 metres from the road.	Yes

Table 14 Checklist city regulations

In *Table 15* the requirements of the client are listed along with an explanation:

N°	Requirement	Solution	Achieved
1	Dimensions	All the dimensions set by the client have been respected during the design of the house	Yes
2	The ground floor	The team has designed a house with the ground floor since it was required by the client.	Yes
3	Location of the bathroom as well as the toilet cannot be in one of the corners	As is shown in the 2D model and 3D model both are not located in any corner.	Yes
4	American open style	The kitchen, living room and dining room have been designed with no walls between them, creating the American open style the client asked for.	Yes

Table 15 Checklist requirements of the clients

Only one of the passive house requirements has not been achieved because it has to be tested on site once the house is built.

During the project, the team follows the planning. When Greenit&Co developed the materials choice report and study report the team underestimated the workload, which caused the team to fall behind on schedule. One important decision was taken by the team in order to finish the project in time (including the technical supervisor). This decision was to not participate in the whole process of making the thermal simulation in Clima-Win™. The technical supervisor helped the team and made the thermal simulation using the material study report, the study report and the 2D house plans, afterwards the results were send to the team.

For the monitoring of the project a logbook was daily filled in and the Gantt Chart was used with the tracking Gantt function. This way the team was able to keep track on the progress of the project. The tracking Gantt delivered a clear overview of the different tasks, their completeness and their possible delay. In the end, a few tasks were delayed, due to the fact that some took more time than the team had previously anticipated. However, this was not a big problem. All the planned tasks have been done and finished in time, meaning that all the deliverables were also finished before the end of the project.

Bibliography

[1] Plan d'Occupation des Sols, Commune de Labastide-Chalosse(40700), 2015

[2] Passive House Institute, (w.d.), Passive House Requirements, retrieved from

http://passivehouse.com/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm

[3] Pure, (2017, March, 30), Methods for risk analysis, retrieved from

http://pure.au.dk/portal-asb-student/files/13101/Method_for_Risk_Analysis_in_regard_of_different_types_of_projects.pdf

[4] Mar, A. (2016, June, 27), Risk examples, retrieved from

http://management.simplicable.com/management/new/130-project-risks

[5] Manick. (2012, February, 23), Risk probability and impact, retrieved from

http://www.justgetpmp.com/2012/02/risk-probability-and-impact.html

[6] Passipedia. (2014, September, 18), PHPP validated and proven in practice, retrieved from

https://passipedia.org/planning/calculating_energy_efficiency/phpp_the_passive_house_planning_package/phpp_-_validated_and_proven_in_practice

[7] Memoria Passivhaus EntreEncinas. (2012, Septiembre), Documentación Proyecto Passivhaus, retrieved from

http://estudioduqueyzamora.com/portfolio-items/casa-entreencinas/

[8] Sketchup. (w.d.), 3D Models, retrieved from

http://3dwarehouse.sketchup.com

[9] Gus astuces,. (w.d.), Heat pump, retrieved from

https://www.gus-astuces.com/pompe-a-chaleur-daikin-altherma-basse-temperature/128-altherma-mural-4-a-8-kw.html

[10] Cost to build. (w.d.), Cost of the garage, retrieved from

http://www.costtobuild.net/input1_garage.html

List of Appendices

Appendix A: Study Report

Appendix B: 2D House Plans

Appendix C: Thermal Simulation Report

Appendix D: 3D CAD Model of the House

Appendix E: House Design Report

Appendix F: Requirements Document

Appendix G: Planning Documents

Appendix H: Monitoring Documents

Appendix I: Meeting Minutes

Appendix I.1 Project Management Meeting Minutes:

Appendix I.1.1 Project management Meeting 1, 14/03/17
Appendix I.1.2 Project management Meeting 2, 20/03/17
Appendix I.1.3 Project management Meeting 3, 20/04/17
Appendix I.1.4 Project management Meeting 4, 11/05/17
Appendix I.1.5 Project management Meeting 5, 30/05/17
Appendix I.1.6 Project management Meeting 6, 07/06/17

Appendix I.2 Technical Meeting Minutes:

Appendix I.2.1 Technical Meeting 1, 13/03/17
Appendix I.2.2 Technical Meeting 2, 20/03/17
Appendix I.2.3 Technical Meeting 3, 16/05/17
Appendix I.2.4 Technical Meeting 4, 17/05/17
Appendix I.2.5 Technical Meeting 5, 02/06/17
Appendix I.2.6 Technical Meeting 6, 20/06/17