Escuela Técnica Superior de Ingenieros de Caminos, Canales y Puertos. UNIVERSIDAD DE CANTABRIA

TRABAJO FIN DE MASTER

Green Envelopes

Technological and Architectural Integration in a Mediterranean Area-Barcelona

Envolventes Verdes
Integración Tecnológica y Arquitectónica en una Zona del Mediterraneo -Barcelona

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1 INTRODUCTION

1.1 Background

The current society is linked to the concept of sustainability that implies growing concern for the environment. The social and economic environment. It means meeting the needs of the current generation without sacrificing the ability of future generations (Brundtland Report, 1987). Phenomena such as climate change, the deterioration of the ozone layer, acid rain, deforestation or the loss of biodiversity create international concern.

The European Commission has the maximum interest to meet the need for sustainability and therefore has established a strategically planned network around a concept: green infrastructure, adapting to the Kyoto protocol. The purpose is to use the European space efficiently and coherently, thus benefiting us from its multiple advantages.

Efforts are key although they do not affect all countries in the same way. Extreme heat and rainfall are expected to continue to affect the Mediterranean region, while countries in the continental region will be more prone to river overflow and forest fires.

According to the United Nations Environment Program (UNEP) and the UN (United Nations Organization), the building construction sector represents a very high percentage of carbon emissions. In European countries, this sector represents 40% of energy consumption and 36% of total greenhouse gas emissions (ONU,2018). At global level of emissions it is a quite serious problem from 2016 to 2017, gas emissions have increased by 0.6%, being Spain the place where more increase, it is expected that by 2030 they will be reduced up to 40% with respect to the values of 1990 according to the Paris Agreement, says Hans Bruyninckx,executive director of the AEM.

Therefore, green roofs and green facades are considered an appropriate solution to solve the problems that lead to increased heat in cities. In this regard, green roofs are considered one of the most appropriate sustainable solutions to solve problems related to urban heat islands. The roofs represent almost 20-25% of the urban surface areas in general. The characteristics of energy saving, thermal insulation, shading and evapotranspiration highlight the key role of green roofs in the overall thermal performance of buildings and the microclimatic conditions of indoor environments.

Within the scope of this investigation, the concept of green roofs and facades is analyzed in depth. And then the existing techniques are analyzed in Barcelona and what benefits they provide.

1.2 Objetive of The Proposal

First: conduct an in-depth analysis of the structure of existing green roofs and facades.

Second. Next, a study will be carried out again in relation to the cases of Barcelona seen in the first objective. The climate, the evolution of the green spaces, the trajectory that it has, the effects of the heat will be studied.

Third :The European city of Amsterdan will be compared with Barcelona, emphasizing the buildings that incorporate vegetation in both cities and the reason why in Amsterdan the number of buildings is higher.

2 GREEN ROOF

Figure 1 (Source :aventurasnahistoria.uol.com)

Figure 2 (Source: elliotts.uk)

2.1 General Description

Green roofs are areas installed on the surface of buildings that are totally or partially covered by vegetation and can be accessible or inaccessible areas.

The use of a natural elements as a complement to architecture comes from ancient time . An example of this is the Hanging Gardens of Babylon, or the landscaped roofs of rural Scandinavia.

Most research and experimentation with green roofs has been carried out in Germany since the 1960s, where construction methods have been perfected over the years.

The green roofs are very helpful because they perform ecosystem services, such as the reduction of the roof temperature in summer and the capture of rainwater that directly contribute to lower energy use of the building and possible economic savings. These services are in turn related to the ecosystem functions performed by the vegetation layer, such as the reflection of radiation and perspiration, but little work has examined the role of the composition and diversity of plant species in improving these functions.

2.2 General Components

- Vegetation
- Type of soil
- Filter layer
- Drainage layer
- Protection layer
- Water Retention
- Anti-root membrane
- Waterproof membrane

Development of the components

For the development of the different component, it has been used as a guide the report of Townshend (2007).

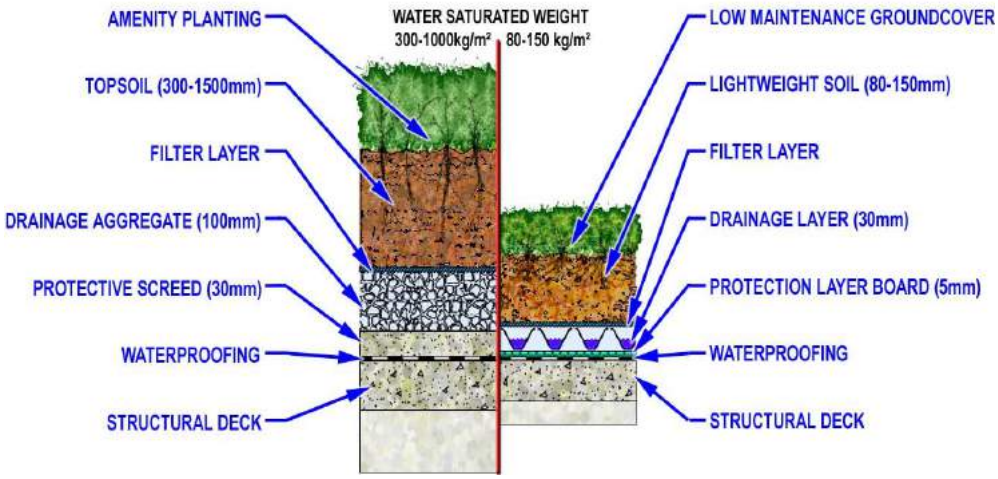


Figure 3. . General Composition of green roof.

(Source; copyright © Urbis Ltd., 2006, Adapted from images from Greenlink Küsters Ltd.)

Basic elements:

Vegetation: It is the variety of plants that you can use.

Type of soil (Substrate) : The roofs need a minimal soil, mixed with a lot of minerals (sand, gravel, etc.) to improve drainage and avoid that plants are accustomed to be in dry environment soaked in water.

Filter layer: Useful for holding a substrate, otherwise be drained, can also serve as additional rooting medium

Drainage layer: Provides a free path for excess water when the substrate and plants are saturated.

Protection layer: It is optional, gives added protection for the waterproofing membrane.

Water retention: It is needed for the stormwater infrastructure, because management the stormwater.

Anti-root membrane : It is only needed on organic roofing types, such as bitumen-based systems.

Waterproofing membrane: Essential for any roof, it protects against leaks and flushes out the overage water when the green roof is saturated.

2.3 General Types

- Extensive Green Roof
- Semi-Extensive Roof
- Intensive Green Roof

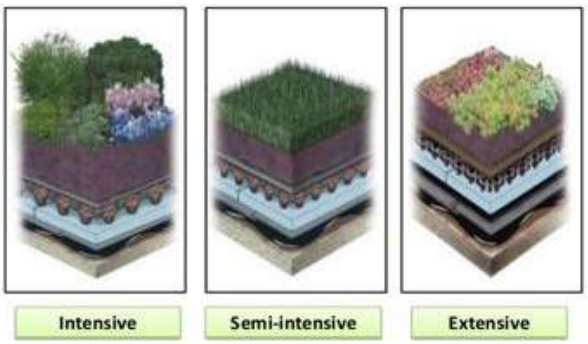


Figure 4. Type of Green roofs

(Source: slideshare.net)

Deep Type of Green Roof with Construction Systems

1. **Extensive System**
   - 1.1. Extensive green roof sedum Carpet
   - 1.2. Extensive Green Roof Rockery Type Plants
   - 1.3. Pitched Green Roofs Up 25 º
   - 1.4. Steep Pitched Green Roofs up 35º
   - 1.5. Irrigated Extensive Green roof
2. **Semi-Extensive Roof System**
   - 2.1. Intensive Green Roof Headther with lavender
3. **Intensive System**
   - 3.1. Roof Garden With Aquatec
   - 3.2. Roof garden
   - 3.3. Parklands on Rooftops
   - 3.4. Natureline
   - 3.5. Urban Rooftop Farming
4. **Biodiversity Green Roof**
5. **Stormwater Management Roof**

Development the Type of Green Roof

1 . Extensive Green Roof

It is a light vegetated roof system, implanted in a shallow substrate with a low nutrient content. It includes a vegetation with few requirements both with respect to development and in terms of maintenance. It is feasible, as long as the pavement is added with the vegetation, since it otherwise has little tread resistance

Figure 5 Building Airport Ibiza, Spain

(source :zinco-greenroof.com)

Characteristic:

The extensive green roof has a low maintenance and needs a drip irrigation system.
The recommended thickness of the sustracts ranges from 8 cm to 15 cm, which require more technical attention while the roof ist being built.

Some of the most important parameters that must be considered: are to ensure good aeration in the roots and ensure good drainage throughout the roof. Which can be achieved by designing a minimum slope on the roof (from 2%) or, if it is not possible, using draining plates of more than 4 cm in height, and providing a very porous substrate that provides the necessary aeration and drainage.

Vegetation:

Resistence Change of Temperature :Succulent plants ,perennial herbaceous plants, ornamental bulbs and underground perennials.

Maintenance:

- Low maintenance
- Visual technical inspection 2 or 3 time per year
- Monitoring and cleaning drainage systems.
- Monitoring of the unwanted plants , animals insects extend

Types of Extensive roof

1.1. Extensive green roof sedum Carpet

It is a type of standard construction, it is a shallow and light green roof with build up height 90 mm,weight saturation 95 kg /m^2 water retention capacity 25 l/m^2, which requires little maintenance.It has compressive strength, a low profile height, low weight and is passable. Sedum species guarantee a lasting green roof. The main flowering is in early summer, dominating the yellow, red and white flowers.(Zinco,2011)

On the other hand, a real budget study was carried out in Annex A .1 of this System with an estimated cost of = 128,62 €

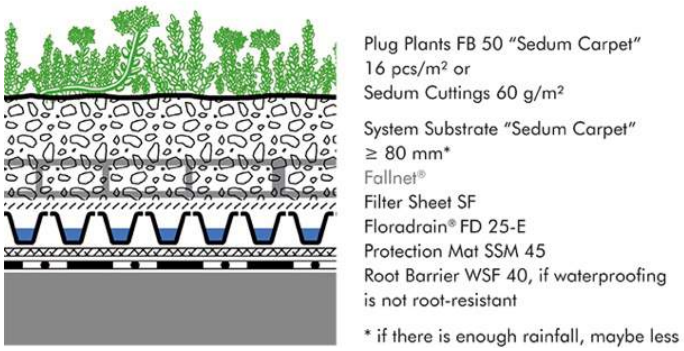


Figure 6.Construction Detail of Green standard extensive roof .

(source :zinco-greenroof.com)

**Anexo A .1 –Budget Database (material-construction and mantainance)*

1.2. Extensive Green Roof Rockery Type Plants

The extensive green roofs that can easily deal with the sun, wind and drought. The construction of Zinco (2011) with a type system: "Rockery type plants", generates: a sophisticated design and individual character.

The substrate has a minimum depth of 80 mm and the constant vegetation of several species Water and nutrients are supplied primarily through natural processes. Rain accumulates in storage cells and roots receive water by diffusion. Water is also stored. The excess water is drained

Sedum species and other perennials are mainly used as soil cover. The vegetation of this system is root plants. It can also be combined with sowing seeds.

Technica Data :

Build up height 100 mm	Weight saturation 110 kg / m^2	Water retention capacity 36 l/m^2

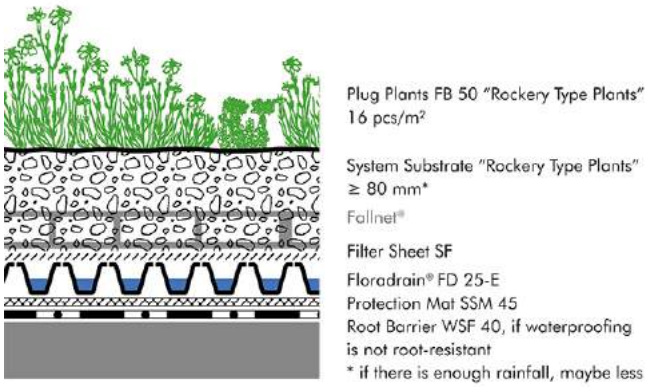


Figure 7.Construction Detail of Green Roof Rockery Type Plants

(source :zinco-greenroof.com)

1.3. Pitched Green Roofs Up 25 º

If you look at the general regulations for extensive roofs with waterproofing, they should have a drop of at least 2%. Sloping roofs begin with an 18% slope. The cutting forces increase with the slope of the roof and must be transferred to stable beams. The substrate layer must be protected against erosion. Plant selection and planting methods must conform to the climatic slope and exposure of the site.(Zinco,2011)

For the roof to last longer, it must be taken into account, that the roof surface must be professionally permeabilized, with bituminous or high polymer membranes. On the other hand, this waterproofing must be root resistant and a mat is needed protection with high water storage.
As in all systems the maintenance of the green roof must be carried out from the initial stage of project planning.

On the other hand, a real budget study was carried out in Annex A .2 of this System with an estimated cost of = 163,94 €

Technical Data :

Build up height 130-150 mm	Weight, saturation 115-145 kg / m^2	Water retention capacity 38-44 l/m^2

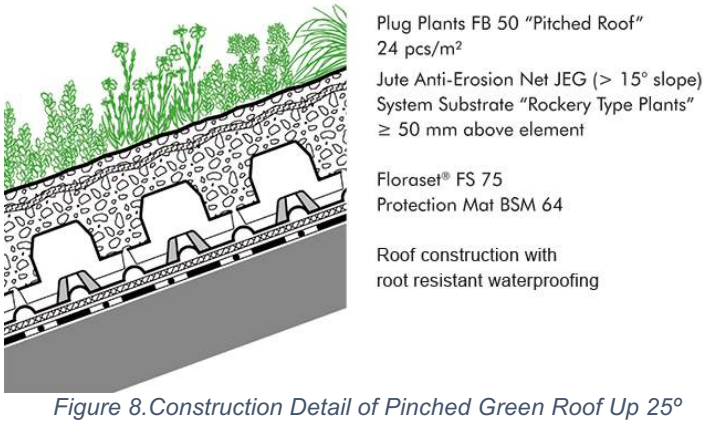


Figure 8.Construction Detail of Pinched Green Roof Up 25º
(source :zinco-greenroof.com)

**Anexo A .2 Budget, Cype Database (material –maintenance – construction)*

1.4. .Steep Pitched Green Roofs up 35º

The construction of this type of system allows the installation of green roofs with slopes greater than 20 ° and up to 35 °.
The elements of this system are made of recycled polyethylene (HD-PE) and intertwine without tools, creating a stable structure. On the other hand, this system offers plenty of space for plant root systems to develop.(Zinco,2011)

The selection of the plant must be well adapted to the extreme conditions of the steep green roofs, since it is significantly affected by solar radiation and the flow of water is much more than on a flat roof. In addition the irrigation is carried out in a planned way.

On the other hand, a real budget study was carried out in Annex A .3 of this System with an estimated cost of = 218,56 €

Technical Data :

Build up height 120 mm	Weight saturation 155 kg / m^2	Water retention capacity 64 l/m^2

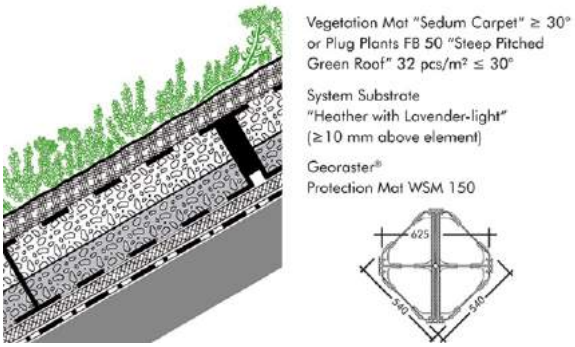


Figure 9.Construction Detail of Pinched Green Roof Up 35º
(source :zinco-greenroof.com)

**Anexo A.3 Database Cost of (material –maintenance – construction) =218,56€*

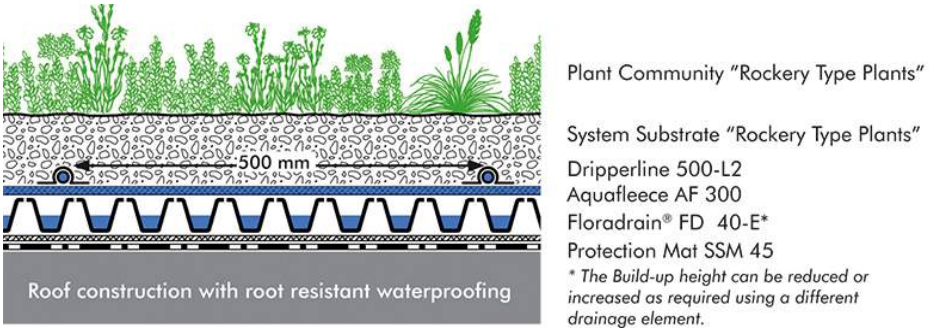
1.5. .Irrigated Extensive Green roof

Figure 10(source :zinco-greenroof.com)

It is a type of extensive system of the company Zinco in which the irrigation is automated. This type of system is very common and used in areas of the Mediterranean, now it is also becoming more important in other regions. This is due to the dramatic climate change that causes severe periods of drought.

This accumulation of green roofs will help to achieve a balance between a cost-effective solution and operation in dry climates. Watering is done under the substrate. As a result, water is available where the plant needs it. Thanks to the lower depth of the substrate, the green roof construction is lighter.

On the other hand, a real budget study was carried out in Annex A .4 of this System with an estimated cost of = 147.48 €



Technical Data:

Build up height 130 mm
Weight saturation 125 kg / m^2

Water retention capacity 37 l/m^2

Figure 11.Construction Detail of Irrigated Extensive Green Roof
(source :zinco-greenroof.com)

**Anexo A.4 Budget Database of this system (material –maintenance – construction)*

2. Semi-Extensive Roof

In this type of roof, more substrate is usually placed than in the extensive covers and the vegetation used is maintained. Therefore, this sort of roof allows to have a more elaborate design than extensive roofs, in which you can carry out more types of compositions like playing with chromatic fringes of vegetation, volumes, shapes. Usual Vegetation : Lawn, herbaceous and scrub

Characteristic:

The semi-extensive roof has a substrate with a thickness from 15 to 30 cm, a moderate maintenance and a drip irrigation system. On the other hand it is also important to retain water to minimize the contribution of irrigation and ensure aeration

For this reason, it is advisable to use a water and nutrient retention blanket, a drainage plate that also fulfills the function of storing water, while providing an air chamber. The drainage plates are higher than in the extensive covers, almost 4 cm, this type of covers need a greater storage of water and more space with air.

Types of semi-intensive roof :

2.1. Intensive Green Roof Headther with lavender

It is a semi-intensive system of sophisticated planting design. However, compared to the intensive green roof, is managed with relatively low maintenance and relatively low accumulation heights. The plants can be perennial resistant to drafts, grasses and low shrubs, for example thyme, origanum or lavender.(Zinco ,2011)

On the other hand, a real budget study was carried out in Annex A .5 of this System with an estimated cost of = 97,64€

Technical Data :

Build up height 160 mm	Weight saturation 195 kg/ m^2	Water retention capacity 70 l/m^2

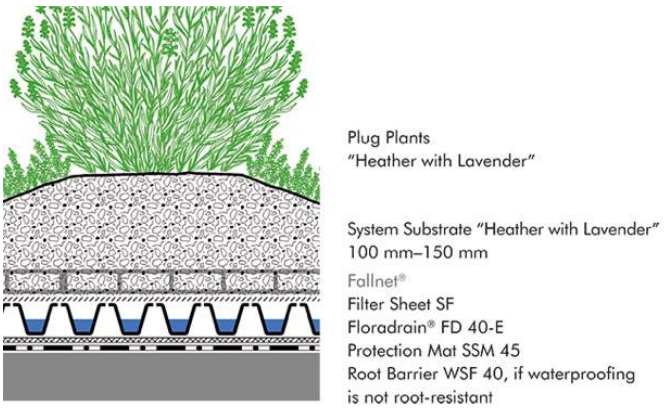


Figure 12.Construction Detail of Green Roof Heather with Lavender

(source :zinco-greenroof.com)

**Anexo A.5 Budget Database of this System (material –maintenance – construction)*

3. .Intensive Green Roof

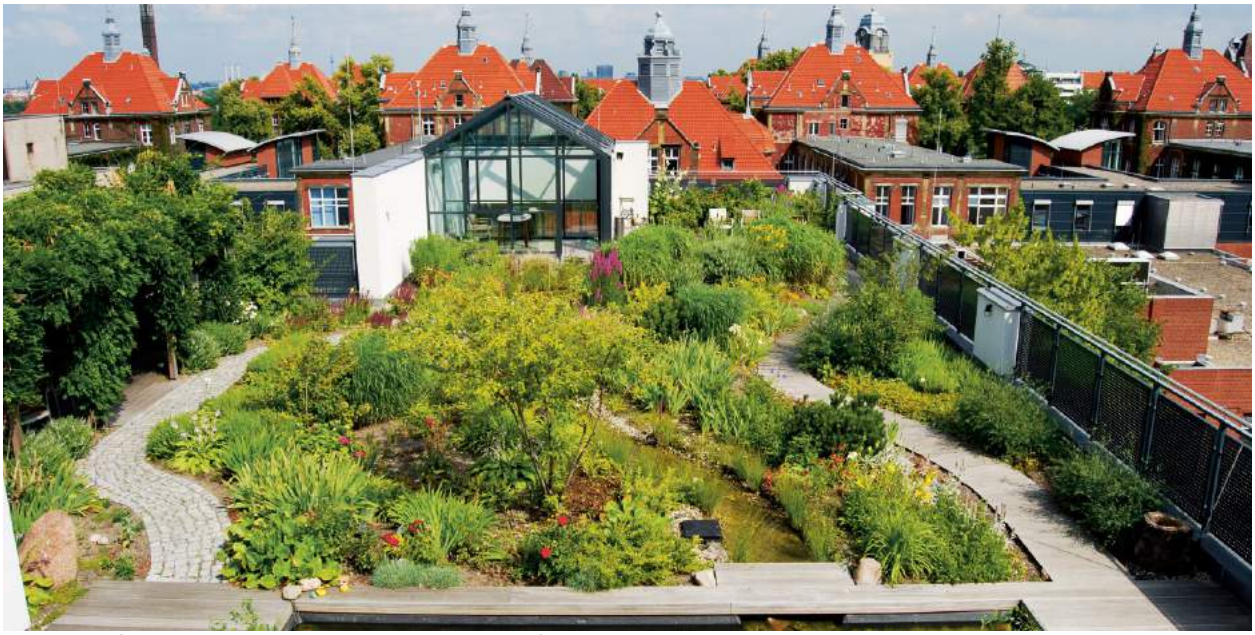


Figure 13.(sourse: www.urbangreenbluegrids.com)

The intensive green roof provides its owners benefits similar to those that a garden would offer. They are designed especially for recreational use and you can install elements such as lighting, sheets of water, waterfalls, paths for people, etc...

Characteristic:

The substrate thickness of this cover is from 30 to 100 cm, this sort of covers also requires a great deal of maintenance, on the other hand it is advisable to use drip irrigation systems.

In the intensive cover, the blanket of protection and retention of water is more resistant than in the two previous cases, since it has to support more weight and the action of the roots of the vegetation is more aggressive. The drainage sheet must be of higher height so that there is more volume of air available for the roots. Plates are usually placed between 4 and 6 cm in height. The combination of these two layers plus the thickness of the substrate results in a better water storage in the cover. The usually vegetation are : Lawn, perennials, shrubs and trees

Types of Intensive Systems of the Company Zinco,(2011).

3.1. Roof Garden With Aquatec

This system is the best solution that balances act between a light –weght and intensive roof.
It allows the realization of designs with grass, perennials and small shrubs, even on roofs with low load capacity.The water storage capacity of Aquatec® elements guarantees maximum retention and supply even during hot and dry periods.

Technical Data :

Build up height 150 mm	Weight saturation 180 kg / m^2	Water retention capacity 60 l/m^2

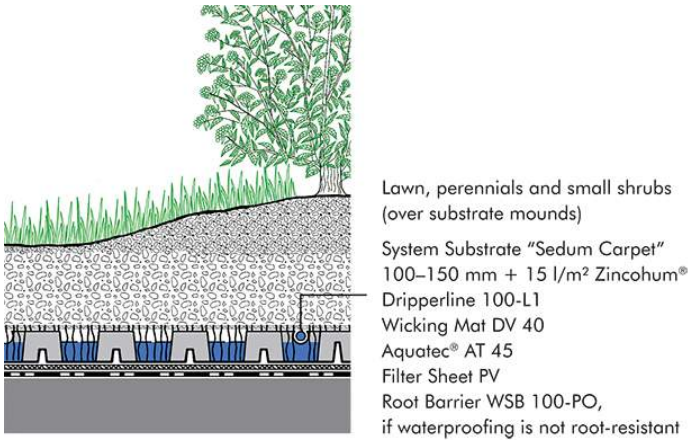


Figure 14 .Construction Detail of Roof Garden With Aquatec
(source :zinco-greenroof.com

3.2. Roof garden

It is a kind of multifunctional green roof construction with high water storage. It is suitable for lawns, perennials and with a deeper system substrate, for shrubs and trees. Integration with hard landscapes is also possible, for example, walkways, terraces, vehicle entrances or play areas, etc.

The drainage element that it uses, is neo Floradrain® FD 60, which allows a very high water retention suitable for all aspects of various of the landscaped roof.This system stores the water and irrigates from below, with an irrigation systems of dams.For to include this system a ceiling placed at 0 ° of fall is required. It has a simple maintenance due to the inspection cameras that it has. And on the other hand, it should be noted that this system can accumulat water in times of drought.
On the other hand, a real budget study was carried out in Annex A .6 of this System with an estimated cost of = 125,44

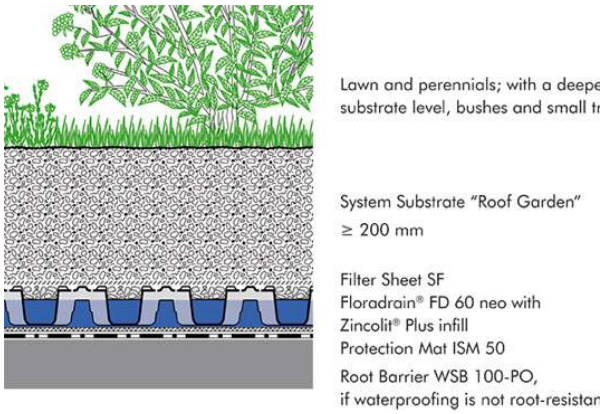


Figure 15.Construction Detail of Roof Garden

(source :zinco-greenroof.com)

Thecnical Data :

Weight saturation 365 kg / m^2
Water retention capacity 135 l/m^2
Build up height 270 mm

**Anexo A.6 Budget Database (material –maintenance – construction)*

3.3. .Parklands on Rooftops

This type of system designed by ZinCo can be installed in underground garage covers. It is designed to withstand heavy loads is a perfect base for a variety of walkways and driveways. There are numerous possibilities and include parking, fire access roads, ...

Technical Data :

Build up height 230 mm	Weight saturation 305 kg / m^2	Water retention capacity 100 l/m^2

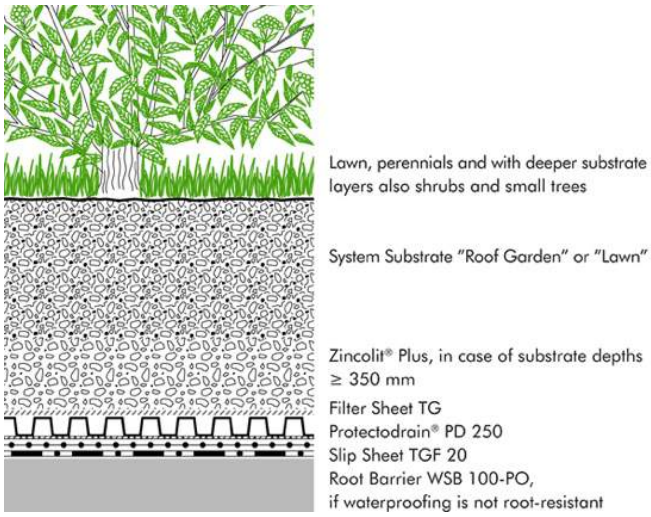


Figure 16.Construction Detail of Parklands on Rooftops
(source :zinco-greenroof.com)

3.4. Natureline

This type of system is an innovative system developed by Zinco with the German company Tecnora Gmbh. It is a fully recycled system, where various elements such as sugar cane are used to create a drain element.

Technical Data :

Build up height 270 m	Weight saturation 340 kg / m^2	Water retention capacity 100 l/m^2

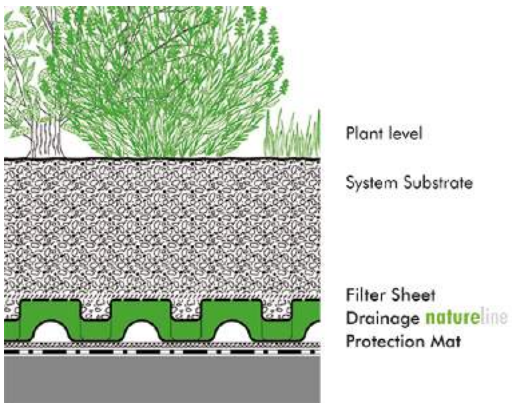


Figure 17.Construction Detail of natureline roof

(source :zinco-greenroof.com)

3.5. .Urban Rooftop Farming

Figure 18 (source :*www.thedailybeast.com*)

It is a typology specialized in the production of food. It is defined as intensive, since it requires a high contribution of water with a system of drip and nutrients and high maintenance.
A garden on the roof can be designed in different ways depending on the surface it occupies on the roof.
One option would be to dedicate the whole area to an orchard (except for access roads, some rest area or to leave tools ...), using the intensive roof construction systems. And another could be to allocate one area of the roof to this function using planters or containers, and the rest, to other purposes.

Characteristics

The thickness of the substrate is between 30 and 40 cm, and can reach 60 cm in the case of fruit tree planting.
The same scheme is used as in the intensive covers. You have to design the perimeter of the garden in relation to the roads to save the difference in height between the area with vegetation, which will have a minimum of 30 cm, and the road area, which can have a height of 8 cm in total. In the design of an urban garden, it is advisable to think of spaces where to locate a shed for tools and materials. In addition to areas with benches to rest and water points where you can connect a hose, it is recommended to provide a compost area for residents.

When working on rooftops personal safety equipment is to be used wherever risks cannot be avoided. ZinCo provides various safety systems and railings which do not penetrate the roof covering.

On the other hand, a real budget study was carried out in Annex A .7 of this System with an estimated cost of = 256,24 €

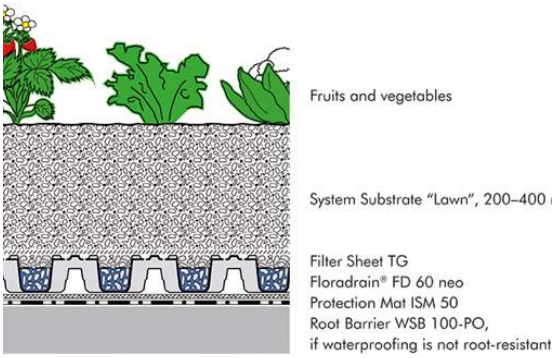


Figure 19.Construction Detail of Urban Rooftop Farming

(source :zinco-greenroof.com)

Technical data :

Build up height 250 mm
Weight saturation 300 kg / m^2
Water retention capacity 100 l/m^2

**Anexo A.7 Budget Database Cype of (material –maintenance – construction)*

4.Biodiversity Green Roof:

Figure 20. (source :zinco-greenroof.com)

The Biodiversity systems are similar to extensive or semi-extensive roofs. However, this system, aim to create a space where there is a balance between species (fauna, flora). The design is done meticulously to encourage the habitat of an indigenous flora and fauna. So that the flora lasts over a long period of time. On the other hand, it is also designed so that different species of animals such as birds, insects, reptile, etc... can coexist with each other comfortably.

Characteristic:

The substrate of this system is often used has intermediate characteristics between extensive cover and semi-extensive cover. If possible, a part of the natural soil of the area will be mixed with technical substrate of extensive covers. The thickness used ranges between 15 and 30 cm and more o less with 450 kg /m^2 of load . In addition ,this type of roof has a low maintenance and a drip irrigation systems.

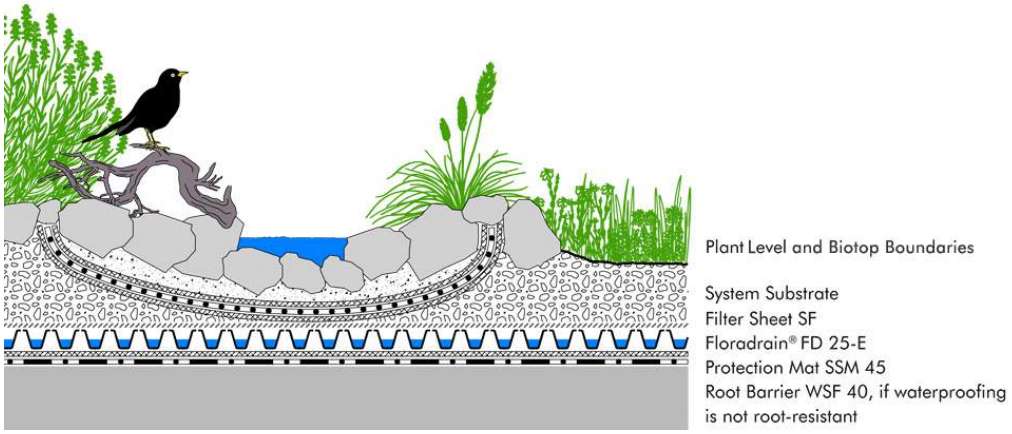


Figure 21.Construction Detail of Biodiversity Green Roof

(source :zinco-greenroof.com)

5. Stormwater Management Roof:

With a water collection system in the building, rainwater management is easier, rainwater is collected by the drainage channels and directed towards a deposit located in the subsoil. The water is recycled and used to bathrooms, kitchens, sprinklers

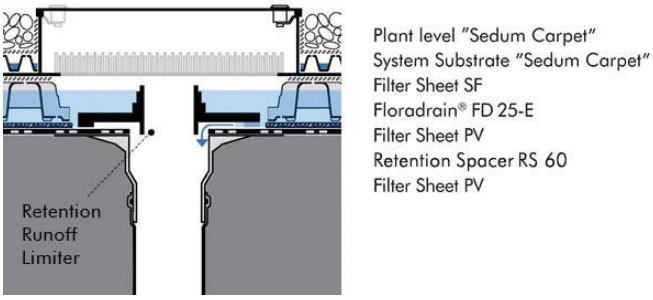


Figure 22. System build-up.

(Source: https://zinco-greenroof.com)

There are different options for storing rainwater:

a) Deposit: the water is collected by drainage channels is made to a deposit located on the deck or underground
b) Water tank: the entire surface of the roof is used as a reservoir to store water
c) Garden landscaped roof: consists of a garden roof, built with a drainage system that allows to have a water deposit in the whole roof and that the water, by capillarity or by pumping in the irrigation network, be available for the plants.

Figure 23. Botanicum, Sistema Intemper TF Jardín Aljibe

(Source : http://www.botanicum.esl)

Maintenance of this System

- High maintenance
- Visual technical inspection according with the schedule manual
- Monitoring and cleaning drainage systems to avoid blockages
- Monitoring of the unwanted plants, insects,animals extend

2.4 Benefits and Limitations

The Advantages

- Reducing problems of water run-off
- Improve the management of the stormwater
- Improve the building insulation
- Improve the aesthetic form of the building
- It is a good way to provide habitats for birds and insects
- Improvement of urban air quality
- Cooling the urban environment
- Reduces the noise pollution

Disadvantages

- Maintenance
- Installation Of Specific Ceilings
- The Costs Can Be High
- It Is Complex To Install Them
- They Require A Particular Structure
- The Weight of a green roof (Collapse)
- Damage that the plants can produce in the building(roots of growing plants)

2.5 The Importance of Perception

The aesthetic value of green roofs and the way they are designed can influence people's perception or opinion of them. Yuen & Nyuk Hien (2005) concluded, through surveys, that most of the population is prefer the installation of this type of green roof in their city. This type of work verifies the importance of the aesthetic aspect in projects to achieve social success.

Subsequent studies have evaluated preferences with respect to different roof design alternatives. In general, intensive green roofs or landscaped roofs composed of trees and shrubs are preferred. (Fernández-Cañero et al., 2013).

They are also more valued by those people who do not have a private garden with trees, compared to those who own it, as well as by those who spent their childhood in an urban or rural environment compared to those who spent it surrounded by forest environment (Fernández-Cañero et al., 2013).

Thus, we can learn that the results mark the greatest success of these structures in urban environments, and value the importance of the choice of species, as well as the heterogeneous design in bearing, shapes and colors of the vegetation, for greater social success. This type of project (Fernández-Cañero et al., 2013) also leads to personal improvement at a mental and social level, developing more united communities. These attributes also allow to increase the potential biodiversity of green roofs, thus achieving a double objective, the ecological and social one (Francis & Lorimer, 2011).

2.6 Construction Requirement

The construction requirement of green roofs is provided in CIRIA (2007), The Greenroof Center and GRO (2014).

For the correct construction of the green roofs, it should be taken into account: the placement of the waterproof membrane, since it is essential for the viability of the green roof.

On the other hand you have to verify the waterproofness and that is why an electronic test is performed to know if there are water leaks. In addition, when this is placed to avoid lifting by the wind, sometimes ballast is needed.

We also have to take into account that the area in which it is going to be cultivated has to be protected so that it does not become too compact during its construction.

It requires a safe access to the green roof in its construction process and also for all activities in areas under the roof.
A health and safety plan for the construction phase is required in accordance with the 2015 Construction (Design and Management) (CDM) Regulations. This should ensure that all construction risks have been identified and eliminated / reduced and / or controlled, as appropriate.

2.7 Maintenance

Inspect all components : including soil substrate, vegetation, drains, irrigation systems, membranes and roof structure for proper operation, integrity of waterproofing and structural stability
Inspect soil substrate : for evidence of erosion channels and identify any sediment sources
Inspect drain: inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system

- Inspect underside of roof for evidence of leakage
- Remove debris and litter to prevent clogging of inlet drains and interference with plant

growth

- Replace dead plants as required
- Remove nuisance and invasive vegetation, including weeds
- Remove fallen leaves and debris from deciduous plant foliage
- Mow grasses, prune shrubs and manage other planting
- If erosion channels are evident.
- If drain inlet has settled, cracked or moved, investigate and repair as appropriate
- Schedule Maintenance Green roof

In accordance with the needs that our roof requires, we will follow some of the following guidelines The construction requirement of green roofs of CIRIA,2007.defined in the schedule:

Operation and maintenance requirements for green roofs		
Maintenance schedule	**Required action**	**Typical frequency**
Regular inspections	Inspect all components including soil substrate, vegetation, drains, irrigation systems (if applicable), membranes and roof structure for proper operation, integrity of waterproofing and structural stability	Annually and after severe storms
	Inspect soil substrate for evidence of erosion channels and identify any sediment sources	Annually and after severe storms
	Inspect drain inlets to ensure unrestricted runoff from the drainage layer to the conveyance or roof drain system	Annually and after severe storms
	Inspect underside of roof for evidence of leakage	Annually and after severe storms
Regular maintenance	Remove debris and litter to prevent clogging of inlet drains and interference with plant growth	Six monthly and annually or as required
	During establishment (ie year one), replace dead plants as required	Monthly (but usually responsibility of manufacturer)
	Post establishment, replace dead plants as required (where > 5% of coverage)	Annually (in autumn)
	Remove fallen leaves and debris from deciduous plant foliage	Six monthly or as required
	Remove nuisance and invasive vegetation, including weeds	Six monthly or as required
	Mow grasses, prune shrubs and manage other planting (if appropriate) as required – clippings should be removed and not allowed to accumulate	Six monthly or as required
Remedial actions	If erosion channels are evident, these should be stabilised with extra soil substrate similar to the original material, and sources of erosion damage should be identified and controlled	As required
	If drain inlet has settled, cracked or moved, investigate and repair as appropriate	As required

Figure 24(Sourse : CIRIA,2007)

2.8 Cost

The green Roof installation and maintenance costs vary according to the type of system and subtract that we are going to use, according to the document called Guide of living roofs and green covers (Borruel, et al.,2011), the cost it is between 70 - 120€/m^2 .

The cost estimation :

- Extensive: 70 -90 €/m2
- Semi-Intensive: 90 -130 €/m2
- Intensive: up 150 €/m2
- Biodiversity: 70 - 130 €/m2.
- Urban Farming: 120 €/m 2 (depends sutract)
- Stormwater Management: --

Maintenance cost estimation:

- Maintenance cost : 0,6 €/$m^2$and 12 €/m^2(Bianchini&Hewage, 2012)

On the other hand, a real budget study was carried out in Annex A of Different types of Green Roof.

The Budget estimation with cype database for the material ,manpower and direct cost are :

- Extensive : 127-208 €/m2 dependest of the system
- Semi-Intensive : 137 €/m2
- Intensive: between : 203 €/m2

2.9 Regulation

Breuning,.J and Yanders, A.C. (2008) created a Regulation Guide called ``Introduction to the FLL Guidelines for the Planning, Construction and Maintenance of Green Roofing - Edition of the Green Roofing Guideline'' that helps in the regulation and public policies process , in all part of Europe .

This guide mainly defines three main components: Planning, Execution and Maintenance, which it helps in aspects such as:

- The load support and water storage of various materials.
- Differences the substrates that are needed for each type of green roof as, intensive and extensive.
- Forms and construction techniques according to the layers.
- The type of maintenance, methods and reports that must have according to the type of green roof that is.
- Result investigation, along with its validity period.

On the other hand , in Spain also we need to use accodring with ASESCUVE,(2012):

- National standards for the construction of flat roofs and their waterproofing (AENOR) Spain, ZVDH (Germany)
- DDV Deutscher Dachgärtner Verband e.V., (Dachgärtnerrichtlinien 1985) for extensive covers
- NTJ 11C TECHNICAL RULES OF LANDSCAPE AND LANDSCAPE on green roofs, January 2012

2.10 Comparison table of Green Roof

	Extensive Green Roof	Semi-Extensive Roof	Intensive Green Roof	Biodiversity Roof	Urban Farming	Stormwater Management Roof
Substrate Soil	Thin Soil (10-25 cm)	15-30 cm	deep soil 30 - 100 cm	15-30 cm	30-40 /60 cm	17 + aljibe 6 cm
Load	120-225 kg/m2	150-450 kg/m2	650 kg /m2	450 kg /m2	450 kg /m2	185 kg/m^2
Irrigation	Little irrigation	Normal irrigation	Normal irrigation	Little irrigation	Continuo Irrigation	Auto-irrigation
Vegetative Layer	Succulent plants, herbaceous perennifolias, cespitosas and vivaces.	Herbaceous plants, perennial, caespitose perennial, sub-shrub and shrub	Cespitose shrub and arboreal plants.	Mix of plant of extensive roof and semi-estesive roof	Vegetation like vegetables and fruits	Depent of the system
Maintenance	Low maintenance	Normal maintenance	Normal maintenance	Low Maintenance	High Maintenance	High Maintenance
Cost	70 -90 €/m^2	90 -130 €/m^2	up 150 €/m^2	70 - 130 €/m^2 .	120 €/m^2	--

Table 1. Comparison table of Green Roof

(Source :own Elaboration)

2.11 Cases Around the World

At present there are many architects from different parts of the world, who are already betting on introducing green infrastructures, in their designs (ZINCO, 2011).

Case 1. In New York, the Project called High line

In New York, the Project called High line was developed by James Corner Field Operations, Diller Scofidio & Renfro, and Piet Oudolf. It is a 2.33 km long straight-line park between the borough of Manhattan and New York, formed in old railway lines. This park was inspired by the Coulée verte René-Dumont in Paris.

Figure 25. High Line Park, New York City, USA .

(source:zinco-greenroof.com)

Case 2. In Germany on the island of Mainau

In Germany on the island of Mainau, the architects Hein Architekten, Bregenz Steinmann Landschaftsarchitektur, Winterthur in 2014 built an intensive green roof with trees and shrubs on the roof of a restaurant. This design was the result of an architectural competition. "Roof Garden" construction system based on the Floradrain® FD 60 drainage element

Figure 26. Roof Garden Comturey, Island Mainau, Germany .

(source : zinco-greenroof.com)

Case 3. In Rotherham, South Yorkshire

In Rotherham, South Yorkshire .The Rotherham Metropolitan Borough Council (RMBC) Streetpride Landscape Design Team in 2005 designed the first building with green roof of Rotherham, using a mixture of traditional and modern materials. The team of architects was interested in craer semi-green roofs extensive, to offer greater visual and biodiversity benefits than the most used sedum roofs.

Figure 27. Moorgate Crofts, Rotherham, Great Britain.

(source : zinco-greenroof.com)

Case 4 .Meydan Retail Complex located in Istanbul

The Meydan Retail Complex located in Istanbul, Turkey. It is a 55.0 m^2 shopping center built by the team of London architects of Foreign Office Architects (FOA) in 2007. This project had a budget of 34 Million Euros.

Figure 28(Source:www.zinco.es)

The mall is constituted by a green meadow on the roof, it was created as natural meadows and partially accessible roof areas. This results in a control of the internal heating and cooling climate of the shopping center. It consists of a total of 50 stores, restaurants with a central plaza.The architecture of the commercial plaza functions as a public space in the middle of the vast sea of buildings.

This project presents a challenge to create the green roofs with the natural vegetation desired by the architects, the manufacturer of the ZinCo system used four different green roof systems. (Zinco,2011)

- A flat roof of 16,000 m² is not accessible
- Another 1,250 m² flat roof accessible,
- A roof of 11,900 m² with sloping up to approx. of 25 °
- A steep sloping roof of 1500 m² up to more than 35 °

The installation of these green roofs was carried out by the Turkish partner of ZinCo, Onduline Avrasya AS.Technical plans Figure. 29 and Figure 30

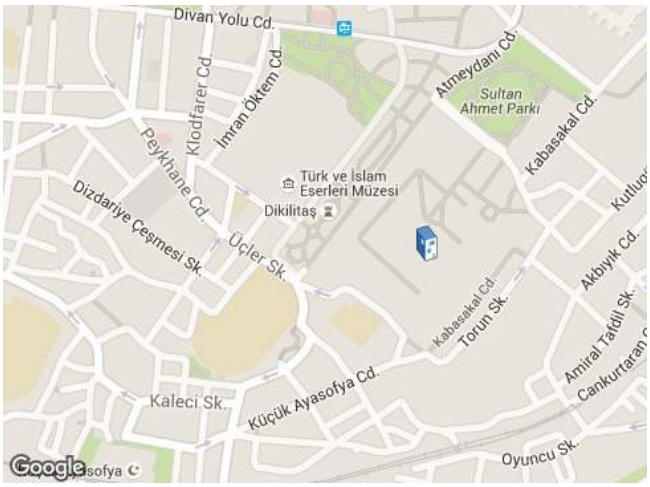


Figure 29: Situation Plan of Meydan Istanbul

(source: www.zinco .se)

Figure 30 : Plan of Meydan Istanbul

(source: www.zinco .se)

Figure 31: Modeling Actual Projectof Meydan

(source: www.zinco .se)

2.12 Cases Around the Mediterranean

Case 1.Terminal Building Ibiza Spain

Figure 32:Terminal Building Ibiza Airport,Spain

(source : zinco-greenroof.com)

At the airport in Ibiza, the architects Javier Martínez and Jesús Sansó in 2010 created, on an approximate surface of 3,200 m^2, a green roof with an extensive sedum tapin system with a Floradrain FD 40-E base.

It had problems at the time of its construction because you had to meet a series of limitations, in reference to the weight of the substrate. According to the specifications had to have a substrate of 850 kg / m3. The company that complied with the requirements was Zinco Cubiertas Ecológica, SL. (Zinco,2011)

Building phases :

1 . Protection mat, drainage elements and filter sheet are ready for installation.

Figure 33:Protection material , draining element and filter sheet area

(source : zinco-greenroof.com

2 . Preliminary work on the roof area to be vegetated

Figure 34 :Preliminary work on the roof
(source : zinco-greenroof.com)

3 . The roof area just after the application of substrate with BigBags

Figure 35 :the roof are with the substrate application

(source : zinco-greenroof.com)

4 . The roof area a few months after the plug plants have been planted.

Figure 36:the roof area after a few months

(source : zinco-greenroof.com

Case 2. The Hellenic Treasury,Constitution Square ,Athens

Figure 37(Source:greenroofs.com)

The Greek Ministry of Finance installed an extensive biodiversity green roof calling it "oikostegi"in 2008, in the Athens Constitution Square. Considered the most important square in modern Athens from a historical and social point of view. The green roof It covers 650 m2, which is equivalent to 52% of the roof space.

They created a light roof because Greece is a seismic hot spot and did not want to exceed the load that the building would support. Taking into account that the wet weight of the accumulation is less than 50 kg / m2, a shallow ceiling of less than 10 cm was made

The selected vegetation was mainly local species: thyme, several sage species, several lavender species, several mint species, Hypericum, Phlomis, poppies, etc ...

Figure 38.(Source:greenroofs.com)

The reason for its installation was to create a research field, about the thermal impact that vegetation creates in the city. Studies conducted in 2008, revealed that thermal performance was affected by the installation. Other studies have subsequently been carried out as in 2009, in which 50% energy savings were observed for air conditioning.

On the other hand, every year that passes, energy savings are recorded, for a total of 5,630 euros per year, is the same as saying: that you save 9% on air conditioning and a 4% savings on heating bills of the building total

Another observation that was made was that the thermodynamic performance of the oikostegi had improved, as biomass was added during the 12 months between the first and the second study. This suggests that additional improvements will be observed. The study indicated that a large number of birds and insects appeared on the roof, which before when it was a normal roof, was not observed.

Case 3 Salesians de Sarrià schools in Barcelona

Figure 39.Barcelona Green Roof- Salesinas de Sarria
(source:construible.es)

The Barcelona City Council, the College of Architects of Catalonia (COAC) and the Mies van der Rohe Foundation, created at the end of 2018 at the Salesians de Sarrià schools in Barcelona the first Extensive Green Roofs on ten of a mucipal project (green roofing competition)

This green roof provides the district with 191 square meters of green surface and had a cost of 45,000 euros of which the city council has subsidized 75%

The objective was to improve visibility from all areas of the school and implement renewable energy to contribute to climate change adaptation.
The roof became passable and accessible so that students and teachers could use it. A series of upholsteries, bushes were planted on the railings, such as lavender, and climbers on the walls(Figure 40).

On the other hand the photovoltaic panels were installed by the same students who helped them as a pedagogical resource

In addition, the project has a drip irrigation system with humidity sensors and an insect hotel that will help pollination of plant species.

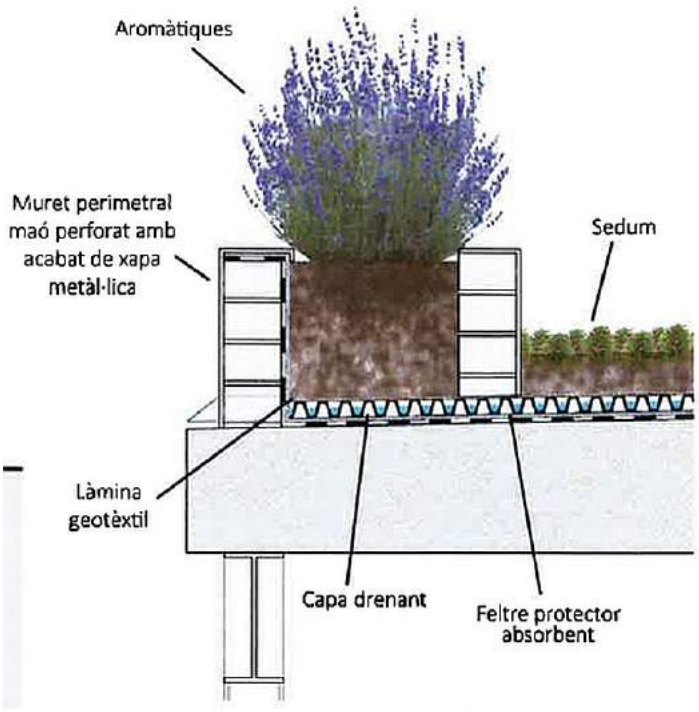


Figure 40 .Construction detail

(Source:ayuntament.barcelona.cat)

2.13 Future Project

Case 1.The Gate Residence Cairo Egypc by Vicent Callebaut

The Gate Residence is a Project located in Cairo Egypc developed by the architect Vicent Callebaut. It is a sustainable project that covers 450,000 m2, has an estimated cost of EGP 4.9 Bn and is destined to end in 2019. The Gate is an innovative project that combines vegetation and building creating a city with a vertical ecosystem and hyperconnected The main objective of this proposal is to fight against global warming. (APSAIDAL, 2016)

Figure 41 : The Gate Residence ,Cairo Egypc

(source: www.apsaidal.com*)*

Figure 42: The Gate Residence ,Cairo Egypc

(source: www.apsaidal.com *)*

Figure 43: The Gate Residence ,Cairo Egypc

(source: *www.apsaidal.com)*

Figure 44: The Gate Residence ,Cairo Egypc
(source: www.apsaidal.coz)

It is definitely an ambitious project that unites green energy and technology. On the roof, green enegias are maximized, where solar panels, heating pipes and green gardens are combined, which provide shade and reduce the electrical and mechanical ventilation demand. (Ceccherini & Sala, 2018).
This construction aims to create a huge urban oasis. It is constituted by an underground parking lot on 4 levels, 9 levels of housing integrating and 3 levels of offices along the inner street. At both ends, the facades are inspired by the gills of fish that act as umbrellas. All balconies are

transformed into suspended gardens along the perimeter of the facades to create green waterfalls that fall into each courtyard.

The ambition of The Gate Project is to create a new inhabited ecosystem prototype that combines principles of passivhaus and renewable energy technology to ensure 50% energy savings. The building is designed to reduce its carbon footprint, and to recycle part of its own waste such as gray water.

The 8 green architecture features integrated into the project are,according with Ceccherini and Sala,(2018):

- Wind collectors were transformed into mega trees in the middle of each green yards.
- The passive geothermal cooling system integrated along each core with the vertical axes.
- The photovoltaic solar cells that cover the entire sunroof and the west and east facades.
- The solar heater tubes located on the roof above each core.
- Wind turbines integrated along the axial spine at both ends of the ride.
- The landscaped roof covers the entire complex improving the thermal inertia of the roof.
- Live walls grow along the 9 Mega Trees and the Fogger system for automatic irrigation by cooling the atmosphere.
- The use of Recyclable and / or Recycled Furniture is recommended to future residents in order to reduce their carbon footprint.

In conclusion, respecting the bioclimatic norms and thanks to the integration of renewable energies, the project aims to gradually reduce the demand for mechanical ventilation and artificial lighting, increasing ventilation and natural lighting systems in all parts of the project. The leitmotif of the "The Gate Residence" is to transform the city into an ecosystem, transform the neighborhood into a forest.

3. GREEN FACADE

Figure 45(Source:Homedit.com)

3.1. General Description

The use of elements of nature as a complement to architecture comes from ancets time . One of the oldest examples is the Hanging Gardens of Babylon, considered one of the Wonders of the Ancient World. Its was create around the years 700-600 a. C

Going through different historical stages and countries where plants have been used to cover homes, the name "green facade" is associated with Stanley White Hart in 1937. Professor of Landscape

Architecture at the University of Illinois (1922 -1959), White called his invention "Botanical Bricks" and developed prototypes in his backyard in Urbana, Illinois.

The use of vegetation on the facades is a legacy of traditional architecture, which, using the available materials, responded to the need for shelter and shelter for the human being. In particularly adverse climatic zones, such as northern Europe (köhler, 2008).

3.2. Classification

- Traditional Facade:

The plants grow from the ground where they have their roots and lean on the vertical surface to grow without receiving nutrients or moisture from the wall.

- Green Facades with Construction Systems:

System where the facades contain artificial elements

Definition of Green Facades

- **Traditional Green Facade:**

The plants grow from the ground where they have their roots and lean on the vertical surface to grow without receiving nutrients or moisture from the wall.

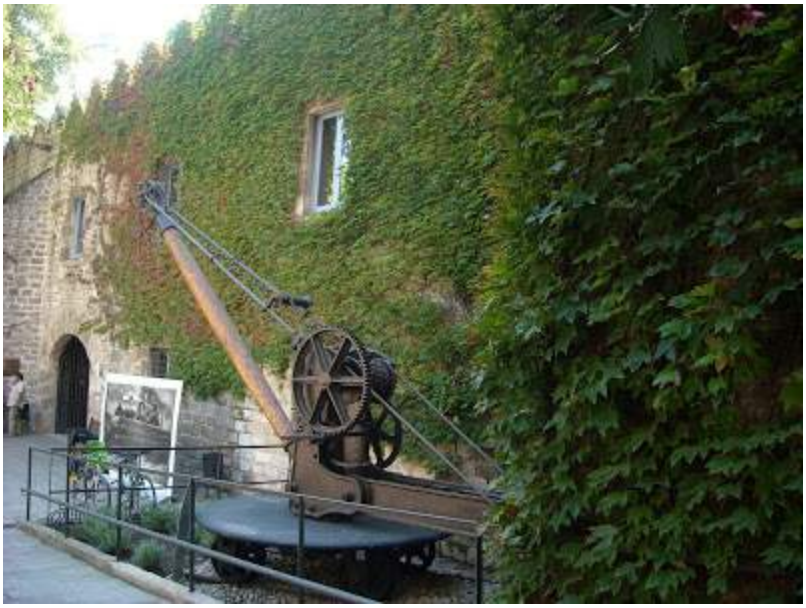


*Figure 46.*Museo Marítimo.Foto: J.LL.Puig 09/2011,Barcelona

Source : http://arquitecturaplusingenio.blogspot.com)

The advantages of this system lie in its simplicity. A climber species perfect for the climate is chosen, and will provide shading for the building with minimal maintenance. Maintenance will consist of pruning the plants and cleaning the windows once a year. On the other hand, the costs derived from installation and maintenance are very low.

The disadvantages, on the contrary, are the following:

Some species of climbers may affect the wall on which they adhere by its methods of anchoring to the support. If they use adventitious roots, they can penetrate through fissures and cracks

Thermal inertia: insignificant insulation compared to other green facade systems (Carrera, 2011).

Time: It takes a long time to develop. This may be the biggest limiting factor of these systems. Manfred Köhler, in some measurements made by himself in six different species, concluded that they grew at a rate of between 0.7 and 1.5 meters per year (Köler, 2008).

- **Green Facades with Construction Systems**:

  System where the facades contain artificial elements.

3.3. General Components

- Before detailing the different types of facades of plants with construction systems, we will define the elements that normally make up a green facade.
- Vegetation support or container element. They can be made of metal or plastic with modules that facilitate the adaptation to the facades. They contain substrate and plants.
- The substrate, land on which the roots are fixed.It is the one that will provide the nutrients to the vegetation.
- Irrigation system.The most common is the drip, that can collect the excess water in the lower part of the system by a channel.

3.4. Types

B) Type of Green Facades with Construction Systems

1. **Vegetable facades as second skin**

   1.1. Braided cable system
   1.2. Modular lattices
   1.3. Greenhouse vegetable facades
   1.4. Sliding facades

2. **Pre-cultivated plant systems**

   2.1. Systems of vegetated panels in metal boxes

2.2. Systems of vegetable panels in draining cells
2.3. Biodiversity System
2.4. Metal gabions

3. **Hydroponic systems**

3.1. F+P hydorponict system
3.2. Modular Hydroponic System Leaf and Box
3.3. Eco-Bim

4. **Organic Concrete**

Development the Type of Green Facades

1. Vegetable Facades as Second Skin

This system is based on traditional vegetable facades, but that vertical surfaces are used. Systems for vegetable facades that act as second skin.These consist of creating a wire mesh, steel meshes and metal lattices on which the climbing plant will grow to cover the entire facade with a vegetable tapestry. The metal structure allows us to redirect the plants so it offers greater aesthetic possibilities (Köler, 2008). In the market different double skin construction systems.

1.1. Braided cable system

The braided cable system is designed to create a structure in the shape of a rhombus using stainless steel cables and rods and accessories, will support climbing plants.

Figure 47 Figure. Braided cable system.

(source :inarquia.es)

There are different solutions depending on the weight and also there are different types of anchors depending on the material this will guarantee the stability and durability of the system.

Characteristic:

It is highly resistant to corrosion, requires little maintenance and is 100% recyclable. Also the installation cost is low and easy to install.

An example is offered by the company Carl Stahl Décor Cable:

FACADESCAPE green wall systems combine the best in stainless steel cable technology with environmental benefits.

Figure 48(source:decorcable.com)

GREENCABLE Greenery System unites high technology with ingenious simplicity. It consists of 3mm or 4mm stainless steel cables and specially designed wall brackets.

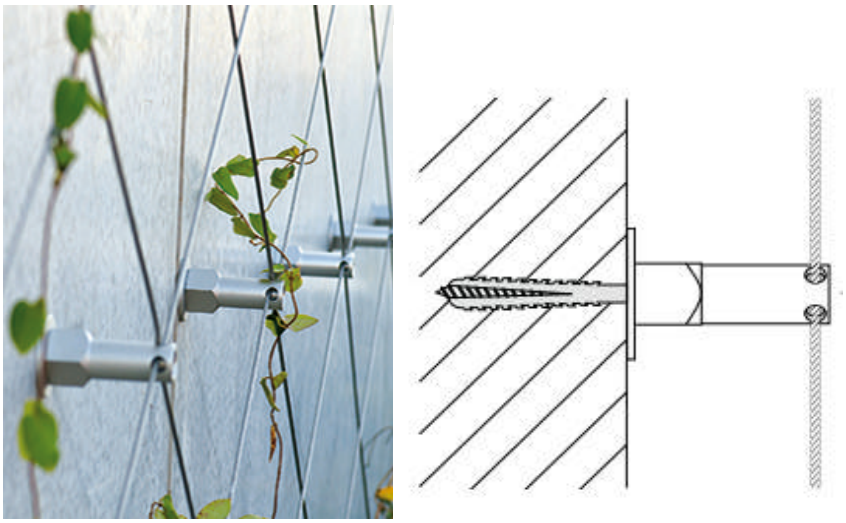


*Figure 49.*Greencable system Construction detail

(Source:decorcable.com)

ARAGrup also offers SCHMITT structures. For the creation of naturalized facades it has different models that fit the needs of the plants and the project. FR1: support for vertical, horizontal and cross climbing plants. Accessories for various types of surface with a separation of 9 or 15 cm.

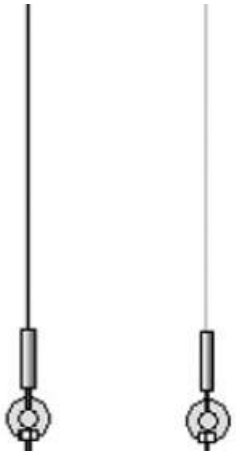


Figure 50(source :decorcable.com)

1.2. Modular Lattices

It is a system that consists of a floating flowerpot holder that is anchored the facade of the building. These containers of plants are a great method to achieve a plant wall without damaging the facade.

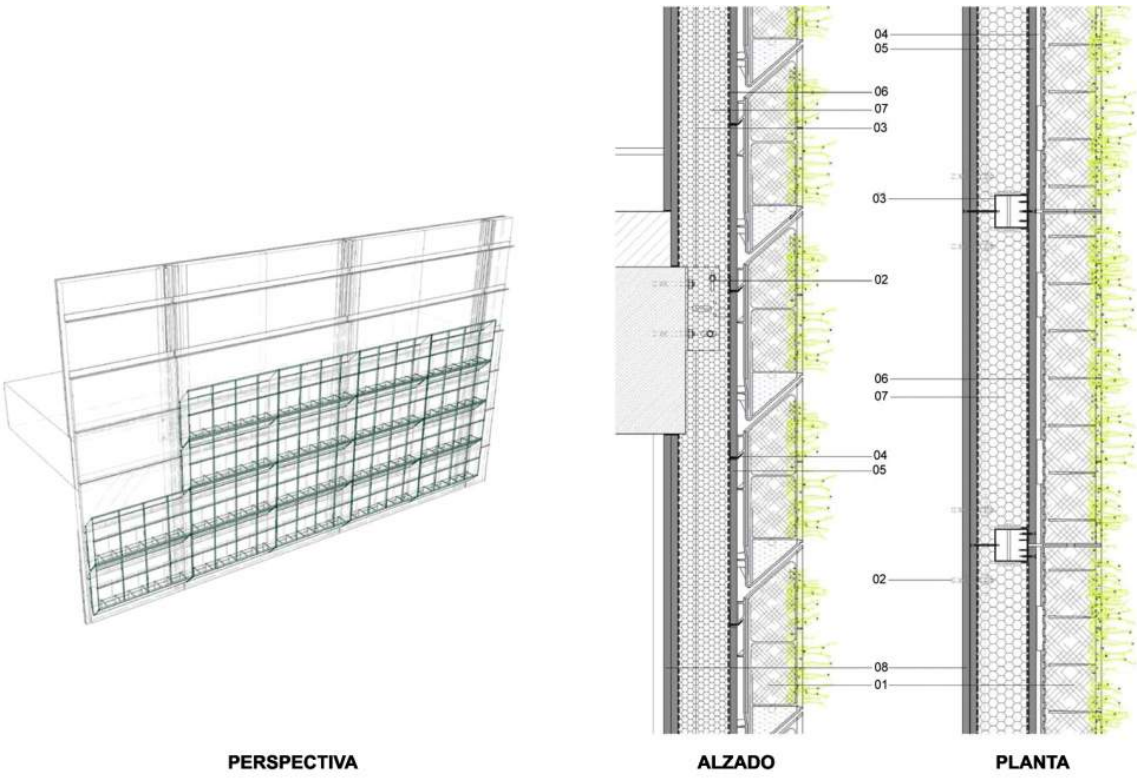


Figure 51 .Coonstruction detail of Modular Lattices

Source: (empresabuntong.com)

Characteristics:

It is composed of five principal elements : the containers, adaptable to any size; insulated containers, provided with cables that provide heat so that the plant does not die by freezing; maintenance; Remote monitoring of irrigation and fertilization, drip with temperature sensors to use only the necessary water and assembly system, designed to be mounted on any type of structure and material.

Its maintenance is relatively cheap. The problem is that it has low thermal insulation, low atmospheric protection and aesthetics is also limited.

Example is offered by the Butong company in the Björns Vertical Garden (Stockholm)

*Figure 52.*External Green facade with module lattice

(Source: empresabutong.com)

1.3.Greenhouse Facades

The plant greenhouse facade is a constructive system that works as thermal ventilation and solar protection.

The method consists of an enclosure in the form of an extra-flat greenhouse that includes a vegetal construction subsystem divided into three layers that lie between the inside and the outside.
Three Layer :

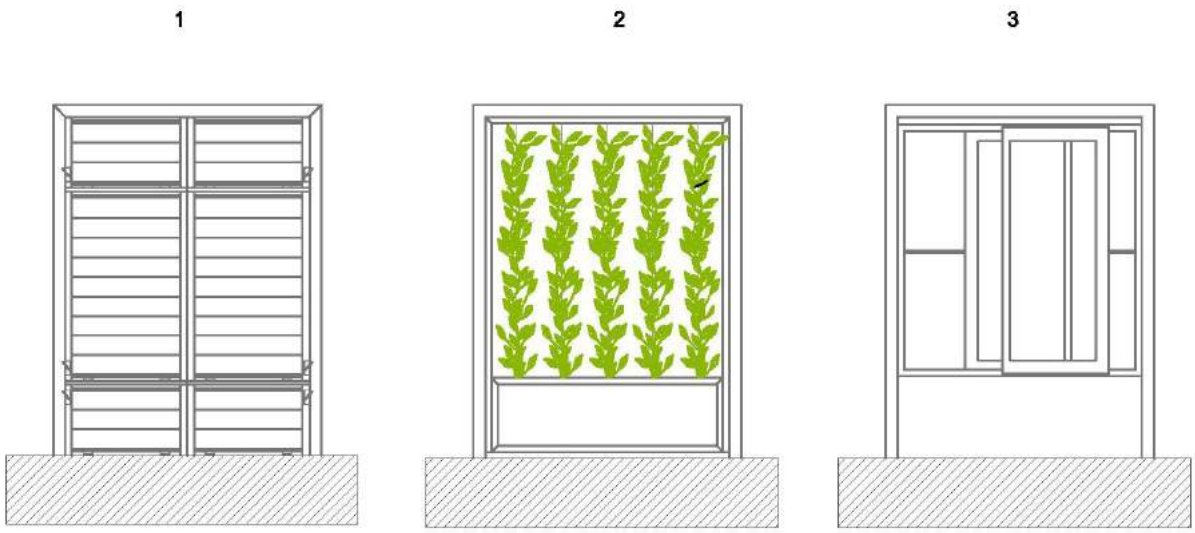


Figure 53. Construction Detail of Greenhouse vegetable Facade

(source : http://signare.es)

Characteristic:

In summer, the density of the vegetation manages to stop the heat and therefore cooling the atmosphere and the outside air passes through the moist vegetable sheet, cooling the indoor environment by a few degrees.
In winter, the vegetation changes with the fall of the leaves, allowing sunlight to enter, creating a warmer environment.

Figure 54 Figure . Greenhouse vegetable facades.

(Source: https://inarquia.es)

Figure 55. Construction Detail of Greenhouse vegetable Facade

(source : http://signare.es)

1.4 Sliding Facades

It is a mobile solar protection system for facade openings that incorporates a panel with plants that it acts as sun protection, shading the facade and causing the air temperature to drop.

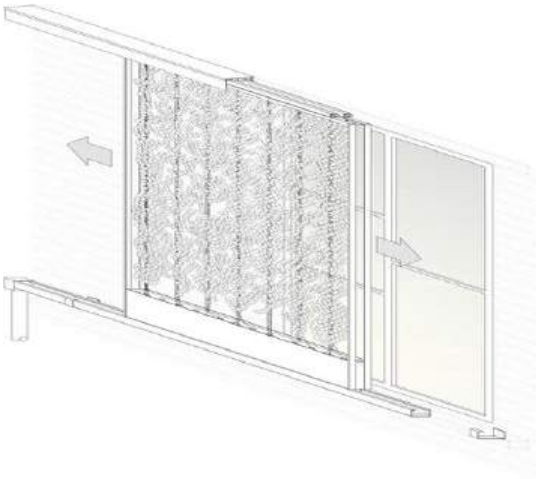


Figure 57. Functioning of the vegetable panel

(Source: habitat.aq.upm.es)

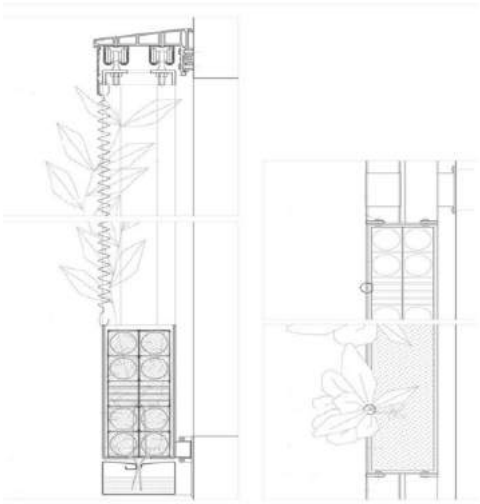


Figure 56. construction section of the vegetable panel

(Source: habitat.aq.upm.es)

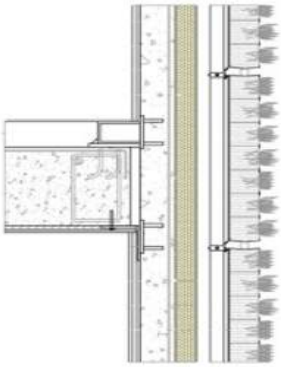
Characteristic:

The support for the vegetation consists of a flowerpot installed in the lower part of the panel and has a cable system to facilitate growth and irrigation system.

This system of construction of plant facades is very easy to assemble. However, the application of the sliding panel is only possible in those buildings that have enough space for their placement.

2. Pre-cultivated Plant Systems

2.1. Systems of vegetated panels in metal boxes



it is a constructive system with modular form.These modules make up the facade so that it can easily removable of facade through a simple metallic anchoring structure.

Characteristics:

The incorporated plant species need a support element that has in its interior the nutrients and elements necessary for its growth and for this reason a metal box is used, whose interior has the substrate wrapped in a geotextile that allows the passage of water.

Figure 58 Figure. Systems of vegetated panels with metal boxes.

(Source: habitat.aq.upm.es)

The metal boxes have an anticorrosive treatment due to their exposure to humidity.
These panels are joined to the building by means of a supporting structure of uprights and crosspieces that allows to take off the vegetated panels of the interior enclosure.

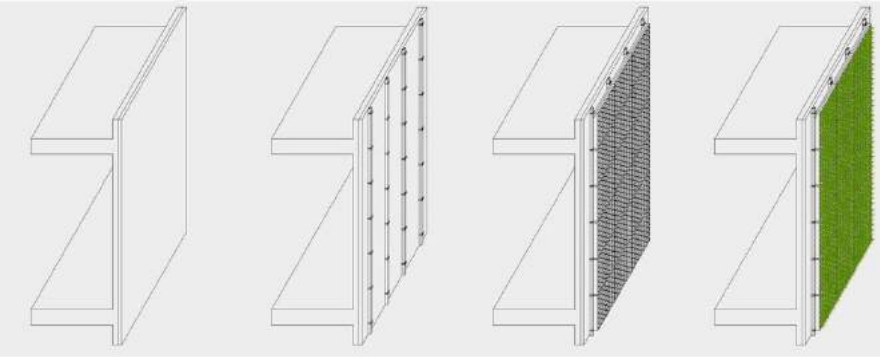


Figure 59 Figure Systems of vegetated panels with metal boxes.

(Source:habitat.aq.upm.es)

It avoids the deterioration of the facade by radiation, avoids the appearance of common pathological cases, but it is an expensive system due to its complexity in terms of design and assembly thereof.

2.2. Systems of vegetable panels in draining cells

Figure 60 VGM modules allow the creation of instant green walls on both free standing walls and on building facades

(Source: elmich.com.au)

The panels vegetated with draining cells are formed by polypropylene cells, with a porosity of 90%. The holes are filled with a substrate previously studied. The set is wrapped with 2mm thick wool felt resulting in a compact package that can be placed parallel to the facade,so that it can be seen. On this face incisions are made in the felt to introduce the plant species and are watered by dripping.

Figure 61. VGM modules allow the creation of instant green walls on both free standing walls and on building facades

(Source :elmich.com.au)

2.3 Biodiversity Green Facades

This Biodiversity Green Facades, it is a living wall system called Plug 'n Plant, aims to integrate the different types of fauna in the urban environment, in a facade.

In addition, the biodiversity system that it is attached to the wall, allows transforming several boxes of pots in birdhouses or cabinets for insects. The system has a hole in front of the pot box, which is simply left open and the boxes will be empty for any bird. In addition, we can connect an additional feeder (Wagemans, 2016).
Improving the biodiversity of the roof is also important. For this reason we can also install insect cabinets in the roof garden. On the other hand, the box can also function as nests for bats.

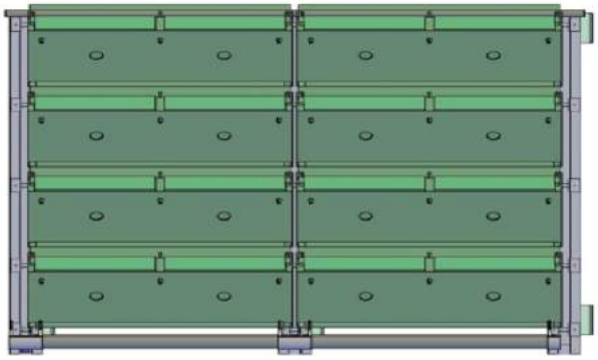


Figure 62.Plug`n plant system with biodiversity –Bird feeder componet

(Source: Wagemans, 2016)

2.4. Metal Gabions

Figure 63 Figure. Wall cabinet and green wall
(source : Vilssa.com)

Gabions (stone boxes) are an industrialized facade solution made of modules formed by a stainless-steel metal mesh, stone, polypropylene drainage cell with substrate, vegetation, insulation and a galvanized metal structure. The modules are filled with stones and vegetation grows between them.

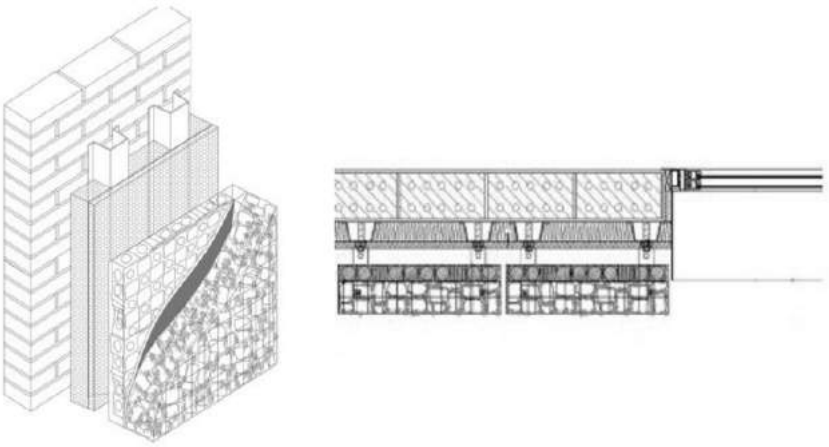


Figure 64. Vegetal Gabions.

(source: habitat.aq.upm.es)

The gabions can be placed on the existing facade, through an auxiliary structure and they work in a similar way to a ventilated facade. One problem of the system is the weight, in addition to the aesthetics, since the panels tend to look very geometric and artificial.

3.Hydroponic Systems

Figure 65 Figure. Palacio de Congresos de Vitoria-Gasteiz

(Source: www.urbanarbolismo.es)

This system consists of the installation of layer with plant growth and a fully automated irrigation system with the capacity to recirculate the water

Characteristics:

For the placement of the panels it will be necessary to install an aluminum railing on the previously waterproofed facade. First of all, the panel muss be fastened and an aminoplast panel layer and an upper layer of geotextile Polyfelt should be placed. On them, species will be planted according to the climate

These types of construction systems are the lightest on the market, independent plants are used each located in a kind of sachet created in the felt thus allowing the individual replacement of each and allows to create an environment with great similarity to natural environments. However, it requires careful installation, a larger initial investment and much more maintenance than other systems.

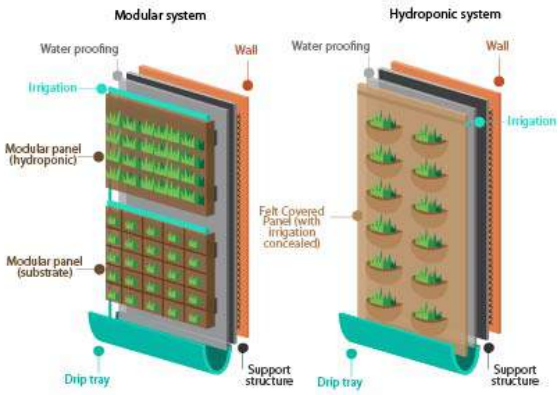


Figure 66 Figure. Green wall modular systems

(Source: www.urbanarbolismo.es)

On the other hand, a real budget study of a hydroponic green facade F + P type has been carried out 388,96 €

**Anexo B Budgets of Hydroponic Green Facades consideration of (material , construction and maintenance)*= 388,96 €

3.1 Hydroponic System with Felt Covered System F+P

The F+P hydorponict system with the Singulargreen Company , system with felt filter . It is coming of the family of living wall system (LWS) which incorporates industrial materials and industrial subproducts .This systen can be of prefabricated elements with vegetation, suitable for new buildings and retrofitting and for the rehabilitation of existing buildings.

Layers of hydroponic system

This system is composed :metal strips anchored to the wall,SG-p10 waterproof panels, non-woven geotextile mineral double-membrane SG-M500 and vegetation, species specially selected for the climate of the area.

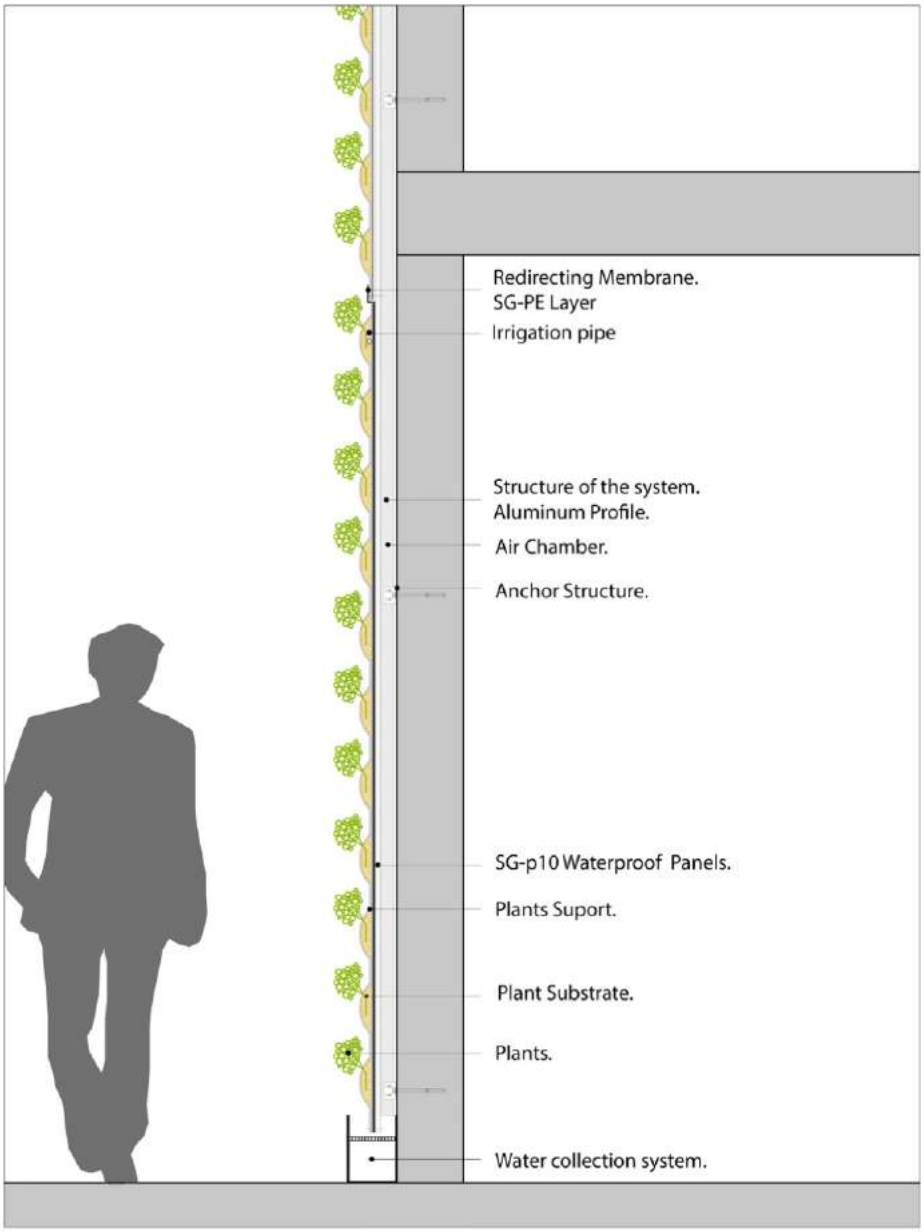


Figure 67. Construction detail of Hydroponic F+P system

(source : own elaboration and singulargreen.com)

3.2 Modular Hydroponic System Leaf and Box

This type of garden is formed by a modular construction that has a large water storage capacity that allows it to have some independence from irrigation periods.
Within the modules the Sphagnum moss substrate fastening mesh is implanted on which the plantation is carried out, retaining up to 20 times its weight in water, also the Sphagnum is antibacterial, ideal against rot, diseases and pests naturally. The metal structure of the panels is plasticized and is specially treated to resist the agents Chemicals used in gardening, which prevents deterioration and corrosion. The total weight of the saturated and planted system is around 75-85 kg / m2.

The usualy vegetation :

- Asparagus sprengeri – Aparagus Fern
- Begonia rex magic
- Chlorophytum comosum variegatum – Spider Plant
- Dryopteris sp. – Wood Fern
- Epipremnum aureum – Golden pothos
- Ophiopogon plasniscapus niger – Opiopogon
- Philodendron scandens – heart-leaf ivy
- Tradescantia zebrina – inchplant
- Tradescantia pallida – wandering jew
- Soleirolia soleirolii – angel's Tears

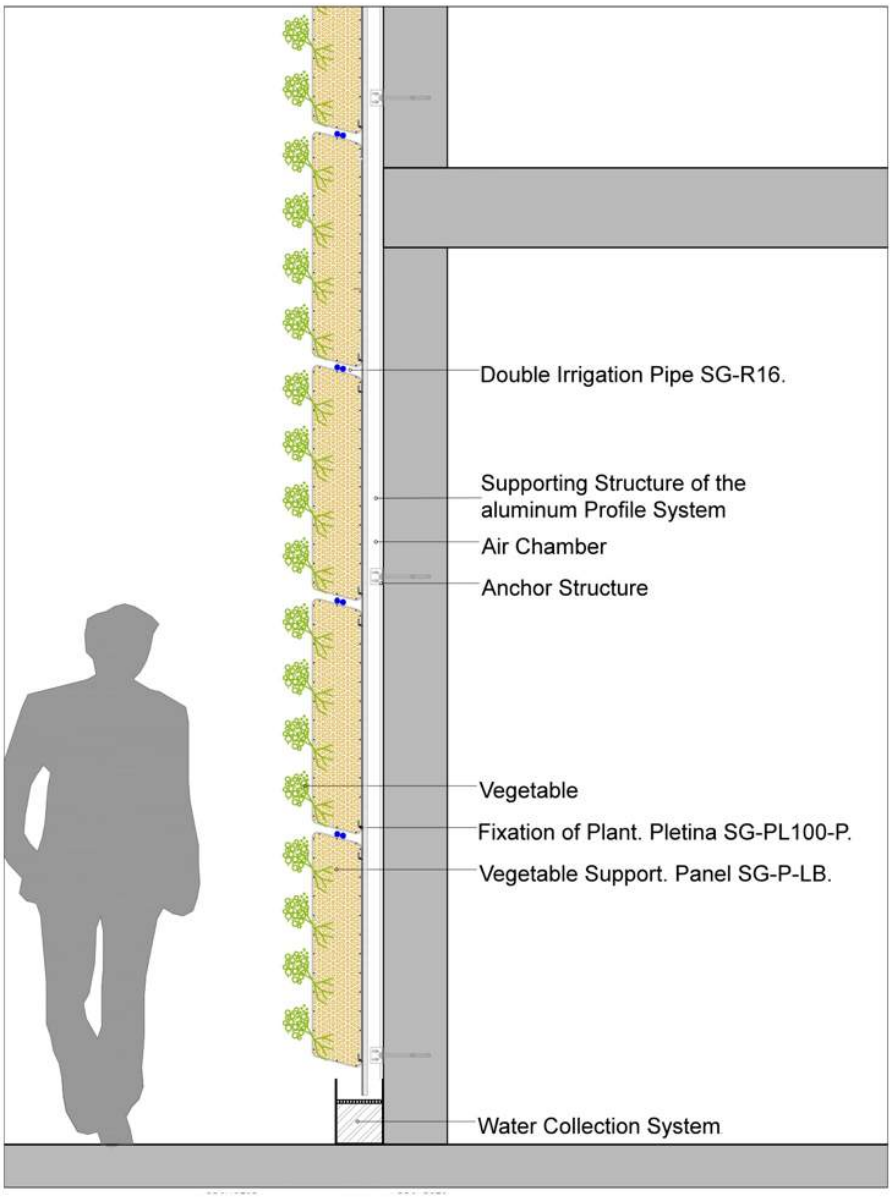


Figure 68. Construction detail of Leaf and Box System

(source : own elaboration and singulargreen.com)

3.3 Hydroponic System Eco Bin

The green wall is fomado by a structure of ceramic elements with a slight inclination towards the interior, each one of the holes acts as an element of acoustic absorption, the configuration of the garden, the substrate and the vegetation creates a hermetic element. The vegetation used in accordance with the climate . The interior of each of these cells has a small amount of Sphagnum moss that performs the function of the plant's substrate.The total weight of the saturated and planted system is around 200 kg / m2.

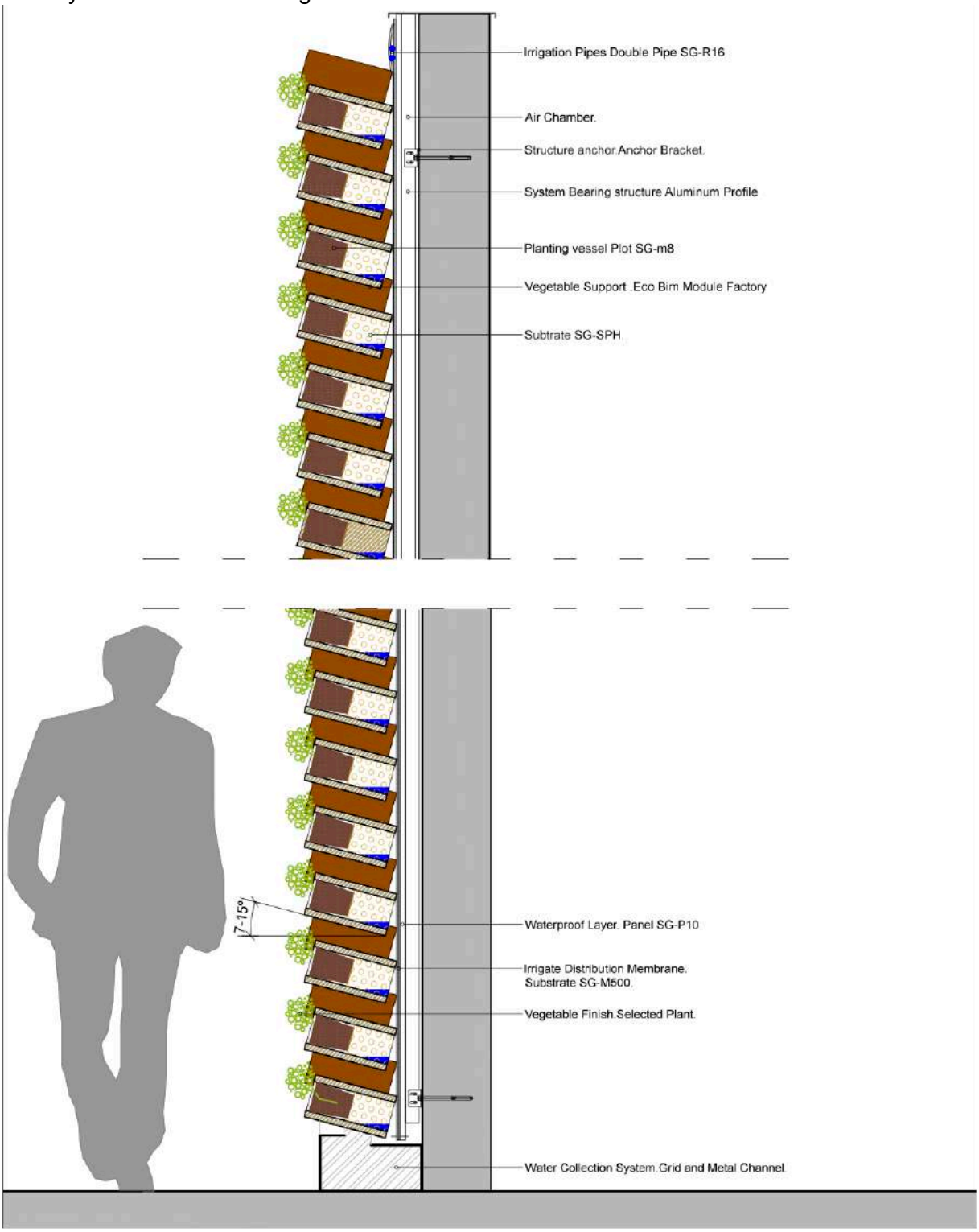


Figure 69. Construction detail of Eco Bin System

(source : own Elaboration and Singulargreen.com)

Development of the all hydroponic system :

It will be verified that the structure has the appropriate verticality. On the other hand, we must take into account that when the support is made of cellular concrete, cement mortar or light aggregate mortar, its surface must be set and dry.It must be taken into account that the water collection and drainage elements must be installed before starting work

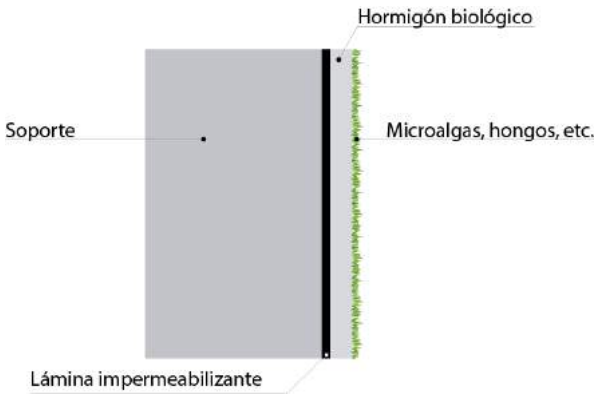
Maintenance of the hydroponic all system:

For the maintenance and conservation. It must be protected during the whole process so that it does not create stains or mechanical damage. On the other hand, the materials accumulated by the wind and any possible vegetation must be eliminated.
If a defect in waterproofing is observed, it must be repaired by a specialized staff.
Irrigation control is totally automatic so that maintenance consists of the periodic and monthly inspection of the facilities as well as the filling of the fertilizer, acid and base tanks.

4. Organic Concrete

Figure 70 Figure. Simulation of plant facade with biological concrete
(Source :arquitecturayempresa.es)

It is a type of ecological concrete with the capacity to grow pigmented organisms in a natural and accelerated way.



To obtain the biological concrete, the pH has been modified by porosity and surface roughness.
The result obtained is a multilayer element formed by a layer of waterproofing placed on another that serves as protection against the passage of water and the next is the biological layer, which allows the colonization of the plants and the accumulation of water inside.

This new vegetal concrete would be easy to put since it is the same as the traditional structural concrete, the finish would be identical to a normal building.

Figure 71 Construction detail of biological concrete

(source : morethangreen.es)

Biological concrete works not only as an insulating material and thermal regulator, so that it serves to decorate the facade of buildings or the surface of buildings with different finishes and chromatic tones.

Example in Sau Paul Brasil :

Figure 72(source : Inhabitat.com)

3.5. Characteristics of Green Facades

Reduce pollution: It can be said that 1 m^2 of vegetable coverture generates the oxygen of a person throughout the year (Darligton, 2001). A 4 floor building with vertical garden facade filters 40 tons of harmful waste per year (Wolverton, 1989)

Improve sound insulation ,the vegetation layer reduces noise pollution to 10 decibels research by Akira Hoyano(Professor, Tokyo Institute of technology) .The vegetal finish (plants substrate reduces noise by absorbing the waves in the substrate and reflection in the vegetation.

Reduce up to 5 º C the interior temperature of a building in summer as well as keep it in winter reseach by Akira Hoyano,(professor at the Tokyo Institute of Technology)

Improves performance and reduces discomfort of people who have vegetation in their workplace (Lohr et al., 1996; Bringslimark, et al.2007)

They save space: The walls of plants hang vertically, taking advantage of an already existing space

3.6. Benefits and Limitations

Advantages

- Improves air quality
- Improves the building aesthetics
- CO2 retention.
- Reduction of stormwater runoff.
- Reduction of the island effect.
- Retention of dust and polluting substances.
- Reduction Temperature
- Recovery of green spaces and biodiversity
- Reduction of acoustic contamination
- Reduction of wind infiltration
- It has positive effects at the social level

Disadvantages

- Cost
- Maintenance
- Insects
- Cold and Hot Temperature

3.7. Maintenance

It is important to carry out an adequate maintenance of the different green facade systems to ensure a long-term good function.

Apart from natural wall vegetation, all plants need additional water and nutrients to survive. This can be added to the plants using an irrigation system.

An irrigation system can be very energy consuming, especially when it is fully automated with a water management system. In this scenario it completely monitors the moisture levels of the soil, resulting in the release of the appropriate levels of water and nutrients.

Dead plants need to be replaced, preferably at least twice a year. This needs manual labor and a lift for high-to-reach places.

Sometimes not only plants, but entire elements need to be replaced. Felt systems, for example, could rip. Pruning (long term maintenance) for plants is recommended. Various companies selling and installing green facades and living wall systems also provide maintenance and check-ups.

For the possible appearance of insects we can use natural products in the water, to mitigate their appearance. This method also mitigates the appearance of possible animals.

3.8. Cost

The green facade installation and maintenance costs vary according to the type of system that we are going to use, according to the document ``Cost benefit analysis for green facades and living wall systems´´ the cost it is between 30 - 1200€/m^2 . (Perini & Rosasco, 2013)

The cost estimation:

- Direct greening system (System direct to the Wall ,grow climbing) : 30-45 €/m^2
- Indirect greening system (grow climbing + supporting material) : 40-75€/m^2
- Indirect greening system with box :combination plants with boxes and supporting systems with plastic material :100-150 €/m^2
- Indirect Greening system zinc-coated steel 600-800 €/m2
- Living wall system : 400-1200 €/m^2 depending the system and the material used

*The cost depends: on the facade surface , location, connections , etc..

On the other hand, a real budget study Anexo B of a hydroponic green facade F + P type has been carried out with a surface of up to 5 m² with stimatin cost of = 388,96 €

3.9. Regulation

European Regulation:

After an exhaustive search of application regulations referring to plant facades and the analysis of the regulations in which the facade companies have concluded that the regulation is scarce.

According to Javier Manzanero in his article "The Vegatal Facade of Jean Nouvel":
Its use is being standardized and, so much so, that there are since April 2012, the Technological Standard on Vertical Landscaping (NTJ-11V) of the Gardening and Landscape Foundation, which represent a reliable technical reference for safe use of the vegetable facades.

In Europe there is a document that regulates the design, construction and maintenance of vertical garden systems. But this document only refers to the vegetable facades with climbing plants and vines and was last revised in the year 2000. Its function was to regulate a very common practice in Germany. This is the "Guidelines for the construction, planning and maintenance of facades with climbing plants" was written in Germany in 1995 and is a regulation published in Germany by the FFL (German Association for Research and Landscape Development).

Of the regulations used by Spanish companies, none of them is specific for plant facades. It is about CTE-DB-HS. Health, CTE-DB-SI. Fire safety and CTE-DB-HE. Energy saving.

3.10. Comparative Table of Green Facade

Type of Facade	Type of Facade system	Advanges	Disadvantages	Cost
Braided cable system	Direct system	Low Cost Easy To Install Little Maintenance 100% Reciclable Highly Resistant To Corrosion	Low thermal insulation Poor protection against atmospheric elements It takes to cover the entire wall Limited aesthetics	30-45 €/m^2

Modular lattices	Indirect System	Low And Cheap Maintenance Easy Installation Low Cost Allows The Removal Of Your Containers For Inspection Good Environmental Behavior	Low thermal insulation Poor atmospheric protection Limited aesthetics	40-75€/m^2
Greenhouse vegetable facades	Indirect System	Good Environmental Behavior Quick Installation Good Aesthetic Contribution Both From The Outside And Inside	This project is still under study	-
Sliding facades	Indirect System	Easy Implementation Of Assembly It Has A Good Environmental Behavior (Sun Protection)	High degree of maintenance Difficult application according to the building It depends on a good irrigation system	100-150 €/m^2

Systems of vegetated panels with metal boxes	LWS Living Wall system	System With Plants Already Developed Good Environmental Behavior Facilitates Installation And Assembly Good Thermal Behavior Protect The Building Uv Radiation	High initial cost High weight Only small plants and shrubs can be used High level of maintenance Needs a treatment for corrosion Geometric and artificial aesthetic appearance	400-1200 €/m^2
Systems of vegetable panels in draining cells		Cover With Plants Already Developed Good Environmental Behavior Easy Implantation Good Thermal Insulation Solar Radiation Protection Possibility Of Recycling Cells	High initial cost High weight Low diversity of plants (small plants and shrubs) High maintenance Treatment against corrosion Geometric and artificial appearance	400-1200 €/m^2
Metal Gabions	LWS (Living Wall system)	Use Of Already Developed Plants Good Environmental Behavior	High initial cost High weight Low plant diversity only rocky species	400-1200 €/m^2

		Easy Implantation Good Thermal Behavior Protect The Building Of Radiation Uv	Treatment to prevent corrosion Geometric and artificial appearance.	
Hydroponic systems		The Lightest System Substitution Of Vegetation Good Environmental Behavior Protect The Uv Building High Diversity Of Vegetation	Careful installation High initial cost High maintenance	400-1200 €/m^2
Organic concrete	Direct system	Easy To Implement Lighter System (It's The Concrete Itself) Good Thermal Insulation Good Environmental Behavior Good Thermal Regulator	This project is still under study	-

Table 2. Comparison table of green facades
(Source: Navarro Portillos, 2013)

3.11. Cases Around the World

At present, many architects from different parts of the world are betting on introducing green facades in their designs.

Case1. In Seoul, the Korean Architect Minsuk Cho

In Seoul, the Korean architect Minsuk Cho, from the Mass Studies studio, wrapped the shop of the Belgian fashion designer Ann Demeulemeester with a cloak of moss.

Figure 73. Shop design by Minsuk Cho Architect

(Source: rmaarchitects.com))

Case 2. In India, the architect Rahul Mehrotra

In India, the architect Rahul Mehrotra avoids the mere decorative character of the plant walls, seeking the environmental improvement of buildings and the creation of new spatial experiences for the people.Figure 74.

Figure 74. Building KMC In Hyderabad (India)

(Source: arquitecturaverdeafa.blogspot.com

Case 3 Switzerland Sihl City Complex In Zurich

*Figure 75.*Switzerland Sihl City Complex In Zurich
Source (:*www.greenroofs.com)*

Architect Theo Hotz in 2007, created a green facade area of 100,000 m^2 in a shopping center in Zurich (shil city) in the Wiedikon district, which was formerly a paper mill. Sihlcity is one of the commercial and leisure complexes largest and most advanced in Switzerland. The work cost CHF 620 million. Currently, four old buildings of the old Sihl paper mill were preserved, and the entire complex is covered with extensive green roofs. (Sihlcity, Architecture).

The mall is quite profitable since it attracts 20,000 visitors a day. It consists of a wide range of shops, restaurants, entertainment venues, cultural events.

Jakob Rope Systems participated in several facets of this project to create the green facade structure. Jakob Rope Systems uses custom made stainless steel cables, nets, rods, fasteners and accessories.
The east facade of the parking lot was equipped with a green wall. With a height of 23 meters and a width of 25.5 meters, the green wall of the parking facilities in Sihl City represents a category of ecological facade projects whose large size and the resulting loads made it impossible to apply standard solutions.

The striking living wall offers an elegant aesthetic solution to the parking facade, as well as a series of performance advantages that include:

- Provide a sunscreen in the summer to help keep the parking lot cool
- An additional layer of insulation during winter.
- A sound insulation level for busy parking
- An effective deterrent for graffiti

European Shopping Award 2008, recognizes the good building of the city of Zurich 2006 - 2010, and Award for the good construction of the canton of Zurich 2013.
Sihlcity is a great example of a significant reuse of an old industrial wasteland with new and reused buildings, along with a beautiful living facade.System used.Figure 76 :

Figure 76. Construction Detail ,Switzerland Sihl City Complex In Zurich
(Source:*www.greenroofs.com)*

3.12. Cases Around Mediterranean

At present, many architects from different parts of world are betting on introducing green facades around the Mediterranean see.

Case 1 Mediarena verde Wall In Barcelona Spain

The Celler Cooperatiu de Rubí building built by the architect Capella Cèsar Martinell, in Barcelona. The building was built in 1919 and was rehabilitated in 2007 when it suffered the sinking of a part of the roof.
The modernist revival with a vertical garden on two of its facades was carried out by the Alijardín companies with Unsual Green. The vertical garden that was used was Hydroponic modul .Leaf-Boxsystem , the main objective being to adapt the plants to the climate, so 8 different types of plants were placed.

Figure 77 . Celler Cooperatui, Barcelona

(Source:*www. singulargreen.com)*

In the first phase we worked on the structure and planting of the species, dried and spoiled plants were eliminated and the organization of the plants began. We can see in the following photographs how it began with the placement of the panels ,(Figure 79) and the automated irrigation system, Figure 78 .**It is a Modular Hydroponic System Leaf and Box**

Figure 79. Construction Facade Detail
(Source:*www.alijardin.es)*

Figure 78.. *Detail of automated irrigation system*
*(Source:*www.alijardin.es)

Figure . Construction Detail
*(Source:*www. singulargreen.com)

Case 2 Children Library San Vicente Town ,Spain

Figure 80(Source:inhabitat.com)

The project with beatiful vertical garden located in the town square of San Vicente del Raspeig in the southeast of Spain. Designed by architect Jose Maria Chofre, the six-story vertical garden is installed on the facade of a new children's library, where it creates a spectacular organic contrast to the urban complex and the surrounding angular concrete buildings.
Using synthetic felted material, plants are inserted into the frame between two metal grids. The garden consists of a metal frame structure and can be easily accessed from several corridors in the back and can be replaced. Smaller plants are housed on the top while ferns take up the space below. **It is a Modular Hydroponic System Leaf and Box**

Figure 81(Source: greenlaunches.com)

Case 3 Hotel Ushuaia Ibiza ,Spain

Figure 82(Source:Blog.is-arquitectura.es)

Jordi Serramia Ruiz with his team of Urban Architecture Architects and with the help of Alijardín develop in 2011 in a Ushuaia Ibiza hotel in Spain a vergetal garden with ceramic bottles. The garden covers several walls with vegetation that act as an acoustic barrier.

The green wall is fomado by a structure of ceramic elements with a slight inclination towards the interior, each one of the holes acts as an element of acoustic absorption, the configuration of the garden, the substrate and the vegetation creates a hermetic element. The vegetation used in accordance with the climate, crass plants, such as Crasssula, Euphorbia, Echeveria, Aeonium, Kalanchoe, Sedum and Sedeveria that adapt to these conditions, plants are located in vertical walls or in situations with very little substrate. Figure 83 .**It is a Hydroponic System Eco Bin .**

Figure 83(Source:alijardin.es)

3.13. Future Project

Case 1. Dutch office building covered in potted plants designs by MVRDV,Amsterdam

Figure 84(source:mvrdv.nl)

This building is located at the southern end of the Dutch city of Sint-Michielsgestel, the Green Village, consists of four floors wrapped in a green facade. The design developed by MVRDV and co-architects Van Boven Architecten created the formation of the facade with shelves that houses a large number of plants ,which are selected and placed taking into account the orientation of the

potted facade, shrubs and trees such as forsitias, jasmine, pine and birch.On the other hand they incorporate sensor-controlled irrigation systems to use the rainwater stored in the pots, which guarantees a green facade throughout the year.

This project is currently being developed in order to create an emblematic building and at the same time be socially aware and environmentally progressive.

3 STUDY AREA-BARCELONA

After having carried out this in-depth study of the new techniques of green facades and green roofs, a study related to the previously seen cases of Barcelona will be rehalized. We will study the climate, the evolution of green spaces, the trajectory it has, the effects of heat there are. Before we start we should analyze the climate in the Mediterranean Sea.

3.1 Mediterranean Climate

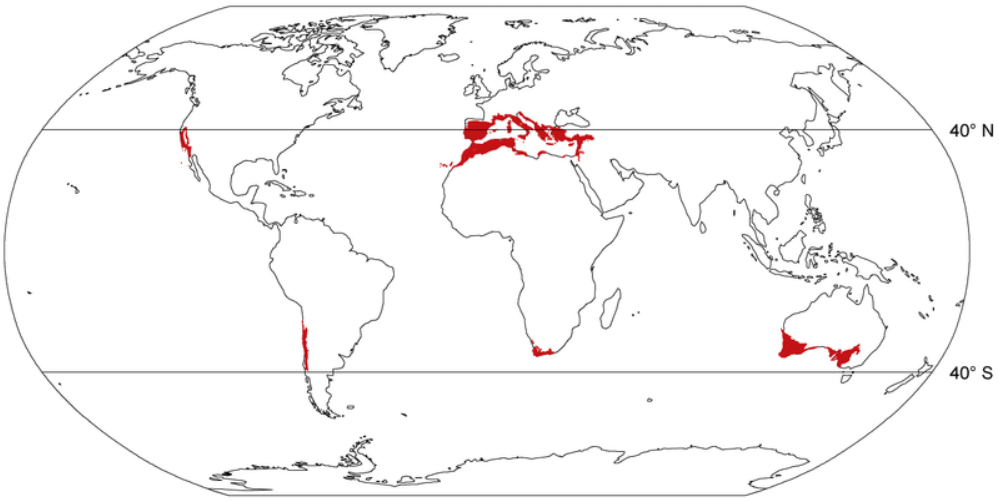


Figure 85(Source : Wales, 2001)

The Mediterranean climate is a type of climate characterized by hot, dry and sunny summers and a rainy winter season, called subtropical dry weather. It is especially favorable for the cultivation of fruit trees. Temperatures are maintained every month above 20 ° C but have seasonal variation, there are cold months below 18 ° C and others warmer than in the typical Mediterranean exceed 22 ° C.

The Mediterranean region is formed by 22 countries and 460 million inhabitants whose axis is the Mediterranean Sea being an inland sea of Europe, Asia and Africa bathes the coasts of Spain, France, Italy, Croatia, Albania, Greece Turkey, Lebanon, Syria and Israel, Egypt, Libya, Tunisia, Algeria and Morocco. (Ferrera, 2005)

3.2 Barcelona Location

Figure 86 . Barcelona Location

(Source : Wales, 2001)

Barcelona is the capital of the autonomous community of Catalonia, and the second largest Spanish city ,in Spain after Madrid. It had a population of 1.620.343 inhabitants in 2018.It is located on the shore of the Mediterranean Sea, between the communities of Valencia, Aragon and about 120 km south of the Pyrenees mountain range and the border with France.

3.3 Barcelona Climate

The city of Barcelona has a Mediterranean climate with maritime influences called the subtropical climate of dry and hot summers. The winters are mild, with an average around 12 ° C in January. Frosts are exceptionally rare within the city, although they are more frequent in the mountainous areas of the municipality due to the altitude. However, the summers are warm, with an average of 26 ° C in August. The maximum average in August, between 28 and 29 ° C. However, the minimum averages are around 23 ° C, with high night humidity.

The average annual rainfall is around 600 mm, with a maximum rainfall at the end of summer and beginning of autumn, reaching over 90 mm on average in October, which is often caused by the phenomenon known as cold drop , which has exceeded many times 100 mm in one day. On the contrary, the minimum occurs at the beginning of the summer, reaching something above the average of 20 mm in July. The average annual humidity is high due to the maritime conditions of the city, standing between 69 and 70% and varying little throughout the year.
Below is a table (Figure 87) that collects the weather values of the meteorological observatories located in the center of the city of the Fabra Observatory, between the years 1981-2010. (Wales, 2001)

Parámetros climáticos promedio de Observatorio de Fabra (Barcelona) (412 m s. n. m.) (periodo de referencia: 1981-2010) [ocultar]

Mes	Ene.	Feb.	Mar.	Abr.	May.	Jun.	Jul.	Ago.	Sep.	Oct.	Nov.	Dic.	Anual
Temp. máx. abs. (°C)	20.3	21.2	27.9	26.0	33.4	35.4	36.6	38.4	33.0	30.0	26.4	19.8	38.4
Temp. máx. media (°C)	11.1	12.5	15.2	17.2	21.0	25.2	28.4	28.3	24.6	20.1	14.7	11.8	19.2
Temp. media (°C)	8.2	9.1	11.4	13.2	16.8	20.8	23.8	23.9	20.7	16.8	11.8	9.1	15.5
Temp. mín. media (°C)	5.3	5.7	7.6	9.1	12.5	16.4	19.3	19.5	16.7	13.4	8.8	6.4	11.7
Temp. mín. abs. (°C)	-7.2	-4.4	-3.4	1.4	3.4	7.6	11.6	11.0	8.0	1.8	-2.6	-3.0	-7.2
Precipitación total (mm)	50.1	43.2	44.5	52.7	57.8	29.8	23.7	41.4	74.9	91.3	65.6	46.2	621.3
Días de precipitaciones (≥ 1 mm)	4.8	4.3	5.1	5.8	5.7	3.5	1.9	4.3	5.5	6.5	5.1	4.6	57.1
Días de nevadas (≥)	0.5	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	2.0
Horas de sol	166.1	174.8	188.4	211.1	248.2	270.5	304.4	262.1	190.5	178.4	157.9	156.4	2508.8
Humedad relativa (%)	69	69	69	68	68	67	66	70	74	75	71	69	70

*Figure 87.*Climate parameters of Barcelona

(Source: Wales, 2001)

Trajectories of the Green facades and Green roofs in Spain

Since the beginning of the nineties there have been initiatives with the "urban nature", when an association called PRONATUR (Promotion of Urban and Rural Nature) dedicated to the collaboration of teachers, researchers, professionals and citizens in general for the greening of the cities (Briz et al., 2014). Since then it has been achieved that the most important cities in Spain such as Madrid, Barcelona, Valencia, Zaragoza or Seville present today local programs for the development of green infrastructure.

On a commercial level, most of the green roofs that are made in Epaña are made with a ZinCo ecological roofing system, a patented system of layers of North-European design consisting of an insulator, a root plate, protective blankets for the root plate and water and nutrient accumulators, a drainage layer that conducts excess water, and finally the substrate and vegetation. On the other hand, for the majority of green facades they are rehalized with Singulargreen, a Spanish company based in Alicante together with the use of vertical gardens, we use rainwater collection and storage systems and reuse of gray water and plant species that optimize the capture of air pollutants.

3.4 Trayectories of the Green in Barcelona

According to the book Green Trajectories of Anguelovski,et al. (2018).The city began to become sustainable with the arrival of the 1992 Summer Olympics. Since then, the city has taken a popular form internationally. It is estimated that the municipal green space amounts to 28.3 km^2 or 17.6 m^2 per resident, including more than 580 urban parks, peri-urban forests and other green areas.

On the other hand, the city council of Barcelona carried out a study in which the growth potential of the green roofs is evaluated, it is estimated that there are about 2,600 hectares of the surface of Barcelona is built, equivalent to approximately a quarter of the extension of the municipality.

If we analyze the roofs there are that, 67% of the roofs of buildings are flat roofs and roofs, 13% would correspond to tile roofs and the remaining 20% to light roofs,(Suñe & Cerrillo, 2014). Logically, not all that roof extension meets the requirements to end up becoming a new urban green

At present, the Barcelona City Council is promoting and approving several projects such as: The Pla del Verd i de la Biodiversitat de Barcelona in 2020, to decreases the island effect and the renaturalization of the roofs, covers and balconies of Barcelona. The main motivation is to populate it with green roofs that allow the capture of rainwater, the absorption of CO^2 and reduce the effective island (City Council Barcelona.,2017).

The City Council of Barcelona with this plan of the Green Biodiversity of Barcelona (.2017) the green roofs competition, financing the preparation of 45 technical projects and rewarding ten green roofs. Currently, one of the 10 winning cuvettes is made the rest of the remaining 9 projects are in execution.
It is estimated that these ten roofs will contribute more than 4,000 square meters of new green in addition to the roofs already made previously in municipal buildings, such as in the Vall d'Hebron Market, in the Zona Nord Library or in the Joan Maragall Library.

3.5 Urban Heat Island in Barcelona

The heat island effect is a phenomenon that modified the local climate due to urban causes, which consists in the heating of urban centers compared to the homes on the periphery,(Forssmann, 2017) .The greatest effect occurs in the months of autumn and winter and in conditions of atmospheric stability. The Heat Island project in the metropolitan area of Barcelona and the adaptation to climate change, led by Javier Martín Vide, Professor of Physical Geography at the University of Barcelona (Forssmann, 2017), concludes that the effect known as heat island produces a great temperature difference between the city center and the periphery.

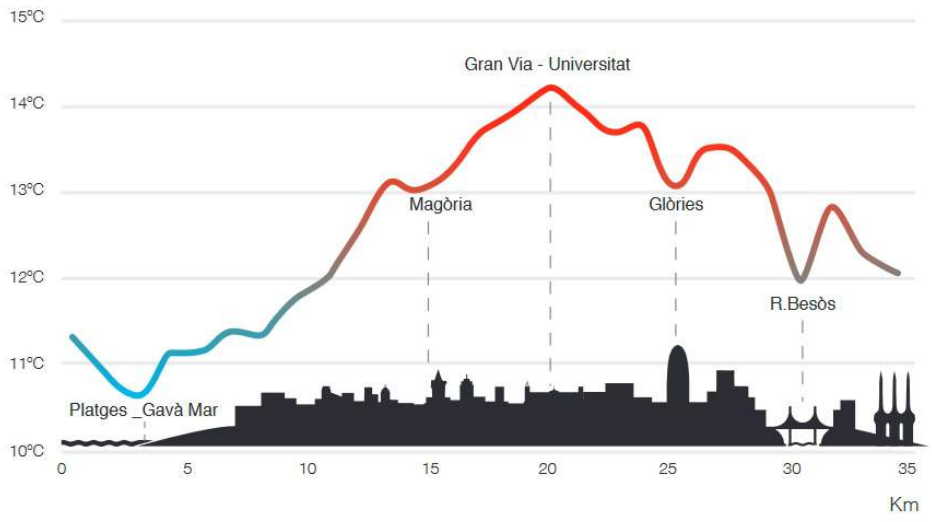


Figure 88. Heat Island Effect In Barcelona

(Source : National Geografic Spain ,nationalgeographic.com.es)

In the various studies it is estimated that the temperature in the center of Barcelona is higher than in the periphery, a difference of 7.5 ° C can be appreciated. The study places the focus of the heat island nucleus in the Plaza de la Universitat, at the meeting point between the end of Eixample and the upper part of the Raval. It can be estimated that urban parks in cities, because they can reduce the temperature inside and around them by more than 2ºC in an area of up to a hundred meters (Forssmann, 2017)

Visual map representation of the island effect (City Council Barcelona,2019)

During the night, a heat island effect is produced in Barcelona, with the greatest intensity being felt in the district of Eixample, and the effects decreasing in the more peripheral areas of the city.

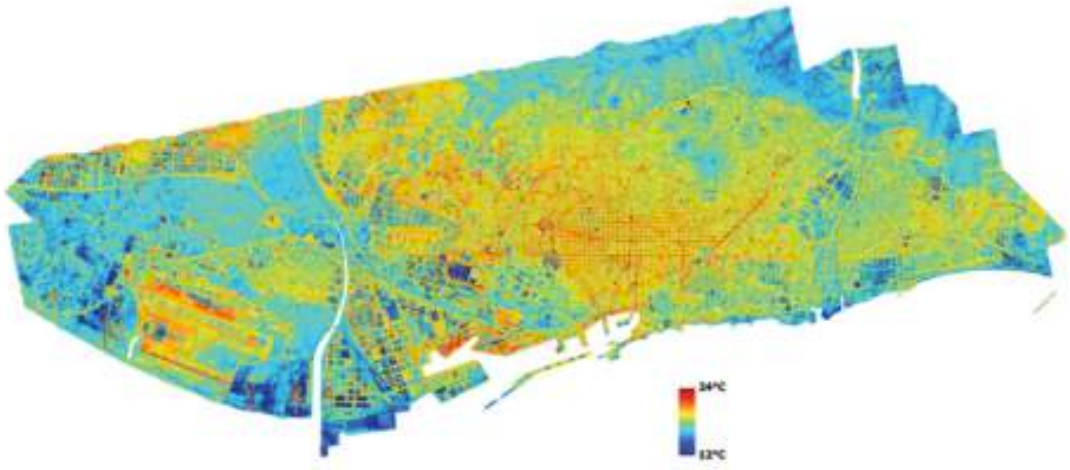


Figure 89(Source; Cartographic and Geological Institute of Catalonia (ICGC) – Barcelona Regional, 2014)

By day, higher heat peaks are found in materials that heat more quickly, showing clear differences in some types of roofs. The low temperature is maintained in areas with vegetation. Here a clear effect of heat distribution is observed

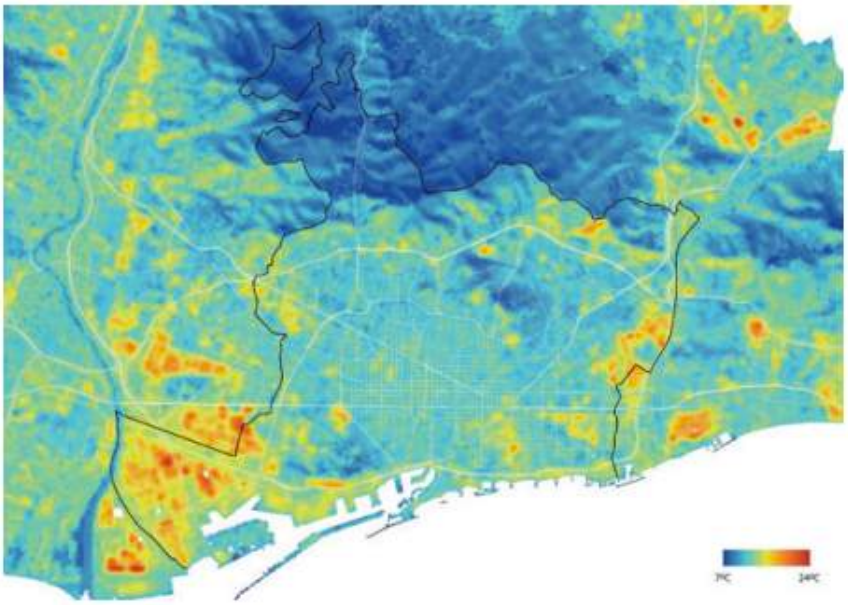


Figure 90(Source; Cartographic and Geological Institute of Catalonia (ICGC) – Barcelona Regional, 2014)

The approach taken by Barcelona Regional to the potential for heat accumulation on the surface taking into account solar radiation
Potential for heat accumulation on the surface taking into account solar radiation

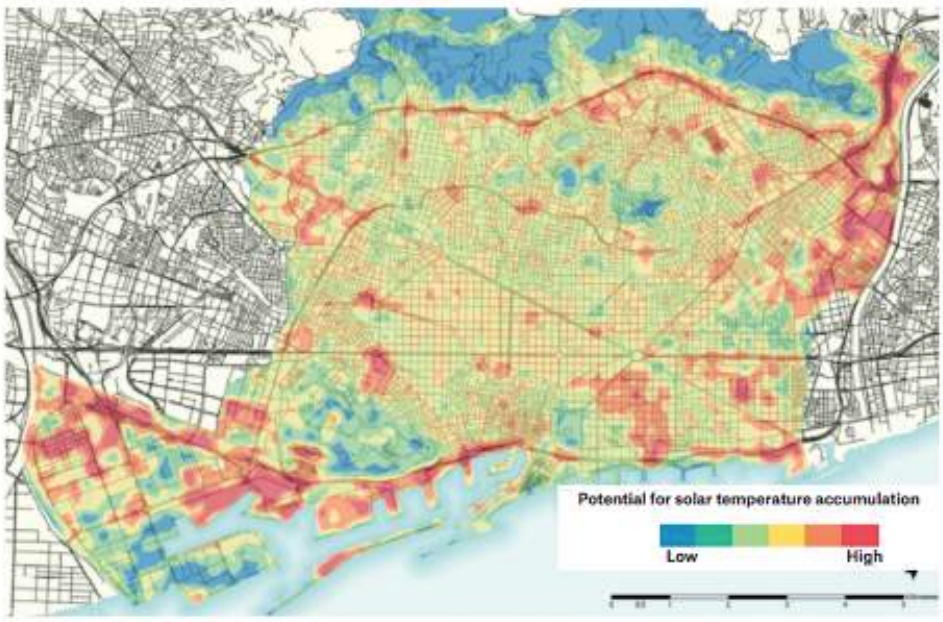


Figure 91(Source; Cartographic and Geological Institute of Catalonia (ICGC) – Barcelona Regional, 2014)

3.6 Green Areas of Integration

Urban Nature Atlas of Green Roof and Green Facades

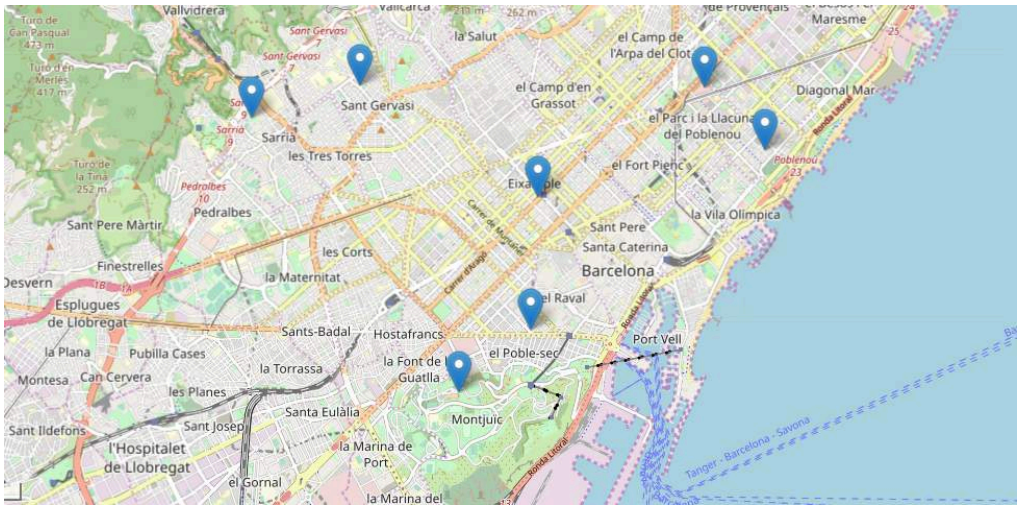


Figure 92 . Urban natura atlas green roof and green facade
(Source : Urban nature atlas ; explora.bcnsostenible.cat)

According to Urban Nature Atlas of Barcelona, this map shows the different green buildings and green roofs that are currently registered in the center of Barcelona, there are some more on the outskirts of the city. I have calculated with different sources sought examples of green roofs and facades that are at least 22 green buildings.

3.7 Vegetation

Common plant in Barcelona city, according with the document Plan of 2020, (Frances,et.al.,2013)

Plants :

Big -sized bushes

Figure 93Orange tree

(Source:nurserylive.com)

Figure 94Say laurel

(Source :ornamental-tree-co-uk)

Figure 95 Laurestine

(Source:pinterest.ca)

Middle-sized bushes

Figure 96. Chaste tree

(Source :naturehills.com)

Figure 97 .Crape Mystle

(Source :homedepot.com)

Figure 98 .Narrowleaf firethorn

(Source : sagebud.com)

Small-sized shrubs

Figure 99.Boxwood

(Source :provenwinners.com)

Figure 100. Rosemary

(Source gonative.co.nz)

Figure 101.Lavender

(Source gonative.co.nz)

Climbing

Figure 102Bougainvillea

(Source:MyBageecha.com)

Figure 103.Bostin ivy

(Source :venenofashion.com)

Perennial and carpeting plants

*Figure 104.**Cast Iron Plant***

(Source:hortology.co.uk)

Figure 105.Sword Fern (Source :Monrovia.com)

Figure 106.Oyster plan (Source:etsy.com)

Figure 107 .Bermuda grass (Source:homedepot.com)

3.8 Examples

The most Common Green Roof in Barcelona

Extensive Cases

Case 1 .It is a Extensive green roof:

This a case described above , In the case around the Mediterranean **Case 3.**
The Mies van der Rohe Foundation, created at the end of 2018 at the Salesians de Sarrià schools in Barcelona

Case 3 Figure 108 .Extensive green Roof Barcelona
(source:construible.es)

Case 2 of Extensive roof :

The Green Roof Frimercat, a Mercabarna.Barcelona

Figure 109. La coberta verda de Frimercat, a Mercabarna. ,Barcelona

(source : Elperiodico.com)

Urban Rooftop Farming :

Case 1 Private green roof building in Aragon estate with Casanova, Barcelona

Figure 110: Private green roof building Aragon estate with Casanova, Barcelona

(source : Elperiodico.com)

Future Green Roof Based on the plan of the Green Biodiversity of Barcelona promoted in June 2017:

Figure 111Garden Project
(Source : https://inarquia.es)

The Barcelona City Council will promote 75% of the works of the 10 private gardens located in private properties and without access to the general public .These are ten projects with heterogeneous characteristics and different areas: 83 m^2 the smallest and 1,085 m^2 the largest, with budgets ranging from 40,000 to 165,000 euros.

Examples of Future Green Roofs in Barcelona :

Case 1 Private garden on a roof of the Porxos d'en Xifré (Barcelona City Council)

Figure 112.Green Roof

(source : https://barcelonarchitecturewalks.com)

Case 2.Recreation of the green roof on a private roof inside Aragó Street (Barcelona City Council)

Figure 113.Green Roof

(source : https://barcelonarchitecturewalks.com)

Case 3 . Green roof in a building of the new Hospital de la Santa Creu i Sant Pau (Barcelona City Council)

Figure 114.Garden Project

(source : https://barcelonarchitecturewalks.com)

Case 4 . Garden project on the roof of a block of flats in Gràcia, (Barcelona City Council)

Figure 115.Garden project
(source : https://barcelonarchitecturewalks.com)

The most Common Technique of Green Facades in Barcelona:

1.Traditional Green Facade

Figure 116Ciutat Vella.Museo Marítimo, Barcelona

Source: :(arquitecturaplusingenio.blogspot.com)

3. Vegetable facades as second skin

3.1. Braided cable system

Case 1 Green Facade in FECSA –ENDESA ,Barcelona

Figure 117.Green Facade in FECSA –ENDESA ,Barcelona

(Source :jardineríabotanica.com)

3.2. Sliding facades

Case 1 Plantations and irrigation of the green facade of the power plant, Barcelona,year 2011,ForGas Architec

Figure 118.Slinding façade
(source: http://abpaisatgistes.cat/es/proyectos)

3. Pre-cultivated plant systems –Modular green Facade

Case 1 The Celler Cooperatiu de Rubí in Barcelona, Green facade described above in the **Case around the Mediterranean Case 1.**
The Celler Cooperatiu de Rubí in Barcelona building built by the architect Capella Cèsar Martinell.The modernist revival with a vertical garden on two of its facades

Figure 119 . Celler Cooperatui, Barcelona
(Source:*www. singulargreen.com)*

Case 2 .Cornellà-El Prat , football stadium of F.C. Spanish, Barcelona

Figure 120 Cornellà-El Prat green Wall, Barcelona

Source :(arquitecturaplusingenio.blogspot.com)

4.Hydroponic System

Case 1 .Cosmo Caixa Building,2018, Barcelona

Figure 121(source:Sebastian.eu)

Case 2 Hydroponic Green Building with 45m^2,BarcelonaIn the neighborhood of El Raval, on the Placa del Pedró.

Figure 122.Hydroponic System
Source : (singulargreen.com)

In relation to green roofs, we can highlight that when an information search is carried out, there are more documents related to the facades than with the green roofs. This is because Barcelona is a region in full sustainable growth.

5 COMPARISON-AMSTERDAM

What would happen if we compare the previous data with an advanced city in the field of green envelopes like Amsterdam?

Before arriving at prescribed conclusions we will analyze the same values as in Barcelona, climate, percentage of population, trajectory of the green and number of facades and current green roofs.

5.1 Amsterdam Location

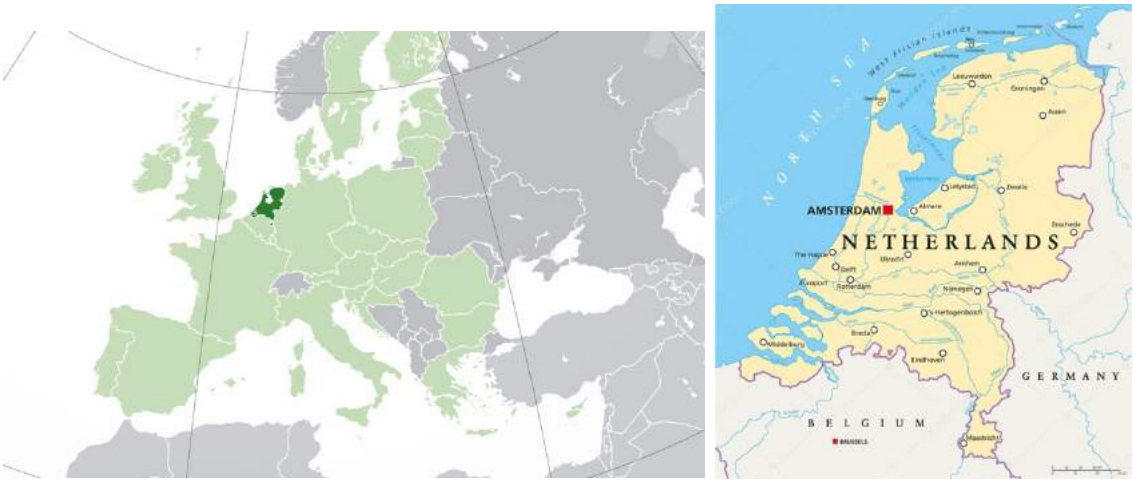


Figure 123.(Source : Wales, 2001)

The official capital of the Netherlands is Amsterdam, it is located between the IJ bay and the banks of the Amstel River. This city, which was founded in the 12th century, is currently one of the largest city in the country, with a population of 810000 inhabitants. It is a country with a great financial center and international culture. (Wales,2011)

5.2 Climate of Amsterdam

Climate of Amsterdam - Airport Schiphol:

The city has a moderate climate , under the strong influence of the Atlantic Ocean to the west and the winds that come from it. Winters are usually cold, but not extreme, although temperatures are very frequent below zero. Summers are hot with temperatures around 22 degrees. Both winters and summers are considered mild, although winters can be quite cold, while summers are quite warm occasionally. The average daily maximum in August is 22.1 °, and 35.5 ° C or more. Record extremes range from - 19.7 ° C to 35.7 ° C.

The average annual rainfall in Amsterdam is 838.2 millimeters. Cloudy and wet days are common during the colder months of October to March.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C (°F)	14.0 (57.2)	16.6 (61.9)	24.1 (75.4)	28.0 (82.4)	31.5 (88.7)	33.2 (91.8)	36.3 (97.3)	34.5 (94.1)	31.0 (87.8)	25.3 (77.5)	18.2 (64.8)	15.5 (59.9)	35.7 (96.3)
Average high °C (°F)	5.8 (42.4)	6.3 (43.3)	9.6 (49.3)	13.5 (56.3)	17.4 (63.3)	19.7 (67.5)	22.0 (71.6)	22.1 (71.8)	18.8 (65.8)	14.5 (58.1)	9.7 (49.5)	6.4 (43.5)	13.8 (56.9)
Daily mean °C (°F)	3.4 (38.1)	3.5 (38.3)	6.1 (43.0)	9.1 (48.4)	12.9 (55.2)	15.4 (59.7)	17.6 (63.7)	17.5 (63.5)	14.7 (58.5)	11.0 (51.8)	7.1 (44.8)	4.0 (39.2)	10.2 (50.3)
Average low °C (°F)	0.8 (33.4)	0.5 (32.9)	2.6 (36.7)	4.6 (40.3)	8.2 (46.8)	10.8 (51.4)	13.0 (55.4)	12.8 (55.0)	10.6 (51.1)	7.5 (45.5)	4.2 (39.6)	1.5 (34.7)	6.4 (43.6)
Record low °C (°F)	−16.3 (2.7)	−19.7 (−3.5)	−16.7 (1.9)	−4.7 (23.5)	−1.1 (30.0)	2.3 (36.1)	5.0 (41.0)	5.0 (41.0)	2.0 (35.6)	−3.4 (25.9)	−8.1 (17.4)	−14.8 (5.4)	−19.7 (−3.5)
Average precipitation mm (inches)	66.6 (2.62)	50.6 (1.99)	60.6 (2.39)	40.9 (1.61)	55.6 (2.19)	66.0 (2.60)	76.5 (3.01)	85.9 (3.38)	82.4 (3.24)	89.6 (3.53)	87.2 (3.43)	76.3 (3.00)	838.2 (33.00)
Average precipitation days (≥ 1 mm)	12	10	11	9	10	10	10	10	12	13	13	13	132
Average snowy days	6	6	4	2	0	0	0	0	0	0	3	5	26
Average relative humidity (%)	88	86	83	78	76	78	79	80	83	86	89	90	83
Mean monthly sunshine hours	63.2	87.5	126.3	182.7	221.9	205.7	217.0	197.0	139.4	109.1	61.7	50.5	1,662
Average ultraviolet index	1	1	2	4	5	6	6	5	4	2	1	0	3

Figure 124. Climate Data of Amsterdam Airport Schiphol

(source : Royal Netherlands Meteorological Institute(1981–2010 normals, snowy days normals for 1971–2000))

5.3 Green Areas In Amsterdam

According to the book Green Trajectories of Anguelovski, et al. (2018). The city currently has about 30 parks that guarantee access for all residents. Urban green development dates back to the General Expansion Plan of 1935 which provided for the development of new neighborhoods surrounded by green. In the last twenty-five years, the projects launched have focused on projects for the reconstruction of docks and the expansion and improvement of parks. To integrate with each other the green and blue spaces in the city. One of the key instruments of the city of Amsterdam to develop and rebuild green spaces is the "Amsterdam Hoofdgroenstructuur" (HGS).

It should be noted that the Netherlands has always been a point of interest to develop landscaping gardens. According to the International Green Roof Association (IGRA), only Amsterdam has about 200 green roofs, with a total area of approximately 120.000 m2 (Figure.125).

On the other hand, in Amsterdam, 20 million euros were invested in green projects with the Green Agenda 2015 plan to duplicate green spaces and transform the city. The plan also mentions an objective of a 25% increase in the green space of the neighborhood in the coming years through the creation of 20 pocket parks.

At present, the development of the plan called `` Amsterdam Plan - Building Green City, 2017 '' was established, which will take place until 2020. This plan is beneficial in such a way that the municipality is committed to having a greater development of green areas to obtain a good quality of life through better air quality, sufficient green space and land and clean water, as well as keeping the city acceptable. However, many owners are reluctant to install a roof garden. Areas with green roofs and green facades at the present

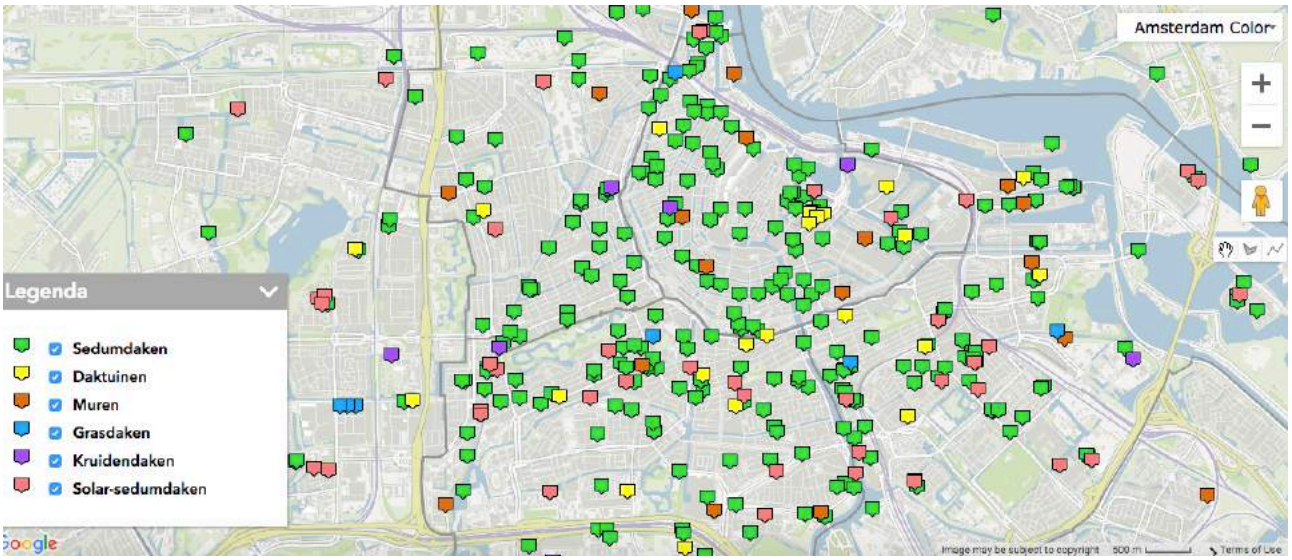


Figure 125. Urban natura atlas green roof and green façade
(Source : City of Amsterdam, 2015)

5.4 Comparison Conclusion

Looking at the data of both cases, we can highlight that Barcelona, although it is a smaller region than Amsterdam, has a higher population (Figure 126).According to press reports (the Vanguard newspaper) it is due to a migratory flow, in addition to other factors such as the climate, gastronomy, etc ... If we compare the climate of both regions, in Barcelona the average annual temperature is 16.5ºC with an average> 2.500 hours of sunshine per year (moderately moderate climate with beneficial temperature for good growth of the vegetation).

In Amsterdam the average temperature is 9.2ºC with 1.549 hours of sunshine per year decreasing in winter and for this reason you have to use vegetation more resistant to gross temperature changes (Prieto, 2017) .In terms of rainfall it stands out that Amsterdam is% higher per year with 838.2 mm while in Barcelona it is 600mm. Hence, Amsterdam is a region prone to collect rainwater with different sustainability methods.

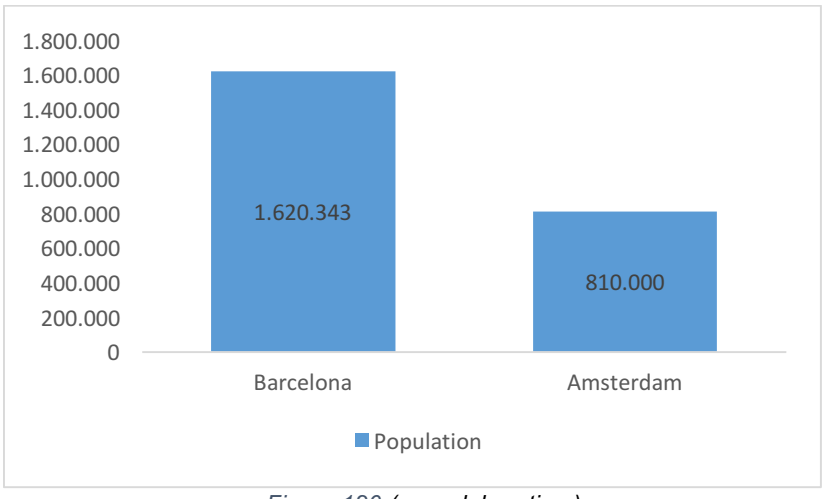


Figure 126 (own elaboration)

Regarding the evolutionary processes of the green areas of both cities, the same cannot be said. Amsterdan is a country that has an advantage with respect to sustainability and green areas since a development plan began to be implemented in 1935 compared to Barcelona that began after the 1992 Olympics. Looking at the images of the Figure 127. and Figure 128. of the different green roofs we can see that in Amsterdan there is an evolution in terms of vegetation integrated into buildings in front of the few buildings that are seen in the figure (although after an intensive search on the internet approximately 22 buildings appear) that reside in Barcelona.

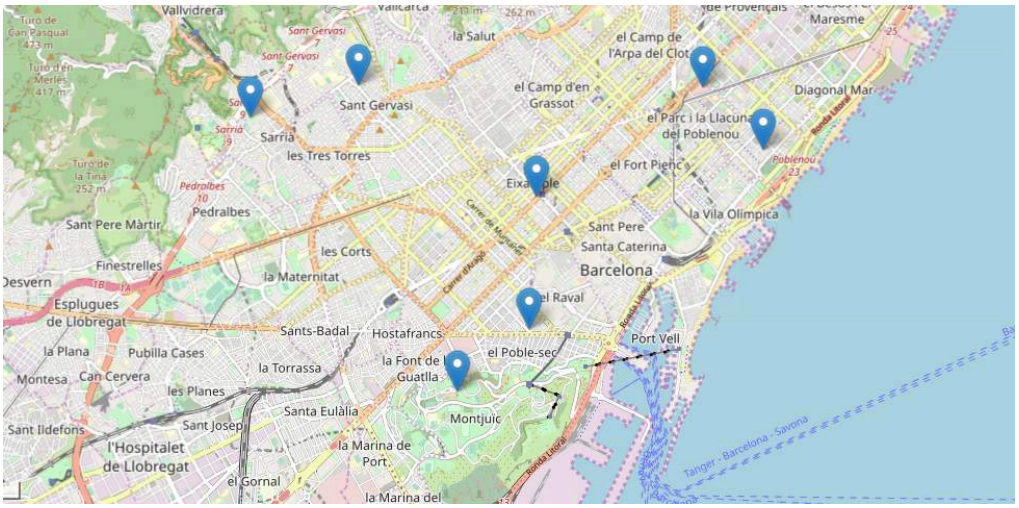


Figure 127 . Urban natura atlas green roof and green facade

(Source : Urban nature atlas ; explora.bcnsostenible.cat)

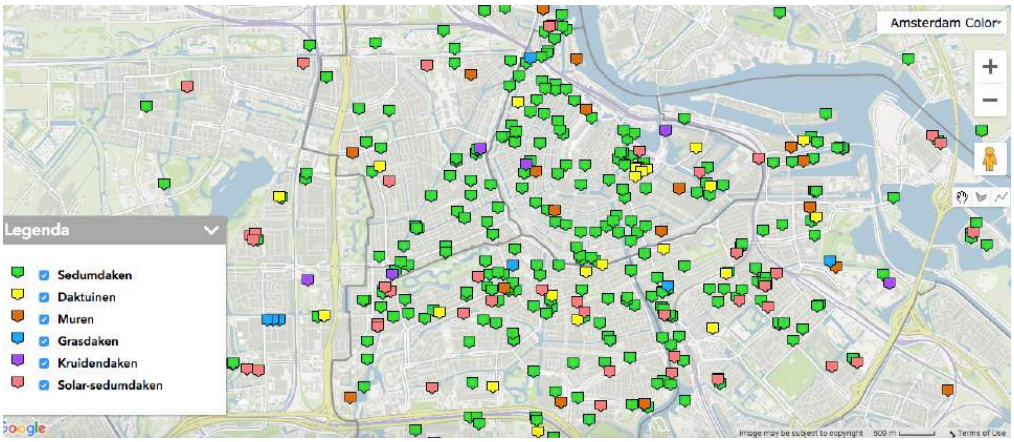


Figure 128 . Urban natura atlas green roof and green façade
(Source : City of Amsterdam, 2015)

We note that green roofs and vertical gardens are a fairly strong ecological trend in Amsterdam and in the process of increasing in Spain. Their benefits and attributes not only embellish the spaces, they also contribute to improving the quality of life in each intervened area.

5.5 Future Green Plan of Both Cities.

Amsterdam

According with de Amsterdam Plan Building Green city .(2017), the city in three years it must install in four places, from 2018 blue-green roofs that absorb more water than common greens and can grow a greater variety of plants.
Social housing in four locations in Amsterdam must be equipped with bluish-green smart roofs to help protect buildings from extreme weather conditions. To this end, European funds have contributed a total of € 4.8 million (SmartCitiesWorld News Team, 2018).

Figure 129(Spurce www.smartcitiesworld.net)

Barcelona

Although green is present in the city they are isolated spots, without continuity. The Plan proposes to strengthen its ecological, environmental, social and economic services by connecting the different areas with vegetation to form a robust and efficient ecological infrastructure.

According to the catalog of actions that will be carried out in Barcelona by 2020 within the Green and biodiversity plan and in relation to the green facades and the green roofs, a series of points are established: (Barcelona City Council, 2013)

1 Strengthen green on roofs, covers , facades and patios

The objetives of this point is to Increase the green area of Barcelona through the landscaping of roofs and patios, and also increase the new promotion and construction of green roofs and green facades in the municipal area.

To achieve this goal in Barcelona, it is described that you must carry out a series of guidelines:

Create a database containing the green roofs and the existing green facades, with all their characteristics, and follow up accordingly.

Run at least one green roof on municipal buildings in each of the ten districts of the city.

2 Promote private green by promoting orchards, balconies, terraces, covers, roofs, walls and garden patios

The objective of this point is to promote the participation of civil society in the creation of new green spaces in the private sphere.

3 Organize ideas contests related to green and biodiversity open to different groups

The objective of this point is to promote citizen participation in activities related to the green spaces of the city and the conservation of biodiversity, through ideas contests.

4 Actions that, together with other lines established in this plan, have the main objective of establishing :Turn Barcelona into a green benchmark, both nationally and internationally.

-It is concluded that with these actions, Barcelona can reach Amsterdam in the shortest possible time, although substantial assistance such as those from the Dutch city would be a great boost,

6 CONCLUSION

Throughout history there has been an evolution of green roofs and facades, due to the beneficial action they present, resulting in significant improvements in both technology and sustainable design. It is understood that the human being has always tried to be linked to or surrounded by nature. However, in recent years it seems that he has become unlinked. Currently, different countries and organizations intend to reconnect the human being with the nature to stop the existing climate crisis (the increase in CO2, acid rain, the island effect ...), integrating various sustainable systems such as green facades and green roofs in cities.

In the first part of this project, an in-depth study of the techniques, of green envelopes, on one side of the green roofs and on the other on the green facades has been carried out. In both cases we can conclude that there is a great variety of construction systems,with different trademarks, both national and international. We can also state that there are no clearly defined constructive typologies in the market, that information on costs and their form of maintenance is scarce, and that in some cases it is poorly classified, since they vary from one brand to another.

In my opinion, the most striking green roof systems offered by the zinco brand (previously described in this project) are: first, the lightweight extensive system named Irrigatted extensive roof (system that according to this zinco brand is very common in areas of the Mediterranean) or the lightweight system of green roof biodiversity that integrates fauna and flora. Secondly the semi-extensive green roof Headther with lavender. In third place could be the intensive Urban Rooftop Farming (which allows , to be created orchad for self-consumption), and lastly, the most noteworthy in my opinion is the Natureline intensive system (fully recyclable system made in part of sugarcane, capable of retain large amounts of water).
As for the systems of green facades that most caught my attention and of which we did not find a lot of information were: firstly the greenhouse facade system (facade that acts as a ventilation wall), secondly it could be said that it is the biodiversity facade (which integrates habitable elements in the facade for animals and fauna), thirdly the hydroponic facades (due to its diversity of plants) and finally the organic facade (a fairly innovative system). Making this study we conclude that the Traditional direct systems are cheaper in terms of price and maintenance, but do not offer as much color variety as hydroponic systems. Many times, in both systems, as green roofs and as green facades, they represent a high economic cost (which varies according to the system) but is amortized over the long term, due to the benefits they offer.

Likewise, it is noted that there are multiple advantages integrated in the systems, of green facades and green roofs, with respect to non-green buildings that do not include them. Highlighting among others: thermal regulation, acoustic insulation, CO2 absorption and polluting particles, reduction of the heat island effect in cities thanks to evapotranspiration, protection of buildings against solar radiation and even the possibility of using these areas as a crop or water collector. Do not forget that it generates an aesthetic value for the city, and that it provides positive psychological aspects to people (improves people's mood and performance), since a green city generates an antidepressant state. In addition, green facades and building roofs add value to the property

On the other hand, we must emphasize that when searching for information about the advantages, we find multiple publications, which guide us to understand, that the benefits they present are not only for buildings, but for the environment and people. But also when we want to detect data about thermal measurements we find that they are difficult to interpret, since these vary depending on the locations, conditions, orientations and systems used. On the other hand, although its efficacy for reducing temperatures is known, thermal resistance and transmittance are difficult to quantify from living elements (plants) or materials that are constantly changing state.

The project analyzes several cases in which these techniques are used. First, different cases of green facades and roofs around the world to have a solid basis of the different cases that we can find in different regions. Secondly, green facades and roofs in the Mediterranean environment, to get an idea of the most used systems in this climate environment, however the documentation referring to this point is scarce and makes it difficult to obtain well-developed cases. To conclude, it is concluded that the best way to see our area of action in the future is to evaluate innovative cases for the future or in the process of construction. This gives us an idea of how the technological advances of these techniques are directed.

Likewise, with the information obtained from our area of activity, we conclude that Barcelona is a city that is in a process of evolutionary development with the use of these techniques. Where we are, with some difficulty, current cases and in the process of development. This development comes from the fact that, in Spain, several sustainable plans have been developed to curb adverse climate problems. Specifically, in Barcelona, a sustainable development plan was implemented for 2020, which generates the growth of green areas, thus reducing the effect of the island and bringing other benefits to the city (personal comfort, sound insulation, integration of animals, ..). By wanting to compare this data with a city like Amsterdam, a city that is understood, thanks to the information collected, which is more evolved than Barcelona, in green areas due to its previous performance creating sustainability plans .We can conclude that Barcelona still has a long way to go,in order to be compared with a city like Amsterdam in terms of green facades and green roofs, but it can take the city as a point of reference for personal development.

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8 FIGURES LIST

9 ANNEXES

Budgets of Green Roof with Cype DataBase -Anexes A

Annex A - Budget of Some Green Roofs

Annex A .1 Extensive green roof-Sedum Tapestry

VE020 m² Transitable extensible green roof, Sedum Tapestry system "ZINCO". € 128.62

Transient flat roof, non-ventilated, extensive garden (ecological), Sedum Tapestry system "ZINCO", consisting of: formation of slopes: concrete cement-based concrete and plasticizing-aerating additive, compression resistance 0.2 MPa and 350 kg / m³ density, made of gray cement and plasticizing-aerating additive, with a thickness of 10 cm, finished with a layer of regularization of cement mortar, industrial, M-5 of 2 cm thick; Adhesive bilayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -30-FV and modified bitumen plate with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to a blower, without overlapping its joints ; Flexible polyurethane low-density membrane, WSF 40 "ZINCO", black; separating layer under protection: protective blanket and retainer SSM 45 "ZINCO", made up of polyester and polypropylene geotextile, with a surface mass of 470 g / m²; drainage layer and water retainer: Floradrain module FD 25-E "ZINCO"; filtering layer: filter system SF "ZINCO", formed by a geotextile of polypropylene fibers; Protective layer: Zincoterra floral "ZINCO", 80 mm thick, plants with flat root, Zinco Sedum Mix "ZINCO".

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt04lcc010c	U	Hollow ceramic brick (brick), for covering, 29x14x9 cm, for use in a protected factory (piece P), density 805 kg / m³, according to UNE-EN 771-1.	3,000	0.16	0.48
mt08cem011a	kg	Cement Pórtland CEM II / BL 32.5 R, gray in sacks, according to UNE-EN 197-1.	30,000	0.10	3.00
mt08adt050	kg	Plasticizing-aerating additive for cellular concrete.	0.300	6.31	1.89
mt08aaa010a	m³	Water	0.047	1.50	0.07
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.038	33.86	1,29
mt16pea020b	m²	Rigid panel of expanded polystyrene, according to UNE-EN 13163, straight lateral machining, 20 mm thickness, thermal resistance 0.55 m²K / W, thermal conductivity 0.036 W / (mK), for expansion joint.	0.010	1.34	0.01
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lba010a	m²	Modified bitumen with SBS elastomer, LBM (SBS) -30-FV, 2.5 mm thickness, nominal mass 3 kg / m², with 60 g / m² fiberglass felt frame, non-surface protected According to UNE-EN 13707.	1,100	3.31	3.64
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection,	1,100	6.86	7.55

		with resistance to penetration of roots. According to UNE-EN 13707.			
mt14lbz020a	m²	Flexible polyurethane low-density polyurethane membrane, WSF 40 "ZINCO", black, for green covers.	1,750	2.92	5.11
mt14lbz040qa	m²	SSM 45 "ZINCO" protective and retainer blanket, formed by polyester and polypropylene geotextile, 5 mm thick, with a water retention of 5 l / m², a resistance to the longitudinal tract of 5.5 kN / m , a CBR resistance to punching 2 kN, and a surface mass of 470 g / m², supplied in rolls.	1,100	2.64	2.90
mt14lbz030aia	m²	Drain and water retention module, Floradrain FD 25-E "ZINCO", of recycled polyolefins with perforations in the upper part, provided in plates. Even union clips.	1.030	8.25	8.50
mt14lbz050a	m²	SF "ZINCO" system filter, formed by a synthetic non-woven geotextile, made up of polypropylene fibers joined by threads, heat-sealed on both sides, 0.6 mm thick, with a longitudinal pull resistance of 7 kN / m , a CBR resistance to punching 1.1 kN, and a surface mass of 100 g / m², supplied in rolls.	1,200	1.10	1.32
mt48saz010b	m³	Zincoterra floral substrate "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.106	88.50	9.38
mt48epz010ia	m²	Plants with flat root, Zinco Sedum Mix "ZINCO", supplied in trays of 60 pieces with 4 or more species of crespinell, for green covers.	1.030	10.08	10.38
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**57.05**
2		**Equipment and machinery**			
mq06cel010	h	Equipment for the manufacturing and pumping of cement-based cellular concrete and plasticizing-aerating additive, of 12 m³ / h.	0.035	23.44	0.82
			Subtotal equipment and machinery:		**0.82**
3		**Labour force**			
mo020	h	Official 1st construction.	0.393	25.08	9.86
mo113	h	Ordinary pedestal construction.	0,524	21.69	11.37
mo029	h	Official 1st applicator of waterproofing sheets.	0.467	25.08	11.71
mo067	h	Helping applicator waterproofing sheets.	0.467	22.78	10.64
mo040	h	Official 1st gardener.	0,515	25.08	12.92
mo086	h	Assistant gardener	0,515	22.78	11.73
			Subtotal manpower:		**68.23**
4		**Complementary direct costs**			
	%	Complementary direct costs	2,000	126.10	2.52
Ten-year maintenance cost: € 40.52 in the first 10 years.			**Direct costs** (1 + 2 + 3 + 4):		128.6

Annex A .2 Extensive Green Roof – Up to 20 º System

QVE021 m² Extensive green cover not transitable, Cover system Inclined up to 20 ° "ZINCO".

Inclined roof not transitable, extensive garden (ecological), system Covered Inclined up to 20 ° "ZINCO", with an average slope of 8.75%, consisting of: formation of slopes (not included in this price); adhesive monolayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to blowtorch; separating layer under insulation: non-woven geotextile made up of polyester fibers joined together, (150 g / m²); Thermal insulation: rigid extruded polystyrene panel, smooth surface and half-lateral machining of 40 mm thickness, compressive strength> = 300 kPa; protective separating layer: de-solubilization sheet, flexible, polypropylene, TGV 21 "ZINCO", with a surface mass of 80 g / m²; drainage layer and water retainer: Module Floraset FS 75 "ZINCO"; Coating layer: Zincoterra floral "ZINCO" 70 mm thick, and plants with flat root, Zinco Sedum Mix "ZINCO".

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.038	33.86	1,29
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14gsa020bc	m²	Non-woven geotextile made up of polyester fibers joined by threads, with a resistance to the longitudinal tract of 1.88 kN / m, a resistance to the transversal traction of 1.49 kN / m, an opening of cone to the test of dynamic drilling according to UNE-EN ISO 13433 less than 40 mm, CBR resistance to punching 0.3 kN and a surface mass of 150 g / m², according to UNE-EN 13252.	1,050	0.45	0.47
mt16pxa010ab	m²	Rigid panel of extruded polystyrene, according to UNE-EN 13164, of smooth surface and machined side of half-mast, 40 mm thickness, compressive strength> = 300 kPa, thermal resistance 1.2 m²K / W, thermal conductivity 0.034 W / (mK), Euroclase E of reaction to fire, with designation code XPS-EN 13164-T1-CS (10 / Y) 300-DLT (2) 5-DS (TH) -WL (T) 0.7- -FT2.	1,050	2.36	2.48
mt14lbz070a	m²	Polypropylene, polypropylene, 21 "ZINCO" de-solidifying sheet, waterproof, water-vapor permeable, 0.55 mm thick, with a surface mass of 80 g / m², supplied in rolls of 1.60x250 m.	1,100	0.99	1.09
mt14lbz030fga	m²	Water drainage and retainer module, Floraset FS 75 "ZINCO", expanded polystyrene, supplied in plates.	1.030	13.97	14.39
mt48saz010b	m³	Zincoterra floral substrate "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.084	88.50	7.43

mt48epz010ia	m²	Plants with flat root, Zinco Sedum Mix "ZINCO", supplied in trays of 60 pieces with 4 or more species of crespinell, for green covers.	1,000	10.08	10.08
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**46.31**
2		**Labour force**			
mo020	h	Official 1st construction.	1.638	25.08	41.08
mo113	h	Ordinary pedestal construction.	1.638	21.69	35.53
mo029	h	Official 1st applicator of waterproofing sheets.	0.266	25.08	6,67
mo067	h	Helping applicator waterproofing sheets.	0.266	22.78	6.06
mo040	h	Official 1st gardener.	0,524	25.08	13.14
mo086	h	Assistant gardener	0,524	22.78	11.94
			Subtotal manpower:		**114.42**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	160.73	3.21
Ten-year maintenance cost: € 51.64 in the first 10 years.			**Direct costs** (1 + 2 + 3):		163.94

Annex A .3 Extensive green Roof – Up to 35 º

QVE022 m² Extensive green cover not transitable, Cover system Inclined up to 35 ° "ZINCO". € 208.21

Inclined roof not transitable, extensive garden (ecological), roof system Inclined up to 35 ° "ZINCO", with an average gradient of 36,4%, consisting of: formation of slopes (not included in this price); adhesive monolayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to blowtorch; separating layer under insulation: non-woven geotextile made up of polyester fibers joined together, (150 g / m²); Thermal insulation: rigid extruded polystyrene panel, smooth surface and half-lateral machining of 40 mm thickness, compressive strength> = 300 kPa; protective separating layer: de-solubilization sheet, flexible, polypropylene, TGV 21 "ZINCO", with a surface mass of 80 g / m²; drainage layer: Georaster module "ZINCO";

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.038	33.86	1,29
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14gsa020bc	m²	Non-woven geotextile made up of polyester fibers joined by threads, with a resistance to the longitudinal tract of 1.88 kN / m, a resistance to the transversal traction of 1.49 kN / m, an opening of cone to the test of dynamic drilling according to UNE-EN ISO 13433 less than 40 mm, CBR resistance to punching 0.3 kN and a surface mass of 150 g / m², according to UNE-EN 13252.	1,100	0.45	0.50
mt16pxa010ab	m²	Rigid panel of extruded polystyrene, according to UNE-EN 13164, of smooth surface and machined side of half-mast, 40 mm thickness, compressive strength> = 300 kPa, thermal resistance 1.2 m²K / W, thermal conductivity 0.034 W / (mK), Euroclase E of reaction to	1,050	2.36	2.48

		fire, with designation code XPS-EN 13164-T1-CS (10 / Y) 300-DLT (2) 5-DS (TH) -WL (T) 0.7- -FT2.			
mt14lbz070a	m²	Polypropylene, polypropylene, 21 "ZINCO" de-solidifying sheet, waterproof, water-vapor permeable, 0.55 mm thick, with a surface mass of 80 g / m², supplied in rolls of 1.60x250 m.	1,100	0.99	1.09
mt14lbz100a	U	"ZINCO" Georaster Module, high density polyethylene (HDPE / HDPE), 80% recycled, 540x540 mm and 100 mm high, with U profile for distribution of loads and profiles in T for union between modules; for drainage and subjection of the substrate layer.	2,560	20.41	52.25
mt48saz010b	m³	Zincoterra floral substrate "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.120	88.50	10.62
mt48maz010a	m²	Jute fiber mesh for erosion control, of 500 g / m² of surface mass and 30 x 40 mm of mesh pass, supplied in rolls of 1.22 x 70 m.	1,100	1.00	1.10
mt48epz010ia	m²	Plants with flat root, Zinco Sedum Mix "ZINCO", supplied in trays of 60 pieces with 4 or more species of crespinell, for green covers.	1,000	10.08	10.08
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**88.49**
2		**Labour force**			
mo020	h	Official 1st construction.	1,314	25.08	32.96
mo113	h	Ordinary pedestal construction.	1,314	21.69	28.50
mo029	h	Official 1st applicator of waterproofing sheets.	0.439	25.08	11.01
mo067	h	Helping applicator waterproofing sheets.	0.439	22.78	10.00
mo040	h	Official 1st gardener.	0.693	25.08	17.38
mo086	h	Assistant gardener	0.693	22.78	15.79
			Subtotal manpower:		**115.64**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	204.13	4.08
Ten-year maintenance cost: € 65.59 in the first 10 years.			**Direct costs** (1 + 2 + 3):		208.21

Annex A .4 Extensive green Roof with Irrigation System

QVE023 m² Coverable green cover, with integrated irrigation system "ZINCO".

Transient flat roof, non-ventilated, extensive garden (ecological), with integrated irrigation system "ZINCO", consisting of: formation of slopes: lightweight concrete, compression resistance 2.0 MPa and 690 kg / m³ density, made in Works with expanded clay and gray cement, with a thickness of 10 cm, finished with a layer of regularization of cement mortar, industrial, M-5 of 2 cm thick; Adhesive bilayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -30-FV and modified bitumen plate with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to a blower, without overlapping its joints ; Flexible polyurethane low-density membrane, WSF 40 "ZINCO", black; separating layer under protection: protective blanket and retainer SSM 45 "ZINCO", formed by geotextile of polyester and polypropylene, with a surface mass of 470 g / m²; drainage layer and water retainer: Floradrain module FD 25-E "ZINCO"; Filtering layer and water dispenser: AF 300 "ZINCO" water distribution felt formed by a polypropylene fiber geotextile and an acrylic sheet on one of its faces; irrigation installation: drip irrigation pipe fixed to the filter layer and water dispenser with velcro strips, black; Protective layer: Zincoterra Floral "ZINCO" substrate, 100 mm thick, plants with bread of flat roots, Zinco Sedum Mix "ZINCO". The price does not include the supply and distribution pipeline or the accessories. Floradrain FD 25-E module "ZINCO"; Filtering layer and water dispenser: AF 300 "ZINCO" water distribution felt formed by a polypropylene fiber geotextile and an acrylic sheet on one of its faces; irrigation installation: drip irrigation pipe fixed to the filter layer and water dispenser with velcro strips, black; Protective layer: Zincoterra Floral "ZINCO" substrate, 100 mm thick, plants with bread of flat roots, Zinco Sedum Mix "ZINCO". The price does not include the supply and distribution pipeline or the accessories. Floradrain FD 25-E module "ZINCO"; Filtering layer and water dispenser: AF 300 "ZINCO" water distribution felt formed by a polypropylene fiber geotextile and an acrylic sheet on one of its faces; irrigation installation: drip irrigation pipe fixed to the filter layer and water dispenser with velcro strips, black; Protective layer: Zincoterra Floral "ZINCO" substrate, 100 mm thick, plants with bread of flat roots, Zinco Sedum Mix "ZINCO". The price does not include

the supply and distribution pipeline or the accessories. irrigation installation: drip irrigation pipe fixed to the filter layer and water dispenser with velcro strips, black; Protective layer: Zincoterra Floral "ZINCO" substrate, 100 mm thick, plants with bread of flat roots, Zinco Sedum Mix "ZINCO". The price does not include the supply and distribution pipeline or the accessories. irrigation installation: drip irrigation pipe fixed to the filter layer and water dispenser with velcro strips, black; Protective layer: Zincoterra Floral "ZINCO" substrate, 100 mm thick, plants with bread of flat roots, Zinco Sedum Mix "ZINCO". The price does not include the supply and distribution pipeline or the accessories.

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt04lcc010c	U	Hollow ceramic brick (brick), for covering, 29x14x9 cm, for use in a protected factory (piece P), density 805 kg / m³, according to UNE-EN 771-1.	3,000	0.16	0.48
mt01arl030ab	m³	Expanded clay, supplied in Big Bag bags, according to UNE-EN 13055-1.	0.105	125.69	13.20
mt08cem011a	kg	Cement Pórtland CEM II / BL 32.5 R, gray in sacks, according to UNE-EN 197-1.	20,000	0.10	2.00
mt08aaa010a	m³	Water	0.012	1.50	0.02
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.038	33.86	1,29
mt16pea020b	m²	Rigid panel of expanded polystyrene, according to UNE-EN 13163, straight lateral machining, 20 mm thickness, thermal resistance 0.55 m²K / W, thermal conductivity 0.036 W / (mK), for expansion joint.	0.010	1.34	0.01
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lba010a	m²	Modified bitumen with SBS elastomer, LBM (SBS) -30-FV, 2.5 mm thickness, nominal mass 3 kg / m², with 60 g / m² fiberglass felt frame, non-surface protected According to UNE-EN 13707.	1,100	3.31	3.64
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14lbz020a	m²	Flexible polyurethane low-density polyurethane membrane, WSF 40 "ZINCO", black, for green covers.	1,750	2.92	5.11
mt14lbz040qa	m²	SSM 45 "ZINCO" protective and retainer blanket, formed by polyester and polypropylene geotextile, 5 mm thick, with a water retention of 5 l / m², a resistance to the longitudinal tract of 5.5 kN / m , a CBR resistance to punching 2 kN, and a surface mass of 470 g / m², supplied in rolls.	1,100	2.64	2.90
mt14lbz030aia	m²	Drain and water retention module, Floradrain FD 25-E "ZINCO", of recycled polyolefins with perforations in the upper part, provided in plates. Even union clips.	1.030	8.25	8.50
mt14lbz060a	m²	Water repellent FelT 300 "ZINCO", made up of a synthetic non-woven geotextile, made up of polypropylene fibers joined by threads, heat-soldered on both sides, with a longitudinal traction resistance of 19 kN / m and an acrylic laminate in one of its	1,200	7.21	8.65

		faces; Of 300 g / m² of surface mass and 2.4 mm of total thickness, supplied in rolls of 2.10x50 m.			
mt48tpz010c	m	Polyethylene tube, 500-L2 "ZINCO", black color, 16 mm in outer diameter, with integrated self-compensating and self-cleaning driers, located every 50 cm, supplied in rolls, with the price increased by 10% for accessories and special pieces	1,200	2.57	3.08
mt48tpz011a	m	Belt of velcro strips, black color, 5 cm wide and 12 cm in length, for the fixation of the 500-L2 tubes of water distribution AF 300 in green roofs "ZINCO".	0.240	2.85	0.68
mt48saz010b	m³	Zincoterra floral substrate "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.130	88.50	11.51
mt48epz010ia	m²	Plants with flat root, Zinco Sedum Mix "ZINCO", supplied in trays of 60 pieces with 4 or more species of crespinell, for green covers.	1.030	10.08	10.38
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**80.53**
2		**Equipment and machinery**			
mq06hor010	h	Concrete mixer	0.073	1.68	0.12
			Subtotal equipment and machinery:		**0.12**
3		**Labour force**			
mo020	h	Official 1st construction.	0.196	25.08	4.92
mo113	h	Ordinary pedestal construction.	0.327	21.69	7.09
mo029	h	Official 1st applicator of waterproofing sheets.	0.467	25.08	11.71
mo067	h	Helping applicator waterproofing sheets.	0.467	22.78	10.64
mo040	h	Official 1st gardener.	0,580	25.08	14.55
mo086	h	Assistant gardener	0,580	22.78	13.21
mo008	h	Official 1st plumbers.	0.013	25.83	0.34
mo107	h	Plumber Assistant	0.065	22.75	1.48
			Subtotal manpower:		**63.94**
4		**Complementary direct costs**			
	%	Complementary direct costs	2,000	144.59	2.89
				Direct costs (1 + 2 + 3 + 4):	147.48

Annex A .5 Semi –Extensive Green Roff –Aromatic System

QVM010 m² Semi-intensive green roof transitable, system Aromatic Plants "ZINCO". € 136.70

Transient flat roof, non-ventilated, semi-intensive landscaped, system Aromatic Plants "ZINCO", consisting of: formation of slopes: expanded clay, driven dry and consolidated in its surface with cement grout, with a thickness of 10 cm, finished with layer of regularization of cement mortar, industrial, M-5 of 4 cm thick; Adhesive bilayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -30-FV and modified bitumen plate with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to a blower, without overlapping its joints ; Flexible polyurethane low-density membrane, WSF 40 "ZINCO", black; protective separating layer: protective blanket and retainer SSM 45 "ZINCO", made up of polyester and polypropylene geotextile, with a surface mass of 470 g / m²; drainage layer and water retainer: Floradrain module FD 40-E "ZINCO"; filtering layer: filter system SF "ZINCO", formed by a geotextile of polypropylene fibers; protective layer: Zincoterra garden substrate "ZINCO", 100 mm thick, plants with flat root, Zinco Sedum Mix "ZINCO".

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt04lcc010c	U	Hollow ceramic brick (brick), for covering, 29x14x9 cm, for use in a protected factory (piece P), density 805 kg / m³, according to UNE-EN 771-1.	3,000	0.16	0.48
mt01arl030aa	m³	Clay expanded, supplied in bags, according to UNE-EN 13055-1.	0.100	135.87	13.59
mt09lec020b	m³	Cement boiled 1/3 CEM II / BP 32.5 N.	0.010	105.10	1.05
mt08aaa010a	m³	Water	0.014	1.50	0.02
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.075	33.86	2.54
mt16pea020b	m²	Rigid panel of expanded polystyrene, according to UNE-EN 13163, straight lateral machining, 20 mm thickness, thermal resistance 0.55 m²K / W, thermal conductivity 0.036 W / (mK), for expansion joint.	0.010	1.34	0.01
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lba010a	m²	Modified bitumen with SBS elastomer, LBM (SBS) -30-FV, 2.5 mm thickness, nominal mass 3 kg / m², with 60 g / m² fiberglass felt frame, non-surface protected According to UNE-EN 13707.	1,100	3.31	3.64
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14lbz020a	m²	Flexible polyurethane low-density polyurethane membrane, WSF 40 "ZINCO", black, for green covers.	1,750	2.92	5.11
mt14lbz040qa	m²	SSM 45 "ZINCO" protective and retainer blanket, formed by polyester and polypropylene geotextile, 5 mm thick, with a water retention of 5 l / m², a resistance to the longitudinal tract of 5.5 kN / m , a CBR resistance to punching 2 kN, and a surface mass of 470 g / m², supplied in rolls.	1,100	2.64	2.90
mt14lbz030ira	m²	Drain and water retention module, Floradrain FD 40-E "ZINCO", of recycled polyolefins with perforations in the upper part, provided in plates. Even union clips.	1.030	10.23	10.54
mt14lbz050a	m²	SF "ZINCO" system filter, formed by a synthetic non-woven geotextile, made up of polypropylene fibers joined by threads, heat-sealed on both sides, 0.6 mm thick, with a longitudinal pull resistance of 7 kN / m , a CBR resistance to punching 1.1 kN, and a surface mass of 100 g / m², supplied in rolls.	1,200	1.10	1.32
mt48saz010d	m³	Zincoterra Substrate Garden "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.147	84.00	12.35
mt48epz010ia	m²	Plants with flat root, Zinco Sedum Mix "ZINCO", supplied in trays of 60 pieces with 4 or more species of crespinell, for green covers.	1,000	10.08	10.08
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**72.71**
2		**Labour force**			
mo020	h	Official 1st construction.	0.118	25.08	2.96
mo113	h	Ordinary pedestal construction.	0.380	21.69	8.24
mo029	h	Official 1st applicator of waterproofing sheets.	0.467	25.08	11.71
mo067	h	Helping applicator waterproofing sheets.	0.467	22.78	10.64
mo040	h	Official 1st gardener.	0,580	25.08	14.55

mo086	h	Assistant gardener	0,580	22.78	13.21
			Subtotal manpower:		**61.31**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	134.02	2.68
Ten-year maintenance cost: € 129.28 in the first 10 years.			**Direct costs** (1 + 2 + 3):		136.70

Annex A.6 Intesive Green Roof –Garden System

QVI010 m² Transitable intensive green roof, Garden system "ZINCO". € 202.33

Flat roof transitable, non-ventilated, intensive gardening, Garden system "ZINCO", consisting of: formation of slopes: expanded clay, dried and consolidated in its surface with cement grout, with a thickness of 10 cm, finished with layer of regularization of mortar of cement, industrial, M-5 of 4 cm of thickness; Adhesive bilayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -30-FV and modified bitumen plate with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to a blower, without overlapping its joints ; Polyolefin flexible anti-loop membrane, WSB 100-PO "ZINCO", black; protective separator layer: Protective blanket and retainer ISM 50 "ZINCO", made up of polyester and polypropylene geotextile, with a surface mass of 850 g / m²; drainage layer and water retainer: module Floradrain FD 60 Neo "ZINCO"; Filtering layer: TG "ZINCO" system filter, formed by a geotextile of polypropylene fibers; Protection layer: Zincoterra garden substrate "ZINCO" 270 mm thick.

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt04lcc010c	U	Hollow ceramic brick (brick), for covering, 29x14x9 cm, for use in a protected factory (piece P), density 805 kg / m³, according to UNE-EN 771-1.	3,000	0.16	0.48
mt01arl030aa	m³	Clay expanded, supplied in bags, according to UNE-EN 13055-1.	0.100	135.87	13.59
mt09lec020b	m³	Cement boiled 1/3 CEM II / BP 32.5 N.	0.010	105.10	1.05
mt08aaa010a	m³	Water	0.014	1.50	0.02
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.075	33.86	2.54
mt16pea020b	m²	Rigid panel of expanded polystyrene, according to UNE-EN 13163, straight lateral machining, 20 mm thickness, thermal resistance 0.55 m²K / W, thermal conductivity 0.036 W / (mK), for expansion joint.	0.010	1.34	0.01
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lba010a	m²	Modified bitumen with SBS elastomer, LBM (SBS) -30-FV, 2.5 mm thickness, nominal mass 3 kg / m², with 60 g / m² fiberglass felt frame, non-surface protected According to UNE-EN 13707.	1,100	3.31	3.64
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14lbz020d	m²	Flexible polyolefin flexible anti-ring membrane, WSB 100-PO "ZINCO", black, for green covers.	1,750	17.05	29.84
mt14lbz040En	m²	Protective and retainer blanket ISM 50 "ZINCO", made up of polyester and polypropylene geotextile, 6 mm thick, with a water retention of 4 l / m², a CBR resistance to punching 3.5 kN, and a mass surface of 850 g / m², supplied in rolls.	1,100	6,88	7.57

mt14lbz030qAa	m²	Draining and water retention module, Floradrain FD 60 Neo "ZINCO", of recycled polyolefins with perforations in the upper part, provided in plates. Even union clips.	1.030	18.48	19.03
mt14lbz050p	m²	TG "ZINCO" system filter, formed by a synthetic non-woven geotextile, made up of polypropylene fibers joined by threads, heat-sealed on both sides, 1 mm thick, with a longitudinal tract resistance of 11 kN / m, one CBR resistance to punching 2.55 kN, and a surface mass of 150 g / m², supplied in rolls.	1,200	1.93	2.32
mt48saz010d	m³	Zincoterra Substrate Garden "ZINCO", composed of ceramic selected crushed and other mineral components mixed with compost and blond peat, supplied in bulk, for green covers.	0.378	84.00	31.75
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**120.92**
2		**Labour force**			
mo020	h	Official 1st construction.	0.118	25.08	2.96
mo113	h	Ordinary pedestal construction.	0.380	21.69	8.24
mo029	h	Official 1st applicator of waterproofing sheets.	0.467	25.08	11.71
mo067	h	Helping applicator waterproofing sheets.	0.467	22.78	10.64
mo040	h	Official 1st gardener.	0.917	25.08	23.00
mo086	h	Assistant gardener	0.917	22.78	20.89
			Subtotal manpower:		**77.44**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	198.36	3.97
Ten-year maintenance cost: € 171.37 in the first 10 years.			**Direct costs** (1 + 2 + 3):		202.33

Anexo A .7 Intensive Green Roof –Urban Farm System

QVI040 m² Green intensive transitable roof, Urban Farm system "PROJAR". € 202.97

Transient flat roof, non-ventilated, intensive landscaping, Urban Farm system "PROJAR", consisting of: formation of slopes: expanded clay, driven dry and consolidated in its surface with cement grout, with a thickness of 10 cm, finished with layer of regularization of cement mortar, industrial, M-5 of 4 cm thick; Adhesive bilayer waterproofing: modified bitumen sheet with SBS elastomer, LBM (SBS) -30-FV and modified bitumen plate with SBS elastomer, LBM (SBS) -50 / G-FP, fully adhered to a blower, without overlapping its joints ; protective separating layer under protection and retention Felt Diadem VLS-500 "PROJAR", of non-woven synthetic geotextile, with a surface mass of 500 g / m²; flexible anti-loop membrane of plasticized vinyl polychloride (PVC-P), Diadem FLW-1000 "PROJAR", Brown; drainage layer and water retainer: drainage sheet Diadem DiaDrain 40H "PROJAR"; filtering layer: filter Diadem VLF-200 "PROJAR", of polypropylene fiber geotextile; Protection layer: CoverPro Urban Farm "PROJAR" substrate, 450 mm thick.

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt04lcc010c	U	Hollow ceramic brick (brick), for covering, 29x14x9 cm, for use in a protected factory (piece P), density 805 kg / m³, according to UNE-EN 771-1.	3,000	0.16	0.48
mt01arl030aa	m³	Clay expanded, supplied in bags, according to UNE-EN 13055-1.	0.100	135.87	13.59
mt09lec020b	m³	Cement boiled 1/3 CEM II / BP 32.5 N.	0.010	105.10	1.05
mt08aaa010a	m³	Water	0.014	1.50	0.02
mt09mif010ca	t	Industrial mortar for palette, cement, gray, M-5 (compression resistance 5 N / mm²), supplied in bags, according to UNE-EN 998-2.	0.075	33.86	2.54
mt16pea020b	m²	Rigid panel of expanded polystyrene, according to UNE-EN 13163, straight lateral machining, 20 mm	0.010	1.34	0.01

		thickness, thermal resistance 0.55 m²K / W, thermal conductivity 0.036 W / (mK), for expansion joint.			
mt14iea020c	kg	Anionic asphalt emulsion with EB-type loads, according to UNE 104231.	0.300	1.38	0.41
mt14lba010a	m²	Modified bitumen with SBS elastomer, LBM (SBS) -30-FV, 2.5 mm thickness, nominal mass 3 kg / m², with 60 g / m² fiberglass felt frame, non-surface protected According to UNE-EN 13707.	1,100	3.31	3.64
mt14lga010mc	m²	Modified bitumen with SBS elastomer, LBM (SBS) -50 / G-FP, 3.5 mm thickness, nominal mass 5 kg / m², with reinforced and stabilized polyester felt frame of 150 g / m², With green mineral self-protection, with resistance to penetration of roots. According to UNE-EN 13707.	1,100	6.86	7.55
mt14lbp020a	m²	Flexible Polyethylene Low Density Polyurethane (LDPE), Diadem FLW-400 "PROJAR", black color, supplied in rolls of 4x25 m; for green covers.	1.030	3.61	3.72
mt14lbp040rc	m²	Felt of protection and retention Diadem VLS-500 "PROJAR", of non-synthetic non-woven fabric, composed of 70% polyethersulfone fibers and 30% polypropylene fibers joined together for picking up, 4 mm in thickness, water 7 l / m², water permeability 50 mm / s, resistance to longitudinal traction 4,4 kN / m, CBR resistance to punching 3.3 kN and surface mass 500 g / m², supplied in rolls.	1,100	2.38	2.62
mt14lbp030nb	m²	Water-draining and retaining sheet Diadem DiaDrain 40H "PROJAR", high-impact recycled polystyrene (HIPS), with 40 mm height nodules and perforations at the top, 338 kN / m² compression resistance, water retention 19.59 l / m², drainage capacity 1.01 l / (s m) with a slope of 2%, supplied in plates of 204x104 cm.	1,100	13.03	14.33
mt14lbp050i	m²	Dijat filter VLF-200 "PROJAR", of non-synthetic non-woven fabric, made up of polypropylene fibers joined by threads, longitudinal drive resistance 16 kN / m, CBR resistance to punching 2.35 kN and surface mass 200 g / m², supplied in rolls.	1,100	1.62	1.78
mt48sap010d	m³	Substrate CoverPro Urban Farm "PROJAR", composed of humus, coconut fiber, sand, compound and fertilizer; with a pH lower than or equal to 7, supplied in Big Bag bags, for green covers.	0.608	65.83	40.02
mt01arc010	t	Rolling edges of 16 to 32 mm in diameter.	0.040	28.00	1.12
			Subtotal materials:		**92.88**
2		**Labour force**			
mo020	h	Official 1st construction.	0.118	25.08	2.96
mo113	h	Ordinary pedestal construction.	0.380	21.69	8.24
mo029	h	Official 1st applicator of waterproofing sheets.	0.477	25.08	11.96
mo067	h	Helping applicator waterproofing sheets.	0.477	22.78	10.87
mo040	h	Official 1st gardener.	1,506	25.08	37.77
mo086	h	Assistant gardener	1,506	22.78	34.31
			Subtotal manpower:		**106.11**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	198.99	3.98
			Direct costs (1 + 2 + 3):		202,97

Annex B - Budget of Hydroponic Green Facade

FJE015 m² Vertical gardening with hydroponic culture in geoproducts, for exterior, system "SINGULAR GREEN". € 243.07

Vertical gardening with hydroponic culture in geoproducts, for outside, system F + P Mixed "SINGULAR GREEN", with a surface of up to 5 m²; composed of: SUBSTRACT SUPPORT: metal mesh of anodized aluminum tubular profiles, square section, 40x40 mm and 3 mm thick, fixed to the base support with sconces and screws, with a modulation of 300 mm; WATERPROOFING: waterproof panel SG-P10 "SINGULAR GREEN", of 3050 x 2050 mm, formed by extruded PVC plates, white, 10 mm thick, with the seals sealed with fast-drying polyurethane putty, set at the substructure support with screws; METHOD OF CULTURE: geocompost made up of a layer of non-woven geotextile and a blanket of retention SG-M500 "SINGULAR GREEN", with pockets filled with organic substrate SG-MS05 "SINGULAR GREEN", of dehydrated moss fibers; fixed to the waterproofing with staples of stainless steel; VEGETATION: species of plants for outside, selected for a minimum temperature in winter without specifying; with a density of plantation of 30 u / m². The price does not include the maintenance and partial replenishment of the vegetation, the installation of irrigation and evacuation, the centralized control system and the gutter for the collection of water.

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt15var040a	m	Anodized aluminum tubular profile, of square section, 40x40 mm and 3 mm thick, with sconces and screws, for the fixation of waterproofing panels.	3,000	6.93	20.79
mt15isg010d	m²	Waterproof panel SG-P10 "SINGULAR GREEN", of 3050 x 2050 mm, formed by plates of extruded PVC, white, 10 mm thick, with the seals sealed with fast-drying polyurethane putty.	1,000	31,19	31,19
mt14ges010d	m²	Geocompost made up of a layer of non-woven geotextile and a blanket of retention SG-M500 "SINGULAR GREEN"; with staples of stainless steel.	1,000	10.50	10.50
mt48sas010d	kg	Organic substrate SG-MS05 "SINGULAR GREEN", of dehydrated moss fibers, for vertical landscaping.	0.450	11.50	5.18
mt48epa020b248	U	Species of plants for outside, selected for a minimum temperature in winter without specifying, 2.48 € / u, supplied in container; for vertical landscaping systems.	30,000	2.48	74.40
			Subtotal materials:		**142.06**
2		**Labour force**			
mo011	h	1st official mounter	1,268	25.83	32.75
mo080	h	Assistant mounter	1,268	22.78	28.89
mo040	h	Official 1st gardener.	0.723	25.08	18.13
mo086	h	Assistant gardener	0.723	22.78	16.47
			Subtotal manpower:		**96.24**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	238.30	4.77
Ten-year maintenance cost: € 639.03 in the first 10 years.			**Direct costs** (1 + 2 + 3):		243.07

FJG011 m² Automation of irrigation of vertical gardening with hydroponic culture in geoproducts. € 145.89

Automation of irrigation of vertical landscaping with hydroponic culture in geoproducts, for exterior, with a surface of between 10 and 25 m², with system with advanced adjustments of operation: activation of the irrigation depending on the humidity or the temperature, time of irrigation, signal of fault, lodged in closet of

installations; composed of the following elements: electronic programmer for automatic irrigation with capacity to put into operation several electrovalves simultaneously and mural placement indoors; ambient temperature sensor, humidity sensor and flow sensor with connection cable; Control elements of fertilization and monitoring of water quality. The price does not include the verification and maintenance of the facilities.

Code	Unit	Description	Performance	Price unitary	Amount
1		**Materials**			
mt48hun901v	m²	System for irrigation automation with water fertilization and evacuation with recirculation for subsequent irrigation, with advanced operating adjustments: irrigation activation depending on humidity or temperature, irrigation time, failure signal; composed of the following elements: electronic programmer for automatic irrigation with capacity to put into operation several electrovalves simultaneously and mural placement indoors; ambient temperature sensor, humidity sensor and flow sensor with connection cable; Control elements of the fertilization and monitoring of the quality of the water, for a landscaped area of between 10 and 25 m².	1,000	25.00	25.00
			Subtotal materials:		**25.00**
2		**Labour force**			
mo003	h	Official 1st electrician.	1,684	24.57	41.38
mo102	h	Assistant electrician.	3,631	21.11	76.65
			Subtotal manpower:		**118.03**
3		**Complementary direct costs**			
	%	Complementary direct costs	2,000	143.03	2.86
Ten-year maintenance cost: € 51.65 in the first 10 years.			**Direct costs** (1 + 2 + 3):		145.89

Direct costs (**FJE010+ FJG011**): 243,07 + 145.89: 388,96