UNIVERSITAT JAUME I

Escola Superior de Tecnologia i Ciències Experimentals

ENGINYERIA AGROALIMENTÀRIA

I DEL MEDI RURAL

The role of biomass at GAIA Ecovillage, and its utilization in establishing new eco-houses

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Summary

This study details the implementation of a biomass boiler obtained from energy crops to produce thermal energy through radiant floor in 11 houses of the left wing of a building of a village isolated from the population in Galgahévíz (Hungary) as an alternative renewable energy. It is an installation to complement the other energies already available.

In the first part of the project, we will deeply study the concept of biomass, including a compilation of data on the types that exist, the forms of conversion in energy, their characteristics. A study will also be carried out to obtain the possibilities and the situation of the biomass within the ecovillage, giving alternatives to possible problems.

Alternatives to this biomass boiler will be studied, and analyzed one by one, to rule out possible better alternatives.

Once placed in situation, we will perform the calculations to obtain the thermal energy demand of the building for the dimensioning of the mentioned plant, where we will analyze all the necessary aspects for the correct dimensioning using different multicriteria studies to decide both the size of the plant and the location.

Afterwards, a study will be carried out to determine the needs of energy crops, selecting the best species for this climatic zone, the cultural actions to be carried out over the next 20 years.

Finally we will carry out the economic feasibility study of the plant in function of the current regulations.

Index of symbols

CU Uniformity coefficient [%]

DU Uniformity of distribution [%]

Ea Efficiency in the application of irrigation [-]

ECe Electrical conductivity of saturation extract [dS/m]

ECw Electrical Conductivity of Irrigation Water [dS/m]

Es Irrigation efficiency [%]

ET Evapotranspiration [mm/día]

ET0 Evapotranspiration of reference [mm/día]

FL Washing factor [-]

Hj Pumping height on shift [m]

Kd Density factor [-]

Ke Factor of specie [-]

Kj Coefficient of garden [-]

Kmc Microclimate factor [-]

Q The demand for power

Cp Coefficient to calculate the flow rate of the heating

Le Efficiency of leaching, 0.70. [-]

NRn Net irrigation needs [mm/día]

NRr Real irrigation needs [mm/día]

P Precipitation [mm/día]

Rp Percolation ratio [-]

Pef Effective precipitation [mm/día]

Q Flow rate of pump [m3/s]

Qi	Flow of the transmitter [m3/s]
ST	Total area of the irrigation zone [m2]
ti	Duration of shift [s]
VT	Total irrigation volume [m3]
RH_{max}	Maximum relative humidity [%]
RH_{min}	Minimum relative humidity [%]
R	The transmission $(W/m^2\ ºC)^{-1}$
T	Air temperature [oC]
$T_{máx}$	Maximum daily temperature [oC]
$T_{máx,K}$	Absolute maximum temperature over a 24-hour period [K]
T_{media}	Average daily temperature [oC]
$T_{mín}$	Daily minimum temperature [oC]
$T_{mín,K}$	Absolute minimum temperature over a 24-hour period [K]
ΔT	Temperature increase
φ	Latitud [rad]
P	The theoretical power
ρ	Water density
g	It's gravity
SV	Free section of ventilation (cm^2)
PN	Nominal power installed
Mtoe	Million Tonnes of Oil Equivalent
TWh	Terawatt hourly
NPV	Net Present Value
IRR	Internal Rate of Return

Q_{comb} The amount of annual combustible needed

CE The annual energy consumption

PCI The lower calorific value of the combustible

HUF Forint (Ft)

Contents of the project

Memory of the project

Index

1. Introduction to the project

This project includes all the details of a holistic rural development program in a town near the capital of Hungary, Budapest. The vast majority of rural communities in Hungary earn their livelihoods through agriculture, which is closely linked to food production, waste management and water management. The majority of people with energy poverty live in rural areas and depend on agriculture as the only way of subsistence, but very often they cannot cover the energy needed to produce their own agricultural production. Therefore the objective of this work is the construction of renewable energy sources, with minimum or zero residues adapted to local conditions and needs. Self-sustaining rural economies and village communities may be the best solution for many people, incorporating the production and sustainable use of renewable energy resources and food production, introducing energy-efficient construction technologies based on natural materials. With a socially cohesive and environmentally conscious development provide safe living conditions for all.

The GAIA Foundation, as explained below, has a multitude of projects around the world, but all of them have the same philosophy in common, halting the growth model that seems unstoppable today, caring for the environment, using natural resources and reusing it, leaving the smallest ecological footprint, so that in this study should be proposed a solution in accordance with this philosophy of the foundation.

The objective of this document is to obtain a diagnosis, as effective as possible, of the current situation of the use of biomass from different sources in rural areas of Hungary, and the feasibility study of this type of renewable energy in the ecovillage of the Foundation. The case study focuses on the use of biomass for thermal energy production in Gaia Ecovillage for the implementation of this in the new buildings under construction. What are the advantages and disadvantages of using biomass? What kind of system, equipment are needed to heat new eco-houses ?. The comparison of costs of energy sources, return-on-investment calculations are necessary in case of installing new equipment, materials of new constructions, etc.

2. Antecedent

Hungary has a population of 9,830,485 people, who live in rural areas, and some of these rural areas do not have a connection to the electricity grid, and the livelihood of these people is closely connected with agriculture. It means that the inhabitants of these areas are linked to their own food production, waste management and water management. Many of these people are energetically poor, their only way of life is agriculture to produce the food they consume, but the problem is, that in many occasions they cannot cover enough energy required for their own agricultural production, and much less to meet the energy needs.

These rural areas disconnected from the electricity grid do not have any type of alternative for the production of energy, neither thermal nor electric, and a lot less the enough money to be able to think about the implantation of solar panel, or small windmills, etc., to produce their own necessary energy, which would allow them to be able to improve their quality of life, at the same time that it would obtain growth respectful with the environment.

To all this we add that Hungary [Figure 1] is situated between the latitudes of 45 ° 45'N and 48 ° 35'N, approximately halfway between the Equator and the North Pole, i.e. according to the location, Hungary is located in the temperate climate zone. Its climate is very erratic, and one of the main reasons for this is the fact that Hungary is located between 3 climatic zones, due to this there are great differences in the climate of the country, despite its lower altitudes and relatively small extent, so that during the winter great frost is reached, especially in the north of the country, to achieve a comfortable life, buildings are needed with thermal power supply during these winter periods.

Figure 1 - Location of hungary in europe

All these reasons are summarized in that the majority of people in the rural areas are energetically poor, and have high thermal energy needs because of the great frosts that occur in these latitudes during the winter periods, but the economy and knowledge prevent to take the step to the renewable energies, obtaining thus a growth in its quality of life linked to the care of the rural environment and of agriculture, since it is its means of life.

2.1 GAIA eco-village

Foundation Gaia is a non-governmental organization (NGO) founded in 1990 by a group of friends with very clear ideas, to face the consumerism established by the society of these times. The objective is to create a more sustainable and environmentally friendly model of life, in order to revive biocultural diversity, regenerate healthy food and ecosystems, improve community ecological governance, halt climate change and challenge corporate dominance. The Gaia Foundation has projects spread all over the world and works with local and indigenous communities, civil society groups and social movements to re-establish a respectful relationship with the Earth.

The name was taken from the word Mother Earth of Greek mythology, the main mission of the Gaia Foundation focuses on the interconnection of all things and the life on earth, and around work for harmony and social justice and environment for living beings. Humans are included in the equation. Therefore, Gaia is not just an environmental organization, but a "whole Earth" organization.

Among many projects, Gaia Foundation began to create an eco-village in Hungary in 1992 with the values that characterize them, and with which they started years ago, a project to create a space to live on their own, and to demonstrate to the Society, that another approach to life is possible. Another project that Foundation GAIA has in Hungary is Galgafarm, a farm with those philosophical aspects, where waste is managed to minimize them, reuse them, and generate energy for food production with its subsequent economic benefit.

As a conclusion, the Foundation has a clear slogan "Consciousness, Responsibility, Action" and is the one that tries to expand and share with its numerous projects that are going on all over the world.

The village receives tourism during the summer periods to do activities on the lake or in the mountains, so this type of projects can act as a 'speaker', as it can expand the foundation's philosophy, make renewable energies known, and show that these alternatives to obtain energy are viable, reliable and are carried out without any problem.

2.1.1 Localization

Gaia Eco-village is located in the north of the country, it is 3 km far away from Galgahévíz, (45 km far away from the capital, Budapest), at the foot of the Gödöllői Protected Landscape Area (Figure 2), on the shores of Lake Bika. Galgahévíz is a village a bit different from the rest of Hungary, because it was a desert village, and was restored by the inhabitants of Galgahévíz, who are conscious of the environment, and they try to reflect their commitment to ecological values.

Figure 2 - Location of the village in Hungary

It is a completely rural enclave in the middle of the mountain, can only be accessed by dirt roads, in the winter periods there is the possibility of being cut off by the snowstorms, and next to a fairly large lake where different aquatic activities can be done.

This place provides everything you could want from a village of these characteristics, far from civilization, close to nature, with very fertile land and a water spring of 130 meters deep.

2.1.2 Background

The Gaia Foundation was founded in 1990 by a group of friends, who remain the original support of the ideological goal. This ideological goal is to create a living space for themselves, which demonstrates that another approach to life is obviously possible with its strengths and threats. This village has been taking shape since 1992, when Galgafarm Cooperation was created, very close to the village itself, where agricultural and food processing activities are carried out, a Training Center, a hotel and a restaurant were also built in 1997. There was a great change from 2006, when they began to build houses to attract more public into the ecological town, and to continue with the diffusion of their philosophy of life. Six years later, in 2012, a demonstration center was created, where they want to convey all the experience and knowledge that they have acquired during the journey towards the more sustainable academic and practical sustainability, because they are convinced themselves, as well, that it is capable to translate outside the village. Therefor a center of reference became in the same year, which was recognized by different institutions of the European Union, to develop a university level eco-village designers and study plans.

This place is built with an integrated design to achieve total self-management, from the generation of its own electricity, production of its food, self-management of water and re-use of its own waste, since the founders of the eco-village recognized that the current economic growth is limited, and cannot be maintained so long, it is not sustainable. This is the reason, why this village operates in a different way from the others. The aspects of sustainability are taken very seriously, people live according to them, and try to leave the smallest carbon footprint behind.

2.1.3 Available resources

As it has been mentioned above, the village is situated in a rural, wooded, fertile land and near to Lake Bika of considerable dimensions, so it provides everything which is necessary for having a self-sufficient life. In addition the foundation has uncultivated land around the village, there is also a forested area very close to the village, things to keep in mind during the present study.

Hungary in general is a very windy area, this provides good characteristics for the production of electric energy by wind turbines. In its plots there are two types of already installed, as well as the different photovoltaic solar panels that are located on the roofs of the common buildings of the village. Therefore the electrical energy would be more than covered. This installation is detailed further in section 2.2.2.

If we talk about thermal energy, in these common buildings solar thermal panels and biomass boilers are installed, as the village has large tracts of land on its property to exploit them and extract all the biomass needed to supply the different buildings, in this exploitation will focus the study on.

At a depth of 130 meters under the soil of the eco-village there is a natural spring, from where water is extracted for domestic use. The water already used coming from the houses is managed for different uses as the irrigation of the fields.

Residents also have a small greenhouse used for the principles of permaculture, explained in more details in section 2.2.1, to be able to harvest food, since as previously said, the lands are rather fertile and are optimal for this activity.

This means that the location is practically perfect as the autonomy of the eco-village is complete.

2.2 Current installation

2.2.1 Description of the village

As previously described in order to arrive the eco-village, it is necessary travel 3km by a dirt road from Galgahévíz. It is possible to define two different zones, a built area where the individual and common buildings are located and another area is much more extensive that surrounds the previous one where the extensions of the field of the Foundation are located [Figure 3].

Figure 3 - Aerial view of the village

Within the built area there is;

- A total of 10 individual houses [Figure 4] inhabited scattered in this area, are not connected to each other but if close enough, each has an underground connection of electricity and pipe to the water management system. They are houses of no more than a height, with gable roof to avoid accumulation of snow in winter times.

Figure 4 - Individual houses

- In the center of the built area is the main building [Figure 5], the largest of all, with a semicircular and symmetrical shape, and with an extension of 101 meters long, 17 meters wide, with two floors and a gabled roof, but in the center has a high dome reaching to surpass the 17 meters of height. This building is designed to house in 20 smaller premises for 16 owners, not equal between them, with small differences, of which they are only built and inhabited 7 [Plan 3 and 4].

Figure 5 - Main building

2.2.2 Description of the current installation

At present the houses already built and inhabited in the village are supplied with 100% energy from renewable energies. This energy comes from different points;

- Electric energy coming from photovoltaic solar panels located in common buildings [Figure 6]. There are 26 panels of silicon cells available. The photovoltaic cells are associated in series to form solar panels, in the case of the plates already installed have 72 cells per plate and are the plates that give output a mpp voltage (around 36 V) and charge 24 V batteries. They decided to put these the following way;

Figure 6 - Photograph of a portion of installed solar panels

Analyzing the advantages, this type of monocrystalline solar panels have;

- The highest efficiency rates since they are made with high purity silicon. The efficiency in these panels is above 15% and in some brands it exceeds 21%.

- The life of the monocrystalline panels is longer.

- They work better than polycrystalline panels of similar characteristics in low light conditions.

- Although the performance in all panels is reduced with high temperatures, this happens to a lesser extent in polycrystalline than in monocrystalline.

Analyzing the disadvantages, this type of panels;

- They are more expensive. By valuing the economic aspect, it is more advantageous to use polycrystalline or even thin-film panels for domestic use.

- If the panel is partly covered by shadow, dirt or snow, the whole circuit may be damaged. If you decide to put monocrystalline panels, but you think they may be shaded at some points, it is better to use solar micro inverters instead of chain or central inverters. Micro inverters ensure that the entire solar installation is not affected by only one affected panel.

- A process called Czochralski is used for the manufacture of monocrystalline silicon. As a result, cylindrical blocks are obtained. Subsequently, four sides are cut out to make the silicon sheets. A lot of silicon is wasted in the process and this does not match the spirit of ecovillage.

- There are 21 solar thermal panels installed, they are the ones that work of simpler form. The rays of the sun heat the panels, which contain a heat transfer liquid that circulates in the interior of the house. These panels, due to their low efficiency and larger size, are only recommended for rural areas, and are also placed together with the photovoltaic solar panels on the roofs of the common buildings of the village.

- There are two types of wind turbines, specifically two tripolar wind turbines [Figure 7] with three-way rotor winding and one vertical axis of smaller size, converting the kinetic energy of the wind into mechanical energy and through a small turbine in electrical energy .

Figure 7 - Photograph of a wind turbine type from the eco-village

The installation of pipes and wiring to the different buildings, both own houses and common buildings, is already carried out. All this installation is underground, avoiding a greater visual impact.

2.2.3 Description buildings construction

This chapter of the study will explain an important part of the work, as it will serve to understand the rest of the study. The GAIA ecovillage, as detailed in point 3, has a different view of the lifestyle of today's society, this is reflected even in the construction of the houses.

The construction of the houses will be made with totally natural materials, these are:

- Wood for the structure of the building

As can be seen in the Figure 8 the wood is a main material for the structure of the building.

Figure 8 - Photograph of the wooden structure of a common eco-village building

There are different types of wood as shown in the following image, which gives consistency and safety to the building [Figure 9].

Why was this type of material used? Wood as the main building material has ever been used by mankind, we can say that from its appearance wood was used as the basic material to build houses. There are great advantages to building wooden houses, according to a study from the University of Georgia, these types of houses provide heating and natural cooling due to the density of the trunks. It is concluded that wooden houses based on logs are houses of conservation of natural energy and as such bring great benefits to the people who live in them. Choosing a wooden house will save on heating and cooling, an important aspect that GAIA is looking for.

Figure 9 - Photograph of the different sizes of wood used in the structure of buildings

The trees chosen by people skilled in the construction of these houses are inclined by the use of pine and spruce. The wood of these 2 types of trees is durable and resistant that is why the wooden houses of this tree is stable and long lasting.

All in all, the main features of wooden homes are long lasting. They have a lot of advantages, such as fire resistance, outdoor appeal, high building standards, noise reduction, heating and cooling costs, energy efficiency.

Figure 10 - Blocks of adobe

- Adobe

The use of adobe [Figure 10] for the walls of the building is another important aspect to detail in this study. This construction technique, like all, has positive and negative aspects. If we talk about the positives and that are related to the philosophical of the GAIA foundation, it is a material that transpires, presents good aeration. It has a great thermal inertia, so it retains either cold or heat and if we want to take this quality to the maximum we must place the insulation material on the outside and not on the inside of the wall, as usual. Another important benefit is that it has a low cost of realization and little investment in support materials. But the most important of all these aspects is that the construction of the building does not require large foundations or large machinery or great efforts, but it is a fast and simple material to work with, a single person can make the bricks and build them with very simple tools, this contributing a point of sustainability and independence to this ecovillage.

As previously mentioned, it also has negative aspects such as the bricks are sensitive to humidity, it is necessary to wait until the bricks dry before putting them in the building, and another important aspect is that it does not serve as a structural wall, when it is used without reinforcements. In the concrete case of this study, adobe bricks are used as walls in conjunction with the wooden structure as shown in Figure 11.

Figure 11 - Photograph of the wall inside the homes

But, how are these types of bricks performed? The technique of the realization is quite simple, first you have to have the main element of the mixture, the soil. The most suitable soil is composed of between 20% and 30% of clay and the rest of sand. The soil is not suitable if it has slime or organic matter (humus).

To check if the soil we are going to use has the right amount of clay and sand we can make a dough by adding some water and making balls with the soil. If they are easily disposed, the soil will probably contain too much sand and we should test hardness with the adobes to see if they are suitable for construction.

An optional material that we can add is the straw that we obtain in the ecovillage. It helps to resist the adobes and prevents them from cracking during drying. The soil is a material that resists very well to compression but does not work as well to traction, so the straw helps to give this property to the adobe. The mixture should contain 4 parts of soil and 1 part of crushed straw. If the soil is too clayey, 1 part of sand may be added. Mix everything dry and add water to obtain a moldable consistency.

An important aspect in the construction of these bricks is the mold. There are different sizes of adobe bricks [Figure 12]. The most common dimensions in Europe are as follows:

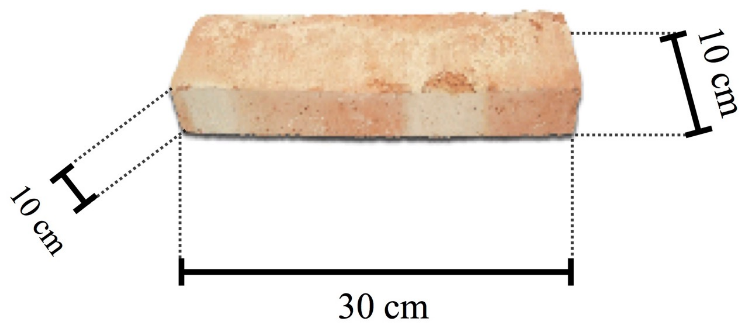


Figure 12 - Block of adobe

The mixture should stand without removing the molds for at least 1 hour. They must be dry to some degree to prevent damage to the bricks when removed from the mold.

Let the adobes dry for about 2-3 days, until the corners start to turn white (indicates they are dry). After this time, we can turn them and sing them to make them dry better. It will take about 1 week to be completely dry. If the bricks crack during drying it means that the soil contains too much clay and we should add sand to the mixture.

During the drying period we can brush the excess of mud and straw in the edges and corners of the adobes.

Once the adobes have completely dried, we must test their resistance. For this we can drop one or two of them to see if they break. We raised the adobe to a height of about a meter and dropped it on the narrow edge. They should stand the fall with little or no damage.

It is always advisable to do a hardness test with 3 or 4 adobe bricks every time we use soil from a different source to check that it is suitable for construction.

If they break, it is probably because the soil contains too much sand and is not useful for construction (the mixture should be stabilized with an additive).

The technical data of adobe bricks depend largely on the type of soil and the proportions we use in the mixture, but approximately are as follows:

– Density: 1500-1700 kg/m^3

– Compressive resistance: 0.8-2 N / mm^2 (at 28 days of manufacture)

– Good tensile or flexural resistance if they has straw or are stabilized

– Poor resistance to water or ice, it is advisable to stabilize or coat lime

– Resistance to fire: excellent

– Coefficient of thermal conductivity: 0.45-0.8 W / m.K (4 times more insulation than brick)

<u>- Wall composition</u>

Another important feature of the walls of the building is its composition when it is built. The wall has a fundamental role, as this will be the one that will allow us not to invest so much money in the heating through the boiler of biomass. The composition of the wall can be seen in Figure 13. First it must be said that the structure is made with wood as discussed above and can be seen in the image.

Figure 13 - Photography of the building wall structure

The wall consists of three main parts. The outer layers, 28 cm each, are made of adobe bricks and in the middle of these two parts, there is a layer of straw and rest of forage, approximately 2 cm thick, which will provide a better thermal and sound insulation, [Figure 14] so that the thickness of the wall will be a total of 60 cm. This means that the wall has a great thickness that will help us to maintain a better heating inside the houses to realize the installation.

The separation wall between the 11 houses has the same composition but changes the thickness, going from 60 cm to 30 cm.

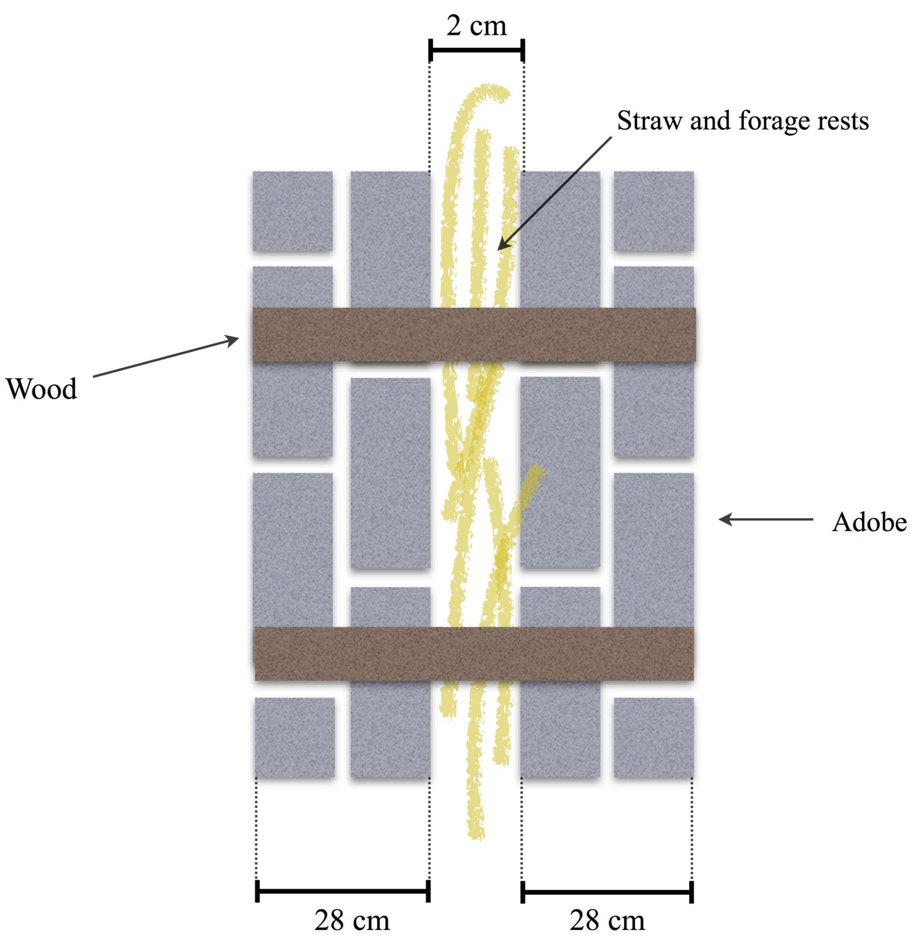


Figure 14 - Building wall structure

All these characteristics of the construction part provide a great insulation of both the cold and the heat to this building, so the demand for thermal energy will be lower.

3. Justification

Hungarian rural areas with a fairly impoverished socio-economic situation live a high percentage of the country's total population. Budapest, the capital of Hungary, is extremely large in proportion to the rest of the country, accounting for a fifth of the total population, and growing every day. This causes a serious depopulation of rural areas, where many people live without being connected to the electricity grid, where in a central European country like Hungary is very necessary because of the low winter temperatures. In addition, a high percentage of these families have a subsistence economy, which means that it is not feasible to spend large amounts of money in the facility to connect to the electricity grid, leaving their homes to move to places with more work and better conditions of life.

This work focuses in improve the living conditions of these rural areas, focusing on a specific example of an isolated village in the middle of nature but will be a role model that can be copied in other rural areas of Hungary with similar characteristics .

On the other hand, the use of renewable energy, and more specifically the use of biomass obtained from energy crops, is highly recommended as biomass is one of the most recommended fuels today. The reasons? Its non-polluting nature, since they are materials that do not contribute to the increase of CO_2 nor cause acid rain.

In this way, we consider it one of the fuels framed within the biodegradable and sustainable. At present, and due to the environmental problems that exist on our planet, the use of non-polluting fuels is a priority option in society.

There is still a need for certain fuels that unfortunately do pollute, such as gas oil in any of its typologies, but there are situations, such as rural areas of Hungary, where it is possible to replace it with a much healthier fuel for the natural environment, as is the biomass.

Biomass is mainly used for the production of heat in homes or premises of not very large dimensions, through stoves or biomass boilers. There are more environmental advantages such as reducing pollutant emissions, CO_2 neutral cycle, reduction of fires due to maintenance and cleaning in the wooded areas to obtain biomass, reduction of pests for the same reason, etc.

In addition to the environmental factor, there are many other reasons to encourage the use of biomass fuels:

Economic factor, biomass is a much cheaper fuel than others, so that users who use it for heat production benefit at the same time from a lower energy expenditure.

Social factor, the biomass industry generates jobs, since it is necessary that there are people who collect the biomass, transport it and market it.

4. Objective

The final objective of this study is the design of the installation to provide, distribute and obtain thermal energy for housing conditioning in the GAIA foundation ecovillage project, isolated from the electricity grid, but which can be reproduced in other housing of the other rural areas of Hungary with similar characteristics.

In order to provide this thermal energy for the conditioning of isolated houses, different fuel alternatives have been designed, excluding those that do not fit the ecovillage philosophy. The fuel that is proposed is that of the biomass, so the agronomic design must be carried out to obtain sufficient plant material.

The objective is to carry out all this design, dimensioning and do the viability study of this installation to bring enough thermal energy for the optimum conditioning of the houses with a system respectful to the environment and that produces social benefits for the fixation of the population in this rural areas increasingly depopulated.

5. Design alternatives to be considered

Once these problems are observed in Hungarian society, the following alternatives are proposed on the implementation of renewable energies in underdeveloped areas with an ecological vision and trying to reduce waste to the maximum, or achieving zero residues, since rural sustaining can be the key to a growth of the interior communities of Hungary.

Therefore this study will focus on the dimensioning of the heating installation in the largest building of the ecovillage described in detail in section 5.1, this building contains 20 houses, of which only 9 of them are completed. The calculations of the present project will focus on the 11 remaining houses that are not built yet.

This building is designed to be as hermetic as possible, with fairly wide partitions and insulating materials, but heating is essential to deal with the low temperatures in winter in this part of Hungary. However, it is necessary to analyze which type of heating is more convenient, since not all houses need the same system. The choice of one or the other will depend on the location of the house, the climatology and isolation, the size and distribution of the house, the number of inhabitants of the house, etc.

The types of heating can be divided according to the energy source (gas, biomass, geothermal, solar and electric) or according to the apparatus or system from which the heat is obtained (radiant floor, air pump, electric by accumulators, electric by convectors, thermoelectric emitters and boilers with water radiators).

5.1 Power source

- Gas heating

It is one of the sources of energy most used in homes. For both heating, cooking and hot water production, 3 types of fuel can be chosen: natural gas, C gas oil or propane gas.

Natural gas is a good solution because we do not have to worry about its storage or distribution, however, its supply is usually far from the cities. The second, diesel C, is somewhat more dangerous, since its storage is in tanks inside the houses. It is also more polluting and dirty, although it is a good choice to heat big homes. Propane gas is perfect for large houses or homes in small towns, as it has a heat output higher than natural gas and similar to diesel. It can be stored outside the house, in small containers or in tanks, which makes it less safe than natural gas.

-Geotermal

This type of renewable energy is obtained by harnessing the heat from the interior of the Earth. The interior of the Earth is hot and the heat increases as it goes deeper. At great depth we find water tables in which the water due to its great temperature, is heated, ascending in the form of water vapor, until reaching the surface.

- Biomass

This source of production is explained in much more detail in section 4.

-Solar

Solar energy is a source of renewable energy that is obtained from solar radiation and with which both heat and electricity can be generated. There are several ways to collect and take advantage of the sun's rays to generate energy that give rise to the different types of solar energies: photovoltaic (which transforms rays into electricity through the use of solar panels) and photothermic (which takes advantage of the heat through solar collectors).

5.2 System obtaining heat

- Electrical heating by accumulation

This is one of the most common heating systems, due to its simple installation, maintenance and safety. Electricity is converted to heat thanks to the electrical resistances inside each electric heater, through which the current flows, converting electricity into heat.

- Electric heating by convectors

This type of heating works by a resistance that heats the air that circulates inside the convectors. In this system, perfect for homes located in hot areas, hot water is obtained by the means of a thermos.

Among its advantages are there the following: a cheap installation, without work, and a comfortable supply of hot water. Its disadvantages are: the cost of its operation is usually expensive and the thermos for the hot water consumes enough while it is on, even if it is not used.

- Boiler with water radiators

It is the most used system in Spain. The heat is produced, by burning fuels like natural gas, in a boiler located in a specific place and distributed to terminal elements (radiators) by water, emitting heat to those spaces that require it.

The choice of water as a heat carrier is because it is a cheap substance, common in all buildings and its specific heat is greater than of other substances, so it requires a lower volume of water to transport the same amount of heat.

As the boiler is located in another space, it can be freely aerated without problems. This can serve a single user (individual central heating), an entire building (central heating collective), a neighborhood and even a city (district heating).

- Thermoelectric emitters

Thermoelectric emitters are oil radiators. This system achieves the transmission of heat through a thermal oil that is heated by a shielded electric resistance of a special steel.

Each radiator is independent and can be plugged anywhere without work, since it has neither boiler nor pipes. To achieve a constant and homogenous temperature, the devices incorporate a thermostat and a programmer, which help to save energy.

Another advantage of this system is that, after turning off the radiators, they continue to radiate heat for hours. They are also safer than water radiators, as the oil does not produce any internal pressure. The disadvantage is that if many radiators are needed, an expensive system is needed and more light power may be required

- Radiating floor

Underfloor heating is one of the most comfortable heating systems for cold climates. It consists of an installation of electric cables or pipes through which water circulates at elevated temperature, hidden under the floor of the house. These give off heat, which spreads upwards, heating the floor and the air inside the house.

One of the advantages of this system is that it saves the consumption of heating between 10% and 30%, provides a warm and uniform heat without drying out the environment and allows a more aesthetic image as there are no heating appliances on the walls. It is a safe system, highly recommended if there are children at home. The installation provides additional acoustic and thermal insulation and requires little maintenance.

Among its disadvantages are the high initial investment and the works involved (the pavement of the house must be raised). In addition, saying that until it reaches the desired temperature takes some time, so it is recommended for habitual residences.

- Heat pump

The heat pump allows heating in winter and air conditioning in summer in a single device. Providing these two options in a single system, lowers the investment and simplifies the installation. The wide variety of models make it possible to install them in different places.

It is an efficient system, since it consumes less energy until reaching the desired temperature, although the heat is also dispersed before. Therefore, it is recommended in warm or temperate climates with mild winters. Among its disadvantages can be mentioned the noise of the fan, which can be somewhat annoying and the high price of the installation of the heat pump by ducts.

The heat pump requires little care except regular cleaning of the air filter, and too in heat pumps when the temperature is below zero degrees loses the efficiency and increases the consumption exponentially.

6. Description of the final solution

The points to be taken into account when constructing potential energy sources are; waste, integration of food production, construction of technologies based on natural materials and environmentally conscious providing safe living conditions for everybody, since the present project has the main objective to continue with the philosophy of the foundation and the inhabitants of the ecovillage.

For these reasons, the use of the 3 types of fuel gas (natural gas, gasoleo C or propane gas) has been ruled out for the implementation of heating in the building, since it is not governed by the principles that are based on the ecovillage and the inhabitants. They would not accept it, either. The use of some types of boilers with water radiators is also completely ruled out, requiring the burning of some kind of fossil fuel for the creation of heat.

The use of geothermal energy was a very acceptable solution to carry it out. In addition, Hungary has very good geological qualities for this type of energy, but the problem is its high initial cost, which is not acceptable by the foundation.

The use of solar panels to create electricity and use it in a heating system such as electric heating by accumulation, electric heating by convectors, the use of thermoelectric emitters or heat pumps are also ruled out since the ecovillage already has photovoltaic solar panels for creating and using electricity, and this study aims to diversify sources of energy to minimize the risk of running out of energy and to increase the range of possibilities.

The final solution that was chosen and detailed in this study is the use of a biomass boiler for the production of hot water and distribution in the houses by pipes under the ground, this emitter is known as underfloor heating.

The biomass has its inertial character in common with the radiant soil, since none of these components can be stopped instantly, the radiant floor due to the heating of the volume of the mortar above the pipeline and the biomass because once the combustion chamber is heated it is impossible stop burning wood until you are finished with those who have entered the last admission.

The radiant floor is based on radiation, and therefore the transmission of comfort is direct, that is, it does not use air as a transmitting element. And the fact of avoiding the air like "intermediary" implies an energy saving.

6.1 Biomass boiler

A biomass boiler works in a similar way to a gas boiler. The fuel burner burns the wood provided, generating a horizontal flame that enters the boiler, as is often the case in diesel systems. The heat generated during this combustion (in this case of natural fuel) is transmitted to the water circuit in the exchanger built into the boiler. The hot water generated is used for heating. Biomass boilers need storage of the biofuel next to the boiler, in this case the village has a deck next to the machine room where it can be stored. From it, an endless screw or suction feeder takes it to the boiler, where the combustion takes place. When burning biomass some ash is produced, which is automatically collected in an ashtray that must be emptied about four times a year. To optimize the operation of the biomass boiler, we can install an accumulator, which will store the heat in a similar way to a solar energy system.

6.1.1 Strengths

We are talking about a system that offers many advantages, when working with an inexhaustible source of energy, such as biomass. It also produces very low levels of environmental pollution and helps to reduce dependence on fossil fuels, which are much more polluting, so it is a part of the philosophy of the foundation. The use of these types of boilers will benefit the vegetable matter left over from cleaning the village and the surrounding plots, which will reduce the risk of fire. On the other hand it is a good system to reuse industrial waste. This system uses a high technology, so the devices are perfectly designed and offer the maximum guarantees, like other energies. In addition, plantations of certain species (energy crops) that can be used as biomass in the ecovillage fields can be carried out, which will increase job creation and prevent soil erosion and degradation. It has a much lower cost than conventional energy: it is up to four times cheaper.

6.1.2 Weaknesses

The disadvantages that we can find when installing a boiler system of biomass is that the boiler offers lower yields than of those offered by fossil fuels. The combustible material has a lower energy density which will increase the need for provisioning and the size of the storage spaces. Installation costs are higher. This is relative because the fuel costs are much lower in relation to gas or diesel, the operation is amortized in a short time and will start to be profitable, and reduce costs. Finally we must say that the different types of biomass fuels are at different degrees of humidity so there are times when they require drying treatments. Fuel delivery and ash removal systems are more complex and require higher operating and maintenance costs.

6.2 Radiating floor

This system consists of pipes throughout the surface of the dwelling under the floor that can be parquet, marble, carpet or other materials. These pipes carry hot water, transmitting heat to the environment of the house from the bottom up, it is a very effective system in Hungary, as the houses in this area are characterized with very high ceilings and that makes difficult their fast acclimation.

The maintenance of radiant floor and one of the essential tasks for the maintenance of the radiant floor in our home is the cleaning and recycling of the water that is inside the system. The maintenance work can be:

- Corrective maintenance: when correcting defects, and fixing or changing any of the elements of the system.

- Preventive maintenance of radiant floor: periodic inspections to check the conditions of the system.

We must extract the accumulated substances from the pipes if we do not want them to be sealed, the water cannot flow and it diminishes the heat transmission and the performance of the installation, or it can produce damages in other elements of the installation. Therefore, preventive maintenance is very important, since if the installation is well-maintained we can spend many years without breakdowns and prolong the life of the components.

6.2.1 Strengths

This type of issuer has advantages, which are as follows;

- The installation of underfloor heating can save from 10% to 20% compared to other conventional heating systems. This is because the water flow temperature is very low (30-45°) compared to traditional systems (80-85 °).

- We achieve greater comfort since the temperature of the air near the ground will be slightly higher than the temperature of the air at the height of the head. And the heat is evenly spread throughout the house.

- It is a healthier system since air currents do not reduce dust, it does not produce dryness as others do, and the low humidity can prevent the appearance of mites

- This system also allows to use the same installation to cool the floor in summer.

- This system can work continuously many hours so it is very useful for houses or buildings with a busy schedule.

- Another advantage is that it does not occupy space like radiators, and is more aesthetic as it does not affect the decoration of the house.

6.2.2 Weaknesses

This type of technology also has a number of drawbacks that will have to pay close attention;

- The installation requires a high initial investment since the price of the floor radiant is greater than that of other systems, but the investment is profitable in the short term.

- Among the disadvantages of radiant floor we find the difficulty of installation, so it is usually used in cases of new work or in an integral rehabilitation, this inconvenience is not present in our case, since it is new construction.

- The time to heat the house when using lower temperatures of water is longer, than with a traditional system.

7. Biomass

The use of biomass is linked to the existence of the human being on Earth, about 500,000 years ago fire was the first great invention of mankind, which primitive man used for warming during the Paleolithic winters, in our era of the Homo sapiens was able to formally dominate the nuclear energy, the main source of energy was biomass.

The firewood was from the domestication of fire until the middle of the nineteenth century the main source of energy, its substitution by coal produced at the end of the XIIX the decisive industrial revolution in the field of technology. The carbon is replaced by oil, which is also formed by fossilized organic waste, but in one case as in the other, because the resources are of a limited nature, the possibilities of exploitation are closer to their end, This together with the risks of nuclear energy, not only for man and nations, but for the ecological balance of the planet, too, obliges to put the eye on the use of new technologies that allow a better use of the first energy used by man, biomass.

7.1 Definition

The energy of biomass, the only vital energy of the planet Earth, has its origin in photosynthesis. Through this process, plants transform energy from the sun into chemical energy by storing it in their cells as carbohydrates.

The energy stored by the plants is transmitted to the herbivorous animals and these to the consumers of second degree or carnivorous (where the human beings are) and is maintained, although modifies, in the residues that these produce. Organic matter from plants and animals that feed on them and can be converted into useful energy is what is known as biomass.

This energy stored by plants can be released by subjecting it to different processes of energy utilization.

7.2 Biomass situation analysis

7.2.1 Global Context

The development and operation of existing production and consumption systems require large amounts of energy to sustain themselves. That is why poor countries have nowadays a low energy consumption, while the energy consumption of rich countries is several times higher than before, even though their processes are much more efficient and there are important awareness campaigns for energy saving.

This means that the development of a country implies a considerable increase in its energy consumption. This situation can be verified in the measure that the increase of the energy consumption of the developing countries is analyzed. The International Energy Agency has developed various biomass projects through its IEA Bioenergy division. This agency estimates that 10% of the world's primary energy comes from resources associated with this source, including those related to liquid biofuels and biogas.

A large part of this percentage corresponds to the poor and developing countries, where it is the most used raw material for energy production, just in those countries where a greater increase in energy demand is expected. According to the data of the United Nations Food and Agriculture Organization (FAO), "some poor countries get 90 percent of their energy from fuelwood and other biofuels."

In Africa, Asia and Latin America it accounts for a third of energy consumption and for 2 billion people is the main source of energy in the domestic sphere. But in many cases, this massive use is not achieved through a rational and sustainable use of resources, but rather as a desperate search for energy that causes deforestation of large areas, leaving the soil defenseless against erosion.

The FAO itself recognizes that " improving the efficient use of biomass energy resources - including agricultural wastes and planting of energy materials - offers employment opportunities, environmental benefits and better rural infrastructures". It goes even further by considering that the efficient use of these energy sources would help to achieve two of the millennium development goals: "eradicate poverty and hunger and ensure environmental sustainability."

Returning to the beginning, biomass could be the energy vector that would allow the development of poor countries, avoiding that the increase of the energy consumption associated to this development would endanger the environment and the security of energy supply of our society.

7.2.2 Context Europe

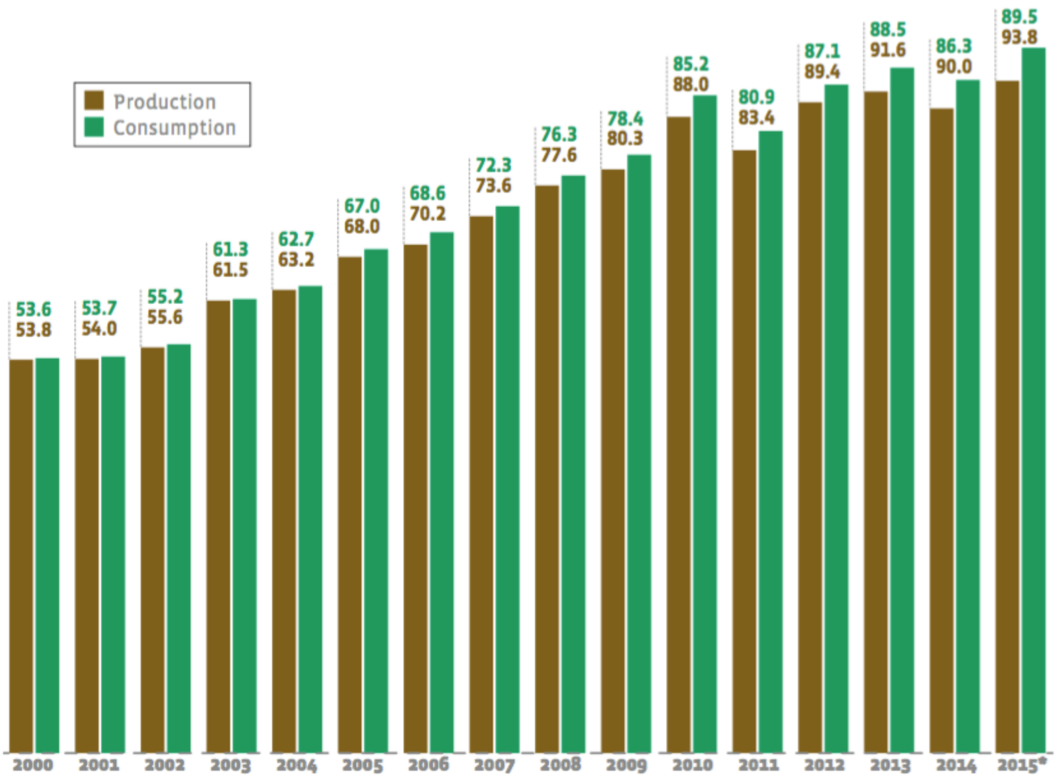
The situation of solid biomass at European level, mainly wood energy, which is still largely governed by heating requirements, and these requirements are climate-dependent. During 2015 according to EurObserv'er, there was a rebound in solid biomass consumption as a consequence that the winter of this same year was not as smooth across the continent as the previous one. Leaving aside climatic variations, the use of solid biomass to produce heat or electricity has tended to increase in the European Union. The highest consumption quota of 93.8 Mtoe was recorded in 2015, an increase of 3.8 Mtoe compared to 2014, due to the impetus of the European support policies and the increase of the awareness of the population by this type of energy.

In the European Union of the 28, solid biomass is by far the main renewable energy source, and in the rest of the world too, in 2014, according to Eurostat, I represent half of all renewable energy consumption, a total of 93.8 Mtoe [Table 1] 201.2 Mtoe.

	2014		2015*	
Country	Production	Consumption	Production	Consumption
Germany	11.417	11.417	12.062	12.062
France**	9.074	9.074	9.559	9.559
Sweden	8.923	8.923	9.129	9.129
Italy	6.539	8.066	6.712	8.357
Finland	8.117	8.137	7.901	7.927
Poland	6.179	6.755	6.268	6.774
United Kingdom	3.165	4.885	3.824	6.097
Spain	5.161	5.276	5.260	5.260
Austria	4.227	4.361	4.473	4.573
Romania	3.646	3.618	3.700	3.620
Czech Republic	2.842	2.763	2.954	2.874
Denmark	1.308	2.351	1.590	2.532
Portugal	2.671	2.351	2.603	2.340
Belgium	1.104	1.689	1.166	1.937
Hungary	1.403	1.390	1.414	1.457
Latvia	2.047	1.337	2.008	1.257
Lithuania	1.117	1.084	1.205	1.204
Croatia	1.375	1.093	1.470	1.200
Netherlands	1.290	1.147	1.364	1.179
Greece	0.869	0.930	0.952	1.013
Bulgaria	1.087	0.992	1.100	1.000
Estonia	1.122	0.789	1.209	0.825
Slovakia	0.759	0.752	0.734	0.734
Slovenia	0.533	0.533	0.590	0.590
Ireland	0.210	0.252	0.201	0.228
Luxembourg	0.060	0.059	0.050	0.059
Cyprus	0.009	0.012	0.010	0.012
Malta	0.001	0.001	0.001	0.001
European Union	86.254	90.036	89.511	93.800

Table 1 - Biomass production and gross inland consumption of solid biomass int he European Union in 2014 and 2015

During the first decade of the millennium, solid biomass consumption in the EU of the 28 increased steadily. But this was slowed down a few years ago, since 2010, where the growth of solid biomass consumption as primary energy has slowed, this is due to the atypical climatic conditions of these years, such as the hurricanes of 2011 and 2014, because these phenomena triggers an increase in heating needs and, subsequently, household consumption of wood. However, despite changing climatic conditions, the general trend over time is that the consumption of solid biomass increases, for either of its two uses, heat or electricity. The figure that determines this constant impact, marks the year 2015, although this year is one of the hottest years recorded before, was not as mild in the whole European Union



Graph 1 - Solid biomass primary energy production and iland consumption growth figure for the UE since 2000 (in Mtoe)

as it was in 2014 (with local exceptions like Finland) and reached 93.8 Mtoe in 2015, breaking its previous consumption record in 2013 (Graph 1).
If we refer only to solid biomass coming from only European Union soil, it also increased slightly with respect to previous years and reached 89.5 Mtoe [Table 1]. Year after year, the difference also increased between net imports, for example in recent years from 2.3 Mtoe in 2012 to 4.3 Mtoe in 2015 is likely to be attributable to higher imports of North American wood pellets, for the increase of this energy also there, mentioned in the section 4.2.1 in more details.

In Table 2 of EurObserv'er, separate the uses of the final energy, electricity and heat, coming from the solid biomass. The European Union's solid biomass electricity production is less sensitive to climate change and is governed more by the policies of a few Member States to develop biomass, either by converting old coal-fired power plants or by biomass cogeneration.

	2014			2015		
Country	Electricity only plants	CHP Plants	Total electricity	Electricity only plants	CHP Plants	Total electricity
United Kingdom	13.852	0.000	13.852	19.418	0.000	19.418
Germany	5.300	6.500	11.800	4.800	6.200	11.000
Finland	1.073	9.894	10.967	1.217	9.372	10.588
Poland	0.000	9.161	9.161	0.000	9.027	9.027
Sweden	0.000	9.007	9.007	0.000	8.977	8.977
Spain	2.856	0.965	3.821	3.126	0.888	4.014
Italy	2.011	1.739	3.750	2.077	1.786	3.862
Belgium	1.388	1.244	2.632	2.298	1.256	3.554
Austria	1.109	2.332	3.440	1.232	2.264	3.497
Denmark	0.000	2.959	2.959	0.000	2.803	2.803
Portugal	0.765	1.765	2.530	0.795	1.723	2.518
France**	0.095	1.543	1.637	0.098	2.042	2.140
Czech Republic	0.054	1.938	1.992	0.049	2.042	2.091
Netherlands	1.436	0.662	2.099	1.724	0.173	1.897
Hungary	1.537	0.165	1.702	1.540	0.173	1.713
Slovakia	0.011	0.905	0.916	0.011	0.842	0.853
Estonia	0.061	0.670	0.731	0.069	0.641	0.710
Romania	0.237	0.217	0.454	0.237	0.217	0.454
Latvia	0.002	0.317	0.319	0.000	0.378	0.378
Lithuania	0.000	0.293	0.293	0.000	0.318	0.318
Ireland	0.251	0.014	0.265	0.184	0.013	0.197
Bulgaria	0.010	0.128	0.138	0.010	0.128	0.138
Slovenia	0.000	0.125	0.125	0.000	0.131	0.131
Croatia	0.000	0.050	0.050	0.000	0.050	0.050
Luxembourg	0.000	0.021	0.021	0.000	0.024	0.024
Greece	0.000	0.000	0.000	0.002	0.000	0.002
European Union	32.047	52.612	84.659	38.886	51.467	90.353

Table 2 -Gross electricity production from solid biomass in the European Union in 2014 and 2015 (in TWh)

Summing up at EU level, biomass electricity production increased by 6.7% (5.7 TWh) in 2014 to 90.4 TWh in 2015. However, it can be misleading because in the last three years the United Kingdom has been the main driving force behind the increase of the solid biomass of the European Union in the use of electricity. Its production increased by 5.6 TWh between 2014 and 2015 and by 9.6 TWh between 2013 and 2015. Growth in other countries has been more uneven with increases in 2015, for example the most prominent, in Belgium (0.9 TWh between 2014 and 2015) in Germany (0.8 TWh) Finland (0.4 TWh), France (0.5 TWh), Denmark (0.2 TWh).

7.2.3 Situation Hungary

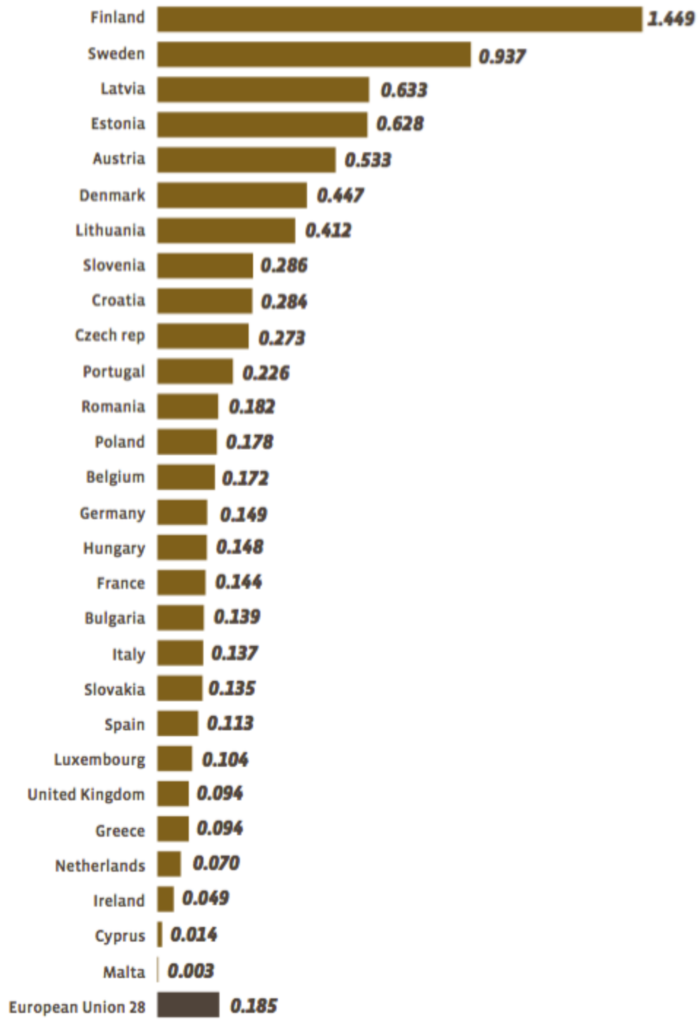
Renewable energy sources used mainly in Hungary for the production of electricity and heat, as well as their use as fuel, in data of 2014 two thirds of the use of this energy is for heating and cooling, 17% electricity and another 17% of the energy used in the transport sector. On the basis of national endowments, solar energy and the use of geothermal energy will continue to play a prominent role. Geothermal energy especially since this country has a perfect geography and geology to be able to extract the heat easily from the earth's surface.

In 2014 the share of renewable energy in Hungary in gross final consumption of energy increased by 9.51 per cent, according to the Eurostat database, far exceeding the original target of 8 per cent target for the year. Statistics show that the country figures in the 2010 calendar outdated, which is on track to reach the Europe 2020 targets.

According to the national energy strategy associated with the European Union's National Action Plan for Renewable Energy in 2020, the target is to reach this year a rate of 14.65% of the gross final consumption should be of renewable energy. The obstacles to be saved to reach this goal is the development of the national economy and the thinking of the local community.

If we speak more specifically of biomass, its production stabilized between 2014 and 2015, since its production only increased very slightly, 0.1TWh [Table 2] is generated mainly by the traditional agricultural production sectors of agriculture and forestry, by-products and forest residues, and the production of crops for energy purposes (energy crops). The use of these resources in this country has realistic opportunities.

Throughout the country, the primary energy managed volume is 1,414 Mtoe and gross domestic consumption of solid biomass around 1,457 Mtoe, according to Eurobserv'er data from December 2016 [Table 2], relatively this value is not very high compared to other countries because their size is quite small, but if we calculate per capita percentage, the results show that Hungary is almost at the EU average of biomass consumption per capita [Graph 2].



Graph 2 -Gross energy consumption of solid biomass in toe per inhab in the European Union in 2015

The distribution of electricity produced in this country in 2015. According to Eurostat data are the following [Table 3]:

Nuclear energy	Lignite and coal	Hydrocarbons	Renewable sources
52,7 %	19,9 %	17,4 %	10 %

Table 3 - Distribution of electricity produced in 2015 in Hungary

Therefore, we observe that biomass is a very small source within the global compute of all the energies that are used, even so, within renewable energies, it is one of the most used in conjunction with solar.

7.3 Obtaining sources

There are different types of biomass that can be used as an energy resource. Although a multitude of classifications can be made, this study has chosen a more accepted classification, which divides the biomass into three different types: natural, residual biomass, in which it is subdivided into dry and wet residual, and energy crops.

- Natural biomass, which is the only one produced in nature without any human intervention. The problem that presents this type of biomass is the necessary management of the acquisition and transport of the resource to the place of use. This can cause the exploitation of this biomass economically and ecologically unfeasible.

- Biomasa residual, within this group is the biomass;

Agricultural; In this first group are all products from the remains of the inhabitants' own crops, and pruning rests. Agricultural surpluses not used for human consumption can be used, for example, for the production of liquid biofuels.

Cattle remains; Manure, offal or waste from agricultural and agri-food activities.

Urban; Biodegradable fractions of urban waste can be used inter alia to make liquid biofuels.

Forest; This group is considered to all the products and remains that come from work of maintenance and improvement of the fields.

- Biomass produced; Energy crops are fields of cultivation with the sole purpose of producing biomass that can be converted into fuel for energy use. Energy farms can supply a large percentage of the world's energy requirements while at the same time revitalizing rural economies, providing energy independently and safely and achieving significant environmental benefits. Nevertheless, its development in Spain is very slow comparing it with countries like Sweden, Finland, Austria. Large tracts of land are needed to achieve cost-effective energy production

7.4 Biomass Advantages

The use of biomass as renewable energy versus non-renewable energy, such as fossil fuels, has the following advantages:

-It does not contribute to the greenhouse effect.

-Reduce sulfur emissions.

-Reduce the emissions of particles.

-Reduces CO, HC and NOx emissions

-Cycle neutral CO_2.

-Possibility of using fallow land with energy crops.

-Providing agricultural waste, avoiding its burning in the field.

-Reduces energy dependence with non-renewable fossil energies.

-Reduction of the hazards associated with fuels derived from petroleum.

-Reducing risks from forest fires and insect pests

-Socioeconomic growth in rural areas

With these advantages, biomass in the future will be a source of potential energy, being an element of great importance in rural areas, as nowadays in Hungary.

7.5 Energy use

The heat that of the solid biomass differs in turn by the direct use to which it arrives, three main uses are evidenced;

- Thermal, stands out for being the most efficient and is subclassified in two according to its purpose of use;

Industrial, if the heat produced goes to industrial processes

Domestic, heat and water in stoves and boilers for domestic use

- Electric, from a boiler we generate steam at high pressure that spins a turbine and this an alternator to produce electricity, this purpose is the one that most contribute to rural development.

-Co-Combustion, replacing part of a fossil fuel such as carbon by biomass to reduce pollutant emissions.

7.6 Parameters to value biomass quality

The main technical parameters to determine the quality of the biomass are;

- Humidity, i.e. the amount of water in biofuel, has a decisive impact on the available energy of each biofuel. Usually, two methods are used referring to the dry product and referred to the wet product to establish the moisture content, according to the procedure used to account for the mass of water. It is important to distinguish them, especially when the moisture content is high. This will determine the calorific power and performance.

- Granulometry, it is the distribution of the particle sizes of the biomass, and this will be linked to the technology of exploitation, the lower particle size greater energy consumption. Not all the boilers accept a certain granulometry and to arrive at a determined granulometry it is necessary to treat the biomass by means of machinery (crushing and mill) but this increases the price considerably.

- Ashes, especially at the domestic level as it is in the ecovillage are an important parameter, are directly linked to the nature of the type of biomass being used and related to the management (or mismanagement)

- Density, is the amount of dry biomass present per unit volume of wet material and will determine transport costs and their efficiency.

8. Sources of biomass available

The inhabitants of the ecovillage completely extract their own biomass, that is, they produce all the biomass that they consume, they do not need from external suppliers to obtain all the thermal demand that they generate. This biomass that the inhabitants use comes from different sources;

- Residual biomass, within this group there are the biomass;

Agricultural; Within this first group are all the products that come from the remains of the inhabitants' own crops, and pruning rests. In this case, a small portion of grass cut in the non-built area is collected for use as an insulation material in the construction of buildings (explained in more detail in section Annex 1) and another for production of thermal energy.

Another portion of biomass within this group are the pruning and maintenance remains that are carried out in the large extensions of field that the foundation has in property. This work is usually done in autumn or late winter every two years and the use of this type of biomass is satisfactory since the calorific value of these remains is medium-high.

Cattle waste; Manure, offal or waste from agricultural and agri-food activities. The usable remains come from the cattle farm in Galgafarm, located 1,5 km far away from the village, but the biogas produced by these manures goes to the production of electricity.

Another small portion of this type of waste comes from the domesticated animals in the ecovillage but in a very small quantity and most of this waste is reused for composting and its subsequent use for the subscriber of the orchards for the production of vegetables in the greenhouse (detailed in Annex 1)

Urban; Biodegradable fractions of waste from individual houses. Although this source would be negligible due to its small quantity and the end use is different from the one of the thermal energy production.

Wood waste; The structure of the houses is made of wood as well as other types of constructions within the plot of the foundation, so it generates a large amount of wood waste, which can be used for the production of thermal energy. This wood is of good quality and has a high calorific value.

To feed the boiler, the types of biomass explained above will be used, but most of the biomass used to ensure a correct operation throughout the year will be from energy crops. The implementation of these crops will be detailed in the following point number 9.

9. Process of obtaining the biomass

9.1 Pruning

Taking into account the part of the biomass that is used in the ecovillage comes from the remains of maintenance as pruning of ornamental plants distributed throughout the perimeter of the built area.

These maintenance processes contribute a type of vegetal material with little calorific power, although it is used both for the generation of thermal energy and insulating material in the new buildings.

The pruning of more interest for the objective of the project, is the pruning that is realized in the spring and at the end of the summer, where the maintenance tasks are bigger.

There is another amount of plant material, this group is considered to all products and remains that come from maintenance work and improvement of the fields surrounding the village. As it is in an enclave with little forest mass, the percentage of this group is not very relevant.

But the biggest amount of biomass comes from energy crops, and pruning is very important. Cutting or harvesting operations must be carried out in a mechanized manner, since a manual cut is economically unfeasible.

The cuttings are done after reaching maturity, which will be a function of the initial density of planting and plant material used. They are carried out during the period of vegetative stop, that is to say, after the fall of the leaves and before the new buds begin to sprout, they must be carried out in a moment in which the ground is able to support the passage of the machinery without excessive compaction of the field.

It is important to ensure the future viability of the stump, making the cut to a height that in no case should exceed 10 cm above the ground, and even recommended lower cutting heights, in order to ensure that with successive crop cycles the stump does not hamper successive cutting tasks [Figure 15].

Figure 15 - Photograph of a correct cut of *Populus*

The number of cutting cycles that are able to support the plantation is strongly influenced by the site characteristics, plant materials and applied management, without the definition of fixed rules. However, it is generally considered that the number of crop cycles can range from two to six.

Once the number of optimal production cycles of the vines has been exhausted, the plot must be cleaned, destroying the root systems as well as the stumps using the available machinery.

9.2 Harvest

Harvesting is the most technically complex operation to perform in this type of crop.

The cut is made in winter, usually between November and February, after the leaves fall. In this operation it is very important to take into account the practicability of the land due to its texture and moisture content, factors that combined, can hinder and even prevent the harvesting operation. If the machine is very heavy, it can compact the land and affect its structure.

In addition, the collection methods to be used also depend on parameters such as the area of harvesting, development and design of the plantation and other indirectly influences such as access to crop plots, availability of biomass storage area, etc.

The wide variety of local circumstances and the very limited experience so far in this operation means that there is no general criterion on how to make the usage. However, two main systems can be distinguished: cutting and splintering in the same operation, or, only short, producing rods in the form of loose beams or rods.

The choice for ecovillage will be only short, since the type of boiler to be used supports this type of wood, in addition as the majority of this wood is to be stored this technique is more interesting due to better conservation of the biomass in these conditions.

9.3 Transportation

The transport of biomass to the plants of conditioning and recovery is a key factor, directly influences the viability of a project of efficient energy use of this type of fuel.

Cultivation plots should not be used for biomass storage in the field, because of the danger of damaging the wheels of the vehicles during these activities, as well as causing damages to the stumps of the plants with the consequent decrease of production in successive years.

So the solution chosen in the ecovillage, is to carry out the plantations near the place of provision, this is possible since the fields owned by the foundation surround the village, to have a more comfortable, simple and more economic transportation.

9.4 Process in the plant

The only process to be carried out to the biomass is the transport explained in the previous point, and the storage and its natural drying, which will be explained in more details in point 9.6.

9.5 Biomass Storage

One of the main advantages of the biomass is its storage, since it can adapt its shape to the different possible storages, its durability is high and the maintenance of the storage is almost nothing. On the contrary, it has a great disadvantage that its storage needs a large space but this is not a big problem for the ecovillage, since as previously stated, the Foundation has large plots and a common building already built that serve to protect the wood stored.

The energy crops present seasonal production patterns, i.e. the harvest dates are for a fixed period, while the consumption of a thermal plant is carried out throughout the year (constant demand), due to this main reason will be necessary to store the production. Storage is relevant, especially when it is for a long period of time, as it will affect costs, quality (calorific value, moisture, molds, ash) or loss of dry matter among others.

The advantage that the ecovillage has, is important, since having a roof already built, and it reduces the investment. The storage of the biomass of the logs from the energetic crops will be carried out here.

9.6 Biomass drying

Usually, the biomass presents a high degree of humidity, except in the case of some biomass of industrial origin that have been previously dried in its processing (wood residues, dried husks, etc.). The drier the fuel, the lower the energy. It is required to evaporate the remaining water and, therefore, the greater energy will be available to generate heat.

The amount of moisture contained in a biomass is a very important factor in the combustion efficiency, since the equipment is designed to operate optimally with a fuel that moves in a strip of humidity. When these levels are exceeded, both above and below the design values, there are usually problems of operation and emissions.

The size of the biomass particles is defined by the type of combustion technology used. In addition, it has an important effect on the absorption of moisture, as it increases as its size decreases. The microbial action on the biomass increases when the particles decrease, increasing the possibility of producing undesirable effects on the fuel as is the autocombustion by the anaerobic fermentation.

Therefore, it is advisable, in the case of long-term storage, not to dispose the biomass in excessively small sizes, reserving the reduction of the biomass prior to its use as fuel. Much of the waste biomass is not directly usable for certain uses for energy purposes, if its moisture content is not previously reduced.

However, the costs of drying use a conventional fuel may in some cases be prohibitive, so that wherever possible moisture reduction methods should be used at the lowest possible cost.

FAO defines the natural drying of biomass as a simple technique based on the use of favorable environmental conditions to facilitate the dehydration of the residues and to obtain humidity levels that allow an economic management and that facilitate the following transformation phases to be carried out, or to obtain acceptable yields in the energy conversion processes to which the waste is destined.

Processes as simple as the turning of the biomass can achieve great reductions of humidity of economic form. In any case, natural drying is a dynamic process, so it must be controlled at all times to obtain a final product suitable for energy recovery. To carry out an adequate storage the following points must be followed;

- Avoid as far as possible the deterioration of quality, as is the increase of Humidity and contamination with dust or dirt.
- It will keep the place as dry as possible, with protections of the possible rains or snowfall
- Ground free of obstacles. Floor in plant and terminal covered with bituminous surface. Non-clay soil and level ground.
- The store must be higher than the rainwater circulation ways.
- To prevent a pile of bales from absorbing soil moisture, place a dry base underneath (pallets, old bales, old trunks). To avoid being moistened by the top cover the pile with a protector (agricultural film, old bales, marquee).

- Storage to minimize self-heating:
  - oAvoid growth of microbes (Humidity < 20%).
  - o Avoid mixtures of different qualities if they are later to be stored.
  - o Preferred small piles and short time.
  - o Avoid compacting material.
  - o Stacks of elongated clusters with wide base, double height

10. Impact of the project for the rural development

Nowadays there is no discussion about the role that biomass can play as a renewable source of energy, capable not only of contributing to achieve energy efficiency targets or reducing emissions of polluting gases into the atmosphere, but also of generating a series of added benefits, such as job creation in rural areas, aid to the conservation of forests, reducing the risk of fire, among many other things.

The technological improvement and the guarantee of supply, from the point of view of the consumer, have been two key elements in the maturing of a still incipient market in many regions, not only of Hungary, but throughout Europe.

The implementation of energy biomass markets generates a series of economic, social and environmental benefits that have been described in numerous publications and are collected by government strategies and plans.

To explain in more details, this series of benefits have been classified into two groups, benefits for the environment and another group referred to social and rural benefits.

10.1 Environmental impact

As detailed in point 7.2, biomass is the most widely used renewable resource in the world and one of the renewable energy sources with the greatest potential for growth over the coming decades. This growth is only due to its countless positive environmental points.

The present project studies the viability of installing biomass heating to homes located in rural settings disconnected from the electricity grid. Normally these types of renewable energy production systems are given a clear benefit, the reduction of the pollutant load caused by fossil fuels. Biomass energy does not contribute to climate change since its CO_2 emissions balance is neutral. This zero balance means that burning the biomass to obtain energy releases CO_2 into the atmosphere, but during the growth of organic plant matter CO_2 is absorbed. In this way the cycle closes and the level of CO_2 emission in the atmosphere remains constant, but in the case of biomass there are other environmental benefits, such as the following:

For example an important aspect that grants the use of biomass as an energy source is to provide the appropriate waste treatment, which in some cases are contaminating pollutants. These are municipal waste, waste water and slurry, which are dangerous to the environmental health as they can reach groundwater underground.

Another aspect to consider is that it generates lower emissions than conventional fuel boilers, reduced sulfur and particulate emissions and reduced emissions of pollutants such as CO, HC and NOX.

On the other hand, depending on the origin of this biomass, it can also provide other environmental benefits, such as when GAIA ecovillage manages waste from pruning and cleaning of the surrounding tree areas, thus limiting the spread of fires. Thanks to this use of the residues of these techniques of maintenance a healthy and clean landscape is observed, that not only provides better aeration for the plants and its better development maintaining the controlled population of pests, but also helps to maintain an ecological balance. Biodiversity is also enhanced by the use of these cleaning tasks.

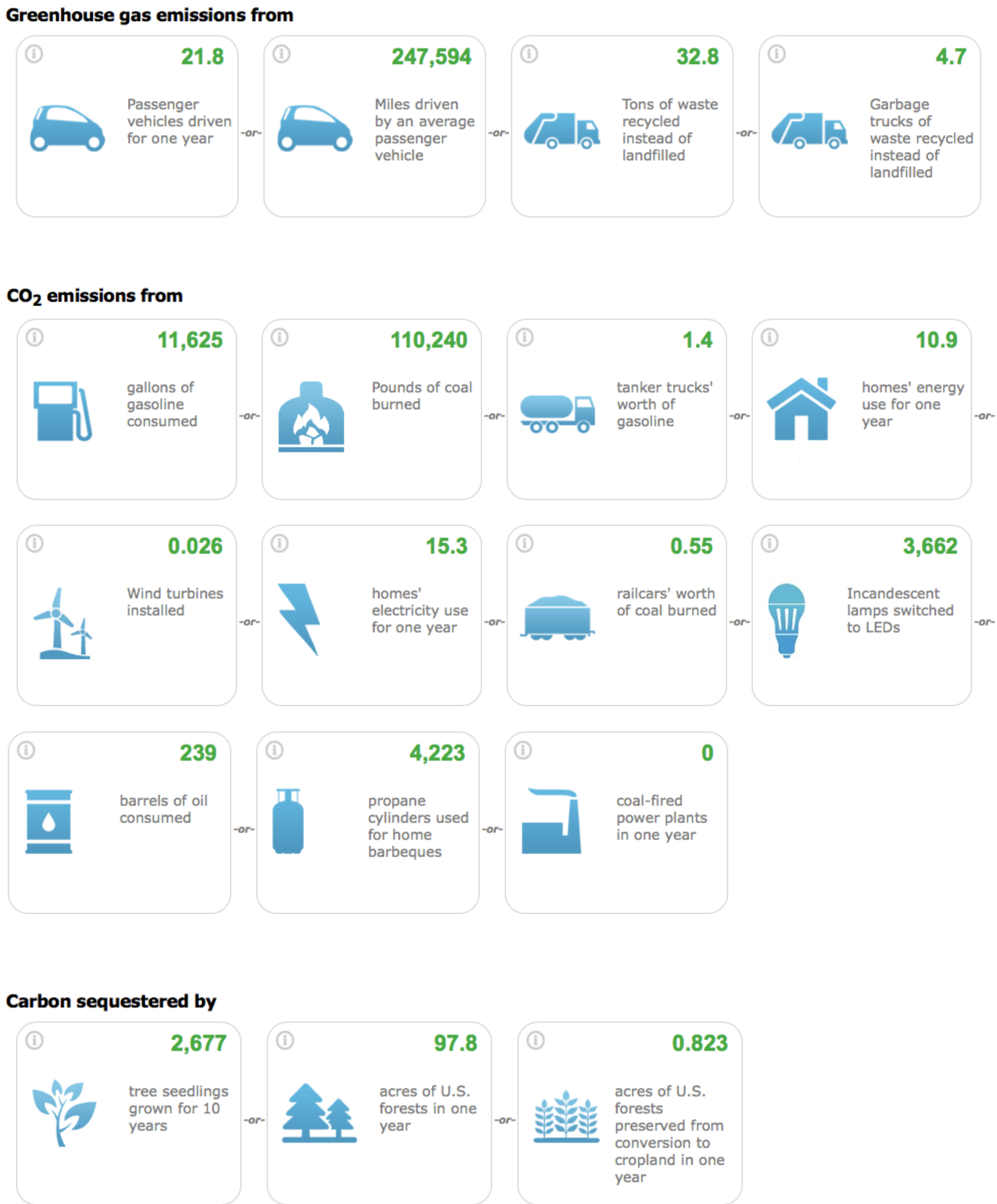
The use of residual forest as fuel for biomass boilers is one of the solutions to facilitate the improvement of forests. In the latter case, stubble and agricultural pruning could be included, whose traditional burning in the field entails, as has been said before, an added risk of fires. This biomass can find a new market in the production of energy even for the foundation itself, since the 300 ha that they have in property may be a favor in order to obtain a large amount of biomass to later obtain economic benefits.

Lastly, it should also be noted that the introduction of energy crops also has environmental benefits, for example the use of abandoned land prevents soil erosion and degradation, which can be a serious problem in certain rural areas of Northern Hungary by the terrain orography, explained in more details in section 7.2.3 of the part of the work memory.

10.1.1 Emissions of CO_2 not emitted

The use of the biomass in this project supposes a saving of the increase of the emissions of CO_2 to the atmosphere, since the amount of CO_2 emitted comes from the fixation of this of the air by the energy crops, reason why the cycle of CO_2 is neutral , a very important aspect not to increase the greenhouse effect.

In order to estimate the CO_2 not increased in the atmosphere, the EPA (United States Environmental Protection Agency) website has been used, with a large database of information and numerous mathematical formulas available on the same website, there is a very simple calculator where you can put the energy you use and automatically translate it to the amount of CO_2 emitted.



In order to realise this estimate of CO_2 not increased in the atmosphere, we have chosen an average of 35 kW for 20 hours per day, for a total of 7 months, since the potency of the worst day is 55 kW and not all year the people use the heating.

The results obtained are a total of 103 tonnes of CO_2 not emitted into the atmosphere.

The website of the EPA also present numerous equivalences so that this result of 103 tons of c02 is much more understandable for people. Below are numerous of these equivalences;

10.2 Social and rural impact

The other large group of these benefits that the usage of biomass as renewable energy for heating in rural dwellings brings is the social benefits and what can contribute to these rural areas.

First of all it should be said that the work is focused on the study of the implantation of renewable energy in a village where people are already aware that this alternative is the best solution. As mentioned in point 3 of the part of the report of the work, the ecovillage belongs to GAIA foundation, which works for the expansion of its philosophy of life, this means that ecovillage is not only a place to live but receives visitors to carry out different activities, from children from schools to trips of old people to learn about how these types of villages work. This means that the use of biomass in the ecovillage not only implies the environmental benefits described above but also a component of expansion of ideas, where visitors can observe, learn and share that this type of renewable energy can serve to expand beyond of the ecovillage. So with a correct use of this energy in the homes of this place can serve as a loudspeaker to expand the use of biomass in other similar places.

In addition biomass produces a strong positive impact on the territory, with added social benefits, these are the following:

On the one hand, it is important to say that the use of biomass as renewable energy in these rural areas, with a population shortage, is a good alternative since it can set people in rural areas and becomes an economic source in those places.

The creation of jobs is a very important aspect to take into account since only in the work of collection, treatment and distribution of fuel can generate different specialized jobs, as in the maintenance of boilers. The number of employees that could be generated would not be excessively high, but in the territory has a great impact, since these are stable jobs and that would help to fix the rural population, with associated benefits that this entails.

These jobs would generate other indirect ones, related to the own chain of distribution and consumption of biomass, plus those that derive from the generation of a more robust and vertebrate local economy.

It would open the possibility of diversifying rural economies, allowing different ways of implementation, from local consumption to international exports, as Hungary is a good place to produce energy crops

11. Budget summary

11.1 General expenses

In this part, and starting from the result of item number 2 above, 15% of the total cost will be added for possible loss or material breakages.

Total costs		Tax	**Total**
EUR	81.368,50	15 %	**93.573,78**
HUF	25.419.519,77	15 %	**29.232.447,74**

11.2 Industrial benefit

In this section 6% is added to the total budget for the industrial benefit;

Total costs		Tax	**Total**
EUR	93.573,78	6 %	**99.188,20**
HUF	29.232.447,74	6 %	**30.986.394,61**

11.3 Designer

This section represents the percentage that the designer charges for the realization of the design of the entire installation, which in this case will be 4% of the total cost of the installation;

Total costs		Tax	**Total**
EUR	99.188,20	4 %	**103.155,73**
HUF	30.986.394,61	4 %	**32.225.850,39**

11.4 Government tax

The tax rate of the Hungarian government is 27%, so with the budget will be increased as follows;

Total costs		Tax	**Total**
EUR	103.155,73	27 %	**131.007,78**
HUF	32.225.850,39	27 %	**40.926.830,00**

12. Payback, IRR and NPV

In this section we will study the economic viability of the project compared to the use of a fossil fuel burner to produce hot water from the underfloor heating.

In the case of this project, as mentioned in the previous section, the initial investment that needs to be made is 131.007,78 € (= 40.926.830 Ft).

To make the comparison, it is necessary to analyze the savings in the cost of gasoil C that is stopped consuming with the installation of the boiler of biomass. The biomass used will come from the planting of energy crops, so the price of this will be determined by the cost of maintenance of the plantation and the cost of the machinery for its collection and processing. Although from the first year there is no wood for the combustion, so in the first year a quantity of wood for supply of three years will have to be bought, with an approximate cost of 3.500 €.

As calculating the increase of the electric energy consumption of the two pumps installed, as calculated in the Annex 3, the total power on the day of maximum demand is 11,6 kWh, so for a year they will be consumed 4.248,6 kW / year. Assuming a cost of 0,085 € / kWh gives a result of 361,13 € / year with an increase of 2% per year.

The saving of the consumption of diesel C (PCI = 8.700Kcal / liter) will be calculated from the opp. Data of the VpClima which details a consumption of 53,85KW, and if we estimate a daily use of heating of 12 hours daily, therefore there is a total consumption of 22.316 l / year of diesel C, with a price of 0,68 € / litre and applying an annual increase of 2%.

The maintenance of the installation is estimated at 450 € / year, and an increase of 3% per year will be considered at this cost.

Year	Electric consumption	maintenance	Energy crops	fuel savings	Cash-flow	Payback
0			-3.500,00			-131.007,78
1	361,13	350,00	0,00	15.174,88	14.463,75	-116.544,03
2	368,35	360,50	0,00	15.478,38	14.749,53	-101.794,50
3	375,72	371,32	836,00	15.787,95	14.204,91	-87.589,59
4	383,23	382,45	0,00	16.103,70	15.338,02	-72.251,58
5	390,90	393,93	0,00	16.425,78	15.640,95	-56.610,63
6	398,72	405,75	0,00	16.754,29	15.949,83	-40.660,80
7	406,69	417,92	836,00	17.089,38	15.428,77	-25.232,02
8	414,82	430,46	0,00	17.431,17	16.585,89	-8.646,14
9	423,12	443,37	836,00	17.779,79	16.077,30	7.431,16
10	431,58	456,67	0,00	18.135,39	17.247,13	24.678,29

As shown in the table above the return period of the investment will be in the 6th year, which means that it is not necessary to ensure a very long life for the boiler.

In this study, net present value is calculated of a 10-year-period with an interest rate of 1,8%, and a value of internal rate of return is;

NPV = 9.935,04€

And a value of net present value is;

IRR = 6,4%

The value obtained is much higher than the normal interest of the money, therefore this installation will be economically profitable.

The return period is the 8,41 years.

13. Conclusions

In the first part of the study the concept of biomass was analyzed in depth, including a compilation of data on the types that exist, the forms of conversion in energy, their characteristics, and a study has also been carried out to obtain the possibilities and the biomass situation within the ecovillage, giving alternatives to possible problems.

Obtaining the conclusion that the use of biomass has a very basic but fundamental advantage, to convert a waste into a resource, i.e. with a correct treatment of biomass involves an increase of recycling and a decrease of waste, with hat this project would perfectly fit within the philosophy of the foundation GAIA.

This project is returning to the beginnings of human existence, to use all the possible resources that nature will provide us for the construction of houses that provide all the needs that today are demanded.

This project can serve to teach and publicize this type of construction, since the eco-village is a tourist place, and increases the demand of the biomass boilers in the nearby populations and look for synergies to obtain biomass, with possible ways of development and new business.

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Annex I ;

External climatic conditions of calculation

Index

1. Introduction

This section of the paper will describe the process according to the size of the facilities of the building of GAIA Ecovillage.

As for the air conditioning of the different houses of the building, the computer program DPCLIMA of the Polytechnic University of Valencia was used, which allows to estimate the thermal loads of the different rooms. This computer program requires the introduction of indoor conditions, exteriors, composition of building enclosures, among others and with these data gives the total thermal loads. It was the basis for choosing the power of indoor and outdoor units needed in each location.

The first step to calculate the thermal loads and energy required of the eco-village, we must know the climatic conditions to which it is subjected. The choice of the external conditions of dry temperature, and, where appropriate, the simultaneous humid temperature of the place, which are necessary for the calculation of the maximum instantaneous thermal demand, i.e. for the dimensioning of necessary equipment and apparatus, will be made on a basis of the criteria of percentile levels, which may be even different for different dwellings of the same facility of the building.

For the calculation of the energy consumption of the building during a year it's necessary the data of the typical year of the location of the building (dry temperature, coincident humid temperature and solar radiation).

2. Latitude, longitude and altitude

The following table shows the latitude, longitude and altitude of Galgahévíz, the village closest to the Ecovillage, which is about 3 kilometers far away.

	Latitude	Longitude	Altitude
Budapest	47,43	19,18	131
Galgahévíz	47,37	19,33	151

3. Dry temperature and humidity

For the dimensioning of energy transfer devices with the external environment, the percentiles of 0.4% in summer and 99% in winter when the weather is dry or wet, as the case may be, shall be considered.

The use of this criterion carries the risk of oversizing the installation, or a part of it, by default, for a certain number of hours per year. This risk must be evaluated according to the use of the building (reliability) and told to the user.

4. Percentile level

For the calculation of the maximum thermal loads in winter, the temperatures of the dry air to be considered will correspond to the following levels:

1. 99% level for hospitals, clinics, nursing homes, centers of calculation and any other space that the design technician considers to be necessary to have this degree of coverage.

2. Level of 97.5% for all types of buildings and spaces not mentioned above.

It is also reflected, that, as extreme summer project conditions, those based on the percentiles of temperatures of dry and wet air in the total hours of June, July, August and September (122 days → 2928 hours).

1. 1% level for hospitals, clinics, computer rooms and any other space that the design technician considers necessary to have this degree of coverage.

2. 2.5% level for buildings and spaces that are of special consideration. As a result, the percentile levels shown in the table below will be adopted:

Type of Building	Percentile level	
No maxima coverage	Summer	Winter
	1 %	-97,5 %

5. Temperatures and humidity

The outside temperatures and humidity used for the dimensioning of the installation are shown in the following table;

Land temperature (°C)	5
Max. Outside temperature (ºC)	33,5
Relative humidity (%)	30,34
Minimum outdoor temperature (ºC)	-7
Relative humidity heating (%)	85,8

6. Temperature oscillations

The maximum oscillations for both winter and summer are as follows:

	ADO	AAO
Summer	18,1	38,8
Winter	0,5	

Where,

ADO Is the Average Daily Oscillation and is expressed in degrees
AAO Is the Annual Average Oscillation and is expressed in degrees

7. Radiation data

An important fact of Hungary is that it is rather plain country, 98% of the area less than 200 m, which causes a very flat area to receive solar radiation. According to a study by Országos

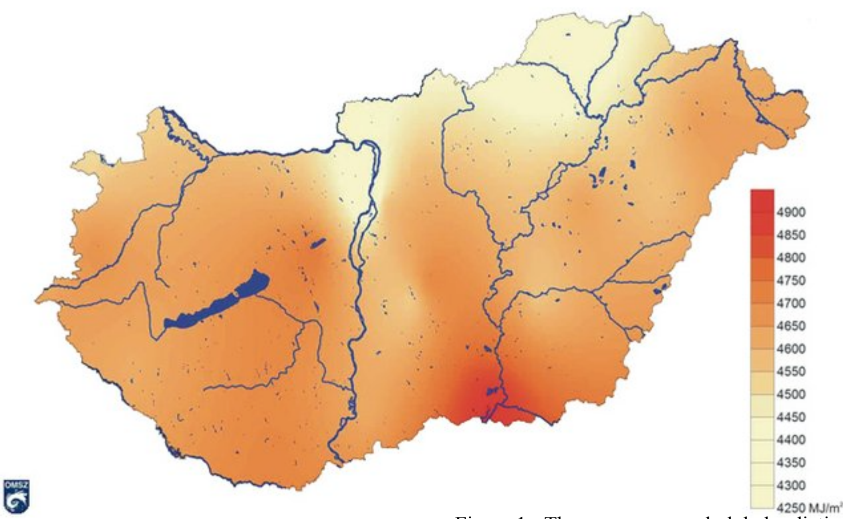

Figure 1 - The average annual global radiation (MJ/m²) in Hungary (2000–2009)

Meteorológiai Szolgálat shows different zones according to the annual average global solar radiation on a horizontal surface in Hungary. By global radiation we mean the sum of the direct radiation of the Sun and the diffuse radiation coming from the sky [Figure 1].

8. Intensity and direction of prevailing winds

In order to obtain this information the Meteoblue data base has been consulted, where data are displayed since 2003 [Figure 2], and in particular in this rose of the winds for Hungary shows the number of hours a year the wind blows and the position of the radial bars shows the direction from where the wind blows and those are the data used in the VPCLIMA program to dimension the installation.

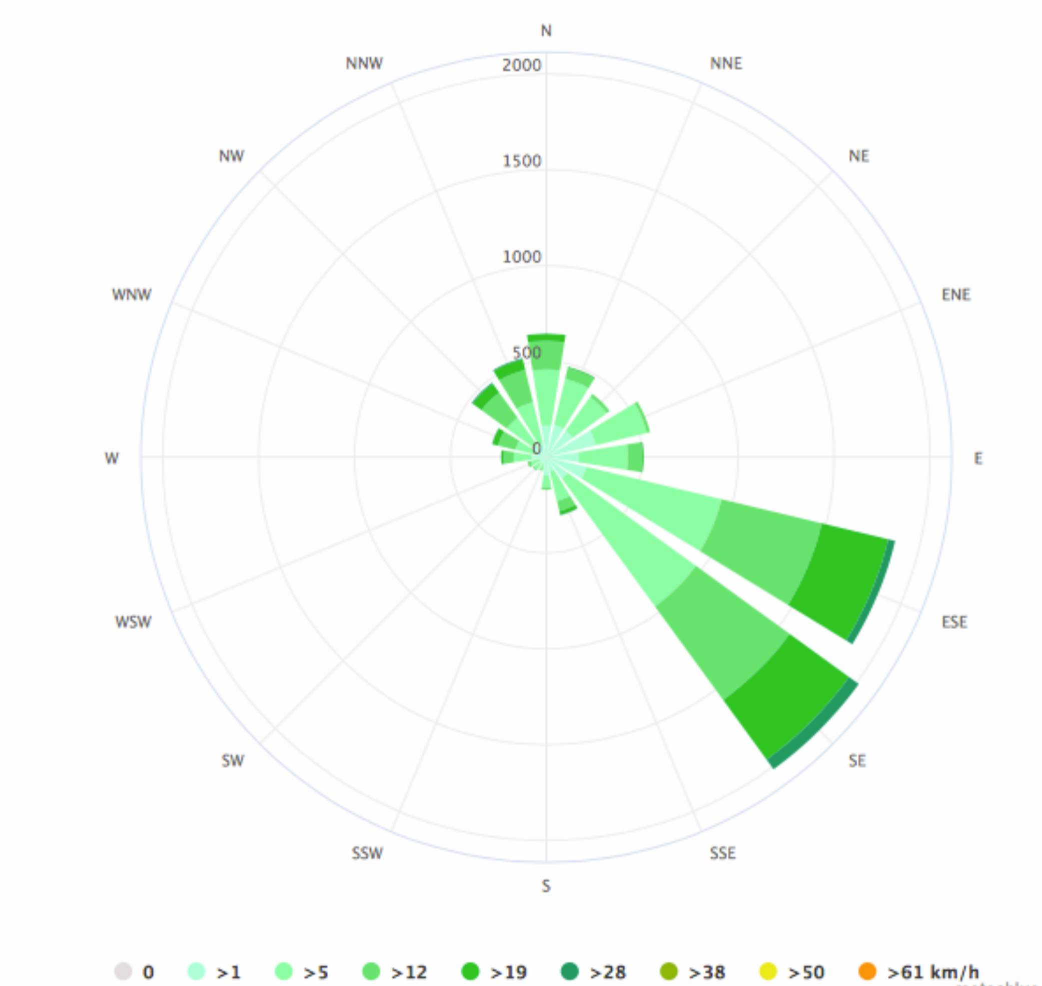

Figure 2 - Intensity and direction of prevailing winds in Hungary (2003–2013)

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Annex II ;

Thermal energy demand calculation

Index

1. Introduction

In this part of the work, all the calculations necessary to determine the demand for thermal energy in the 11 houses of the main building of the village will be detailed. To do so, first determine the interior conditions of the dwellings, then the coefficients of heat transfer of the building elements of the dwelling, this part is the most important to understand the final result of the project.

From the above data, the calculations of the thermal loads and the radiant floor will be explained step by step.

2. Internal conditions of calculation

For dimensioning the entire installation, data are also needed on the interior conditions of the dwellings, whether they are all the same or if there is any difference between them.

2.1 Temperature

The design of the thermal installations must be based on a set of premises, knowledge of internal conditions to be fulfilled, the external conditions, as well as the criteria and precepts that allow to estimate and achieve their adequate behavior with respect to the welfare functionality, security and rational use of energy. Thus, thermal well-being means those characteristics that condition the human body's thermal exchanges with the environment, depending on the person's activity and the thermal insulation of his clothing, and which affect the feeling of well-being of the occupants.

This project seeks an air temperature inside the heated homes, which will not exceed 21 C°, when it requires energy consumption for the generation of heat by the heating system. The temperature of the air in the refrigerated rooms will not be less than 26 C° and as regards the above temperature conditions will be concerned with maintaining a relative humidity between 30% and 70%.

2.2 Humidity

The above temperature conditions will be related to the maintenance of a relative humidity between 30% and 70%.

Therefore, in compliance with the above requirements, the following values of relative humidity will be taken in the project:

Season	Relative humidity (%)
Summer	50 %
Winter	40 %

2.3 Noise and vibration

The noise generated by the components of the thermal installations can affect the well-being and comfort of the occupants of the premises of the building, as well as the vibrations to the adjustment of the machines, the sealing of the ducts and the structure of the building.

In this sense, the design of the installation should take into account those techniques or systems that guarantee the attenuation of noise and vibrations to the values specified below.

To maintain vibration levels below an acceptable level, equipment and lines must be insulated from the structural elements of the building.

3. Coefficients of heat transfer of the building elements

The purpose of this section is to determine the different elements that make up the building, classify and analyze them in order to dimension the installation of the heating.

3.1 Composition of the constructive elements

In the whole building we find the following elements that condition the losses of the installation;

- Doors and windows
- Enclosure exterior walls of building
- Ground of building in contact with the land
- Wall between floors
- Interior partition

Doors and windows

This section summarizes the characteristics of the windows that are included in this project:

Materials	Thickness (m)	R = W(m² ºC)⁻¹
Crystal	0,006	
Air chamber	0,008	
Crystal	0,006	
		2,5

The transmission of the gap is 2,5 W(m^2 ºC)$^{-1}$, with a percentage of the frame of 10% and a solar factor of the grap of 0,45. In the ecovillage there are different types of windows that only differentiate between them by size, the largest have a surface of 2,1 m^2, and the smallest 0,36m^2, and are combined in different homes.

Enclosure exterior walls of building

The facade of the building is made up of three different materials, with the peculiarity that all of them are governed by the ecological philosophy without neglecting efficiency, these characteristics are summarized in the following table:

Materials	Thickness (m)	R = W(m^2 ºC)$^{-1}$
Adobe	0,56	0,246
Straw and forage rests	0,20	0,250
Wood of medium weight	0,20	0,110

The total result is U=0,71W W/m^2 ºC and a total weight of 464,10 Kg/m^2 .

Ground of building in contact with the land

This section describes the composition of the ground floor that consists of different types of wood forming a structure, which is just above the ground on which the building is built, this terrain is flat and has grass:

Materials	Thickness (m)	R = W(m^2 ºC)$^{-1}$
Very light leafy wood	0,20	0,154
Wood of medium weight	0,20	0,110
Very heavy leafy wood	0,35	0,069

The total result is U=1,98W W/m^2 ºC and a total weight of 37,6 Kg/m^2 .

Wall between floors

This section summarizes the characteristics of the interior wall that divides between the two floors and between the dwelling, the loft and in turn serves as ground of the upper floor, and influences considerably in this project:

Materials	Thickness (m)	$R = W(m^2\ ºC)^{-1}$
Wood of medium weight	0,2	0,110
Straw and forage rests	0,2	0,250
Very heavy leafy wood	0,2	0,087

The total result is U=1,62W W/m^2 ºC and a total weight of 56 Kg/m^2 .

Interior partition

The composition of this type of enclosures is as follows:

Materiales	Thickness (m)	$R = W(m^2\ ºC)^{-1}$
Adobe	0,280	0,246
Very heavy leafy wood	0,230	0,087
Straw and forage rests	0,200	0,250

The total result is U=0,92 W/m^2 ºC and a total weight of 261,2 Kg/m^2 .

4. Calculation of thermal charge

In this section, all the final loads of the village and the energy consumption of the heating, will be calculated all together, and separately for each dwelling, too. The following calculations were performed with the VpClima software, based on all the data collected in the field study and detailed in points above 2, 3 and in annex 1.

The following is a simplified summary of the calculations made in this software.

4.1 Building description

The building where to be installed the installation, as explained above, has 11 houses where will be install the heating, of which 2 of the second floor are connected with two of the first floor, so even though are considered different local, are of the same property. Of four locals they form two houses of two plants.

The building in total has these characteristics;

Building description	Results
Conditioned area	475 m^2
Volume of the air conditioning	1321 m^3
No conditioned area	0

The building is divided into 11 locals, which are not the same, have different dimensions, they are described in the following table;

Number of house	Area (m^2)	Volume (m^3)	Number of people
House 1	43,46	129,08	2
House 2	39,98	111.14	2
House 3	38,97	108,34	2
House 4	35,40	98,41	1
House 5	36,32	100,97	1
House 6	38,77	107,78	2
House 7	58,74	163,30	2
House 8	32,18	89,46	1
House 9	40,68	113,09	2
House 10	53,82	149,62	2
House 11	53,82	149,62	2

The composition of these houses is as follows;

- Residential housing, with a maximum space of 25 m^2 / peop. and with a very light work activity.

- A sensitive power of 86 W/peop.

- Types of led lights, which transmit 7 W/m^2 and other power sensitive by another type of electronic equipment of 5 W/m^2

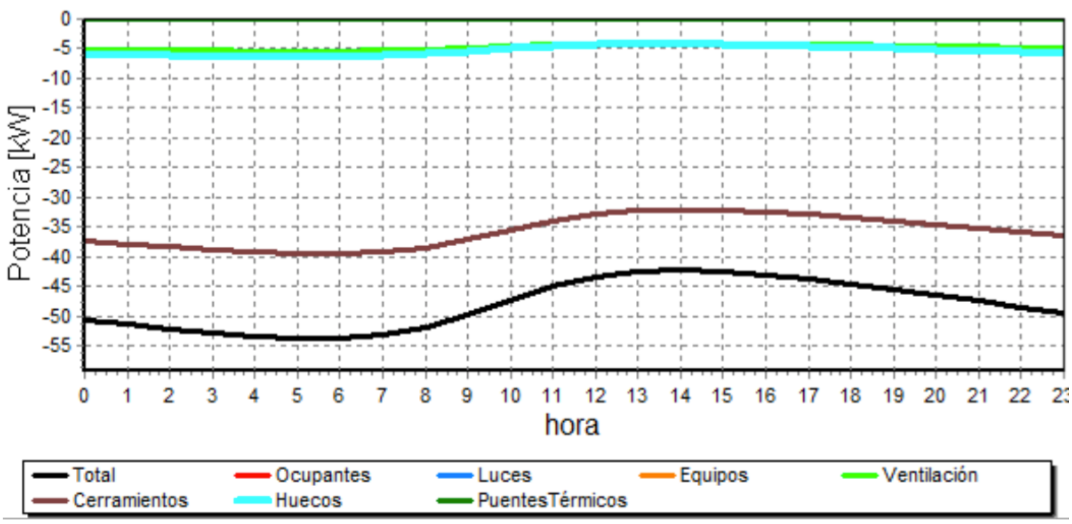
4.2 Calculation of thermal loads of the village

The software determines maximum demand for heating of a day, in the specific case of this study it is in February at 6 in the morning. This chapter will detail the results of that day.

In the following table are represented the results of the thermal loads of the sum of the 11 houses of the building.

Building	Results
Area (m^2)	475,11
Total Loads (kW)	53,85
Ratio (W/ m^2)	113,33
Ventilation (kW)	5,40
Enclosure walls(kW)	39,49
Spaces (kW)	6,40
Enlargement factor (kW)	2,56

The following graph shows the same previous results but shows the variation of demand during the different hours of that day of peak demand in February:

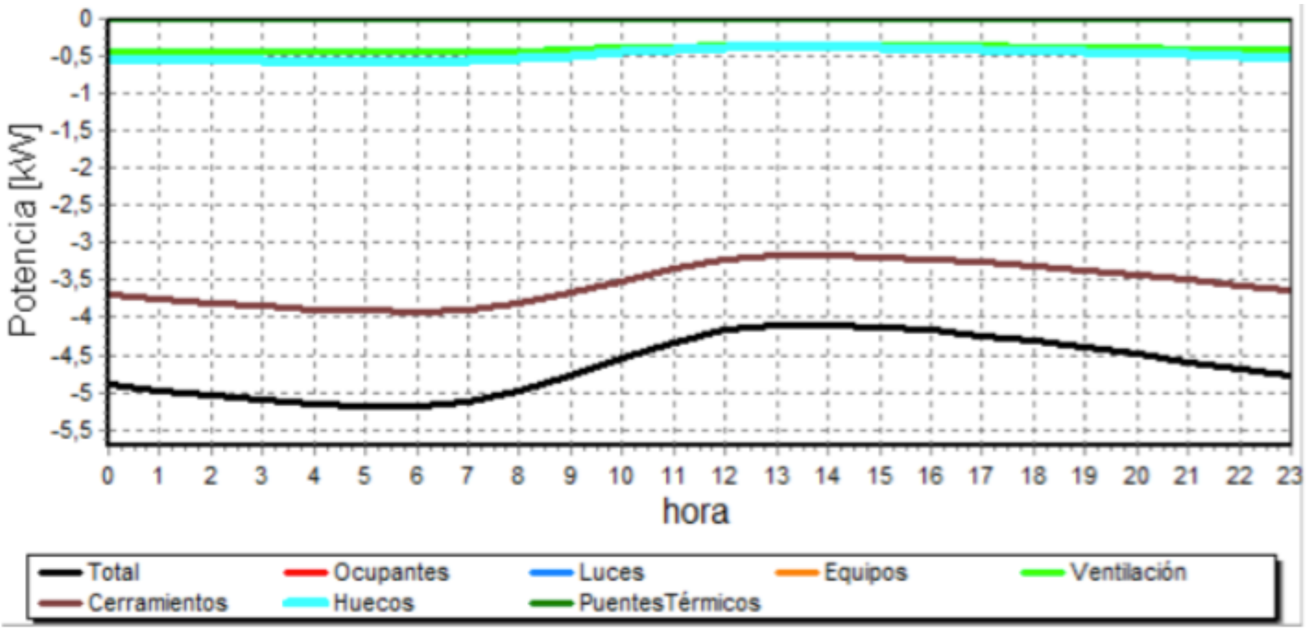


The black line represents the sum of the different colored lines, expressed in kW along the day of maximum demand of the year.

The individual results of each house will be shown below:

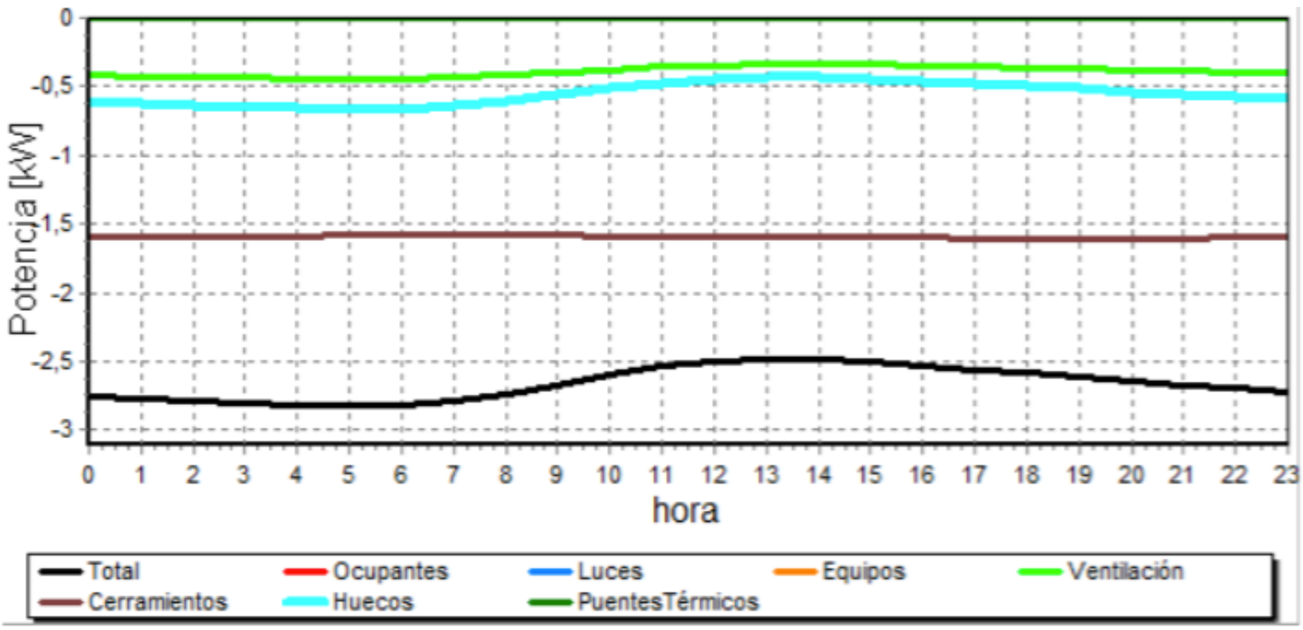
- House 1

House 1	Results
Area (m^2)	46,43
Volume (m^3)	129,08
Total Loads (kW)	5,68
Ratio (W/m^2)	122,39
Ventilation (kW)	0,53
Enclosure walls(kW)	4,33
Spaces (kW)	0,55
Enlargement factor (kW)	0,27



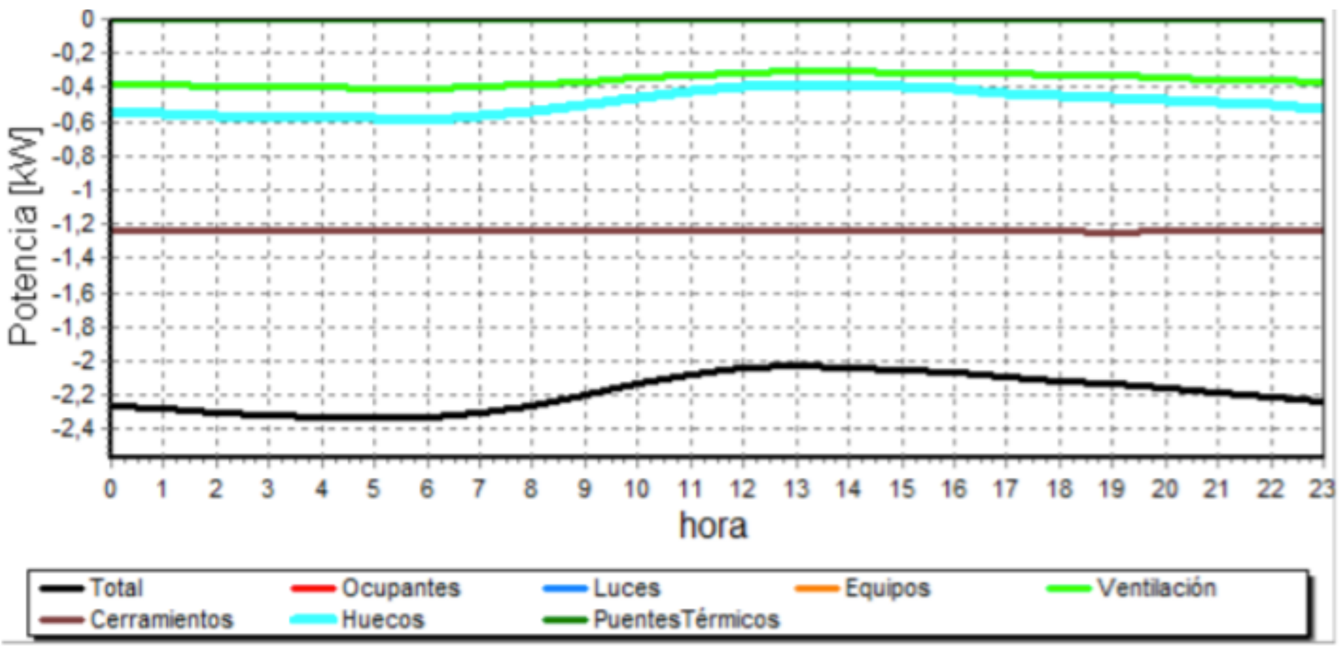
- House 2

House 2	Results
Area (m^2)	39,98
Volume (m^3)	111,14
Total Loads (kW)	5,20
Ratio (W/ m^2)	129,95
Ventilation (kW)	0,45
Enclosure walls(kW)	3,92
Spaces (kW)	0,52
Enlargement factor (kW)	0,25



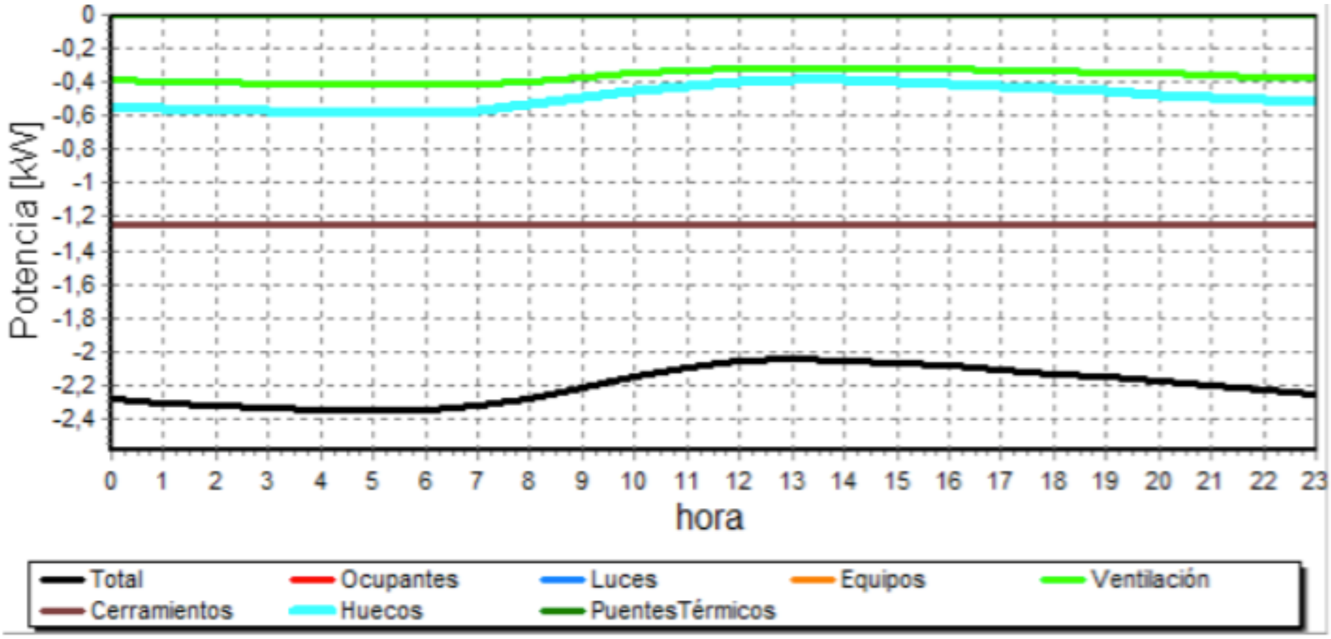
- House 3

House 3	Results
Area (m^2)	38,97
Volume (m^3)	108,34
Total Loads (kW)	2,82
Ratio (W/ m^2)	72,47
Ventilation (kW)	0,44
Enclosure walls(kW)	1,58
Spaces (kW)	0,13
Enlargement factor (kW)	0,27



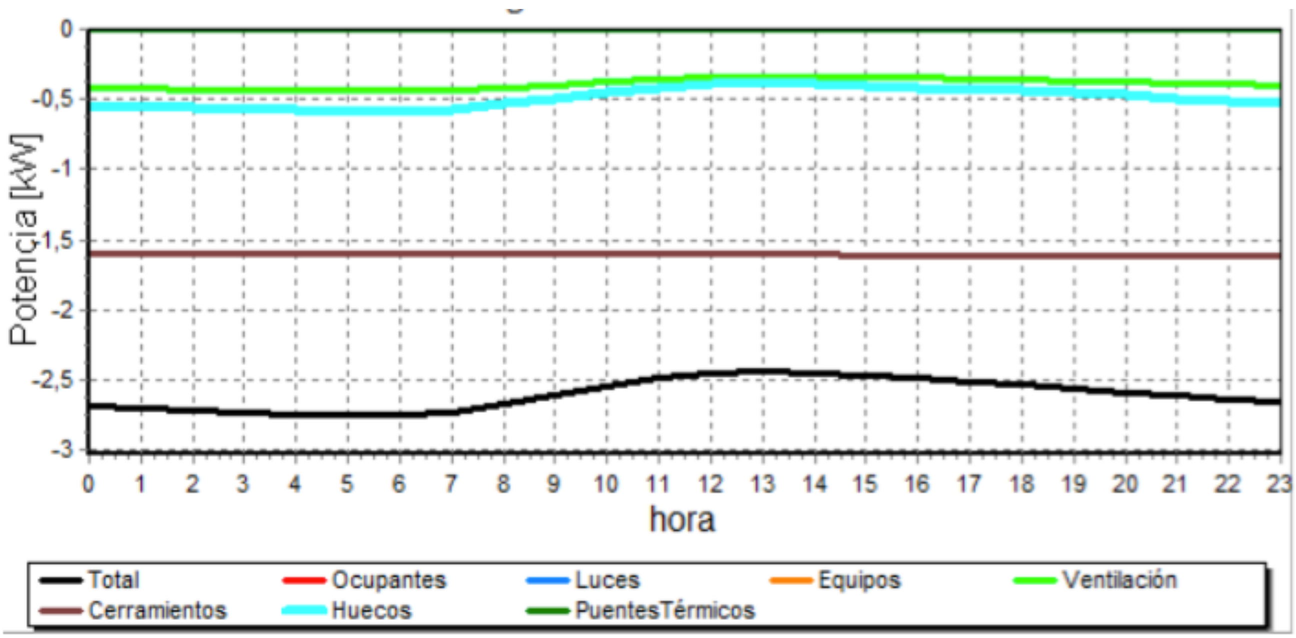
- House 4

House 4	Results
Area (m^2)	35,40
Volume (m^3)	98,41
Total Loads (kW)	2,33
Ratio (W/ m^2)	65,86
Ventilation (kW)	0,40
Enclosure walls(kW)	1,23
Spaces (kW)	0,59
Enlargement factor (kW)	0,11



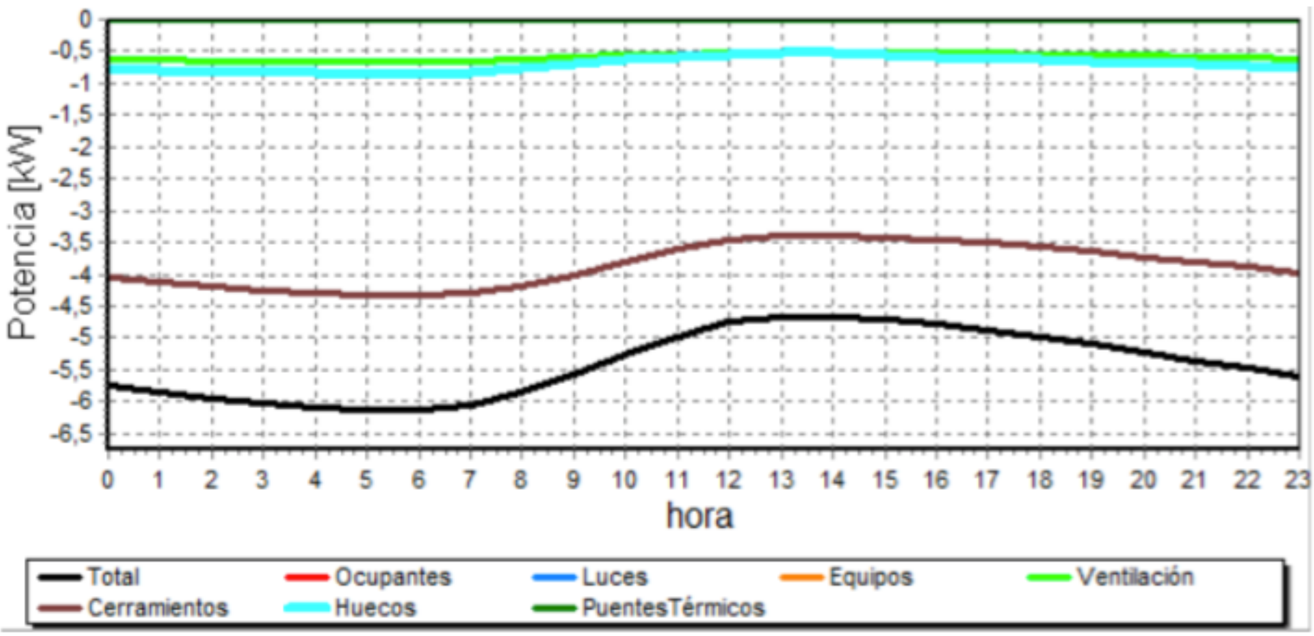
- House 5

House 5	Results
Area (m^2)	36,32
Volume (m^3)	100,97
Total Loads (kW)	2,35
Ratio (W/ m^2)	64,73
Ventilation (kW)	0,41
Enclosure walls(kW)	1,24
Spaces (kW)	0,59
Enlargement factor (kW)	0,11



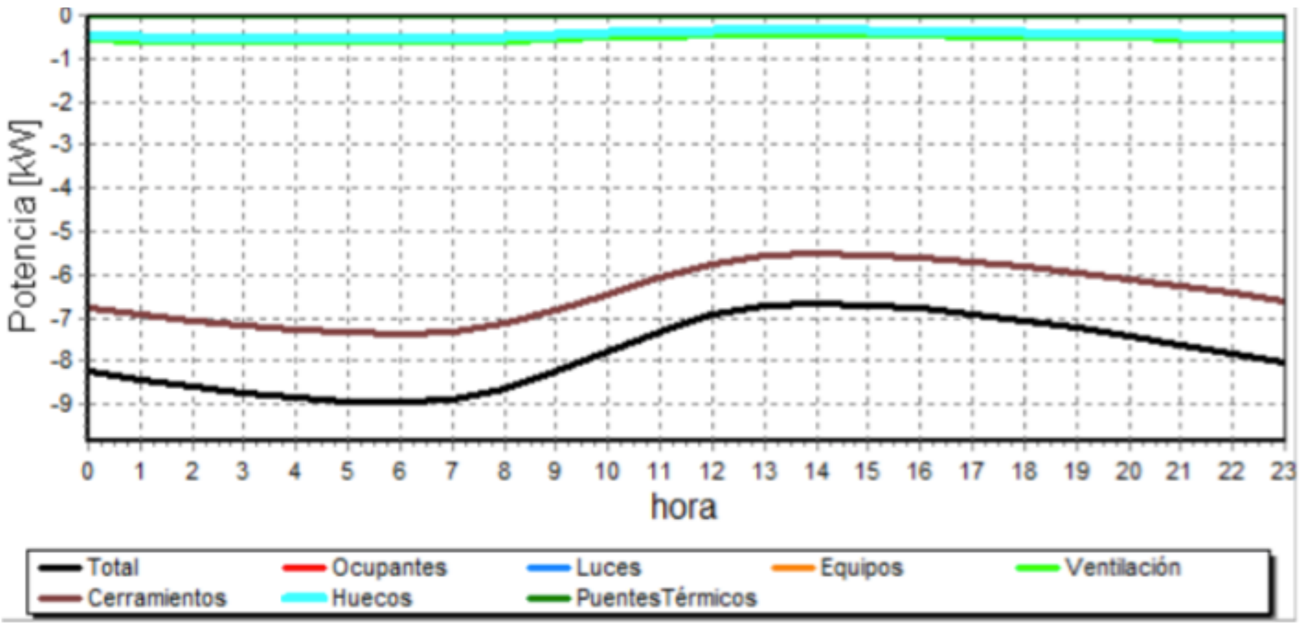
- House 6

House 6	Results
Area (m^2)	38,77
Volume (m^3)	107,78
Total Loads (kW)	2,75
Ratio (W/ m^2)	70,93
Ventilation (kW)	0,44
Enclosure walls(kW)	1,59
Spaces (kW)	0,59
Enlargement factor (kW)	0,13



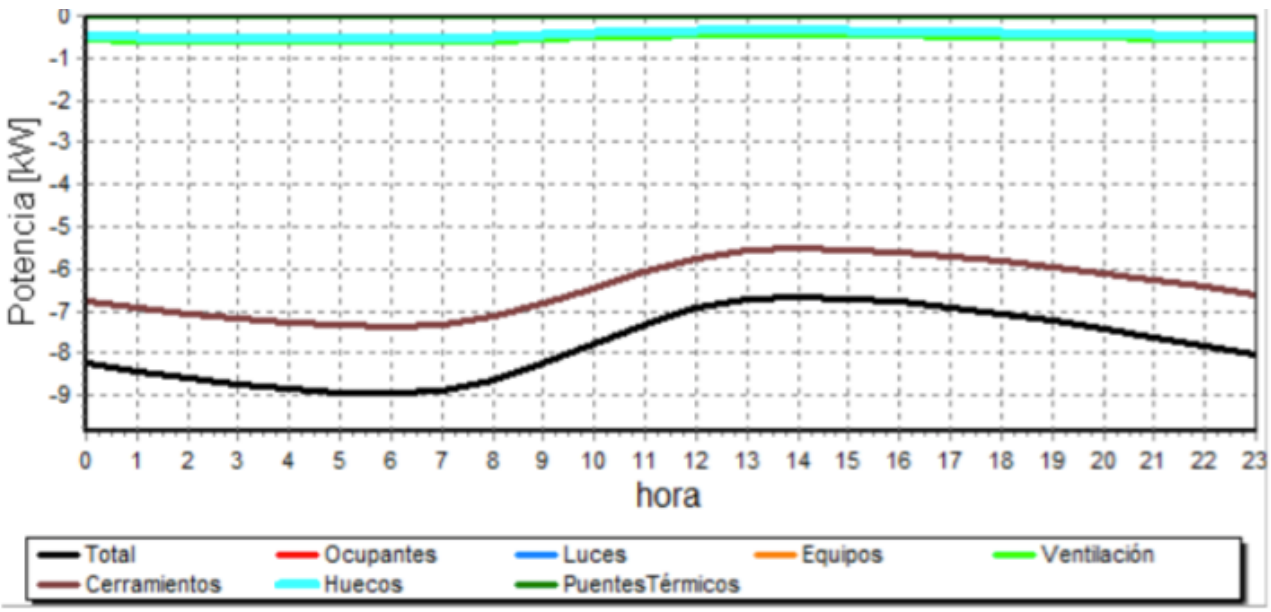
- House 7

House 7	Results
Area (m^2)	58,74
Volume (m^3)	163,30
Total Loads (kW)	6,14
Ratio (W/ m^2)	104,44
Ventilation (kW)	0,67
Enclosure walls(kW)	4,33
Spaces (kW)	0,85
Enlargement factor (kW)	0,29



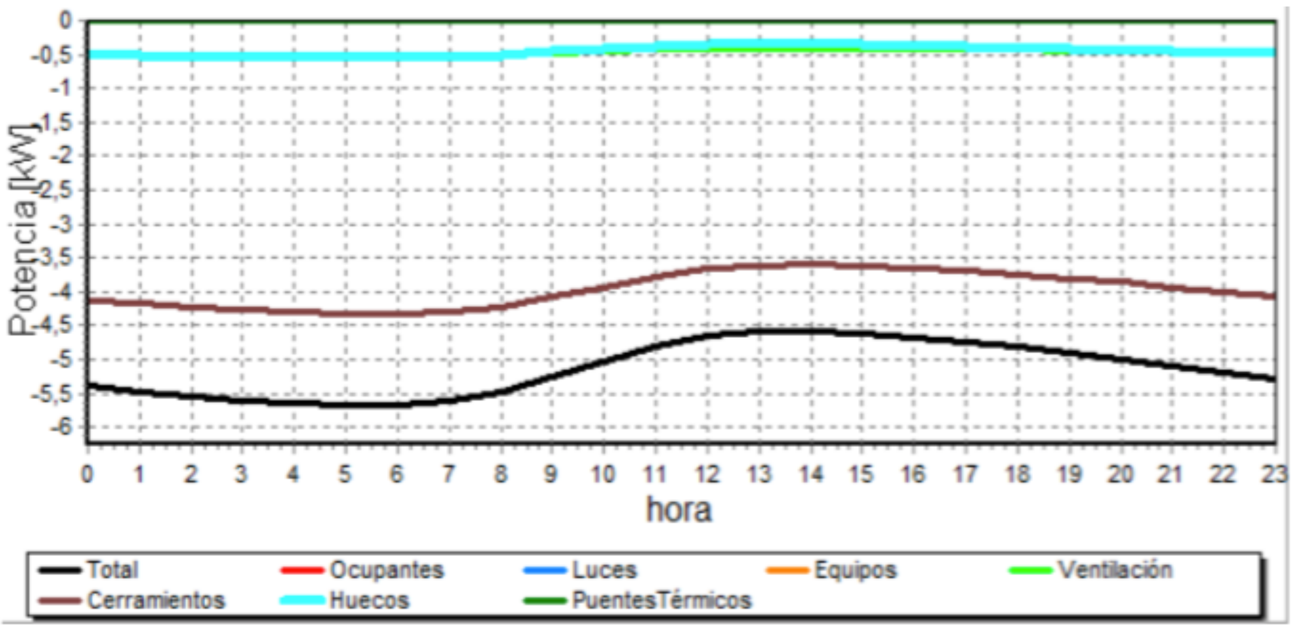
- House 8

House 8	Results
Area (m^2)	32,18
Volume (m^3)	89,46
Total Loads (kW)	3,99
Ratio (W/ m^2)	123,99
Ventilation (kW)	0,37
Enclosure walls(kW)	3,00
Spaces (kW)	0,44
Enlargement factor (kW)	0,19



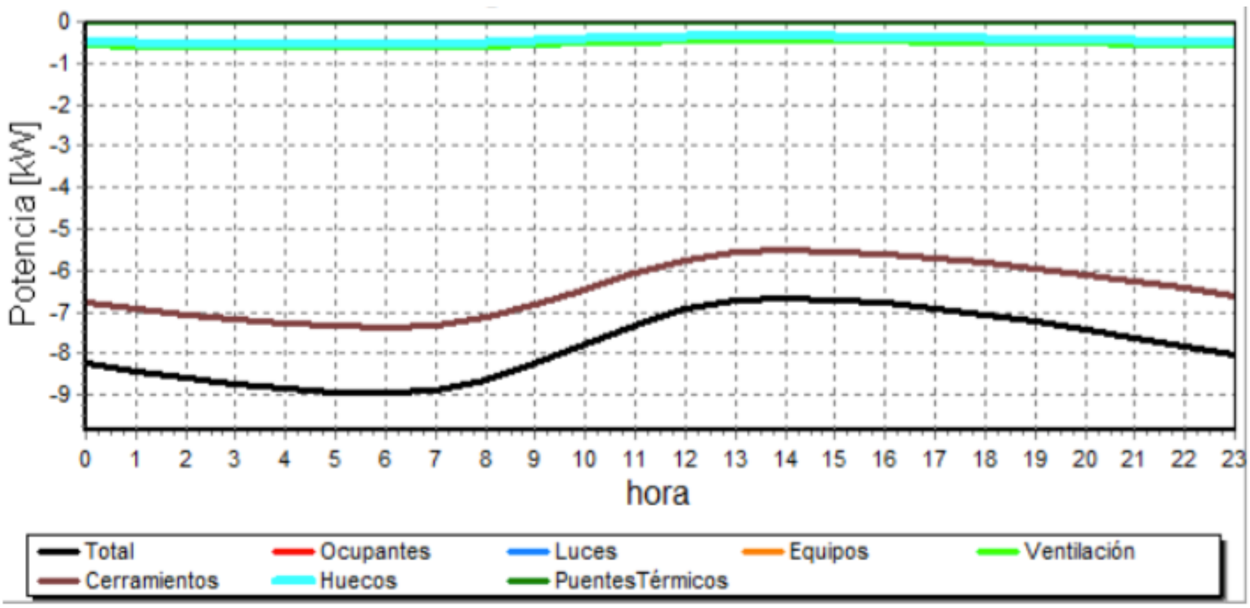
- House 9

House 9	Results
Area (m²)	40,68
Volume (m³)	113,09
Total Loads (kW)	4,68
Ratio (W/ m²)	115,13
Ventilation (kW)	0,46
Enclosure walls(kW)	3,56
Spaces (kW)	0,44
Enlargement factor (kW)	0,22



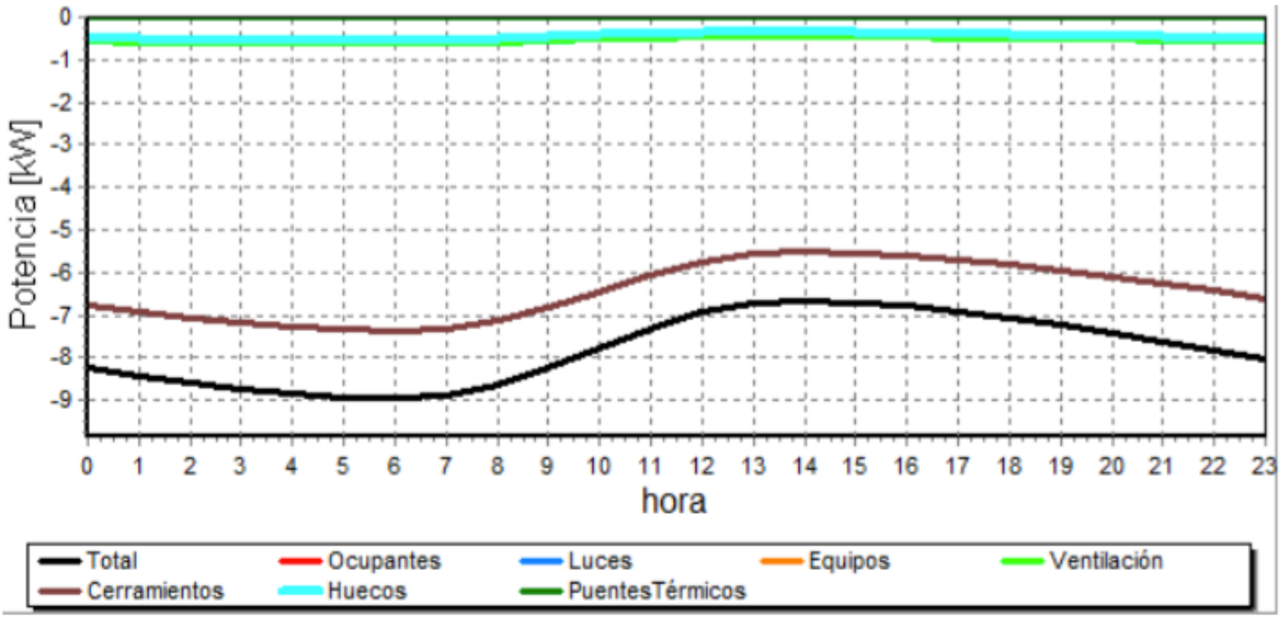
- House 10

House 10	Results
Area (m^2)	53,82
Volume (m^3)	149,62
Total Loads (kW)	8,95
Ratio (W/ m^2)	166,32
Ventilation (kW)	0,61
Enclosure walls(kW)	7,35
Spaces (kW)	0,56
Enlargement factor (kW)	0,43

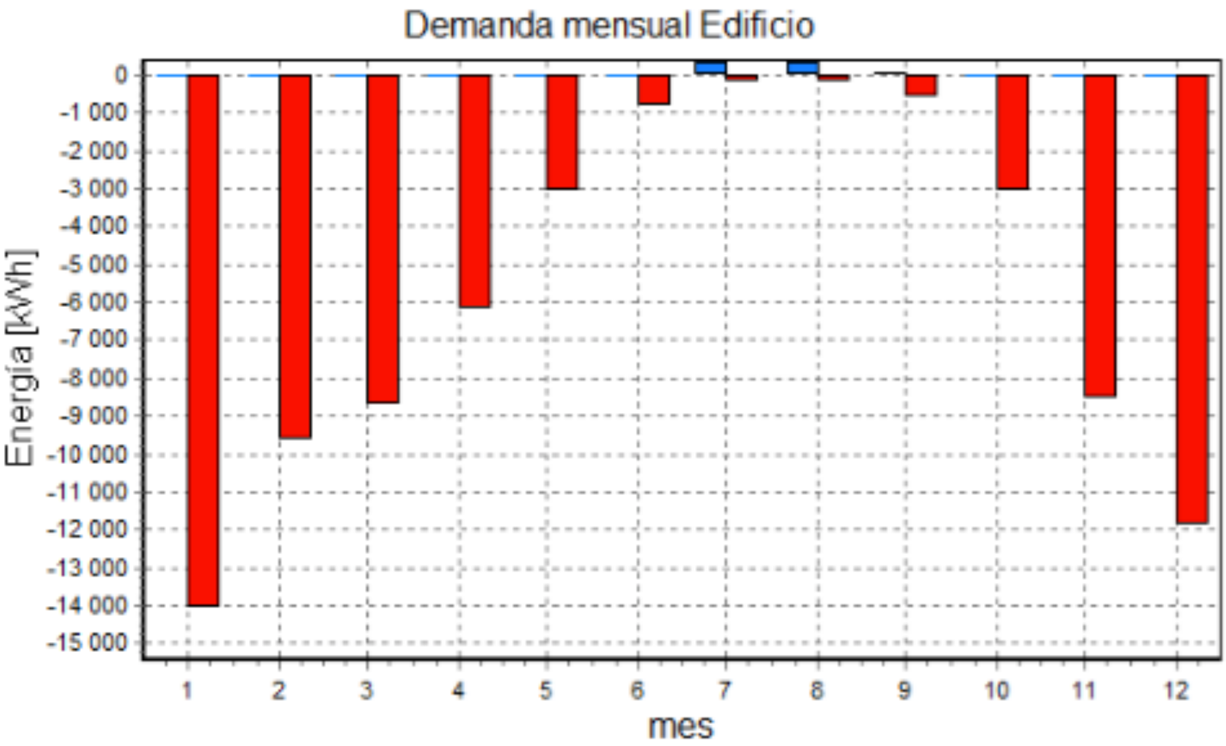


- House 11

House 11	Results
Area (m^2)	53,82
Volume (m^3)	149,62
Total Loads (kW)	8,95
Ratio (W/ m^2)	166,32
Ventilation (kW)	0,61
Enclosure walls(kW)	7,35
Spaces (kW)	0,56
Enlargement factor (kW)	0,43



The following graphic shows the demand for the building over a year.



5. Calculation of underfloor heating

5.1 Initial data

To determine the characteristics of the installation of underfloor heating has been taken into account;

- Diameter of the pipe, a tube with an outer diameter of 16 mm will be installed.

- Outgoing temperature, i.e. the temperature at which the water enters the collection, which is determined by the boiler, and as detailed in point 5, will be 50 °C.

- The average temperature of the soil, which will be 20 ºC, since the soil has a good thermal transmission.

- A standard surface will be chosen for all the houses, which will be of an average of 43,19 m^2, so as not to oversize the installation.

- A thermal power of 4.894,72 W, since there will be no distinction between rooms and the same distribution will be installed in all rooms.

5.2 Calculation of specific heat

In this chapter the needed specific heat for each house will be calculated on the day of maximum demand.

As each home has a minimum variation of size, to simplify this calculation, we will make an average of all surfaces and this will be the one chosen for this calculation. We have a total area for heating of 475.11 m^2, spread over 11 houses, which gives us an average of 43.19 m^2.

As detailed in section 5, the calculations of the VpClima give us the required power on the day of maximum demand, which is 113.33 W/m^2. Therefore the specific heat of 4894.72 W is per house.

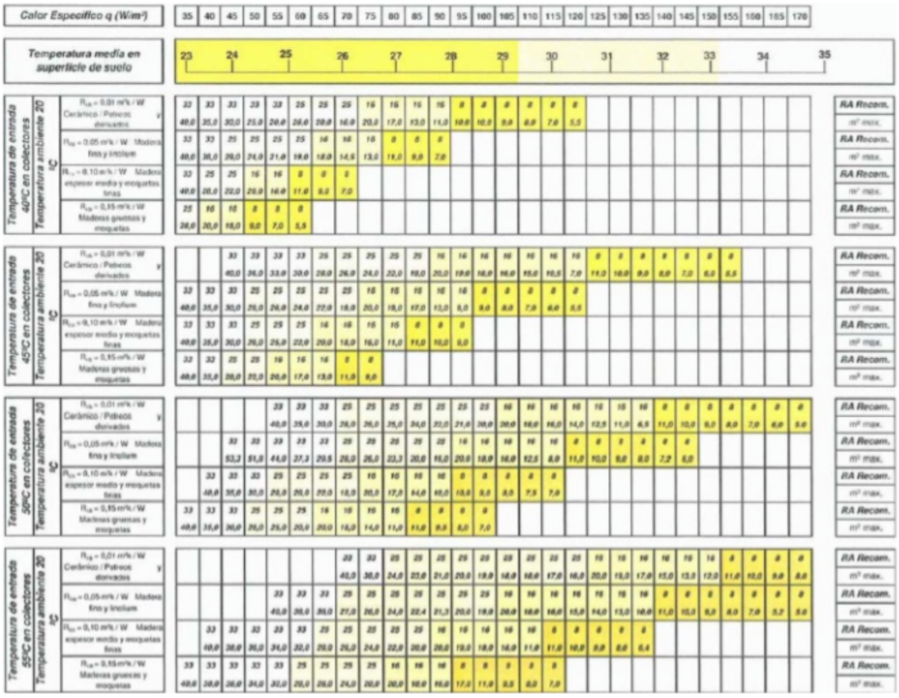


Table 1 - Polytherm method

Looking at the table [Table 1], we can see that it is possible to use a collector inlet temperature (flow temperature) of 50 ° C with a medium wood floor, and with a distance between pipes of 8 cm (RA8) it meets the necessary conditions. We could also have taken a temperature of 55ºC with a separation between the tubes of 16 cm (RA16) to make the installation more economical because you need less tube, but with our choice gives priority to energy saving and to get more comfort.

5.3 Calculation of linear meters

The first step is to calculate the number of circuits that each house has, so we deduce that if the maximum surface per circuit is 8 m^2, and we know that the total area of the house average is 43.19 m^2, it will be necessary to install 6 circuits in each house.

The second step is to determine the linear meters of pipe to be installed, we will take into account the initial values of point 5.1, which are summarized in the following table

Data	House
Area (m^2)	43,19
Thermal power (W)	4.894,72
Type of pavement	Thick wood
Specific heat (W/m^2)	113,33

Tª average floor (ºC)	29
RA (cm)	8
m^2/circuit	7,8
Tª of water (ºC)	50

With a distance between pipes of 8 cm and with a maximum surface per circuit of 7.8 m^2 we calculate that it will be necessary to install 6 circuits per dwelling, that is to say 336.88 meters of pipe in each house.

The total length is found by adding the linear meters of each circuit by multiplying by 2 to take into account the length of going and return, and adding the distance between them and the collector.

$$336{,}88 \times 2 = 673{,}76 + (8 \times 6) = 721{,}76 \text{ m}$$

The total pipe length of each house in the building is 721.76 meters.

5.4 Calculation of the flow

In this section we will calculate the necessary flow that will circulate through the pipes of the radiant floor, to ensure the correct air conditioning, for it is chosen the data obtained from the software VpClima on the day of maximum demand in each home.

Number of house	Maximum thermal demand (kW)
House 1	5,68
House 2	5,20
House 3	2,82
House 4	2,83
House 5	2,35
House 6	2,75
House 7	6,14
House 8	3,99
House 9	4,68
House 10	8,95
House 11	8,95

The next step is to make the calculation with the following formula:

$$M = \frac{Q}{Cp \times \Delta T} \qquad \text{Equation 1}$$

Where ;

M; Is the flow

Q; Is the demand for power

Cp: coefficient

ΔT: Temperature increase

For example, in the house number 1, the required flow rate would be:

$$M = \frac{Q}{Cp \times \Delta T} = \frac{5{,}68 \times 10^3}{4{,}186 J/g^oC \times 10^oC} = 135{,}88 \ g/s$$

And this result we move it to liters per second:

$$135{,}88 \ g/s \times \frac{1 \ Kg}{1000 \ g} \times \frac{1l}{1Kg} = 0{,}135 \ l/s$$

So for housing number 1 is needed a total flow of 0.135 l/s on the most unfavorable day. The same procedure will be performed for the rest of the dwellings:

Number of house	Maximum thermal demand (kW)	Flow (l/s)
House 1	5,68	0,136
House 2	5,20	0,124
House 3	2,82	0,067
House 4	2,83	0,056
House 5	2,35	0,056
House 6	2,75	0,066

House 7	6,14	0,147	
House 8	3,99	0,095	
House 9	4,68	0,112	
House 10	8,95	0,214	
House 11	8,95	0,214	
		1,286	Total

The final result is a total of 1,29 liters per second.

6. Bibliography

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Annex III ;

Measured of the elements of the machine room

Index

1. Introduction

The ecovillage, as explained in point 3.1 in the annex 2 of this document, has a common building, attached to the shed to store the biomass. This building houses all the necessary machinery to supply electricity to the entire ecovillage, and it is where the biomass boilers will be installed for the realization of thermal energy.

2. Dimensions

This building that houses the machinery is located a few meters from the main building and has an area of 64,64 m^2 (10,1 m x 6,4 m) to locate the boiler, the inertia tank and in general elements to carry out the installation.

To comply with the regulations and size of the installation with safety the minimum height should be 2,5 m, which this room already has, and also respecting a height of pipes and obstacles on the boiler of 0,5 m. There shall be a free space in front of the hips of at least 1 m, with a minimum height of 2 m free of obstacles.

The requirements for the machinery room, besides those shown below, are the need to have a point where to deposit the ashes produced by the biomass boiler.

3. Inertia tank

A deposit of inertia which is an accumulation deposit that has the following functions:

- Accumulates heat to be able to supply consumption tips and ensures that the boiler works constantly
- Different outputs can be derived from the tank, since it is an accumulator and exchanger at the same time.
- Can store residual heat at the time of boiler stoppage

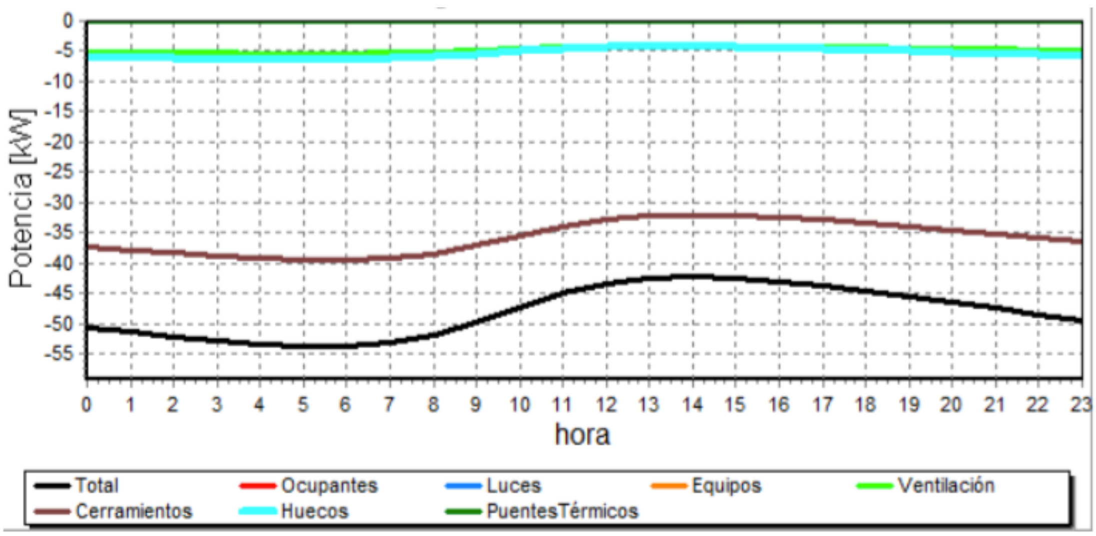
These elements that go together to the heating systems, in the case of biomass, it does not need inertia for the range of temperatures, but for the reason of the combustion chamber. Every time the biomass boiler is started, the combustion chamber must be heated so that wood burning is chemical (the biomass boiler uses the wood gas obtained by heating the combustion chamber as combustible), this heating is done by means of an electrical resistance that is not efficient for the saving of the installation, which is a measure of great efficiency install inertia so that once we start the boiler and the power is turned on we can get the highest possible energy.

Also when the demand is finished it cannot be done as with a gas boiler in which the gas supply is cut off and the boiler is stopped, in the pellet boilers it will have to burn all the wood that is at that moment in the chamber of the combustion, and that heat we have to drive somewhere, into the tank of inertia.

To dimension an inertia tank we need to know how much energy we have to store before it is required to heat the building and so we can design a management strategy that will contain the boiler, which will always work with the deposit, and the deposit that will be from where will leave and where the hot water will flow that will travel the circuits of the building.

From the VPCLIMA, we will obtain the graph of the necessary powers during the most unfavorable day, which corresponds to the month of February [Graph 1]. As you can see, the lowest powers are logically during the central hours of the day and rise during the night.

The graph shows the different power demand along the worst day of the year. The black line shows the sum of all the thermal loads of the different houses of the building (lights, infiltrations, etc.).



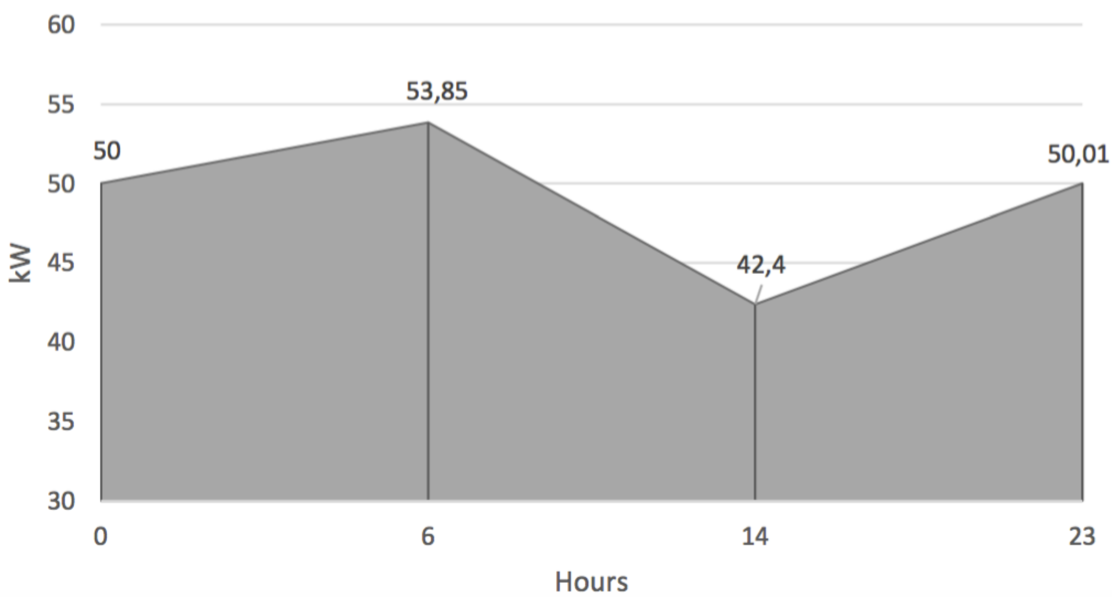
Graph 1 - Thermal demand of the building

The energy required over a period of time is, mathematically, the area below the curve between the hours to be analyzed. The computer program VPCLIMA gives us this graph, and obviously the line is not straight, so this area would be calculated with the integral defined between that interval that interests us with a time differential, but as it is based on an approximation of the VPCLIMA, we will simplify the graph joining the powers more prominent through straight lines. It is much easier to calculate the area under a geometric curve. To be able to observe it better with the points extracted from the Vpclima [Table1] for the most unfavorable day is divided the area to be calculated in three, divided by three the most outstanding thermal demands.

Hour	Thermal load (kW)
0	50,01
1	51,20
2	51,97
6	53,85
7	52,80
8	51,10
14	42,40
15	42,86
16	43,65
23	50,13

Table 1 - Thermal load per hour in Kilowatts

Therefore we will simplify the graph in the following way;



Graph 2 - Thermal demand of the building

The total energy needed for the day of greatest demand can be calculated as the shaded area, the sums of the three areas that represent the 24 hours of a day by all the houses of the building. For example the first area is of the period from 12 at night until 6 o'clock in the morning, it will be the sum of the area of the rectangle plus the area of the triangle above;

$$50{,}01 \times 6 + \frac{(53{,}85 - 50{,}01) \times 6}{2} = 311{,}55$$

Since on the vertical axis there are kW i on the horizontal axis there are hours, the calculated energy will be expressed in units of kWh. The above example will be done for the following two areas:

Period	Energy (kWh)
0 a 06	311,55
06 a 14	385,00
14 a 24	462,00
Total	**1158,55**

In short, on the most unfavorable day, we will need to provide 1158.55 kWh of heating energy.

The next step is to consider how much power our boiler will have, less than the 53.85 kW required to cover the peak of 6 am on the worst day of the year. Calculations will be made for a 46 kW boiler and the possible viability of this is studied:

- Boiler of 46 kW

In this case, with this power, we must subtract the 46 kW we will get to each of the three sections of the boiler;

$$46 \times 24 = 1.104 \ kWh$$

In this way, the energy stored by the boiler throughout the day would be:

$$1158{,}55 \ - \ 1.104 \ = \ 54{,}55 \ \ kWh$$

- Volume of inertia tank required

It is assumed that the tank temperature is 50 °C for the start-up of the boiler and 90 °C to stop the machine. This means that the inertia tank works with a thermal jump ΔT of 40 °C

It is also predicted that the inertia tank has a thermal efficiency η of 0.95. If, once the deposit is chosen, it substantially differs from this value, the necessary corrections will be made

Knowing that stored energy is calculated with;

$$Eem \ = \ \frac{m \ \times \ Cp \ \times \ \Delta T}{\eta}$$

Equation 1

- Boiler of 46 kW

$$54{,}55 \ = \ \frac{m \ \times \ 4{,}18 \ \times \ 40}{0{,}95 \ \times \ 3600}$$

$$m \ = \ 1.115{,}79 \ \ Kg$$

And the time required for the storage of this energy under these conditions is:

$$t \ = \ \frac{Eem}{P} \ = \ \frac{54{,}55}{46} \ = \ 1{,}18 \ \ hores$$

With all the above data, the next step is the choice of the inertia tank. The first characteristic that we must focus on is that this device can always provide the necessary power, even during all the hours of the most unfavorable day, as calculated, must be installed a tank of more than 1115.79 liters. In Figure 1 you can see the inertia tank of the company Lapesa that will be installed in the machine room of the ecovillage, with a quantity of 1500 liters, and its characteristics are:

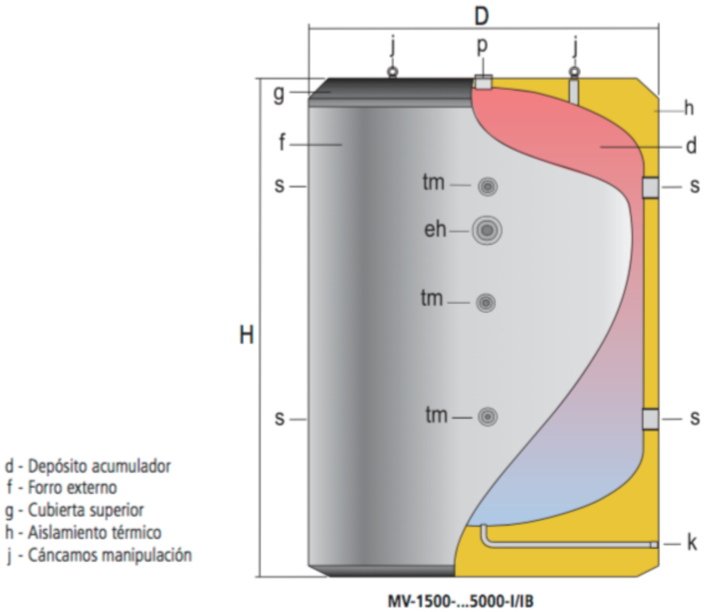


Figure 1 - Inertia tank

Características técnicas /Conexiones /Dimensiones			MV1500I
Capacidad depósito de inercia		*l*	*1500*
Temperatura máx. depósito de inercia		*ºC*	*100*
Presión máx. depósito de inercia (*)		*bar*	*6*
Peso en vacío aprox.		*Kg*	*273*
Cota A:	*diámetro exterior*	*mm*	*1360*
Cota B:	*longitud total*	*mm*	*1830*
Cota C:		*mm*	*160*
Cota D:		*mm*	*720*
Cota E:		*mm*	*610*
Cota F:		*mm*	*1237*
Cota M:		*mm*	*210*
p:	*conexión superior*	*"GAS/H*	*2*
s:	*conexión lateral*	*"GAS/H*	*4*
e:	*desagüe*	*"GAS/M*	*1-1/2*
eh:	*conexión lateral*	*"GAS/H*	*2*
tm:	*conexión sensores laterales*	*"GAS/H*	*1/2*

Figure 2 - Inertia tank characteristics

4. Boiler

As described in the previous point number 5, through the VPclima program, the need for a thermal power in the boiler is of 53,85 kW.

Tatano is an Italian manufacturer, which markets a type of wood boilers, and the characteristics are as follows;

Boiler	data	K2102	K2104	K2106	K2108
Nominal power	kW	23	46	65	93
Capacity	L	64	116	158	200
Dimensions (mm)	width	760	860	860	860
	depth	813	979	1170	1379
	heigth	1030	1178	1178	1178
Chimney (mm)	diameter	150	200	200	200

Table 2 - Types of boilers

Therefore the biomass boiler to be selected for this facility is the Kalorina K2104 of Tatano.

This boiler has a range of 23 to 93 kW [Figure3] and its main technical characteristics are:

- Body of steel boiler, which guarantees quality and durability over time.
- Minimum heat loss guaranteed by total insulation
- Horizontal heat exchanger with smoke pipes, which ensures the efficient heat exchange
- Combustion chamber of large volume with 4 wet walls
- Wide wick that allows the use of large pieces of wood
- Possibility of using liquid fuels after the application of a suitable burner

Figure 3 - Boiler of 46 kW from Tatano

A notable characteristic that will help users of ecovillage homes is that this boiler stands out for its technology, and that from your home via the internet can have all the information on the operation of the boiler, if you need more wood, its full the ash box, etc, without having to move to the machine room.

5. Pumps

The installation of a pump in the installation is very necessary, since it is a closed circuit, it does not receive external energy and only with the inertia of the heat of the water would be very slow and ineffective. The pumps have been chosen to be able to overcome the losses of load that are in the closed circuits and to be able to work with the required flow calculated previously in the annex 2.

In this section the necessary power of the pump to be installed will be calculated. The first place is to take into account that the pipe through which the fluid circulates produces a friction, because the pump must overcome it to achieve the desired objective. The keys, elbows and other accessories of the installation also produce a pressure drop.

The load loss of the pipe is calculated according to an abacus that each manufacturer must provide. It is important to know that we must select a pipe that allows us to work with a speed around 1 m/sec or less, to avoid noises in the installation. It would also be desirable not to exceed a head loss of 40 mmcda/metro

In this project we must calculate the loss of load of the circuit from the inertia tank to the installation of underfloor heating, with stainless steel pipes. To simplify the vision of the installation of the pipes, the following diagram was carried out [Figure 4].

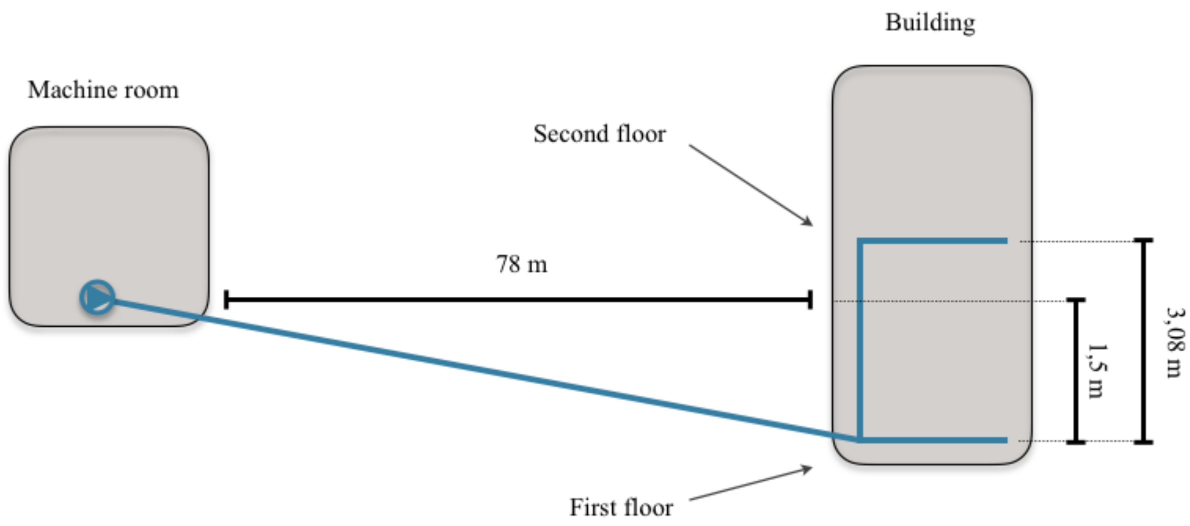


Figure 4 - Schematic of the pipe connecting the building to acclimate and the machine room

The distance that the water must cross where the boiler is located, machine room, (to the left) a total of 78 meters until with a descent of 1,5 meters, that will go in favor of the liquid during one way, and against during the return. On the right is the building to be heated, with its two floors, which have a difference of height of 3,08 meters, a significant loss of load that the pump must overcome.

5.1 Loss pump-building

To calculate the losses from the machine room to the building we observe the abacus [Table 3] , For a flow rate of 4.629,6 liters/hour (1,29 liters / second) with a pipe of 42 mm we will have a load loss of 30 mmcda/meter.

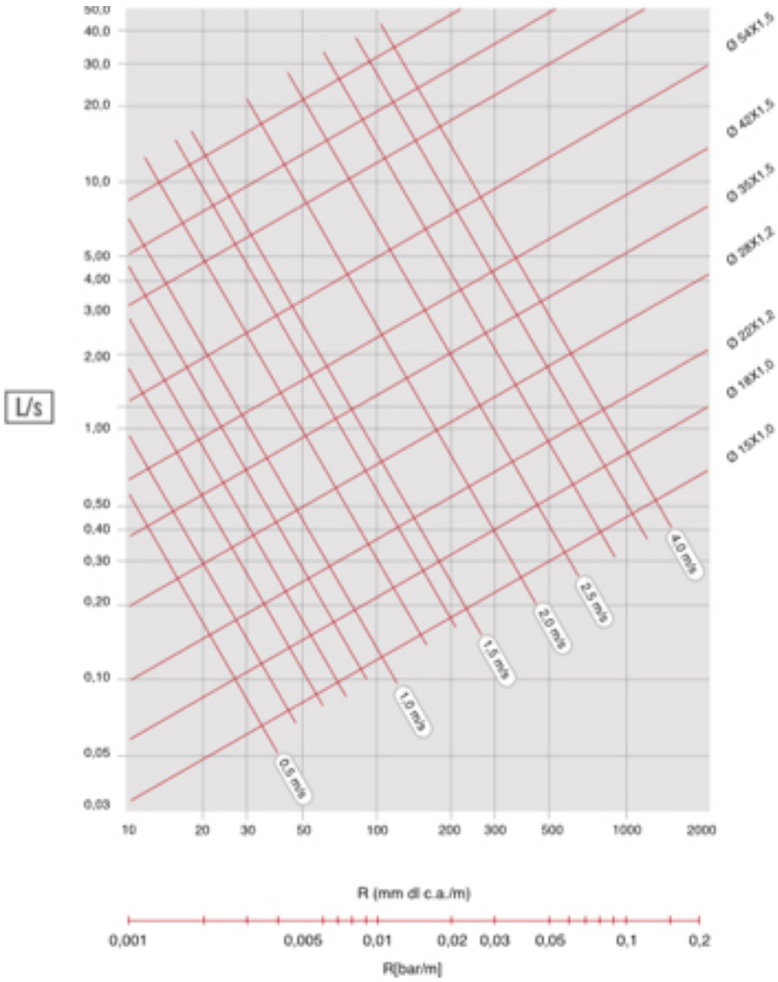


Table 3 - Abacus to determine the size of the pipe

Knowing that we have 78 meters of pipe to the collector (and another 78 of return), we calculate the total loss of load, increasing by 30% by the loss of load of the accessories that we can have in the installation (we could calculate the exact loss of load , accessory per accessory, but 30% is a generally acceptable percentage).

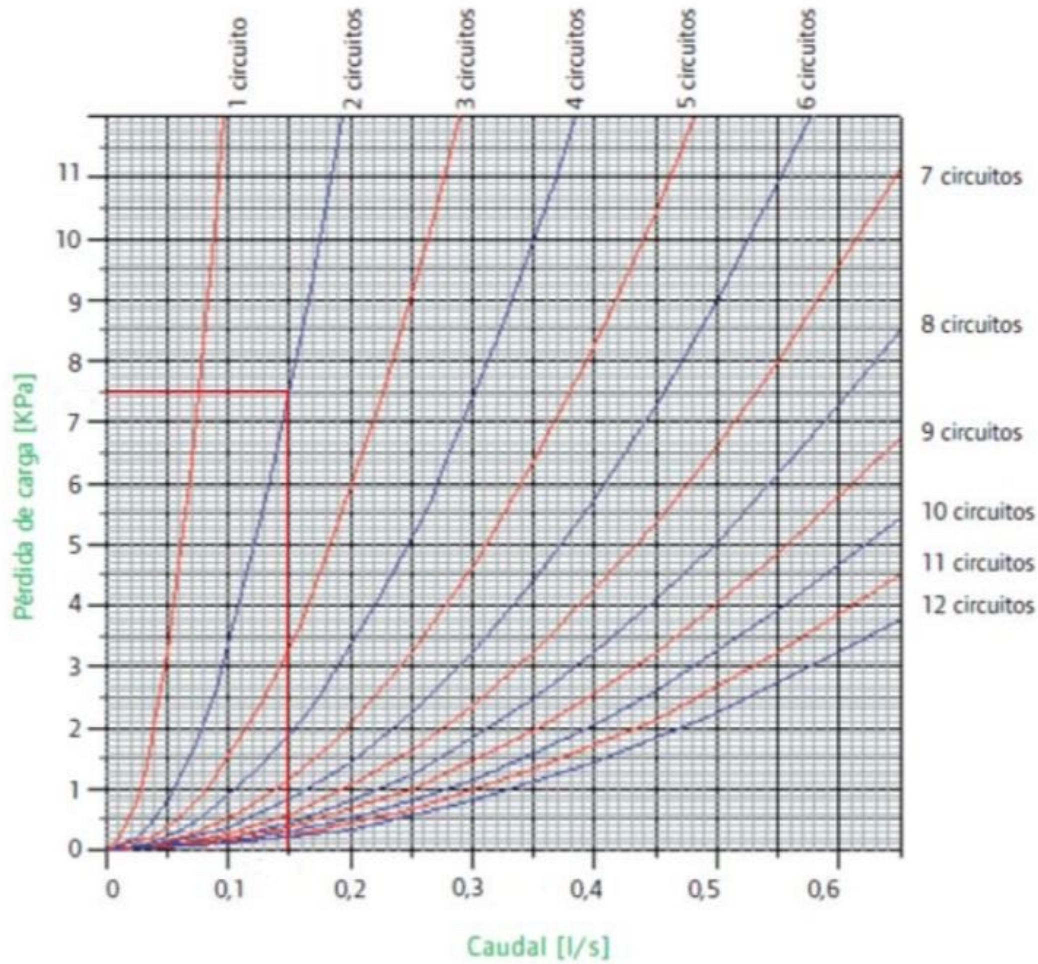
$$H = 30 \times ((78 + 78) \times 1{,}3) = 6.084 \ mmcda = 6{,}09 \ mcda$$

The result in a total of 6,09 mcda.

5.2 Loss of manifold

Corresponds to the loss of load that occurs in the manifold. To calculate these losses we will use Graph 3, for example in building 9 the required flow rate is 0,214 l/s and have six circuits.

The following figure shows the graph used:



Graph 3 - Graph to determine the number of circuits

Obtaining a value of;

$$\Delta P = 2{,}3 \ KPa = 0{,}234 \ mca$$

The following values of the different houses are;

Number of house	Flow (l/s)	Losses (mca)	
House 1	0,136	0,021	
House 2	0,124	0,013	
House 3	0,067	0,005	
House 4	0,056	0,004	
House 5	0,056	0,004	
House 6	0,066	0,004	
House 7	0,147	0,023	
House 8	0,095	0,004	
House 9	0,112	0,105	
House 10	0,214	0,234	
House 11	0,214	0,234	
		0,644	**Total**

There is a total of 0.644 mca of losses in the manifold.

5.3 Loss of height

This loss of load corresponds to that produced by the effect of gravity, with the maximum height of the installation H = 3,08 [m]. The formulation is as follows:

$$\Delta Paltura = \rho \times g \times \mathrm{H} = 30{,}18\ KPa = 3{,}08\ mca$$

Finally, summing all the individual losses, is obtained a maximum loss of load:

$$\Delta Ptotal = \Delta Pheight + \Delta Pmanifold + \Delta Ppump\text{-}building \quad \text{Equation 3}$$

So that gives a result of:

$$\Delta Ptotal = 6{,}09 + 0{,}644 + 3{,}08 = 9{,}81\ mca$$

5.4 Pump selection

The pumps located in closed circuits are recirculates, to assure the movement of fluid inside the conduits.

Two of them will be connected in parallel and only one is operated. In case there is a high demand that it is necessary to heat all the houses at maximum power at the same time or if there are problems with the pump, we make sure that the water arrives perfectly.

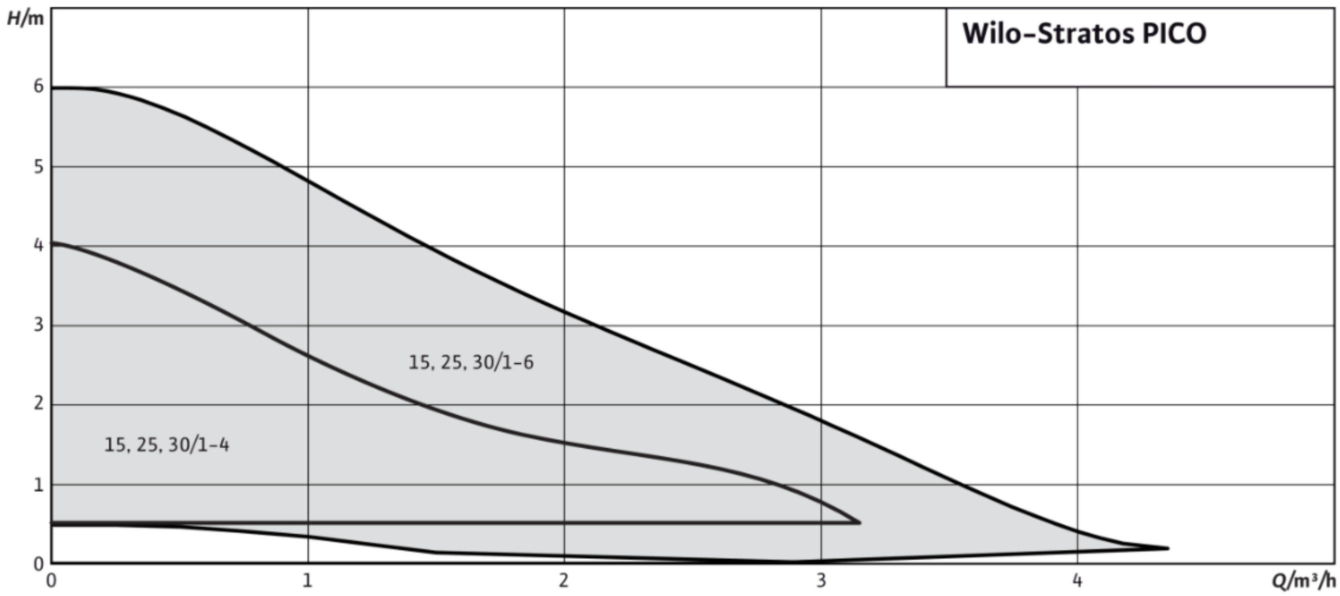
The selected recirculating pumps are Wilo-Stratos PICO from the manufacturer Wilo [Figure 5], is a wet rotor pump with threaded connection, EC motor resistent to blocking and electronic regulation of the integrated power.

The specific characteristics of the product are as follows:

- Application in heating, cooling and air-conditioning installations from +2 ° C to +110 ° C
- Only 3 W minimum power consumption
- Indication of current power consumption or flow rate and accumulated kWh
- Additional functions: Dynamic Adapt, ventilation routine, night reduction, keyboard lock and reset function

Figure 5 - Pump Wilo-Stratos PICO from Wilo

As can be seen in Graph 5 provided by the manufacturer on this pump, a single pump can face 6 mca, so the two pumps that are connected series will be more than enough to reach 9 mca on the day of maximum demand.



Graph 5 - Characteristics of the pump Wilo-Stratos PICO from Wilo

And the pump size scheme:

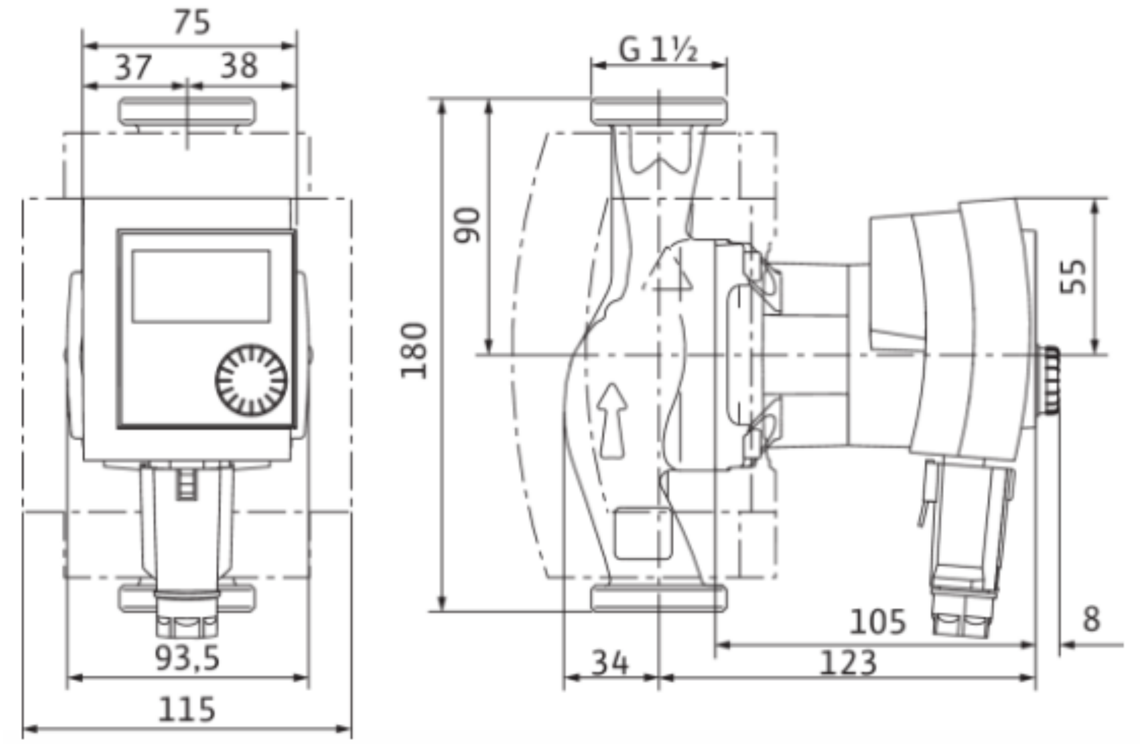


Figure 6 - Figure of the dimensions of the pump Wilo-Stratos PICO from Wilo

5.5 Power calculation

At this point the electrical power required for the pump selected above will be calculated with the following formula:

$$P = H \times \rho \times g \times Q$$ Equation 4

Where;

P; Is the theoretical power

ρ; Water density

g; It's gravity

Q ; Is the flow rate of the pump

With the previous data we replaced;

$$P = 78m \times 1000\frac{Kg}{m^3} \times 9{,}8\frac{m}{s^2} \times 4{,}6\frac{m^3}{h} = 0{,}97kW$$

If we multiply the power of the pump by 12 hours to the day of operation, a total of 4,5 kWh comes out.

6. Smoke evacuation

A fireplace for the boiler has been installed in the engine room, for the evacuation of the fumes produced by the combustion. The material of the conduit is stainless steel and the outermost part will be covered by insulation. The tube should not have welds, as this will avoid cold starts due to possible overpressures.

The flue chimney will be located on the side of the boiler, so it will cross to the deck. The chosen one is the face DINAK, and it is a self-supporting fireplace, consisting of a circular section smoke pipe with self-supporting capacity, heat-insulated with high density rock wool, and equipped with external pre-assembled envelopes.

7. Ventilation

The boiler room needs to be properly ventilated to maintain an acceptable temperature level in the room. In addition, this system favors the combustion of the boiler and allows to dissipate gases and fumes in the installation.

By having fluids at elevated temperatures circulating inside the ducts, it will be necessary to provide the pipes and equipment with the necessary insulation to avoid large heating in the room.

The minimum section of the ventilation aperture is obtained with the following expression:

$$SV \geq 5 \cdot PN \qquad \text{Equation 5}$$

Where:

SV: Free section of ventilation (cm^2).

PN: Nominal power installed

It is advisable to make more than one opening and place them at different heights, so that currents of air are created that favor the sweeping of the room.

In the engine room will be placed two openings of 20 cm diameter.

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Annex IV ;

Agronomic design of energy crops

Index

1. Introduction

In this part of the work, it is detailed all the design carried out to determine how the planting of the energy crops will be realized for a better efficiency of the obtaining of the vegetal material.

Figure 1 - Example of planting of energy crops in Gyöngyös

For this purpose, we study the best planting distance, the layout, the density of trees, care, treatments, irrigation, organic soil amendments, cutting periods, etc.

2. Planting

As explained in the annex 5, planting is carried out by stakes. A good stake should measure 18-25 centimeter long and about 20-30 millimeters in diameter and have at least three shoots. It is advisable to moisten the stakes in case they have resected. In addition, application by immersion with Fention (Lebaycid) to the 1% the active product in water is necessary to eliminate possible parasites.

In most cases the orientation of the plantation depends on the best length of the edge in the plot, but as in this study, the plot is considered quite large it is necessary to emphasize the convenience of an east-west orientation, even something south east -Northern, to collect as much light as possible by increasing the photosynthetic capacity, reducing the shadow between the plants as much as possible. As the land available does not have large slopes, no contours will be realized.

The plantation can be done manually but for this study, and due to the considerable increase of the yield in the activity, a semi-mechanized plantation will be considered.

In the absence of specific plantation machinery, a low-power agricultural tractor can be used, in which two furrow openers are coupled at a distance from each other and with two compaction rollers so that the worker simultaneously introduces the stake. The distance between the stakes can be controlled by a planting wheel.

3. Distance and density planting

The effects that seem to have a significant influence on the decision of the plantation designs and the management of the forest energy crops are the following (Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA), 2007):

– The final constant production law, which states that the biomass yield increases with the density, although from a given density the production becomes independent of the same, which could be used to determine the maximum number of stakes per hectare in plantations.

– A competition between individuals is established with the presence of dominant and dominated trees. The cutting time should be established about these competing states, in order to avoid a decrease in the viability of the stump.

– According to Yoda's self-clear out law (1963), the total biomass per unit increases exponentially without mortality until maturity. After maturity the plants will stop their growth if the density is not reduced. Spacing and shifting should be balanced to avoid loss of competition. In addition to these two variables, others should be considered such as the duration of planting, mortality, possible rot and costs.

– In short shifts, high densities are used, with an implant scheme in single or double rows.

– In long shifts the density decreases and the rows are simple.

The reasons for selecting one density or another can be very variable: machinery available for work, biomass need to be obtained at a specific time (a spaced mass can delay its cutting time so that it supplies the material at a time of greater demand), diameter to be obtained at the time of the cut and shift, limitations on the capital invested, etc.

The plantation distance chosen for this study is 2,5 m by 0,7 m, so the density of the plantation is 5.500 plants/ha.

This means that the initial investment consists of 5.500 cuttings, half of the species *Populus* and the other half of the species *Salicaceae*, plus 5% more, for possible losses, damages, death of the plant, etc.

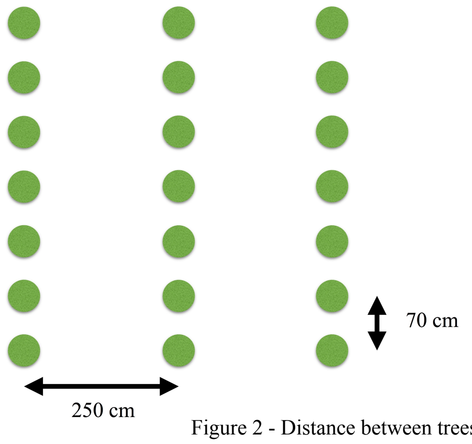

Figure 2 - Distance between trees

4. Calculation of available biomass

In this section, will be made the necessary calculations to estimate the amount of available biomass from the two species used in energy crops.

4.1 Pruning

There have been numerous, to worldwide level, planting distance tested on experimental plots of these crops , with the aim of increasing yields and finding the optimum density for a given production cycle and species. This has been proven from low densities around 1.000 trees/ha to 310.000 trees/ha. In addition to planting density, different running shifts have also been tested, from annual shifts to shifts close to usual for these fast growing species (about 14 years), in order to optimize the crop and its use.

For the implantation of the energy crops in the ecovillage a first cut was chosen that was realized at the age of three years and the next every 2 year until completing the turn of 21 years, in the last cut is also included the process of removing the stumps. The process of removing the stumps is that this tree after the pruning leaves part of the trunk and the root under the surface of the lands that normally have to clear. The process of removing the stumps consists of extracting them from the ground and filling the gaps during the clearing of the land. For the analysis of the costs, the model with the different types of irrigation (drip and blanket) has been considered.

To obtain a sufficient biomass production a density of 5.500 plants/ha was chosen.

The dry tons of the first cut are difficult to predict because they influence different factors and not all species are the same, so for calculations we will take the means of the ranks of grades according to a study by Montoya Oliver.

Quality	Since	To	Average
I	77,3	88,3	82,8
II	56,70	69,30	63,00
III	44,10	56,70	50,40
IV	31,50	44,10	37,80

Taking our general quality as reference number I.

Year	Diameter	Labour	Possibility (th/ha)	Possibility (ts/ha)
0		Level and subsoiling		
0		Plantacion y abonado		
2		Fertilization		
3	8 cm	Pruning	82,9	37,3
5		Fertilization		
7		Pruning	75,2	33,8
9		Pruning	75,2	33,8
11		Pruning	75,2	33,8
13		Pruning	75,2	33,8
15		Pruning	75,2	33,8
17		Pruning	75,2	33,8
19		Pruning	75,2	33,8
21		Pruning	75,2	33,8
		Removing the stumps	18,8	8,5

Being th tone produced with an assumption moisture content of 50%, while ts are considered the dry material (0%).

Thus, the average annual possibility is 16,7 ts/ ha·year.

As the plantation will not exceed its normal diameter of 8 centimeters, for better management of the wood, and its easy placement inside the boiler.

It means that at the end will be proceeded to remove the stumps. Stump biomass has been considered as 25% of the total biomass extracted in the last final cut.

4.2 Biomass

To calculate the amount of fuel that the boiler needs to supply heating to the different houses of the building, we use the following formula:

$$Qcomb = CE / PCI$$ Equation 1

Where:

Qcomb, is the amount of annual combustible needed
CE, is the annual energy consumption
PCI, is the lower calorific value of the combustible

The lower calorific value of the combustible (PCI) depends on the type of combustible used. The calorific value depends on the moisture content, varies with the species, in this study we used two species (*Populus sp* and *Salix sp*) and also the part of the plant to be used. For this study, data are chosen from the IDAE. For the calculation, an average of the two species used in the energy crops is carried out and assuming that the wood will not be completely dry and that it will contain 20% moisture during its storage. The next value will be chosen;

$$PCI = 4{,}12 \text{ kWh/Kg}$$

As a result of that average of calorific power and the annual energy consumption calculated in point 5 with the program VPCLIMA, we obtain the consumption of biomass during a year;

$$Qcomb = (63932{,}75 \text{ kWh}) / (4{,}12 \text{ kWh/Kg})$$

$$Qcomb = 15.090{,}47 \text{ Kg}$$

4.3. Viability

In order to study the feasibility of the parameters chosen above, such as the plantation frame, the pruning, etc., we must compare the amount of biomass that the boiler needs each year with the amount of biomass produced.

As described in point 4.1, the average annual capacity is 16,7 ts/ha·a year and the quantity required by the boiler is 15,1 th each year, i.e. 1 ton of excess will be produced, which is determined viable.

It is recommended that there is this excess because the pruning will not be good every year, and there will be years when the production will fall. For this reason we must have a stock for an emergency. In addition, this surplus wood can be used to repair homes or other ecovillage purposes.

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Annex V ;

Energy crops

Index

1. Introduction

The biomass that this study will focus on will only highlight lignocellulosic energy crops. These crops that are made for the production of solid biofuels for thermal applications or for the generation of heat and electricity should be as close as possible to a series of characteristics that are set out below. Energy crops, like any other, must take advantage of nature but in no case obviate its laws. Therefore, it is advisable to take into account the following:

- That they adapt to the climatic conditions of the place where they are implanted: the plants give the highest productivities in those places that meet conditions that are more favorable to them.
- High levels of biomass production with low production costs: production that require a lot of cultural attention are complicated and expensive to exploit.
- They are easy to use and require the best known techniques and machinery. What present positive energy balance. This means that more energy is extracted from them than is invested in the crop and its energy plant.
- A high capacity for rooting from esquejes.
- Fast initial growth.
- A great capacity of regrowth and a long duration of the strains.
- That it does not contribute in the degradation of the environment and allow the easy recovery of the land, to implant later other crops in some cases. When possible, rotation is feasible and beneficial at all stages. The great majority of the biomass that will be used in the ecovillage boilers to obtain thermal energy will be through these energy crops, that is to say, plantations are generated with the sole purpose of producing biomass to produce that energy required.

These plantations will be realized in the large extensions of field of property of the foundation GAIA, which reach an extension of 300 ha. The type of biomass required by the ecovillage for the boilers is lignocellulosic.

2. Types of land

In order to fulfill this first characteristic of the above list, it is necessary to know that the influence of the land cannot be totally separated from the climate, since the land-climate ensemble forms an ecological unit. The most suitable soil is deep, with good aeration and drainage. When analyzing the terrain, there are a number of basic parameters (Padilla, 1997) that is necessary to know: the type of the land, active limestone content, organic matter, phosphorus, potassium, pH, land salinity, etc. Among them, the active limestone content and salinity of the soil must be considered, together with the conductivity of the water to be used for irrigation. The combination of these factors together with drought resistance and required vigor will allow us to choose the right species.

The land that presents the area where the energy crops will be introduced will present a land, which due to its strong alluvial or sandy character, has a large amount of water, so it is conducive to this type of crops. The contents of organic matter in these soils are medium-high. They are also favorable in nitrogen and potassium, in this zone it emphasizes the existence of an area of saline-limestone lands, they are lands of fine texture and weak structure. According to an eusoil study of the souls of Hungary Calcareous brown lands are the most important with a high content of calcium carbonate, ranging from 35% to 63% with a pH close to 8. The organic matter presents values of 1% to 2% and decreasing with depth, the contents of chloride, sodium and gypsum are very low, rising in the lower horizons.

3. Selected species

Populus sp It is a deciduous tree, large, it can reach 20-30 meters in height, are characterized by their extraordinary avidity to water and light, they are generally fast growing, they have great ability for vegetative reproduction and interspecific hybridization [Figure 1].

Poplar cultivation requires loose, well-aerated, deep lands with a low clay content (less than 15%), preferring free or sandy-loam textures, and it is not susceptible to frequent flooding. The pH should be close to neutrality (between 6 and 8), with contents in organic matter higher than 2% and concentrations of active limestone of less than 6%, as well as absence of salinity.

Its adaptability to different lands and climatic conditions has led to their widespread use in developing and developed countries, playing an important role in the rural life of underdeveloped countries with economies in transition. They supply various products (wood, wood logs, firewood, poles

Figure 1 - photograph of *Populus* on the field

and fodder), as well as other services such as protection for soil, crops and livestock, and can give aesthetic value to visitors of the village [Figure 2].

Figure 2 - photograph of *Populus* in Gaia Ecovillage

Traditionally they have been integrated in many agricultural systems with temperate or subtropical climate, but recently a new scope has arisen that it can be used use as biomass, as well as its environmental value.

This species is easy to multiply by vegetative means (cuttings and cuttings). These characteristics allow to develop new cultivars facilitating to the workers to multiply with speed and simplicity, and the descendants of certain trees with desirable attributes (fast growth, straight shaft, white wood, etc.). This procedure is called cloning, which allows the establishment of artificial plantations with certain characteristics, it has its drawbacks, if a particular clone is susceptible to attack by a pest or disease, although on the other hand the only problems concerning this type of crops are those causing death or reduced production, and not small-caliber pests that cause aesthetic damage, since only a quantity of wood is needed in the shortest possible time.

Figure 3 - photograph of *Salix*

Salix, Genus composed of some 400 species of deciduous trees and shrubs within the family Salicaceae, are distributed in the cold and temperate areas of the Northern Hemisphere, mainly in humid lands, which presents interesting characteristics for ecovillage, although nowadays it is widely found spread throughout the world (including the southern hemisphere) [Figure 3].

All willows have watery bark, wood is hard, flexible and usually soft. They have slender and fibrous branches and often stoloniferous roots, of which most notable characteristics are their hardness, length and resistance. They also easily develop aerial roots.

As the sexes of the species belonging to this genus are separated [Figure 4], a phenomenon of cross-fertilization occurs, where pollination between individuals is required to generate offspring. This has led to natural crosses between species, generating hybrid organisms (usually a hybrid that arises between two plant species is not fertile, i.e. cannot leave offspring, although there are cases where it is possible and is where they form new species naturally), which improves harvesting after harvesting, although it is easier to reproduce by cuttings.

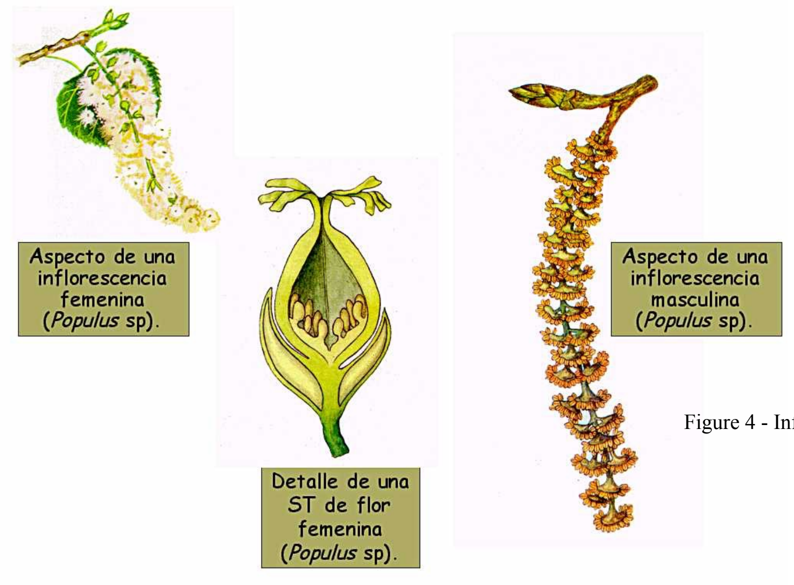

Figure 4 - Inflorescence of *Populus sp*

4. Operations to be carried out before planting

The preparation of the land for the planting of energy crops is a very important part. In the lands owned by the GAIA foundation they have a soil with an organic material of 1,8%. This level of organic matter is quite high, but as our cultivation of *Populus sp* needs a very good soil to grow as fast as possible, we would like to increase this level to 2,5%, thus leaving a soil of very good conditions for this type of Energy crops.

4.1 Calculation of available fertilizer

4.1.1 Organic matter in the soil

As mentioned in the introduction, we want to increase the amount of organic matter in the soil to 2,5%, for this we must know the amount of manure needed to previously have the soil.

For this calculation the top 40cm of the soil of the 1ha plot is chosen, this is a total of;

$$\text{Soil volume} = 4.000\ m^3$$

This soil volume calculated at a density of 1.8 t / m3;

$$4000\ m^3 \times 1.8t / m^3 = 7.200t$$

Of these 7.200 tons of soil only 1.8% is organic matter, this means that there will be 129,6 tons of organic matter already present in the soil.

4.1.2 Galgafarm dung

As mentioned at the beginning of the project, the GAIA foundation has two projects, Galgafarm and GAIA Ecovillage, the first project is a cow farm located one kilometer from the village, so we can take advantage of dung produced by cows. At present, this farm has a total of 45 adult cows,

$$1\text{ cow} \rightarrow 25\text{ to }40\text{ kg of dung / day}$$

If we choose an average value of 30 kg of dung per day and per cow, we obtain;

$$45\text{ cows} \times 30\text{ kg} = 1350\text{ kg / day}$$

To this amount of dung per day it is necessary to subtract 60% of humidity to him;

$$1350\text{ kg / day} - 60\% = 360\text{ kg / day}$$

The result is 360 kg every day, so that at the end of a year, Galgafarm will produce a total of 132 tons of dung per year.

4.1.3 Calculation of necessary dung

In the above calculations we observe that the organic matter of the soil is 1,8% (= 129,6 to) so to increase that percentage to 2,5% we will have to contribute a certain amount, for this we first calculate the organic matter Needed in tonnes to reach that percentage.

7200t x 2,5% = 180t organic matter

If the soil already has an amount of 129,6 t;

Organic matter required = 180 t - 129,6 t = 50,4 t

Therefore, before the planting of energy crops, a contribution of 50,4 tons of dung from the 45 cows on the farm of Galgafarm will have to be made.

5. Operations to be carried out after planting

5.1 Planting time

The ideal period of planting is once the strong frost is analyzed, that is to say, in the months of February-March and can be extended to March-April by the use of sticks preserved in cold. The stakes are taken to the field in packs of 100 stakes for better handling. The implantation should be done as vertical as possible and with the buds facing upwards. In addition, it is convenient to carry out, after implantation, a first irrigation for a suitable settlement in the soil. Once the soil is wet and the material is settled, it is advisable to have two buds in the aerial part. The planting can be carried out manually by obtaining yields of 1.200 - 1.300 stakes per day, or planters machines both forestry and agriculture, which greatly increase yield.

5.2 Control of weed

The control of the herbaceous vegetation is a practice that is essential for the correct establishment of the plantation and for its later development until the maturity. It is not only motivated by the decrease in terms of production can lead to this vegetation, as they compete for the use of water and nutrients, but also to the intense competition that is established in the first year by space and light, to be able to drown the development of the young plants and make the crop unviable.

This need for control should be continued immediately after establishing the plantation. The most efficient method is the use of residual herbicides that provide a temporary advantage to the poplar plants, in such a way that they can acquire a size that is clearly competitive against the population of weeds. But the use of these chemicals does not fit the philosophy of the ecovillage, so other methods of control, such as the use of tasks in a mechanized way, may be less effective in that they do not allow the elimination of the herb. Within the zone near the tree, which can force to resort to a manual weeding.

The application of herbicides requires that the buds are closed at the time of application, since there are no selective herbicides available for use in poplars. Although active substances that have been shown to be suitable for use immediately before sprouting in these species are diverse, the registration of plant protection products authorizes a single active substance, oxyfluorfen, with a persistence ranging from 3 to 5 months depending on the type of soil and provided that the film that the herbicide forms on the ground is not altered, either by adverse meteorological factors after application (rain or hail) or mechanical (footprints, tractor passes, etc.). According to VADEMECUM defines Oxyfluorfen, with residual activity and slight effect also by contact, is absorbed by the plant (epicylate, hypocotyl and leaves), acting on foliar meristematic tissues and controls a wide range of dicotyledonous and monocotyledonous species. The same active material can be presented under different brand names, to be able to vary the support and the additives that accompany it, and therefore to present different commercial names.

Once the planting phase is over, and except for very specific problems, a new application of herbicides will not be necessary, because the high growth rate of the poplar, together with the high density of the crop, produces a high percentage of shading over land. However, if there are problems of persistent invasion that after a correct assessment of the threshold of damage made it advisable to intervene, it is possible to resort to mechanical weeding or applications directed with the active substance glyphosate, authorized for use in forestry operations, always taking into account that it is a total and systemic herbicide, and therefore it is necessary to protect the crop.

The control of weeds through the use of herbicides requires compliance with basic rules that guarantee the effectiveness of the treatment through the proper application of the product (suitable machinery, correct dose, etc.), as well as guaranteeing safety for the applicator (adequate protection) and respect for the environment (improper disposal, disposal of packaging, etc.).

This technique does not coincide with the philosophy of the ecovillage, so two solutions are proposed.

In recent years, specific machinery has been developed for the mechanical control of weeds in Northern Europe. Weedler is an example of that (www.salix.se). However, its characteristics limit it to a specific plantation framework. Carrying out a work with a wheel tractor with discs also allows to eliminate the weeds [Figure 5] , to emphasize the trees in windy zones, and, additionally, to leave buried the dripping pipe if there was one, which can contribute to minimize losses by evaporation of the contributed water.

Figure 5 - Grass removal machinery

The other alternative is the use of plastic covers, similar to those used in horticultural crops. This type of roof, regardless of its economic value, is generally suitable for the control of annual species.

5.3 Replenishment of trees

If planting success is judged to be scarce, between 10% and 15% of trees, which may have happened for various reasons (poor conservation of the crop, poor choice of planting time, unsuitability of the land, death By asphyxiation caused by weeds, etc.) it is not advisable to carry out replenishment in the following vegetative period, a practice that is usually common in plantations with a logging objective. The high planting density would imply a strong competitive disadvantage of the new cuttings in a plantation that already has a vegetative period, which would lead to a new failure. In this case there are two possibilities:

- Assume a major production loss
- Raise and reinstall the plantation. If the percentage of dead trees exceeds 15% it is advisable to re-plant.

When there is no significant loss in the number of plants installed, but rather low growth due to inadequate control of weeds, a cut will be made at the end of the first vegetative period that offers the possibility of repairing this ineffective control. The growth in this vegetative period will have the advantage of plants that will take a year of root development.

At the same time the cut material, shoots of a year, can be used to make cuttings to be used in a new plantation, which helps to diversify the production of biomass and therefore the income obtained by it.

5.4 Fertilization

As mentioned in the previous sections, the response of plantations to fertilization depends on a multiple set of factors acting in an interrelated way: land type, initial nutrient content, soil moisture content, seed bank in the land, time and system of application, etc. It is necessary to do a previous analysis both land and foliar before to make a fertilization rationally.

Once the bottom fertilizer has been used to prepare the land, it may be necessary to apply nitrogen on the cover once the crop is already installed, if the content is considered insufficient on the basis of the above analyzes.

In order to reduce the economic and environmental costs, it is necessary to take into account that the contributions provided by the fall of leaves at the end of the vegetative period contribute to the recirculation of nutrients, which reduces the dependence of fertilizers.

According to Domínguez (1997), poplar plants with concentrations in leaves below those that appear in the table 1, would show nutritional deficiency, which may imply the need to use complex fertilizers.

Element	%
Nitrogen (N)	2,2
Phosphorus (P)	0,17
Potassium (K)	1,3
Calcium (Ca)	0,2
Magnesium (Mg)	0,15

Table 1 - Nutritional deficiency according to Domínguez (1997)

The type of machinery available will determine the fertilizer application system, and can be distributed in the total area, in the crop bands (optimizing the product), or dosed in the irrigation water, allowing a uniform distribution that the irrigation system is drip irrigation.

The solution that will be adapted in this study is the application of irrigation by waste water coming from the homes of the ecovillage, these waters are rich in organic matters, so it is a possibility of reducing fertilization.

5.5 Irrigation

In general terms the highly productive species and hybrids of the genus Populus are characterized by a marked hygrophilia. On the other hand, rainfall maps Segun Hungaria Meteorology Service (http://www.met.hu/en/idojaras/aktualis_idojaras/muhold/) precipitations are scarce, and are around of 500 and 600 mm annually. They are concentrated, above all, in the summer, which is the rainiest season. However, thanks to the low temperatures, there are no periods of aridity. It is detailed with more extension in point 2. With a seasonal distribution which is not favorable for poplar, implies important limitations to the development of the crop without the use of regular irrigations during a good part of the vegetative period.

Among the irrigation systems to be used, the application of gravity irrigation (through gutters, etc.), which may initially appear to be more economical, undoubtedly implies inadequate water consumption, while at the same time favoring other unwanted effects such as increased nutrient washing or increased weed proliferation.

Sprinkler irrigation is inadequate in these types of plantations when the plants reach a high size in a short time. Likewise, it can favor the propagation of pests and diseases, by facilitating a high degree of humidity that is also increased by the high density of the plantation.

The solution selected in the present study is drip irrigation (low flow and high frequency), despite its higher initial cost of installation, and the possible discomfort when cutting, presents different advantages. These include saving water consumption by reducing the volume of soil wetted around 35%, which prevents losses by evaporation, less soil nutrient washing, as well as favor the lesser presence of competing weeds. In parallel, this irrigation system allows the application of fertilizer through it, which is commonly known as fertigation. The disadvantage attributed to drip irrigation in Hungary is the possibility of causing tree misalignment when important winds occur, favoring the development of a more superficial root system, since Hungary is characterized as being a windy zone. However, this is not considered important when the poplar is grown in high density and short rotation, and our experience points to a good behavior of the crop under this irrigation system. A possible solution is the use of street cleaning machinery that allows the routing of the rows, could solve this inconvenience while leaving the dripping pipe buried and facilitates the cutting tasks.

The volumen of the flows to be applied will be very variable and dependent. It is always desirable that the amount of water to be applied is calculated according to the potential evapotranspiration (ETP) and the crop coefficient, thus seeking a greater efficiency in the use of water.

6. Control of biotic and abiotic damages

Crop protection encompasses all those fundamentally biological causes that cause loss or decrease in plant production, study how these causes act and how to reduce or avoid these effects (Laborda, 2010)

The presence of plagues or diseases that cause significant losses of foliage during the vegetative period or significant perforations in the wood, can have very negative repercussions in terms of production.

In this class of crops what we want to get from them is biomass, that is why we do not worry too much about insects, fungi, etc, which can produce stains on stems and leaves of the herbaceous plants or on the leaves and trunk of trees. The most important thing to keep in mind, are the plagues that can cause the plant to die, and the most dangerous periods are in the herbaceous plants when the shoots start to emerge after planting and in the trees after the initial planting and later on.

Since in Hungary the number of hectares with this productive purpose is scarce at this moment, as detailed in point 7.2.3, we have to refer to the main phytosanitary problems in Europe for this type of plantations as well as the main plagues or diseases of these crops for wood and which may have importance in this mode of cultivation.

The family of the Salicacea, the species chosen in point 9.2, presents insects that can affect the yield of the growth of these plants or even the death, so much attention must be paid, these are;

- *Populus sp* (Poplar);

Megaplatypus mutatus; Fam: Platypodidae. Order: Coleopterous

Insect xylomycephagus that is present in many species of forest interest (polyphitochore), attacks developed plants. They realize internal galleries in the main trunk or thick branches, in the form of spiral and arranged of perpendicular way to the longitudinal axis of the shaft. Their larvae and adults live inside the trunk, are not fed by wood, but a group of fungi called

"Ambrosia" that develop in the galleries. It does not cause the plant to die but its performance decreases. The wind can cause the breakage of the branches.

Gen.y sp. Stenodontes spinibarbis N.V. “Large drill”

Fam: Cerambycidae.

Order: Coleóptera.

They attack poplars, willows and other species of forest interest. Adults are large beetles measuring 6 to 6,5 cm. They appear in December and January. The damage is done by larvae that produce large internal galleries, parallel to the longitudinal axis of trunks and branches. It is necessary to maintain the vigor of plants to reduce the probability of attack. Wood for carpentry loses its commercial value.

Gen.y sp. Megacyllene spinifera N.V. “Taladro”

Fam: Cerambycidae.

Order: Coleóptera.

Drill that attacks branches and logs. Its main hosts are species of the genus Prosopis, although it can be found in other forest species, including Pópulus sp. Adults are very active, appearing in late summer and early fall, they are grayish-brown with transverse stripes resembling a yellowish-colored W with dark edges. The larvae measure between 1,8 and 2,5 cm in length. They perform irregular galleries in the trunk, which can become numerous, with a large production of fine sawdust.

Gen.y sp. Hylesia nigricans N.V. “Burning bug”

Fam:Hemileucidae.

Order: Lepidóptera.

Defoliate butterfly of Salicáceas and other forest species (polyphithophaga). Causes shrinkage in the potential yield of the tree. In control can be realized by chemical products, like the pyrethroids and by Bacillus thuringiensis that is efficient in the fourth and fifth stage of the larva.

Gen.y sp. Automeris viridescens N.V. “Big burner bug”

Fam: Hemileucidae.

Order: Lepidóptera.

Insect defoliator lepidoptera of Salicaceae and other forest species. The larvae are large, with stinging hairs, emerge in spring and buzz in the trunk. They have a wintering cocoon.

Gen.y sp. Oiketicus platensis

Fam: Psychidae.

Order: Lepidóptera.

Lepidoptera of crepuscular or nocturnal habits whose larva feeds on leaves of a large number of broadleaf (polyphitochore) forest species, the poplar, willow, ash, white acacia, maple, including ornamental shrubs are very attacked. Chemical and biological controls are needed.

Gen.y sp. Pemphigus populitransversus N.V.

Fam: Eriosomatidae.

Order: Hemiptera1

Greenfly that causes the formation of subglobular galls with a transverse orifice and located in the petiole of the leaves of Pópulus sp. When the gills, which is the colony of this insect, break, release individuals who are dispersed on the plant. The damage is caused by the sucking sap. They produce defoliation.

Gen.y sp. Melodoigyne incógnita

Fam:Heteroderidae.

Type: Remata.

Nematode can be found on the ground. Causes decay of the branches, and can cause the death of the plants. The species susceptible to its attack are willow-poplar, poplar and hybrid willow. It is recommended to cultivate the susceptible species in low and flooded lands, where the nematode does not progress.

- In *Salix sp* (Willow):

Gen.y sp. Nematus oligospilus (desantissi) N.V. “Wasp of willow”

Fam: Tenthredinidae.

Order: Hymenóptera.

It attacks willows, producing severe defoliations. Winter spends like wintering larvae on the ground. The adult female emerges in early spring, apparently in coincidence with the foliation of the willows. Biological and chemical controls are needed. Monitoring with yellow glue traps is recommended.

Gen.y sp. Tuberolachus salignus N.V. “Giant Willow Agar”

Fam: Aphididae

Order: Hemiptera1

Large greenfly, reaching 5 mm, gray ash color, with presence of a dorsal root tuber conical in the abdomen (differential character). It is observed periodically on branches of 1 or 2 years of willow. They also are in cutting and in wicker plantations.

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- MODULE 1: RENEWABLE ENERGY AND LOCAL DEVELOPMENT, CHAPTER 4. Development in rural areas, Subchapter 4.3. Social sustainability and development. Living and working in rural areas

Annex VI ;

Irrigation installation of energy crops

Index

1. Introduction

In this section of the work the necessary calculations will be made for the calculation of the water needs of the energy crops, in this specific case of the species *Populus sp* and *Salix sp*, with the density of planting previously proposed in the plot of the village and property of the GAIA foundation. To do this, the calculation method used and the source of the data used will be explained, with the respective calculation formulas.

2. Method of calculation

To measure an irrigation system, the first step is to calculate the water needs of the chosen species, ie the amount of water that must be supplied daily to keep them in full production.

There are several possibilities for its calculation, however, in this case has been selected the CROPWAT program developed by the FAO and of free use to evaluate the water needs. This program calculates the water requirements according to the climatic data of the zone, rainfall data, the type of soil and the type of plants, thus proposing a model that takes into account the variability of these parameters in time, which leads to fairly realistic values.

Climatic and rainfall data can be obtained from the CLIMWAT database also developed by FAO. The CLIMWAT database contains real data on maximum and minimum temperatures, evapotranspiration and rainfall in a multitude of countries, and within each one there are different climatic stations, which allow obtaining more accurate and real data. On the other hand, to select the type of soil and type of plant, CROPWAT has its own database, in which a specific soil type and a particular crop can be selected. However, the program has the advantage of being able to modify data from that previous database. In addition, it is also necessary to enter a planting date, so CROPWAT is able to determine when the crop coefficient (Kc) will be higher.

For this project, CLIMWAT data for the country of Hungary have been selected, namely two stations located east and north of the city of Budapest, since it is the closest to the study area (Figure 1). Located in the coordinates 19,18º Longitude and 47,43º Latitude to 139 meters on the level of the sea and 20,78º Longitude and 48,1 Latitude to 233 meters on the level of the sea.

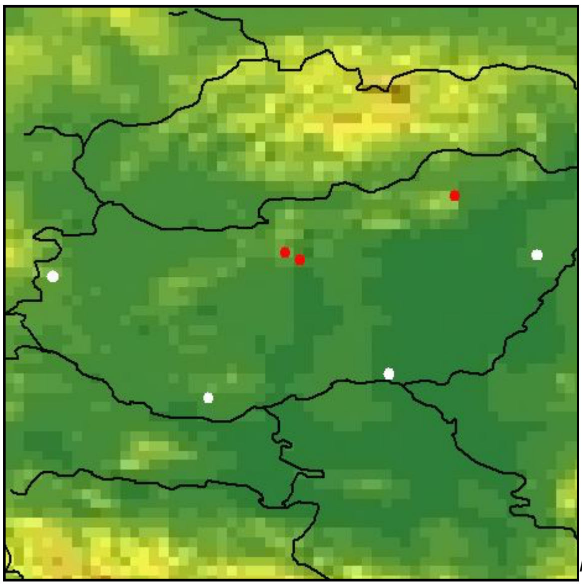


Figure 1 - Satellite map of Climwat stations in Hungary

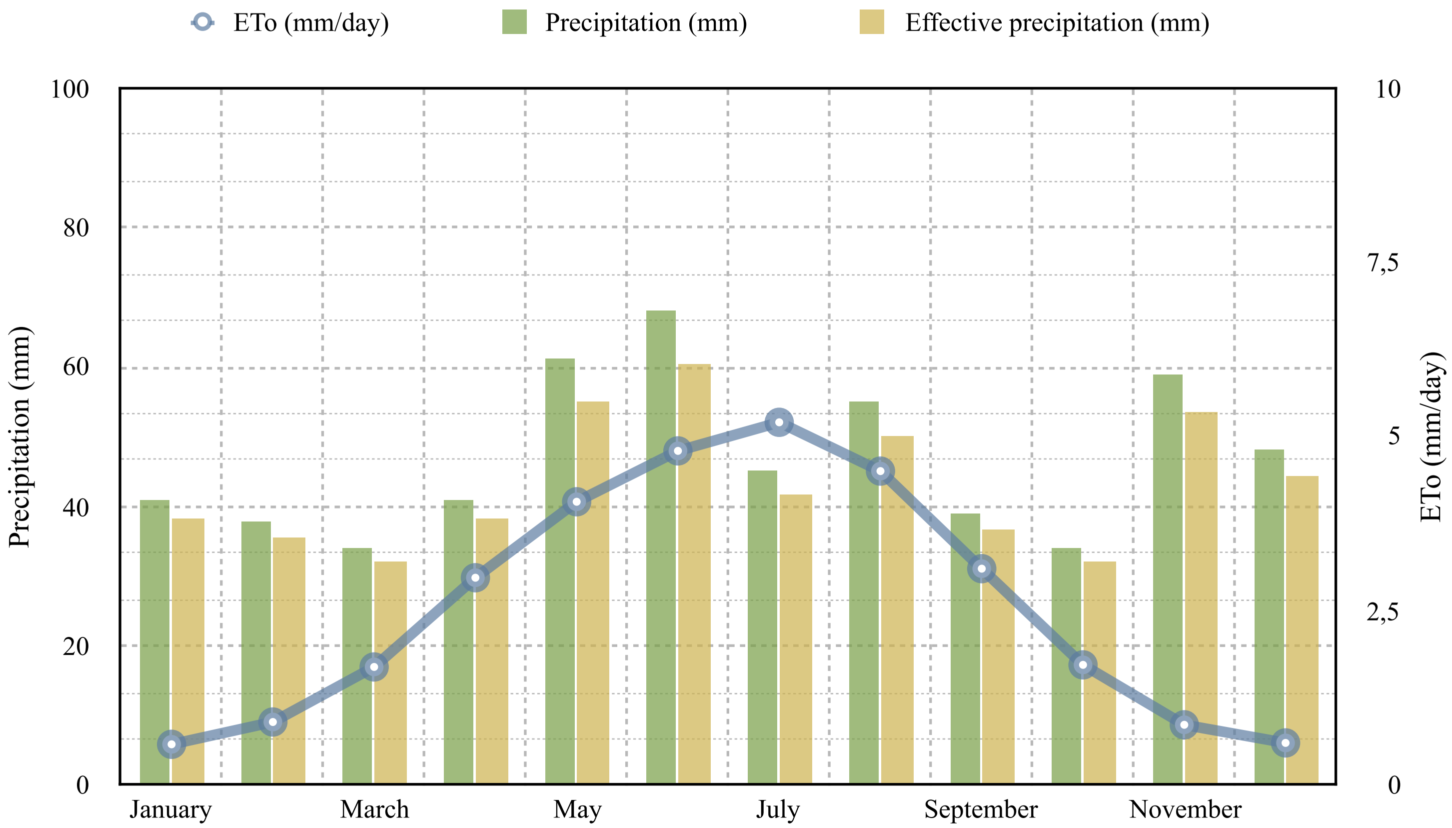
3. Water requirements

Water requirements have been calculated jointly for the two crop species used, and then the total water requirements are proposed for a plot of 10.000 m^2 which are the dimensions of the study plot.

The CROPWAT program calculates the net water requirements of decadal and daily crops according to climatic, pluviometric factors, date of planting and crop coefficients in each plant development period, therefore, the data obtained are quite accurate .

The data selected for the calculation of common water needs in the three crops were: climatic and rainfall data from CLIMWAT of the Budapest city station (Hungary); The type of free soil, since several soil analyzes were carried out with samples of the plot in which it was to be cultivated and it was obtained that it was a free soil and the date of first planting in spring.

Below is a graph showing the reference evapotranspirations and monthly precipitation at the Budapest station.



Graph 1 - Data table of the study area

In the graph above we can see that in this area of northern Hungary there are no dry seasons, as the rains are low but constant throughout the year. The maximum rainfall occurs in late spring and early summer, where temperatures are higher and also evotranspiration. The problem presented in this study is whether rainfall is sufficient for a good performance of energy crops.

3.1 Efficiency of application

The data offered by CROPWAT are the net irrigation needs (NRn) calculated by the balance between inputs and water losses. However, the irrigation water supply has an efficiency (Ea) that never reaches 100%, since in the application of the same can present losses due to increased irrigation to compensate saline waters, losses by deep percolation or compensation losses of deficiency in the homogeneous distribution of water. This fact gives rise to the fact that the water that must be contributed in the irrigation, that is to say, the total irrigation needs (NRt) is always greater than the NRn.

In this section we will calculate the irrigation efficiency in the study plot. Thus, the relationship between the three variables is as follows:

$$NRt = \frac{NRn}{Ea}$$ Equation 1

where;

NRt = Total irrigation needs (volume of water to be applied) [mm]

NRn = Net irrigation needs [mm]

Ea = Application efficiency [-]

The parameters on which the Ea depends are:

$$Ea = Rp \cdot Fl \cdot CU$$ Equation 2

Where;

Rp = Percolation ratio [-]

FL = Washing factor [-]

CU = Uniformity coefficient [-]

Then, each of these parameters will be calculated if necessary.

• **Percolation relationship.** This parameter estimates the amount of water infiltrating the soil below the

- Depth of roots. It depends on three factors:
- Type of soil: Loamy
- Climate: humid (see Annex II), therefore it will be taken as arid.
- Depth of roots: between 75 and 150 cm (ROSELLÓ, (2014a, 2014b and 2014c))

Based on these data, Table 1 gives the value of Rp:

Valores de R_p

CLIMAS ARIDOS				
Profundidad radicular (cm)	Textura			
	Gravosa	Gruesa	Media	Fina
< 75 cm	0.85	0.90	0.95	0.95
75 a 150	0.90	0.90	0.95	0.95
> 150	0.95	0.95	1.00[1]	1.00

CLIMAS HUMEDOS				
Profundidad radicular (cm)	Textura			
	Gravosa	Gruesa	Media	Fina
< 75	0.65	0.75	0.85	0.90
75 a 150	0.75	0.80	0.90	0.95
> 150	0.85	0.90	0.95	1.00

Rp = 0,95

Table 1 - Rp values with different situations

• Washing factor.

During the stay in Gyöngyös (Hungary) documentation was reviewed and the different technicians were asked about possible problems of salts in the soil, at all times the answer was no, since they are land owned by the foundation that have never been worked with other types of crops . For this reason, the washing factor is not to be taken into account for the calculation of efficacy.

• Coefficient of Uniformity.

When designing the irrigation should be imposed uniformity of the same, thus avoiding that areas of the plot remain without irrigation. For this reason, high CU that involving precise installations should be adopted.

Emisores	Pendiente suelo	CU	
		Clima árido	Clima húmedo
Espaciados más de 4 m. en cultivos permanentes	Uniforme (< 2%)	0.90-0.95	0.80-0.85
	Uniforme (> 2%) u ondulada	0.85-0.90	0.75-0.80
Espaciados menos de 2.5 m. en cultivos permanentes o semipermanentes	Uniforme (< 2%)	0.85-0.90	0.75-0.80
	Uniforme (> 2%) u ondulada	0.80-0.90	0.70-0.80
Tuberías porosas en cultivos anuales	Uniforme (< 2%)	0.80-0.90	0.70-0.80
	Uniforme (> 2%) u ondulada	0.70-0.85	0.65-0.75

Table 2 - CU values with different situations

Based on the table of recommended CU values and knowing the characteristics of the irrigation system (emitters spaced less than 2.5 m, there is no slope and humid climate) the recommended CU is between 0.75-0.80. To assure the water requirements of the crops, the most restrictive value is taken:

Therefore, with calculated Rp and CU, and applying Equation 2, we obtain that the Ea for the plot of the GAIA foundation;

$$Ea = 0{,}95 \times 0{,}8 = 0{,}76$$

The application efficiency will be 76%.

3.2 Calculation of water requirements

	Decada	ETc (mm/day)	ETc (mm/dec.)	Effec. Prec. (mm/dec.)	Irrigation (mm/dec.)
March	1	1,66	16,6	10,8	5,7
March	2	1,96	19,6	10,3	9,3
March	3	2,45	26,9	11,1	15,8
April	1	2,93	29,3	11,8	17,6
April	2	3,3	33	12,3	20,7
April	3	3,45	34,5	14,3	20,2
May	1	3,55	35,5	16,8	18,7
May	2	3,6	36	18,8	17,1
May	3	3,47	38,2	19,3	18,9
June	1	3,33	29,9	18,3	9,6
June	2	3,36	20,2	12,8	9,5
June	3	3,46	34,6	18,8	15,7
July	1	3,6	36	15,2	20,8
July	2	3,72	37	12,7	26,5
July	3	3,53	38,9	14	24,8
August	1	3,32	33,2	16,5	16,8
August	2	3,16	31,6	17,7	14
August	3	2,83	31,1	15,9	15,4
September	1	2,5	25	13,4	11,8
September	2	2,22	22,2	11,8	11
September	3	2,01	20,1	11,4	8,7
October	1	1,76	17,6	10,4	7,2
October	2	1,47	14,7	9,5	5,2
October	3	1,29	14,2	12,3	2,5

Table 3 - CROPWAT results in the months needed for irrigation

Looking at the results table of the CROPWAT program, we observed that in July it is where the critical days for the correct growth of the crops are produced, so that the irrigation system is sized according to that critical day.

Total needs for the critical day;

Knowing that 26.5 mm of water need the plants every ten days in the critical month, so that 2.65 mm of water is required every day.

The plot of our study has a size of 10.000 m^2;

$$NRn = 10.000m^2 \times 2,65mm = 26500mm$$

26.500 mm of water to irrigate the whole plot on the critical days of the most critical month.

If we apply the equation number 1, we obtain total irrigation needs;

$$NRt = \frac{26.500mm}{0,76} = 30.868mm$$

A total of 30.868mm of water for the whole plot.

If 1mm = 1l / m^2, a total of 30,868 l is required to water during critical days.

4. Irrigation installation design

To project a system of irrigation located and that also works correctly is first of all a complex work, own of agricultural engineers and agronomists. However, in the following article we will give all the guidelines, so that at the end of this text, which will consist of several parts, the reader will be able to project a simple drip irrigation system with all its components.

The example with which we are going to illustrate the subject is a real project of transformation of irrigation carried out in a citrus farm in the province of Valencia. The calculations have been simplified to the maximum to facilitate the understanding of the case.

When designing a localized irrigation system, two phases are distinguished:

- Agronomic design, which based on plant production factors (climate, soil, plant, ...) will allow to know the flow of water needed to cover the water needs of the crop.

- Hydraulic design, that guarantees an optimum distribution of the above determined flow, by means of an optimum dimensioning of the irrigation network and the elements that compose it.

4.1 Agronomic design

Once the water needs are obtained and the calculation of irrigation needs, the next step is the calculation of the frequency, the irrigation time and the flow.

- Frequency and time of irrigation

One of the advantages of drip irrigation is the saving of water, precisely because it is not necessary to wet all the land as it happens in flood irrigation. The area to be wetted is equivalent to the plantation frame, knowing that citrus is recommended to wet 30-50% of the soil. The area wetted by the dropper varies according to the flow rate of the dropper and the texture of the soil. The flow rate of the droppers will be 4 L / h (at a lower flow rate, greater obstruction), and the approximate surface that dips a dropper is approximately a diameter of 1.25 m, although this data varies according to the texture of the floor. To avoid calculations we will use the tables of the integrated production regulations, designed for this purpose.

Our soil is of medium texture, a free soil, and a planting that will be around 20 years, with which we will use 6 drippers per tree. Recall that we will size the system to meet the needs of the crop in the worst season, the month of July, which according to the second table gives us a frequency of daily irrigation.

Figure 2 - CROPWAT results in the months needed for irrigation

Number of emitters per tree in drip irrigation.

Tipo de suelo				
Edad del arbol	Arcilloso	Franco	Arenoso	Gravoso
1 – 2	1	1	1 – 2	2
3 – 4	1	2	2 – 4	4
5 – 6	2	4	4 – 6	6
7 – 8	2 – 4	4 – 6	6 – 8	8
>8	4	6	8	8 – 12

Tipo de suelo				
Epoca	Arcilloso	Franco	Arenoso	Gravoso
PRIMAVERA	G- 2 V.P.S.	G- 3 V.P.S.	G- DIARIO	G- 1-2 V.P.D.
VERANO	G- 3 V.P.S.	G- DIARIO	G- DIARIO	G- 2-3 V.P.D.
OTOÑO	G- 2 V.P.S.	G- 3 V.P.S.	G- DIARIO	G- 1-2 V.P.D.

Table 4 - Table of number of emitters per tree in drip irrigation.

Frequency of irrigation recommended in localized systems.

V.P.S. ; Times per week

V.P.D. ; Times per day

G ; Drip irrigation system

MA ; Microwave irrigation system

But how much time do you have to water a day? For this we must know that each tree will consist of 6 droppers, 4 L / h, which will provide a total of 24 L / h. From here we obtain that:

Irrigation time (t) = 4,64 L plant and day / 24 L / h = 1.19 hours per day

Calculation of the flow

Finally, we calculate the flow needed to supply our area (1 ha), multiplying the needs per plant by the number of trees, which we know to be 5,500 (15,000 m^2 / 6 × 4):

4,64 L plant and day x 5.500 trees = 25.520 L / day for the 1 Ha

These data will serve as a starting point when dimensioning all the components of the installation in the second part of the project; The hydraulic design.

4.2 Hydraulic design

In the previous article we learned to calculate the flow needed to meet the water needs of the crop in the worst period of the year. Based on soil and climatic parameters. The next step we will design the layout of the distribution network of our irrigation system located. Our orange farm has a size of 10.000 x 10.000 meters. The water comes from a raft and is pumped from an irrigation head. From the pumping group there is an ascending slope of 2% and a slope of 0.1%.

Data	
Ascending slope	2 %
Side	0,1 %
Plot	10.000 m^2

Components of our distribution network

Primary pipe. It is responsible for conducting water from the head to each irrigation sector of our farm. The chosen material (PVC or PE), will depend on the results of the calculations that will be carried out later, taking into account that from 50 mm PVC is usually used, because it is more economical. PVC pipes are placed buried to protect them from sunlight.

Secondary pipes (PE). They conduct the water circulating through the primary to each unit of irrigation.

Tertiary pipes. Polyethylene (PE), arranged on the surface, perpendicular to the crop lines.

Irrigation port or lateral pipes. PE, are the pipes on which the drippers are inserted. They are arranged in parallel to the crop lines.

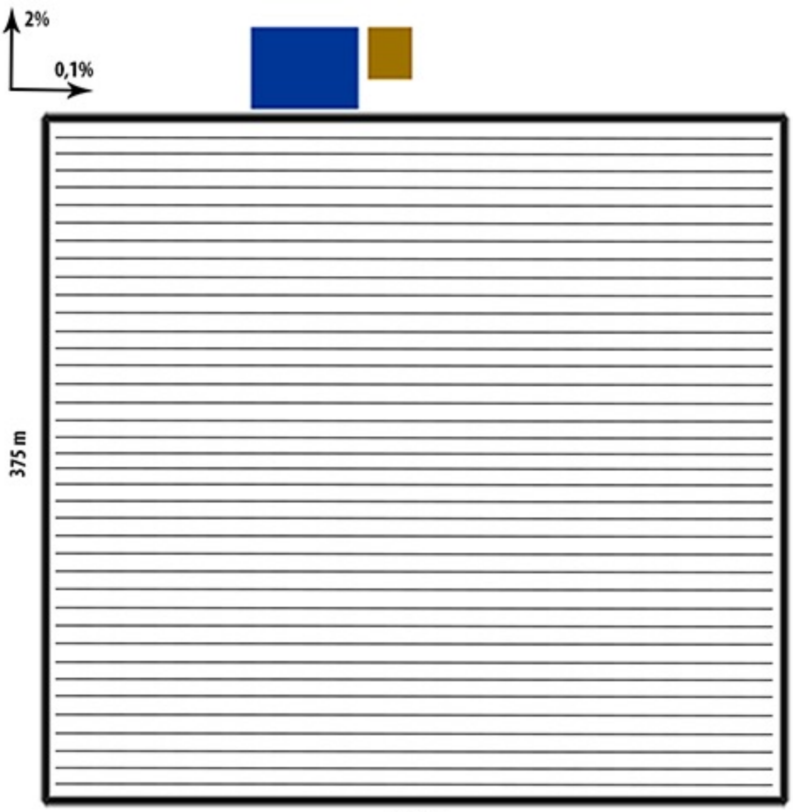
The size of the farm will determine how many branches we need to make. In small plots of less than one hectare, it may be sufficient to place the lateral pipes attached to a tertiary pipe and this to the hydrant, whereas in larger farms we must employ a greater branching. In flat plots the irrigation sides should never exceed 140 meters in length (100 meters in ascending slopes), as the load losses would be excessive and the drippers would not function properly due to excessive pressure differences between the first dropper and the last dropper.

For this reason, the large lengths will be covered by pipes of larger diameter, producing a lower pressure drop, instead of straightening the sides from the main one.

Design of the distribution network

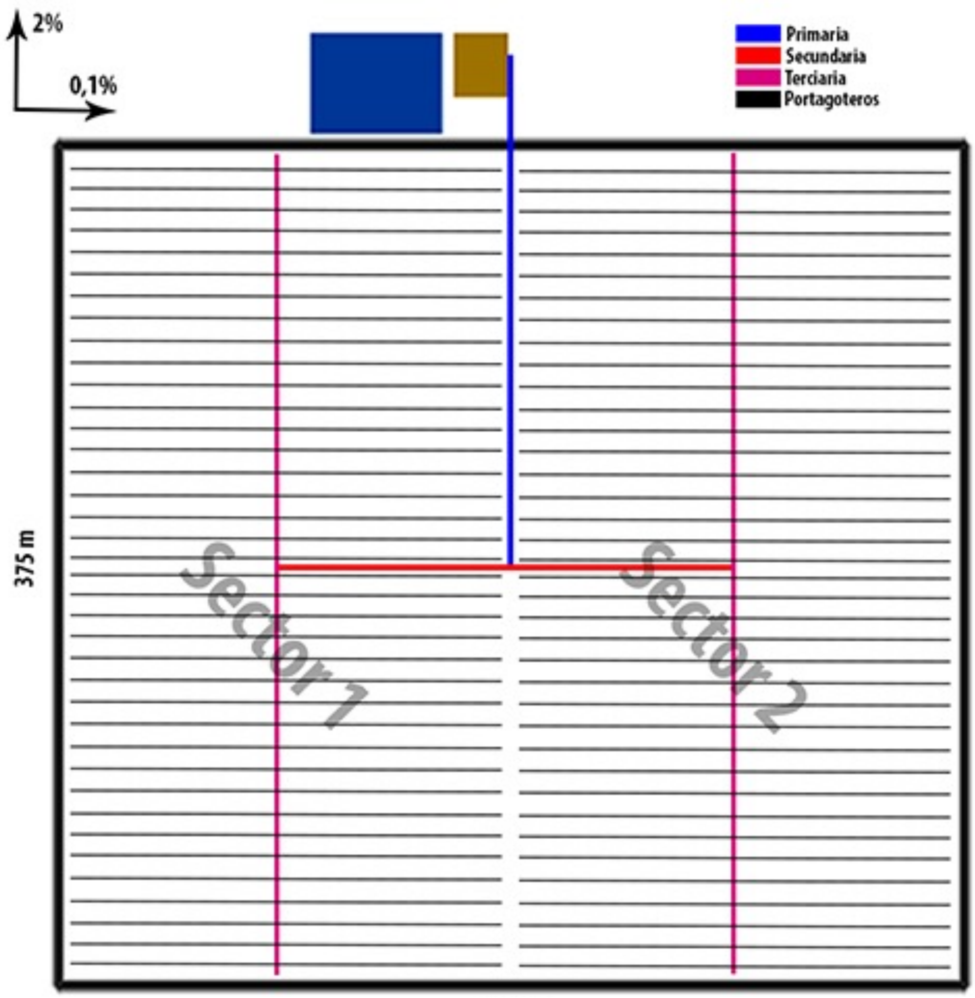
On a plane of known dimensions, we indicate the location of the water intake and note the slope of the plot. The slope is obtained by topographic methods (level, total station or GPS), although on small farms we can get an idea using the hose method. We have a hose filled with water from the hydrant towards the end of the ground. From the lower area, lift the hose until it stops flowing, taking into account that it must always be well filled with water. With one meter, we measure the height from the ground and obtain the slope depending on the length of the hose.

We start at the end, that is to say by the irrigation sides or pipes, that we have in the direction of the smaller slope, so that the differences of pressure in drippers are minimum. In our case the smallest slope is on the x-axis, ie from right to left.

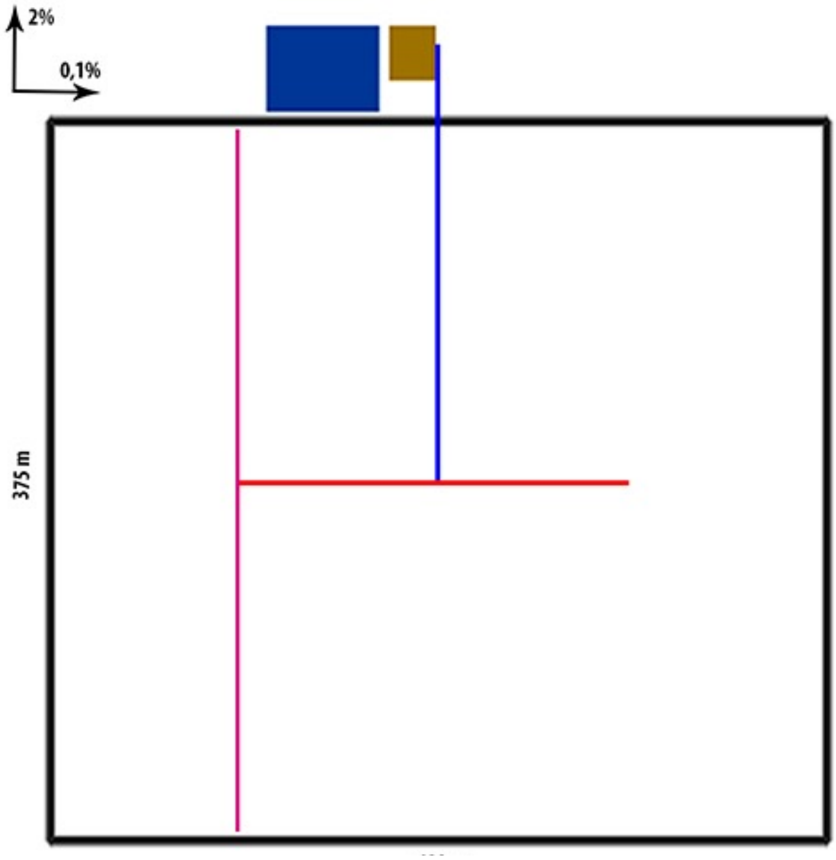


As we have seen previously, we must use lateral irrigation of 100 m at most, so that we divide the farm into segments of 100 meters, obtaining 4 in our case.

With this approach and we only have to join the sides with the irrigation head in the best possible way. Note that in the previous step we have also divided the farm horizontally, in two parts, as we will obtain a better behavior of the system joining the pipes by their midpoint, as shown below.



Firstly, we have tended the tertiaries that connect with the pipelines with drippers, then join the secondary with each tertiary pipe by its midpoint, and the primary as well as the secondary. In addition we have divided the farm into two sectors. The following image shows the final result of each section of the entire plot of 1 hectare.



Each of the two sectors will have, upstream, a pressure regulator, a pressure gauge, and a control key, allowing their isolation when necessary.

We will have self-compensating and anti-draining drippers, which give the same flow although slightly varying the pressure. They will be 4L / h and work at a nominal pressure of 10 m.c.a (1kg / cm^2 or 1 bar).

9. Bibliography

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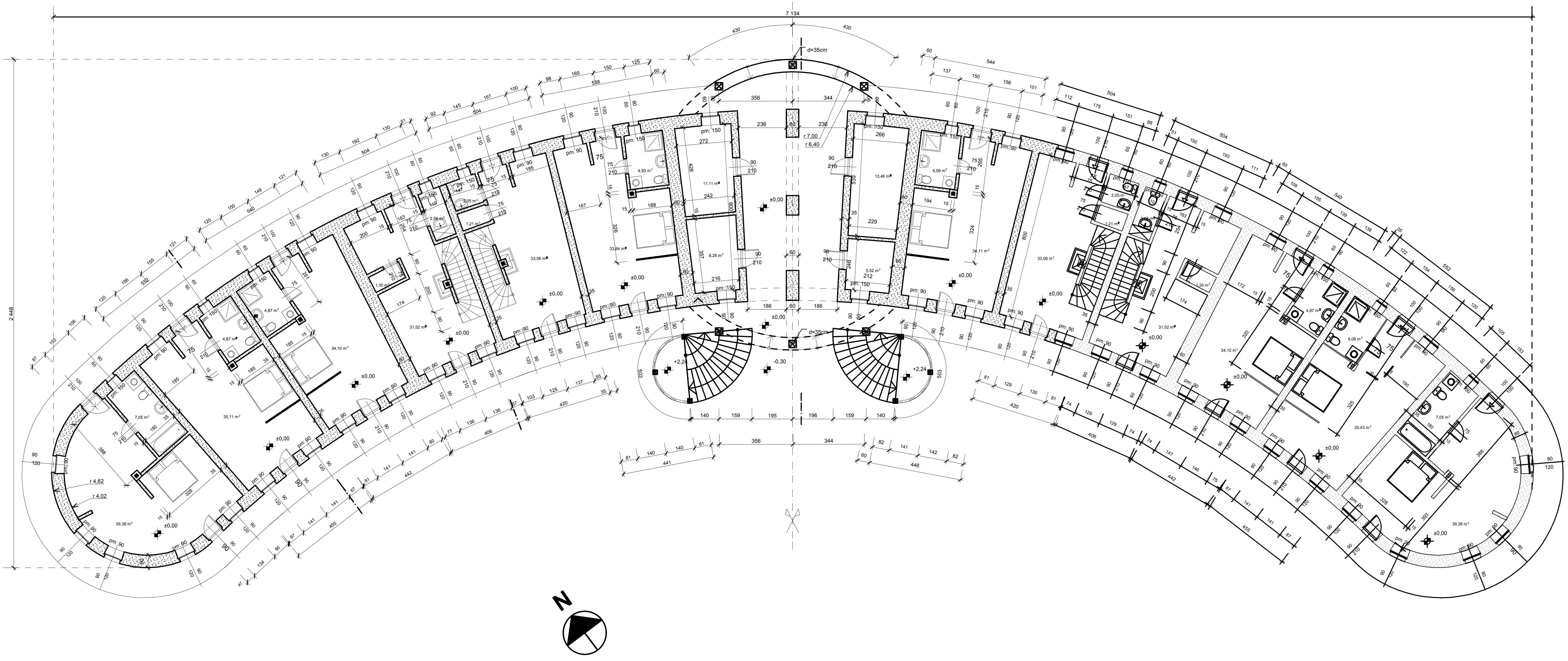
Plans

Index of plans



Project : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses

Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary

Plan Nº1

Escale 1:150

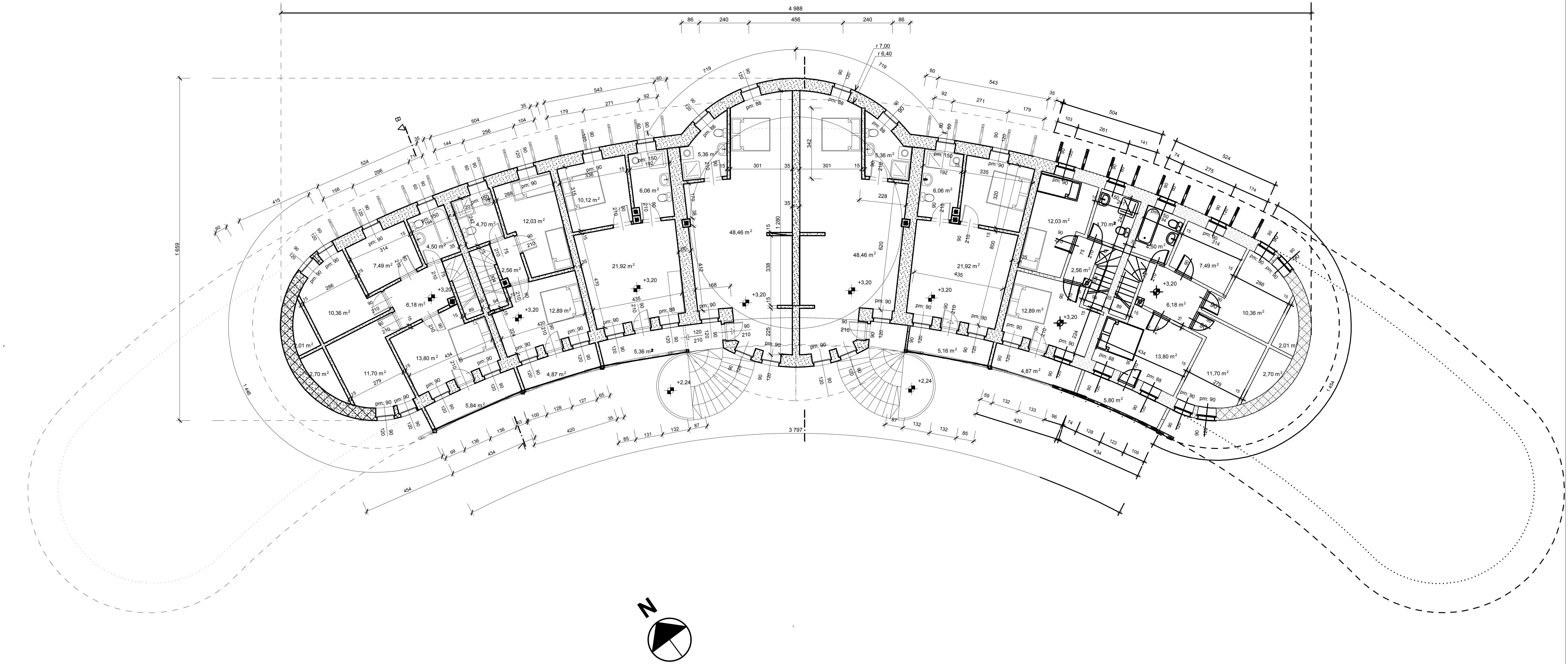
Plan : First floor of the building

Date: April 2017

Author : Gaia. Modified by Javi Castelló Mollar

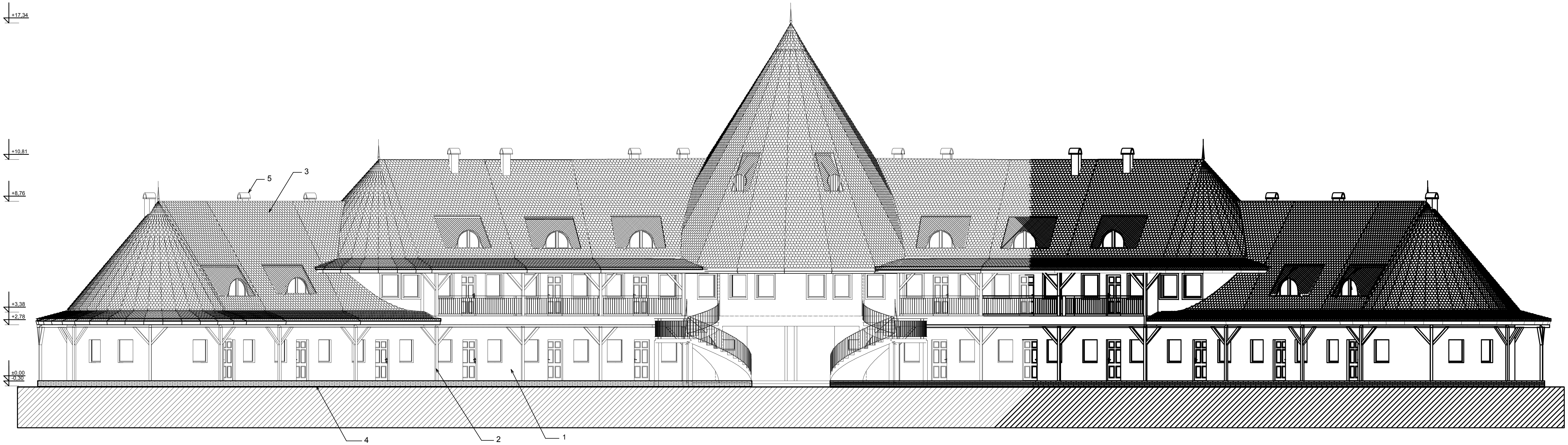
Unit: cm

UNIVERSITAT JAUME•I



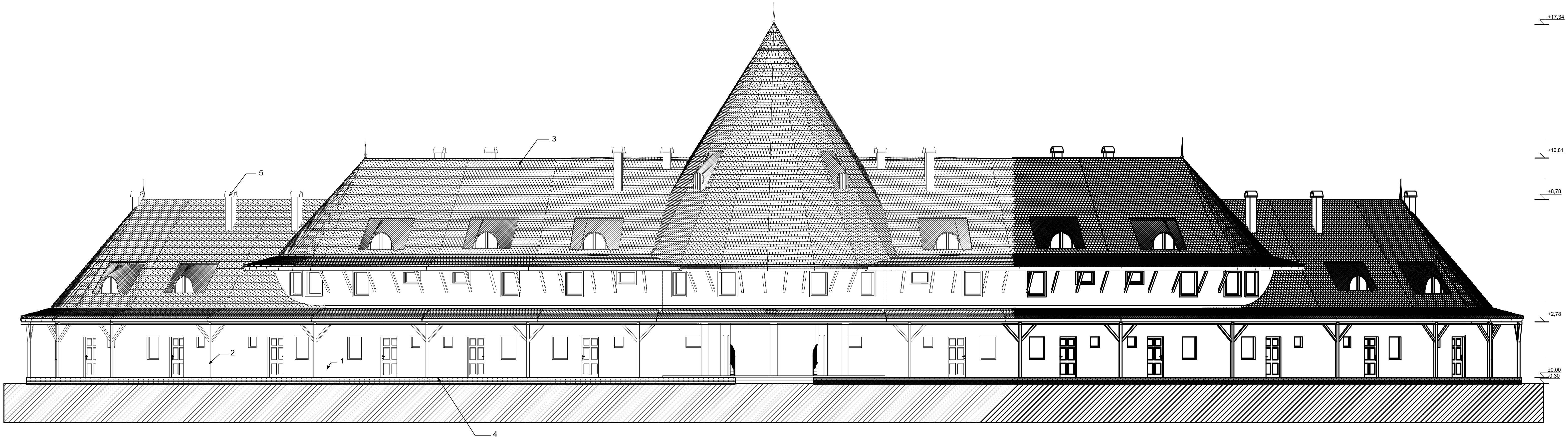
Project : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses		
Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary		Plan Nº2
Escale 1:150	**Plan** : Second floor of the building	Date: April 2017
	Author : Gaia. Modified by Javi Castelló Mollar	Unit: cm

UNIVERSITAT JAUME•I



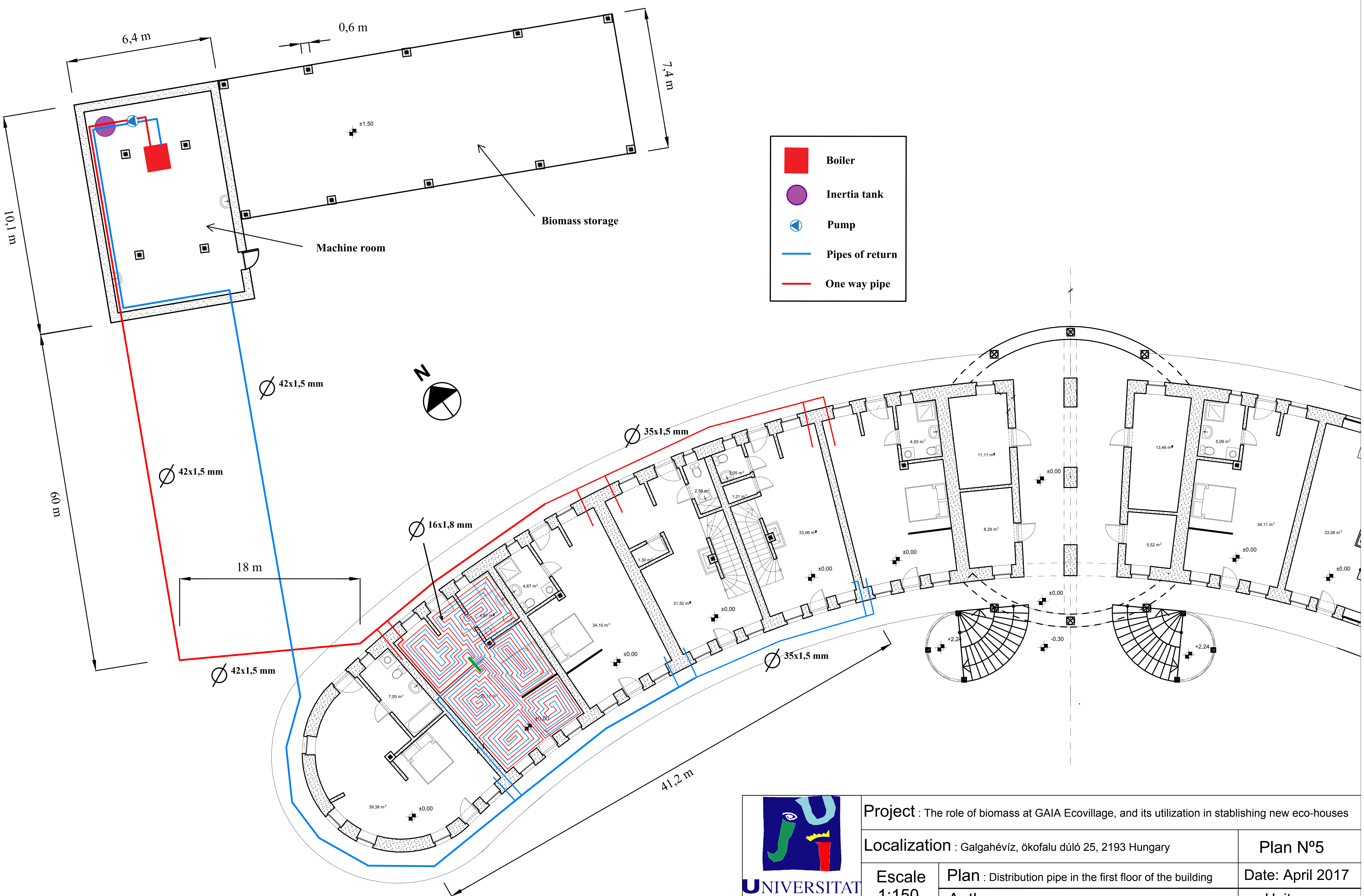
1 Wall
2 Posts of wood
3 Ceiling structures: Wooden boards
4 Masonry bricks
5 Chimney

UNIVERSITAT JAUME•I	**Project** : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses	
	Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary	Plan Nº3
	Escale 1:180 / **Plan** : Front of the building	Date: April 2017
	Author : Gaia, modified byJavi Castelló Mollar	Unit: m



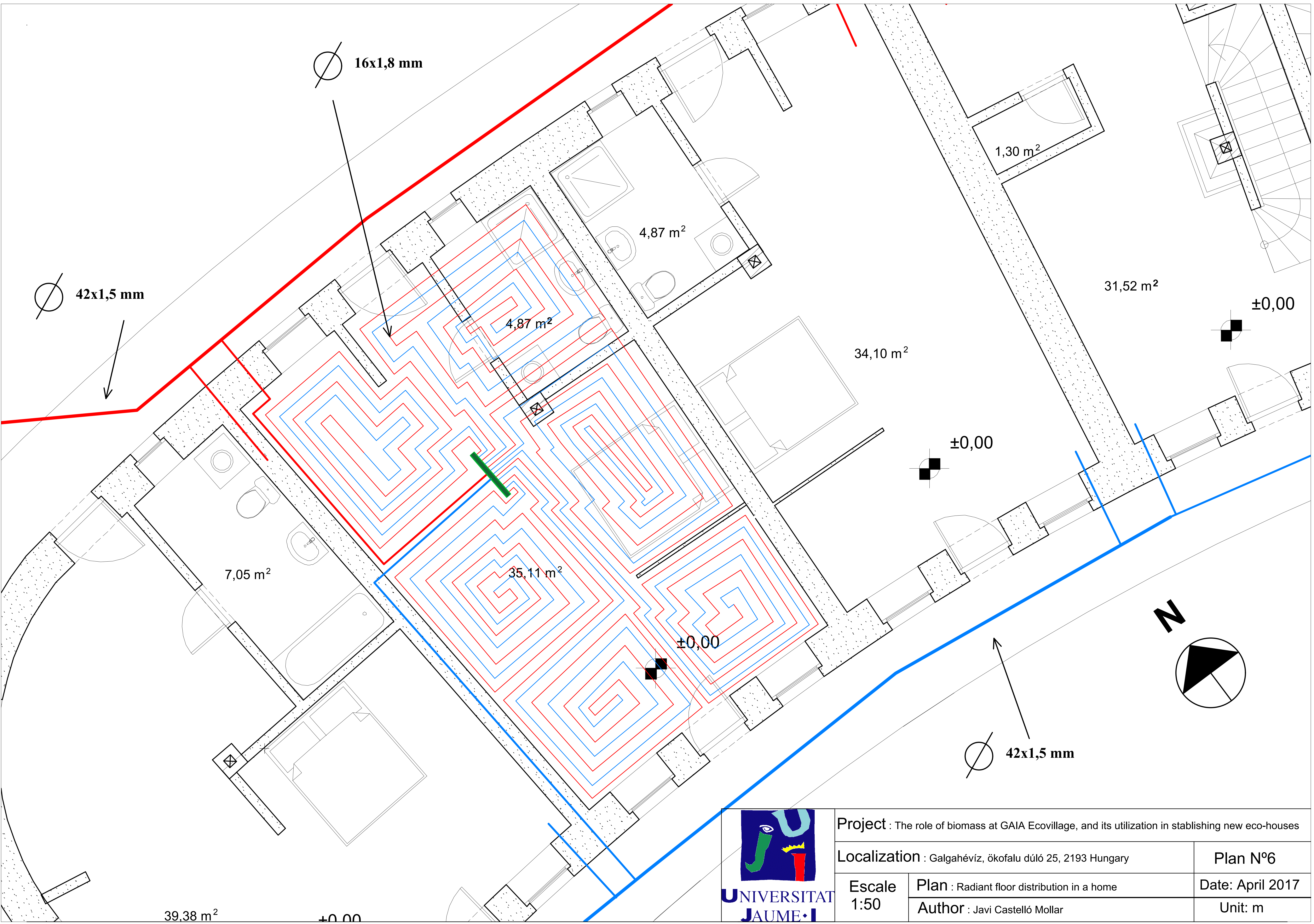
1 Wall
2 Posts of wood
3 Ceiling structures: Wooden boards
4 Masonry bricks
5 Chimney

UNIVERSITAT JAUME·I	**Project** : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses	
	Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary	Plan Nº4
Escale 1:180	**Plan** : Back of the building	Date: April 2017
	Author : Gaia, modified byJavi Castelló Mollar	Unit: m



Project : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses		
Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary		Plan Nº5
Escale 1:150	**Plan** : Distribution pipe in the first floor of the building	Date: April 2017
	Author : Javi Castelló Mollar	Unit: m

UNIVERSITAT JAUME•I



UNIVERSITAT JAUME·I

Project : The role of biomass at GAIA Ecovillage, and its utilization in stablishing new eco-houses

Localization : Galgahévíz, ökofalu dúló 25, 2193 Hungary

Plan Nº6

Escale 1:50

Plan : Radiant floor distribution in a home

Date: April 2017

Author : Javi Castelló Mollar

Unit: m

Terms and conditions

Index

1. Chapter 1; Elements of the machine room

- Unit of construction: PIPING FOR INTERIOR INSTALLATION.

MEASURES TO ENSURE THE COMPATIBILITY BETWEEN THE DIFFERENT PRODUCTS, ELEMENTS AND CONSTRUCTION SYSTEMS THAT COMPUTE THE WORK UNIT.

Avoid using different materials in the same installation.

TECHNICAL CHARACTERISTICS

Supply and installation of piping for interior installation, placed on the surface and fixed to the wall, formed by PE-X series 5 polyethylene tube, 25 mm outside diameter, PN = 6 atm and 2.3 mm thickness, Supplied in rolls. Even p / p of auxiliary material for assembly and subjection to the work, accessories and special pieces. Fully assembled, connected and tested by the installation company through the corresponding service tests (included in this price).

APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Measured length according to graphical Project documentation.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation and route correspond with those of Project, and that there is sufficient space for its installation.

-PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Staking and plotting. Placement and setting of tube and accesories. Performing service tests.

CONDITIONS OF TERMINATION.

The pipes will have closure plugs, placed at the points of exit of water, until the reception of the sanitary apparatuses and the taps.

SERVICE TESTS.

Test of mechanical resistance and watertightness.

Regulations of application:

- CTE. DB-HS Health.
- UNE-ENV 12108. Piping systems in plastic materials. Recommended practice for the installation inside the structure of the buildings of piping systems of hot and cold water intended for human consumption.

CONSERVATION AND MAINTENANCE.

It will protect against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The length actually executed according to the specifications of the Project will be measured.

- Unit of construction: BOILER FOR THE COMBUSTION OF WOOD.

TECHNICAL CHARACTERISTICS

Supply and installation of boiler for the combustion of splinters, nominal power from 12.1 to 55 kW, with welded steel body and pressure tested, 1590x710x1070 mm, insulation inside, combustion chamber with automatic burner system by means of a grill Tilting, vertical tube heat exchanger with automatic cleaning mechanism, ash collection and extraction system of the combustion module and removable ash deposit, combustion control with integrated probe, integrated control system with touch screen, for control Of the combustion, the ACS accumulator, the inertia tank, the return temperature rise system and the mixing valve for rapid heating circuit heating, anti-vibration support base, return temperature rise system Above 55 ° C, consisting of a motorized 3-way 5/4 "diameter valve and pump Circulation system, ash extraction system with flexible auger helical conveyor, galvanized steel ash drawer, 240 liters, for ash removal system with flexible auger helical conveyor, 200 mm diameter puller with anti-explosion clapper, connection antivibration for smoke ducts of 200 mm diameter, thermal safety limiter, calibrated at 95 ° C, not including the conduit to evacuate the products of the combustion that links the boiler with the chimney. Fully assembled, connected and commissioned by the installation company to verify its correct operation.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation corresponds to the one of Project and that the zone of location is completely finished and conditioned.

OF THE CONTRACTOR.

Coordinate the installer of the boiler with the installers of other installations that may affect its installation and the final assembly of the equipment.

- PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Stake out. Presentation of the elements. Assembly of the boiler and its accessories. Connection with the water, sanitation and electrical conduction networks, and with the conduit for the evacuation of the products of combustion. Start up.

CONDITIONS OF TERMINATION.

The boiler will be fixed solidly on bench or bench and with enough space around it to allow the cleaning and maintenance work.

CONSERVATION AND MAINTENANCE.

All elements will be protected from shocks, aggressive materials, dampness and dirt.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

- Unit of construction: INERTIA TANK

TECHNICAL CHARACTERISTICS

Supply and installation of combination tank model LM23 "LUMELCO", formed by 500 l inertia tank with coil and A.C.S. Of 250 l lined with thermosetting resin, height 2045 mm, diameter 950 mm, insulation of 50 mm thickness with high density polyurethane, CFC free, protection against corrosion by magnesium anode. Even cutting valves, mounting elements and other accessories necessary for its correct operation. Fully assembled and tested connections.

- MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that your situation corresponds to the one of Project and that the zone of location is completely finished.

PHASES OF EXECUTION.

Stake out. Placement of the accumulator. Connection.

CONSERVATION AND MAINTENANCE.

It will protect against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

- Unit of construction: CIRCULATION PUMP.

TECHNICAL CHARACTERISTICS

Supply and installation of centrifugal electric pump, cast iron, three-speed, with a power of 0.071 kW, technopolymer impeller, chromed steel motor shaft, 1 1/2 "male threaded holes, H-class insulation, for single-phase power supply 230 V. Even manometer bridge formed by manometer, ball valves and copper pipe, w / o of assembly elements, electrical junction box with condenser and other accessories necessary for its correct functioning. Fully assembled, connected and tested.

- APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that his situation corresponds to the one of Project.

PHASES OF EXECUTION.

Stake out. Placing the circulation pump. Connection to the distribution network.

CONSERVATION AND MAINTENANCE.

It will protect against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

2. Chapter 2; Radiating floor

- Unit of construction: WATER DISTRIBUTION PIPE.

MEASURES TO ENSURE THE COMPATIBILITY BETWEEN THE DIFFERENT PRODUCTS, ELEMENTS AND CONSTRUCTION SYSTEMS THAT COMPUTE THE WORK UNIT.

The pipe will not be welded under any circumstances to the fasteners, and an elastic ring must be fitted between the two. The pipe will not pass chimneys or ducts.

TECHNICAL CHARACTERISTICS

Supply and installation of hot water distribution pipes made of reticulated polyethylene (PE-X), oxygen barrier (EVOH), 40 mm outside diameter and 3,7 mm thick, PN = 6 atm , Supplied in rolls, placed superficially on the exterior of the building, insulated by means of a glass wool insulation protected with asphalt emulsion coated with protective paint for white insulation. Even p / p of auxiliary material for assembly and subjection to the work, accessories and special pieces. Fully assembled, connected and tested by the installation company through the corresponding service tests (included in this price).

- APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Measured length according to graphical Project documentation.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation and route correspond to those of Project, and that there is sufficient space for its installation.

- PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Stake out the path of pipes, fittings and special parts. Placement and fixing of pipes, accessories and special parts. Insulation placement. Application of insulation surface coating. Performing service tests.

CONDITIONS OF TERMINATION.

The facility will have mechanical strength. The set will be watertight.

SERVICE TESTS.

Test of mechanical resistance and watertightness.

Regulations of application:

• CTE. DB-HS Health.

• UNE-ENV 12108. Piping systems in plastic materials. Recommended practice for the installation inside the structure of the buildings of piping systems of hot and cold water intended for human consumption.

CONSERVATION AND MAINTENANCE.

It will protect against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The length actually executed according to the specifications of the Project will be measured.

- Unit of construction : HEATING SYSTEM BY RADIANT SOIL.

TECHNICAL CHARACTERISTICS

Supply and installation of underfloor heating system composed of polyethylene foam (PE) strip, 150x10 mm, thermal insulation with 40 mm thick rock wool, aluminum heat diffuser, 1150x185 mm, for 17 mm in diameter on wood screens and cross-linked polyethylene (PE-Xa) tube with oxygen barrier and modified polyethylene (PE) protection layer, 17 mm outside diameter and 2 mm thickness, including special parts. Fully assembled, connected and tested by the installation company through the corresponding service tests (included in this price).

- APPLICATION REGULATIONS

Installation: UNE-EN 1264-4. Underfloor heating. Systems and components. Part 4: Installation.

MEASUREMENT CRITERION IN PROJECT

Usable area, measured according to the graphic documentation of the Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation and route correspond with those of Project, and that there is sufficient space for its installation. It will be verified that all the partitions are raised and that the drainage network is finished

- PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Preparation and cleaning of the support surface. Staging of the installation. Fixing the perimeter socket. Placement of the panels. Installation of diffusers on screens. Stake out of the pipe. Placing and fixing the pipes. Performing service tests.

CONDITIONS OF TERMINATION.

The finished surface will have strength and flatness.

SERVICE TESTS.

Test of mechanical resistance and watertightness.

Application regulations: CTE. DB-HS Health

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The surface actually executed according to the specifications of the Project will be measured.

- Unit of construction: PRESSURE LIMITING VALVE.

TECHNICAL CHARACTERISTICS

Supply and installation of 1/2 "brass pressure relief valve DN 15 mm in diameter, maximum inlet pressure of 15 bar and outlet pressure adjustable between 0.5 and 4 bar, with two gate valves Cast brass and brass waste retainer, including pressure gauge, mounting elements and other accessories required for proper operation Fully assembled, connected and tested.

- APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that your situation corresponds to the one of Project and that the zone of location is completely finished.

- PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Stake out. Placing and connecting the stopcocks. Placing and connecting the filter. Placement and connection of the limiting valve.

CONDITIONS OF TERMINATION.

The drive shaft will be horizontal and aligned with that of the pipe.

CONSERVATION AND MAINTENANCE.

It will protect against blows.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

- Unit of construction: COLLECTOR.

TECHNICAL CHARACTERISTICS

Supply and installation of plastic manifold (PPSU), in H, with input of 20 mm in diameter and three leads, one of 20 mm and two of 16 mm in diameter. Fully assembled and tested connections.

- APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation corresponds to the one of Project and that there is sufficient space for its installation.

- PROCESS OF IMPLEMENTATION

PHASES OF EXECUTION.

Stake out. Installing the manifold. Piping connection.

CONDITIONS OF TERMINATION.

The connection to the network will be adequate.

CONSERVATION AND MAINTENANCE.

The element will be protected against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured

3. Chapter 3; Energy crops

- Unit of construction: FUSION ACCESSORY FOR PE TUBE.

TECHNICAL CHARACTERISTICS

Supply and installation of elbow 45 ° of polyethylene, for electrofusion joint, of nominal 32 mm diameter, PN = 16 atm.

APPLICATION REGULATIONS

Installation: Norms of the supplier company.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that its situation corresponds to the one of Project and that there is sufficient space for its installation.

PHASES OF EXECUTION.

Stake out. Mounting and wiring.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

- Unit of construction: PUMP.

TECHNICAL CHARACTERISTICS

Supply and installation of centrifugal electric pump, cast iron, three-speed, with a power of 0.071 kW, technopolymer impeller, chromed steel motor shaft, 1 1/2 "male threaded holes, H-class insulation, for single-phase power supply 230 V. Even manometer bridge formed by manometer, ball valves and copper pipe, w / o of assembly elements, electrical junction box with condenser and other accessories necessary for its correct functioning. Fully assembled, connected and tested.

- APPLICATION REGULATIONS

Installation: CTE. DB-HS Health.

MEASUREMENT CRITERION IN PROJECT

Number of units planned, according to graphical documentation of Project.

PREVIOUS CONDITIONS TO BE FULFILLED BEFORE THE EXECUTION OF WORK UNITS

OF THE SUPPORT.

It will be verified that his situation corresponds to the one of Project.

PHASES OF EXECUTION.

Stake out. Placing the circulation pump. Connection to the distribution network.

CONSERVATION AND MAINTENANCE.

It will protect against splashing and splashing.

MEASUREMENT CRITERION AND FERTILIZATION CONDITIONS

The number of units actually executed according to Project specifications will be measured.

Budget and economic analysis

Index

1. Economical aspects of the project

This part of the study specifies the economic evaluation of the project, divided into two different subsections, the first part to calculate the different costs of the elements of the installation, etc., together with the final total cost, and the second part where will be study the viability of the project.

2. Budget of the installation

This chapter presents the detailed budget of the planned facility. Measurements of materials, their quantity, the unit price and resulting amount will be shown:

2.1 Chapter 1 ; Elements of the machine room

At this point we summarize the necessary elements for the installation of the boiler and its different elements of the installation from the values obtained in point number 8 of the part of the calculations. The tables show the budget in euros as well as in Hungarian Forints, on 1 May, 2017 (€ 1 = 312.4 Ft.). The necessary components are as follows;

Description	Unit	Quantity	Price Ud. (€/ud)	Total price (€)	Total price (Ft)
Boiler K2104 of Tatano	ud	1	14.040,00	14.040,00	4.386.096,00
Anti-vibration support base, for boiler	ud	1	140,40	140,40	43.860,96
Ash deposit	ud	1	280,00	280,00	87.472,00
Pump Wilo-Stratos PICO	ud	2	910,50	1.821,00	568.880,40
Inertia tank MV1500	ud	1	2.989,70	2.989,70	933.982,28
Chimney extracting smoke, DINAK	ud	1	324,00	324,00	101.217,60
Supply of rigid copper pipe of diameter 1'' (tube of 5m of length)	m	2	13,03	26,06	8.141,14
Accessories such as cutting wrenches, non-return valves, pressure gauges, safety valves, etc.	ud	8	15,42	123,36	38.537,66
MTS. TubePP. gris FASER 42	m	98	23,77	2.329,46	727.723,30
MTS. Tube PP. gris FASER 42	m	41,2	15,87	653,84	204.260,87

Set of adapters to the hydraulic circuit. Racor male 18-3/4 (4 Units)	ud	1	10,00	10,00	3.124,00
Start-up and training in the management of biomass boiler	ud	1	325,25	325,25	101.608,10
Safety thermal limiter, calibrated at 95 ° C, consisting of valve and temperature probe	ud	1	70,90	70,90	22.149,16
			Total	**23.133,97**	**7.227.053,48**

- Workforce

Description		Hours	Hourly rate	Amount (€)	Amount (Ft)
Boiler K2104 of Tatano	Official 1st heating	7	17,82	124,74	38.968,78
	Heating assistant	7	16,10	112,70	35.207,48
Tube PP	Official 1st heating	14	17,82	249,48	77.937,55
	Heating assistant	14	16,10	225,40	70.414,96
Inertia tank MV1500	Official 1st heating	1,5	17,82	26,73	8.350,45
	Heating assistant	1,5	16,10	24,15	7.544,46
Pressure limiting valve 1/2" DN 20 mm	Official 1st plumber.	0,375	17,82	6,68	2.087,61
	Assistant Plumber	0,375	16,10	6,04	1.886,12
Pipe Fitting Accessory	Official 1st plumber.	2,5	17,82	44,55	13.917,42
	Assistant Plumber	2,5	16,10	40,25	12.574,10
Inertia tank MV1500	Official 1st heating	1,71	17,82	30,47	9.519,52
	Heating assistant	1,71	16,10	27,53	8.600,68
Pump Wilo-Stratos PICO	Official 1st installer of air conditioning.	6,1	17,82	108,70	33.958,50
	Assistant air conditioning installer.	6,1	16,10	98,21	30.680,80
			Total	**1.125,64**	**351.648,44**

2.2 Chapter 2; Radiating floor

At this point the necessary elements for the installation of the radiant floor heating are summarized from the values obtained in point number 6 of the part of the calculations. The tables show the budget in euros as well as in Hungarian Forints, on 1 May 2017 (€ 1 = 312.4 Ft.). The necessary components for the 11 houses are as follows;

Component	Description	Unit	Quantity
Perimeter insulation band	Polyethylene foam strip that is installed as a skirting board on all vertical surfaces to absorb the expansion of the pavements and eliminate the thermal bridges with the enclosures.	m^2	475,11
Feed and return manifolds	Made of thermally stabilized polyamide, reinforced with fiberglass, resistant to hot water, suitable for all underfloor heating systems. Quick mounting system; Manual drain, tags and wrench are included. 9 circuits.	ud	11
Box for manifolds	Box to install the connectors in one Wall, recessed. 8 to 10 Departures.	ud	11
Tube PE 16 X1,8 mm	Intended for use in hot and cold water installations within the structure of buildings. PE-Xc-16 x 1,8 mm.	m	7.940
Floor plate PST 30	Fixing element of the tubes, maintaining a horizontality and homogeneous separation of the same	m^2	421,29
Guide kink	Reinforced polypropylene curve with Fiberglass for the protection of the pipes at the exit of the mortar towards the distributor. 2 install per circuit	ud	198
Thermostat	Electronic thermostat with switch Stop / stop, for control of Ambient temperature (its placement for underfloor heating ranges from 1 to 1.5 M. ground).	ud	11
Thermostat Signal Distributor	Distributor of signals from the thermostat. Up to 10 circuits.	ud	11

Component	Unit	Quantity	Price Ud. (€/ud)	Total price (€)	Total price (Ft)
Perimeter insulation band	m^2	475,11	0,85	403,84	126.160,71
Feed and return manifolds	ud	11	367,00	4.037,00	1.261.158,80
Box for manifolds	ud	11	110,75	1.218,25	380.581,30
Tube PE 16 X1,8 mm	m	7.940	1,67	13.259,80	4.142.361,52
Floor plate PST 30	m^2	421,29	3,81	1.605,11	501.437,89
Guide kink	ud	198	1,95	386,10	120.617,64
Thermostat	ud	11	23,00	253,00	79.037,20
Thermostat Signal Distributor	ud	11	98,20	1.080,20	337.454,48
			Total	**22.243,31**	**6.948.809,54**

- Workforce

Description		Hours	Quantity	Hourly rate	Amount (€)	Amount (Ft)
Radiating floor	Official 1st heating	0,57	440	12,23	3.067,28	958.219,52
	Heating assistant	0,57	440	10,81	2.711,15	846.962,64
Isolation	Official 1st heating	0,57	440	12,23	3.067,28	958.219,52
	Heating assistant	0,57	440	10,81	2.711,15	846.962,64
Thermostat and Distributor	Official 1st heating	0,57	11	12,23	76,68	23.955,49
	Heating assistant	0,57	11	10,81	67,78	21.174,07
Perimeter insulation band	Official 1st heating	0,45	440	12,23	2.421,54	756.489,10
	Heating assistant	0,45	440	10,81	2.140,38	668.654,71
Manifold	Official 1st plumber.	0,17	11	12,23	22,87	7.144,62
	Assistant Plumber	0,17	11	10,81	20,21	6.315,07
Pressure limiting valve 1/2" DN 20 mm	Official 1st plumber.	0,175	4	12,23	8,56	2.674,46
	Assistant Plumber	0,175	4	10,81	7,57	2.363,93
Pipe for interior installation	Official 1st plumber.	0,05	2148	12,23	1.313,50	410.338,02
	Assistant Plumber	0,05	2148	10,81	1.160,99	362.694,53
				Total	**18.796,95**	**5.872.168,30**

2.3 Chapter 3; Energy crops

This section summarizes the budget that will be necessary the first year for the implementation of energy crops:

Component	Unit	Quantity	Price Ud. (€/ud)	Total price (€)	Total price (Ft)
Stakes	ud	6.000	0,38	2.280,00	712.272,00
Pump; Wilo-Yonos PICO,	ud	2	910,50	1.821,00	568.880,40
MTS. Tube PP. gris FASER 36	m	100	15,87	1.587,00	495.778,80
MTS. Tube PP. gris FASER 12	m	200	12,77	2.554,00	797.869,60
Tube PE 16 mm	m	1000	3,23	3.230,00	1.009.052,00
Pipe Fitting Accessory	ud	25	4,78	119,50	37.331,80
Pressure limiting valve 1/2" DN 20 mm	ud	2	34,00	68,00	21.243,20
Droppers	ud	27000	0,08	2.241,00	700.088,40
Guide kink	ud	22	1,95	42,90	13.401,96
Connecting	ud	22	0,87	19,14	5.979,34
			Total	**13.962,54**	**4.361.897,50**

- Workforce

Description		Hours	Hourly rate	Amount (€)	Amount (Ft)
Machinery; Clear of grass	Official 1st	6	88,00	528,00	164.947,20
	Assistant	6	12,38	74,28	23.205,07
Machinery; Level the land	Official 1st	8	17,21	137,68	43.011,23
	Assistant	8	12,38	99,04	30.940,10
Machinery; Stake planting	Official 1st	10	67,00	670,00	209.308,00
	Assistant	10	12,38	123,80	38.675,12
To size; Plantation distance	Official 1st	10	17,21	172,10	53.764,04
	Assistant	10	12,38	123,80	38.675,12
Pressure limiting valve 1/2" DN 20 mm	Official 1st plumber.	0,375	17,82	18,20	5.684,12
	Assistant Plumber	0,375	16,10	16,48	5.146,79
Pipe installation	Official 1st plumber.	12	17,82	29,82	9.315,77
	Assistant Plumber	12	16,10	28,10	8.778,44
Pipe Fitting Accessory	Official 1st plumber.	2,5	17,82	44,55	13.917,42
	Assistant Plumber	2,5	16,10	40,25	12.574,10
			Total	**2.106,09**	**657.942,52**

2.4 Total

Costs		Total price (€)	Total price (Ft)
Chapter 1	Elements of the machine room	23.133,97	7.227.053,48
	Workforce	1.125,64	351.648,44
Chapter 2	Radiating floor	22.243,31	6.948.809,54
	Workforce	18.796,95	5.872.168,30
Chapter 3	Energy crops	13.962,54	4.361.897,50
	Workforce	2.106,09	657.942,52
		81.368,50	**25.419.519,77**

The total budget of the facility and the workforce to carry it out is 81.368,50 € or 25.419.519,77 Ft.

3. Indirect cost

All projects have a number of indirect costs, such as the salary of the designer, taxes in this case of the Hungarian government., industrial benefit, etc. All this will be detailed in the following points;

3.1 General expenses

In this part, and starting from the result of item number 2 above, 15% of the total cost will be added for possible loss or material breakages.

Total costs		Tax	**Total**
EUR	81.368,50	15 %	**93.573,78**
HUF	25.419.519,77	15 %	**29.232.447,74**

3.2 Industrial benefit

In this section 6% is added to the total budget for the industrial benefit;

Total costs		Tax	**Total**
EUR	93.573,78	6 %	**99.188,20**
HUF	29.232.447,74	6 %	**30.986.394,61**

3.3 Designer

This section represents the percentage that the designer charges for the realization of the design of the entire installation, which in this case will be 4% of the total cost of the installation;

Total costs		Tax	**Total**
EUR	99.188,20	4 %	**103.155,73**
HUF	30.986.394,61	4 %	**32.225.850,39**

3.4 Government tax

The tax rate of the Hungarian government is 27%, so with the budget will be increased as follows;

Total costs		Tax	**Total**
EUR	103.155,73	27 %	**131.007,78**
HUF	32.225.850,39	27 %	**40.926.830,00**

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