POLITECNICO
MILANO 1863

Co- thrive

Back to the future

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Sustainable Architecture and Landscape Design

Building and Architectural Engineering

Self-sufficient living in nature without sacrificing the metropolitan lifestyle.

Abstract

This paper presents a comprehensive review of the energy performance of Alfonsine, Italy, following the raising of the water level in the eastern part of the country. The energy efficiency index is calculated by the energy performance network of the building's existing energy services and existing power plants. Buildings are designed to be Nearly Zero-Energy Buildings (NZEB) with a total energy consumption of less than 5 kWh per year, which are generally characterized by high insulation, energy-efficient windows, and doors, energy-efficient heating and cooling systems, and passive solar design strategies that reduce the need for artificial lighting and heating. This combined approach can result in highly energy-efficient buildings that reduce their dependence on non-renewable energy sources and reduce environmental impacts.

Sinossi

In questo articolo viene presentata una revisione completa delle prestazioni energetiche di Alfonsine, in Italia, dopo l'innalzamento del livello dell'acqua nella parte orientale del paese. L'indice di efficienza energetica viene calcolato dalla rete di prestazioni energetiche dei servizi energetici esistenti e dalle centrali elettriche esistenti dell'edificio. Gli edifici sono progettati per essere edifici a energia quasi zero (NZEB) con un consumo energetico totale inferiore a 5 kWh all'anno, che sono generalmente caratterizzati da un'elevata coibentazione, finestre e porte ad alta efficienza energetica, sistemi di riscaldamento e raffreddamento ad alta efficienza energetica e strategie di progettazione solare passiva che riducono la necessità di illuminazione e riscaldamento artificiali. Questo approccio combinato può portare a edifici altamente efficienti dal punto di vista energetico che riducono la loro dipendenza da fonti di energia non rinnovabili e riducono gli impatti ambientali.

Contents

INTRODUCTION

1. Introduction

1.1 Introduction

Flooding will affect the northern and eastern portions of Ravenna Province in roughly 50 years, putting Ravenna and the communities on the coast at risk. Only a few cities in the low-risk region, such as AlfonsIne, Fusignano, and Mezzano, will be safe to live in. (Figure 1-1)

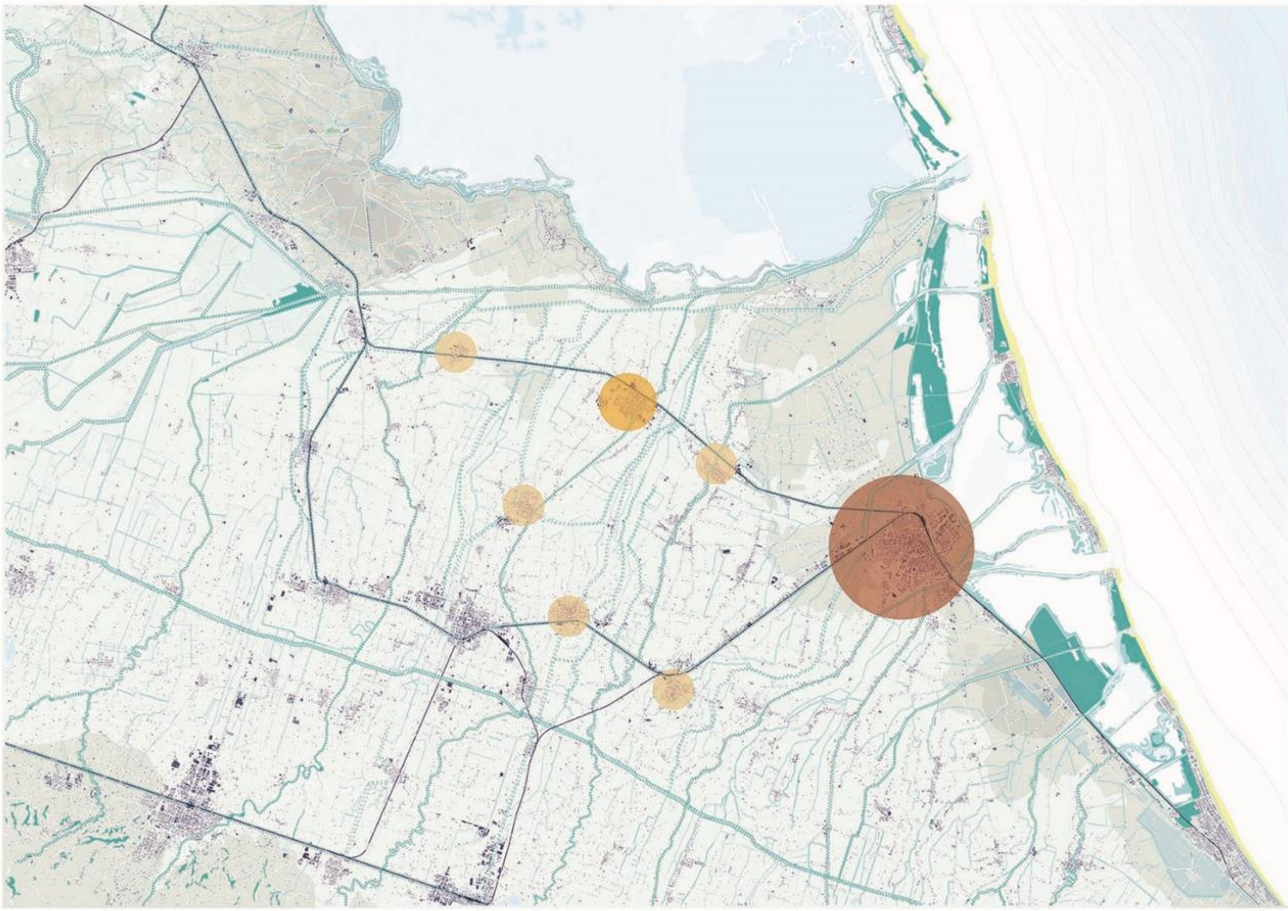


Figure 1 - 1

Following the flooding, it is expected that a large number of people from Ravenna and other cities will migrate to low-risk areas, due to the increase in population in such areas. As a result, city expansion will occur through the creation of additional dwelling settlements. (Figure 1-2)

Figure 1 - 2

Because the new residents are largely from Ravenna, we must accommodate them in a more proper manner than before. (Figure 1-3)

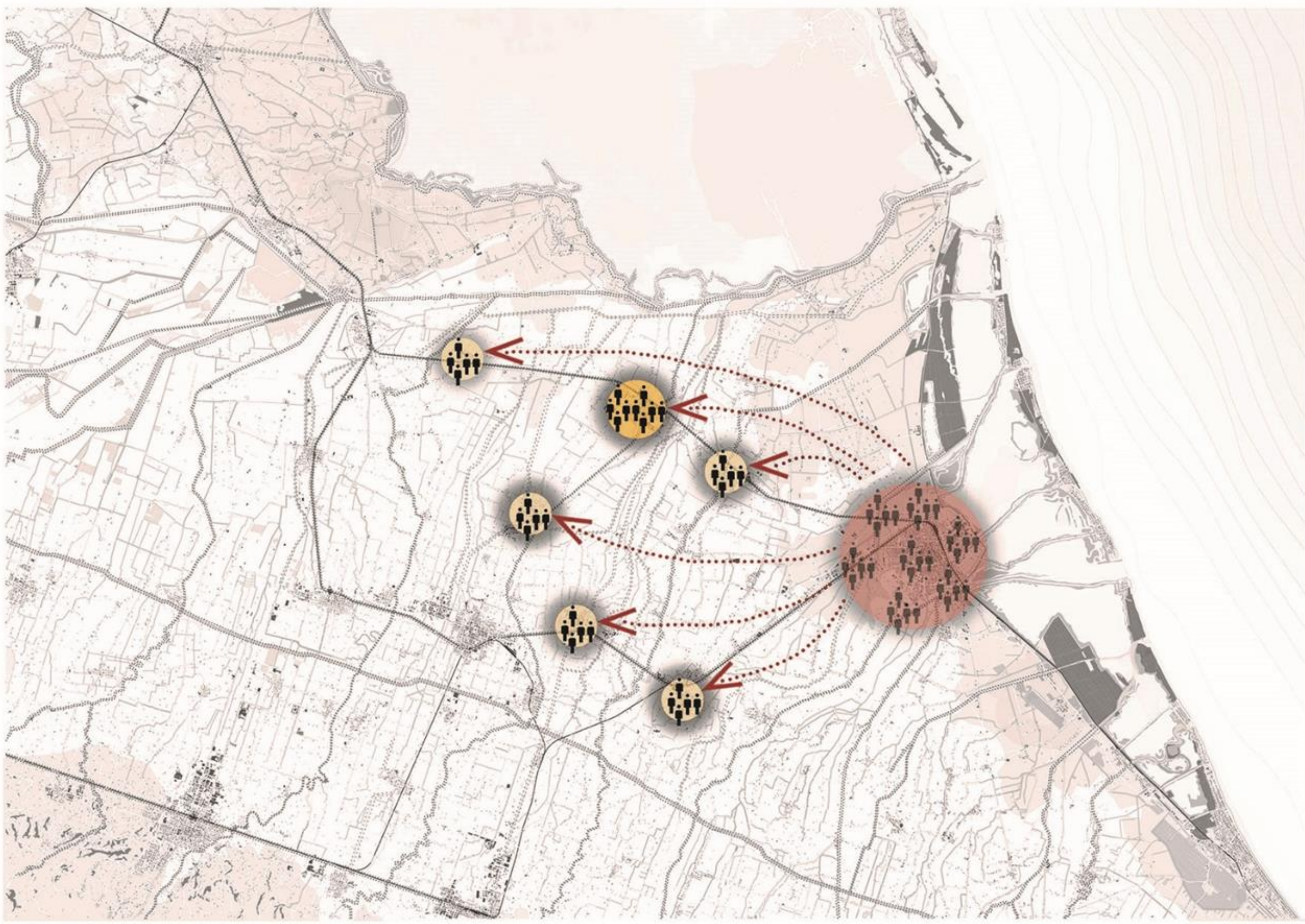


Figure 1 - 3

People's basic needs for their life will increase as the population grows, and the economy will be put at danger as a result of all of these issues.
(Figure 1-4)

Figure 1 - 4

1-2-1 Water Level

In 50 years, the sea level will rise. We can see that Ravenna and the cities on the water's edge are vulnerable to flooding, while cities distant from the sea can be considered a safe-zone for future migration from flood-prone areas. (Figure 1-5, Figure 1-6)

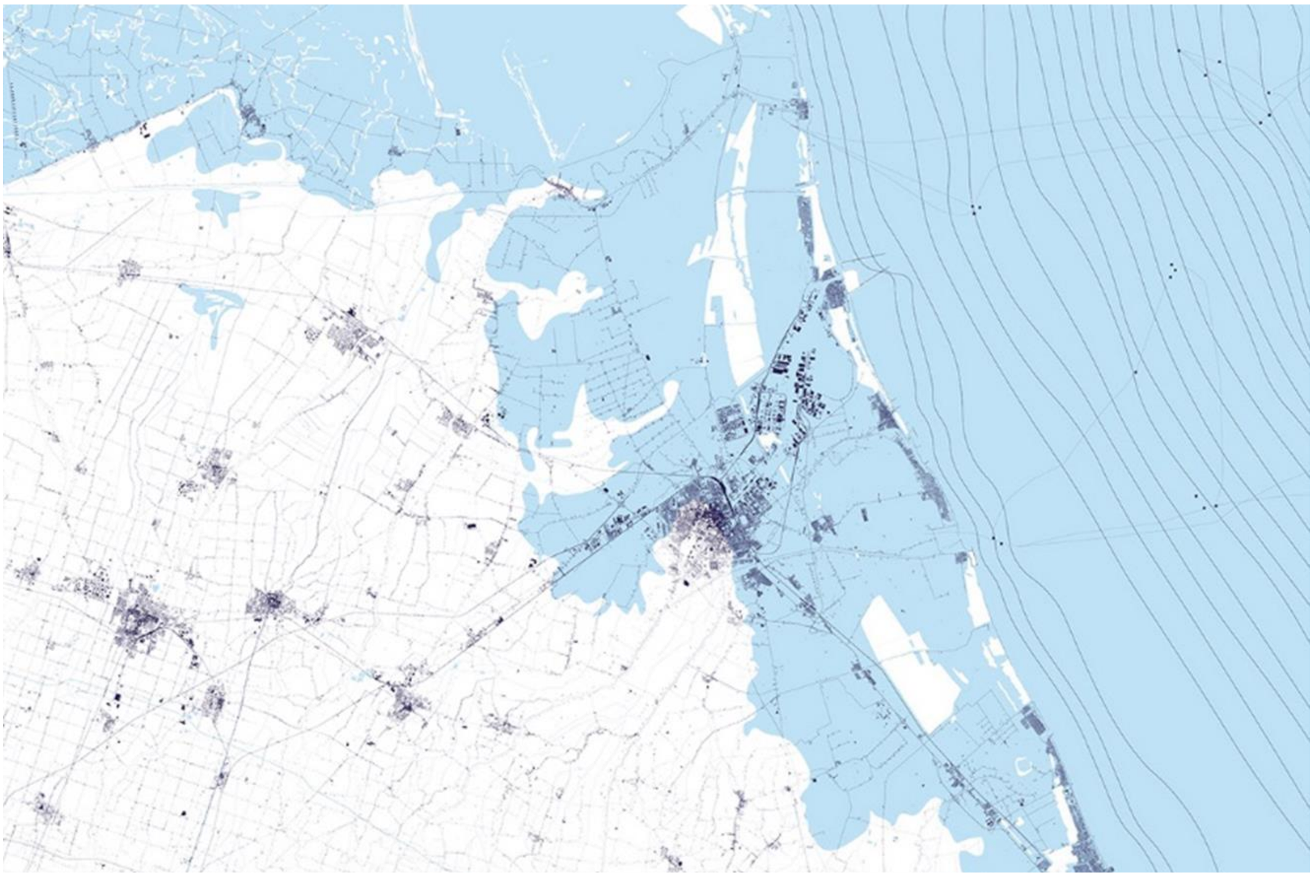


Figure 1 - 5

1-2-2 Flood risk Areas

As can be seen, cities such as Alfonsine, Mezzano, and FuzIgnanoo are in the less frequent flood zone, whereas the part of the river that is in the frequent flood zone is surrounding the river, which we tried to examine the best approach to prevent flooding in river-side regions. (Figure 1-6)

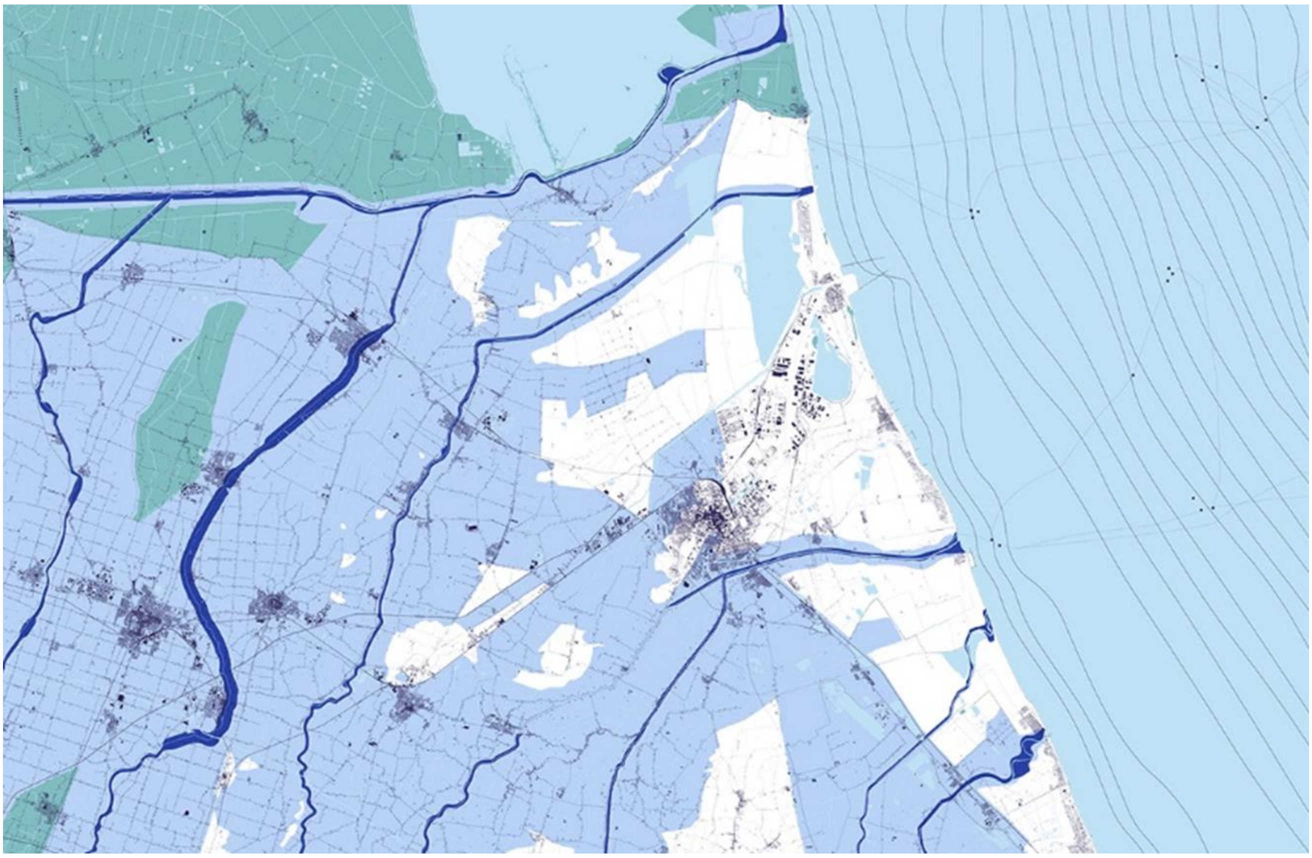


Figure 1 - 6

1-2-3 Hydrogeological Risk

As we can see that city like Alfonsine, Mezzano and Fuzlgnanoo are the low-risk area. (Figure 1-7)

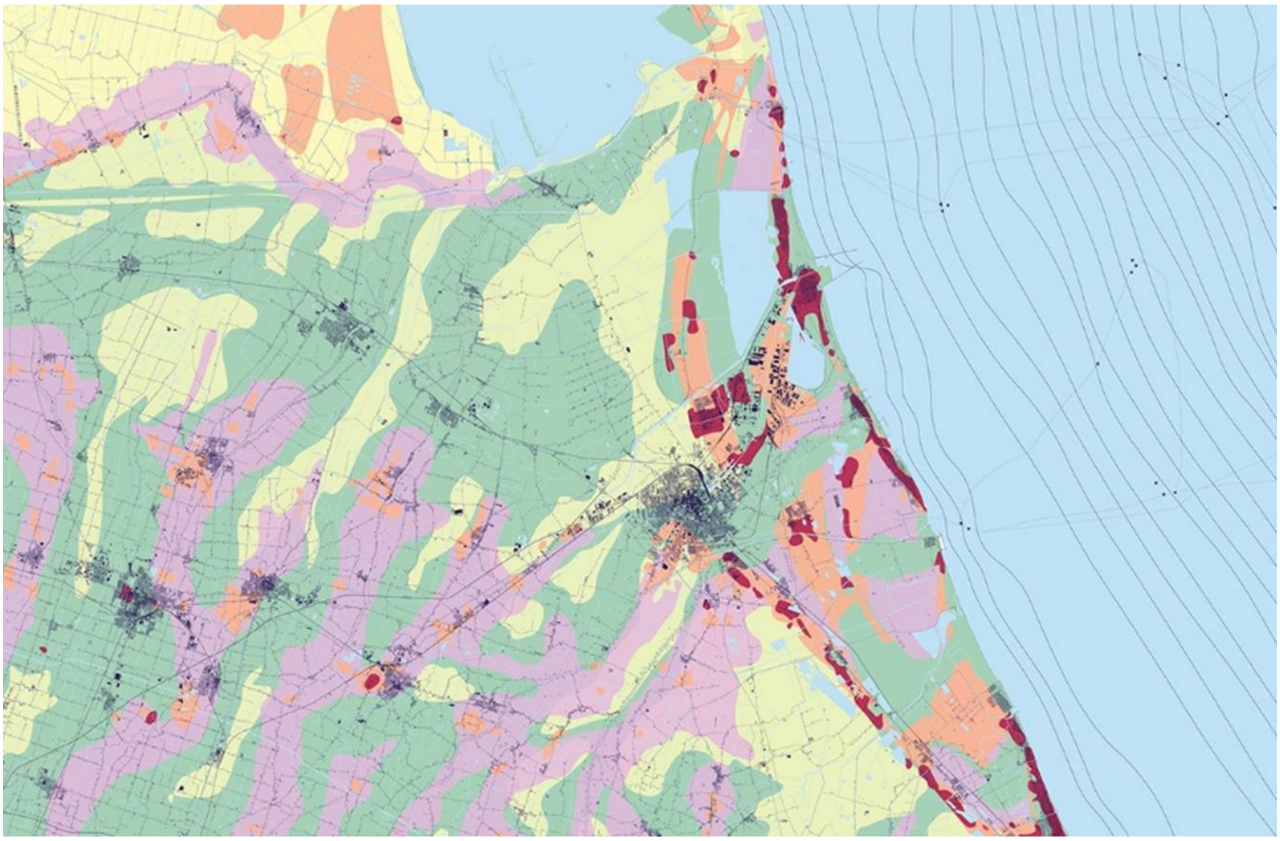


Figure 1 - 7

1-3 Alfonsine (Selected)

After considering the cities around the Ravenna, in order to be specific of what is going to be happened in future, we decided to choose Alfonsine as the pattern that all functions can be applied the sample to be repeated to the other cities which are in the same safe zone areas. (Figure 1-8)

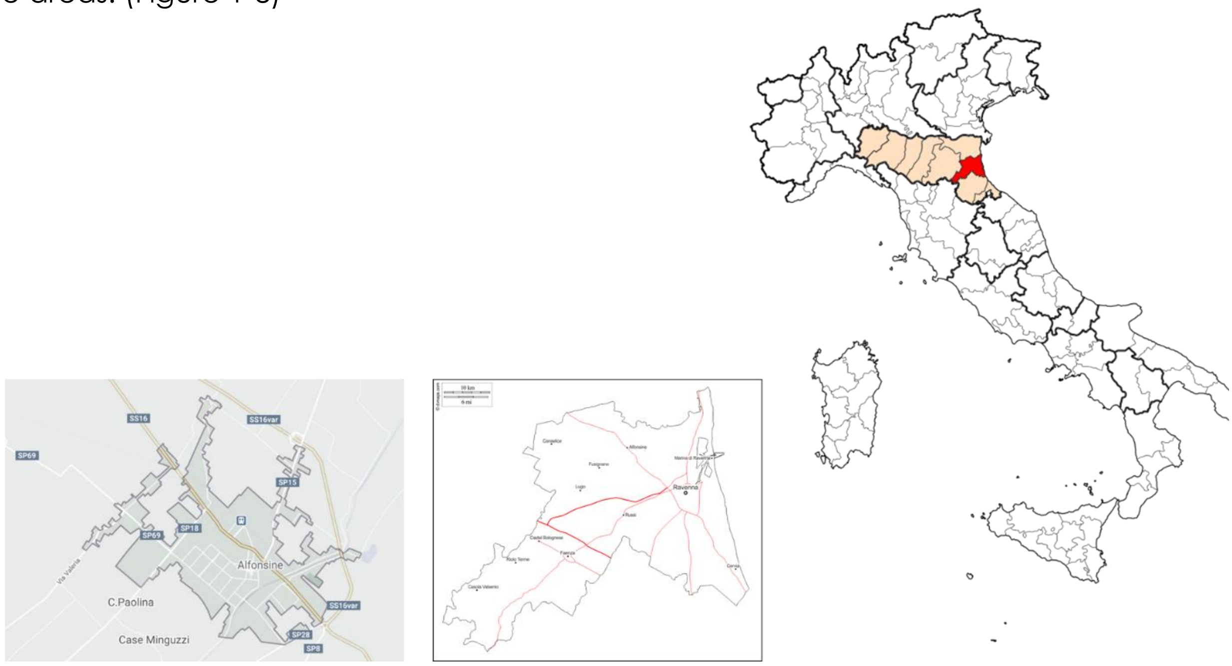


Figure 1 - 8

1-3-1 Location

After considering the cities around the Ravenna, in order to be specific of what is going to be happened in future, we decided to choose Alfonsine here you can see the location of the city. (Figure 1-9)

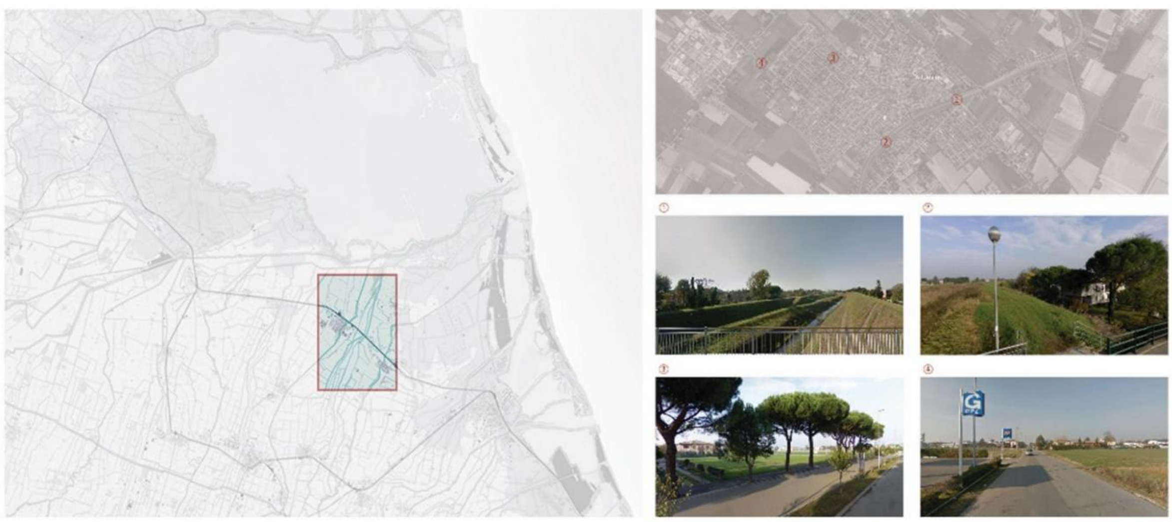


Figure 1 - 9

1-3-2 Territorial analysis

In Agriculture lands map we can see how much dense we have in agriculture fields which can be the main factor for developing the new settlements in the right direction according to the location of the city from the highways and railway. (Figure 1-13) So, in this case we can use these routes to export the products to the cities around and further abroad. (Figure 1-10)

Density of **Agricultural lands**

Figure 1 - 7

The ecological map of Alfonsine helped us to direct the green corridors and have a green connection from old town to new town in future. (Figure 1-11)

Figure 1 - 8

Gray infrastructures which are affecting our region

Gray Infrastructure-Alfonsine

Figure 1 - 9

The vacant land which clearly shows the spaces we can use to connect the functions in old town and pave the way to have better connection to the new town.

Water channels in Alfonsine show the better way of the irrigation in the field of new town settlements and also to provide the ponds to prevent the flood in future.
(figure 1-13)

Figure 1 - 10

1-3-3 Decision for vacant areas and land use

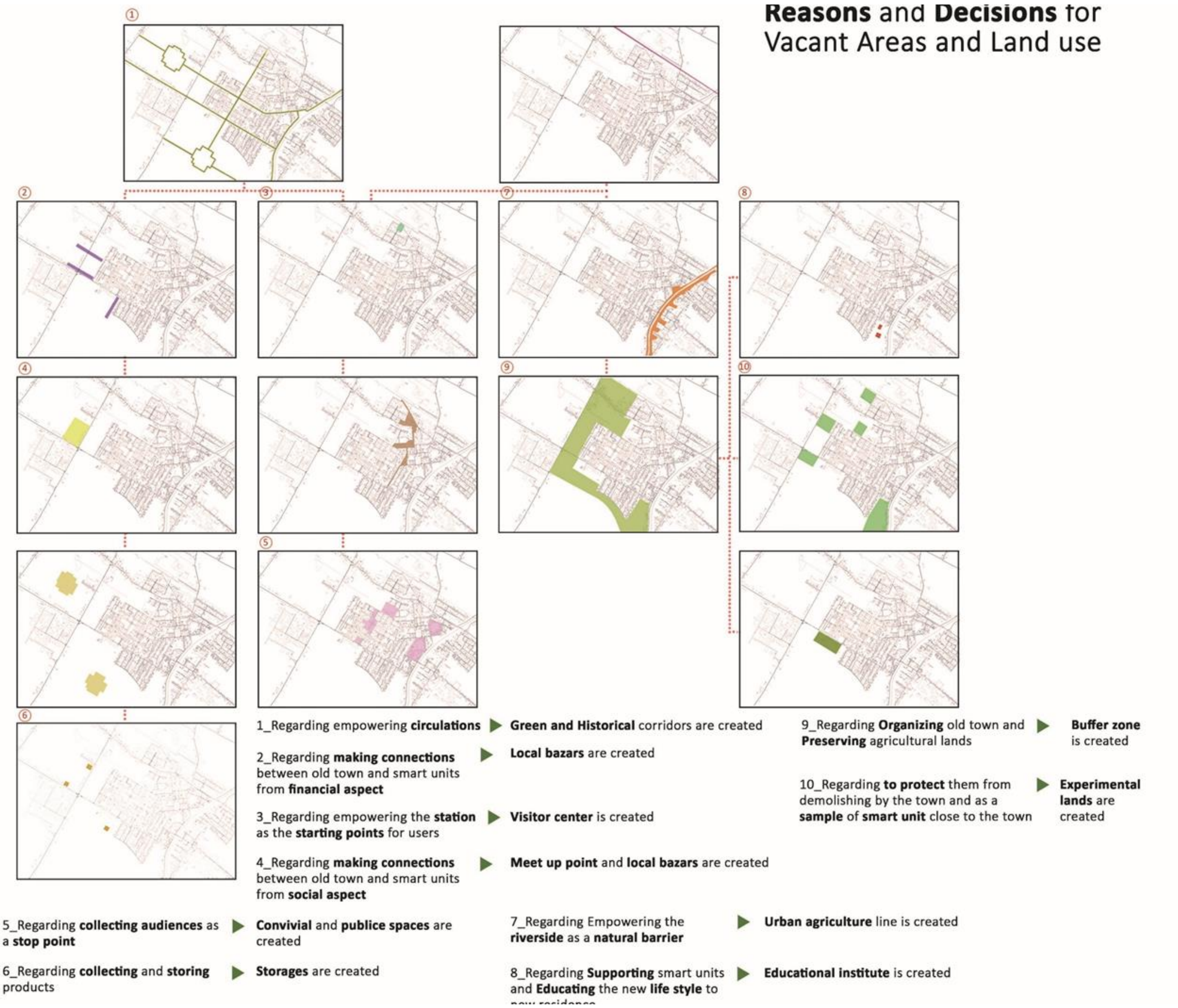


Figure 1 - 11

1-3-4 History

Alfonsine was founded in 1464 when some land north of the city of Fusignano, consisting primarily of wetlands, was donated by Borso d'Este to Teofilo Calcagnini who began an aggressive reclamation process. In 1468 Calcagnini expanded his territory through the acquisition of additional land north of Fusignano from a Venetian noble. The original town center was developed in part on land north of the Senio river and in part around the church of Nostra Signora (Our Lady), built in 1502 by Alfonso Calcagnini, Teofilo's son.

This area was disputed territory between the city-state of Ravenna and the land controlled by the Este family. A compromise was eventually signed in 1506, giving the land to Ravenna. In 1509, the territories under the domain of Ravenna came under the control of the Papal States. In 1519 Pope Leo X transferred ownership of the region to Theophilus Calcagnini. To honor his benefactor Calcagnini called his land "Leonian territory". The Calcagnini family became feudal Lords on behalf of both the Church and the Este family. The family's position was confirmed by pope Clement VIII at the end of the 16th century.

During the 18th century the town's population and its economy grew. However, the living conditions of the commoners were harsh due to heavy taxation by the feudal class which left them impoverished.

The Napoleonic period saw the emancipation of Alfonsine, which in 1814 became a municipality.[6] The following year, after the fall of Napoleon, the country returned to the Holy See. In 1859, with the loss of papal power in Romagna, Alfonsine was annexed to the Kingdom of Sardinia, which in 1861 became the Kingdom of Italy.

Figure 1 - 12

1-3-5 Expansion

As we can see, the direction of the expansion in the city as of 19th century was towards north, which is clear that the river and the railway played as the boundaries and also direct this expansion, therefore the city expands towards north west guided by 3 main elements. Senio river, via Reale and via Borso. (Figure 1-16)

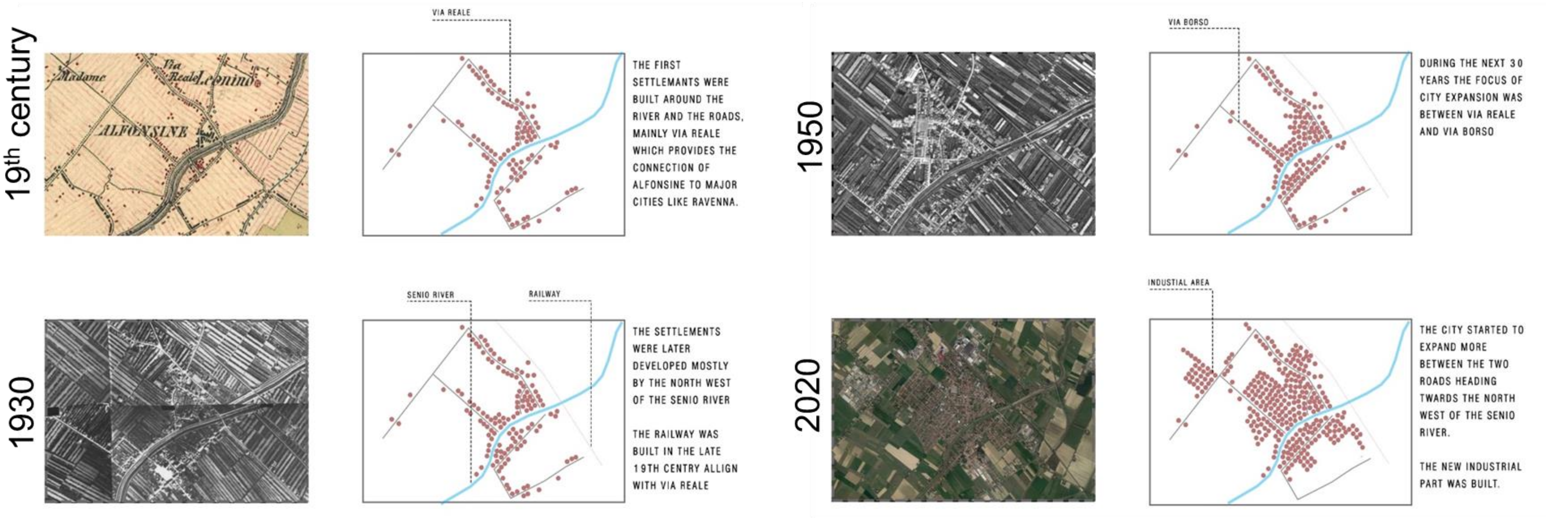


Figure 1 - 13

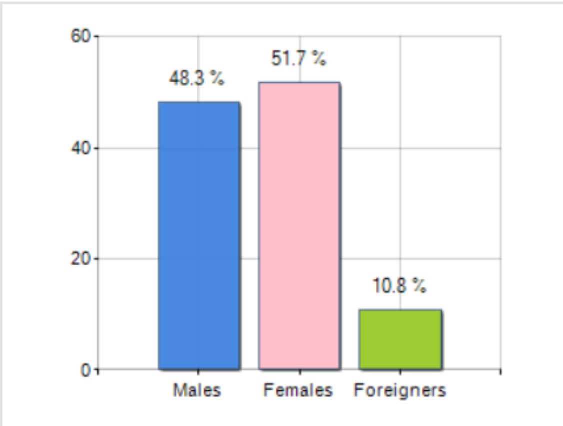
1-3-6 Synthesis data

Territorial extension of Municipality of ALFONSINE and related population density, population per gender and number of households, average age and incidence of foreigners. (Figure 1-19)

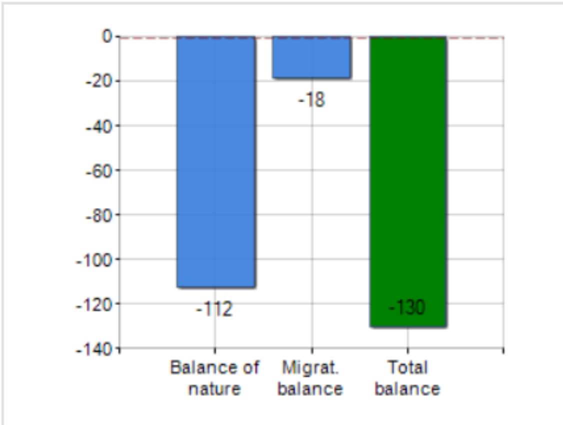
TERRITORY	
Region	Emilia Romagna
Provinces	Ravenna
Sign Province	RA
Hamlet of the municipality	11
Surface (Km2)	106.79
Population density (Inhabitants / Kmq)	110.6

DEMOGRAPHIC DATA (YEAR 2019)	
Inhabitants (N.)	11.808
Families (N.)	5.349
Males (%)	48.3
Females (%)	51.7
Foreigners (%)	10.8
Average age (years)	49.0
Average annual variation (2014/2019)	**-0.62**

MALES, FEMALES AND FOREIGNERS INCIDENCE (YEAR 2019)



DEMOGRAPHIC BALANCE (YEAR 2019)



Balance of nature [1] , Migrat. balance [2]

Figure 1 - 14

1-3-6-1 Population

Resident population and its related trend since 2019, balance of nature and migratory balance, birth rate, death rate, growth rate and migration rate in Municipality of ALFONSINE. (Figure 1-18)

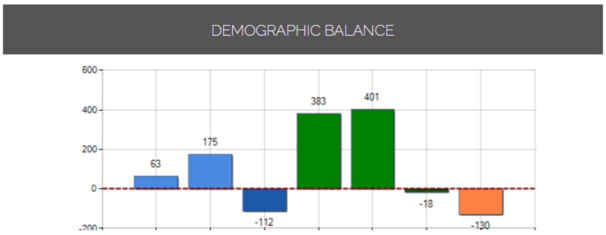
DEMOGRAPHIC BALANCE (YEAR 2019)

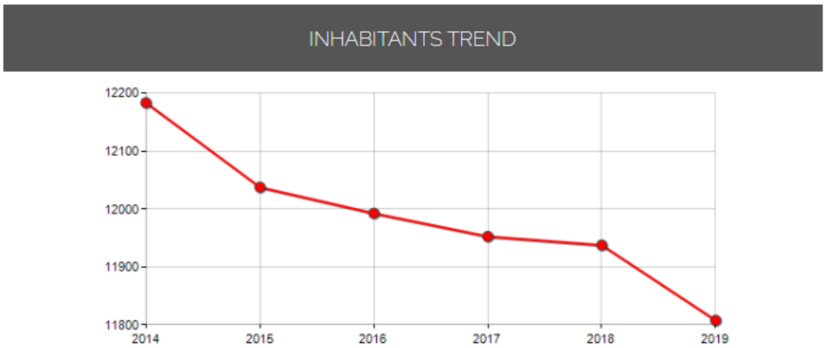
Inhabitants on 1th Jan.	**11.938**
Births	63
Deaths	175
Balance of nature [1]	**-112**
Registered	383
Deleted	401
Migration balance [2]	**-18**
Total balance [3]	**-130**
Inhabitants on 31th Dec.	**11.808**

INHABITANTS TREND

Year	Inhabitants (N.)	Variation% on previous year
2014	12.184	-
2015	12.038	-1.20
2016	11.993	-0.37
2017	11.953	-0.33
2018	11.938	-0.13
2019	11.808	-1.09

Average annual variation (2014/2019): **-0.62**
Average annual variation (2016/2019): **-0.52**



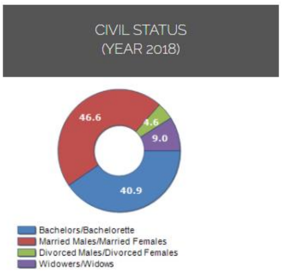


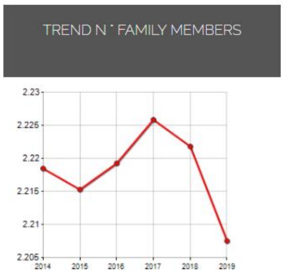
- ^ Balance of nature = Births - Deaths
- ^ Migration balance = Registered - Deleted
- ^ Total balance = Balance of nature + Migration balance
- ^ Birth rate = (Births / average Inhabitants) * 1,000
- ^ Death rate = (Deaths / average Inhabitants) * 1,000
- ^ Migration rate = (Migration balance / average Inhabitants) * 1,000
- ^ Growth rate = Birth rate - Death rate + Migration rate

Figure 1 18

1-3-6-2 Families

Resident families and related trend since (Year 2019), the average number of members of the family and its related trend since (Year 2019), civil status: bachelors / Bachelorette, married, divorced and widows / widowers in Municipality of ALFONSINE. (Figure 1-19)





CIVIL STATUS (YEAR 2018)

Civil Status	(n.)	%
Bachelors	2.577	21.59
Bachelorette	2.252	18.86
Married Males	2.748	23.02
Married Females	2,749	23.03
Divorced Males	230	1.93
Divorced Females	318	2.66
Widowers	214	1.79
Widows	850	7.12
Total Residents	**11.938**	**100.00**

FAMILIES TREND

Year	Families (N.)	Variation% on previous year	Average components
2014	5,492	-	2.22
2015	5.434	-1.06	2.22
2016	5.404	-0.55	2.22
2017	5.370	-0.63	2.23
2018	5.373	+0.06	2.22
2019	5.349	-0.45	2.21

Average annual variation (2014/2019): **-0.53**

Average annual variation (2016/2019): **-0.34**

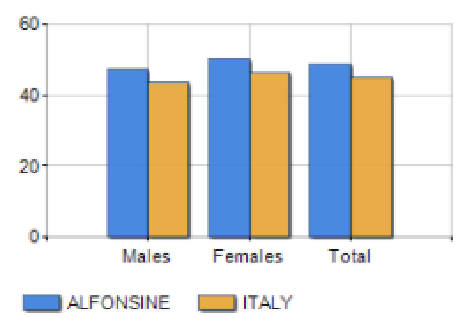
Figure 1 - 19

1-3-6-3 Ages

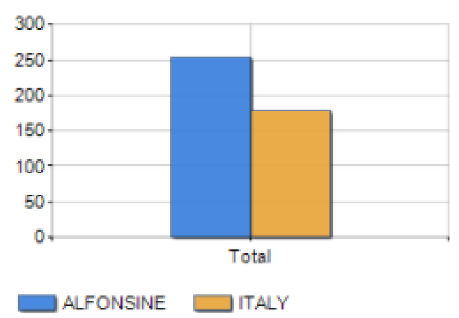
Age classes for gender and related impact, average age and old-age index in Municipality of ALFONSINE. (Figure 1-20)

AVERAGE AGE AND OLD-AGE INDEX (YEAR 2019)			
	Males	Females	Total
Average age (Years)	47.54	50.34	48.99
Old-age index [1]	-	-	254.45

AVERAGE AGE (YEARS)



OLD-AGE INDEX



^ Old-age index = (Inhabitants> 65 years old / Inhabitants 0-14 years old) * 100

POPULATION BY AGE (YEAR 2019)						
	Males		Females		Total	
Classes	(n.)	%	(n.)	%	(n.)	%
0 - 2 age	111	1.94	90	1.48	201	1.70
3 - 5 age	130	2.28	130	2.13	260	2.20
6 - 11 age	302	5.29	324	5.31	626	5.30
12 - 17 age	294	5.15	310	5.08	604	5.12
18 - 24 age	375	6.57	308	5.05	683	5.78
25 - 34 age	474	8.31	450	7.38	924	7.83
35 - 44 age	679	11.90	708	11.60	1.387	11.75
45 - 54 age	961	16.84	941	15.42	1.902	16.11
55 - 64 age	810	14.19	869	14.24	1.679	14.22
65 - 74 age	792	13.88	820	13.44	1.612	13.65
75 and more	779	13.65	1.151	18.87	1,930	16.34
Total	**5.707**	**100.00**	**6.101**	**100.00**	**11.808**	**100.00**

AGE CLASSES (YEAR 2019)

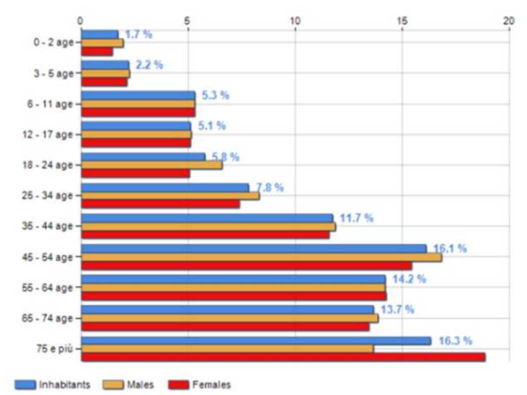


Figure 1 - 15

1-3-6-4 Foreigners

Foreign residents in Municipality of ALFONSINE by gender and its related demographic balance, number of foreign minors, families with foreign head of household and number of households with at least one foreigner, segmentation per citizenship. (Figure 1-21)

NATIONALITY (YEAR 2019)

Nationality	(n.)	% on foreigners	% on population
Romania	441	34.56	3.73
Morocco	236	18.50	2.00
Ukraine	140	10.97	1.19
Senegal	107	8.39	0.91
Albania	61	4.78	0.52
Poland	57	4.47	0.48
Egypt	19	1.49	0.16
Brazil	19	1.49	0.16
China People's Rep	18	1.41	0.15
fruit salad	17	1.33	0.14
Tunisia	16	1.25	0.14
Guinea	14	1.10	0.12
Nigeria	12	0.94	0.10
San Marino	11	0.86	0.09
Russia Federation	10	0.78	0.08

^ Foreigners Growth rate = Foreigners Birth rate - Foreigners Death rate + Foreigners Migration rate

SYNTHESIS DATA (YEAR 2019)

	(n.)	% on foreigners	% on population
Total Foreigners	1.276	100.00	10.81
Foreigner males	616	48.28	5.22
Foreigner Females	660	51.72	5.59

DEMOGRAPHIC BALANCE (YEAR 2019)

	(n.)	% on population
Foreigners on 1th Jan.	**1.266**	**10.72**
Births	16	0.14
Deaths	3	0.03
Balance of nature	**+13**	**0.11**
Registered	159	1.35
Deleted	162	1.37
Migration balance	**-3**	**-0.03**
Total balance	**+10**	**0.08**
Foreigners on 31th Dec.	**1.276**	**10.81**

Figure 1 - 16

1-3-7 Agriculture Products

Agriculture products which can be used for the future design of the new town. (Figure 1-22)

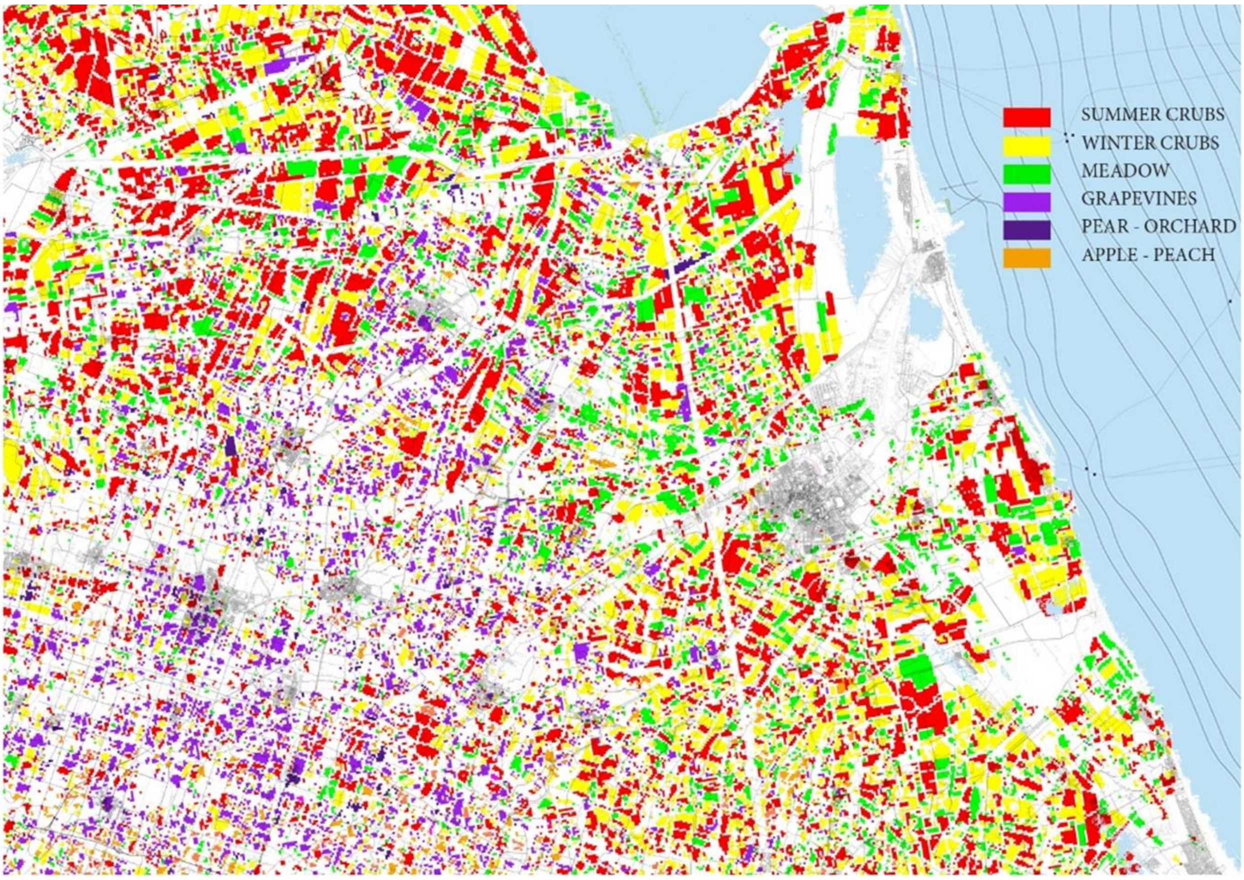


Figure 1 - 17

CASE STUDY

2. Case studies

2.1 Types and patterns of rural settlements

A rural settlement is mostly an agricultural land and as such it cannot be separated from the land whose use it ensures. Its shape and understanding are often in strict accord with the kind of work, the agricultural technique and the way the soil is used. The arrangement of rural settlement as geographical entities express the grouping of dwellings and their interrelationship, makes the different types of rural settlements. Rural settlements are classified in different ways. Some geographers have considered site as important criteria for the classification of rural settlements. On the one hand the pattern has been guided by physical aspects such as nature of topography, source of water supply, drainage pattern, soil condition, etc. On the other hand, it is also related to the socio- economic conditions such as land use, land tenure, crop association, means of transportation and density of population Rural settlement types and pattern are used sometimes as synonymous. But they are sometimes interchangeable and one being element or part of other.

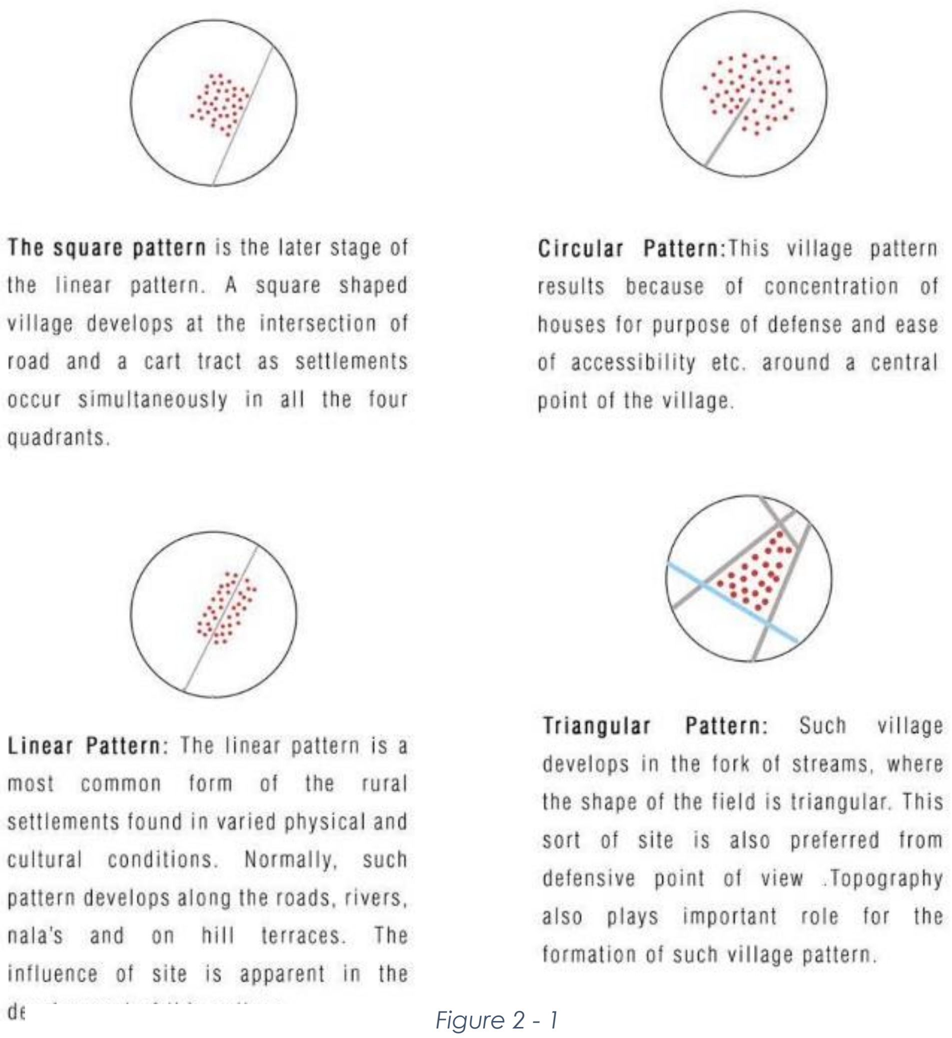


Figure 2 - 1

2.2 New town modeling

Delft University of Technology, the Netherlands

Master of Architecture, Urbanism and Building Sciences

Track of Urbanism Yu Ye

In order to attract residents from crowded city center of Shanghai, the main function in Songjiang new town is living. Not only apartments for middle-class people, luxury villa is built in this new town as well. In addition, Chinese urbanists have learnt from European new town developments and the 'new-town concept' is based on independently functional nodes, in contrast to old dormitory towns. Take Songjiang new town for example, seven universities have moved in, followed with more than 100,000 students and 40,000 staffs, showed in light blue in the picture below (Figure 1.8). This is an attempt to avoid the oversimplified function in newly development areas. However, even the guiding theory of new town development has been improved, the urbanity is still low in this new town.

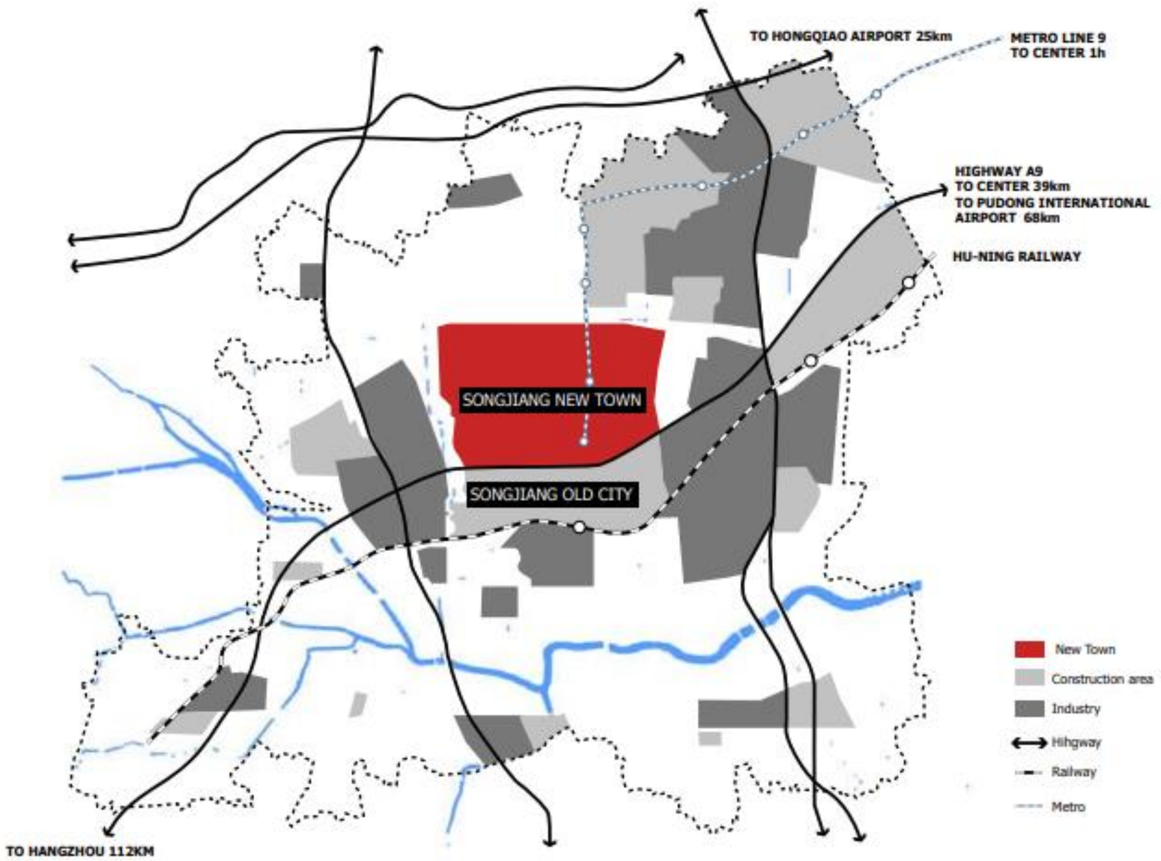
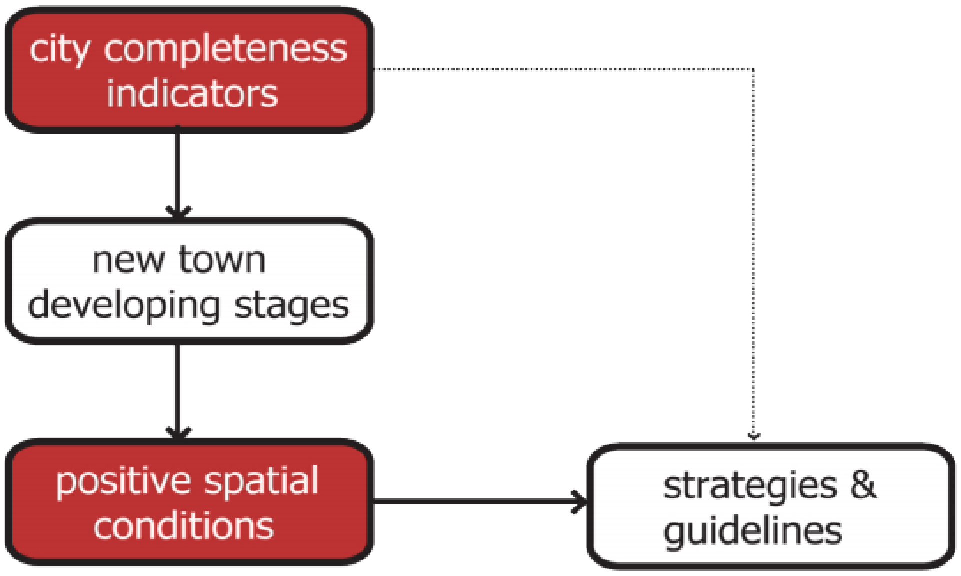


Figure 2 - 2 Smart village   graduation_plan__theory_paper_Yu_Ye

An analysis of Songjiang new town and old city using S p a c e S y n t a x m e t h o d, spatial accessibility is shown by a color index ranging from dark red – most integrated to dark blue – least integrated, spatial hierarchy has been revealed by this color pattern. (Figure 2-3)

Figure 2 - 3

it is very important to distinguish the indicators of city completeness and spatial principles may accelerate the new town transformation towards a complete city. In the following researches, the city completeness indicators mentioned above will be used to define new town's developing stage. Then, based on the order 59 36 in developing stages, positive spatial conditions which are important for becoming a more complete new town would be searched.



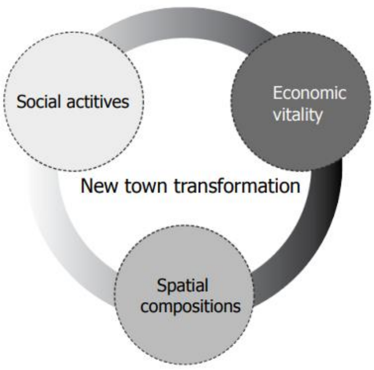


Figure 2 - 4 Interacted spatial and socioeconomic

The Matrix with color codes used for aggregating the Space Syntax and Spacematrix data in GIS, (source: Van Nes, Berghauser Pont and Mashhoodi, 2011, p. 19). The combination of Space Syntax and Spacematrix in GIS, (source: Van Nes, Berghauser Pont and Mashhoodi, 2011, p. 19).

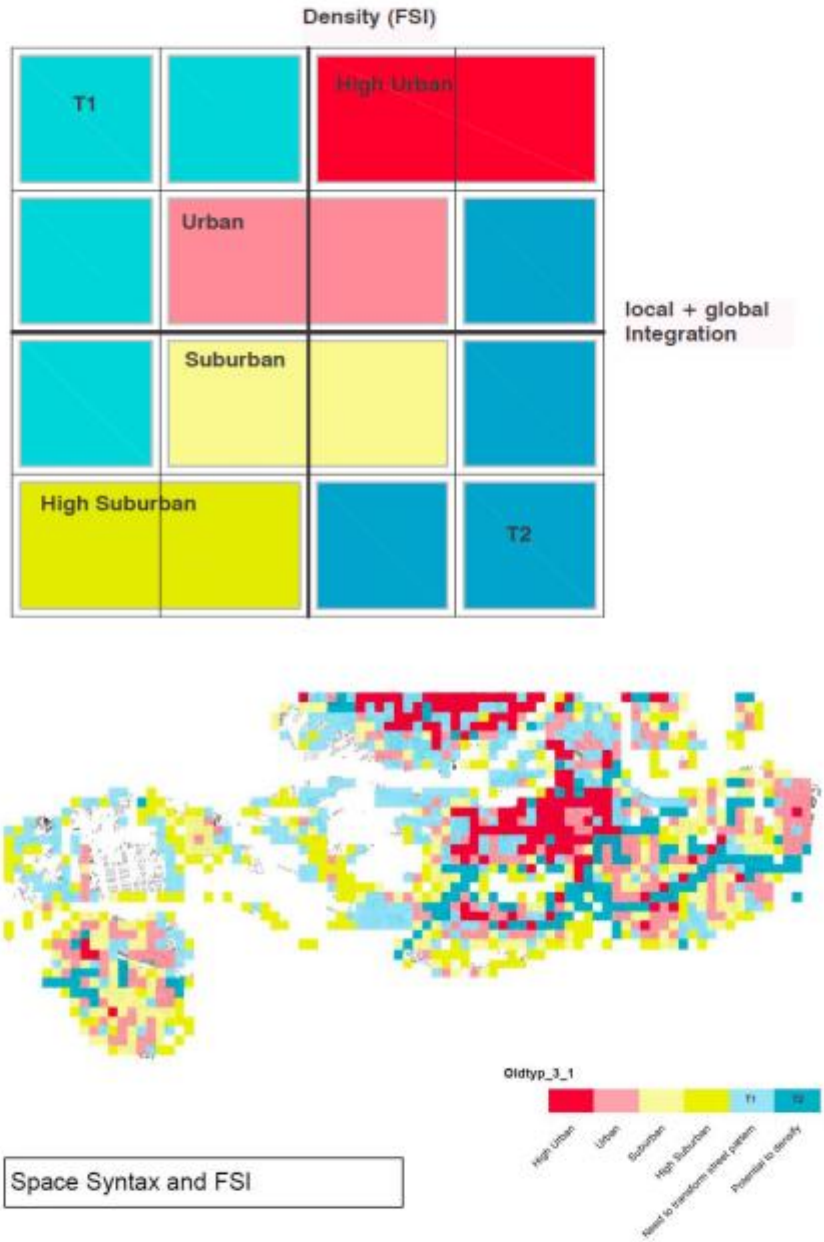


Figure 2 - 5

2.3 Community Park construction aids in storm water management

Village of Kimberly, Wisconsin

Village of Kimberly, Wisconsin, residents pinpointed a neighboring field as the origin of cyclical flooding and erosion that affected the homeowners' properties as well as the surrounding roadways. During rain events and seasonal snowmelt, water accumulated in the residents' yards and caused spillage over roadways, making travel hazardous. The vacant neighborhood field suffered from nutrient depleted topsoil caused by frequent rainfall and years of erosion, so much so it could no longer absorb accumulating storm water. With nowhere to go, the storm water spread into the surrounding area where it would collect and remain for multiple days until eventually evaporating or soaking into the ground. Tired of the endless cycle of property repairs and flooded roadways, residents gathered to present their concerns to village officials and request a resolution.

Figure 2 - 6

Rib Rock units are larger in size and weight, measuring approximately 2' x 4' x 2' and weighing more than 1,800 pounds each, compared to traditional-sized retaining wall units, which range in dimensions and typically weigh between 30 to 100 pounds each. Working with greater square-footage units allows more wall area to be covered with the use of less materials. Not only would the overall cost be reduced, but the installation time would be as well. Project engineers also considered climatic conditions and the impacts of a pond application. Being in central Wisconsin, the park's pond would be prone to freezing temperatures and temperature fluctuations. Engineers considered the possibility for water freezing and thawing between the joints and ice expanding or shrinking, possibly causing traditional size wall units to shift in a pond application like this. However, by constructing the perimeter pond wall with Rib Rock units, the structural integrity of the wall is enhanced by the units' substantial weight, built-in interlock and fewer joints to reduce freezing and thawing affects. Once presented with the benefits of using Rib Rock, the project committee agreed to move forward.

Figure 2 - 7

Following one year of construction, Memorial Park opened to the community during the spring of 2017. The park's namesake originated from the World War I and World War II Memorial that is placed within a prominent park garden bed. Since the storm water management system's installation, it has proven effective and residential flooding and erosion has dissipated. Residents are pleased with the implemented solution and enjoy the park's recreational features. The addition of the multipurpose park increased the perceived and actual value of neighboring homes, which homeowners are satisfied with. In 2018, one year after the project's completion, village officials approved the installation of the park's latest feature, a lighted gazebo. The gazebo, constructed by Kimberly High School students in technical education courses, was installed near the retaining wall overlooking the fountain pond. Memorial Park has proven to be a valuable asset now and for years to come.

Figure 2 - 8

Retention ponds can provide both storm water attenuation and water quality treatment by providing additional storage capacity to retain runoff and release this at a controlled rate. Ponds can be designed to control runoff from all storms by storing surface drainage and releasing it slowly once the risk of flooding has passed. Runoff from each rain event is detained and treated in the pond. The retention time and still water promotes pollutant removal through sedimentation, while aquatic vegetation and biological uptake mechanisms offer additional treatment. Retention ponds have good capacity to remove urban pollutants and improve the quality of surface runoff.

Figure 2 - 9

Detention ponds primarily manage storm water quantity, but also somewhat contribute to treating the water quality. When it rains over a detention pond's drainage area, the runoff water either travels to the pond across the land surface or is routed there by gutters or underground pipes. In some cases, the water is passed through a pretreatment wetland or sedimentation tank. Because they are a designated area for water storage, detention ponds prevent water from flooding in the community's developed areas.

The runoff is stored in the pond, and slowly released in the storm water sewer system. The storage-release process reduces the peak runoff volumes and runoff rates. The implications of these reductions in "quanity" are that the stormwater sewer system and treatment facility can be designed to handle smaller volumes. Also, when the water pools in the basin, its velocity is significantly reduced. This allows suspended sediments to sink to the bottom of the pond, and the organic pollutants to be digested by the organisms present in the pond. This improves the water "quality."

Figure 2 - 10

2.4. Helsinge garden city

The village of tomorrow: A model for sustainable living in the countryside

In collaboration with EFFEKT, Atkins, CFBO and Trafikplan, Karres en Brands developed a master plan for Garden City – Village of Tomorrow in Helsinge. Today, many young families have a desire to move to the countryside to be closer to nature, fresh air, affordable living and to provide a better environment for their children. However, due to intensive farming and a prioritization of car transportation, the landscape is to a large extent inaccessible to the rural population and the exisIn collaboration with EFFEKT, Atkins, CFBO and Trafikplan, Karres en Brands developed a master plan for Garden City – Village of Tomorrow in Helsinge.

Figure 2 - 11

Today, many young families have a desire to move to the countryside to be closer to nature, fresh air, affordable living and to provide a better environment for their children. However, due to intensive farming and a prioritization of car transportation, the landscape is to a large extent inaccessible to the rural population and the existing building mass is outdated and cannot fulfill the dreams for young families anymore. Many urban residents hesitate to move to the countryside due to a lack of good public transportation, the distance from job opportunities and the lack of alternative housing forms. As the concept of work changes, the supply of jobs and the transportation options will be less important and the urban-rural movement can seriously take off. ting building mass is outdated and cannot fulfill the dreams for young families anymore. Many urban residents hesitate to move to the countryside due to a lack of good public transportation, the distance from job opportunities and the lack of alternative housing forms. As the concept of work changes, the supply of jobs and the transportation options will be less important and the urban-rural movement can seriously take off.

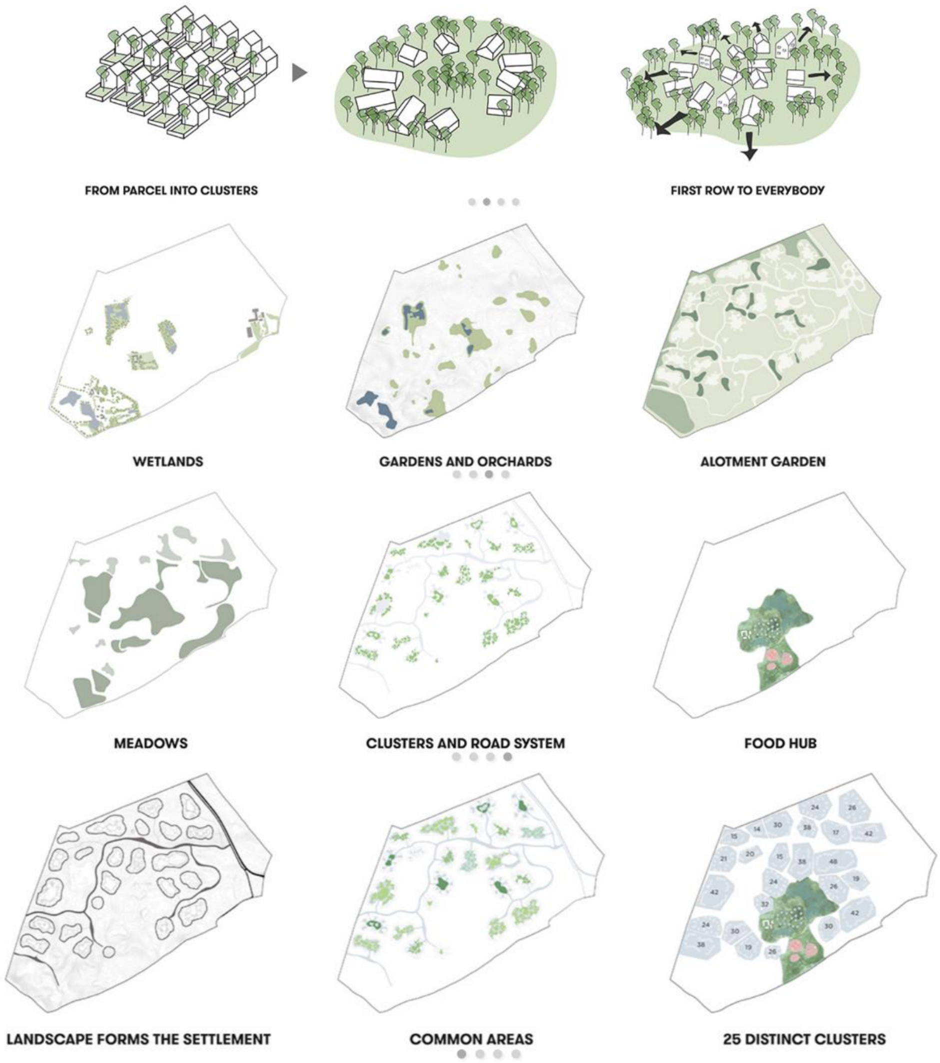


Figure 2 - 12

Helsinge Garden City is a proposal for a new way of living in the Danish countryside, in close connection to the surrounding landscapes, with a strong identity and sense of community. The settlement is structured in clusters, with a large number of common spaces and a high degree of sharing that enables a more sustainable way of living. The master plan has been developed with three main parameters in mind: Environmental, social and economic sustainability, which together will provide new possibilities to live a healthier self-sufficient life, in close connection to the landscape and in commuting distance from Copenhagen.

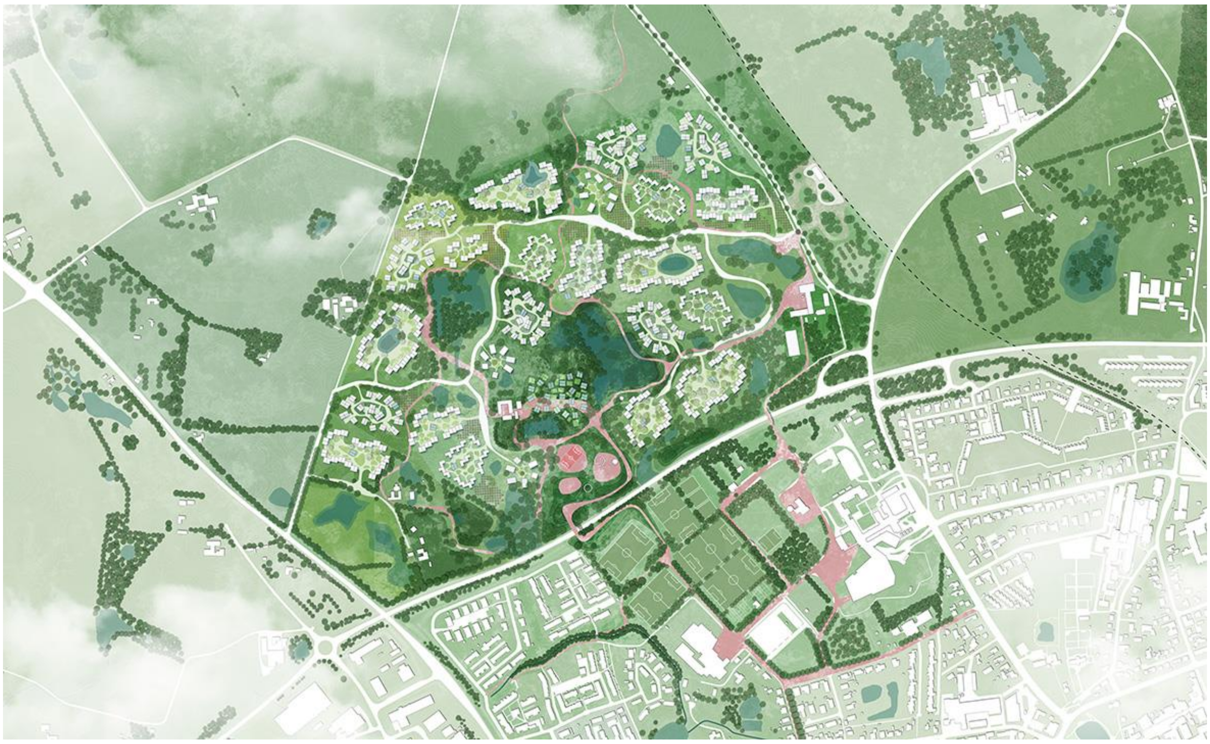


Figure 2 - 13

The master plan for the new village community is an organic plan, were landscape and settlement blend together. In order to strengthen community life and create a stronger relation to the surrounding landscapes, the settlement is developed as dense living clusters, with a limited amount of private outdoor spaces. The landscape and the in-between spaces are common areas, used for recreational purposes and with production of food integrated in the landscape, such as fruit orchards, permaculture and husbandry.

Figure 2 - 14

The master plan for the new village community is an organic plan, were landscape and settlement blend together. In order to strengthen community life and create a stronger relation to the surrounding landscapes, the settlement is developed as dense living clusters, with a limited amount of private outdoor spaces. The landscape and the in-between spaces are common areas, used for recreational purposes and with production of food integrated in the landscape, such as fruit orchards, permaculture and husbandry.

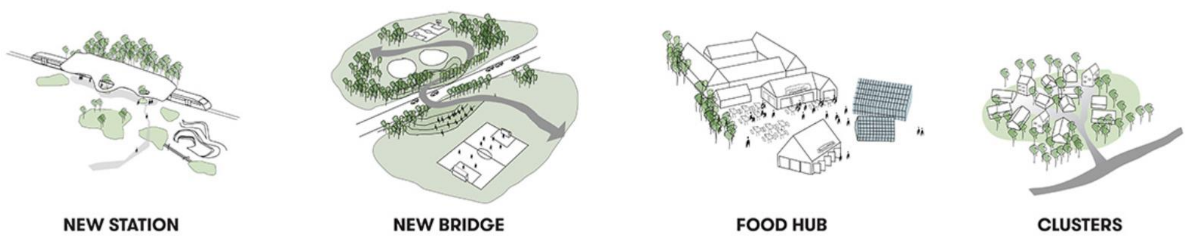


Figure 2 - 15

To create a neighborhood with social diversity, both regarding income and lifestyles, the clusters differ in form, materiality, sizes and types of ownerships. However, all houses have a private outdoor area and a direct connection to the common landscapes. The clusters will be developed as 25 small villages, with each their own characteristics, inspired from the qualities of their location. As in the old Danish villages, they are all structured around a common, a pond or a square, where the community and public life can unfold and thrive.

Figure 2 - 16

2.5. Letchworth Garden City

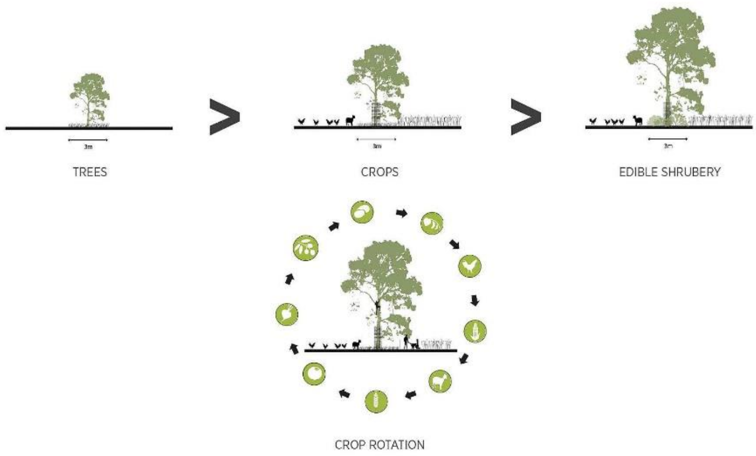
Re-imagining the Garden City

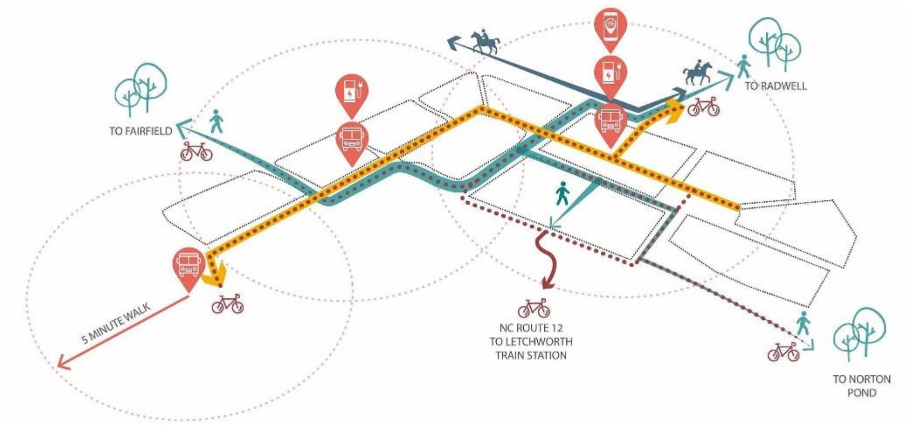
The masterplan is focused on a modern interpretation of the 'Hamlet' and is developed from the inside out; from the smallest residential scale to the larger hamlet scale.

Landscape is a key catalyst for the masterplan and has informed all strategic design decisions and the framework of the new masterplan is built around links and synergies between productive, performance and amenity landscapes. A wild landscape surrounds the masterplan, providing

Figure 2 - 17

shelter from noise and wind whilst enhancing the sense of enclosure and biodiversity. The new parkway takes advantage of the existing hedgerows and connects the site to Letchworth Garden City, providing different activities along the way.


TREES
CROPS
EDIBLE SHRUBERY
CROP ROTATION


TO FAIRFIELD
TO RADWELL
5 MINUTE WALK
NC ROUTE 12
TO LETCHWORTH
TRAIN STATION
TO NORTON
POND

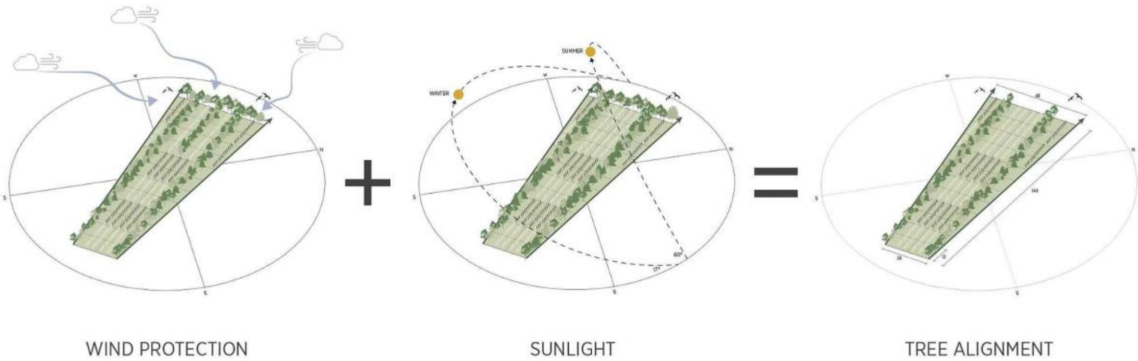

WIND PROTECTION
SUNLIGHT
TREE ALIGNMENT

Figure 2 - 18

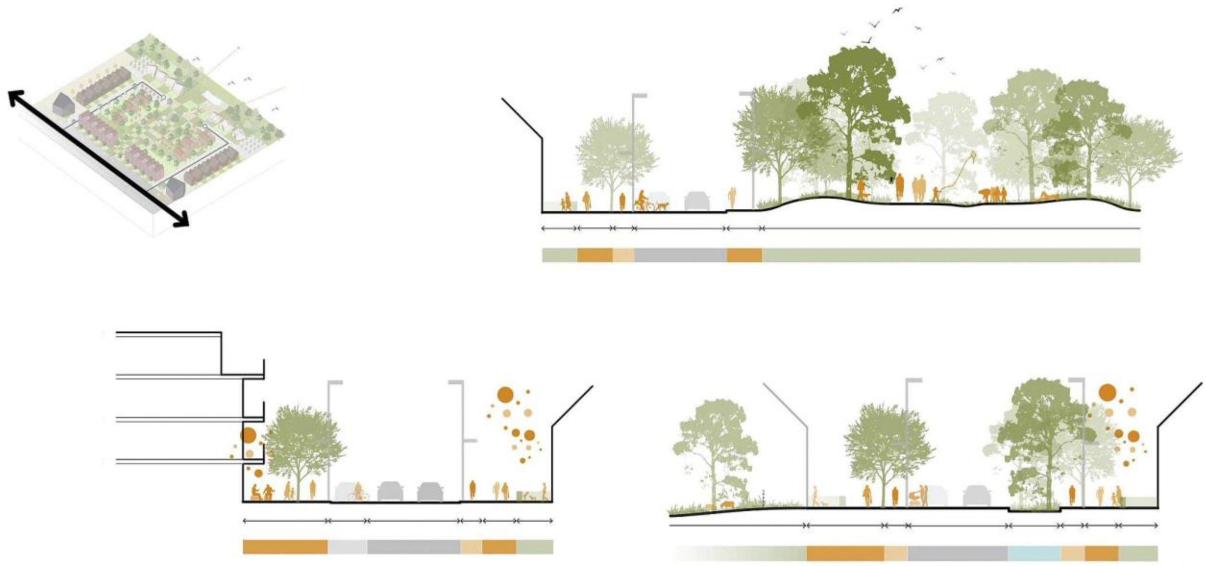


Figure 2 - 19

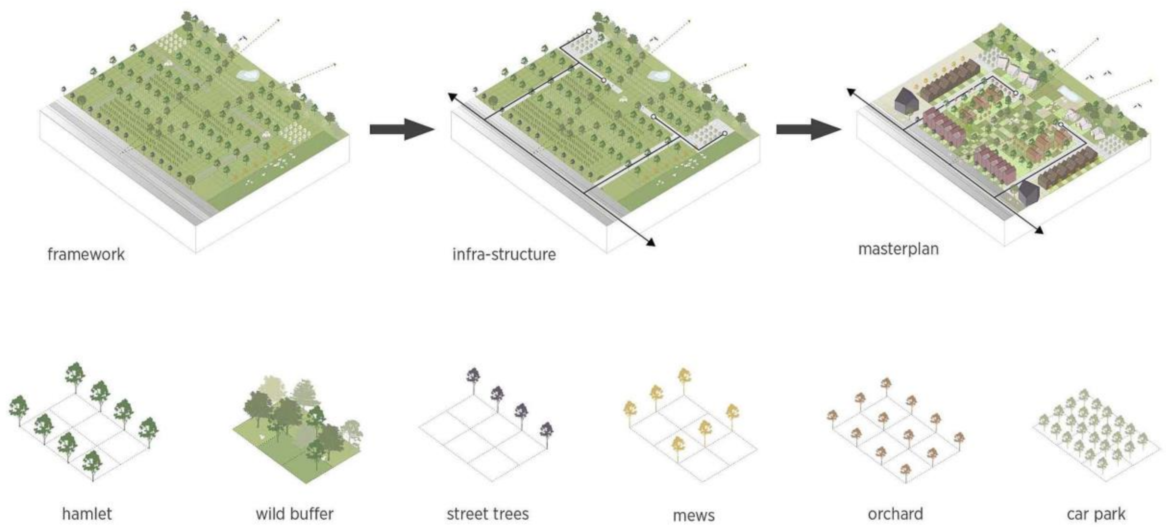


Figure 2 - 20

Figure 2 - 21

Figure 2 - 22

2.6. Circular 'garden city' in Brondby

Out of this world! Incredible drone footage captures amazing circular 'garden city' that looks like an 'alien civilisation'

The bizarre village can be found in Brondby, which is on the outskirts of the Danish capital, Copenhagen

The abodes are generally rented by garden-starved city-dwelling Danes with green fingers.

The imagery, by photographer Henry Do, shows the bizarre Danish suburb of Brøndby Garden City, in Brondby - on the outskirts of Copenhagen - which is formed from houses and gardens arranged in a neat circular fashion.

Figure 2 - 23

'Space is extremely limited if you're living in the main city so this is the perfect way to have your own garden and get back to nature.

'The intention behind this unique layout was to mimic the traditional patterns of the 18th-century Danish villages, where people would use the middle as a focal point for hanging out and mingling with neighbors.'

Figure 2 - 24

Figure 2 - 25

Buffers are defined as physical separations between land parcels which utilize topographic features, a substantial vegetation barrier, a water barrier, a landscape berm, separations, or a combination of these and other design features. Where buffers are to be implemented as part of an overall development project, they are typically designed specifically for that particular application and locale. The specific type and location(s) of buffering will be required by the City at the time a development project is proposed on one or more parcels which are located adjacent to agricultural uses. Buffers may be located on the non-agricultural or agricultural parcel(s).

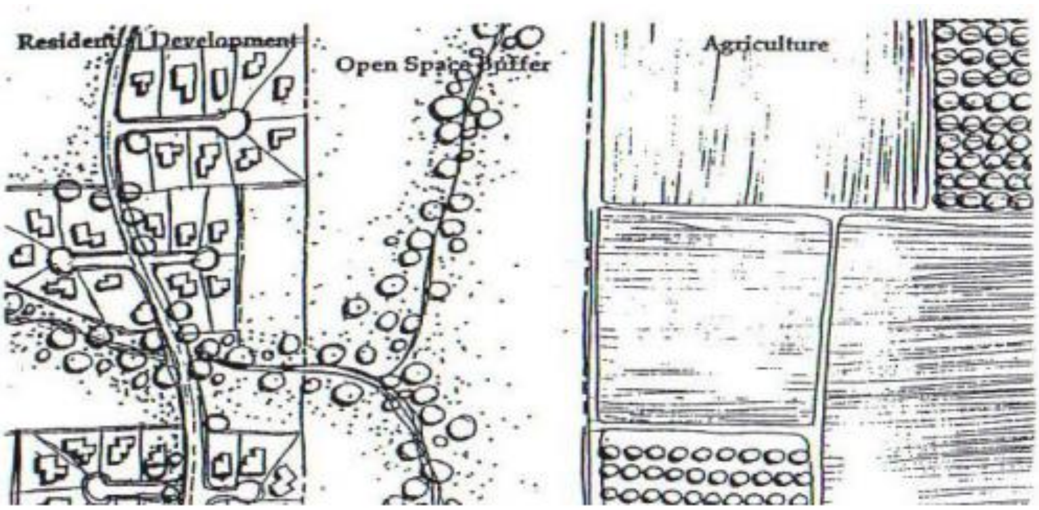


Figure 2 - 26

Creative project design and the use of additional buffering design features, strategies and techniques may permit a reduction of the recommended separations at the City's discretion. The project applicant may be required by the City to seek with input from various qualified consultants* (at the applicant's expense), and may be requested to provide scientifically-valid recommendations regarding the specific buffer proposed. The City and recommending agencies will also consider the type of development proposed, the natural features of the site, and will also consider compatible land uses which may be located in and adjacent to the buffer and which will not significantly impact agriculture or other adjacent land uses.

*Consultants may include experts or professionals with experience relating to the proposed buffer type, including, but not limited to: Resource Ecologists, Biologists, Farm Advisors, Licensed Pest Control Advisors, Landscape Architects, and Agricultural Production Experts.

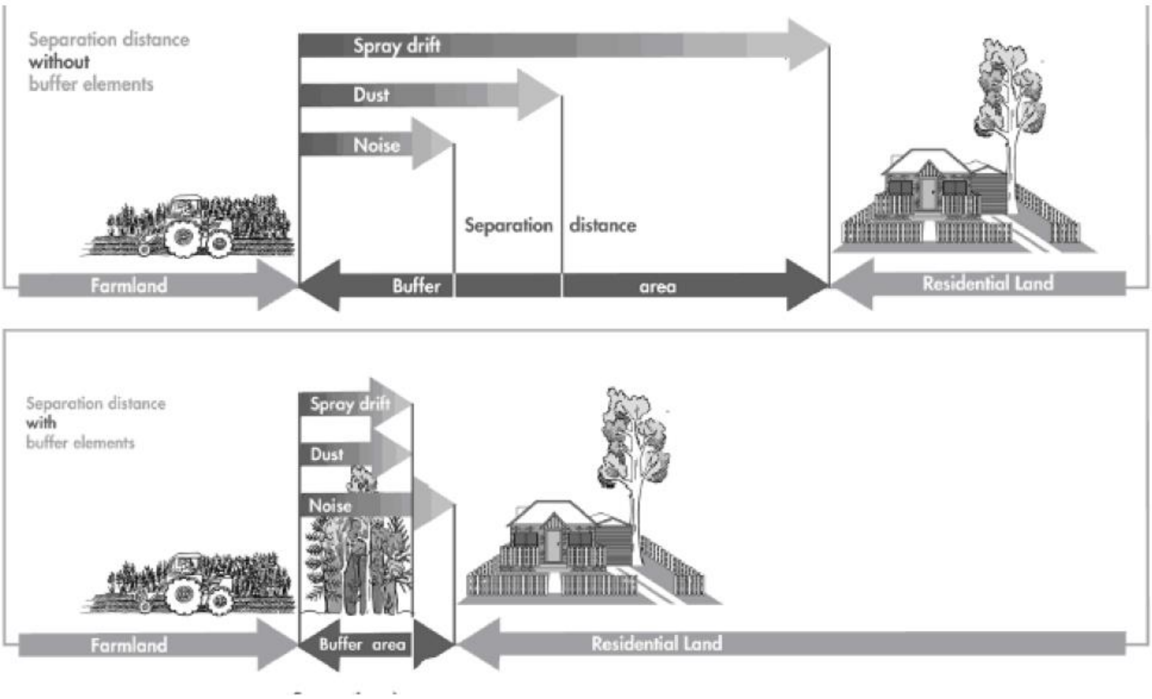


Figure 2 - 27

Consider a required buffer area as an opportunity to include compatible land uses into the buffer area. Compatible uses include some industrial uses, some commercial uses, park and recreation areas, open space, and parking areas, uses, wetlands/habitat other uses such as landscaped areas etc.

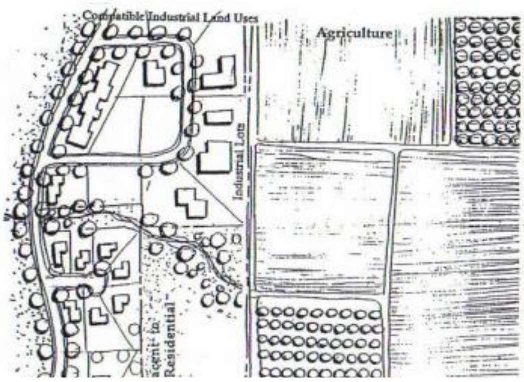


Figure 1 - 28

2.7. Regen Villages

ReGen Villages is a new visionary model for the development of off-grid, integrated and resilient eco-villages that can power and feed self-reliant families around the world.

ReGen stands for regenerative, where the outputs of one system are the inputs of another. The concept has a holistic approach and combines a variety of innovative technologies, such as energy positive homes, renewable energy, energy storage, door-step high-yield organic food production, vertical farming aquaponics/aeroponics, water management and waste-to-resource systems.

Figure 2 - 28

With the integration of such technologies, ReGen Villages holds a potential in changing some of the challenges of a growing population, increasing urbanization, scarcity of resources, the growing global food crisis as well as reducing the global CO2 emission and reducing the burdens on municipal and national governments in dynamically changing planetary and economic times.

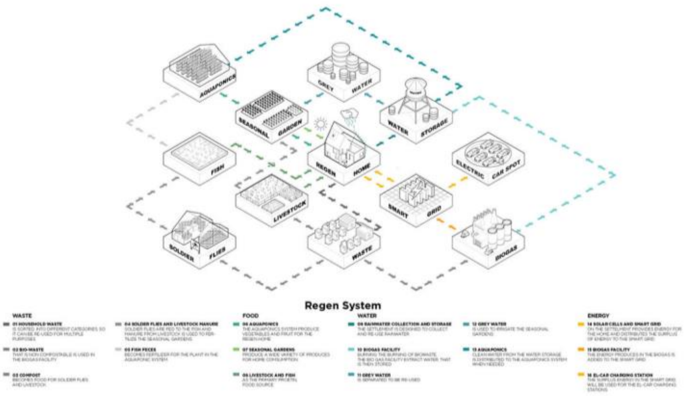


Figure 2 - 29

ReGen Villages is all about applied technology. Already existing technologies are simply being applied into an integrated community design, providing clean energy, water and food right off the doorstep. ReGen Villages adds not only environmental and financial value, but also social value, by creating a framework for empowering families and developing a sense of community, where people become part of a shared local eco-system: reconnecting people with nature and consumption with production.

Each ReGen community will contain a variety of homes, greenhouses and public buildings, with built-in sustainable features, such as solar power, communal fruit and vegetable gardens and shared water and waste management systems. The five principles underpinning the concept are:

energy positive homes, door-step high-yield organic food production,mixed renewable energy and storage, water and waste recycling, empowerment of local communities

Figure 2 - 30

2.8. White Arkitekter + ReGen Villages Create First Circular, Self-Sufficient Communities for Sweden

White Arkitekter, in collaboration with Silicon Valley-based ReGen Villages, have joined forces to create fully circular, self-sufficient and resilient communities in Sweden. Inspired by computer games, the project puts in place organic food production, locally produced and stored energy, comprehensive recycling, and climate positive buildings.

Figure 2 - 31

White Arkitekter, in collaboration with Silicon Valley-based ReGen Villages, have joined forces to create fully circular, self-sufficient and resilient communities in Sweden. Inspired by computer games, the project puts in place organic food production, locally produced and stored energy, comprehensive recycling, and climate positive buildings. In order to tackle the challenges that cities have to face nowadays, like climate crisis, rapid urbanization and housing shortage, White Arkitekter, and ReGen Villages Sweden, a subsidiary of the Holland-based company ReGen Villages Holding, have teamed up to develop self-sufficient communities in and around cities. While White Arkitekter is in charge of the overall site planning and the design of energy-positive buildings, including housing, ReGen Villages has been conducting, for the past 4 years, meetings with Swedish municipalities, landowners, property developers, and stakeholders.

Figure 2 - 32

Meeting the Global Goals for Sustainable Development, the project, set to start in 2020, aims to "make our cities and communities less vulnerable by lessening the load on central infrastructure". Based on the latest climate-smart technologies which are adapted to site-specific conditions, a ReGen Village introduces new technologies for food, energy, and water, "combined in an unprecedented way into a single circular system with the help of Village OS". Through AI technology and machine learning, food will be supplied from vertical farming and aquaponics, energy will be secured from solar panels and biogas produced from local waste, and water is collected, cleaned and reused.

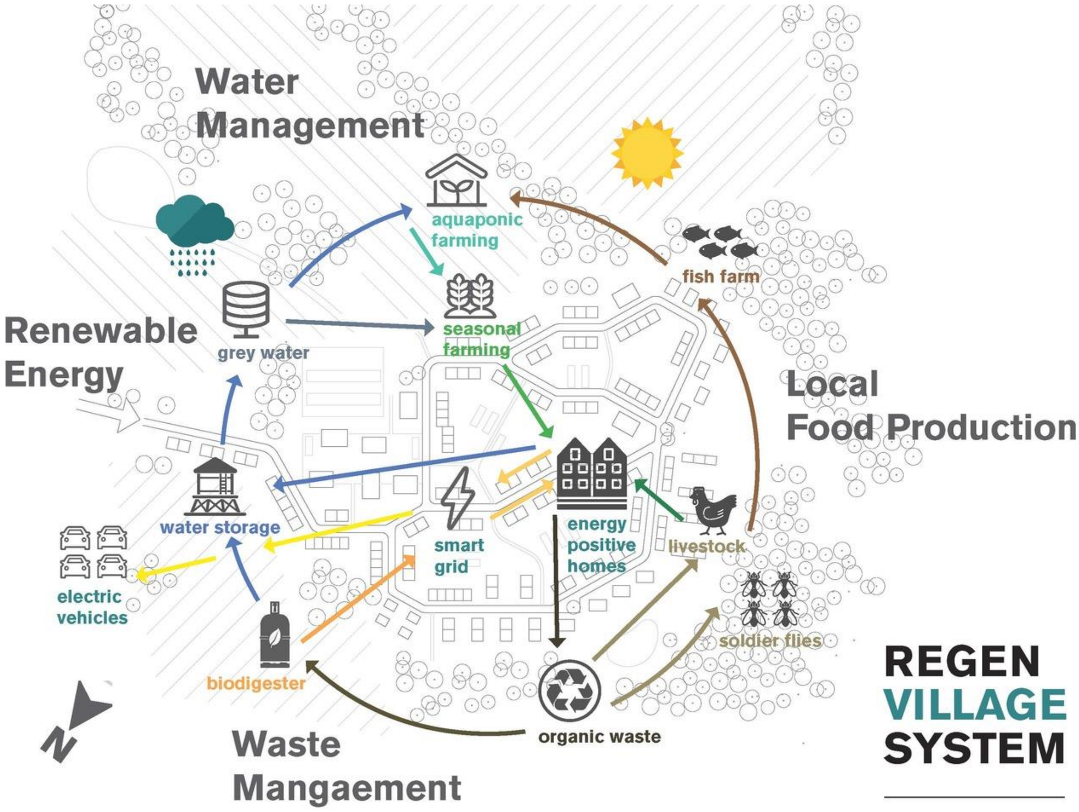

Water
Management
aquaponic
farming
seasonal
farming
fish farm
Renewable
Energy
grey water
Local
Food Production
water storage
smart
grid
energy
positive
homes
livestock
electric
vehicles
soldier flies
biodigester
organic waste
Waste
Mangaement
REGEN
VILLAGE
SYSTEM

Figure 2 - 33

2.9. The Netherlands Will Soon Be Home to a Self-Sustaining Eco Village

White Arkitekter, in collaboration with Silicon Valley-based ReGen Villages, have joined forces to create fully circular, self-sufficient and resilient communities in Sweden. Inspired by computer games, the project puts in place organic food production, locally produced and stored energy, comprehensive recycling, and climate positive buildingswith fresh fruits, vegetables, and legu.

Figure 2 - 34

Imagine a neighborhood where landscaping comes in the form of vertical gardens bursting mes; where the roads are only wide enough to walk or bike to a friend's house; where you can volunteer at the local community center in exchange for homeowner association (HOA) fee discounts, tracked using blockchain technology, of course. Silicon Valley–based construction company ReGen Villages has imagined a place like this and is planning to develop the world's first self-sufficient suburb 20 minute outside of Amsterdam in the Dutch town of Almere.
Inspired by research for the Solar Decathlon from Stanford University as well as a UN sustainability brief from the Stanford Center for Design Research—which was co-authored by ReGen Villages founder James Ehrlich outlining preliminary plans for the villages—the construction firm aims to address the issue of exponential population growth by creating affordable, sustainable housing options, according to its website.

Figure 2 - 35

Figure 2 - 36

URBAN DESIGN

3. Urban Design

3-1 Strategy Plan

After affection Ravenna city, immigration to the cities close by are going to happen, our overall strategy is dividing each city into 3 parts. Old town which is the main existing city have been protected by the buffer zone and the expansion of the city shows in yellow considered as smart villages which are the new towns. (figure 2-1)

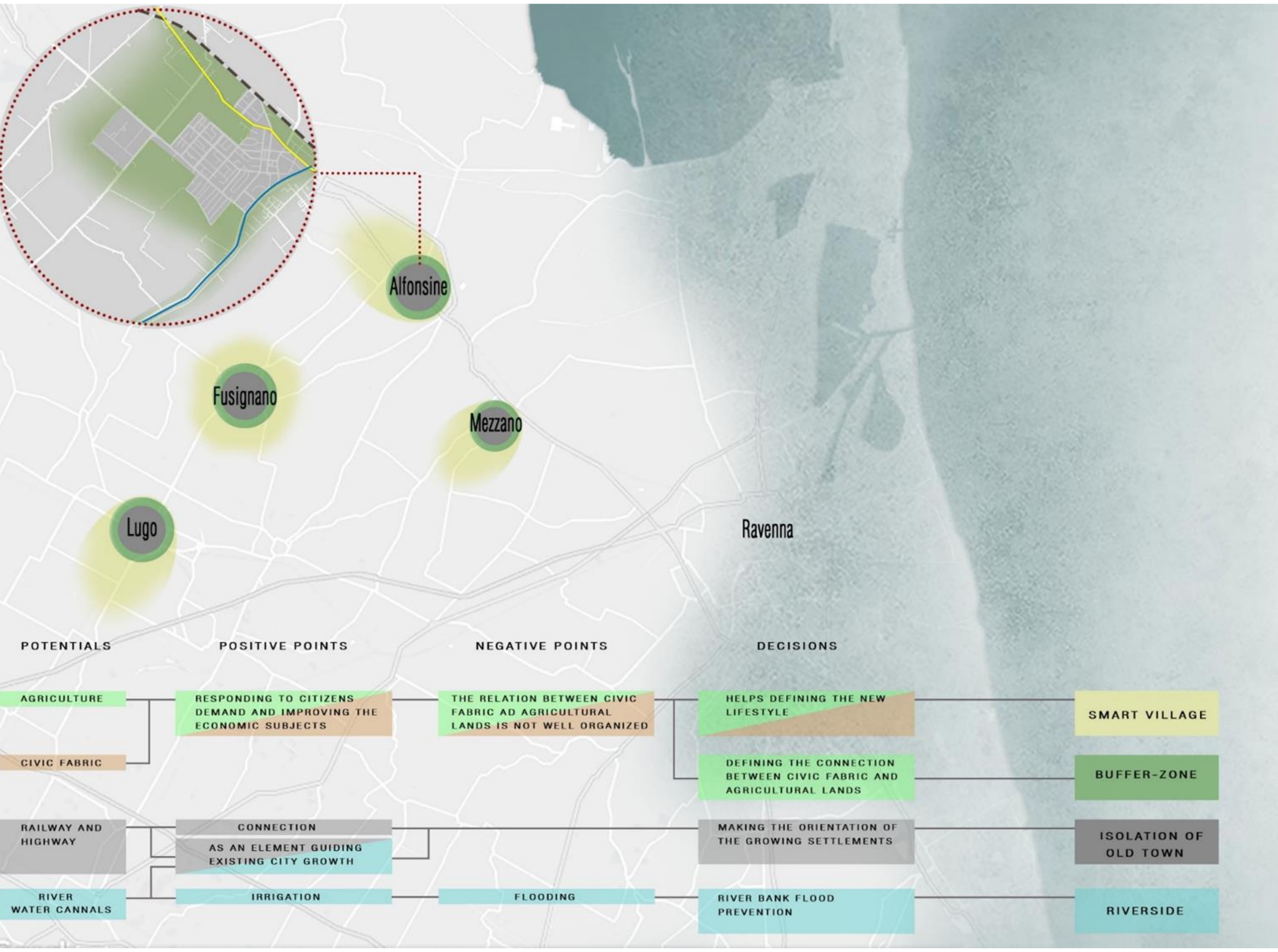


Figure 3 - 1

3-2 Expansion Strategy

By analyzing the historic expansion of the cities around Ravenna since 1900 to 2020, the direction of the expansion of the cities show in the picture. So, the direction of the expansion of new villages will be in the same direction as before. (figure 2-2)

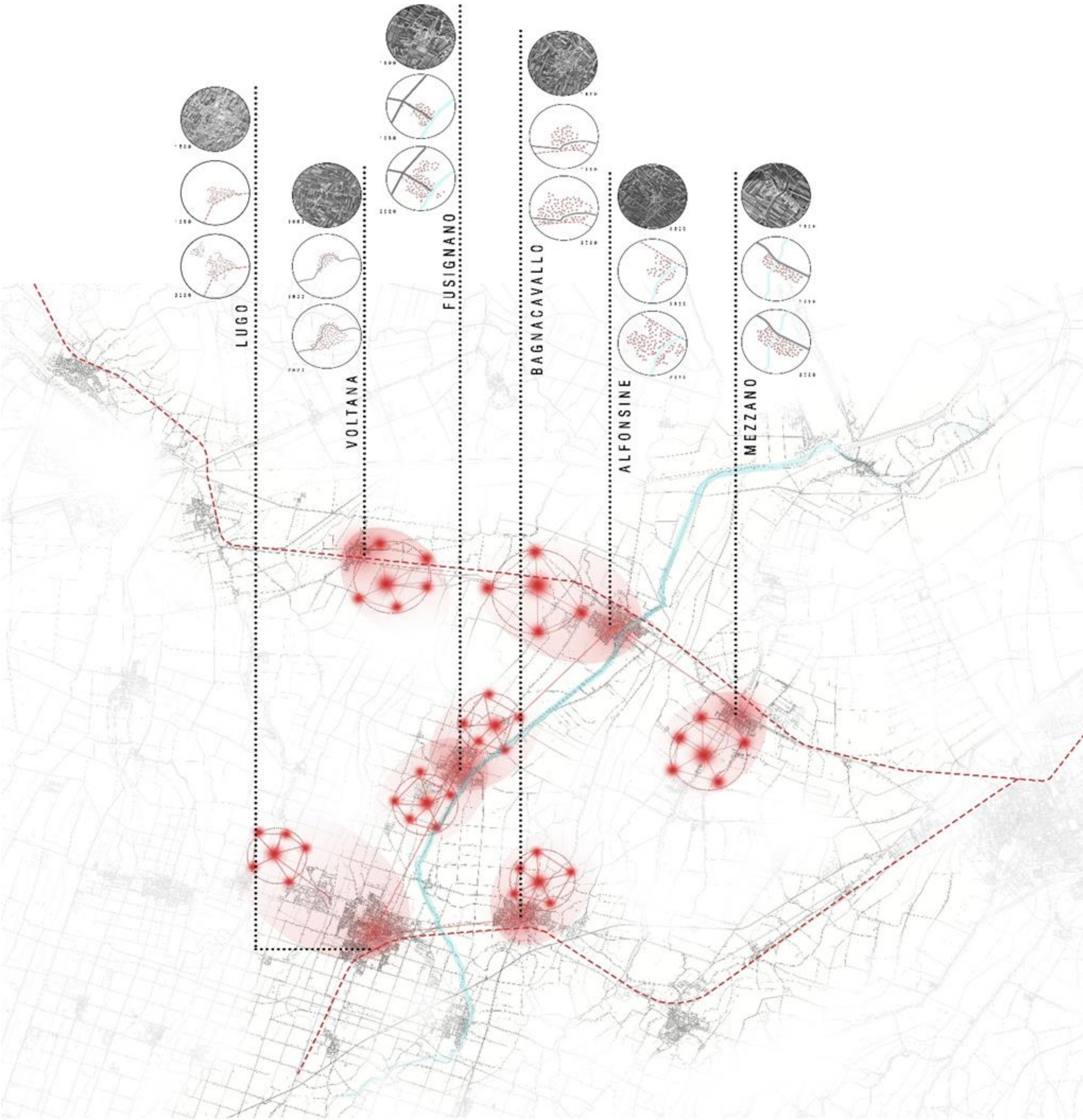


Figure 3 - 2

3-2-1 Old town and Borders

In this map, Railway and the river are acting as the borders to direct the direction of the expansion of the city,

Protect its outstanding values and promote its harmonious adaptation to the needs of life in a modern village. and to ensure that its unique qualities and its global significance are understood in order to conserve and to safeguard the inherited cultural and historic assets.

Co-ordinate action between new city and old city through the medium of a Management Plan like connecting by the green corridors in order to have contentiously interaction inside out.

meet users' needs and respect the World Heritage Site's cultural and historical significance.

and strong partnerships with local, national and international communities and organizations in order to bring people together to deliver the vision. make it accessible, inclusive and enjoyable for all. (figure 2-3)

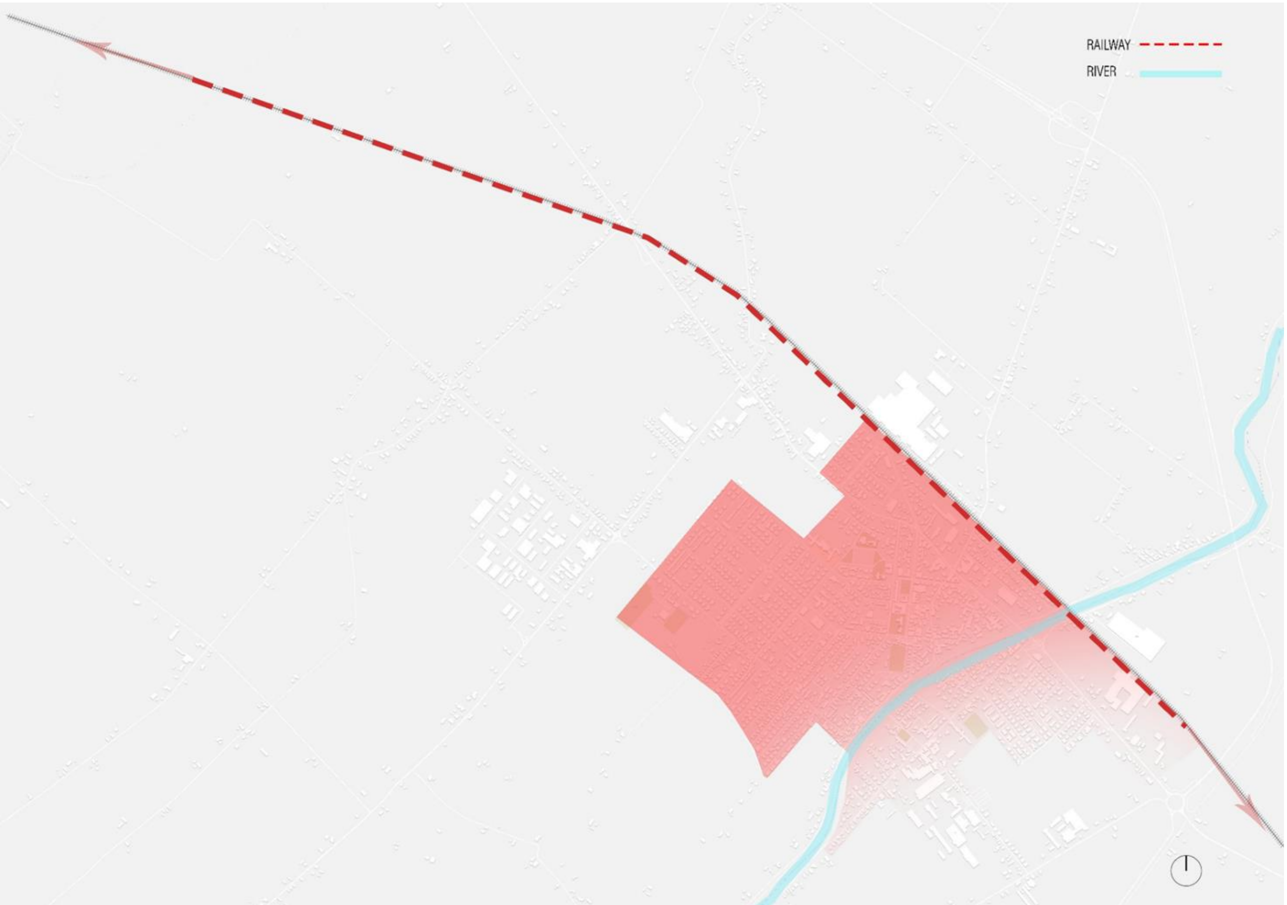


Figure 3 - 3

3-2-2 Buffer zone

The absence of a buffer zone is assumed to be one of the causes of the impact and the recently adopted Historic Urban Landscape approach aims to assist on managing and mitigating impacts of urban development by integrating urban heritage conservation and urban management. To ensure that eminent patterns of change caused by urban development do not negatively impact the attributes conveying cultural significance of outstanding universal value, it aims to discuss the effectiveness of the current management plan including tools such as the local conservation areas. (Figure 2-4)

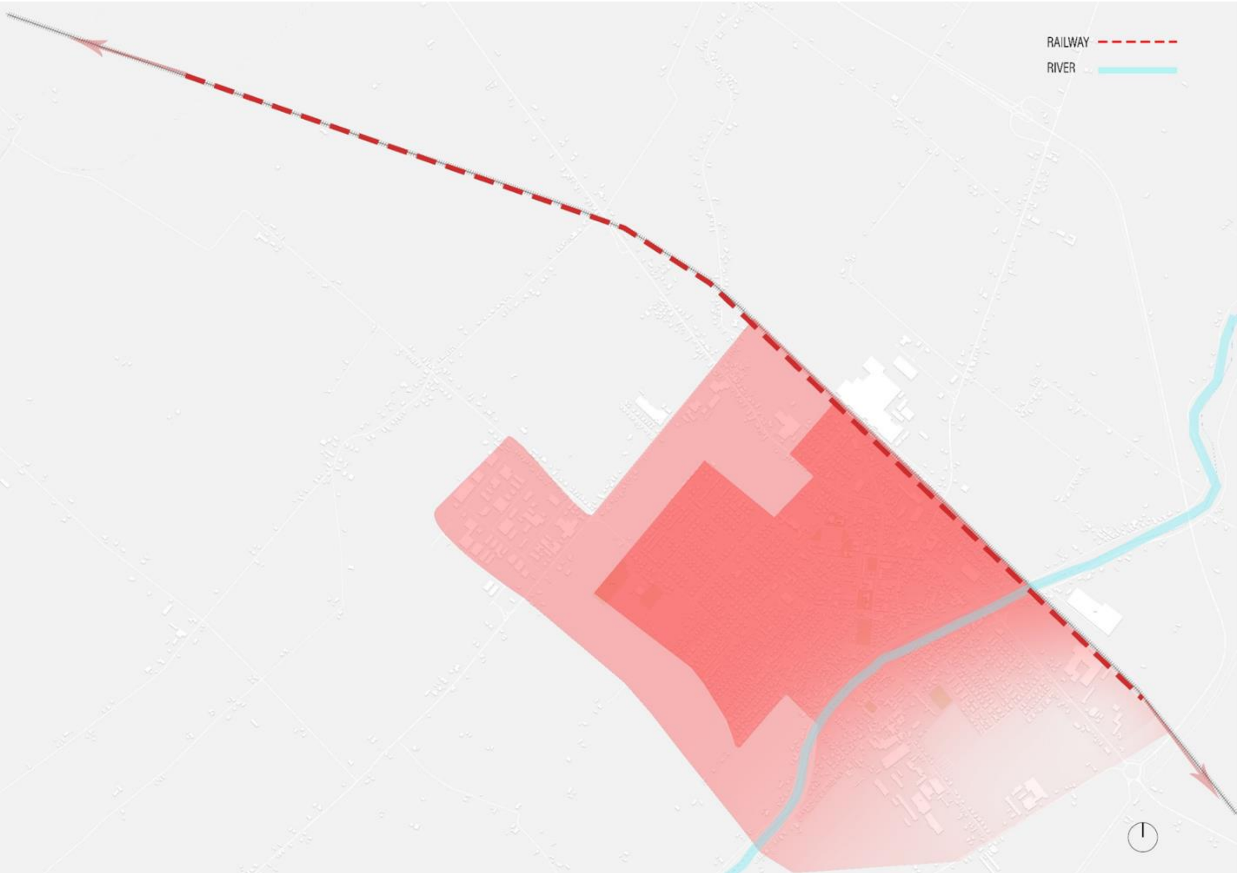


Figure 3 - 4

3-2-3 Newtown direction

New town direction affects from the 2 highways that pass thought the city to the cities around, so we decided to locate the establishments in between these 2 high ways, the way that railway passes in the middle of the city can be the best opportunity as the starting point of exporting the materials to the other cities.
(Figure 2-5)

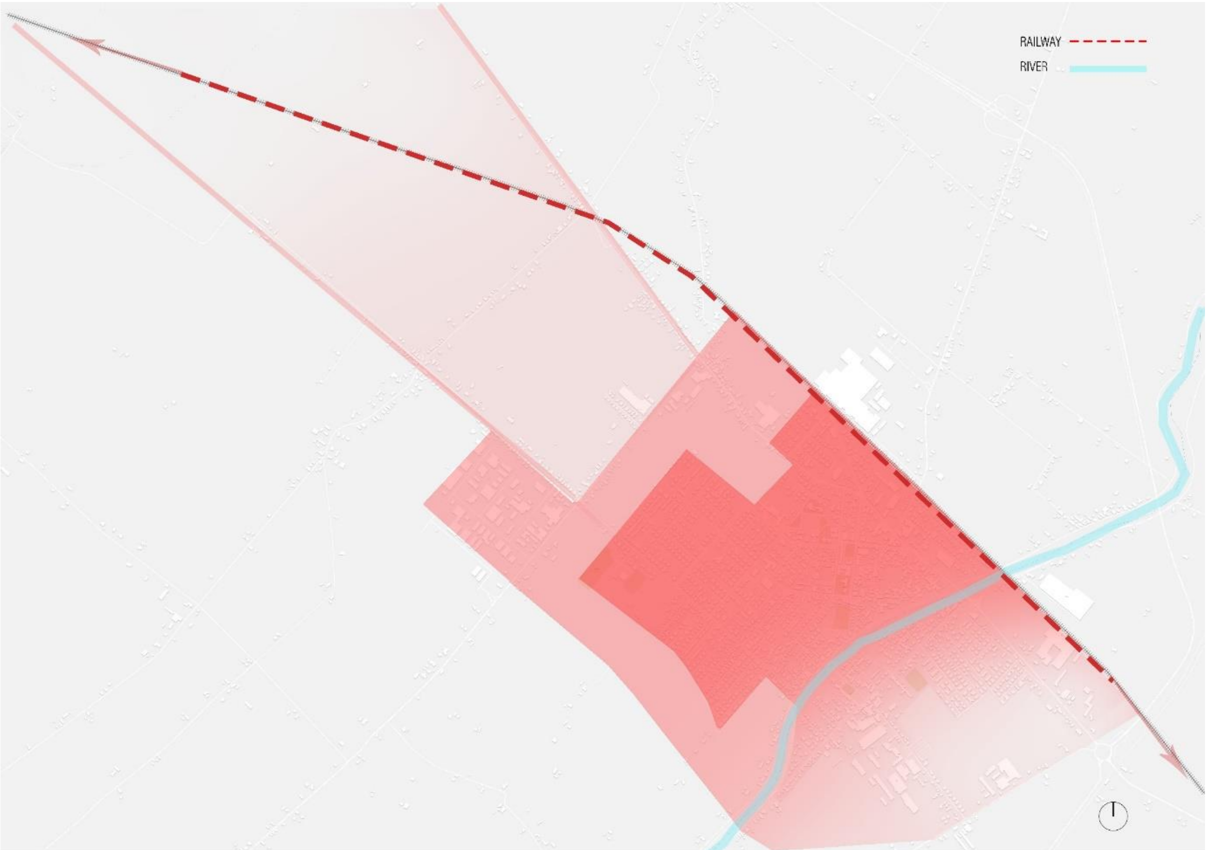


Figure 3 - 5

3-2-4 Clusters location

New villages are acting as each individual cluster which are kind of self-sufficient, but also has the connection either in materials or interaction with the clusters around,

The main cluster which is located in the middle of the circle zone (the circular ones) are concluding the main function as education, recreation and services and the other clusters around (the square ones) are mainly for the units and houses and the functions contributed to the houses and units, like aquaponics, seasonal garden and community garden. And each main circular cluster has the connection to the old town inside out. (figure 2-6)

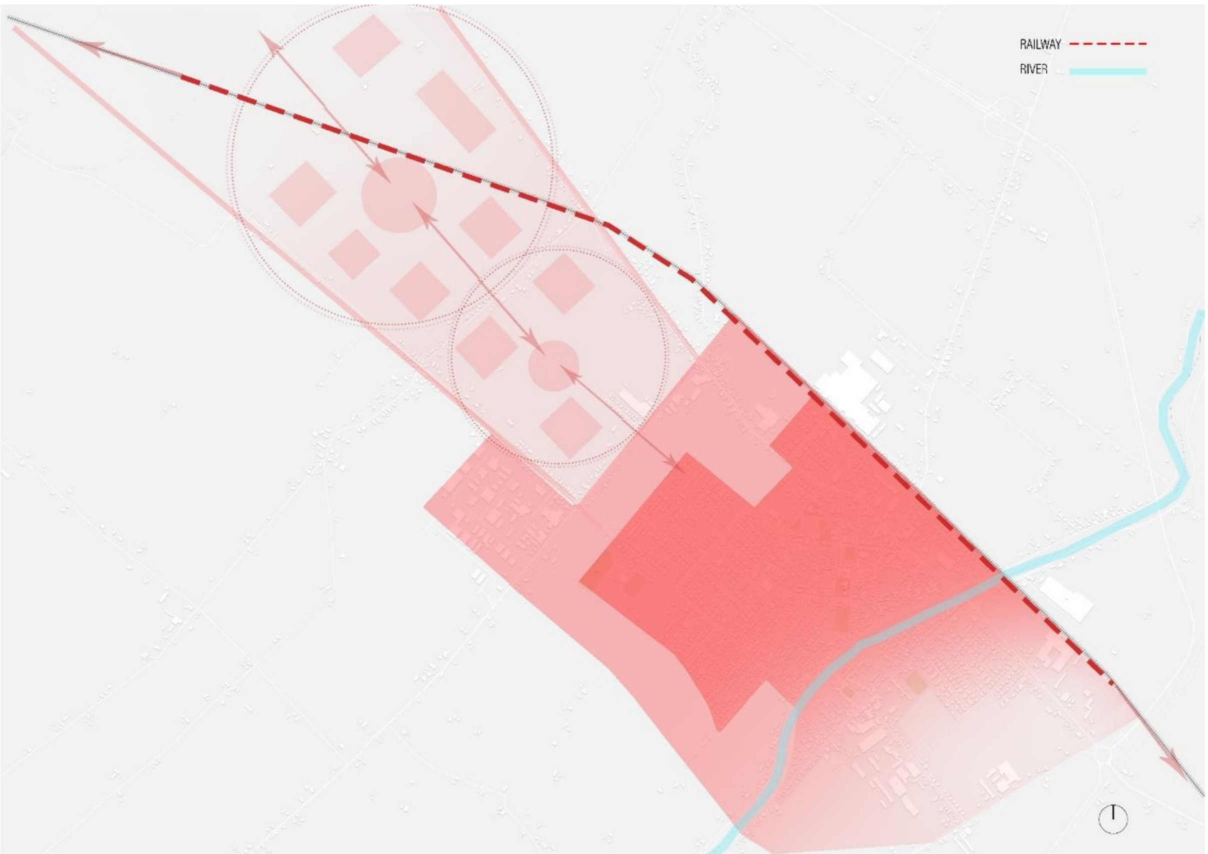


Figure 3 - 6

3-3 General Strategy

The old town, the buffer zone and the new town. Which the old town has been preserved by the buffer zone in the case of expansion of the city and preserve its historical values. And the buffer zone as the connector to connect old town and new villages, 2 main linear buffers to show the direction of the expansion and the idle linear green connection somehow connect old to new. (Figure 2-7)

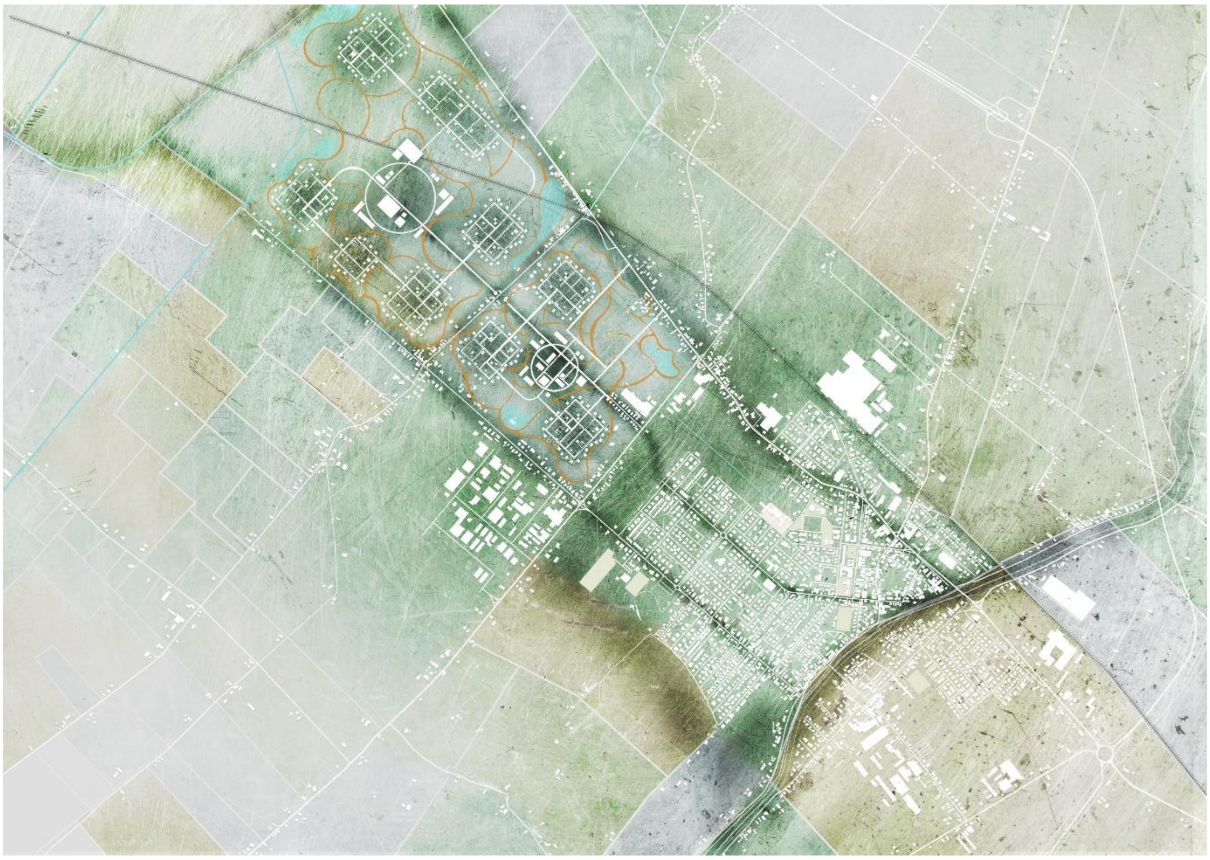


Figure 3 - 7

3-3-1 Old town (existing city)

People who come from station has the insight of about the things happen in new town by considering the exhibition directly faced to the station, we tried to connect the green spaces in the old town with green corridor and connect all to the new town. The is the joint in the connection of the 2 main corridors that we decide to lace the recreational park and organize some functions like seasonal garden and community center in the park. (Figure 2-8)

Figure 3 - 8

3-3-1-1 Green spaces and corridors

2 main green corridors connect the old town to the new town and also pass from buffer zone and the other one connects the railway station to the center of the town and finally to the new town, the green park's location in the focal point and each has their own function. (Figure 2-9)

Figure 3 - 9

3-3-1-2 Exhibition

There is the exhibition close by the station for the people who come to the old town to have the new insight of what will going on in the new town as the exhibition. The pattern of the building is the sample of the units in the new town. (Figure 2-10)

Figure 3 - 10

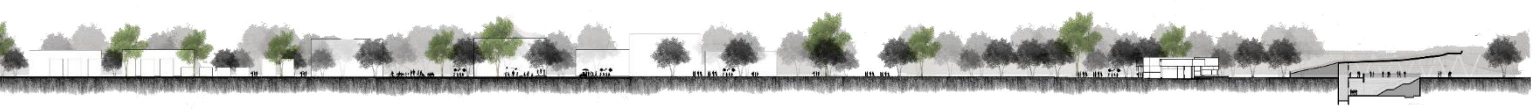


Figure 3 - 11

3-3-1-2 View from the exhibition

Figure 3 - 12

Figure 3 - 13

Figure 3 - 14

3-3-1-3 Intersection Park

To connect the railway station green corridor and the river front corridor, we decided to put the park as the recreation in order to guide the ones who come from aside have the better sight to the new town in this, we tried to locate some facilities like community garden and seasonal garden in the park to have the feeling of the new town in the intersection location park. (Figure 2-16)

Figure 3 - 16

Figure 3 - 15

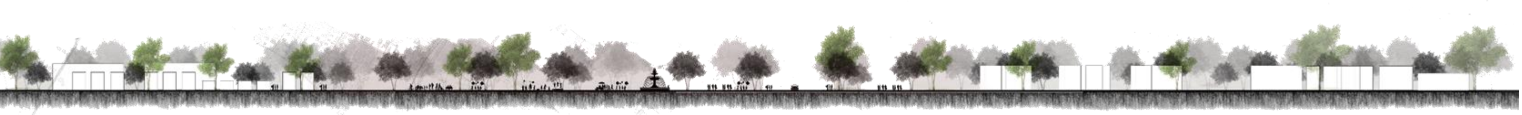


Figure 3 - 17

3-3-1-3-1 View from the Intersection Park

Figure 3 - 18

Figure 3 - 19

3-3-1-4 River front

In order to prevent the flood, this location can be used as the recreational park which is in the border of the river, and also function as the way to prevent the flood or in the verge of the rising the water, slow down the flood by using the steps, vegetation and rocks to slow down the velocity of the water. (Figure 2-18)

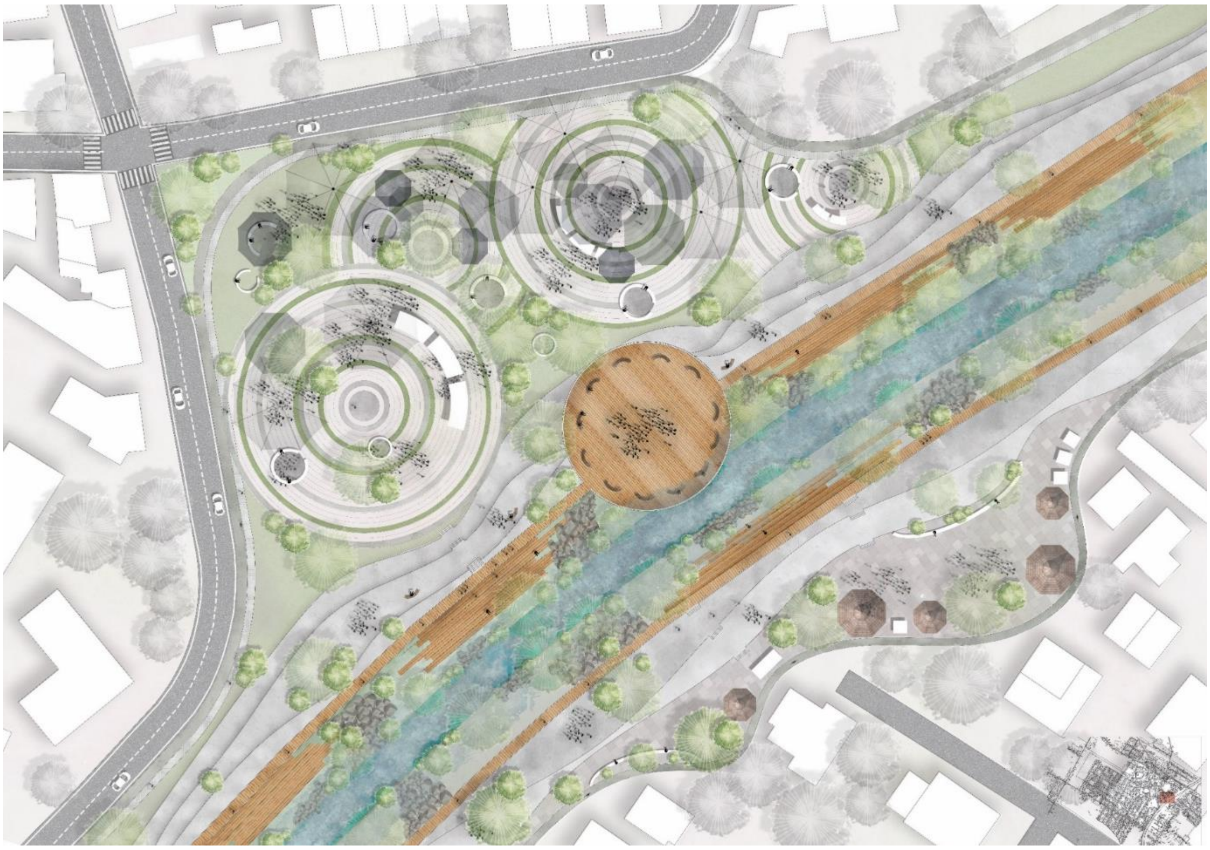


Figure 3 - 20

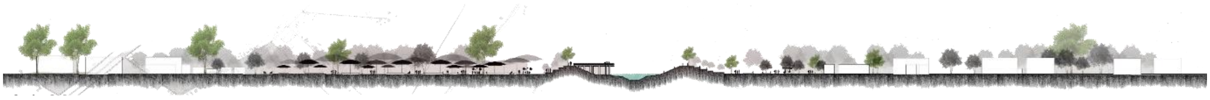


Figure 3 - 21


Figure 3 - 22


Figure 3 - 23


Figure 3 - 24


Figure 3 - 25

3-3-2 Buffer Zone

In order to preserve the old town, we decide to create he buffer zone as not only the preserver, but also the pattern to direct the proper way of expansion of the city. In this buffer e put Agri voltaic panels for saving the energy, and the urban park which is placed in the verge of the water canals. And the experimental lands covering the green corridor connecting the old to new to and the linear park in order the preserve the left side of the city to expand on that direction, and the educational center to educate people in the way of the process of living and producing inn the new town. (Figure 2-27)

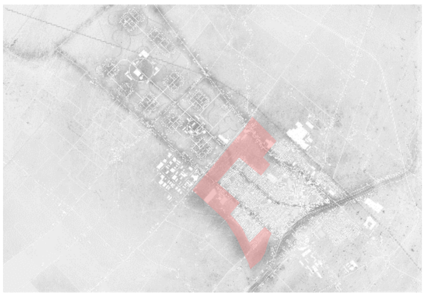


Figure 3 - 26

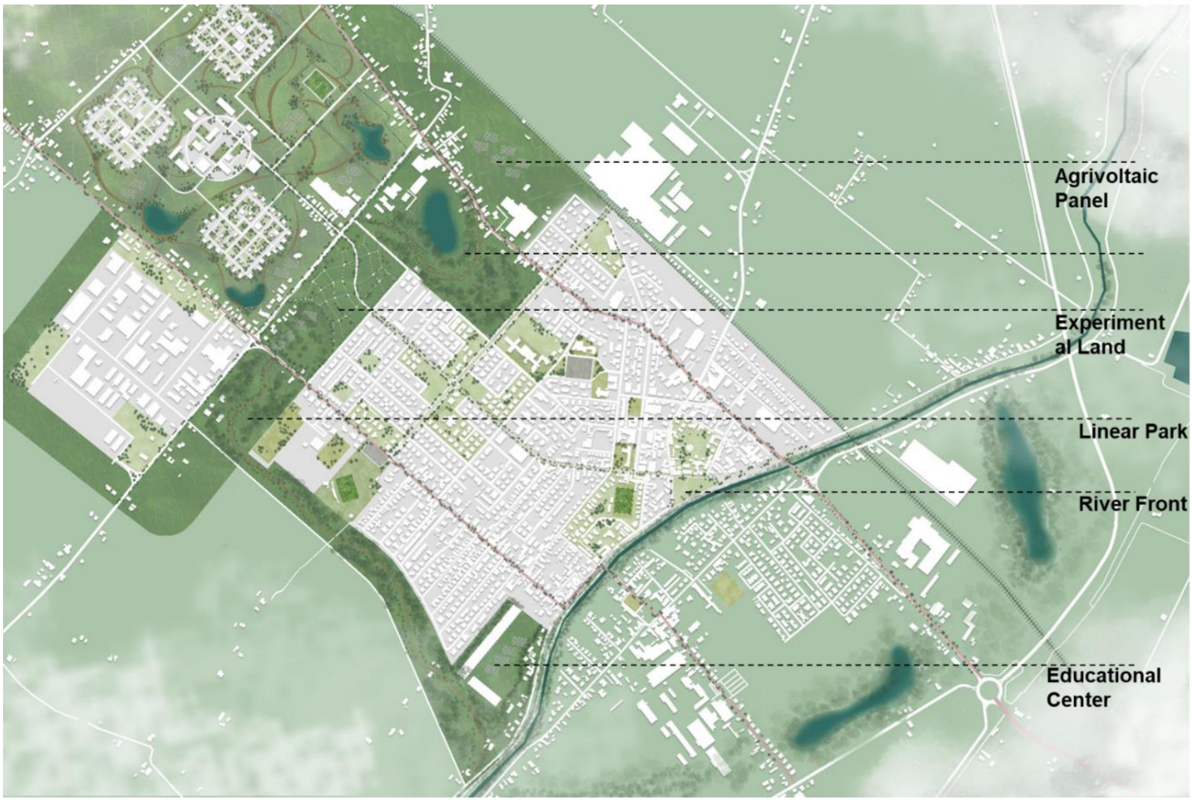


Figure 3 - 27

In order to guide the expansion of the city in the right way, railway and the river are acting as the existing boundaries. We decided to create the buffer on the other 2 sides to add the new town in the proper direction.

In the north side, the entrance to the new town, we put the experimental lands and the rest is the linear park to surround the old town. And the south part organized for the educational land. (Figure 2-28)

Figure 3 - 28

3-3-3 New Town

The Green corridor connects the old and New town, in the beginning of the entrance of the green corridor in the new town, we decided to place the bazar, which is the old houses renovation to act as the old bazar. Exactly locate on the verge of the connection of new and old town, in this sample city (Alfonsine) we have 2 blocks of expansion, each block has their own main cluster (circular one) and the clusters around as the house's units and residential. The main cluster functionally work as services like education and facilities. On the second block, organizing the main circular Cluster on the railway and lace the storage to manage all product in order to be prepared to export to the other cities. And the walking path locating in the agriculture lands in approximate 1 meter on top of the lands and not directly touch it. And the ponds located on the connection of the existing water canals in order to be the case of preventing the flood in time of the high level of water to act as water storm or storage. (Figure 2-26)

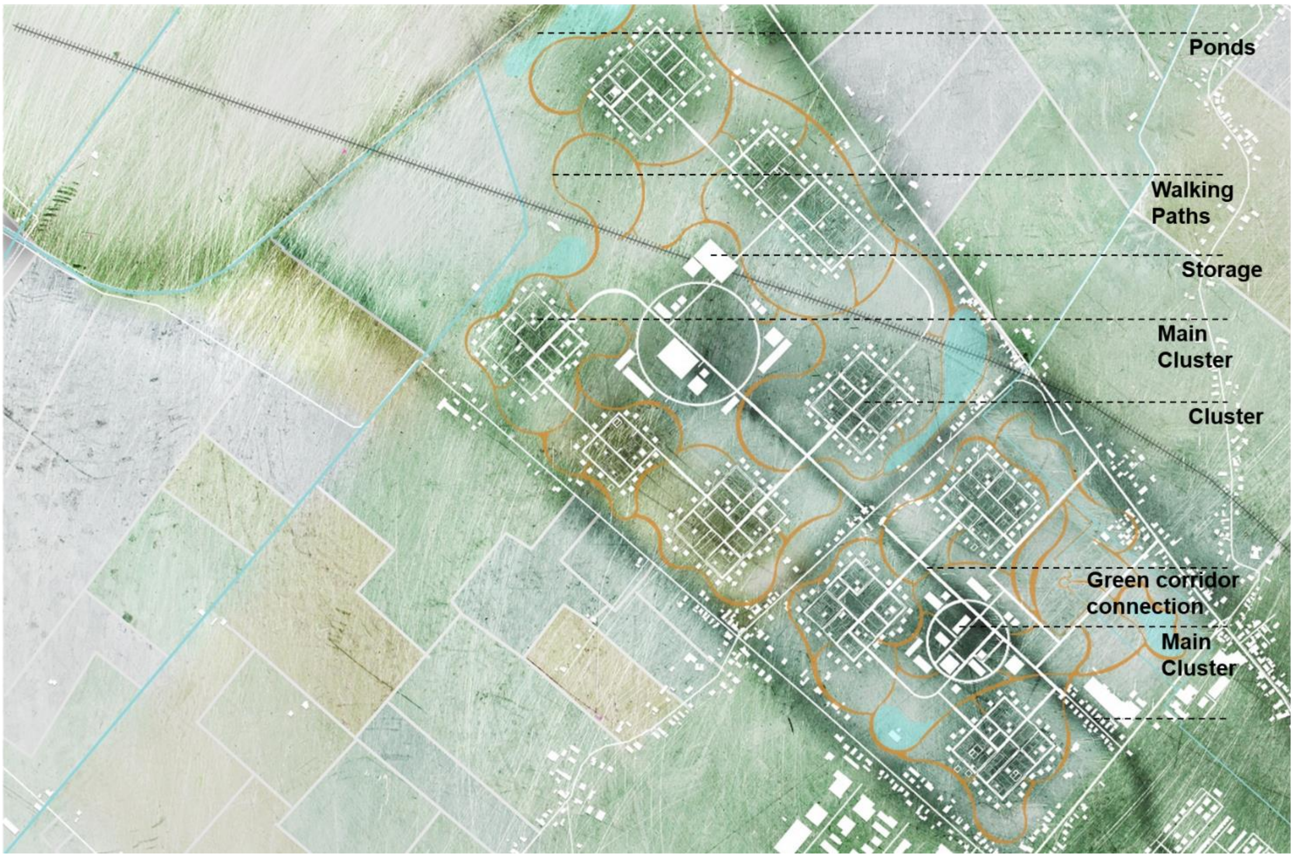


Figure 3 - 29

Figure 3 - 30

3-3-3-1 Clusters

It is about 25-30 housing units with 3 or 4 people for each unit which is organized in the edge of the clusters. The units expanded the glass wrap to great better condition for the vegetation to grow. The food production facilities located in the middle wrapped by the glass which is consider as the group community.in the center of the housing there is public space with recreational functions, and the parking locating in the entrance of each village. There is car path just has the connection to the face of the housing units and all in the middle is pedestrian and bike path. Some community and seasonal garden are specifically located for each house units and some of them creating to work in group units. (Figure 2-28)

Figure 3 - 31

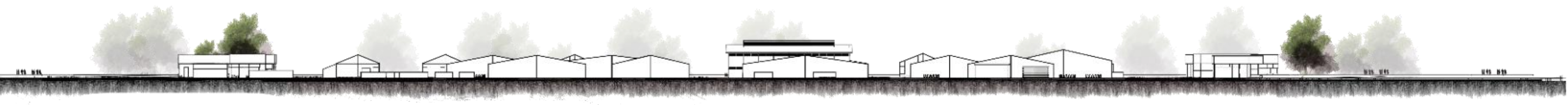


Figure 3 - 32

Figure 3 - 33

2-3-3-1-1 Overall view of the Clusters

Figure 3 - 34

Figure 3 - 35 View of the street and seasonal garden – some parts of the seasonal garden will be temporary covered according to the needs of the planted products

Figure 3 - 36 View of the aquaponics and community gardens

Figure 3 – 37 Inside view of Aquaponics

Figure 3 - 38 View of the aquaponics and the street

Figure 3 - 389 View of the community garden

Cluster Design

4. Cluster Design

4.1. Weather analysis

he dry bulb temperature is a measure of the air temperature taken with a thermometer that is not affected by the moisture content in the air. It is the most common measure of air temperature and is usually reported in degrees Celsius. Ravenna is a city located in the Emilia-Romagna region of Italy, on the Adriatic coast. It has a humid subtropical climate with hot summers and mild winters. In the summer months, the dry bulb temperature in Ravenna can reach up to 30-35°C, while in the winter months, it can drop down to around 5-10°C.

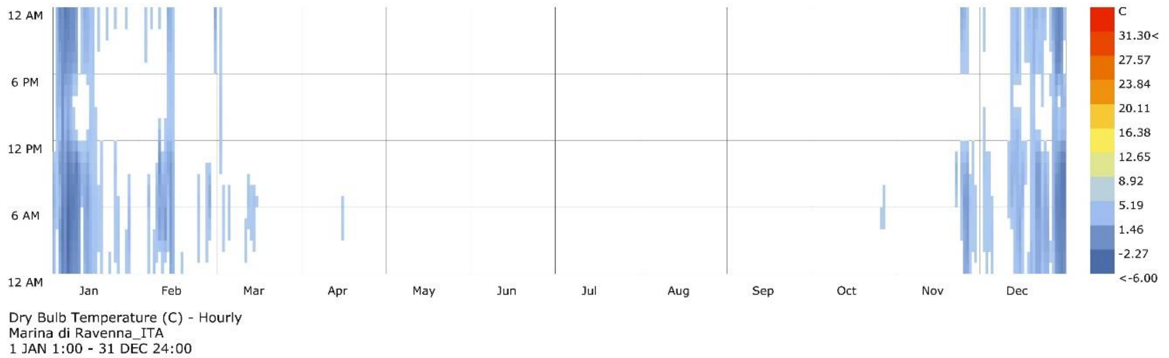


Figure 4- 1 Dry Bulb Temperature

the dew point temperature is the temperature at which the air becomes saturated with water vapor, causing dew or condensation to form. It is a measure of the amount of moisture in the air, and it is usually reported in degrees Celsius. the dew point temperature in Ravenna varies throughout the year, depending on the prevailing weather patterns. In the summer months, when the air is warm and humid, the dew point temperature can be quite high, often reaching 20-25°C or higher. In the winter months, the dew point temperature tends to be lower, often ranging from 0-10°C.

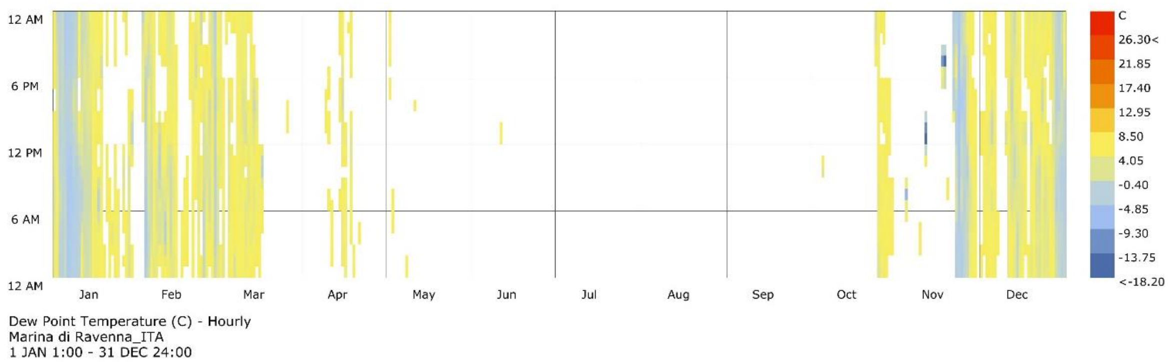


Figure 4- 2 Dew Point Temperature

Ravenna is a coastal city on the Adriatic Sea and is known to experience moderate to strong winds at times. The prevailing wind direction in Ravenna is from the north/northeast, with the highest average wind speeds occurring in the winter months. the average wind speed in Ravenna ranges from around 7-12 km/h (4-7 mph) in the summer months, to around 10-20 km/h (6-12 mph) in the winter months. However, it is important to note that actual wind speeds can vary widely depending on weather conditions as you can see in the graph, and gusts can be significantly stronger than the average wind speeds.

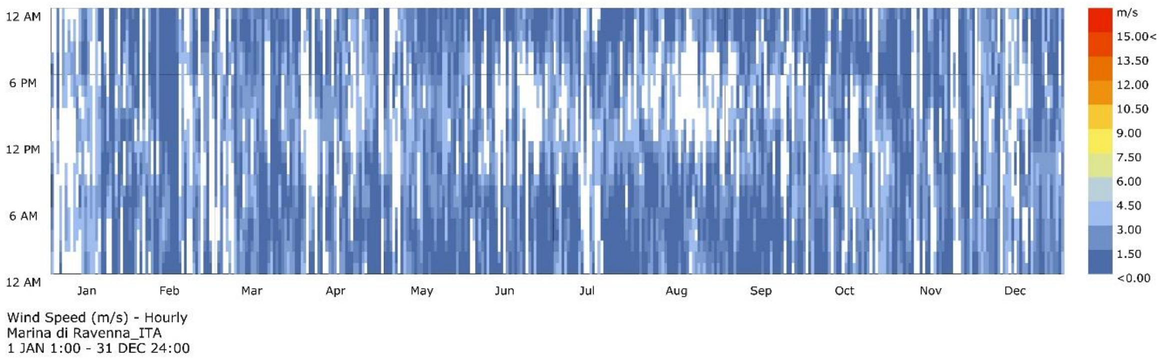


Figure 4- 3 Wind Speed

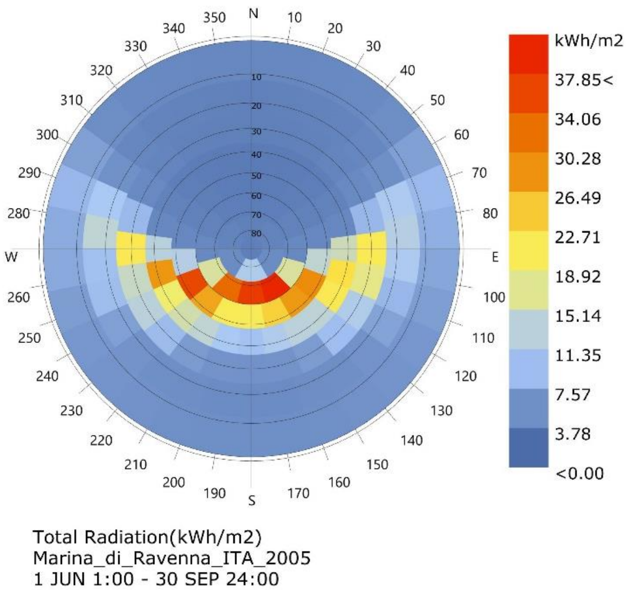


Figure 4- 4 Total Radiation

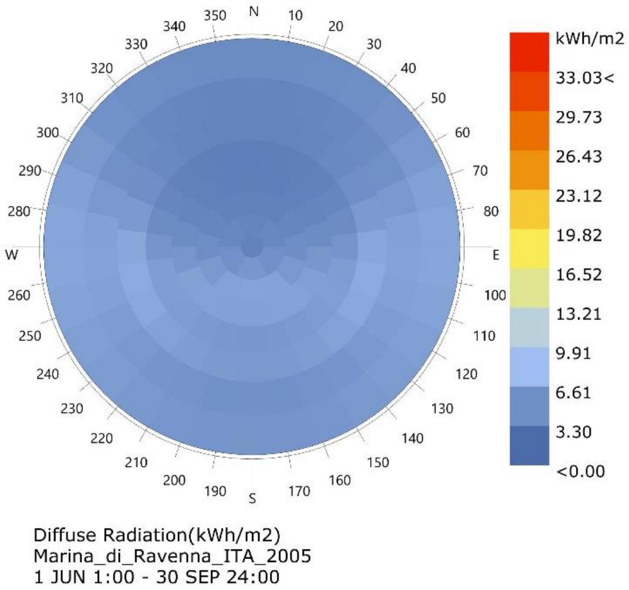


Figure 4- 5 Diffuse Radiation

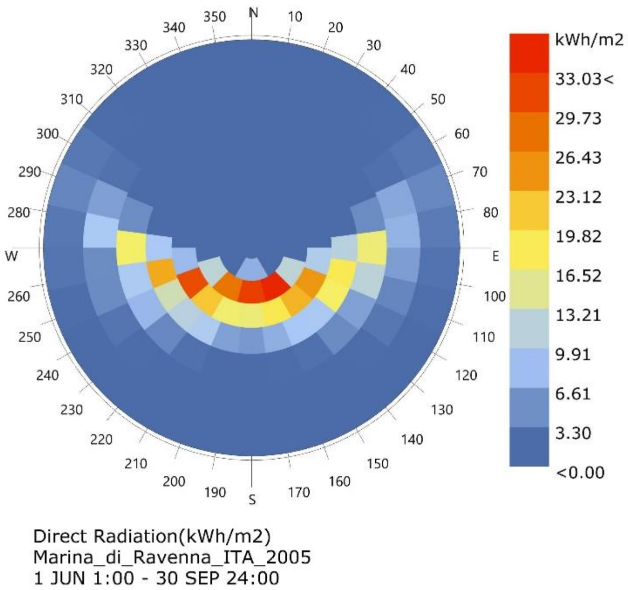


Figure 4- 6 Direct Radiation

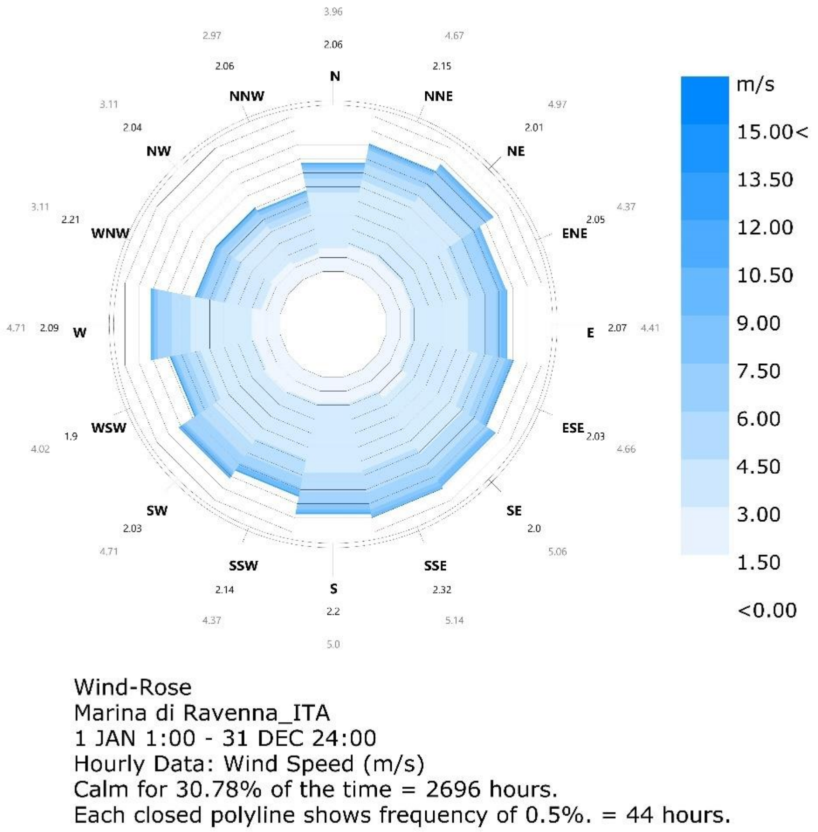


Figure 4- 7 Wind Rose

4.2. General Idea

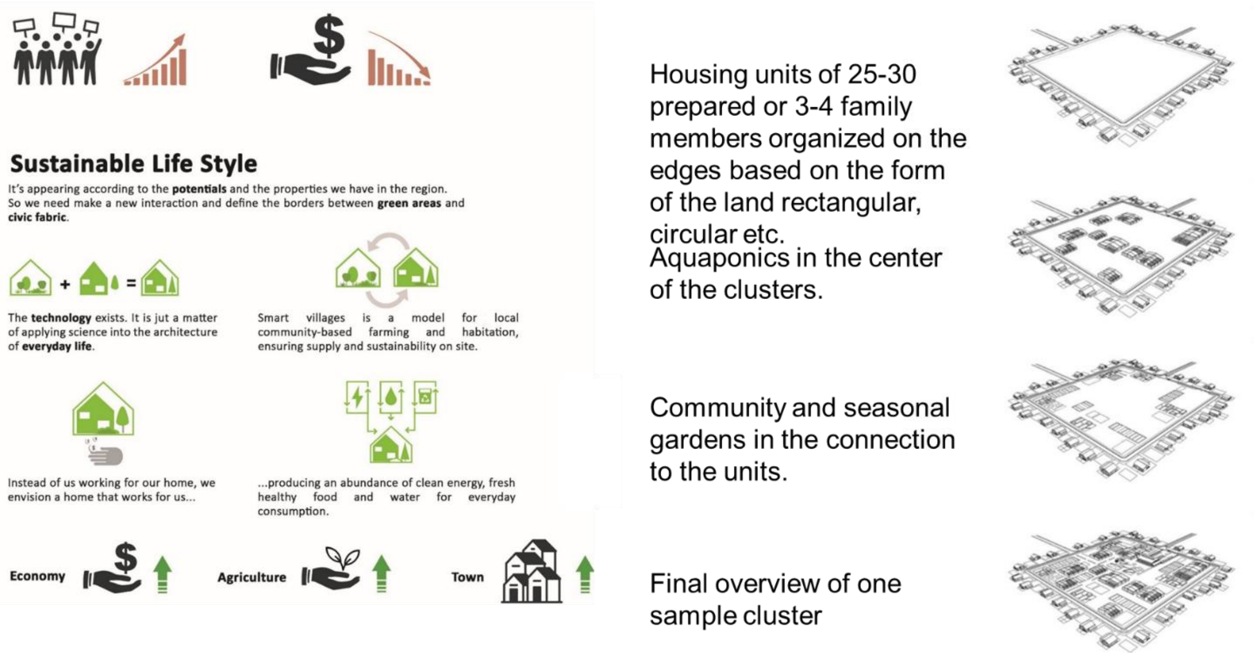


Figure 4- 8

4.3. Cluster

We have 4 different cluster but we are going to focus only on one cluster

Figure 4- 9 Focus Area

It is about 25-30 housing units with 3 or 4 people for each unit which is organized in the edge of the clusters. The units expanded the glass wrap to great better condition for the vegetation to grow. The food production facilities located in the middle wrapped by the glass which is consider as the group community.in the center of the housing there is public space with recreational functions, and the parking locating in the entrance of each village. There is car path just has the connection to the face of the housing units and all in the middle is pedestrian and bike path. Some community and seasonal garden are specifically located for each house units and some of them creating to work in group units.

Figure 4- 10 General design

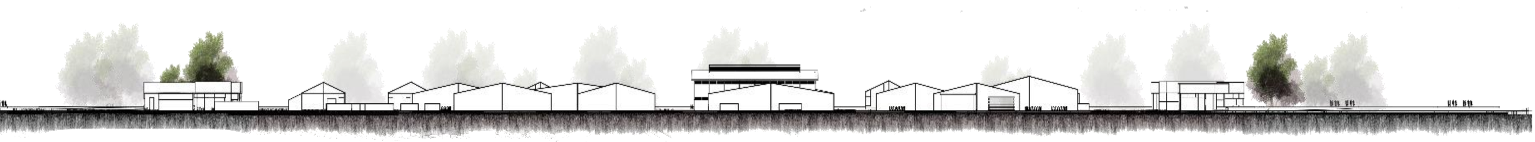


Figure 4- 11 General Section

4.3.1. Functions

Functions that are provided inside each cluster can be say as:

- **Housing units**

Figure 4- 12 Housing Units

- **Private Garden**

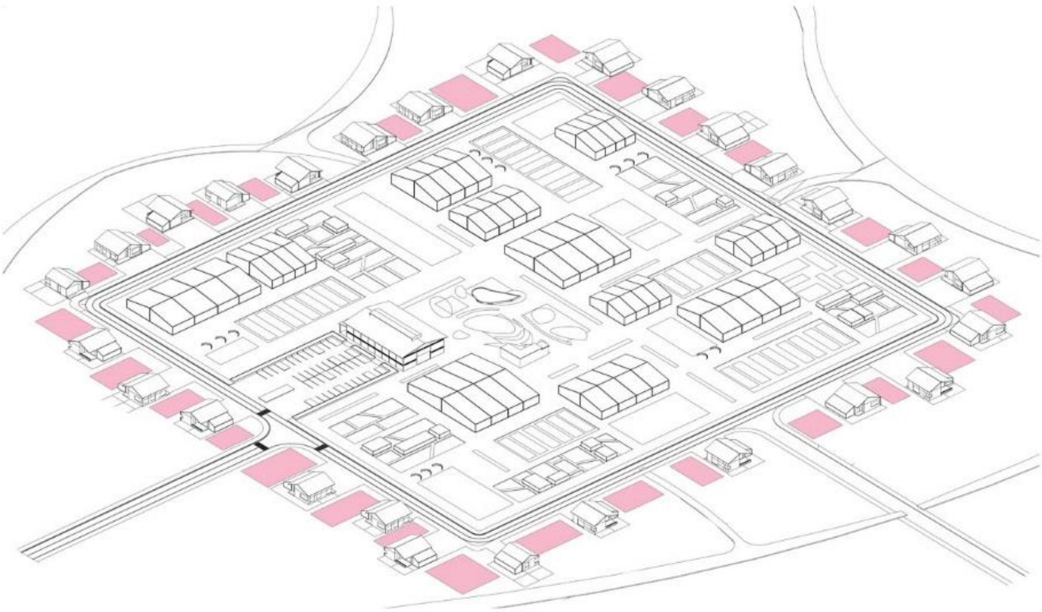


Figure 4- 13 Private Garden

- **Public Park**

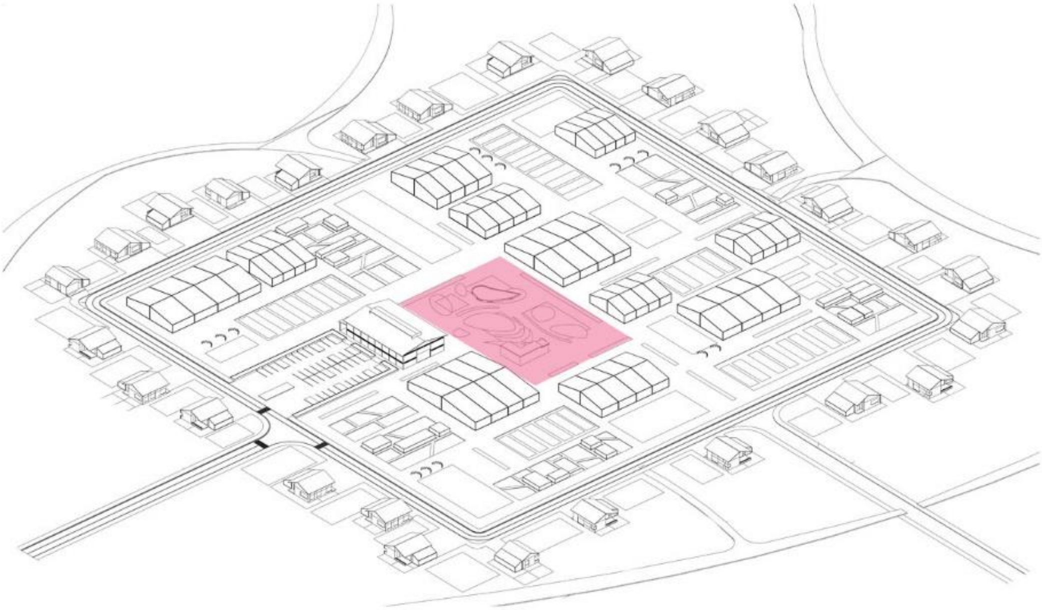


Figure 4- 14 Public Space

- **Seasonal garden**

Figure 4- 15 Seasonal Garden

- **Community garden**

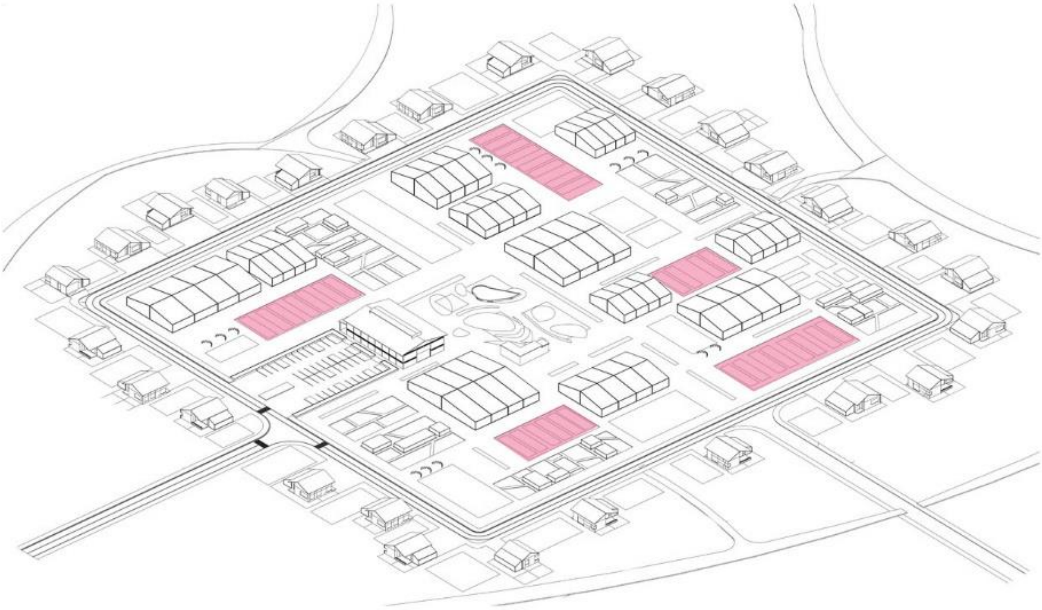


Figure 4- 16 Community Garden

- **Parking**

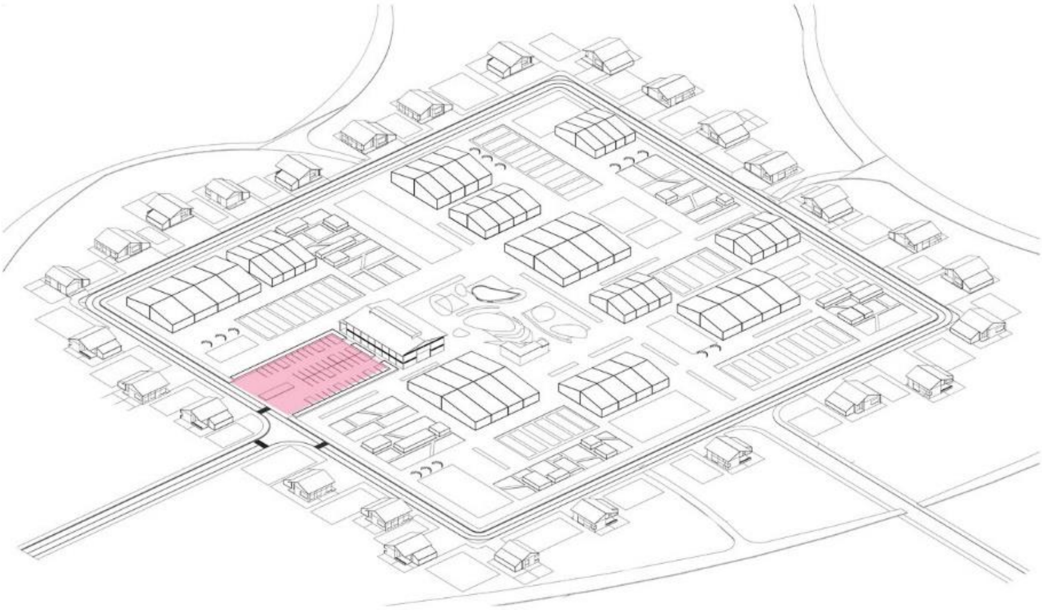


Figure 4- 17 Parking

- **Storage**

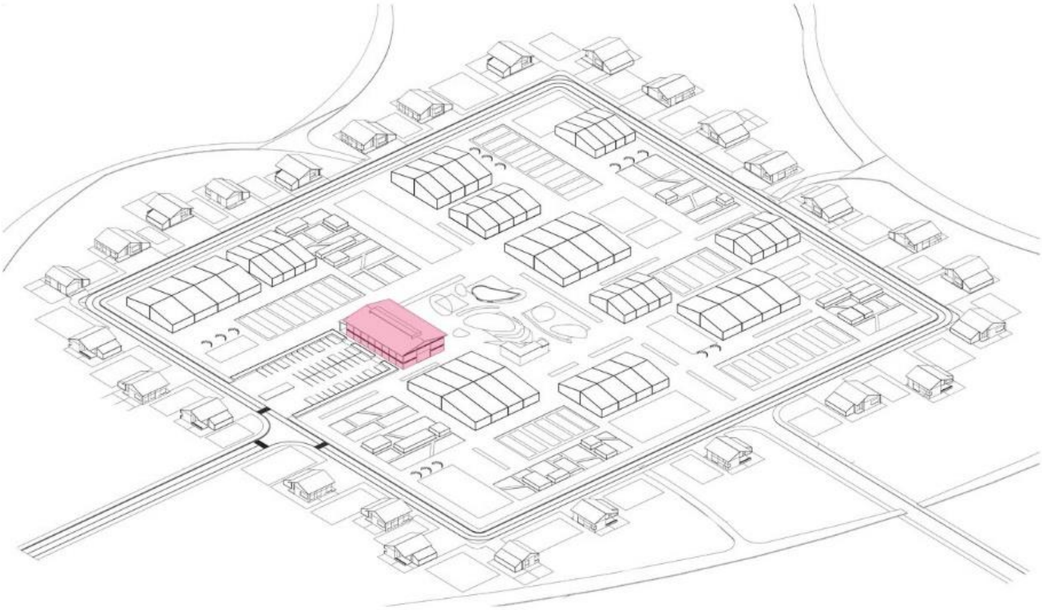


Figure 4- 18 Storage

- **Aquaponics**

Figure 4- 19 Aquaponics

- **Motor Road**

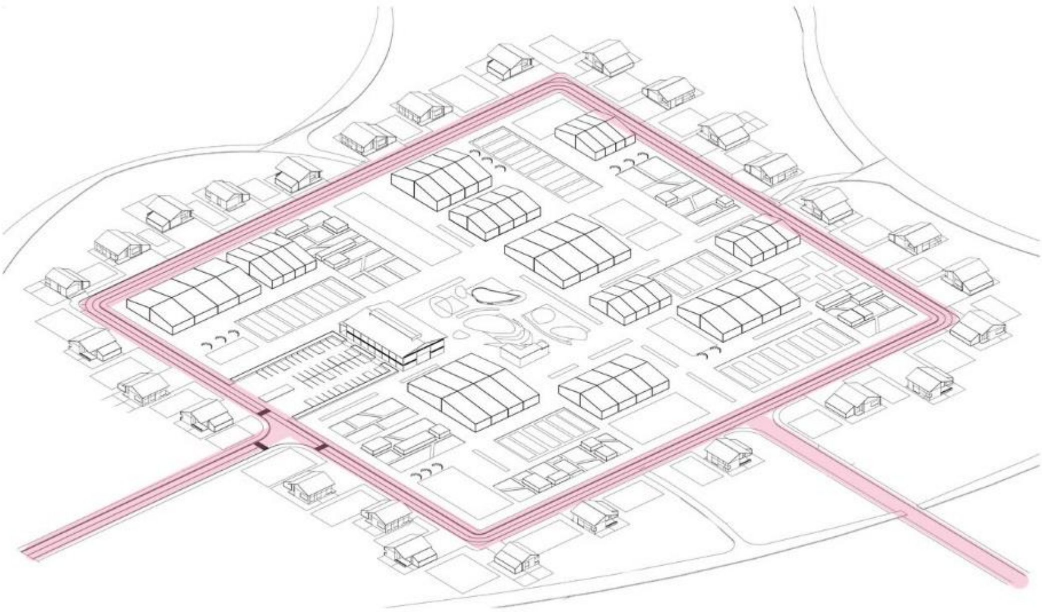


Figure 4- 20 Motor Road

- **Bike parking**

Figure 4- 21 Bike Parking

- **Pedestrian path**

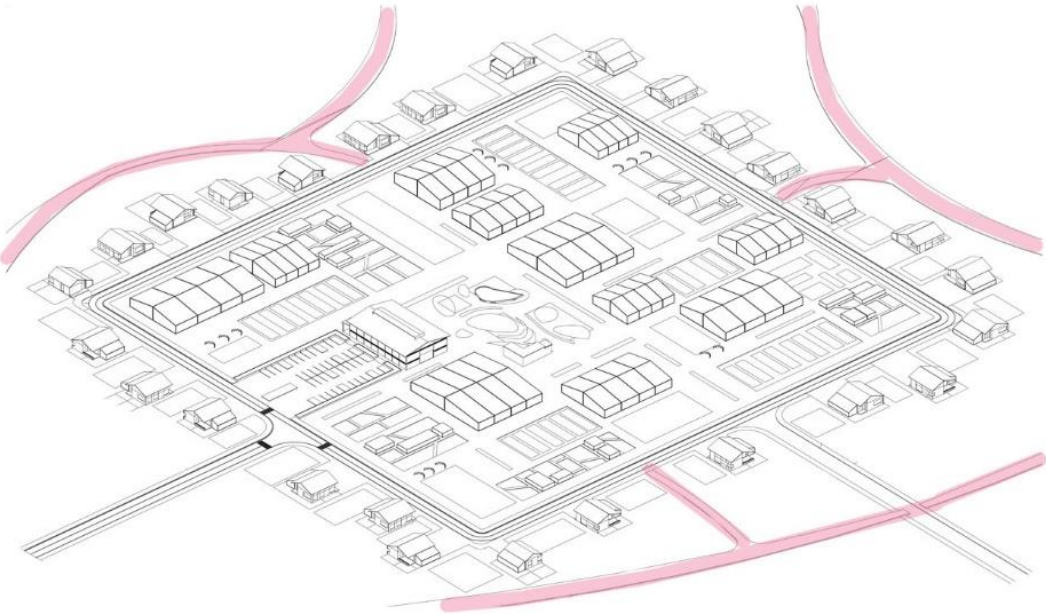


Figure 4- 22 Pedestrian path

- **Bike and Pedestrian path**

Figure 4- 23 Bike and Pedestrian path

- **Gardens**

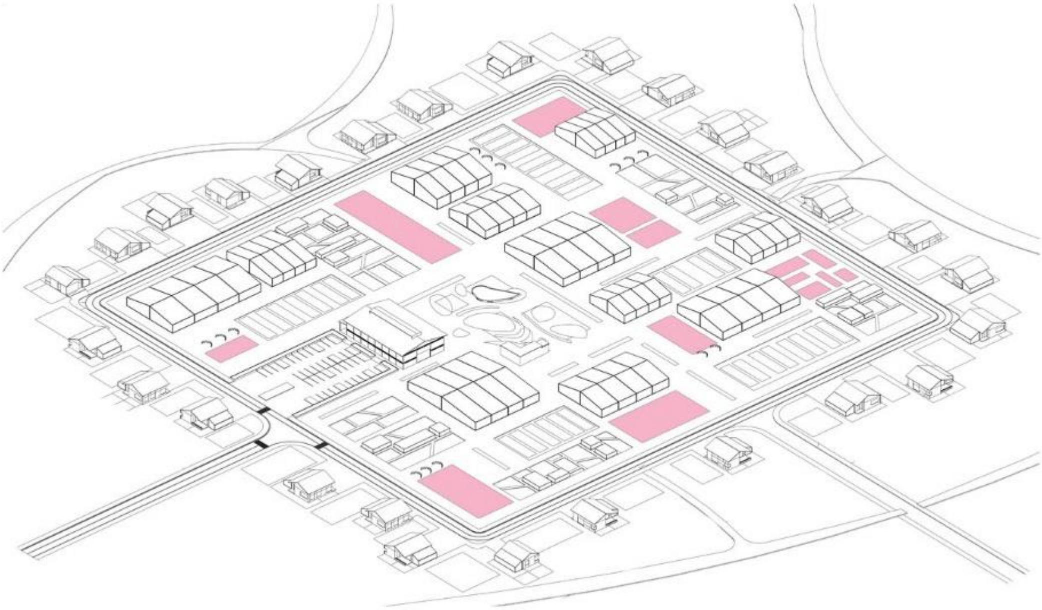


Figure 4- 24 Gardens

According to the diagrams that we saw we can say that each cluster can have 13 different functions.

4.4. Cluster (New town)

The General design of the cluster that we focused on:

Figure 4- 25

4.5. Materials

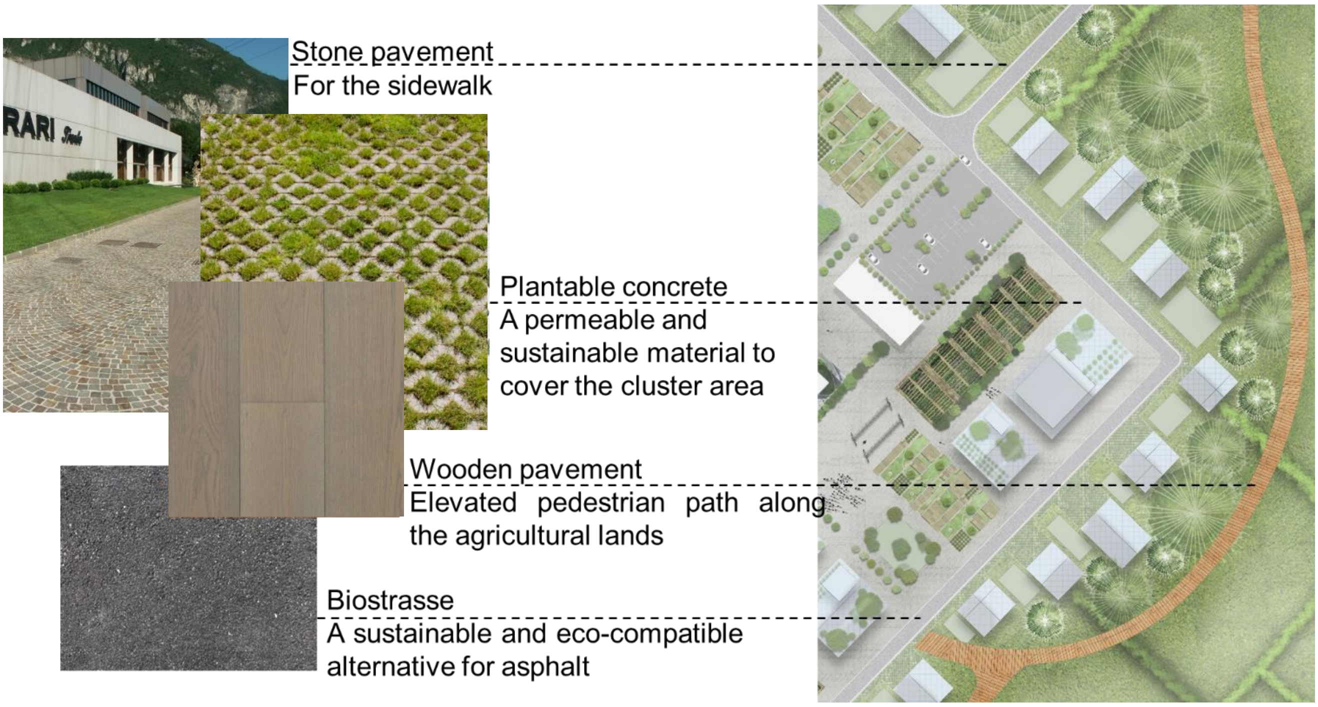


Figure 4- 26

Stone Pavement (Porphyry setts)

Porphyry setts are the most common porphyry shape used for external paving and they lend themselves easily to the creation of shapes like arches, circles and straight lines.

They are often irregular in size and shape, leading to an improved laying quality because the porphyry setts can be positioned to reduce the space between them.

An interesting note: porphyry setts change name depending on the area: in the North they are often referred to as Bolognini, while in Rome they are known as Sampietrin

As it is shown in the figures, we choose the material from the Porfiroberto company for the stone pavement with the dimension highlighted in grey color

To use as a pavement around the cluster zones.

PORPHYRY SETTS – SAWN OR FLAMED FACE, LOOSE OR IN CRATES

EVEN THICKNESS	WEIGHT kg./mArchieSub
cm. 2	45
cm. 3	75

SQUARE HEAD PORPHYRY OR CARRARA MARBLE SETTS, LOOSE OR IN CRATES

SIZE cm.
6X6
8x8
10x10
12x12

TurfStone Pavers

Turfstone pavers are a unique style of concrete paver that feature a number of additional benefits that are not seen with other pavers. First, these pavers allow for natural grass to grow between the individual stones, which is beneficial to those who want to keep more greenery throughout their landscape. Turfstone also helps with erosion and preserving the soil underneath. Rainwater is able to filter through the bricks and into the soil.

Overall, Turfstone gray concrete pavers are very effective in many scenarios in which you want to provide a secure walkway without completely covering the existing soil and grass. However, in addition to that, Turfstone concrete pavers are also a more inexpensive option when compared to asphalt and poured concrete. When you have a large space that you need to cover with paving, this is definitely the way to go. For example, you may need extra space to park cars on your property but you don't want to cover the space completely with asphalt or concrete. A Turfstone driveway or parking lot is the perfect solution.

Oak Brushed Slate Oiled

The Oak wood has a great sustainability to match with the environment and also Oak is a highly popular species that is a real classic and is suitable for a wide range of finishes and appearances, so that you can achieve the style you want.

The combination of light and dark shades of grey in the Brushed Slate oil finish work with the surface to add depth to the timber. The dark grey tones and scattered knots add boundless character and style.

This is a distinctive floor which celebrates the natural beauty of wood with on-trend grey tones. Unlike a painted floor, the detailing of oak is there for all to see and admire. The natural, simple beauty of the oak is enhanced not smothered.

4.6. Unit Design

There are 3 typologies for the houses surrounding the clusters. All these houses have a small private greenhouse attached to the building and separate gardens

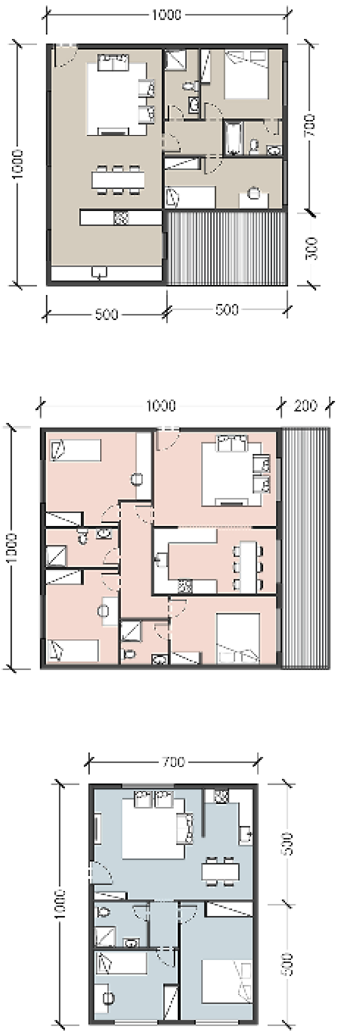


Figure 4- 27

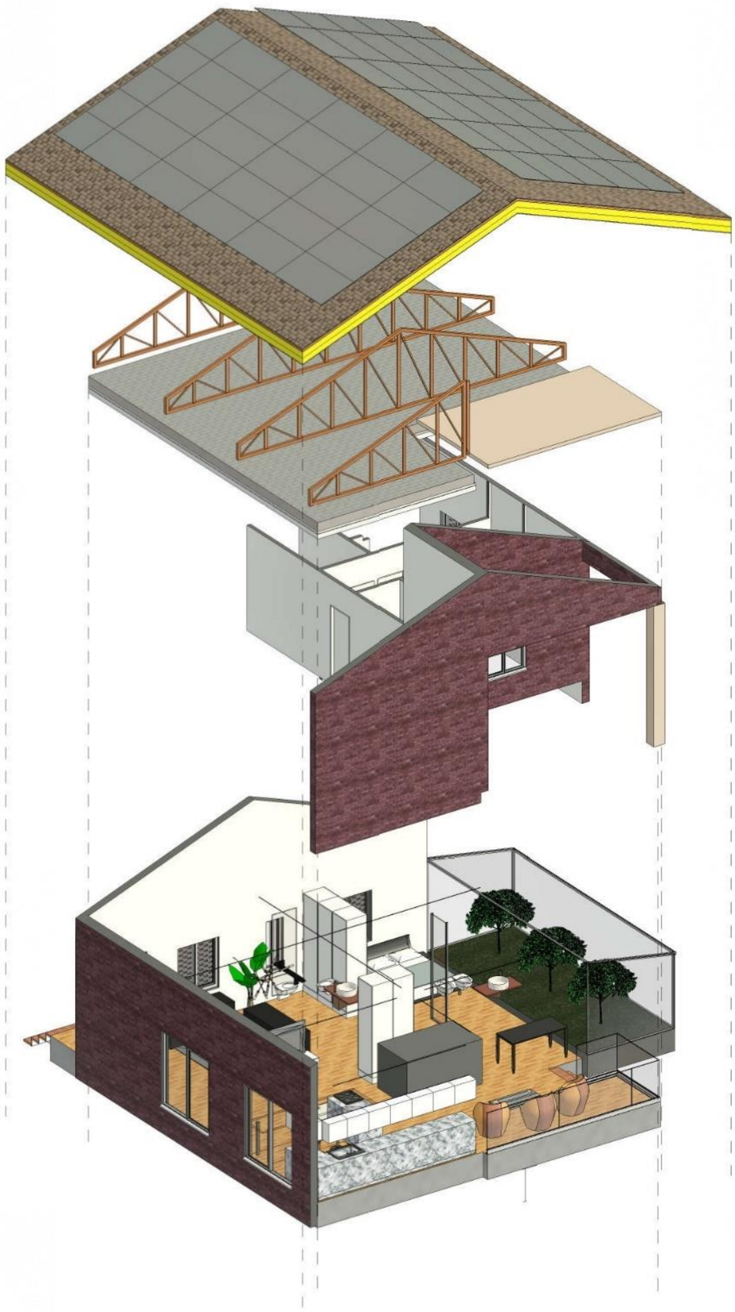


Figure 4- 28 – Unit Design

4.6.1. Unit Design

For this goal, we will concentrate our efforts on a single structure, which we will analyze in order to make it zero-energy.

Here we can see the layout of the unit we're interested in; the property includes two bedrooms, one of which is a master suite and the other a single room.

4.6.1.1 Plan

The unit has a balcony and a backyard, and all of the units have a balcony and a backyard.

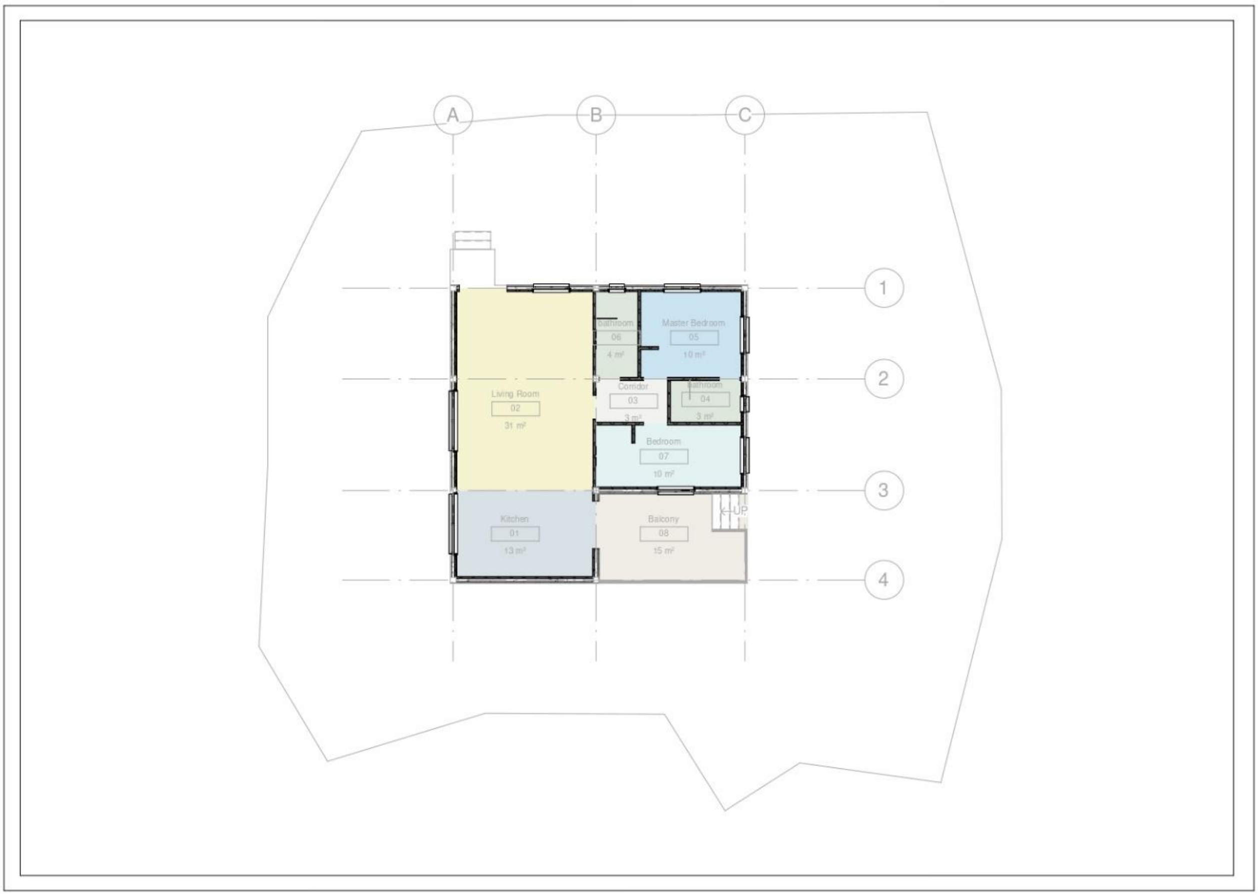


Figure 4- 29 Plan

As you can see, we have a total of 73 sqm for a property with two bedrooms and a 15 sqm balcony.

4.6.1.2. Interior Render

Here you can see some interior of a single unit,

Figure 4- 29 single bedroom

4.6.1.3 Section

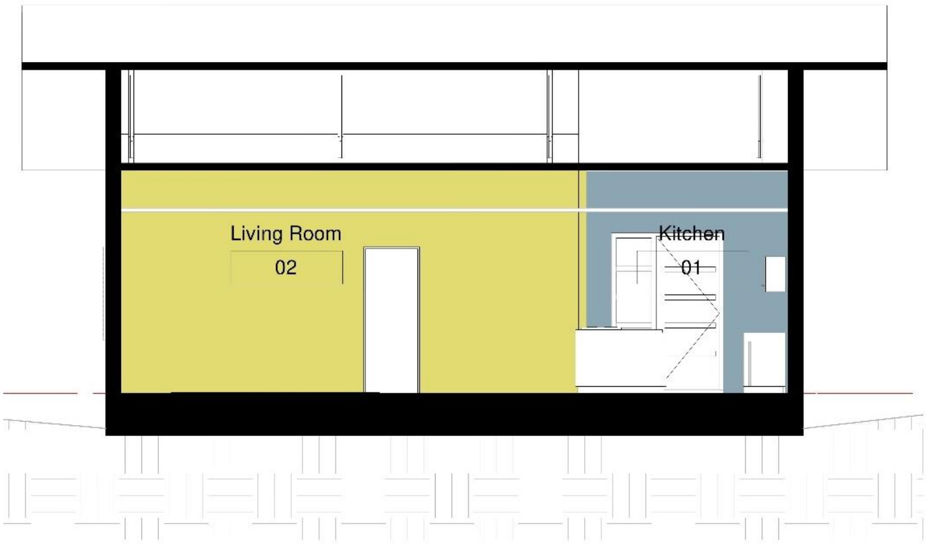


Figure 4- 31 Section A-A

Figure 4- 32 Section B_B

4.7. Sustainability

4.7.1 Approaches to The Energy Innovation

Carbon dioxide, methane, and nitrous oxide concentrations in the atmosphere are unprecedented in at least the last 800,000 years. Their combined impacts, along with those of other anthropogenic factors, are causing global warming. From 1880 to 2017, the global average temperature of the earth increased by 0.85°C. It has been proven that climate change is to blame for 90% of natural disasters in Europe since 1980, hence initiatives to minimize GHG emissions should be implemented:

- Demand management
- Utilizing alternative energy sources

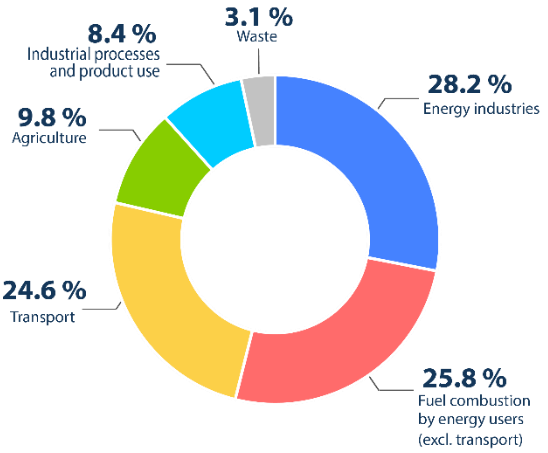


Figure 4- 33 Share of EU greenhouse gas emission by source, 2017

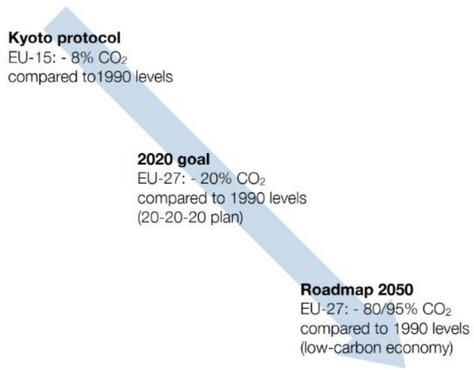


Figure 4- 34 Global action plan

The ultimate goal of refurbishments is, of course, to lower the building's useful energy consumption first and foremost through construction-related measures.

- Creating opportunities for natural ventilation to reduce the amount of time air handling equipment or air conditioning plants have to run.
- boosting summer heat protection by adding sun protection devices, or uncovering or increasing the storage mass
- updating transparent components by employing superior frame constructions and glazing (The idea of retrofitting storage mass in the form of latent heat stores contained in composite gypsum boards is an interesting option for existing building stock.)
- increasing the utilization of daylight
- insulating the opaque envelope

Making a house zero energy means that it generates as much energy as it consumes over a year, reducing its reliance on non-renewable sources of energy. Here are some steps to help you make your house zero energy:

- Insulate your home: Adequate insulation will help keep the heat in during winter and out during summer, reducing your energy consumption. You can add insulation to your walls, floor, and roof to improve energy efficiency.
- Install efficient windows: Replacing old, single-paned windows with energy-efficient windows can make a big difference in your energy consumption. Look for windows with a low U-value (a measure of heat transfer) and a high solar heat gain coefficient (a measure of how much heat the windows allow in).
- Invest in energy-efficient appliances and lighting: Energy-efficient appliances, such as refrigerators, washing machines, and air conditioners, can help you save on energy costs. LED lighting is also more energy-efficient than traditional incandescent light bulbs.
- Harness renewable energy: You can install solar panels or a wind turbine to generate clean, renewable energy for your home. A small-scale solar or wind energy system can help you meet a significant portion of your energy needs.
- Consider a geothermal heating and cooling system: A geothermal system uses the stable temperature of the ground to heat and cool your home, reducing your reliance on fossil fuels.
- Monitor energy usage: Installing a smart meter or monitoring system can help you track your energy consumption and identify areas where you can make changes to reduce your energy usage.

Remember, making a house nearly zero energy can be a significant investment, but it can pay off in the long run by reducing energy costs and helping the environment.

NZEB buildings

NZEB stands for Nearly Zero Energy Building. It refers to a building that has very low energy consumption and is able to produce or generate most of its own energy on-site using renewable sources. The goal of NZEB is to create buildings that are highly energy efficient, have low emissions, and are cost-effective over the long term. In order to achieve NZEB status, a building must meet strict energy efficiency standards and use advanced building technologies and materials. The European Union has set a target for all new buildings to be NZEBs by the end of 2020.

We also consider energy by focusing on two approaches:

- Passive Strategies
- Active Strategies

4.7.1.2 Passive Strategies

Passive strategies in building design refer to techniques that make use of natural processes, such as sunlight, wind, and gravity, to maintain a comfortable and energy-efficient indoor environment without the need for mechanical systems. These strategies are often used to reduce the energy consumption of a building and to promote a healthier indoor environment.

Some examples of passive strategies include:

- Orientation: Designing a building to take advantage of the sun's path to provide natural light and heating.
- Insulation: Providing high levels of insulation to reduce heat loss and gain through the building envelope.
- Ventilation: Designing a building to provide natural ventilation, using cross-ventilation and stack ventilation to bring fresh air into the building and remove stale air.
- Shading: Providing shading devices, such as eaves and shading screens, to reduce the amount of direct sunlight entering the building and to provide thermal comfort.
- Thermal mass: Using materials with high thermal mass, such as concrete or masonry, to store heat and regulate indoor temperature.

These passive strategies are often used in combination with active strategies.

4.7.1.2 Active Strategies

Active strategies refer to the various technologies, systems, and devices that are used to actively manage, control, and optimize the energy usage in a building. These strategies involve the use of mechanical and electrical systems, such as HVAC systems, lighting systems, and appliances, to reduce energy consumption and increase energy efficiency.

Examples of active strategies include:

- Heating, ventilation, and air conditioning (HVAC) systems that use energy recovery ventilation, heat pumps, and programmable thermostats to efficiently manage heating and cooling.
- Lighting systems that use occupancy sensors, dimming controls, and high-efficiency light sources to optimize lighting levels and reduce energy use.
- Appliances and equipment that use energy-efficient motors, drives, and controls to reduce energy consumption.
- Renewable energy systems, such as photovoltaic panels and wind turbines, that generate electricity on-site to reduce the building's energy needs.

Active and passive strategies are complementary approaches to improving the energy efficiency of buildings.

Active strategies involve the use of mechanical and electrical systems, such as heating and cooling systems, lighting systems, and renewable energy systems, to control and manage energy use.

Passive strategies, on the other hand, are focused on optimizing the design and orientation of the building, as well as the materials and systems used, to minimize energy consumption without relying on active systems. This includes measures such as designing the building to maximize natural light, using high-insulation materials and efficient windows, and optimizing the building's orientation to reduce the need for heating and cooling.

To combine active and passive strategies, one should first focus on implementing passive strategies to reduce energy consumption as much as possible. Then, active systems can be used to complement the passive strategies and further improve energy efficiency. For example, a well-insulated building with efficient windows can be fitted with a renewable energy system such as a photovoltaic panel to reduce its carbon footprint. This combined approach can result in a highly energy-efficient building that reduces its reliance on non-renewable energy sources and reduces its environmental impact.

In our project, both active and passive strategies can be used to improve a building's energy efficiency. Here are some strategies that we choose to use:

Active Strategies:

- Renewable Energy Systems: Alfonsine is located in a sunny area, making it an ideal location for solar energy systems. Many buildings in Alfonsine are equipped with solar panels to generate clean, renewable energy.
- Building Automation Systems: Automated building management systems can help monitor and control a building's energy usage, reducing energy waste and improving efficiency.
- radiant heating: Radiant heating systems use energy in the form of electricity, natural gas, or other fuels to heat the building. This heat is then transferred to the surfaces in the building, such as the floor or walls, and warms the space through radiation. This method of heating is considered active because it requires an energy source and a mechanical system to distribute the heat.

Passive Strategies:

- Insulation: Adequate insulation is crucial in reducing energy consumption in buildings in Alfonsine, particularly in the colder months. Wall, floor, and roof insulation can help keep heat in and reduce the need for heating systems.
- Shading: The use of shading devices, such as external shading, can help reduce heat gain in buildings and minimize the need for air conditioning.
- Passive Solar Design: Taking advantage of the sun's energy for heating and cooling can be an effective passive strategy in Alfonsine. Orienting a building to maximize natural light and ventilation, while minimizing exposure to direct sun, can improve the building's energy efficiency.

Geothermal energy can be considered both an active and passive strategy, and we decided to use the passive one.

In passive geothermal systems, the earth's natural heat is used to regulate the temperature of a building. This can be achieved through a number of techniques such as ground-coupled heat exchangers, where pipes are buried in the ground and circulate fluid to transfer heat to or from the building.

4.7.1.3. Active and Passive Strategies

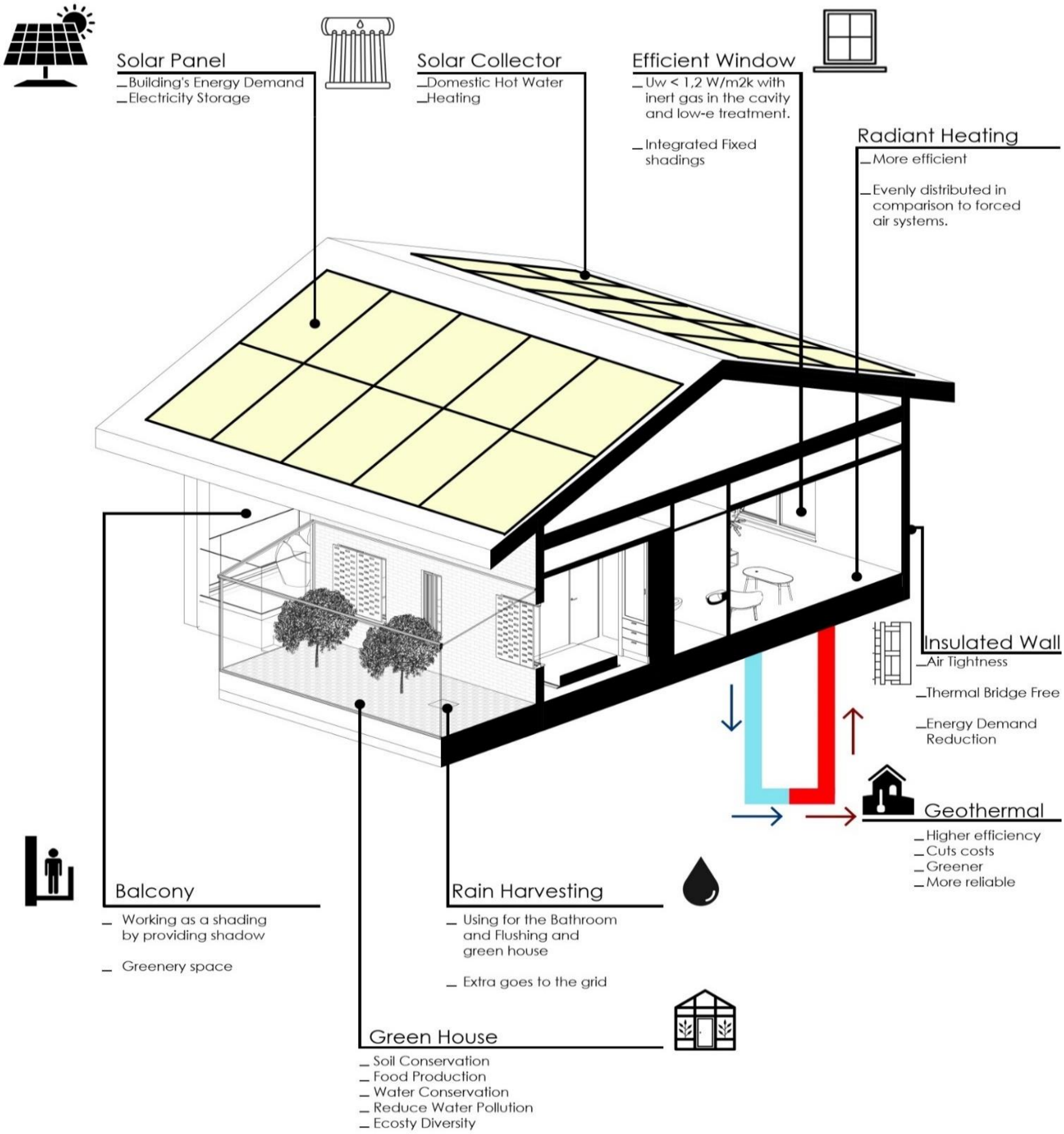


Figure 4- 35

4.7.2 Energy consumption (Using Blumatica as a software)

GENERAL DATA **Usable for 110% tax deductions only**

Intended use

[X] Residential

[ ] Non residential

Classification DPR 412/93: E.1.1

Subject of the certificate

[X] Whole building

[ ] Real estate unit

[ ] Group of real estate units

number of real estate units of which the building is composed: 1

[ ] New construction

[ ] Change of ownership

[ ] Lease

[ ] Important renovation

[ ] Energy requalification

[X] Other: Super bonus after surgery

Identification data

Region:	Emilia Romagna	Climate zone:	And
Common:	RAVENNA	Year of construction:	
Address:	, no.	Useful heated surface (m²):	77.16
Floor:		Useful surface cooled (m²):	0.00
Internal:		Gross volume heated (m³):	317.05
GIS coordinates:		Gross volume cooled (m³):	0.00

Cadastral municipality	RAVENNA			Section				Sheet				Particle			
Subordinates	from		to		from		to		from		to		from		to
Other subordinates															

Energy services present

[X] Winter air conditioning

[ ] Mechanical ventilation

[ ] Lighting

[X] Radiant Heating

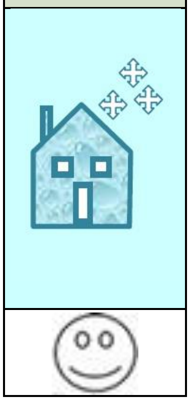
[X] Domestic hot water production

[ ] Transport of people or things

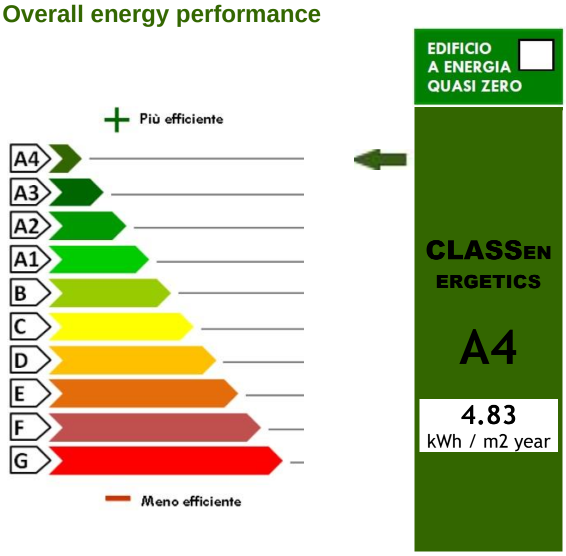
GLOBAL AND BUILDING ENERGY PERFORMANCE

The section reports the global non-renewable energy performance index as a function of the building and the energy services present, as well as the energy performance of the building, net of the performance of the existing plants.

Energy performance of the building

WINTER	SUMMER
	

Overall energy performance



References

Properties similar to this one would have the following classification on average:

If new:

If existing:

ENERGY PERFORMANCE OF THE PLANTS AND ESTIMATED CONSUMPTIONS

The section shows the renewable and non-renewable energy performance index, as well as an estimate of the annual energy consumed annually by the property according to standard use.

Energy performance of plants and estimation of energy consumption

	ENERGY SOURCES USED	Annual quantity consumed in standard use	Energy performance indices global and emissions
X	Electricity from the grid	191.09 kWh	Performance index non-renewable energy **EPgl, nren** kWh / m²year **4.83**
	Natural gas	-	
	LPG	-	
	Coal	-	
	Diesel fuel	-	
	Burning oil	-	
	Propane	-	Performance index renewable energy **EPgl, ren** kWh / m²year **57.50**
	Butane	-	
	Kerosene	-	
	Anthracite	-	
	Biomass	-	
X	Solar photovoltaic	3,882.83 kWh	
X	Solar thermal	950.83 kWh	
	Wind power	-	CO emissions$_2$ kg / m²year **1.14**
	District heating	-	
	District cooling	-	
	Other	-	

When a building uses less than 5 kWh of energy per year, it means that the building is extremely energy-efficient and consumes very little energy to meet its heating, cooling, lighting, and other needs.
A building with such a low energy consumption is often referred to as a "zero energy building" or a "net-zero energy building," meaning that the building is designed to generate as much energy as it consumes over the course of a year. This can be achieved through a combination of energy-efficient design, the use of renewable energy sources, and energy-saving technologies.
A building with a total energy consumption of less than 5 kWh per year is typically characterized by high levels of insulation, energy-efficient windows and doors, efficient heating and cooling systems, and the use of passive solar design strategies to reduce the need for artificial lighting and heating.
Overall, a building with a total energy consumption of less than 5 kWh per year is considered to be a highly sustainable and environmentally friendly building, as it significantly reduces the carbon footprint of the building and contributes to a more sustainable future.

4.7.2.1 Summary

This document certifies the performance and energy class of the building or real estate unit, or the amount of energy necessary to ensure comfort through the various services provided by the technical systems present, under conventional conditions of use. In order to identify the potential for improving energy performance, the certificate contains specific information on the energy performance of the building and systems. The highest energy class achievable in case of implementation of the recommended improvement measures is also indicated, as described in the "recommendations" section.

General informations: the reasoning behind the drafting of the EPA is included in the general information. Within the period of validity, this does not preclude the use of the APE itself for the purposes of the law, even if different from those indicated therein.
Overall energy performance (EPgl, nren): annual non-renewable primary energy requirement relating to all the services provided by the technical systems present, on the basis of which the performance class of the building is identified on a scale from A4 (most efficient building) to G (least efficient building).
Energy performance of the building: qualitative index of the energy requirement necessary to satisfy internal comfort, independent of the type and performance of the systems present. This index gives an indication of how the building, in summer and winter, thermally insulates the internal environments from the external environment. The qualitative evaluation scale used observes the following criterion:

HIGH QUALITY	**MEDIUM QUALITY**	**LOW QUALITY**

The threshold values for the definition of the quality level, divided by type of indicator, are reported in the Guidelines for the energy certification of buildings referred to in the decree provided for by article 6, paragraph 12 of Legislative Decree 192/2005.
Nearly zero energy building: building with very high energy performance, calculated in accordance with the provisions of the legislative decree 19 August 2005, n. 192 and the ministerial decree on the minimum requirements provided for by article 4, paragraph 1 of Legislative Decree 192/2005. The very low or almost zero energy requirement is covered to a significant extent by energy from renewable sources, produced within the system boundary (in situ). A check in the appropriate space adjacent to the classification scale indicates that the building object of the APE belongs to this category.
References: comparison with the global non-renewable performance index of a similar building but with the minimum requirements of new buildings, as well as with the average of the performance indexes of similar existing buildings, or characterized by the same type of use, type of construction, area climatic conditions, dimensions and exposure of that object of the certificate.

Energy performance of plants and estimated consumption: the section shows the renewable and non-renewable energy performance index of the property subject to certification. These indices provide information on the percentage of renewable energy used by the building compared to the total. Finally, the section provides an estimate of the

amount of energy consumed annually by the property according to standard use, broken down by type of energy source used.
Recommendations: below is the table that classifies the types of intervention recommended for energy requalification and major renovation.

ENERGY REQUALIFICATION AND RENOVATION OF IMPORTANT BUILDING / REAL ESTATE UNIT - Code Table

Code	TYPE OF SURGERY
R.EN1	BUILDING - OPAQUE ENCLOSURE
R.EN2	BUILDING - TRANSPARENT ENCLOSURE
R.EN3	AIR CONDITIONING SYSTEM - WINTER
R.EN4	AIR CONDITIONING SYSTEM - SUMMER
R.EN5	OTHER PLANTS
R.EN6	RENEWABLES

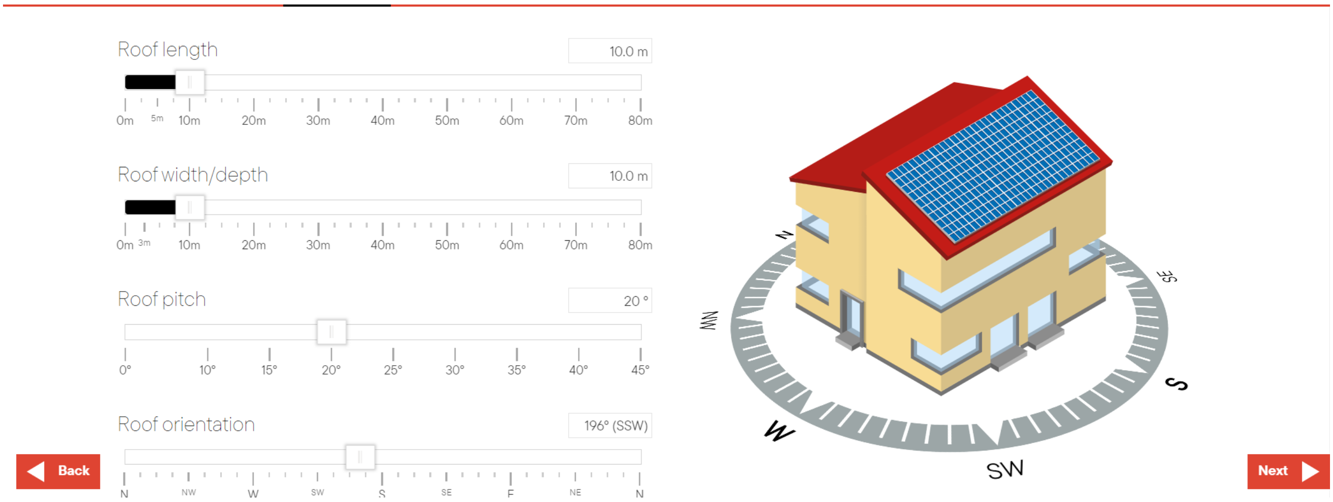


Figure 4- 36 Solar panel

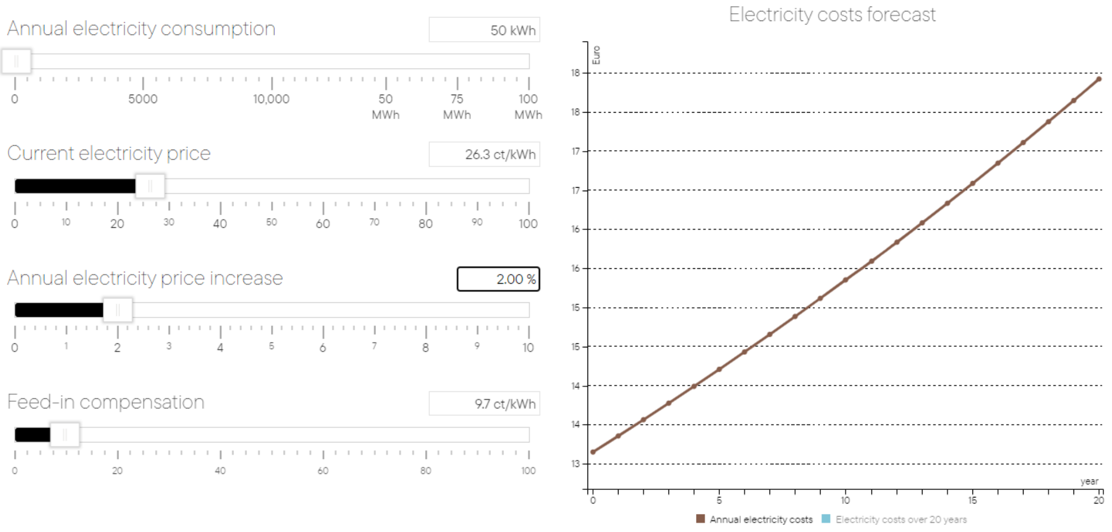


Figure 4- 37 Electricity Cost Forecast

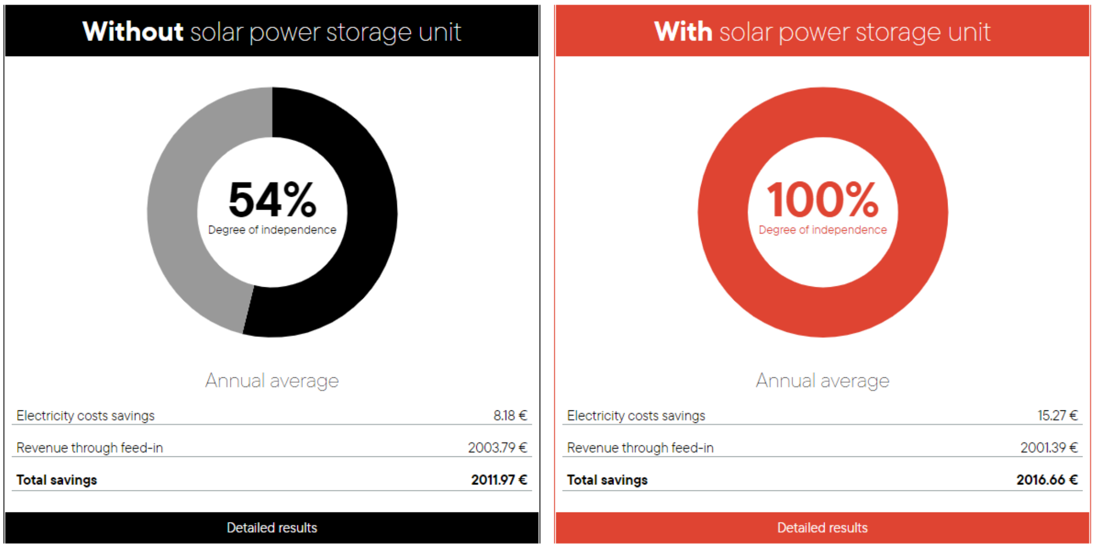


Figure 4- 38 Saving by using Solar panel

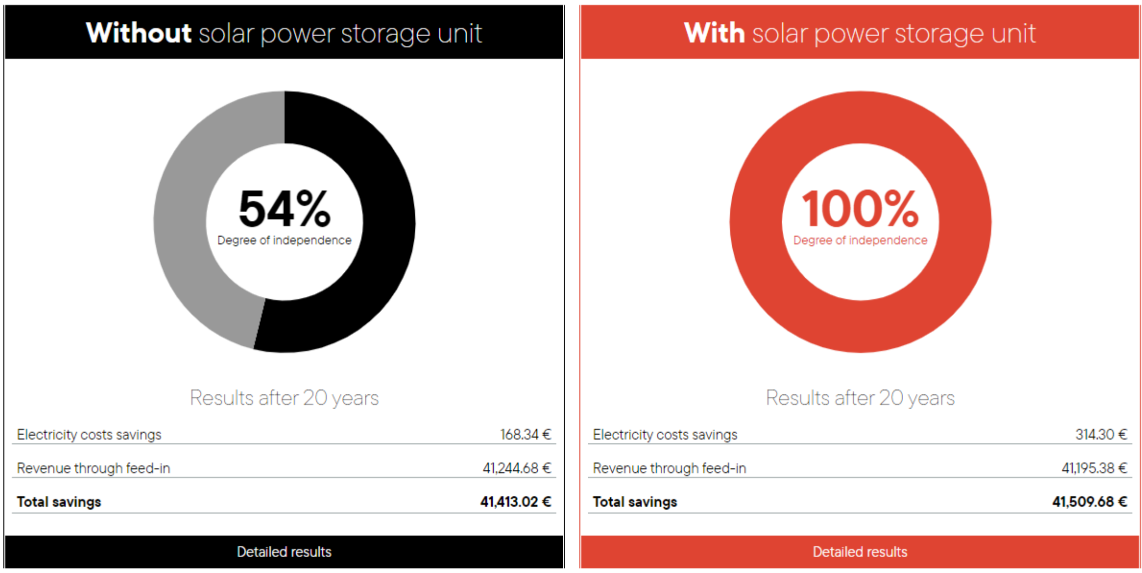


Figure 4- 39 Saving by using Solar panel after 20 years

4.7.2.2. Radiant heating

Radiant panels provide the human body with much greater comfort than traditional systems. They confer the ideal climate with a constant and even temperature and no convective currents, thus featuring a limited environment impact. Today modern thermoregulation technologies enable to adopt radiant systems also for summer cooling, with a healthy difference between the inside and outside temperature of the building. Heating and cooling radiant floors use water as the thermal fluid flowing through the plastic pipes concealed in the concrete layer which generally supports flooring materials such as ceramic, marble, granite, grass and wood. Thermal transfer from the flooring to the surrounding ambient and surfaces is obtained through irradiation. It has been proven that radiant floors properly dimensioned and realized according to modern technologies provide the human body with greater comfort and wellness levels compared to traditional heating systems. This ensures a constant and even temperature in the various ambientes: a comparison of the comfort curves of various heating systems shows how the curve representing the comfort offered by radiant floors is the one closer to the ideal curve.

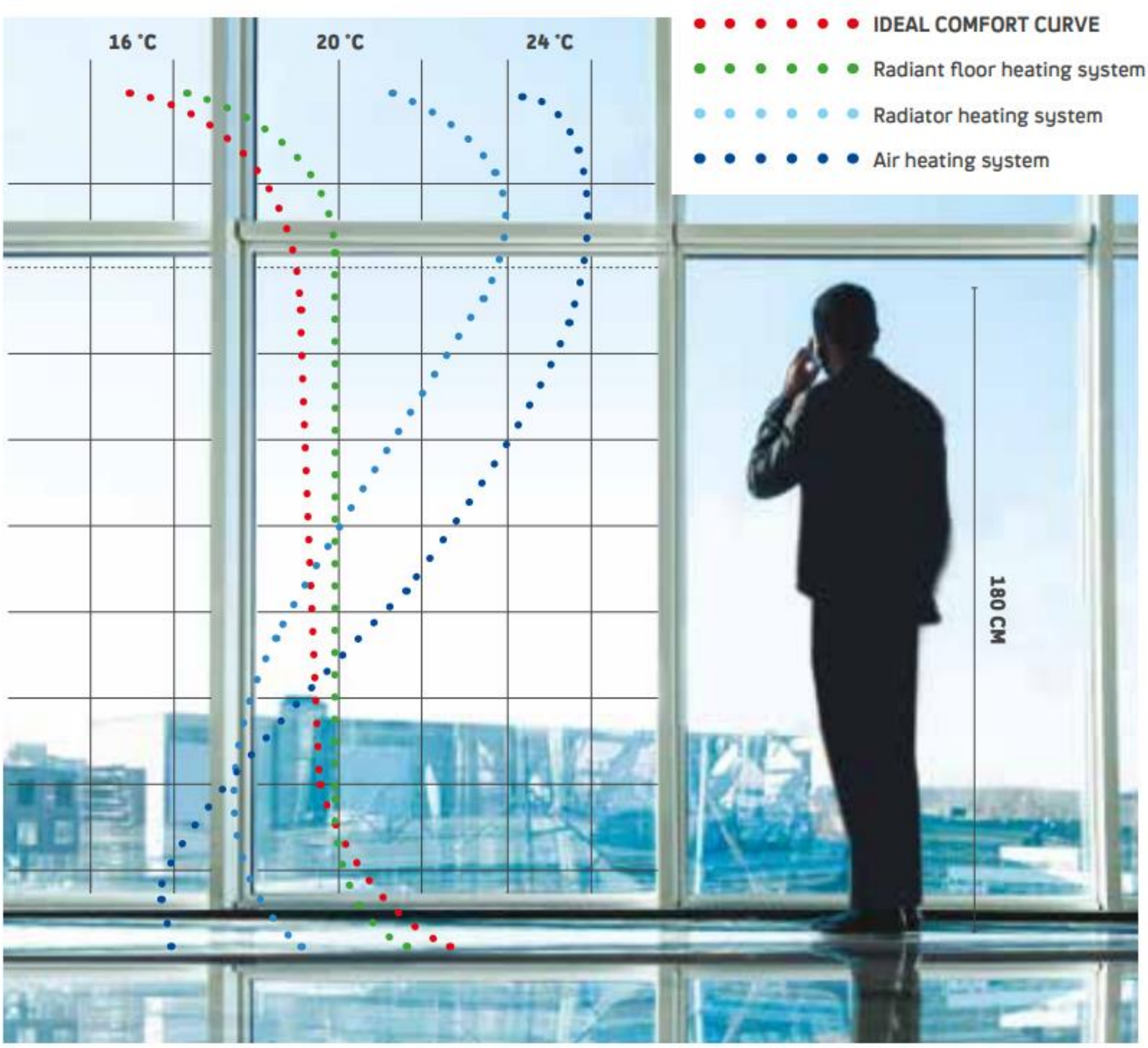


Figure 4- 40 The temperature vertical distribution in a radiant floor system follows a comfort curve very close to the ideal

The technologic evolution of thermoregulation devices has made radiant floors rapidly popular also for summer cooling systems. This winning alternative to air conditioning has become a reversible system exploitable for the entire thermal cycle of residential units. However, as opposed to winter when the user just needs to increase the room air temperature, in summer temperature and humidity must be reduced to obtain the ideal comfort. This function is assigned to a special dehumidification system which decreases the humidity level by balancing the latent thermal loads, while the radiant floor reduces the temperature eliminating the sensible thermal loads.

ENERGY SAVING

The small difference between the temperature of air conditioned ambientes and the temperature of the air outside enables to reduce heat dispersion, thus offering an extremely interesting level of energy saving, complying with the latest rules. In addition, delivery temperatures typical of radiant systems enable to use energy sources within a higher efficiency range (solar panels, heat pumps, condensing boilers).

ACOUSTIC INSULATION

The low speeds of the water circulating inside the synthetic piping guarantee the utmost operational quietness. In addition, the insulation panel used for the radiant package also works as a sound-absorbing device which greatly reduces the noise coming from the other dwelling floors.

THE ULTIMATE DECORATION FREEDOM

Flexibility of the domestic space and freedom to decorate are by now essential requirements for modern residential units. There is no limit to creativity for arranging furniture when it comes to radiant floor systems which eliminate the functional and aesthetical boundaries represented by traditional air conditioning units (radiators, fan coil units). This kind of system is also the perfect solution for historical buildings where it is almost impossible to install unconcealed heating elements: the ambient remains aesthetically unaltered, ensuring a state-of-the-art result.

LONG LASTING AND LIMITED MAINTENANCE

All the system components are long-lasting with an operational duration generally greater than the building service life. The plastic pipes used for the distribution lines are not subject to breaks caused by corrosion. Once the insulation panels are installed under the radiant screed they are not affected by specific installation and environment stresses. Also, all the other components do not require specific care as the system includes very few mechanic parts

4.7.3. Thermal insulation system

To establish a good thermal insulation system, we must first eliminate thermal bridging.

PARAMETERS RELATING TO THE BUILDING

CHECK FOR TRANSMISSION LOSSES

Global heat transfer coefficient [W / m²K]

H'T	**0.226**	*overall average coefficient of heat exchange per transmission per surface unit*
H'T, L	**0.650**	*global mean limit coefficient of heat exchange by transmission per unit of surface area*
Verify	**H'T <H'T, L**	[_] * NA [X] Yes [_] No

Thermal transmittance of building components: separation walls

In implementation of the MiSE 3.16 faq of December 2019, the verification of the components was carried out for the structures of the same type, grouped by types of structures corresponding to the tables of appendix B of the Ministerial Decree Minimum Requirements and weighting them on the corresponding thermal bridges in order to to obtain a single weighted average transmittance. Below is the table of weighted average transmittances compared with the limit values set by the mandatory legislation:

Typology:	Opaque vertical components towards the outside, non-air-conditioned environments or against the ground				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
Ex-wall-1	External	Building envelope (Sup, tot: 123.82)	0.219	0.280	Verified
Detail of affected components					

Description	**Surface [m²]**	**U [W / m²K]**
External walls	18.65	0.246
External walls	22.31	0.246
External walls	16.13	0.246
External walls	25.53	0.246
External walls	9.17	0.246

External walls		32.03	0.246
Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**
Protruding corner with pillar	3.73	1.00	-0.039
Coverage	5.00	0.50	-0.754
Attic	5.00	0.50	0.060
Protruding corner with pillar	3.73	1.00	-0.039
Window	4.82	1.00	0.125
Window	6.00	1.00	0.125
Coverage	7.00	0.50	-0.754
Attic	7.00	0.50	0.060
Recessed corner with pillar	3.73	1.00	0.305
Window	6.00	1.00	0.125
Coverage	5.00	0.50	-0.754
Attic	5.00	0.50	0.060
Protruding corner with pillar	3.73	1.00	-0.039
Window	9.55	1.00	0.125
Window	8.75	1.00	0.125
Coverage	10.00	0.50	-0.754
Attic	10.00	0.50	0.060
Protruding corner with pillar	3.73	1.00	-0.039
Coverage	3.00	0.50	-0.754
Attic	3.00	0.50	0.060
Window	6.24	1.00	0.356
Protruding corner with pillar	3.73	1.00	-0.039
Window	4.42	1.00	0.125
Window	6.00	1.00	0.125
Coverage	10.00	0.50	-0.754
Attic	10.00	0.50	0.060
Window	6.12	1.00	0.356

Typology:	Opaque horizontal or inclined components of roofing towards the outside or non-air-conditioned environments				
Code	**Border**	**Detail**	**U, pond**	**U, lim**	**Verify**

			[W / m2K]	[W / m2K]	
TERMAC-SOL02	Non-air-conditioned environments (btrx: 0.7)	Building envelope (Sup, tot: 85.00)	0.188	0.343	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**
Inter-floor slab	85.00	0.188

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Opaque horizontal floor components, towards the outside, non-air-conditioned environments or against the ground				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
SO01	Non-air-conditioned environments (btrx: 0.45)	Building envelope (Sup, tot: 85.00)	0.184	0.644	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**
37 cm floor	85.00	0.184

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS1	0.800	1,400	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS2	0.800	1,400	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS3	0.800	1,400	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS4	0.800	1,400	Verified

Detail of affected components		
Description	**Surface [m2]**	**U [W / m2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**

CA02	Insulated bin	Thermal zone 1> Room 1> CAS5	0.800	1,400	Verified
Detail of affected components					
Description				**Surface** [m^2]	**U** [W / m^{2}K]
Detail of the thermal bridges involved					
Guy			**Length** [m]	**Coeff. of assignment**	**Psi** [W / mK]
Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond** [W / m2K]	**U, lim** [W / m2K]	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS6	0.800	1,400	Verified
Detail of affected components					
Description				**Surface** [m^2]	**U** [W / m^{2}K]
Detail of the thermal bridges involved					
Guy			**Length** [m]	**Coeff. of assignment**	**Psi** [W / mK]
Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond** [W / m2K]	**U, lim** [W / m2K]	**Verify**
CA02	Insulated bin	Thermal zone 1> Room 1> CAS7	0.800	1,400	Verified
Detail of affected components					
Description				**Surface** [m^2]	**U** [W / m^{2}K]
Detail of the thermal bridges involved					
Guy			**Length** [m]	**Coeff. of assignment**	**Psi** [W / mK]
Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond** [W / m2K]	**U, lim** [W / m2K]	**Verify**
DE04	Energy-saving armored external door with sealing gasket.	Thermal zone 1> Room 1> POR1	0.600	1,400	Verified
Detail of affected components					

Description					Surface [m2]	U [W / m2K]
Detail of the thermal bridges involved						
Guy			Length [m]	Coeff. of assignment	Psi [W / mK]	
Typology:	Transparent and opaque technical closures					
Code	Border	Detail	U, pond [W / m2K]	U, lim [W / m2K]	Verify	
DE04	Energy-saving armored external door with sealing gasket.	Thermal zone 1> Room 1> POR2	0.600	1,400	Verified	
Detail of affected components						
Description					Surface [m2]	U [W / m2K]
Detail of the thermal bridges involved						
Guy			Length [m]	Coeff. of assignment	Psi [W / mK]	
Typology:	Transparent and opaque technical closures					
Code	Border	Detail	U, pond [W / m2K]	U, lim [W / m2K]	Verify	
IE-01	Fixtures	Thermal zone 1> Room 1> INF1	1,200	1,400	Verified	
Detail of affected components						
Description					Surface [m2]	U [W / m2K]
Detail of the thermal bridges involved						
Guy			Length [m]	Coeff. of assignment	Psi [W / mK]	
Typology:	Transparent and opaque technical closures					
Code	Border	Detail	U, pond [W / m2K]	U, lim [W / m2K]	Verify	
IE-02	Fixtures	Thermal zone 1> Room 1> INF2	1,200	1,400	Verified	
Detail of affected components						
Description					Surface [m2]	U [W / m2K]

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
IE-01	Fixtures	Thermal zone 1> Room 1> INF3	1,200	1,400	Verified

Detail of affected components		
Description	**Surface [m^2]**	**U [W / m^2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
IE-03	Fixtures	Thermal zone 1> Room 1> INF4	1,200	1,400	Verified

Detail of affected components		
Description	**Surface [m^2]**	**U [W / m^2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
IE-03	Fixtures	Thermal zone 1> Room 1> INF5	1,200	1,400	Verified

Detail of affected components		
Description	**Surface [m^2]**	**U [W / m^2K]**

Detail of the thermal bridges involved			
Guy	**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
IE-01	Fixtures	Thermal zone 1> Room 1> INF6	1,200	1,400	Verified
Detail of affected components					
Description				**Surface [m²]**	**U [W / m²K]**
Detail of the thermal bridges involved					
Guy			**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Typology:	Transparent and opaque technical closures				
Code	**Border**	**Detail**	**U, pond [W / m2K]**	**U, lim [W / m2K]**	**Verify**
IE-02	Fixtures	Thermal zone 1> Room 1> INF7	1,200	1,400	Verified
Detail of affected components					
Description				**Surface [m²]**	**U [W / m²K]**
Detail of the thermal bridges involved					
Guy			**Length [m]**	**Coeff. of assignment**	**Psi [W / mK]**

Below is the detail of the components:

OPAQUE VERTICAL STRUCTURES, TOWARDS OUTSIDE, NON-CLIMATE ENVIRONMENTS OR AGAINST THE GROUND

Code	Typology	Description	U, pre [W / m²K]	U, post [W / m²K]	Yie [W / m²K]	Insulation type	Thicknes s [cm]
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10
Ex-wall-1	WallExternal	External walls	0.246	0.246	0.207	External	10

HORIZONTAL OR INCLINED OPAQUE STRUCTURES, TOWARDS OUTSIDE OR NON-CLIMATE ENVIRONMENTS

Code	Typology	Description	U, pre [W / m^2K]	U, post [W / m^2K]	Yie [W / m^2K]	Insulation type	Thickness [cm]
TERMAC-SOL02	Interior attic	Inter-floor slab	0.188	0.188	0.113	External	15

OPAQUE HORIZONTAL FLOOR STRUCTURES, TOWARDS OUTSIDE, NON-AIR-CONDITIONED ENVIRONMENTS OR AGAINST THE GROUND

Code	Typology	Description	U, pre [W / m^2K]	U, post [W / m^2K]	Yie [W / m^2K]	Insulation type	Thickness [cm]
SO01	FloorExterior	37 cm floor	0.184	0.184	0.058	Internal	15

TRANSPARENT AND OPAQUE TECHNICAL STRUCTURES

Code	Typology	Description	U [W / m^2K]	U limit [W / m^2K]	Verified
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
CA02	Dumpster	Insulated bin	0.800	1,400	Yup
DE04	Brings	Energy-saving armored external door with sealing gasket.	0.600	1,400	Yup
DE04	Brings	Energy-saving armored external door with sealing gasket.	0.600	1,400	Yup

IE-01	Single frame	Fixtures	1,200	1,400	Yup
IE-02	Single frame	Fixtures	1,200	1,400	Yup
IE-01	Single frame	Fixtures	1,200	1,400	Yup
IE-03	Single frame	Fixtures	1,200	1,400	Yup
IE-03	Single frame	Fixtures	1,200	1,400	Yup
IE-01	Single frame	Fixtures	1,200	1,400	Yup
IE-02	Single frame	Fixtures	1,200	1,400	Yup

Passive air conditioning technologies for roofs (if provided)

Passive air conditioning technologies were used for the roofs	[_] Yup [X] No
Description of the technologies adopted or, failing that, technical-economic reasons that led to the non-adoption of the technologies in question:	

CONFIGURATION OF THE THERMAL SYSTEM

OBLIGATION FOR ENERGY DIAGNOSIS

Scope of the intervention:

[_] NEW INSTALLATION of heating systems, in existing buildings, with nominal heat output of the generator greater than or equal to 100 kW

[_] RENOVATION of heating systems, in existing buildings, with nominal heat output of the generator greater than or equal to 100kW

[_] REPLACEMENT OF THE HEAT GENERATOR, in existing buildings, with nominal heat output of the generator greater than or equal to 100kW

[X] The intervention DOES NOT fall within the areas identified above, therefore it is excluded from compliance with this requirement

[_] The energy audit in compliance with the provisions of Annex 2 Section D.2 of this deed is attached

OBLIGATION OF CENTRALIZED THERMAL SYSTEMS FOR PUBLIC BUILDINGS OR PUBLIC USE

The intervention does not concern public buildings or buildings for public use

OBLIGATION TO CONNECT TO EVACUATION SYSTEMS OF COMBUSTION PRODUCTS FOR SYSTEMS INSTALLED AFTER 31 AUGUST 2013

Scope of the intervention:

[_] NEW INSTALLATION of heating systems in existing buildings

[_] RENOVATION of heating systems in existing buildings

[_] REPLACEMENT OF THE HEAT GENERATOR in existing buildings

It is asserted that:

[_] The connection to special chimneys, flues or combustion products evacuation systems provides for the outlet above the roof of the building at the height prescribed by the technical regulations in force.

MINIMUM EQUIPMENT OF THERMAL ENERGY PRODUCED BY RENEWABLE ENERGY SOURCES FOR THE PRODUCTION OF DHW

Scope of the intervention:

[_] NEW INSTALLATION of heating systems in existing buildings

[_] RENOVATION of heating systems in existing buildings

Minimum supply of thermal energy from RES for DHW production

[X] THE REQUIREMENT IS NOT APPLICABLE

Requirements for heat generators fueled by biomass fuels for the purpose of recognizing the RES quota

No biomass powered generator present

Requirements for heat pumps for the purpose of recognizing the RES quota

Name	Typology	SCOP	SPF	Lower limit SPF	Verified	Eres * [kWh / year]
PBM2-i heat pump 20	Electricity	5.2	0.42	1.15	[_] Yes [X] No	0.00

[_] heat pump energy It is considered energy from renewable sources

[X] heat pump energy IS NOT to be considered energy from renewable sources

4.7.3.1 INSTALLATION REQUIREMENTS

Average efficiencies of the utilization subsystems, design data and limit values

Project data			Reference building			Verified
H.	C.	W	H.	C.	W	
0.951		0.926	0.810		0.700	[_] * NA [X] Yes [_] No

Average efficiencies of generation subsystems, design data and limit values

	Project data			Reference building			
Generation subsystems	H.	C.	W	H.	C.	W	Verified
PBM2-i heats pump 20	5.20		5.20	3.00		2.50	[_] * NA [X] Yes [_] No

4.7.2.2. SYSTEM DESCRIPTION

Central: "Thermal Power Plant"

Service type:	Combined heating and domestic hot water production service	
Description of thermal zones served	**Acs**	**Heating**
Thermal Zone 1	Yup	Yup

Configuration of the heating system

[_] Centralized system [X] Autonomous system

Treatment of heat transfer fluids in hydronic systems

[_] in relation to the quality of the water used in thermal systems for air conditioning, the provisions of the UNI 8065 standard are applied, and in any case a chemical conditioning treatment is envisaged

[_] there is a softening treatment (to be completed in the case of a system with a thermal power greater than 100 kW and with feed water with total hardness greater than 15 French degrees)

SPECIFICATIONS OF THERMAL ENERGY GENERATORS

Installation of a domestic hot water volume meter [x] Yup [ ] No

Installation of a system make-up water volume meter [x] Yup [ ] No

Type of generator	Heat pump
Description	**PBM2-i heat pump 20**
Use	**Heating / DHW**
Typology	**Electric**
Fuel used	**Electricity**
Heat pump type (external / internal environment)	**External air / water system**
Useful thermal power	**21.5**
Absorbed electrical power	**4.1**
Coefficient of Performance (COP)	**5.2**
Minimum value prescribed by the regulation	**3.6**
Check minimum requirements	**VERIFIED**

SPECIFICATIONS RELATING TO THE REGULATION SYSTEMS OF THE THERMAL SYSTEM, Type of management

Type of winter conduction planned:

[_] continues 24 hours

[_] continuous with night attenuation

[_] intermittent

Type of summer conduction planned:

[_] continues 24 hours

[_] continuous with night attenuation

[_] intermittent

The thermal zones are equipped with the following regulation systems:

Thermal zone "Air-conditioned zone 1 - Thermal zone 1":	
- Adjustment type:	+ Climatic zone
- Features of the regulation:	P band prop. 0.5 ° C

Detail of the emission subsystems of the individual thermal zones:

Thermal zone "Air-conditioned zone 1 - Thermal zone 1":	
- Type of premises:	Up to 4 meters
- Delivery terminals:	**radiant floor**
- Nominal heat output:	2636 W

FUNCTIONAL DIAGRAMS OF THERMAL SYSTEMS

The single-line diagram of the heating systems is attached, specifying:

- The positioning and power of the dispensing terminals;

- The placement and type of generators;

- The positioning and type of the distribution elements;

- The positioning and type of the control elements;

- The positioning and type of the safety elements;

4.7.3.3. PHOTOVOLTAIC SYSTEMS

PV panels, or photovoltaic panels, are devices that convert sunlight into electricity. They are made up of a number of photovoltaic cells, which are composed of semiconducting materials like silicon. When sunlight hits the cells, it causes the flow of electrons, which generates an electric current that can be used to power a building or other electrical devices.

There are several benefits to using PV panels:

- Clean energy: PV panels generate electricity from a renewable and clean source of energy, reducing dependence on fossil fuels and reducing greenhouse gas emissions.
- Cost savings: Over time, the cost of producing electricity from PV panels becomes less expensive than traditional electricity sources, resulting in cost savings for the building owner or operator.
- Increased energy independence: By producing their own electricity, building owners and operators can become less dependent on the traditional electricity grid, reducing their vulnerability to power outages and price spikes.

The electricity produced by PV panels can be used directly in a building to power lights, appliances, and other electrical devices. Any excess electricity can be sold back to the grid through a process called net metering.

Connecting PV panels to the grid is beneficial for several reasons. First, it allows building owners and operators to sell excess electricity back to the grid, offsetting their electricity costs. Second, it provides a reliable source of backup power during outages, ensuring that the building continues to have access to electricity even if the traditional grid fails.

To connect PV panels to the grid, building owners and operators typically need to install an inverter that converts the direct current (DC) electricity generated by the PV panels into alternating current (AC) electricity, which is compatible with the electrical grid. They may also need to obtain permits or interconnection agreements with their local utility company.

The best inverter for a small residential house depends on several factors, including the size of the PV system, the amount of electricity that will be generated, and the specific requirements of the building and its electrical system. And we decided to use SMA Solar Technology; SMA is a well-known brand in the PV industry, and their inverters are known for their reliability and efficiency.

Description:	Photovoltaic system
Orientation with respect to the SOUTH (Y) - Azimut:	10,000 °
Horizontal inclination of the panels (β):	33,000 °
Environmental reflection type:	Standard reflection coefficient (albedo)
Reflection coefficient:	0.200

Energy irradiated on the module level [kWh/m2]

	JAN	FEB	MAR	APR	MAG	BELOW	JUL	NEEDLE	SET	OCT	NOV	DEC
And	54.43	95.22	135.39	155.11	187.91	193.50	204.31	174.62	140.80	115.20	84.44	54.22

***Total Irradiation:*1595.149 kWh / m²**

Characteristics of photovoltaic panels

Type of photovoltaic module:	Mono crystalline silicon
Degree of ventilation of the modules:	Non-ventilated modules
Collecting surface:	40,000 m²
Kpv:	0.150
FPV:	0.700
Peak power Wpv:	12,000 kW

Electricity produced (Eel, pv, out) [kWh]

	JAN	FEB	MAR	APR	MAG	BELOW	JUL	NEEDLE	SET	OCT	NOV	DEC
Eel, pv	457.25	799.81	1137.30	1302.89	1578.43	1625.36	1716.20	1466.79	1182.73	967.69	709.33	455.47

Total Energy produced: 13399.251 kWh

4.7.3.4. ENERGY REPORT

We can design buildings that use almost little energy by utilizing these technologies, therefore the energy we can get from the PV panels as indicated above is around 13399 kwh/year. We can transmit the additional power we produce throughout the year to the grid by completely insulating the house, using energy-efficient windows, and installing a heating and cooling system, allowing us to draw electricity from the grid if we require it during the cold season.

4.7.3.5. External walls

N.	Description (from the inside out)	s [m]	λ [W / mK]	ρ [kg / m^3]	c [J / kgK]	μ [-]	R. [m^2K / W]
	Internal surface resistance						0.130
1	Gypsum mortar with aggregates	0.010	0.290	600.00	840.00	11	0.034
2	Plaster	0.005	0.180	600.00	1000.00	4	0.028
3	Lightweight concrete (vermiculite)	0.050	0.150	400.00	1000.00	60	0.333
4	Plaster	0.005	0.180	600.00	1000.00	4	0.028
5	Extruded expanded polystyrene (XPS) panel with leather	0.100	0.030	30.00	1450.00	50	3.333
6	Brick masonry external walls (um. 1.5%)	0.050	0.360	600.00	840.00	7	0.139
	External surface resistance						0.040
	TOTAL	0.220					4.066

Figure 4- 37 wall layers

Legend

s Thickness of the layer — *λ Thermal conductivity of the material* — *c Specific heat of the material*

ρ Density — *μ Factor of resistance to vapor diffusion* — *R. Thermal resistance of the layers*

Thermal parameters			
Thickness	s	22	cm
Thermal transmittance	U	0.246	W / m^2K
Heat resistance	R.	4.066	m^2K / W
Surface mass	M.	65.00	Kg / m^2
Thermal capacity	C.	60.59	kJ / m^2K
Periodic thermal transmittance	YIE	0.207	W / m^2K
Internal air thermal capacity	k1	26.94	kJ / m^2K
External air heat capacity	k2	27.84	kJ / m^2K
Attenuation factor	fd	0.841	-
Phase displacement	φ	4.00	h
Internal thermal admittance	Yii	1.860	W / m^2K
External thermal admittance	Yee	1.880	W / m^2K
Surface mass (excluding plasters)	Ms	53.00	kg / m^2

Figure 4- 38 Thermal Parameters

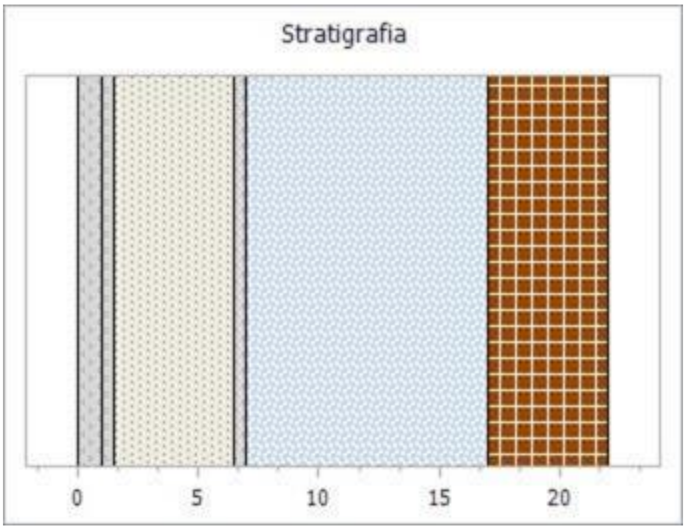


Figure 4- 39wall layer Stratigraphic

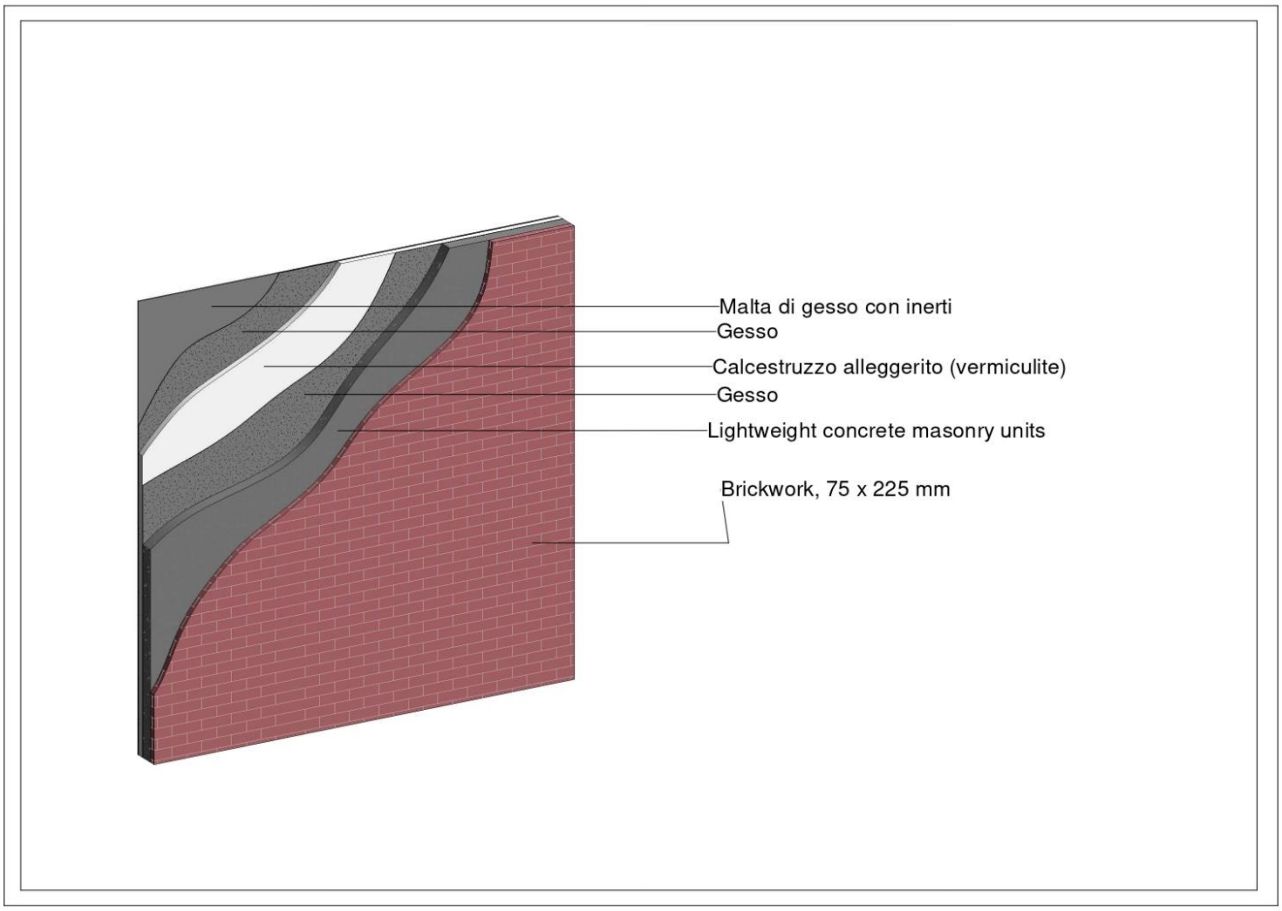


Figure 4- 41 wall detail section

Month	θe [° C]	φe [%]	Pvap, e [Pa]	Psat, and [Pa]	θi [° C]	φi [%]	Pvap, i [Pa]	Psat, i [Pa]
January	2.10	87.50	622	710	20.00	58.07	1357	2337
February	4.10	74.59	611	819	20.00	54.56	1275	2337
March	8.90	68.48	780	1140	20.00	54.54	1275	2337
April	12.50	70.78	1025	1449	20.00	59.55	1392	2337
May	16.80	62.30	1191	1912	18.00	68.10	1405	2063
June	21.60	57.67	1487	2579	21.60	61.55	1587	2579
July	24.20	52.32	1579	3018	24.20	55.63	1679	3018
August	22.20	57.61	1541	2675	22.20	61.35	1641	2675
September	18.90	70.79	1545	2182	18.90	77.16	1684	2182
October	15.50	70.24	1236	1760	20.00	64.01	1496	2337
November	9.30	84.49	989	1171	20.00	62.87	1469	2337
December	3.90	87.78	709	807	20.00	59.05	1380	2337

Key to symbols
θ- Temperature
φ- Relative humidity
P.- Pressure

Subscript legend
the- Internal
And- External
vap- Steam
sat- Saturation

Unit of measure legend
° C- Celsius degrees
%- Percentage
Pa- Pascal

Figure 4- 42 Boundary Condition External walls

		Jan	Feb	Mar	Apr	Mag	Below	Jul	Ago	Set	Oct	Nov.	Dec
$P._{sat}(\theta_{yes})$	Pa	1357	1275	1275	1392	1405	1587	1679	1641	1684	1496	1469	1380
$\theta_{yes,\ min}$	° C	11.51	10.57	10.56	11.89	12.03	13.90	14.77	14.41	14.81	12.99	12.71	11.76
$f_{R,\ yes,\ min}$	[-]	0.526	0.407	0.150	-0.081	0.000	0.000	0.000	0.000	0.000	-0.558	0.319	0.488

Legend
$P._{sat}(\theta_{yes})$ *Minimum acceptable saturation pressure on the surface*
$f_{R,\ yes,\ min}$ *Minimum acceptable surface temperature factor*
$\theta_{yes,\ min}$ *Minimum acceptable surface temperature*

Critical month:		January
Temperature factor of the critical month:	fR, yes, max	0.526
Component temperature factor:	fR, yes	0.968
Surface condensation check:	(fR, yes, max ≤ fR, yes)	**Verified**

Figure 4- 43Surface condensation check External walls

The layers that make up the structure were divided into interfaces designed as substrates of the same material so that they do not exceed a thermal resistance of 0.25 m2K / W in order to verify the production of interstitial condensation, as described in UNI 13788. The following are the interfaces, sorted from outside to inside, as specified below:

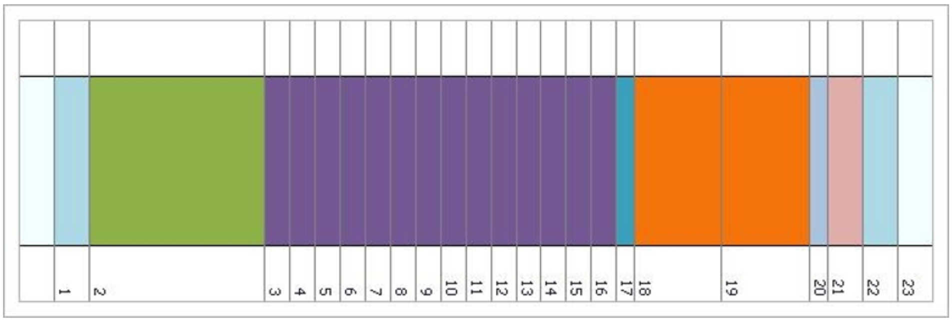
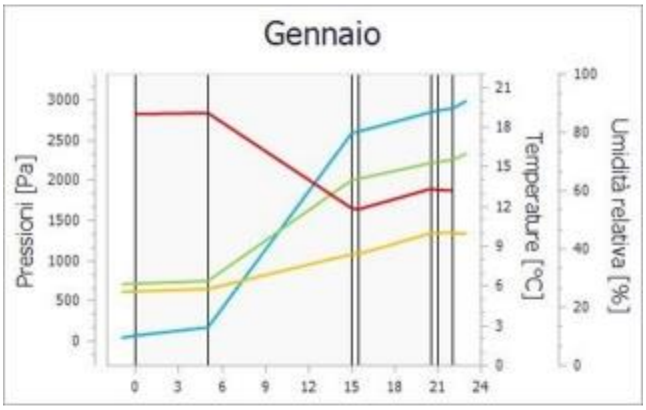
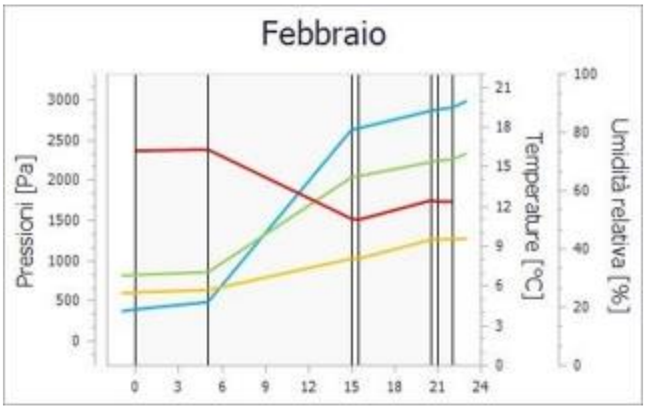
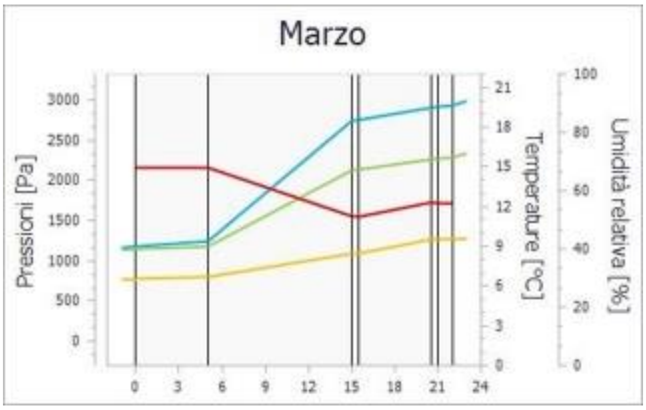


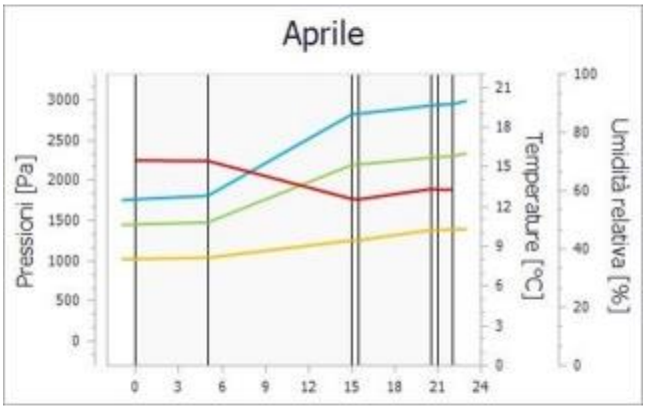
Figure 4- 44 Interstitial Condensation Check

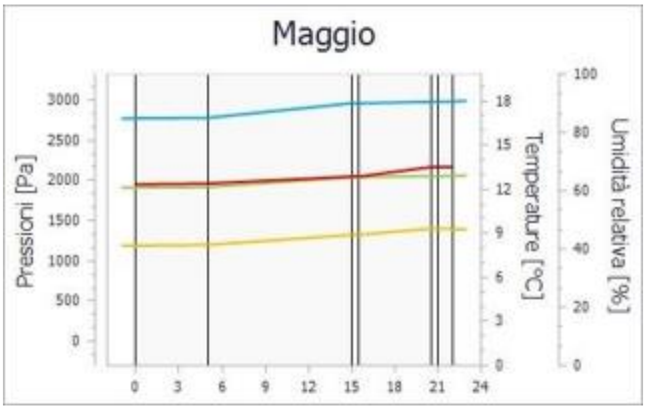
Below, the diagrams of temperatures, pressures and humidity:

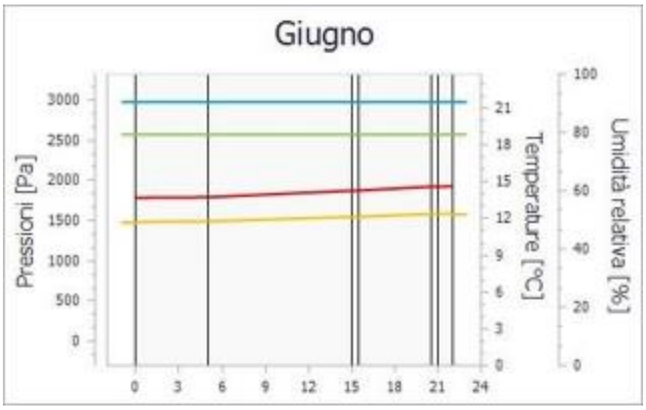












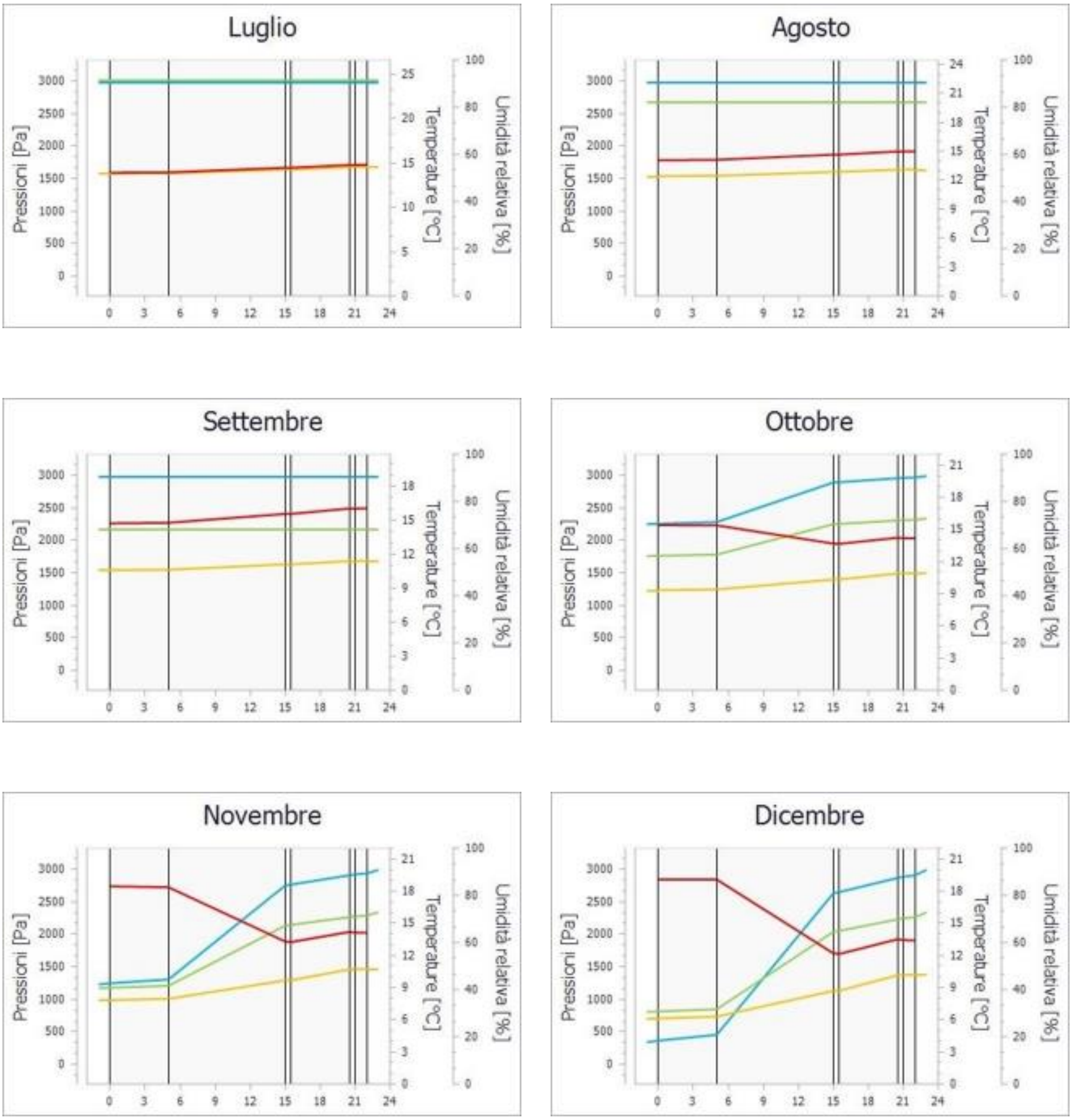


Figure 4- 45 Pressure and temperature diagrams

Legend

Temperature **Vapor pressure** **Saturation pressure** **Humidity**

4.7.3.6. Roof Technology

In the project we used a pitched roof with the timber structure under it and by using that many different technologies can be reached:

1. Solar Panels: we decided to installed PV panels on the pitched roof to generate renewable energy from sunlight.

   PV panels, or photovoltaic panels, are devices that convert sunlight into electricity. They are made up of a number of photovoltaic cells, which are composed of semiconducting materials like silicon. When sunlight hits the cells, it causes the flow of electrons, which generates an electric current that can be used to power a building or other electrical devices.

There are several benefits to using PV panels:

- Clean energy: PV panels generate electricity from a renewable and clean source of energy, reducing dependence on fossil fuels and reducing greenhouse gas emissions.
- Cost savings: Over time, the cost of producing electricity from PV panels becomes less expensive than traditional electricity sources, resulting in cost savings for the building owner or operator.
- Cost savings: Over time, the cost of producing electricity from PV panels becomes less expensive than traditional electricity sources, resulting in cost savings for the building owner or operator.

The electricity produced by PV panels can be used directly in a building to power lights, appliances, and other electrical devices. Any excess electricity can be sold back to the grid through a process called net metering.
Connecting PV panels to the grid is beneficial for several reasons. First, it allows building owners and operators to sell excess electricity back to the grid, offsetting their electricity costs. Second, it provides a reliable source of backup power during outages, ensuring that the building continues to have access to electricity even if the traditional grid fails.
To connect PV panels to the grid, building owners and operators typically need to install an inverter that converts the direct current (DC) electricity generated by the PV panels into alternating current (AC) electricity, which is compatible with the electrical grid. They may also need to obtain permits or interconnection agreements with their local utility company.
For the inverter we decided to use " SMA Solar Technology" SMA is a well-known brand in the PV industry, and their inverters are known for their reliability and efficiency.

2. Insulation: Roof insulation can be installed to reduce heat loss and improve energy efficiency. Common types of insulation include fiberglass, cellulose, and spray foam insulation.
   For the project we are using the XPS insulation.
   XPS insulation, also known as extruded polystyrene insulation, is a type of rigid foam insulation made from polystyrene resin that is expanded and then extruded into solid foam board. XPS insulation is known for its high insulation value, low moisture

absorption, and durability. It is commonly used in construction for roofing, wall, and floor insulation, as well as for insulation around foundation walls, pipes, and ducts. XPS insulation is easy to cut and install, and it does not settle or compress over time like some other insulation materials. It also provides a good barrier against air and moisture, making it a popular choice for many building projects. And we choose to use "Open-cell XPS" This type of XPS insulation is less dense than closed-cell XPS and has a slightly lower resistance to moisture. However, it is still a good choice for use under the roof, particularly in areas with moderate moisture levels.

3. Rainwater Harvesting Systems: Rainwater harvesting systems can be installed on pitched roofs to collect and store rainwater for use in non-potable applications.
    - Here are a few factors that we consider for our system:
        - Collection capacity to collect the water and be used for the watering the green house and used as domestic water.
        - Filtration to remove debris and contaminants from the collected rainwater.

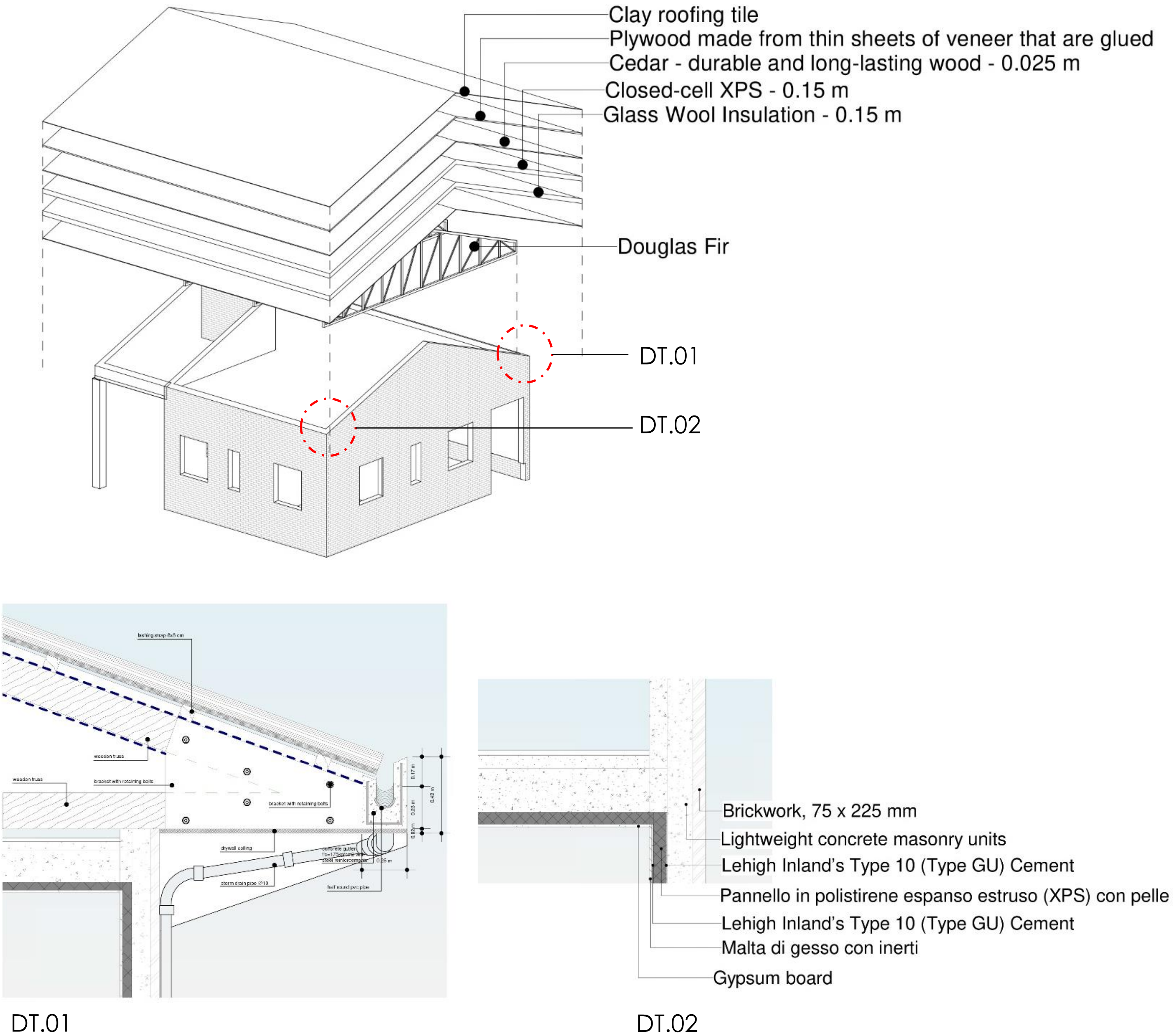


Figure 4- 46 – Roof Detail

N.	Description (from the inside out)	s [m]	λ [W / mK]	ρ [kg / m^3]	c [J / kgK]	μ [-]	R. [m^{2}K / W]
	Internal surface resistance						0.100
1	Lime and gypsum plaster (interior)	0.010	0.700	1400.00	840.00	11	0.014
2	Slab block	0.050	0.600	1800.00	1000.00	9	0.083
3	Extruded expanded polystyrene (XPS) panel with leather	0.150	0.030	30.00	1450.00	50	5,000
4	Cement mortar	0.040	1.150	1800.00	880.00	100	0.035
	External surface resistance						0.100
	TOTAL	**0.250**					**5.332**

Figure 4- 47 Roof component detail

Legend

s Thickness of the layer

λ Thermal conductivity of the material

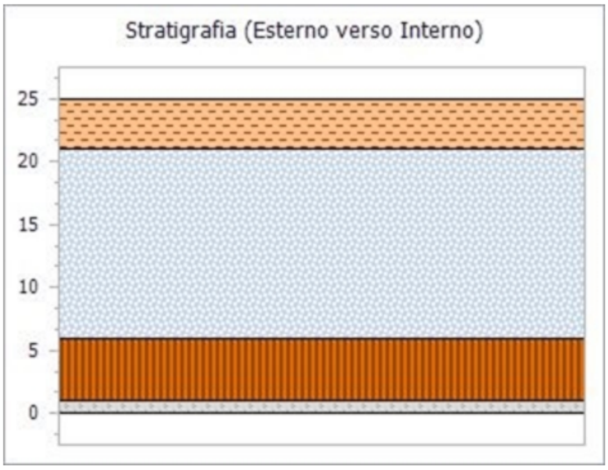
c Specific heat of the material

ρ Density

μ Factor of resistance to vapor diffusion

R. Thermal resistance of the layers

Thermal parameters			
Thickness	s	**25**	cm
Thermal transmittance	U	**0.188**	W / m^{2}K
Heat resistance	R.	**5.332**	m^{2}K / W
Surface mass	M.	**180.50**	Kg / m^2
Thermal capacity	C.	**171.65**	kJ / m^{2}K
Periodic thermal transmittance	YIE	**0.113**	W / m^{2}K
Internal air thermal capacity	k1	**72.40**	kJ / m^{2}K
External air heat capacity	k2	**58.12**	kJ / m^{2}K
Attenuation factor	fd	**0.603**	-
Phase displacement	φ	**6.84**	h
Internal thermal admittance	Yii	**5.170**	W / m^{2}K
External thermal admittance	Yee	**4.118**	W / m^{2}K
Surface mass (excluding plasters)	Ms	**166.50**	kg / m^2



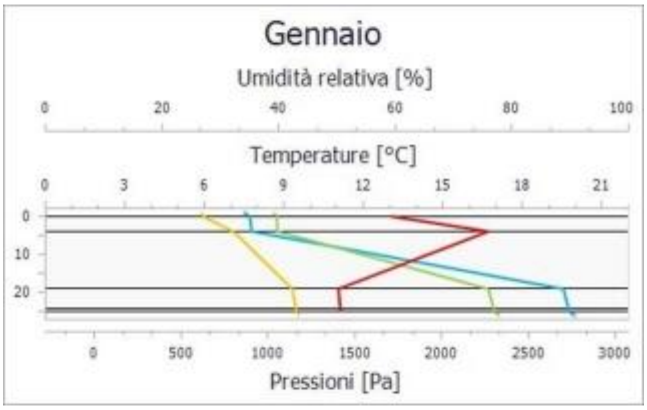
Month	θe [° C]	φe [%]	Pvap, e [Pa]	Psat, and [Pa]	θi [° C]	φi [%]	Pvap, i [Pa]	Psat, i [Pa]
January	7.47	60.11	622	1034	20.00	49.91	1166	2337
February	8.87	53.68	611	1137	20.00	47.31	1106	2337
March	12.23	54.84	780	1423	20.00	49.48	1156	2337
April	14.75	61.13	1025	1677	20.00	56.13	1312	2337
May	17.76	58.63	1191	2032	18.00	66.45	1371	2063
June	21.12	59.39	1487	2504	21.12	63.38	1587	2504
July	22.94	56.44	1579	2798	22.94	60.02	1679	2798
August	21.54	59.98	1541	2569	21.54	63.87	1641	2569
September	19.23	69.35	1545	2228	19.23	75.07	1672	2228
October	16.85	64.44	1236	1918	20.00	61.96	1448	2337
November	12.51	68.25	989	1450	20.00	57.99	1355	2337
December	8.73	62.88	709	1127	20.00	51.72	1209	2337

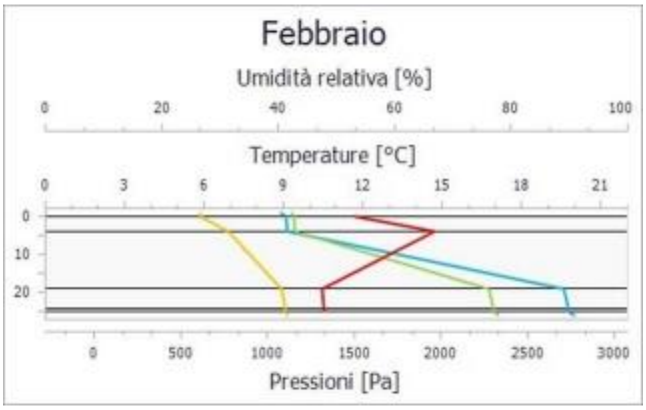
Figure 4- 48 Boundary conditions

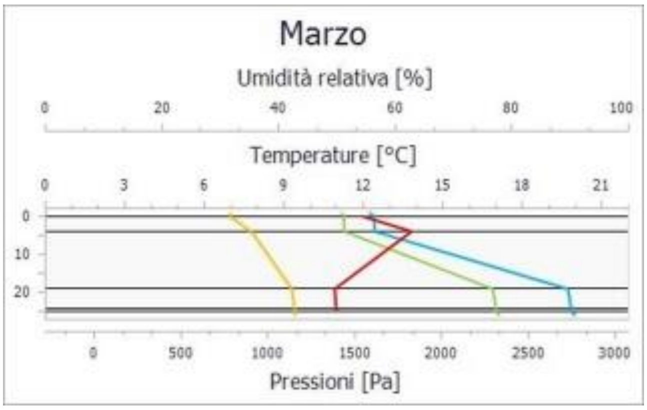
Below, the diagrams of temperatures, pressures and humidity:

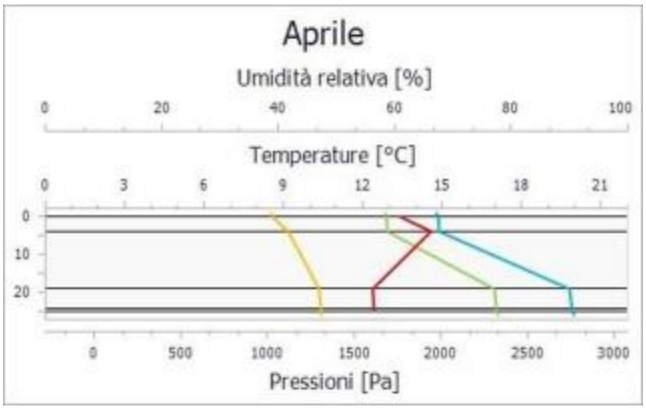
Legend

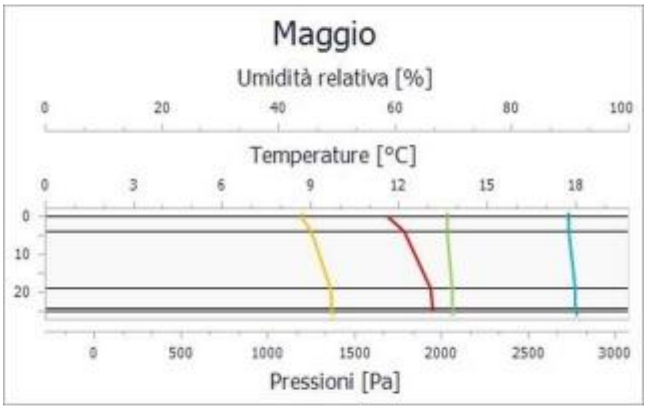
Temperature **Vapor pressure** **Saturation pressure** **Humidity**

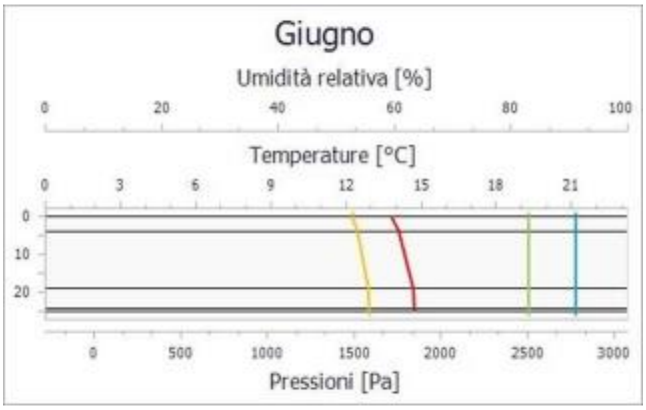












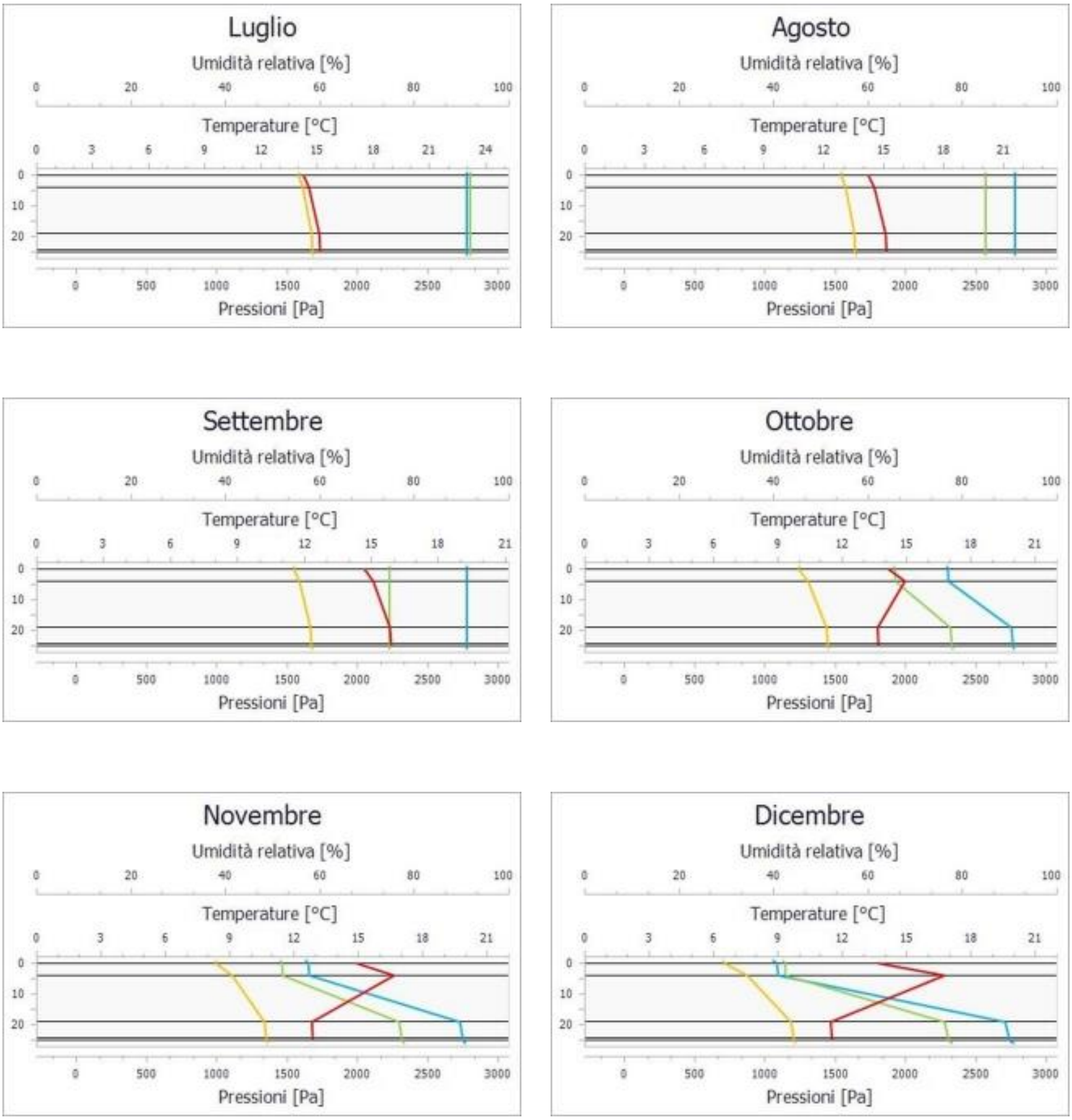

Luglio
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]
Agosto
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]
Settembre
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]
Ottobre
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]
Novembre
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]
Dicembre
Umidità relativa [%]
Temperature [°C]
Pressioni [Pa]

Figure 4- 49

4.7.3.7 Floor

N.	Description (from the inside out)	s [m]	λ [W / mK]	ρ [kg / m³]	c [J / kgK]	μ [-]	R. [m²K / W]
	Internal surface resistance						0.170
1	Parquet	0.010	1,300	2300.00	840.00	200	0.008
2	Concrete	0.020	1.150	1800.00	1000.00	100	0.017
3	Extruded expanded polystyrene (XPS) panel with leather	0.150	0.030	30.00	1450.00	50	5,000
4	Waterproofing with bitumen	0.010	0.170	1200.00	920.00	50000	0.059
5	Concrete	0.080	1.150	1800.00	1000.00	100	0.070
6	Coarse gravel without clay (um. 5%)	0.100	1,200	1700.00	840.00	5	0.083
	External surface resistance						0.040
	TOTAL	**0.370**					**5.447**

Legend

s Thickness of the layer *λ Thermal conductivity of the material* *c Specific heat of the material*

ρ Density *μ Factor of resistance to vapor diffusion* *R. Thermal resistance of the layers*

Thermal parameters			
Thickness	s	**37**	cm
Thermal transmittance	U	**0.184**	W / m²K
Heat resistance	R.	**5.447**	m²K / W
Surface mass	M.	**389.50**	Kg / m²
Thermal capacity	C.	**359.69**	kJ / m²K
Periodic thermal transmittance	YIE	**0.058**	W / m²K
Internal air thermal capacity	k1	**45.70**	kJ / m²K
External air heat capacity	k2	**125.98**	kJ / m²K
Attenuation factor	fd	**0.316**	-
Phase displacement	φ	**10.01**	h
Internal thermal admittance	Yii	**3,269**	W / m²K
External thermal admittance	Yee	**9.104**	W / m²K
Surface mass (excluding plasters)	Ms	**366.50**	kg / m²

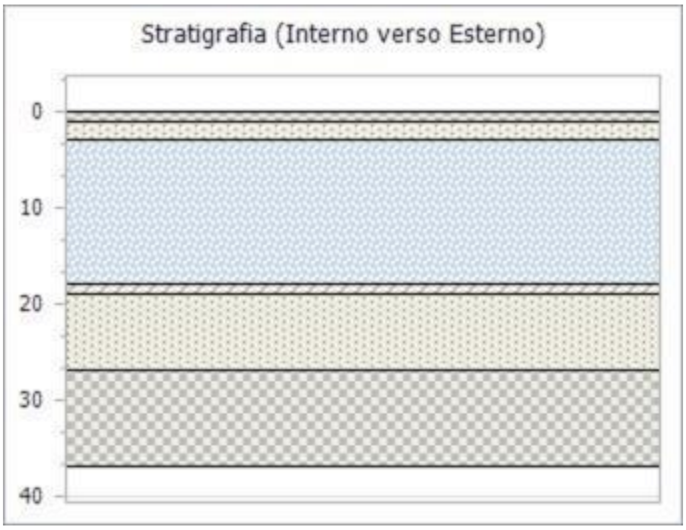


Figure 4- 50

Verification Parameters

Calculation method	Indoor vapor concentration class
Concentration class:	Class 3 - Accommodations without controlled mechanical ventilation
φ mold:	0.80 [-]
φ condensate:	1.00 [-]

Boundary conditions

Month	*θe* [° C]	*φe* [%]	*Pvap, e* [Pa]	*Psat, and* [Pa]	*θi* [° C]	*φi* [%]	*Pvap, i* [Pa]	*Psat, i* [Pa]
January	11.95	100.00	1397	1397	20.00	58.07	1357	2337
February	12.85	100.00	1482	1482	20.00	54.56	1275	2337
March	15.01	100.00	1705	1705	20.00	54.54	1275	2337
April	16.63	100.00	1891	1891	20.00	59.55	1392	2337
May	18.56	100.00	2137	2137	18.56	65.75	1405	2137
June	20.72	100.00	2443	2443	20.72	64.96	1587	2443
July	21.89	100.00	2625	2625	21.89	63.97	1679	2625
August	20.99	100.00	2484	2484	20.99	66.06	1641	2484
September	19.51	100.00	2266	2266	19.51	74.31	1684	2266
October	17.98	100.00	2060	2060	20.00	64.01	1496	2337
November	15.19	100.00	1725	1725	20.00	62.87	1469	2337
December	12.76	100.00	1473	1473	20.00	59.05	1380	2337

Key to symbols	*Subscript legend*	*Unit of measure legend*
θ- *Temperature*	***the***- *Internal*	***° C***- *Celsius degrees*
φ- *Relative humidity*	***And***- *External*	***%***- *Percentage*
P.- *Pressure*	***vap***- *Steam*	***Pa***- *Pascal*
	sat- *Saturation*	

Check Mold

		Jan	Feb	Mar	Apr	Mag	Below	Jul	Ago	Set	Oct	Nov.	Dec
$P_{sat}(\theta_{yes})$	Pa	1696	1594	1593	1739	1756	1984	2099	2051	2105	1870	1836	1725
$\theta_{yes, min}$	° C	14.93	13.96	13.96	15.32	15.46	17.38	18.28	17.91	18.32	16.45	16.16	15.19
$f_{R, yes, min}$	[-]	0.370	0.156	-0.210	-0.388	0.000	0.000	0.000	0.000	0.000	-0.754	0.203	0.336

Legend

$P_{sat}(\theta_{yes})$ Minimum acceptable saturation pressure on the surface — *$\theta_{yes, min}$ Minimum acceptable surface temperature*

$f_{R, yes, min}$ Minimum acceptable surface temperature factor

Critical month:		January
Temperature factor of the critical month:	fR, yes, max	0.370
Component temperature factor:	fR, yes	0.969
Mold check:	(fR, yes, max ≤ fR, yes)	**Verified**

Surface condensation check

		Jan	Feb	Mar	Apr	Mag	Below	Jul	Ago	Set	Oct	Nov.	Dec
$P._{sat}(\theta_{yes})$	Pa	1357	1275	1275	1392	1405	1587	1679	1641	1684	1496	1469	1380
$\theta_{yes,\ min}$	° C	11.51	10.57	10.56	11.89	12.03	13.90	14.77	14.41	14.81	12.99	12.71	11.76
$f_{R,\ yes,\ min}$	[-]	-0.054	-0.318	-0.889	-1.403	0.000	0.000	0.000	0.000	0.000	-2.462	-0.513	-0.137

Legend

$P._{sat}(\theta_{yes})$ Minimum acceptable saturation pressure on the surface

$\theta_{yes,\ min}$ Minimum acceptable surface temperature

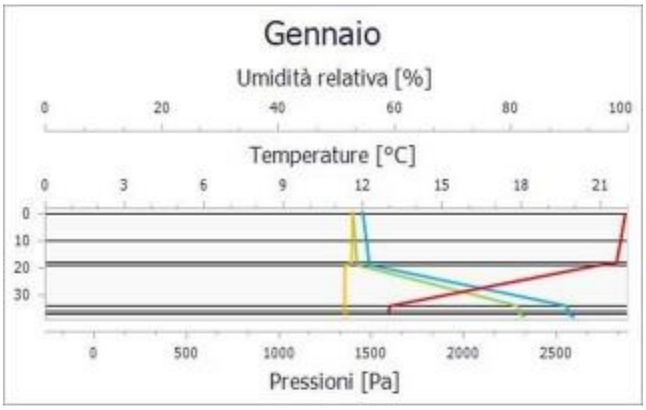
$f_{R,\ yes,\ min}$ Minimum acceptable surface temperature factor

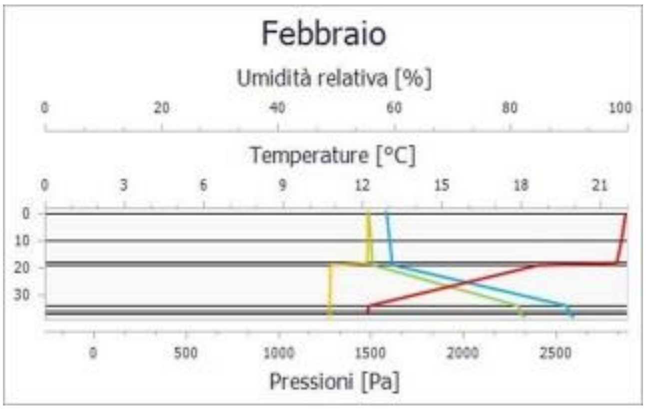
Critical month:		May
Temperature factor of the critical month:	fR, yes, max	0.000
Component temperature factor:	fR, yes	0.969
Surface condensation check:	(fR, yes, max ≤ fR, yes)	**Verified**

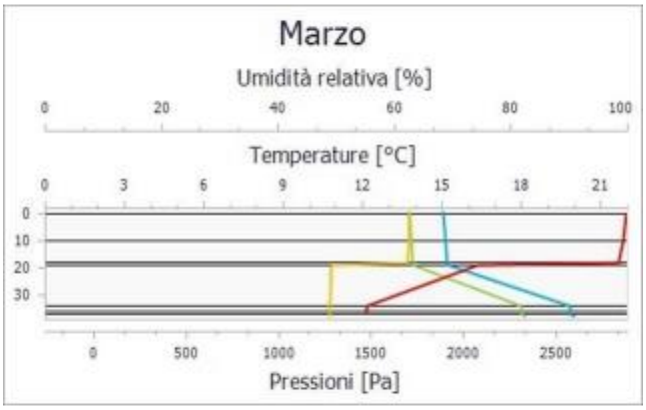
Below, the diagrams of temperatures, pressures and humidity:

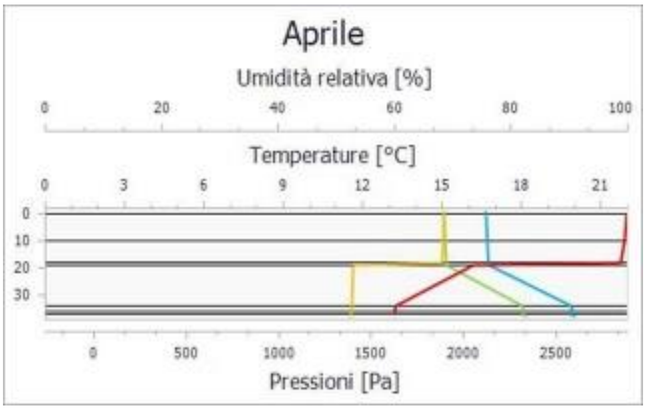
Legend

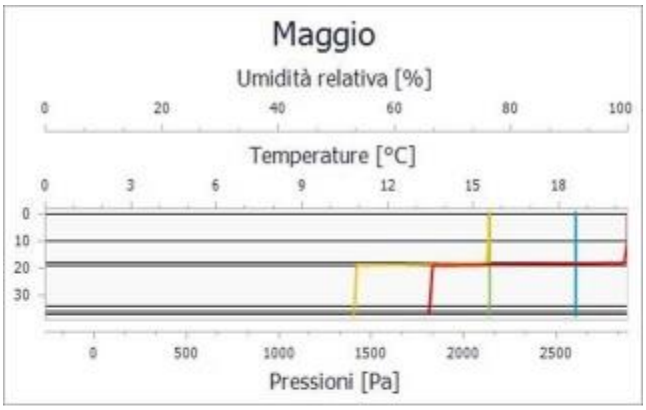
Temperature **Vapor pressure** **Saturation pressure** **Humidity**

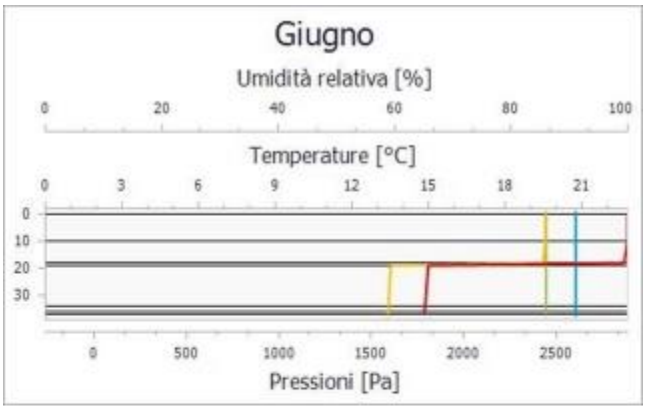


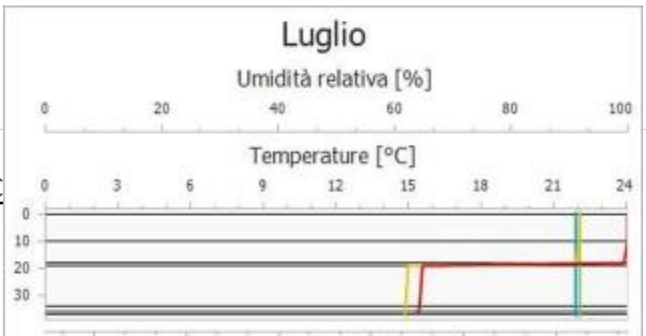


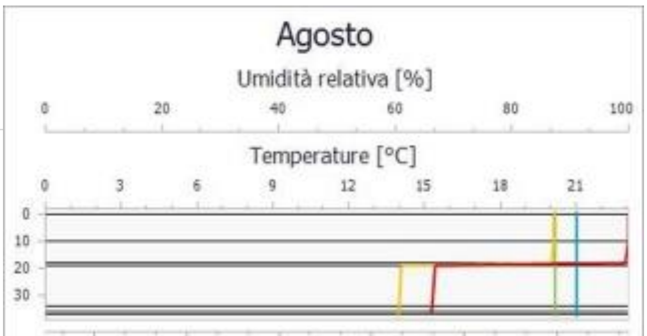












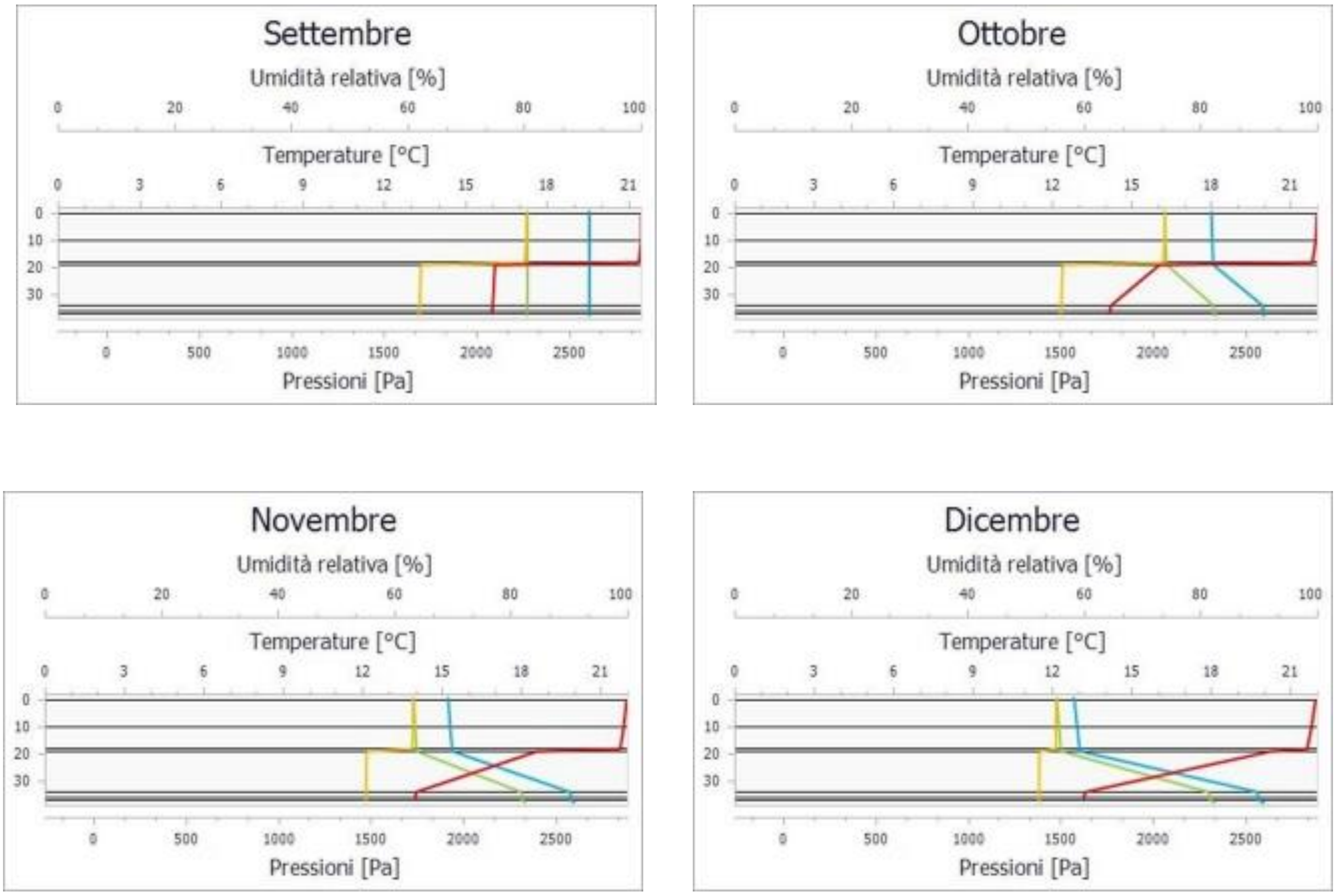


Figure 4- 51

External connection detail

We have an external garden which will work

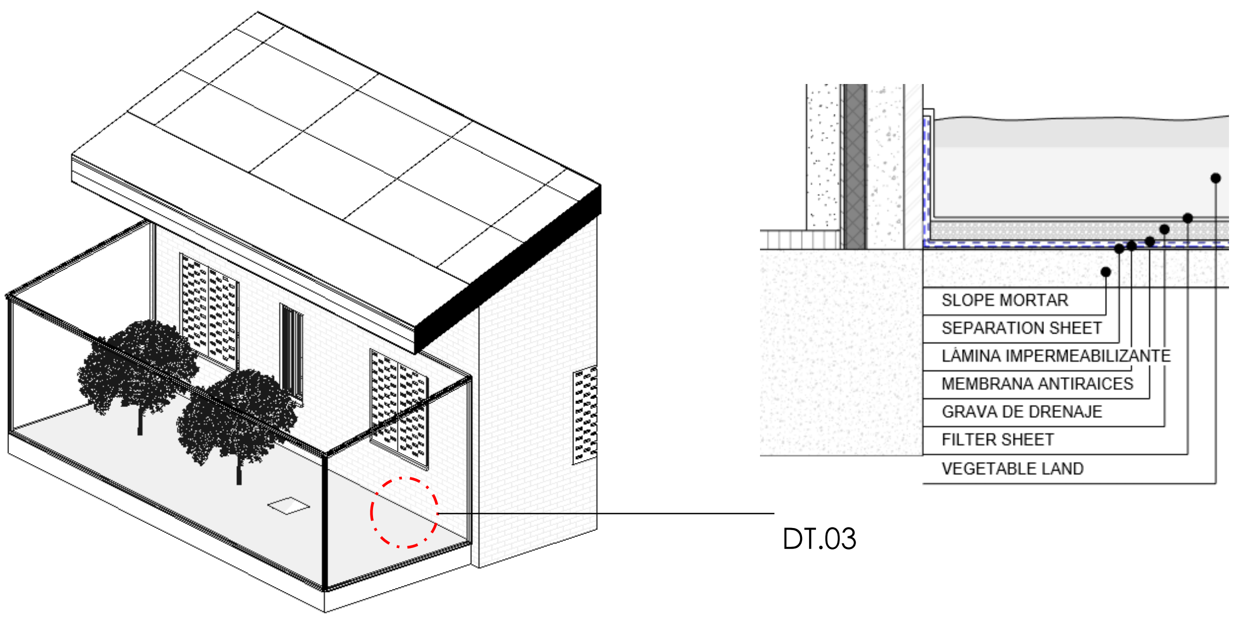


Figure 4- 52 – Green Garden Detail

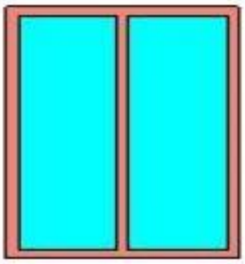
4.7.3.8 Windows

Cod.	Window type	Description
IE-01	**Single**	**Fixtures**

Glass data	
Guy	Double glazing A slab with surface treatment
Solar energy transmittance (ggl, n)	0.670

Chassis data	
Guy	PVC - Hollow profile

Frame data	
Transmittance (Uw) *	1,200 W / m2K
Air permeability class	Without classification



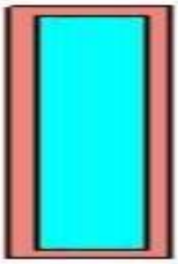
** Transmittance provided by the manufacturer*

Cod.	Window type	Description
IE-02	**Single**	**Fixtures**

Glass data	
Guy	Double glazing A slab with surface treatment
Solar energy transmittance (ggl, n)	0.670

Chassis data	
Guy	PVC - Hollow profile

Frame data	
Transmittance (Uw) *	1,200 W / m2K
Air permeability class	Without classification



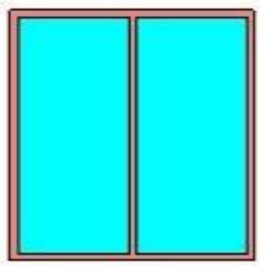
** Transmittance provided by the manufacturer*

Cod.	Window type	Description
IE-03	**Single**	**Fixtures**

Glass data	
Guy	Double glazing A slab with surface treatment
Solar energy transmittance (ggl, n)	0.670

Chassis data	
Guy	PVC - Hollow profile

Frame data	
Transmittance (Uw) *	1,200 W / m^2K
Air permeability class	Without classification



* *Transmittance provided by the manufacturer*

How to Connect windows to the wall

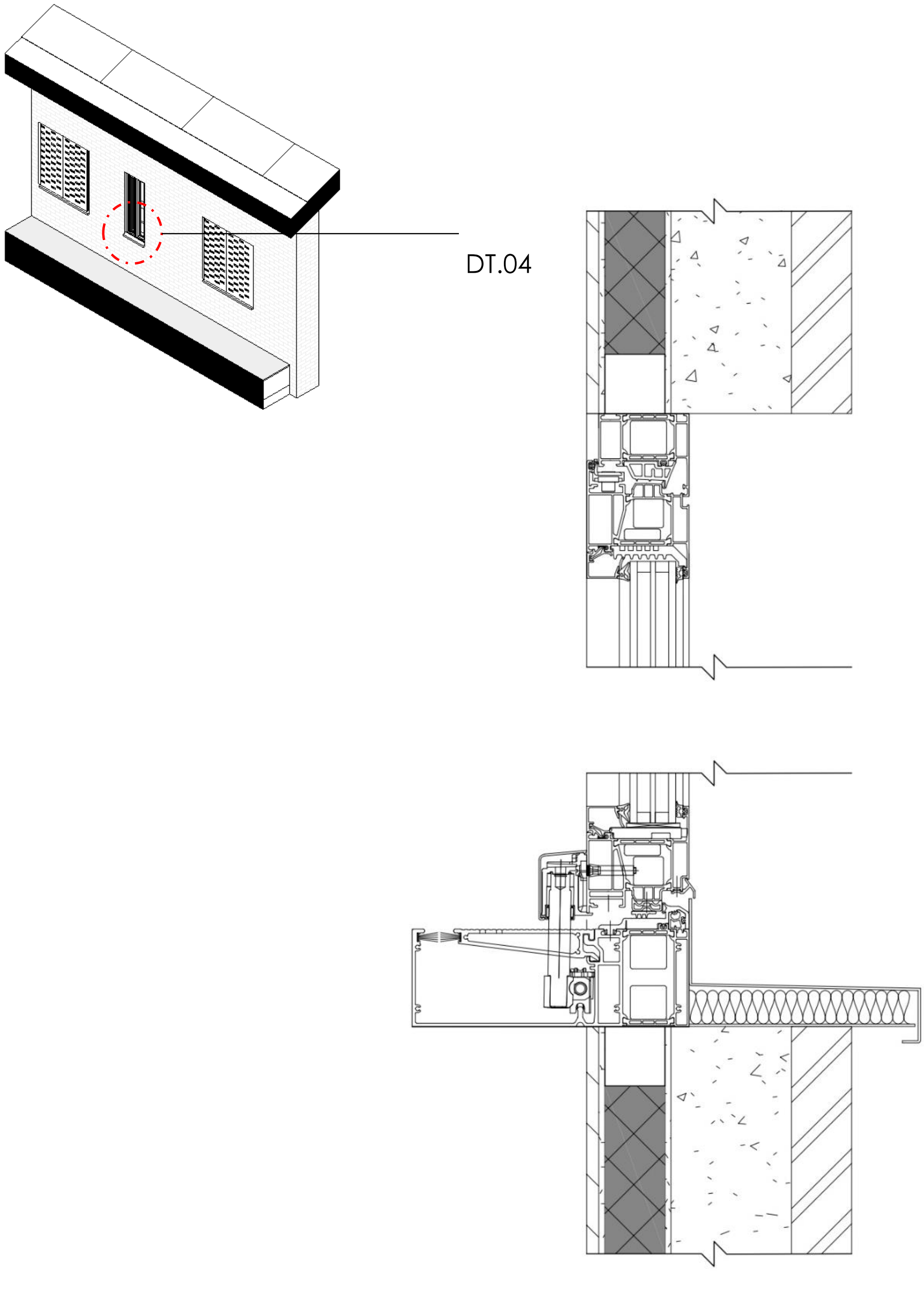


Figure 4- 54 - Window Detail

THERMO-HYGROMETRIC CHECKS

The thermohydrometric checks of the components subject to intervention are reported below.

Components outwards

Code	Description	Border	Surface condensation	Interstitial condensation	Mold
Ex-wall-1	External walls	SOUTH	Not present	Not present	Not present
Ex-wall-1	External walls	EAST	Not present	Not present	Not present
Ex-wall-1	External walls	SOUTH	Not present	Not present	Not present
Ex-wall-1	External walls	WEST	Not present	Not present	Not present
Ex-wall-1	External walls	EAST	Not present	Not present	Not present
Ex-wall-1	External walls	NORTH	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
CA02	Insulated bin	External (Horizontal)	Not present	Not present	Not present
DE04	Energy-saving armored external door with sealing gasket.	EAST	Not present	Not present	Not present
DE04	Energy-saving armored external door with sealing gasket.	NORTH	Not present	Not present	Not present

Components to non-air-conditioned environments

Code	Description	Border	Surface condensation	Interstitial condensation	Mold
TERMAC-SOL02	Inter-floor slab	Attic / insulated roof	Not present	Not present	Not present
SO01	37 cm floor	Against the ground	Not present	Not present	Not present

7.4.4. INTRODUCTION OF THE MATERIAL

The energy efficiency of a building often follows from the materials that create its envelope. And whether or not a project complies with today's increasingly stringent energy standards greatly depends on the type of insulation used. PIR, PUR, XPS and EPS are popular insulation materials, each with their specific qualities. This article provides an overview of the differences between these products, enabling you to select the best type of insulation material for your project.

- WHAT IS XPS?

XPS (extruded polystyrene insulation) is manufactured using extrusion: a continuous process which results in a closed-cell structure with a smooth skin on the top and bottom of the board. XPS' closed-cell structure prevents water penetrating the structure of the insulation board and provides long term strength and durability.

- WHAT IS EPS?

EPS (expanded polystyrene insulation) is manufactured using beads of foam within a mould. Heat or steam is applied directly to the beads, causing them to expand and fuse together. One cubic meter of EPS contains about 10 million beads, each counting approximately 3,000 cells which are closed off and filled with air. EPS is, in other words, composed of 2% polystyrene and 98% air. The manufacturing process results in a closed-cell structure, but not a closed-cell insulation board (due to voids that can occur between the beads).

- PIR AND PUR

Like XPS, PIR and PUR are closed-cell insulation materials, but contrary to EPS and XPS, chemicals are the main ingredients of PIR and PUR. The latter insulation products consist of foam that is inserted between two liners or facings, such as a multilayer aluminum finish or mineral fleece. On the one hand, these facings ensure that the foam stays put. On the other, they trap the gas that is responsible for the excellent lambda value characterizing the PU product family.

THE THERMAL CONDUCTIVITY OF EPS, XPS, PIR AND PUR

Insulation is one of the most practical and cost-effective ways to improve a building's energy efficiency. By improving the insulation in new and existing buildings, significant cost savings and reductions in energy usage can be achieved.

Both XPS and EPS provide good thermal conductivity performance. However, the air trapped in the voids in the EPS will conduct heat. A much higher density EPS board will therefore be required to match the thermal performance of XPS insulation.

The lambda values of PIR and PUR are even better than that of XPS, allowing for very thin insulation layers. Yet when the facing that trap the foam (and the gas in the cells) is punctured or ripped, the lambda value declines.

COMPRESSIVE STRENGTH: XPS COMES OUT ON TOP

Excellent compressive strength is a must for insulation materials in the most challenging environments, such as under slabs on a flat roof, concrete floors, foundations, plaza and podium decks and cold storage. In general, when densities are compared, XPS has a greater compressive strength than EPS and PIR/PUR.

XPS, or Extruded Polystyrene foam, is a type of insulation material commonly used in construction. It is made from a mixture of polystyrene beads, a blowing agent, and a stabilizing agent, which are melted together and then extruded into foam panels. Some of the key features and benefits of XPS insulation include:

- Durability: XPS is a rigid foam that is highly resistant to water absorption and compressive strength, making it an excellent choice for use in areas exposed to moisture and heavy loads.
- Energy efficiency: XPS provides a high R-value (a measure of thermal resistance) per inch of thickness, making it an effective insulator that can help reduce energy consumption and lower heating and cooling costs.
- Versatility: XPS can be cut and shaped to fit a wide range of applications, making it a popular choice for use in walls, roofs, floors, and other building components.
- Long-term performance: XPS does not settle or lose its insulation value over time, ensuring consistent performance for the life of the building.
- Easy to install: XPS panels are lightweight and easy to handle, making installation quick and easy.

Overall, XPS is a highly effective insulation material that provides a range of benefits for buildings, including energy efficiency, durability, versatility, and long-term performance. When used in combination with other insulation and air sealing measures, XPS can help create a high-performance building envelope that is comfortable, energy-efficient, and sustainable.

XPS, or Extruded Polystyrene foam, is a type of insulation material commonly used in construction. It is made from a mixture of polystyrene beads, a blowing agent, and a stabilizing agent, which are melted together and

WATER VAPOUR DIFFUSION RESISTANCE

EPS has a water vapour diffusion resistance of 30-70, whereas XPS reaches 80-250. Slightly more permeable to air and moisture, EPS is less resistant to water vapour than XPS. If you're looking to insulate a space prone to humidity (e.g. floors, cellars, and foundation walls), XPS is your best option. PIR and PUR are a no-go in those scenarios, because water may soak into the compound of the product, increasing its weight and (in the longer term) reducing its thermal value.

APPLICATIONS: WHAT IS THE DIFFERENCE BETWEEN PIR AND XPS?

The best choice of insulation material depends on individual project circumstances.

XPS has many applications. It is particularly suitable for inverted roofs, thanks to its closed-cell structure and extreme moisture-resistance.

Often used under slabs, concrete floors, foundations and underground works, due to its exceptional compressive strength.

PIR and PUR cannot be used in inverted roofs but are compatible with traditional warm roofs.

As a part of our service, Soprema remains at your disposal to help you select the appropriate insulation type for your project. We also consider hybrid insulation systems, which can be more cost-effective or offer advantages in terms of thermal value, design, and so on.

In addition, our insulation experts can help with your tapered roof design plans, zooming in on anything from gutters to outlets. The required slope can, for example, be achieved with a combination of EPS and PIR insulation products. Our designs are always done within the latest codes of practice, including the Building Regulations and BS 6229:2018.

THE SUSTAINABILITY QUESTION

For construction industry players who aim to build for the future, the environment is top of mind these days. PIR and PUR are chemical products that cannot be recycled, while EPS and XPS are more sustainable. EPS is made of only one material, and therefore easy to recycle. XPS, too, is 100% recyclable. Moreover, the latter insulation product is manufactured with – among other ingredients – end-of-life EPS and the cutting waste of other XPS boards, making it the choice par excellence for circular construction projects and proving that plastics in construction can indeed be sustainable.

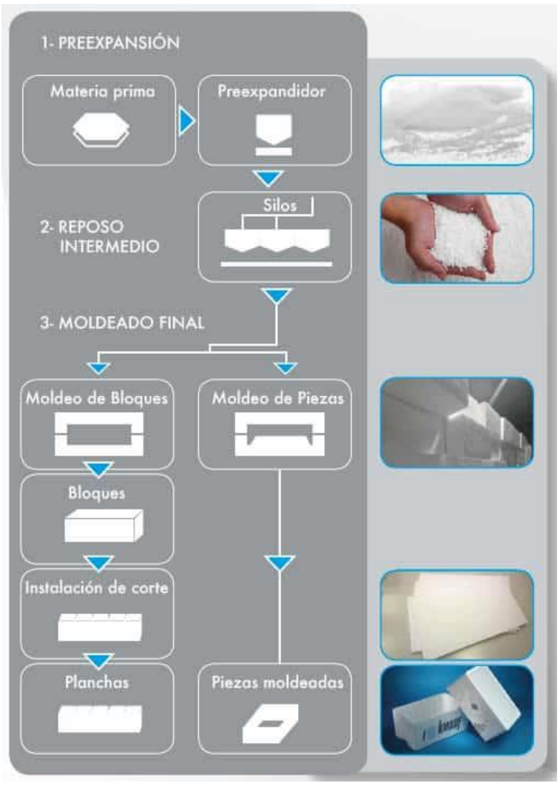
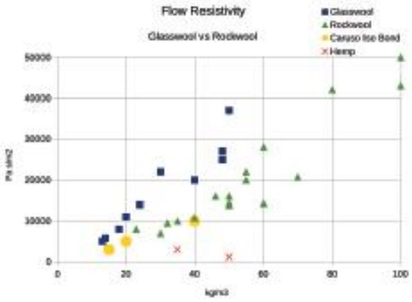


Figure 4- 55

- The relationship between weight and flow resistivity is most clearly shown in a graphic.



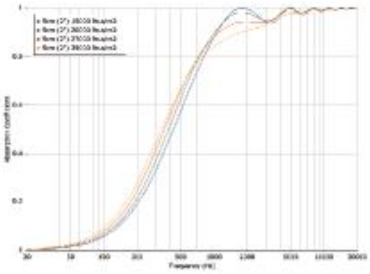


Fig 6.7
5cm without gap

EXAMPLES OF DIFFERENT ABSORBER DEPTHS

- the following examples, give a small guideline to find a reasonable flow resistance

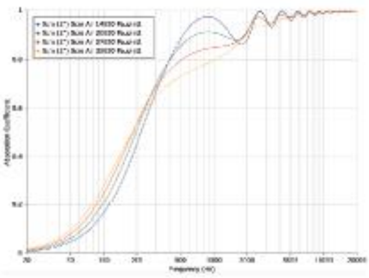


Fig 6.8
5cm (2") with 5cm (2") wall distance

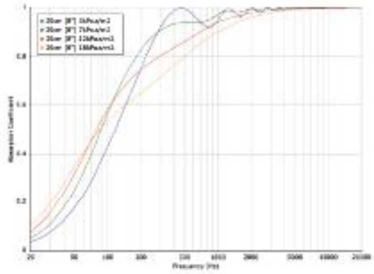


Fig 6.11
20cm (8")
without gap

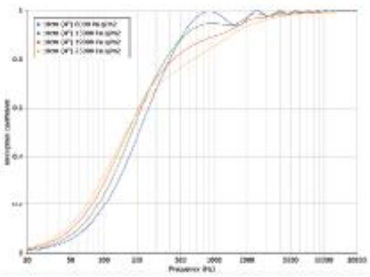


Fig 6.9
10cm (4")
without gap

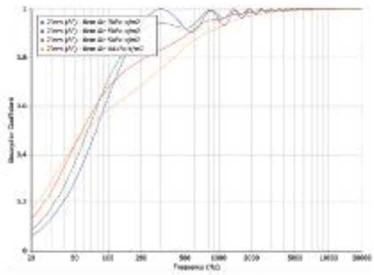


Fig 6.12
20cm (8") with 10cm (4") gap

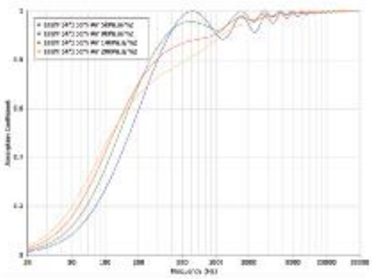


Fig6.10
10cm (4") with 5cm (2") gap

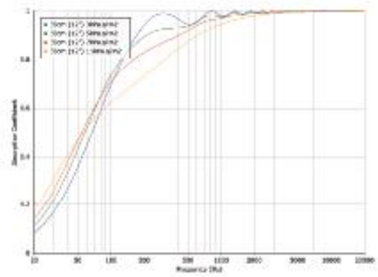


Fig 6.13
30cm without wall distance

Figure 4- 56

→ Excellent thermal performance

→ Excellent compressive

strength → Good vapor resistance

→ Lightweight and easy to handle

→ Complies with CAM requirements on recycling content

• Product standard: EN13950

• Fire reaction class: B-s1, d0

• Available thicknesses: 9.5 + 20/30/40 mm - 12.5 + 20/30/40/50/60/80 / 100 mm

• Width: 1200 mm

• Available lengths: 2000 - 3000 mm

• Sheet density: 680 kg / m^3

• Insulation density: 33 kg / m^3

• Thermal conductivity l: 0.20 W / mK (sheet) - 0.032 / 0.035 W / mK (insulating)

• Steam resistance factor m: 10 dry - 4 wet (sheet) - 100/150 (insulating)

• Specific heat: 1000 J / kg K (sheet) - 1450 J / kg K (insulator)

4.8. Lighting

In many existing buildings, the lighting system accounts for a significant amount of power use, as well as the building's high CO2 emissions and primary energy demand. Inadequate use of available daylight and obsolete lighting systems are mostly to blame for the high level of consumption.

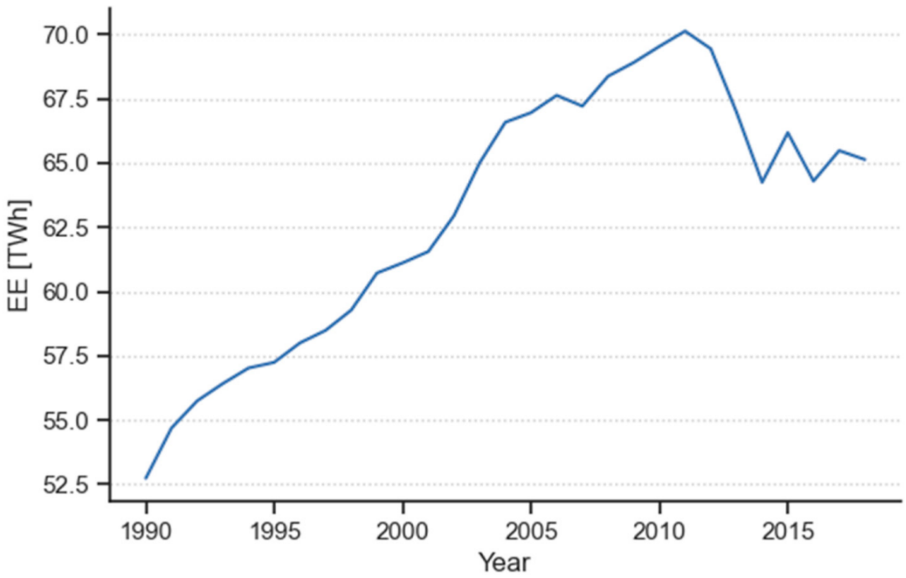


Figure 4- 57 Average electricity consumption in Italy residential building

4.8.1 Artificial light Type

The followings are Artificial light type:

- Quality of light source and light fixture
- Ballasts in discharge lamps
- Electronic control
- The type of lighting (direct or indirect)

4.8.2. External movable shading systems

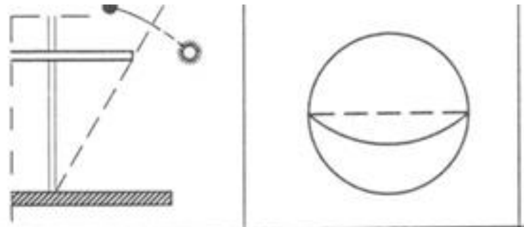
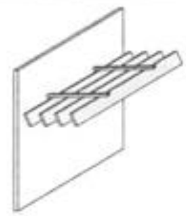
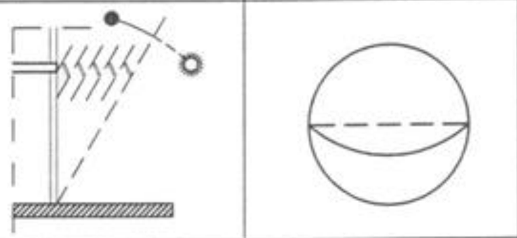
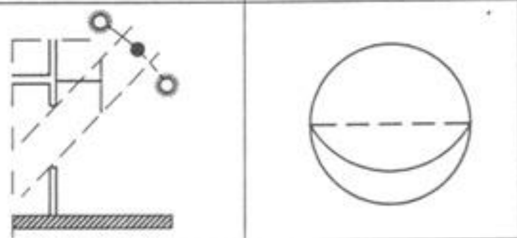
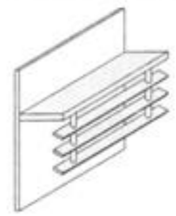
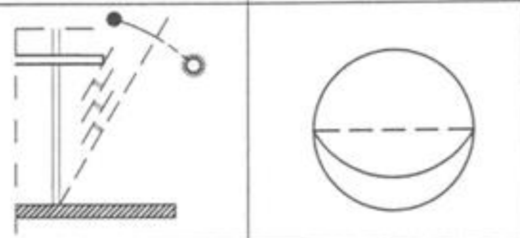
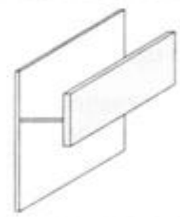
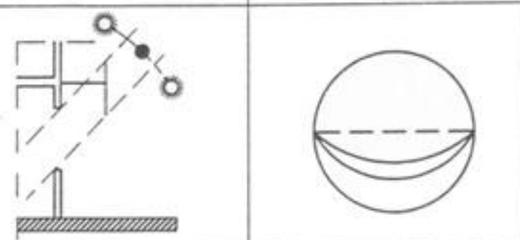
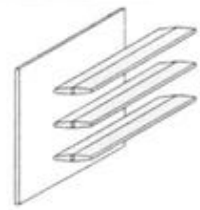
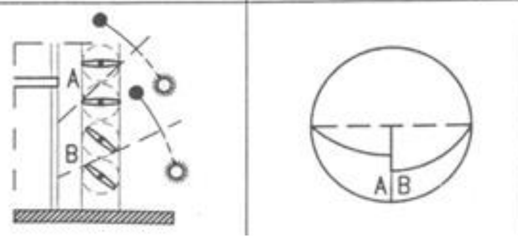
3D VIEW	BEST ORIENTATION	PROS AND CONS
		• Trap hot air • Can be loaded by snow and wind
		• Free air movement • Snow or wind load is small
		• Free air movement • No snow loads • View restricted
		• Trap hot air • Can be loaded by snow and wind • View restricted
		• Free air movement • No snow loads • View restricted
		• Trap hot air • Can be loaded by snow and wind • View restricted

Figure 4- 58

Fixed shading devices can be horizontal, vertical, or a combination of both, commonly called an “eggcrate.” Horizontal shading devices are effective on the equatorial facing façades when the sun altitude is high and are suitable for the summer months. Vertical shading devices are preferred in the east and the west directions where the solar altitude is low and the entire window faces the sun. They function best when placed on the polar side, perpendicular to the window. The exception to this is in tropical latitudes where the sun is much higher even in the winter. It is recommended that the ratio between the depth of the shading device and the spacing of the element remain constant. (DeKay & Brown, 2013) The designing of shading devices should consider the position of windows, their location, and essentially latitude. The various categories of shading devices according to Lechne

- External shading is used to reduce the amount of solar heat gain entering a building. This helps to keep the building cooler during the warm months, reducing the need for air conditioning and improving energy efficiency. External shading can also help to reduce glare, which can be a distraction in the building and cause discomfort to occupants.

There are several benefits of using external shading in a building:

- Energy Efficiency: By reducing the amount of solar heat gain entering the building, external shading can help to improve energy efficiency and reduce energy costs.
- Comfort: By reducing glare and limiting heat gain, external shading can improve the comfort of occupants in the building.
- Protection from UV rays: External shading can provide protection from harmful UV rays, which can cause damage to interior furnishings, such as carpets, drapes, and upholstery.
- Aesthetics: External shading can also be an attractive feature of a building, providing a distinctive and attractive look and improving the overall appearance of the building.
- Adaptability: External shading can be adjusted to suit changing weather conditions, such as seasonal changes, time of day, and cloud cover.

We consider the orientation, location, and specific requirements of the building when we selected the type of external shading to be used.r that you can see on the table above.

As you can see the table and the different types of design, we decided to have the shader outside on the exterior part of the wall in order to reduce the heat loss and control the amount of the sunlight that is coming from the outside.

By having this idea, we reached to a conclusion that the design of the shader would be like the figure below.

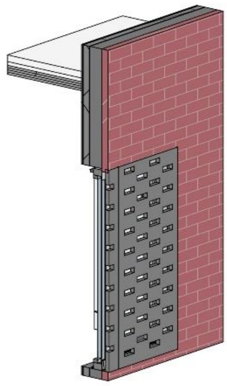


Figure 4- 59

4.8.3 Daylight Analysis

To begin the daylight study, we analyze the Daylight Factor and SDA of the various windows to determine the ideal value for the structure in order to reduce artificial light.

SDA, ASE, DF, and LUX are all terms used in various aspects of building design and energy performance. Here's a brief explanation of each term:

- SDA (Solar Daylight Autonomy): This is a metric used to measure the amount of daylight that reaches a building interior during the day. It is expressed as a percentage and indicates the proportion of time that a specific point within a building is lit by natural daylight, without relying on electric lighting.
- ASE (Annual Solar Exposure): This is a metric used to measure the amount of solar radiation received by a building over the course of a year. It is used to assess the potential for using passive solar heating or daylighting in a building design.
- DF (Daylight Factor): This is a metric used to quantify the amount of natural light in a building interior. It is defined as the ratio of the illuminance on a horizontal plane inside a building to the external illuminance on an overcast day. A higher Daylight Factor indicates more daylight in a space.
- LUX: This is a unit of measurement for illuminance, which is the amount of light that falls on a surface. It is used to quantify the amount of light in a particular area and is often used in the evaluation of lighting conditions in a building.

SDA (Solar Daylight Autonomy) and ASE (Annual Solar Exposure) are two metrics that are used to evaluate the performance of a building's daylighting design and shading strategy. They can be used to inform decisions about the design and orientation of the building and the placement and design of shading devices.

- SDA: SDA is used to measure the amount of natural light that reaches the interior of a building during the day. A higher SDA score indicates that a greater portion of the interior space is lit by natural light, reducing the need for artificial lighting and saving energy. When designing a building, the SDA score can be used to inform decisions about the placement and design of windows, skylights, and shading devices to maximize the amount of natural light entering the space.
- ASE: ASE is used to measure the amount of solar radiation received by a building over the course of a year. A higher ASE score indicates that a building is well-suited for passive solar heating and could benefit from the use of shading devices and solar-oriented building design. When designing a building, the ASE score can be used to inform decisions about the orientation of the building, the placement and design of shading devices, and the use of passive solar heating strategies.

For example, our building is located in a region with high solar exposure, we choose to orient the building to the north to minimize the amount of direct sunlight entering the space, and we are using external shading device, to reduce the amount of solar radiation entering the building.

We started with three large windows and no shade.

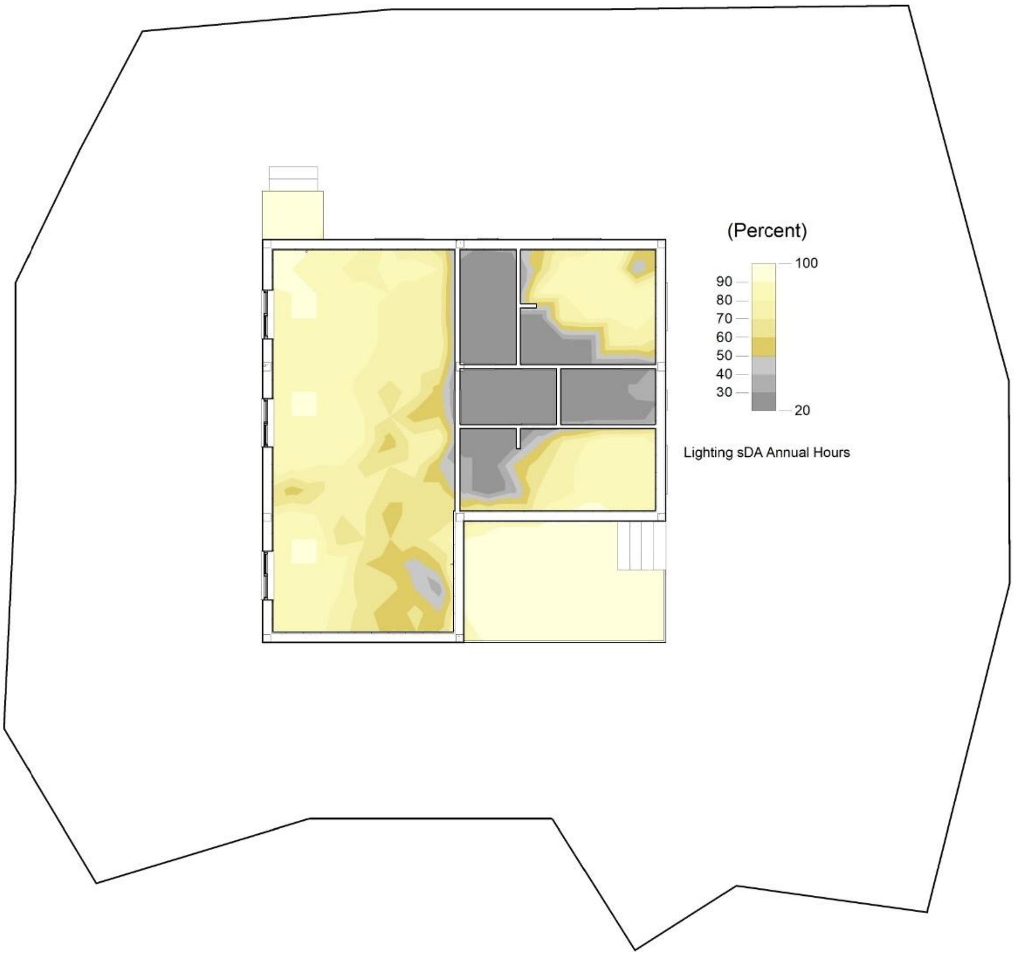


Figure 4- 60 sDA 3 large window 2m x 3m

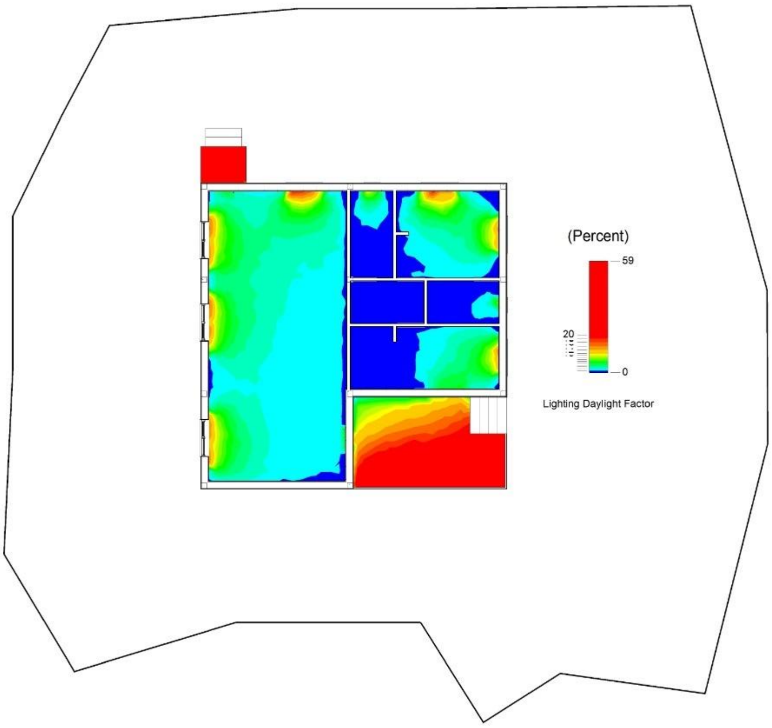


Figure 4- 61 Daylight Factor large window 2m x 3m

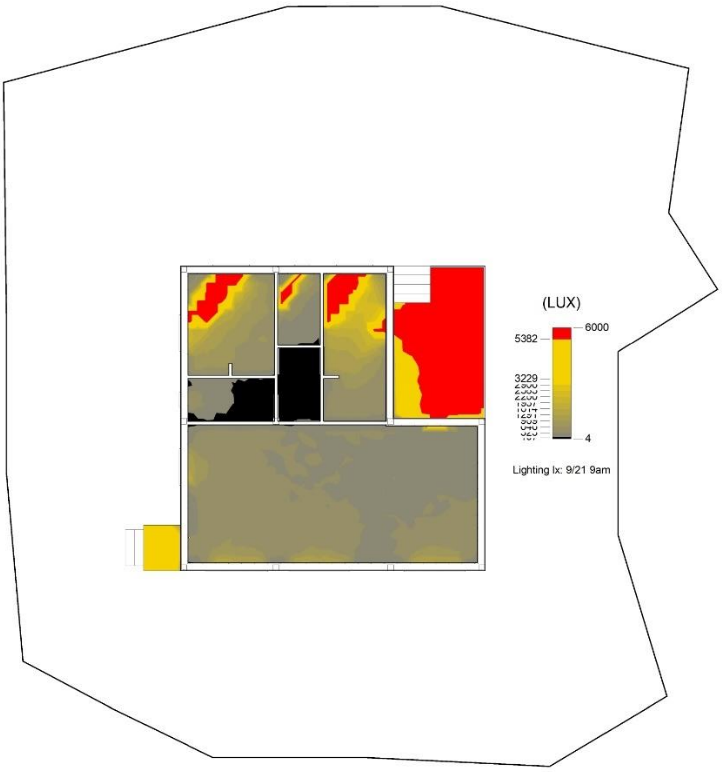


Figure 4- 62 Lux large window 2m x 3m

We could see that having three huge windows would result in over lighting, so we tried to make them smaller.

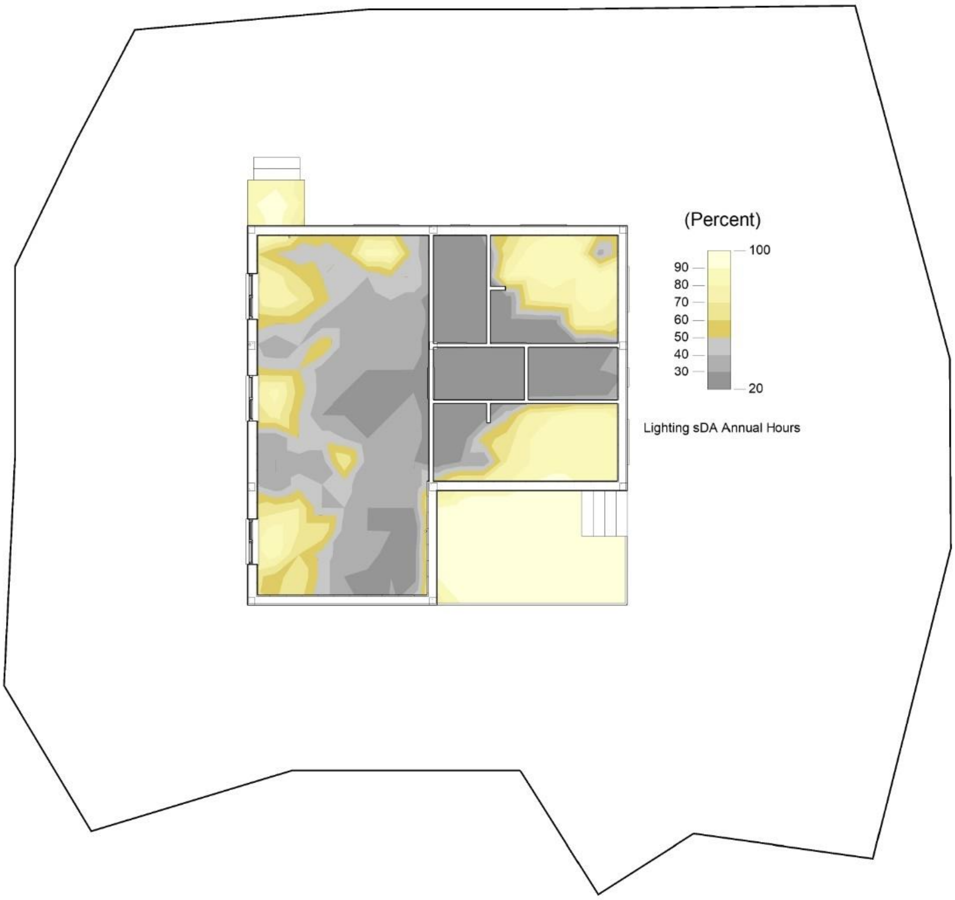


Figure 4- 63 sDA window 2m x 2m

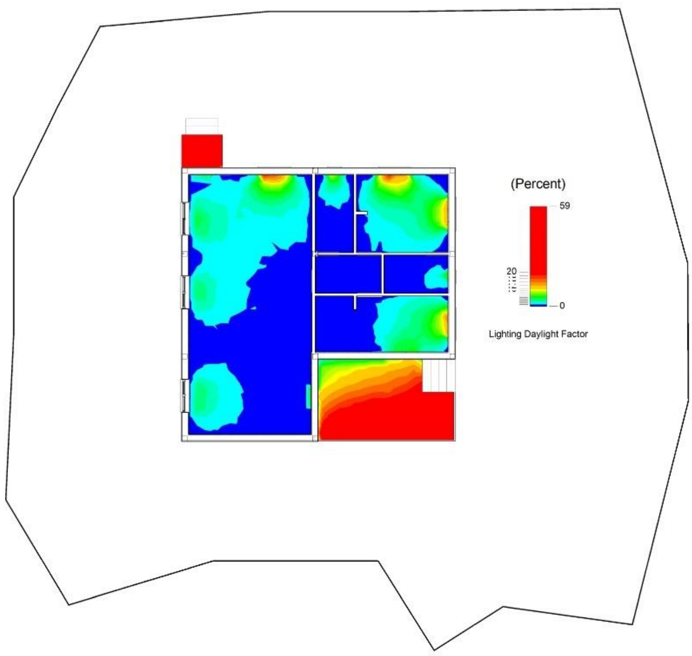


Figure 4- 64 Daylight Factor window 2m x 2m

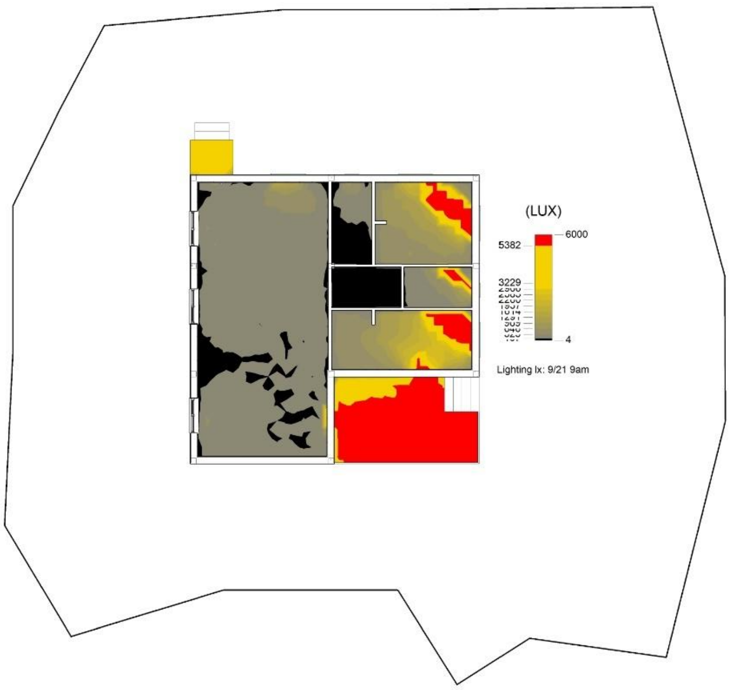


Figure 4- 65 Lux window 2m x 2m

Then we tried to decrease one window and having 2 large windows.

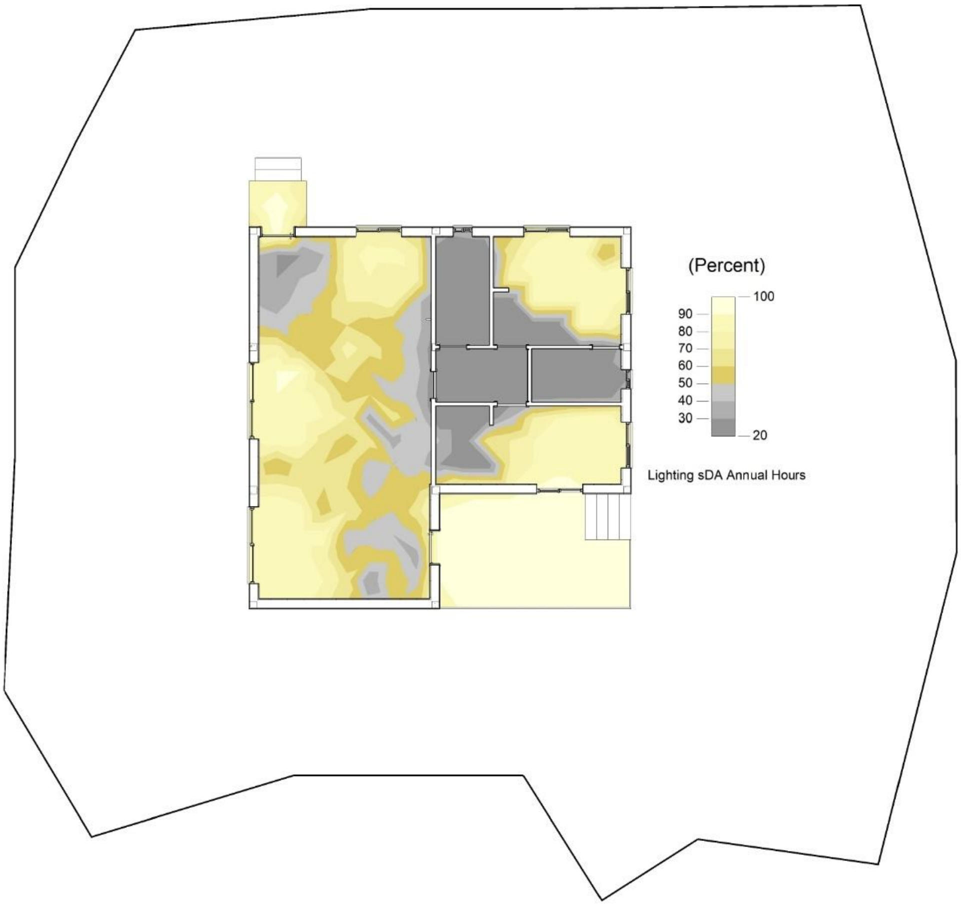


Figure 4- 66 sDA window 2m x 3m

After defining the windows, we began to add shaders to see how they performed on hot days.

Figure 4- 67 sDA two large windows 2m x 3m with shader

Finally, we examined how lighting hours differed on the hottest and coldest days of the year.

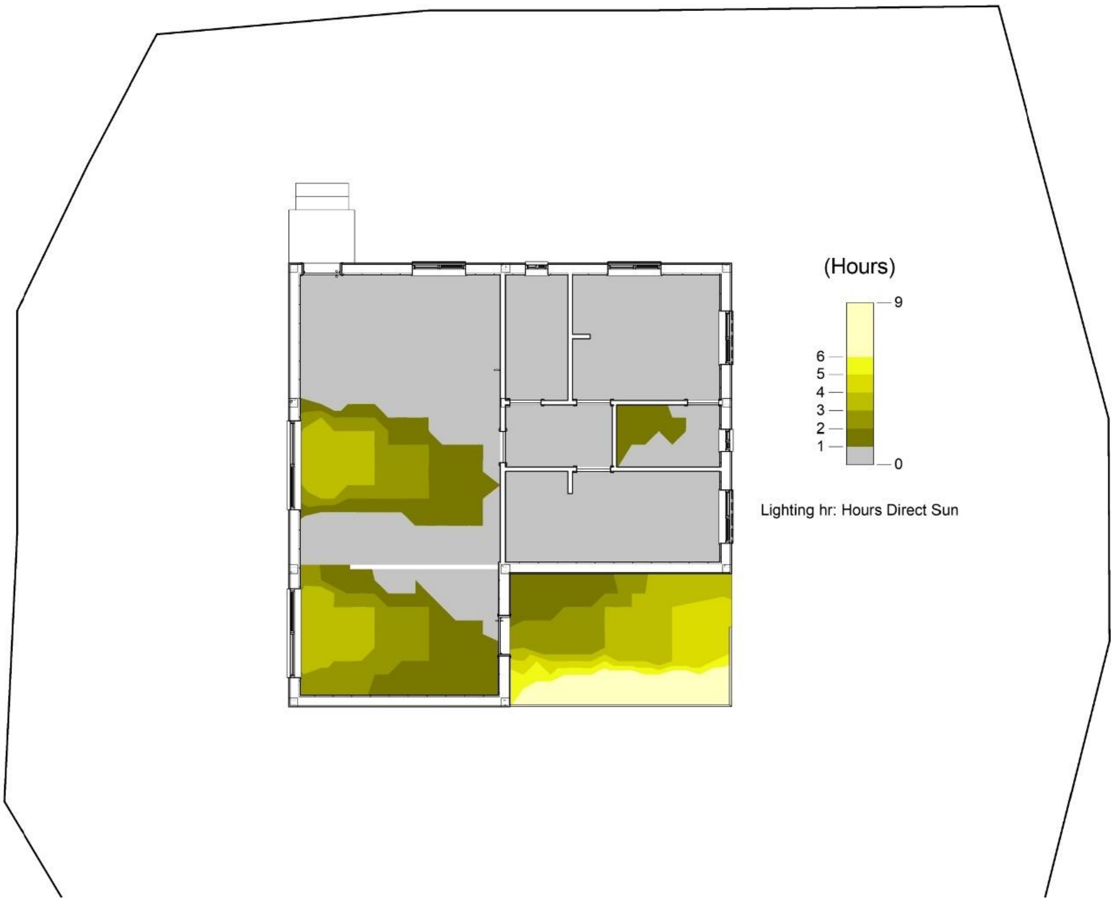


Figure 4- 68 lighting hours 21st of June

Figure 4- 69 Lighting Hours 21December

4.9. Structure

4.9.1. Building Description

The proposal takes into account the following information while designing a residential structure to be located in Ravenna: geometrical quantities:

A = 4.8 m, B = 5.0 m

Foundation design and design of reinforced concrete floors, beams, and columns

putting the First Story of the building.

Assuming the Eurocodes or, equivalently, the Italian Code serve as reference codes.

Skipping through the horizontal actions

Concrete's typical cubic compressive strength is Rck = 37MPa.

Steel's characteristic yield strength is fyk = 450MPa.

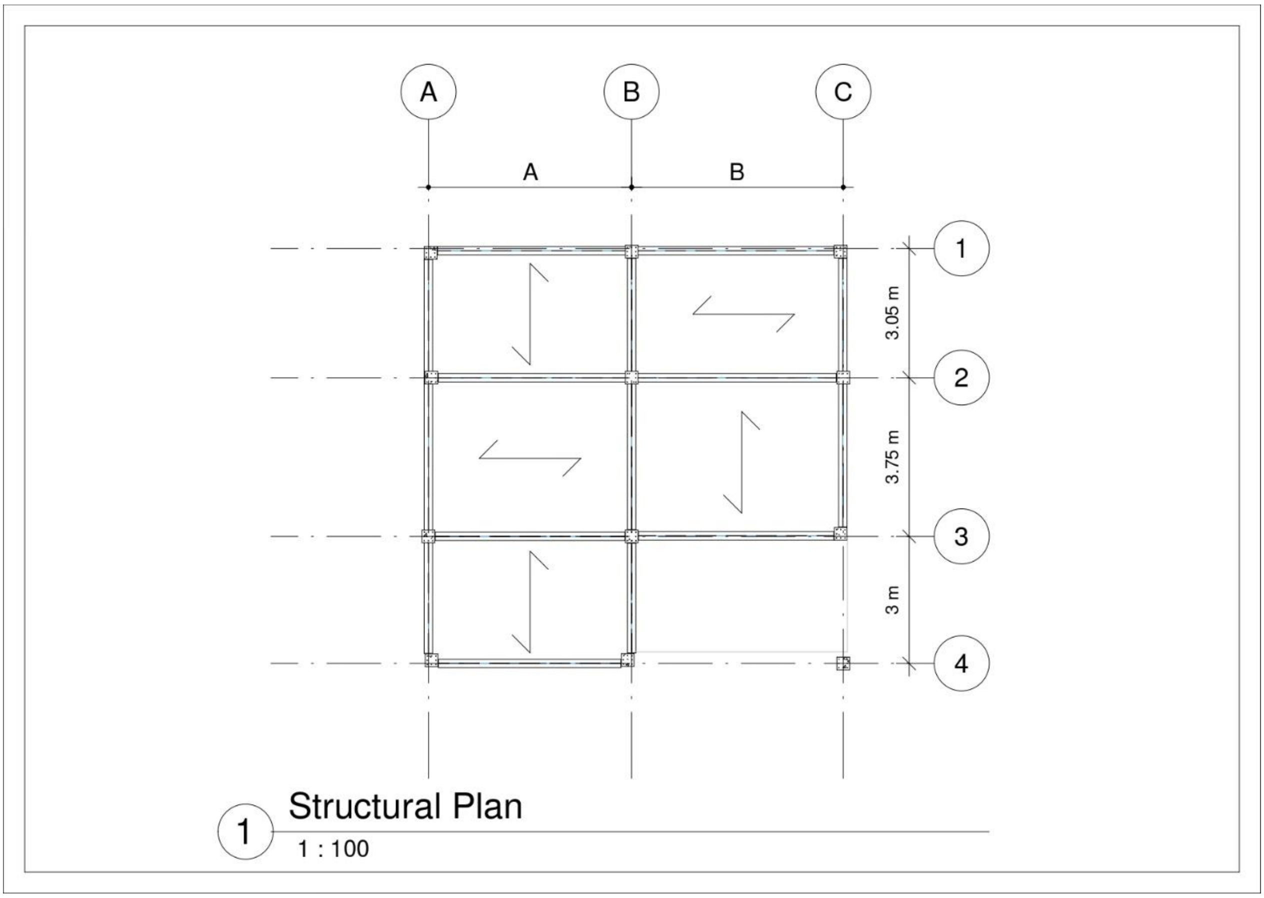


Figure 4- 70 Structure Plan

4.9.2 Structural scheme and element dimensions

4.9.2.1. Beams

Wide shallow beams are employed; shallow buried beams in seismic zones should be avoided due to their low ductility; a minimum width of 30 cm is needed. For the first storey, beams with a 22.5 x 30 cm rectangular cross-section are employed.

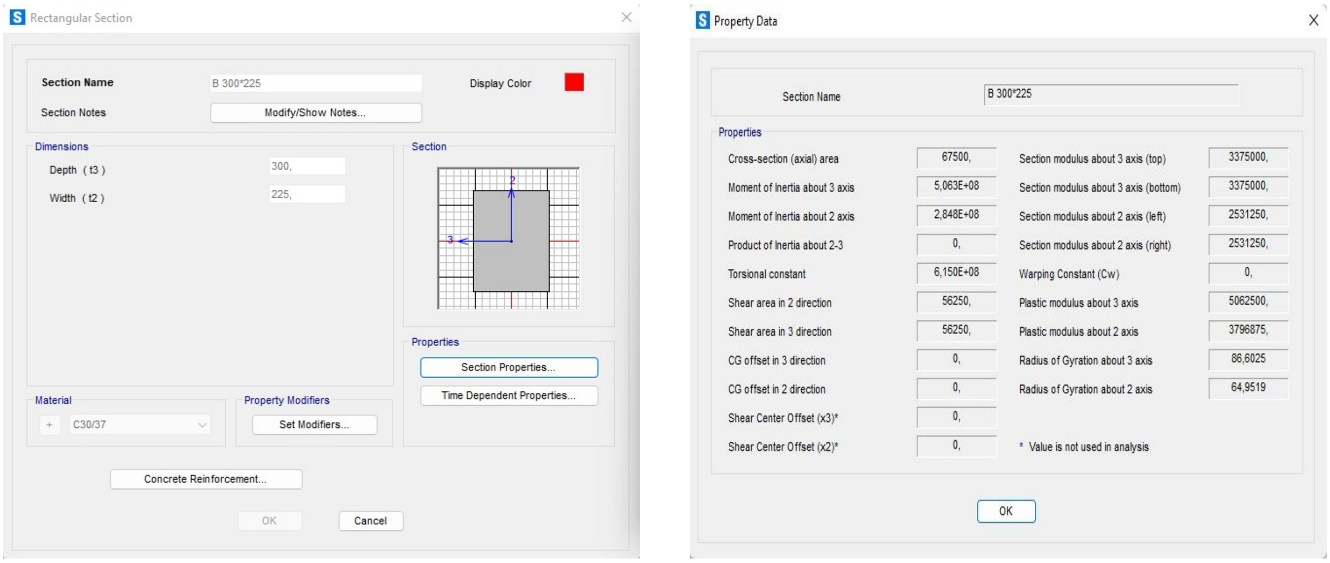


Figure 4- 71

4.9.2.2. Columns

To minimize torsional impacts and balance stiffness in both longitudinal and transverse directions, columns are placed. Internal building activities caused by decreasing vertical loads also result in smaller column and beam cross sections. For columns, a column with the proportions 30 x 30 cm is set to use.

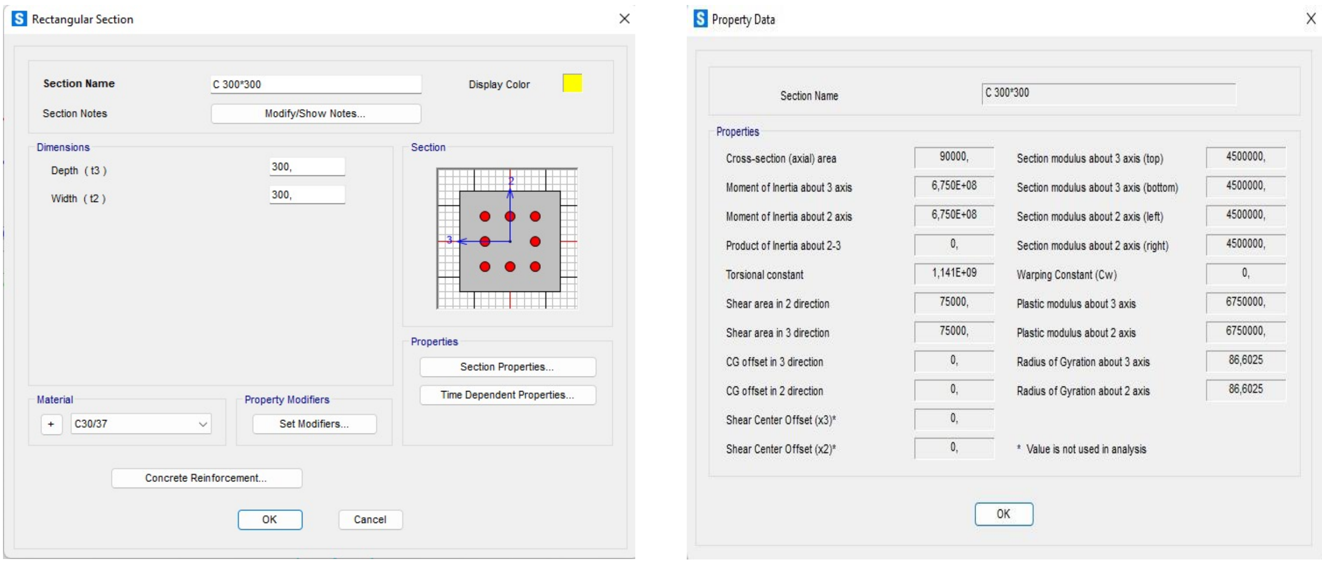


Figure 4- 72

4.9.2.3. Materials

Material mechanical properties

Cast-in-place reinforced concrete, or concrete and steel, should meet the material criteria of Eurocode 2 and Eurocode 8 for residential structures.

4.9.2.3.1. Concrete

A concrete class lower than C 20/25 must not be used when developing a DCH construction. The table below lists the mechanical parameters of the concrete, which is class C 30/37.

Partial safety coefficient for concrete: ɣc = 1.5
Characteristic compressive cylinder strength of concrete at 28 days: fck = 30 N/mm2

Coefficient that takes into consideration the long-term effect resulted from the way the loads are applied: acc = 0.85

Design compressive strength: fcd = acc*(fck/ɣc) = 0.85 (30/1.5) = 17 N/mm2

Allowable compressive stress under characteristic combination: σc,adm = k1*fck =0.6 30 = 18N/mm2

Medium tensile strength: fctm = 0.3(fck)2/3= 0.3 (30)2/3 = 2.90 N/mm2

Characteristic tensile strength: fctk,0.05= 0.7 x fctm = 0.7 x 2.90 = 2.03 N/mm2

Design tensile strength: fctd = act (fctk;0.05/ɣc) = 1.0 x (2.03/1.5) = 1.35 N/mm2

Coefficient that takes into consideration the long-term effect on tensile strength and of unfavorable effects from the way loads are applied: act = 1

Secant modulus of elasticity: Ecm =22(fctm/10)0.3 = 22((fck + 8)/10) 0.3 =22((30+8)/10) 0.3 =32 837 N/mm

4.9.2.3.1. Steel

Type B450C high ductility steel: Steel partial safety coefficient: ɣs = 1.15
Yield strength characteristics: fyk 450 N/mm2.

Design yield strength: 391 N/mm2 (fyd = fyk/s = 450 / 1.15).

Under a given characteristic combination, the permissible compressive stress is c,adm = k3*fyk = 0.8x450=360 N/mm2.

elasticity modulus: Es = 200 kN/mm2.

4.9.2.4 Actions

Construction Elements	#	Layer	Thickness (m)	Specific Weight (KN/M3)	Load Characteristic value (KN/M2)
Exterior Wall	1	Muratura in laterizio pareti esterne (um. 1.5%)	0.050	19.500	0.975
	2	Pannello in polistirene espanso estruso (XPS) con pelle	0.100	23.068	2.307
	3	Gesso	0.005	15.691	0.078
	4	Calcestruzzo alleggerito (vermiculite)	0.050	23.595	1.180
	5	Gesso	0.005	15.691	0.078
	6	Malta di gesso con inerti	0.010	15.691	0.157
	TOTAL				4.775
Interior Wall	1	Malta di gesso con inerti	0.010	15.691	0.157
	2	Gesso	0.005	15.691	0.078
	3	Calcestruzzo alleggerito (vermiculite)	0.070	23.595	1.652
	4	Gesso	0.005	15.691	0.078
	5	Malta di gesso con inerti	0.010	15.691	0.157
	TOTAL				2.122
Floor	1	Ceramic tiles	0.010	2.300	0.023
	2	Concrete	0.020	1.800	0.036
	3	Extruded expanded polystyrene (XPS) panel with leather	0.150	0.300	0.045
	4	Waterproofing with bitumen	0.010	1.200	0.012
	5	Concrete	0.080	1.800	0.144
	6	Coarse gravel without clay (um. 5%)	0.100	1.700	0.170
	TOTAL				0.260
Roof	1	Lime and Gypsum	0.010	1.400	0.014
	2	Slab Block	0.050	1.800	0.090
	3	extruded expanded polystyrene (XPS) panel with leather	0.150	0.300	0.045
	4	Cement Mortar	0.040	1.800	0.072
	TOTAL				0.221

- Snow Loads

S	1.2 KN/m²	$\mu_i . C_e . C_t . s_k$
S		Characteristic value of snow on the roof
μ_i	0.8	Snow load shape coefficient equal to 0.8 for an angle of the pitch roof less than 30°
C_e	1	Exposure coefficient function of the topography of the site. Ce=1.0 for normal topography that is "areas where there is no significant removal of snow by wind on construction work, because of terrain, other construction works, or trees".
C_t	1	Thermal coefficient that should be used to account for the reduction snow loads on the roof without high thermal transmittance Ct=1
S_k	1.5 KN/m²	Characteristic value of the snow load on the ground. For Province of Lecco, for a design working life of the structure of 50 years in accordance with the initial design assumptions S_k = 1.5KN/m²

- Live Load

According to (EN 1991-1-1 §6.3.1.2, Tables 6.1 e 6.2), the imposed load for floors in residential building is 2.00 KN/m2

4.9.2.5. Load combination

Effects of seismic action are obtained by means of a modal response spectrum analysis, considering the

combination of the effects of the components of seismic action above-mentioned.

Then, seismic combinations are combined with loads acting on the structure as follows:

$$\sum Gk,j + P + \gamma I AEk + \sum \psi 2,iQk,i$$

where:

Gk is the characteristic permanent action;

P is the prestressing force;

AEk is the characteristic value of the seismic action for the reference return period;

γI = 1 is the importance factor for ordinary buildings;

$AEd = \gamma IAEk$ is the design value of seismic action;

$\psi 2,i$ = 0.30 is the combination coefficient for variable action for residential type of occupancy;

Qk is the characteristic variable action.

8 load combinations are defined in the computer code, considering seismic action combined with permanent

and variable loads.

Fundamental combination of actions has to be considered too: two fundamental combinations are defined in

SAP2000, considering partial factors for permanent and variable loads where unfavorable and, at first, snow

load as dominant variable action, then, roof variable load as dominant variable action.

$$\sum \gamma G,j\ Gk,j + \gamma P\ P + \gamma Q,1\ Qk,1 + \sum \gamma Q,i\ \psi 0,i\ Qk,i\ j \geq 1\ i \geq 1$$

where:

γG = 1.4 is the partial factor for permanent action,

where unfavorable;

γP is the partial factor for prestressing force;

γQ = 1.5 is the partial factor for variable action, where unfavorable;

$Qk,1$ is the dominant variable action;

$\psi 0,i$ = 0, 0.5 are the combination coefficients for roof variable load and snow load on building, respectively.

At the end, an envelope of internal actions is defined.

- Check at the damage limit state

The structure shall be designed and constructed to withstand a seismic action having a larger probability of occurrence than the design seismic action, without the occurrence of damage and the associated limitations of use, the costs of which would be disproportionately high in comparison with the costs of the structure itself. The seismic action to be taken into account for the damage limitation requirement has a probability of exceedance of 10% in 10 years and a return period of 95 years. In the absence of more precise information, the reduction factor ν applied on the design seismic action may be used to obtain the seismic action for the verification of the damage limitation requirement.
The damage limitation requirement is considered to have been satisfied, if, under a seismic action having a larger probability of occurrence than the design seismic action corresponding to the no-collapse requirement, the interstorey drifts are limited in accordance with Eurocode 8 provisions.

4.9.2.6 Modelling by computer code

The structure is modeled using the finite elements computer code SAP2000. The structural model is a three-dimensional frame with shear walls made up of nodes that beams and bi-dimensional shells are framing into, as well as one-dimensional frames in the x and y directions.

When simulating R/C elements, stiffness and mechanical-geometrical properties are defined without taking into account the cross-patriotization, section's omitting both the contribution of the reinforcement and the reduction effects brought on by cracking. Results obtained using this premise are typically more conservative because the stiffness of the building is overestimated. As a result, the vibration periods are shorter than those predicted by a more accurate model, which causes more seismic actions.

When beams and columns are modeled as tridimensional frame elements, each end node offers three degrees of freedom for translation and three for rotation. To constrain all the joints at each story level, the number of degrees of freedom is reduced by defining 4 rigid diaphragms. For each floor, the displacements and rotations of each node are unambiguously determined as a function of the 3 degrees of freedom in the rigid diaphragm plane. The overall structure has 12 degrees of freedom, and each story's total mass is concentrated in the rectangular shape's center of gravity, which perfectly encloses the rigid diaphragms.

Supports that are completely restrained are thought to ignore soil-structure interaction.

Shear walls are modeled as 4-node shell elements with a 16-element mesh, which allows for the modeling of both thin and thick wall behaviors in a single shoot.

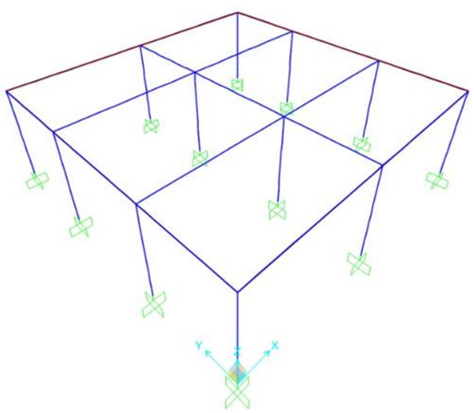


Figure 4- 73

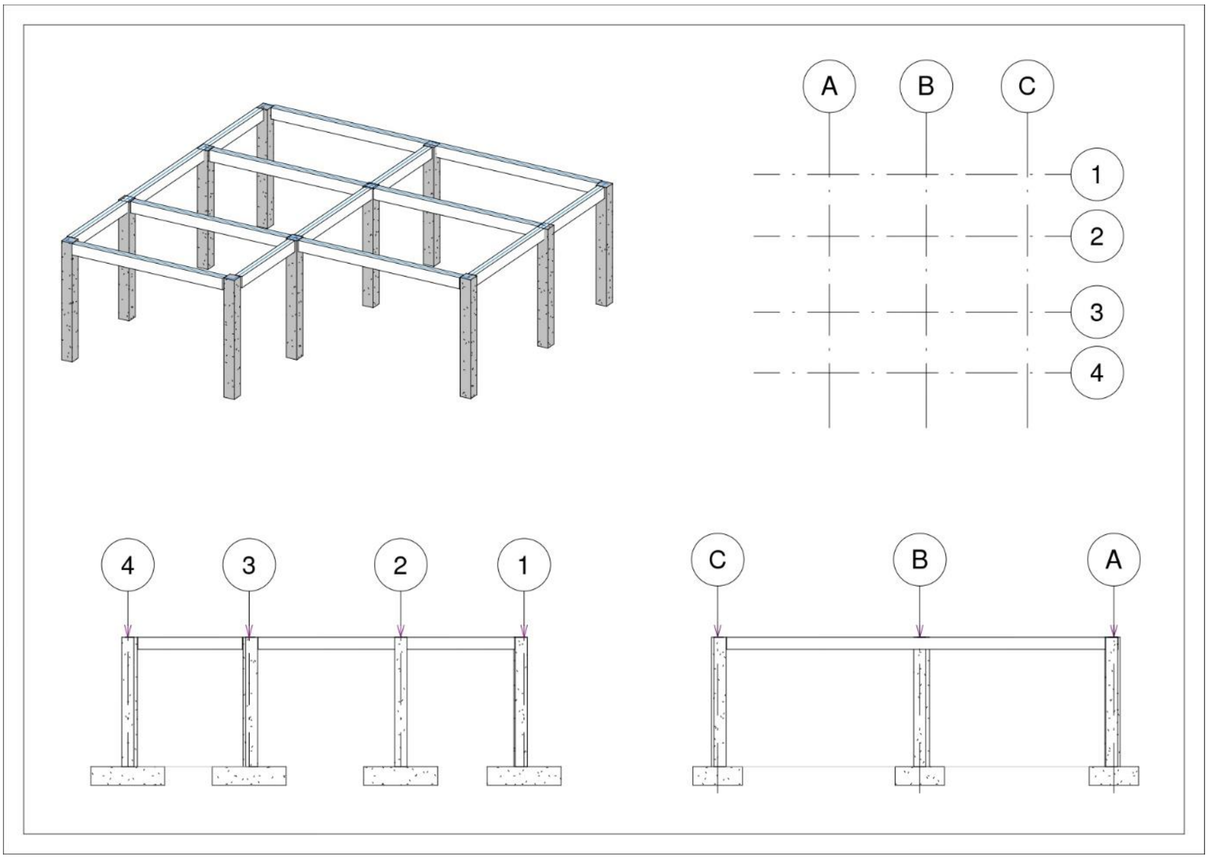


Figure 4- 74 Structure design plan

4.9.2.7 Analysis

We take into account Column C4 and the beam that is highlighted in red for the design.

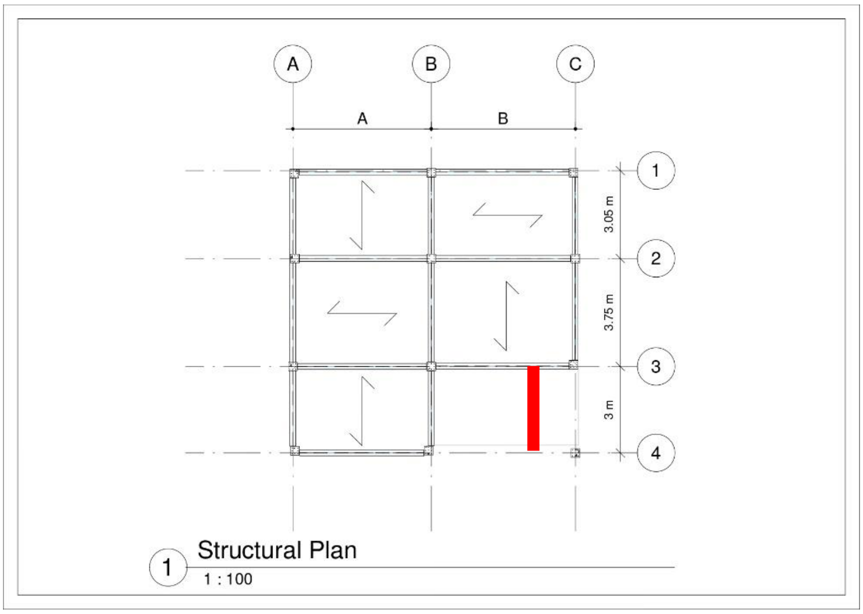


Figure 4- 75 Structure Plan

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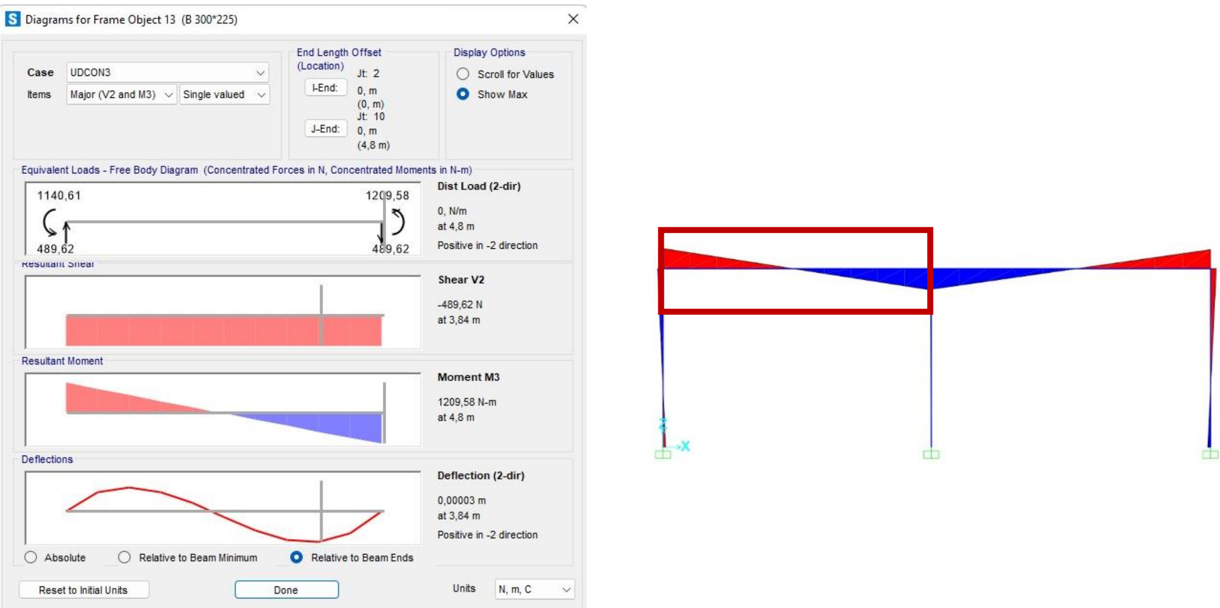
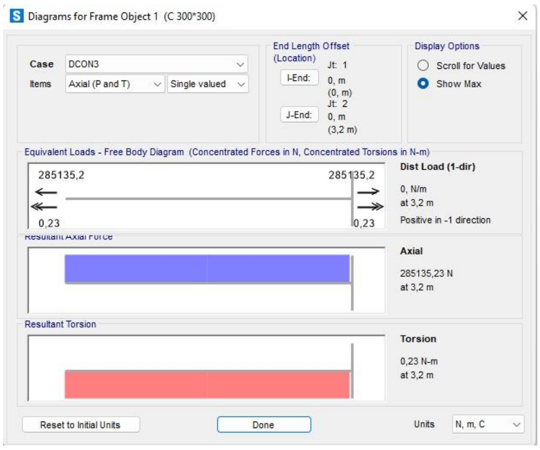


Figure 4- 76 Bending and shear forcer of the beam



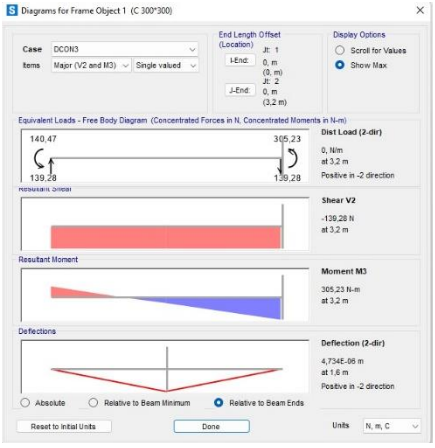
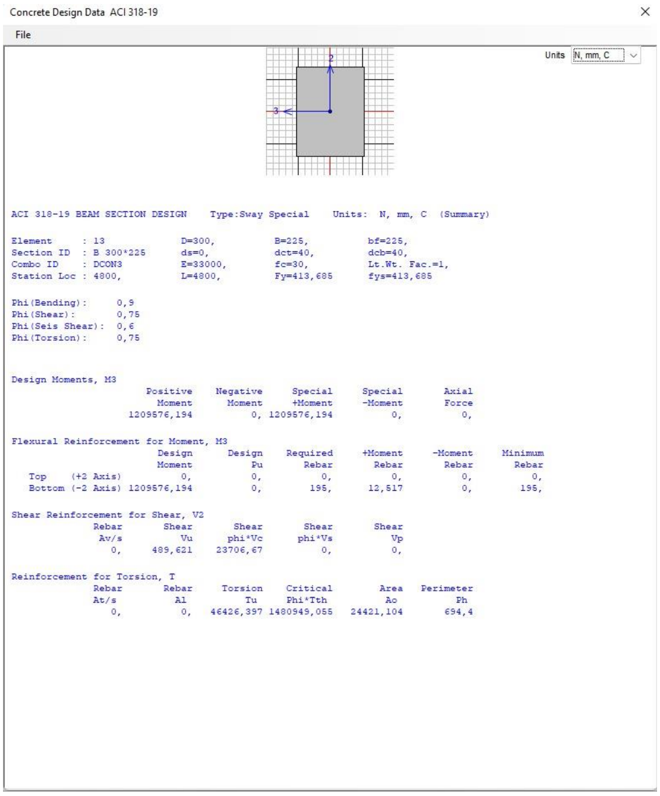


Figure 4- 77 Axial bending and shear force of the selected column



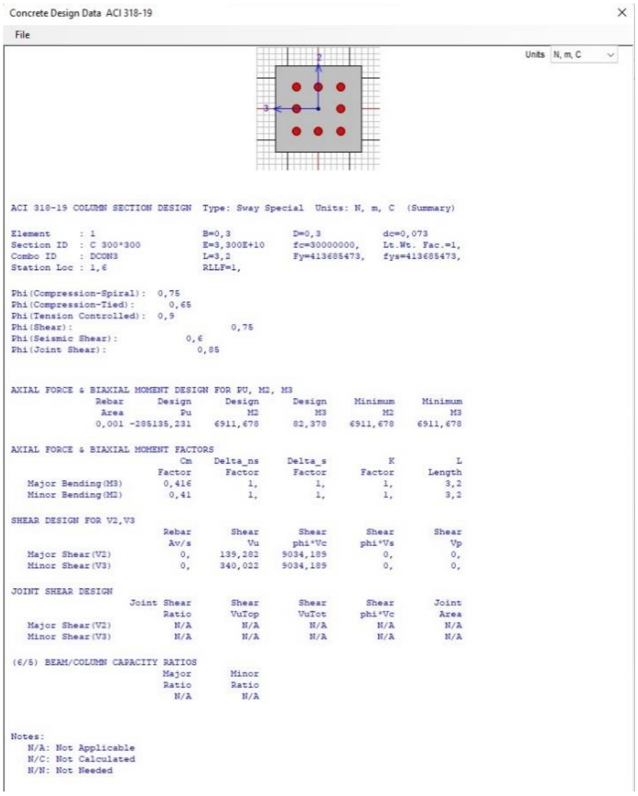


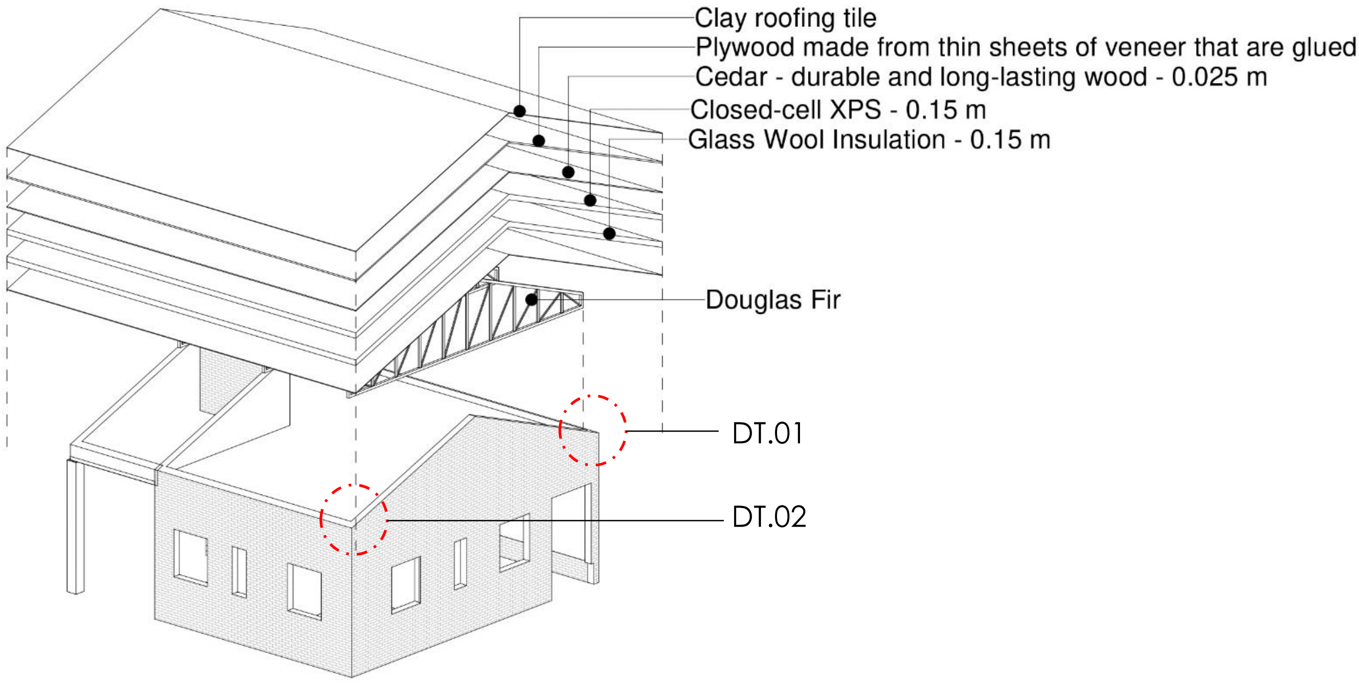
Figure 4- 78 Beam and column Design

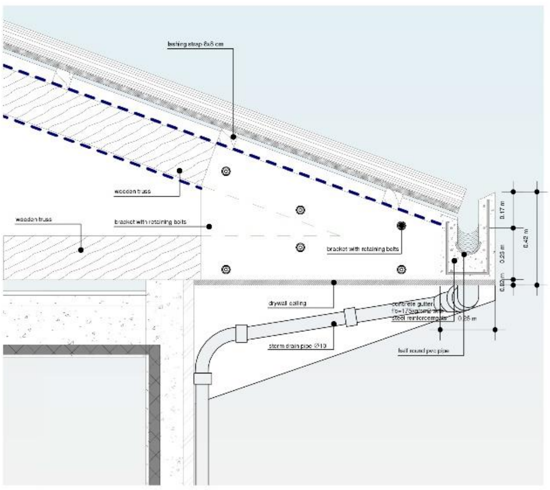
To determine if this design would fail or not, we utilized SAP to analyze the building's structure and compute the portions that may fail under stress.

The maximum bending and shear forces are determined from the data, and the design is based on these findings.

4.9.3. Details

As you can see here we tried to show how the junctions are working from outside to the interior part, where we have the small greenhouse so we tried to add a detail in order to stop the water to get into the building and also by adding layers of insulation to the wall we also tried to stop the thermal bridge, this is more evidence in the roof detail where we have the layers of insulation so we can prevent from the thermal bridge and also the water which would cause a problem in terms of raining.





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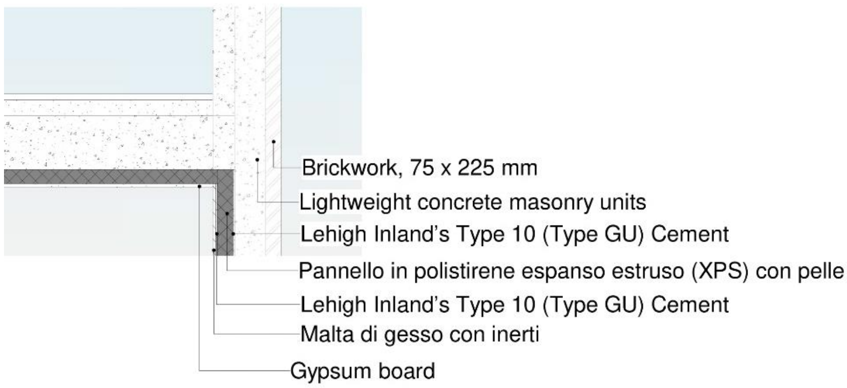

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Figure 4- 79 – Roof Detail 1.20

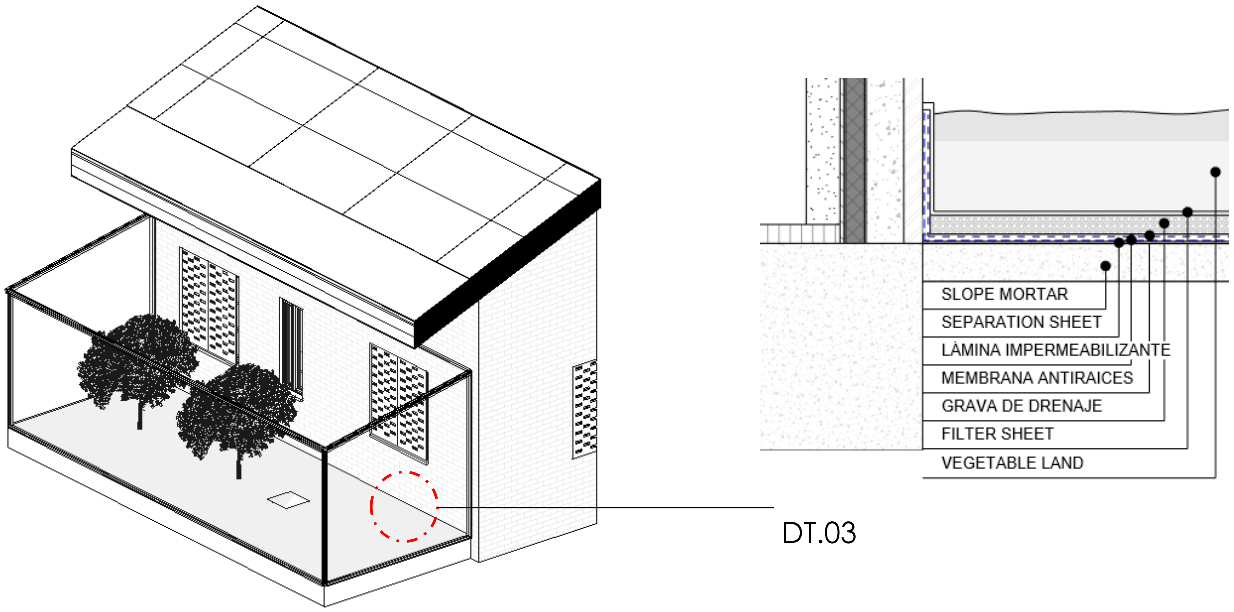


Figure 4- 80 – Green Garden Detail 1.20

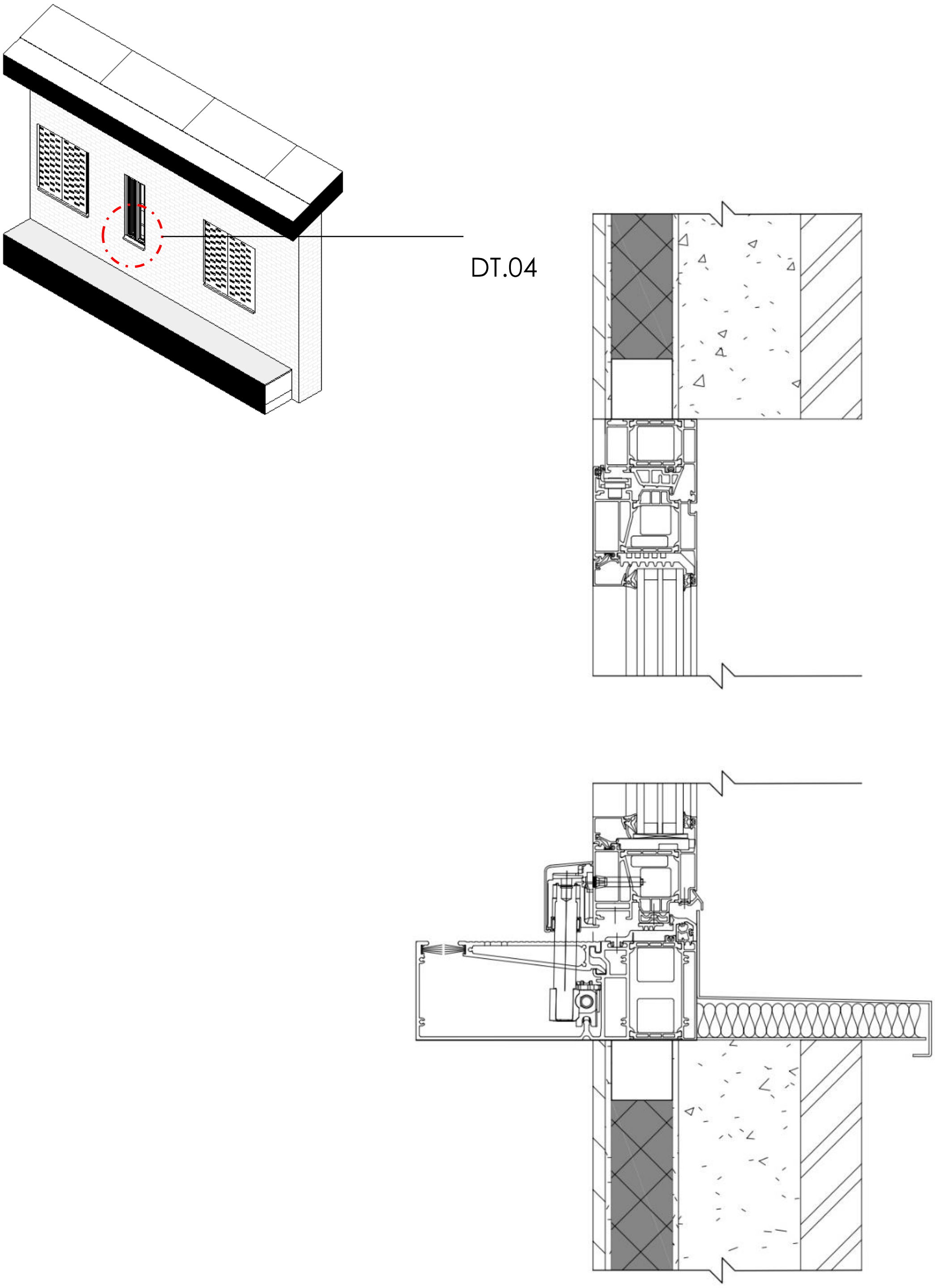
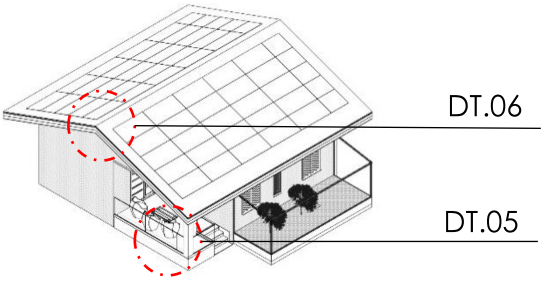


Figure 4- 81 - Window Detail 1.10



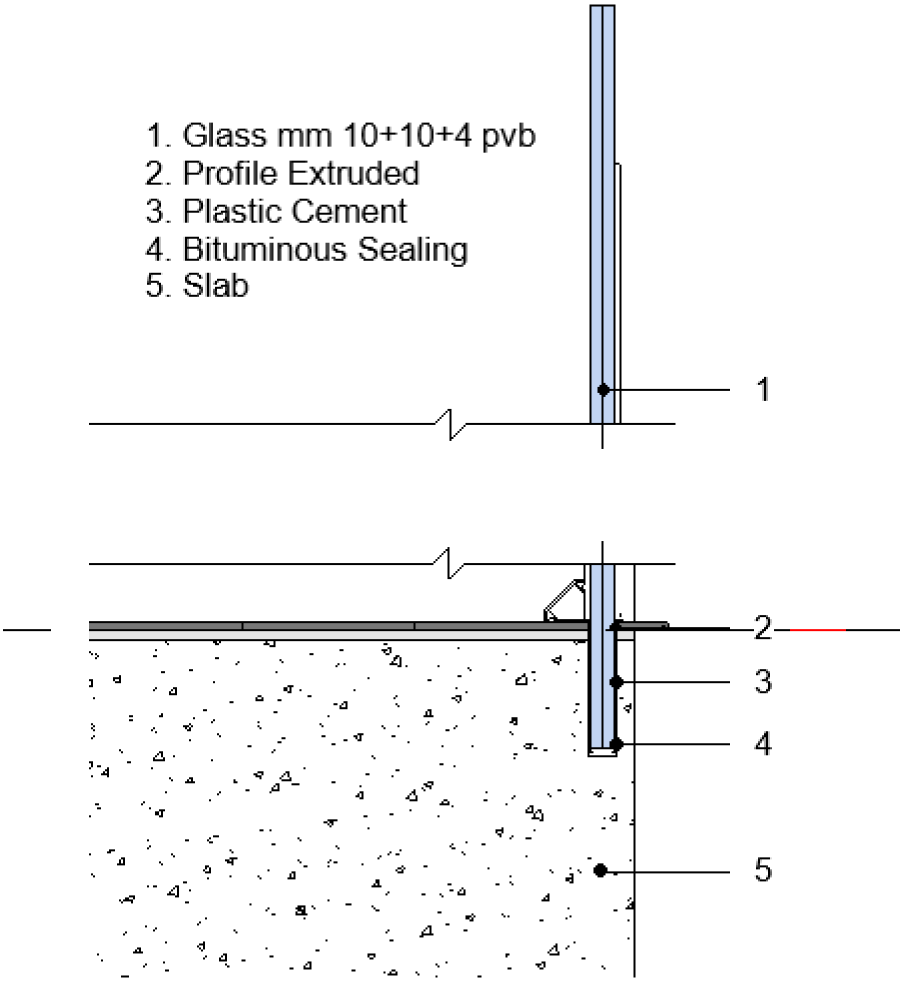


Figure 4- 82 – Detail 5 - Balcony railing Detail 1.5

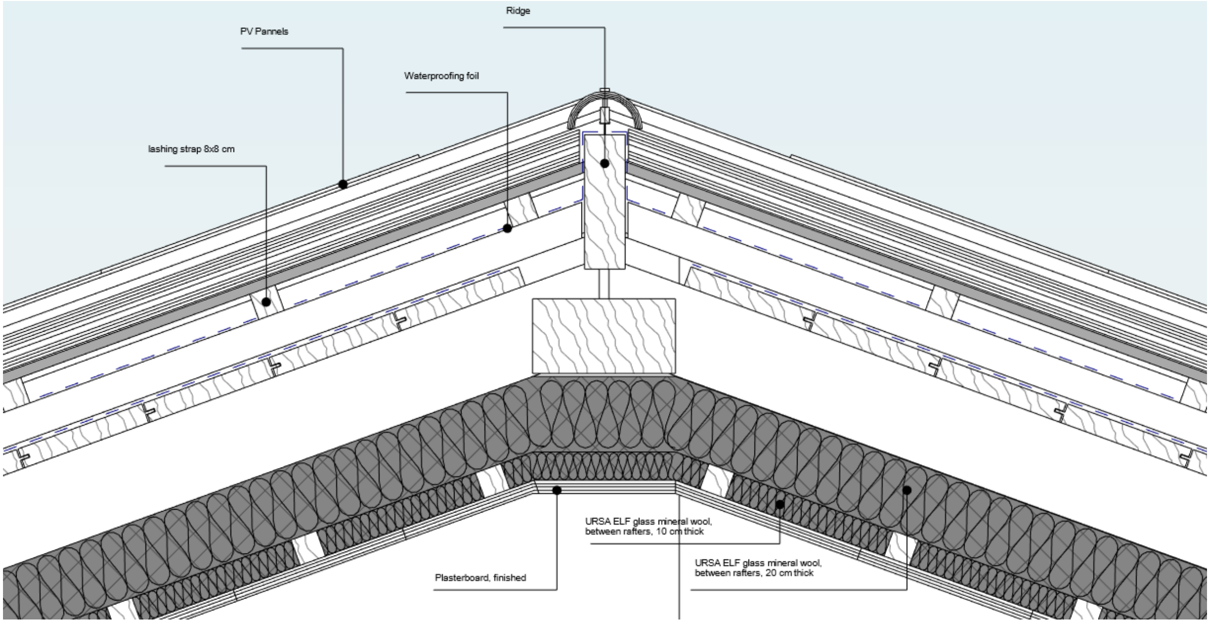


Figure 4- 83 - Detail 06 Pitched Roof 1.10

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