DIRECTION

Demonstration at European Level of Innovative and Replicable Effective Solutions for very Low Energy new Buildings

D1.1: Selection, description and performance values identification of suitable envelope combined solutions

WP1 , Task 1.1

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[1]PU = Public

PP = Restricted to other programme participants (including the Commission Services).

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Table of Content

0 Executive Summary

This document describes the concepts, systems and envelope solutions that have been selected to be incorporated in the three demonstration buildings (Nuovo Parco Tecnologico di Bolzano, NuOffice Munich and Cartif III). Key points analyzed are:

- Orientation
- Wall insulation.
- High energy-efficiency windows.
- Integration processes for ensuring air tightness and minimize thermal bridges
- Integration of building services within the envelope core.

Since the available information is not homogenous for the three buildings at the moment, this version serves as a first approach to the passive energy savings strategies to be adopted by each demonstrator. Since the buildings analysis has been performed using the construction projects as main source of information, all comments and suggestions expressed in this document are not definitive and further iterations with the buildings designers are needed to arrive to more solid conclusions and, therefore, to more accurate suggestions and optimization proposals.

This will be then summarized in the definitive version (M18) of this document.

1 NuOffice Munich, Germany

1.1 General Description

This first subchapter will be dedicated to the NuOffice Munich in Germany. Some of the most important concepts and techniques that are considered in the original building design are:

- There is a nearby connection to district heating. It makes sense to use it as heating source.
- The development plan considerably limits the visual and geometric appearance of the building.
- An external sunshade will need to be installed to reduce demands on the cooling technology.
- A ventilation system, which makes it possible to adjust the air exchange as needed, will provide ventilation to all zones of the building.
- Heating and cooling will be conducted via thermal activation of structural parts, which guarantees the lowest temperatures for heating and highest temperatures for cooling in the building.
- An innovative approach will be taken to heating the building via an absorption heat pump supplied by district heating.

1.2 Site Location. Weather Conditions

First of all we understand that the architecture design has been defined together with the Property. Therefore we will not analyze spaces, distribution or areas.

But we would like to analyze the envelope composition in order to reduce energy demands. As we do not have those we cannot analyze in detail the building behaviour. The simulations results that we will like to receive are, at least:

- Total Heating Load and the percentage of each load component.
- Total Cooling Load and the percentage of each load component.
- Month by month cooling and heating demand with every component spread.
- Each façade thermal behaviour detailed for every month.
- Daylight behaviour for every façade.
- Shading systems simulations and optimizations.

Once we have those simulations we will be able to suggest modifications and/or optimizations.

1.2.1 Munich Weather

One of the most important aspects to be considered in an energy efficient design is the local weather.

Munich has a continental weather strongly modified by the proximity of the Alps.

During summertime the mean temperature will be around 24ºC. In winter it is quite cold, with an average temperature around -2ºC. Depending on the Föhn wind, warmer temperatures can be reached in any year period.

Design HVAC conditions suggested by ASHRAE are:

- Elevation: 529 m
- Winter Dry bulb temperature: -15.4ºC
- Summer Dry Bulb /Wet Bulb temperatures: 29/18.7 ºC
- Maximum WB: 19.6ºC. So, to obtain a water temperature of 27-29ºC is quite simple with a cooling tower.
- Maximum Dew Point: 17.1ºC. This is an important data because will limit surfaces temperatures above 19ºC at least.

1.3 Architectural Solutions.

In the documents we have now the most important information is related to envelope compositions:

- **Regular façade (ground floor to 5th floor).** Perforated façade made of 15cm precast concrete balustrade panels, improved 30 cm polystyrene insulation and a rear ventilated rain screen façade consisting of Alucobond panels framing the window strips and plaster baseboard and plaster covering the remaining surfaces. Triple glazing windows with wood/aluminium composite frame made of wood from sustainable forestry. External shading-system consisting of aluminium slat Venetian blinds with central control to prevent overheating.

  We will like to have a detail drawing of the façade composition as well as the glass characteristics. The glass behaviour shall be detailed with visible transmittance and solar factor. We suggest using a high visible transmittance together with low solar factors. We took some catalogue with us to the meeting.

  We agree the idea of those venetian blinds but we will like to review its design.

- **Special facades (north-east entrance façade, southern "bubble" building).** Curtain wall made as wood/aluminium composite transom construction with triple glazing (wood from sustainable forestry too). External shading-system consisting of aluminium slat Venetian blinds with central control to prevent overheating in south oriented facades on the first floor. Electrochrome glass in south-oriented façade on the ground floor for improved overheating protection ("bubble" only).

Same comments that in prior façade.

- **Roof.** Reinforced concrete ceiling with inverted seal/insulation system consisting of: double layered bituminous sealing and 32 cm extruded polystyrene high-resistance foam (insulation) on top. The system is covered with a separation and drainage layer and a layer of stone chippings. Depending on the usage area (solar cells, terrace or extensive vegetation) the surface will be finished with a covering of gravel, gravel and paving slabs or planting substrate.

Once again we suggest the use of simulation in order to improve the roof composition. The use of plants will help to protect the building as those are living being and will keep in temperatures around 22ºC depending on the plant type

1.4 Envelope Solutions Implemented

Already explained in chapters 2.2 and 2.3

1.5 Passive Solutions

Already explained in chapters 2.2 and 2.3

1.6 Conclusions and Expected Results

Simulations in the architectural part are needed to allow evaluation of energy savings performance.

2 Cartif III building, Valladolid (Spain)

2.1 General Description

CARTIF III building is located in Valladolid, in the centre of Spain, under a Mediterranean Continental Climate.

CARTIF III building was designed to have several industrial activities zones and some offices for R&D activities of CARTIF Foundation. So, there are four industrial areas of 3100 m2 and an office area of 935 m2.

The building has basement, ground floor and first floor, but not into whole plant, some of the industrial zones were designed as cathedral ceiling or double height.

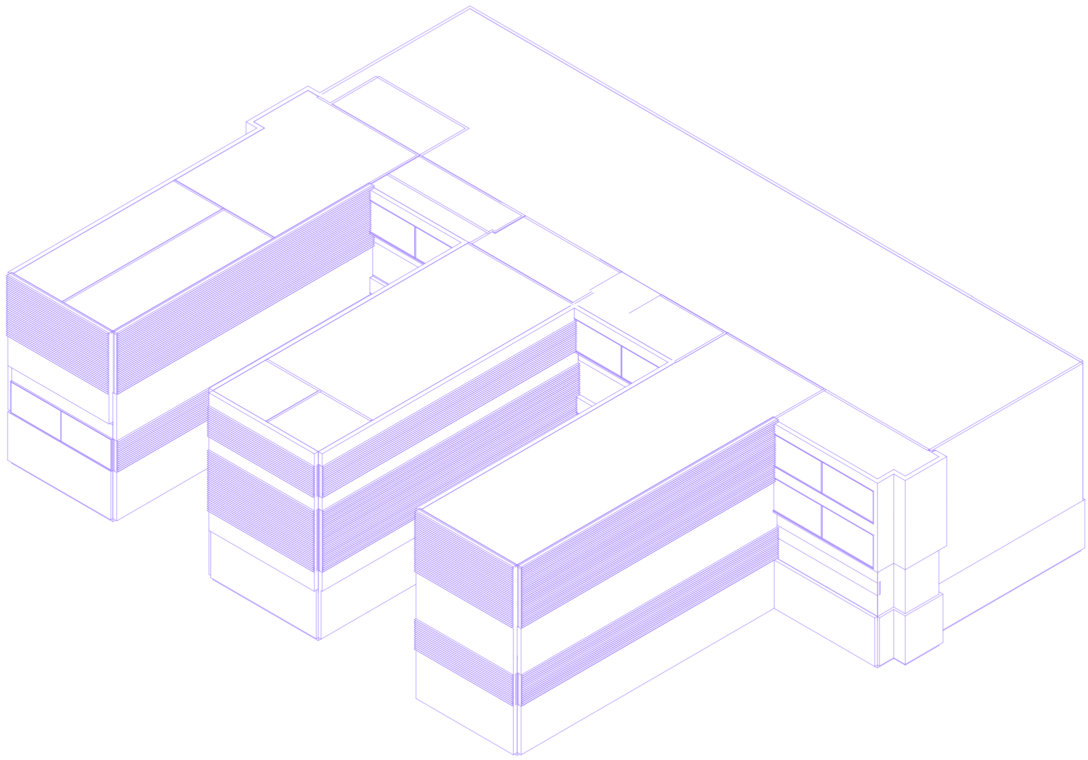
It has been designed as a very low energy building, which will integrate a lot of solutions for saving energy and to improve the overall energy efficiency.

The envelope has been designed to minimize thermal energy and light electrical demand through a special concept (glass wall and louvers blinds) that allows an important use of daylight with high solar gain and so to reduce thermal requirements. Also high efficiency lighting equipment will be used on the building.

There will be integrated a polygeneration renewable energy facility, designed as a combination of thermal plants (using a geothermal and biomass integrated systems) that will ensure high efficiency, energy balances between winter and summer periods (by means of the use of the ground storage capacity) and zero CO_2 emissions.

A PV plant will be installed in order to supply an important portion of the total electricity consumption.

And of course there will operate an advanced building management system (BMS) that will optimize energy uses by means of an efficient distribution and final use of the overall energy involved in each system and process.



CARTIF III building global view

2.2 Site Location. Weather Conditions

The Cartif III building is located in the province of Valladolid, Spain. The climate of this area is Mediterranean Continental. It is similar to the Mediterranean climate but with typical characteristics of the continental climate, with extreme temperatures. Besides this climate is not influenced by sea, so the temperatures are the most extreme of Spain, with very hot summers and relatively cold winters with a variation of 18.5 C °.

The summer season is the driest and very often exceeds 30 ° C, occasionally reaching over 35 ° C. However, in winter the temperatures often drop below 0 ° C, producing frosts and sporadic snowfalls.

Rainfall is spread fairly irregular throughout the year, although there is a minimum in summer and charged up in autumn and spring. Annual rainfall is between 400 and 600 mm and the average relative humidity throughout the year is 65%.

The precipitations are very irregular throughout the year, although there is a minimum in summer and a maximum in autumn and spring. The annual precipitation is between 400 and 600 mm and the average relative humidity throughout the year is 65%.

In the calculation of the maximum and minimum heat loads it is considered extreme conditions from UNE 100001-2001 "HVAC. Climatic conditions for projects".

For cooling (a reference day of July at 15 solar hour):

- Percentile summer conditions 2.5%
- Temperature dry summer 31.6 ° C
- Temperature wet summer 18.3 ° C
- Relative humidity of summer 26.5%

And for heating calculations (any time and winter month):

- Percentile winter conditions 97,5 %
- Temperature dry winter -4,4 °C
- Temperature wet winter -4,9 °C
- Relative humidity of winter 90,0 %

Weather conditions for energetic annual demand, the other days of the year, are obtained by applying corrections tables UNE 100014-2004 "HVAC. Basis for the project. Conditions Outdoor design" (Annual evolution hourly) according to the following parameters:

- Diurnal variation of temperature 15.2 ° C
- Annual variation of temperature 36.0 ° C

2.3 Architectural Solutions

In the design of the building was taken into account to achieve a energy efficient building and get a building with spaces that satisfy user needs in size, facilities, etc ....

Bellow is shown the measures to improve energy efficiency in CARTIF III building relatives to architectural solutions:

- Orientation
- Glazing
- Shading (louvers)

2.3.1 Orientation

Choosing a good orientation of the building is important to improve the energy efficiency in the building.

The orientation must be defined to capture the solar energy in the form of heat in winter, solar heat is rejected by louver blinds in the summer.

The ideal orientation is that the main long axis of the building runs East-West (±20 degrees). The most glass on the building must be facing towards the Sun. It is important to orient the building a few degrees to east to capture the morning sun.

But, the ideal orientation is not always easy to get because it depends on external items like the urban layout. When deciding the building orientation take into account the location of landscape features on your plot.

Cartif building has a good orientation because it has a high level of heat loss area oriented to the south with a high percentage of glazing.

The main façade is south oriented, with almost the entire façade and the entire southwest side closed with a glass wall that improves solar gain and a blind with oriented louvers, fixed to optimize the daylight use, avoiding glare.

In the next table the orientation of the façades is shown:

Orientation	Percentage façades (%)	Percentage Glazing (%)
North	50.0	5.1
Southeast	33.5	44.7
Southwest	16.5	58.0

2.3.2 Glazing

The glass wall in building Cartif III is in the southeast and southwest façade, that will allow reduce heating load due to a very important solar gain.

The percentage of glazing surface related to floor area is around 58% to the SW and 44.7% to the SE.

The energy of the sun gets into the building as radiation through the windows. That radiation will decrease the heating demand and will increase the cooling demand.

In winter the benefits of solar radiation will be taken. It will be necessary the use of solar shadings devices, in this case, oriented louvers, in order to avoid overheating in summer.

2.3.3 Shading (Louvers)

Shadings are used to reduce solar heat gains during summer. These devices should allow radiation to reach the building in winter and but decrease the radiation in summer.

In Cartif building, there are oriented aluminium louvers to optimize the daylight use. These louvers are oriented automatically by a control system and depending on the needs.

Louvers's size is 457cm x 48cm (width x height). The distance between axes is 46cm.

Glazing and louvers blinds also allow an important use of daylight with high solar gain.

2.4 Envelope Solutions Implemented

The main property of a thermal insulation is a low thermal conductivity. Although other criteria have to be taken account in the choice, like:

- Building use
- Interior and exterior climate.
- Space availability.
- Thermal and moisture properties of materials.
- Durability of materials.
- Compatibility with adjacent materials.
- Performance expectations of the assembly.

From the point of view of energy, the insulations in building envelopes have to conserve energy by reducing the building´s heat loss and gain, control surface temperatures for comfort, help control temperatures in a structure and reduce the tendency for water condensation on inside and outside surfaces.

Thermal insulation material may also do additional functions, although these should be consistent with the capabilities of the materials and their primary aim. Some of these functions are:

- Adding structural strength to a wall, ceiling or floor section.
- Providing support for a surface finish.
- Impeding water vapour transmission and air infiltration.
- Preventing or reducing damage to structures from exposure to fire and freezing conditions.
- Reducing noise and vibration.

Cartif III is classified like an industrial building. The Spanish legislation doesn´t specify minimum values for thermal transmittance in industrial buildings. But like the main aim of this building is get an improvement of energy efficiency, and to achieve a decrease of thermal demands, we have considered the thermal transmittance values for a no-industrial building as reference values, being more restrictive.

The document HE DB Energy of The Technical Building Code (TBC) establishes the requirements for energy efficiency and renewable energy that should be carry out by new buildings. The requirements according to the building envelope are described in HE1: Limitation of energy demand. The maximum and minimum values are established In the Technical Building Code.

The building envelope shall be appropriate to the requirements needed to achieve thermal comfort inside, taking into account climatic, seasonal or use conditions.

In the selection of the envelope is taking into account more factors than the characteristics of isolation, like inertia, air permeability and exposure to solar radiation, the risk of surface humidity and interstitial condensation and thermal bridges.

In order to Valladolid weather conditions, the insulation of the floor slab and basement is not such an important factor, because for the same value of transmittance, heat losses from the ground are less than that obtained with air. Otherwise, the roof insulation is a very important factor because heat losses in both summer and winter on the roof are great. Also in summer the roof has great sun exposure.

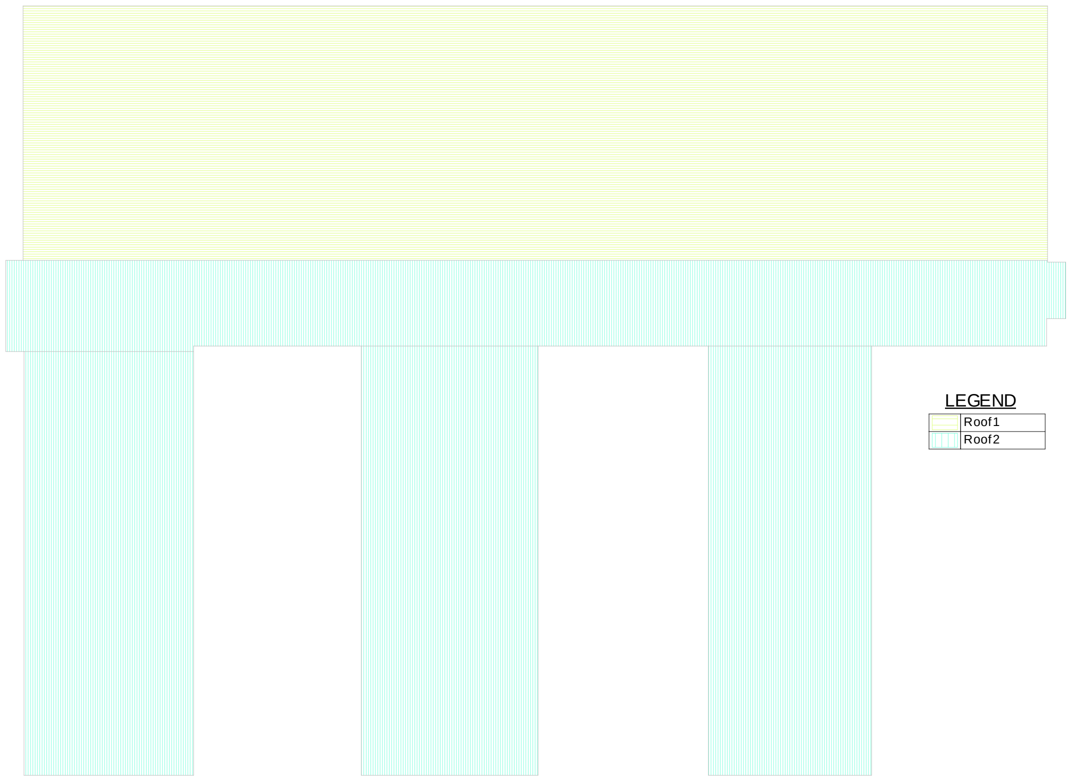
Good insulation of walls limits the heat losses in wintertime and increases the interior surface temperatures, thus increasing thermal comfort and reducing the risk of damages due to the excess humidity. During hot periods in summer, it reduces the heat flow from the outside to the inside, including the heat generated by solar radiation on the exterior surface, and support both night ventilation strategies and energy efficient active cooling concepts whenever the interior temperature drops below the daily average of the exterior surface temperature.

The limit transmittance values established by The Technical Building Code are based on the climate of the area in which the building is located. The TBC establishes maximum and limit coefficient of transmittance for each of the elements of the envelope according to the area.

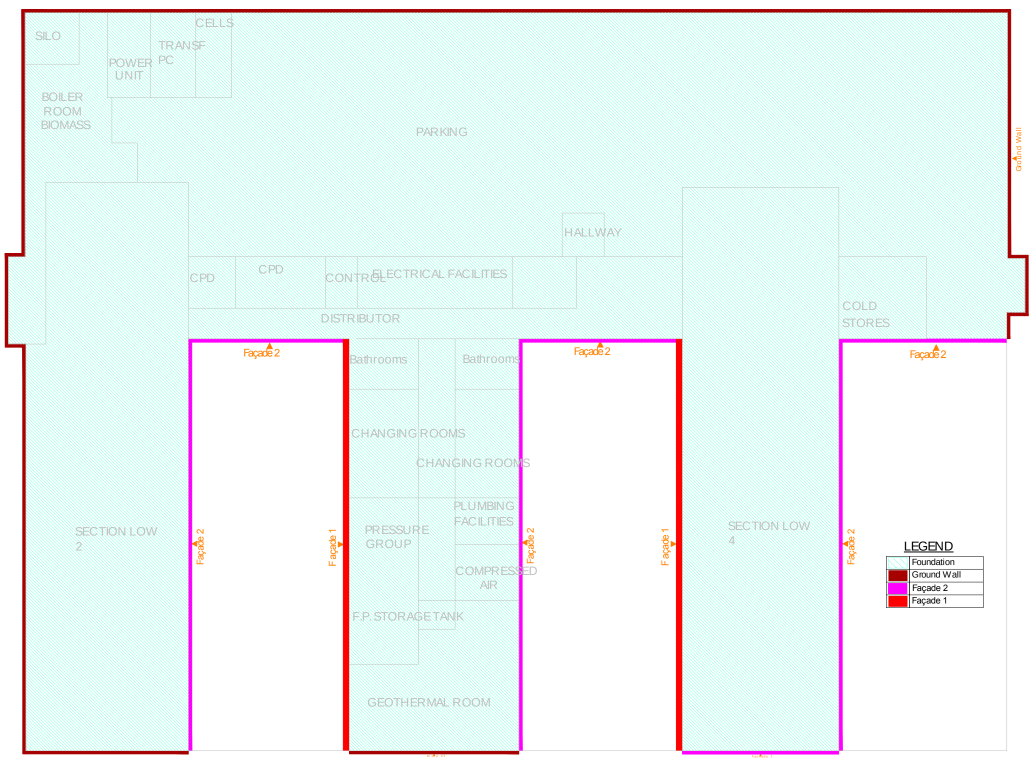
Below shown the Cartif Building´s transmittance value vs. TBC´s transmittance value:

ENCLOSURE SYSTEM	U actual (W/m^2K)	U max (W/m^2K)	U lim (W/m^2K)	Shading Coefficient F	Shading Coefficient F
Basement	0.207	0.64	0.49	-------	-------
Façade 1	0.627	0.860	0.660	-------	-------
Façade 2	0.452	0.860	0.660	-------	-------
Façade 3	0.453	0.860	0.660	-------	-------
Façade 4.1	0.336	0.860	0.660	-------	-------
Façade 4.2	0.601	0.860	0.660	-------	-------
Roof 1	0.402	0.49	0.380	-------	-------
Roof 2	0.339	0.49	0.380	-------	-------
Office's Windows	1.995	3.5	3.5 (N) / 3.2 (SE) / 3.0 (SO)	0.29	0.41 (SE) / 0.36 (SO)
Glass Wall	1.517	3.5	3.5 (N) / 3.2 (SE) / 3.0 (SO)	0.32	0.41 (SE) / 0.36 (SO)

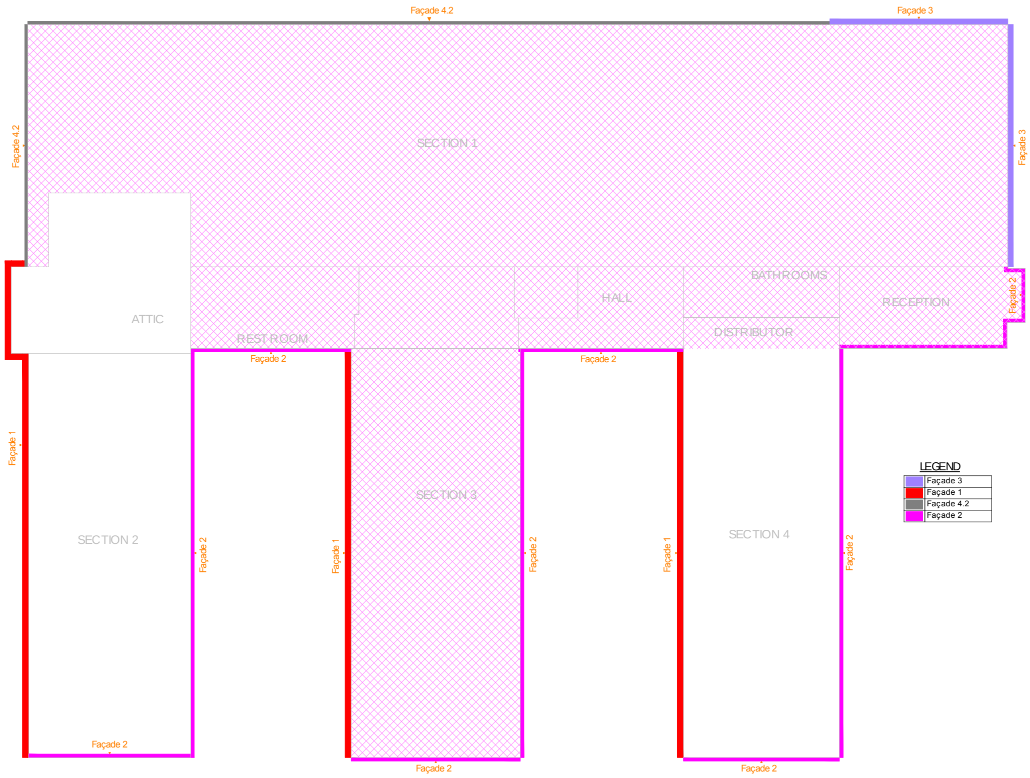
In the following figures is shown the location of each enclosure system:



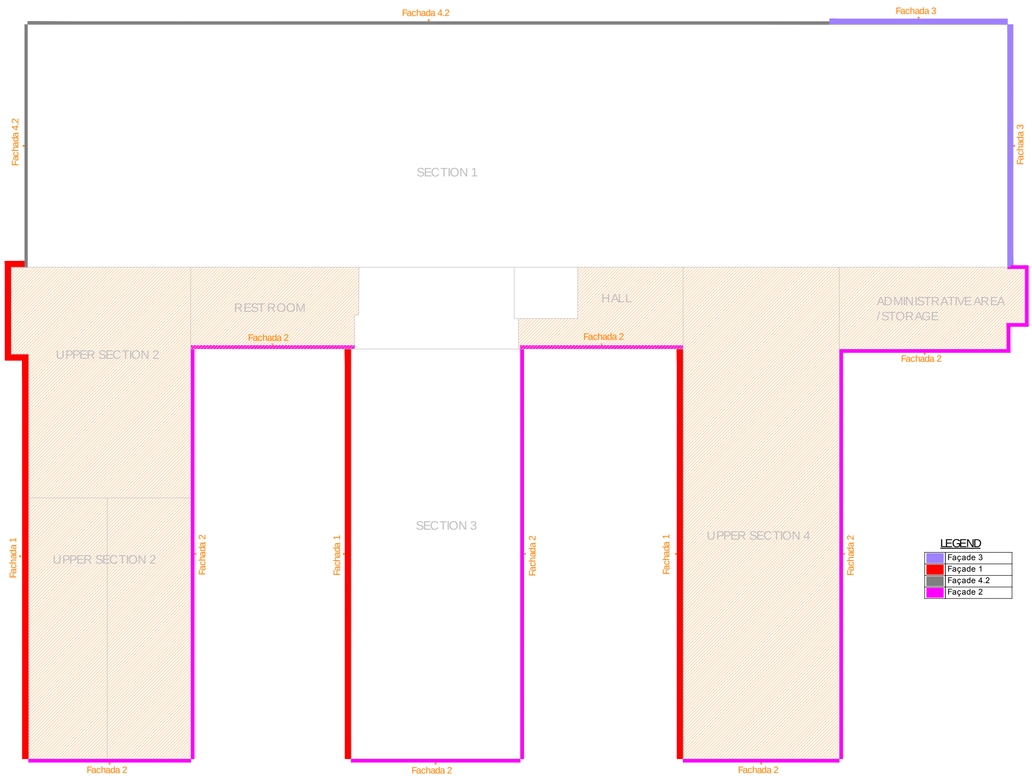
ROOF FLOOR LEVEL 11.24 m



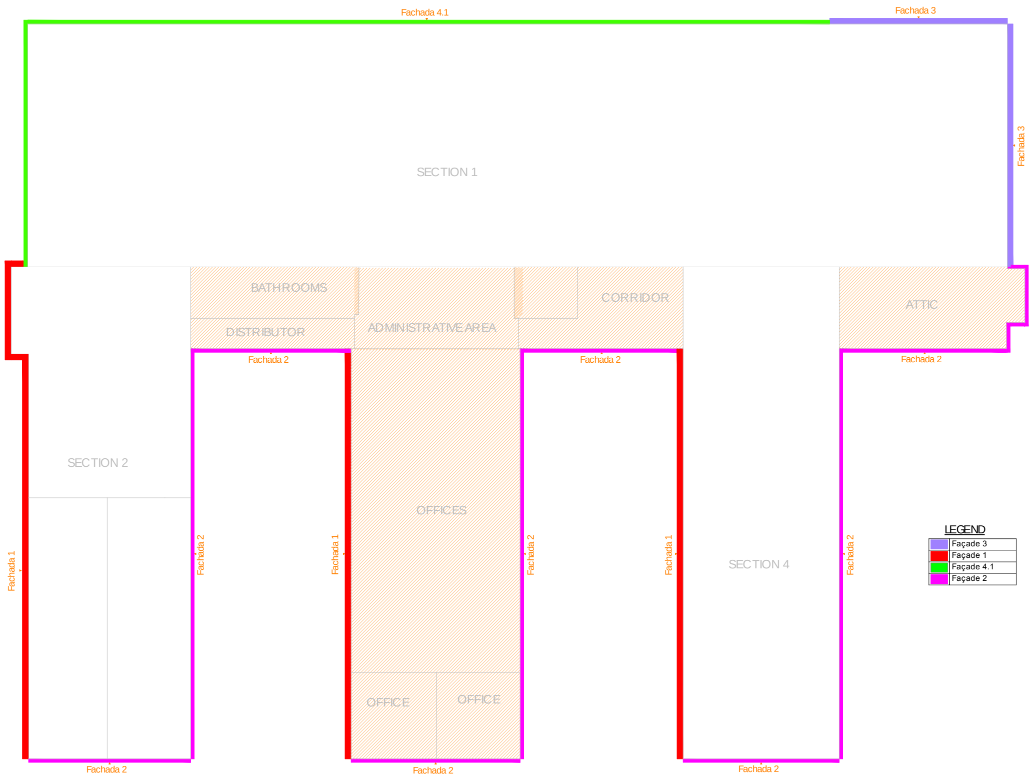
FLOOR LEVEL -3.85 m



FLOOR LEVEL 0 m



FLOOR LEVEL 3.85 m



FLOOR LEVEL 7.47 m

The transmittance values of the building envelope are significantly lower than those allowed under Spanish current regulations.

The featured strategies for design are great insulation for the building envelope and a low emissivity glazing.

2.5 Conclusions and Expected Results

A comparative has been made between real building and reference building to check the effectiveness of the measures taken. As reference building is considered one whose envelope has the limit values set by the Building Code.

For the calculation of the thermal demand and load, it has been used the calculation method developed by Mitalas and Stephenson called "Z-Transfer functions" and described by ASHRAE in its manual "HVAC Fundamentals", thereby it is obtained the expected energy demand in the building as well as the maximum value of power required.

In the next table it is shown the obtained results of annual thermal loads and demands.

Scenario	Heating Load kW	Cooling Load kW	Heating Demand kWh	Cooling Demand kWh
Reference building	235.4	180.9	119,599	132,037
Real building	205.9	131.3	108,041	82,245

Observing results obtained shown in the table above, it is concluded that the improvement achieved in the building heating consumption with the measures taken is 11% compared to the reference building. Furthermore decreased cooling demand of the building is gained 37.7%. Both improvements were achieved mainly due to the installation of the louvers of the SW and SE façades, glazing and the employment of a suitable isolation well above the maximum level indicated in Spanish Regulation.

The louvers and high efficiency glazing help to decrease the cooling needs, because these devices are able to reduce the possible extra-heating in the building.

The location and distribution of glazing in the building is also a very important factor in the use of the daylight.

And finally the improvement of insulation of all building envelope involves a considerable reduction in heating loads, which is important considering that in Valladolid there is heating demand for 8-9 months a year.

3 Nuovo Parco Tecnologico di Bolzano, Bolzano (Italy)

3.1 General Description

The building to be analyzed in this chapter is the Black Monolith of the New Technology Park in Bolzano. It is a new building that will be erected on an ex-industrial area. The building is adjacent to historical industrial buildings and will contain conference halls and a technical room on the basement, an entrance hall and expo area on the ground floor, and offices on the four upper floors.

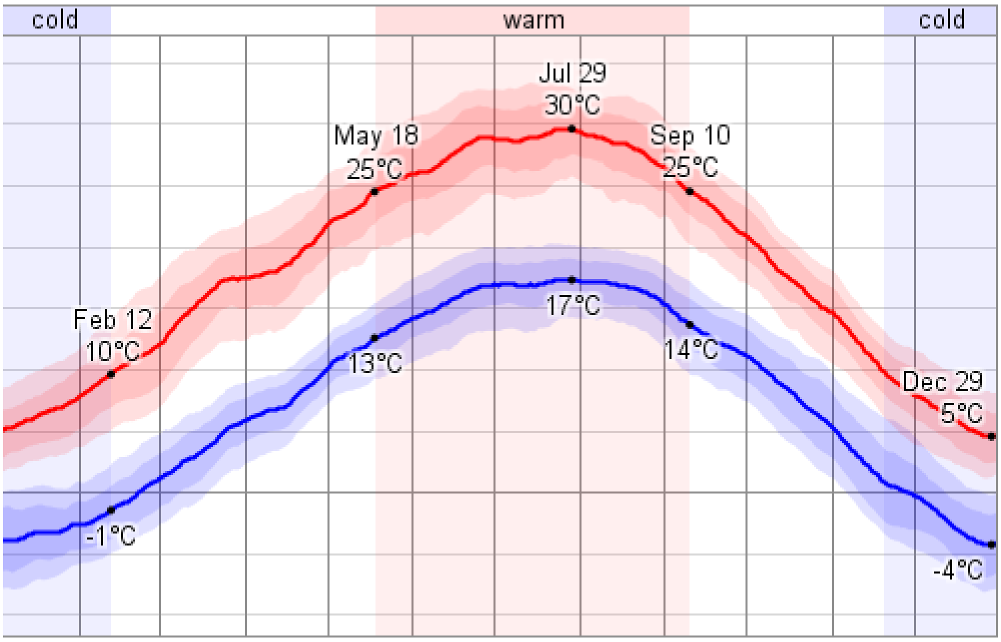
It is recommended to develop full simulation and report of the demo building.

3.2 Site Location. Weather Conditions

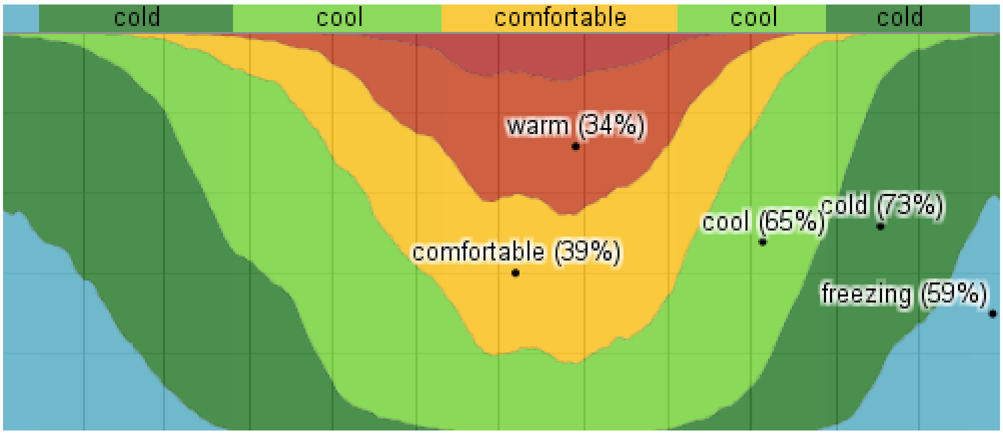
Considering where is it located, Bolzano weather should be strongly influenced by the mountains. This is part of what we can conclude after we analyze the main data of it (source http://weatherspark.com).

3.2.1 Temperatures

Next graph shows the daily high and low temperatures during the year. Minimum temperature will be -4ºC and maximum temperature will be 30ºC. The air temperature is rarely below -8ºC or above 34ºC.



Next graph shows the daily fraction of time spent in various temperature bands



According to this graph almost 60% of time in December or January the temperature is freezing (between 0 and -9ºC). While almost 39% of time in the end of June or the first days of July it is comfortable (between 18 and 24ºC).

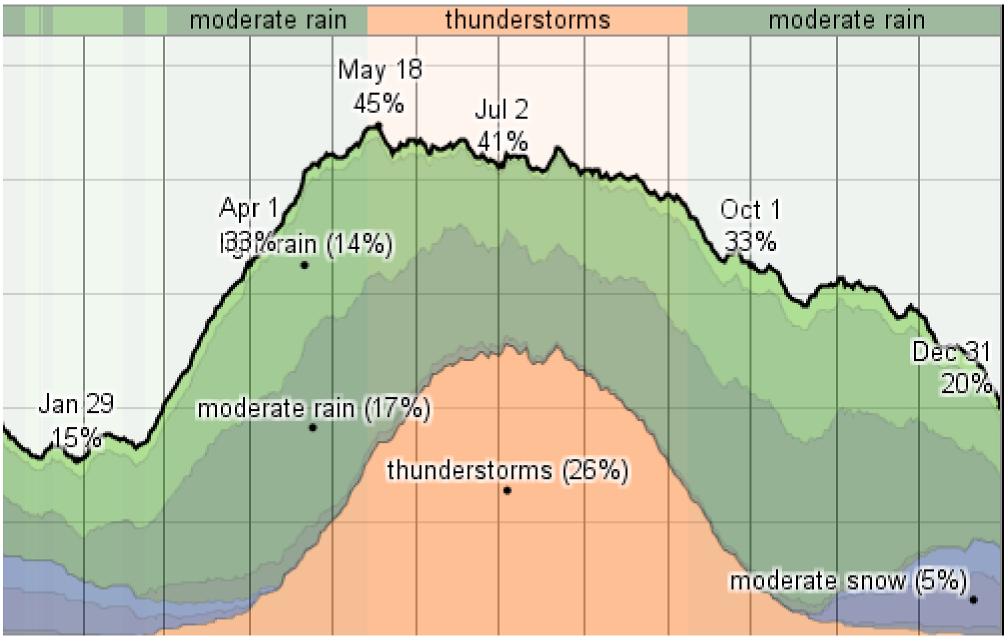
So we can conclude that Bolzano has cold winter and soft summers.

3.2.2 Sun

Typical day in Bolzano is partly cloud as the typical wind will come from the south. In winter the mean cloud cover will rise up to 78% (November).

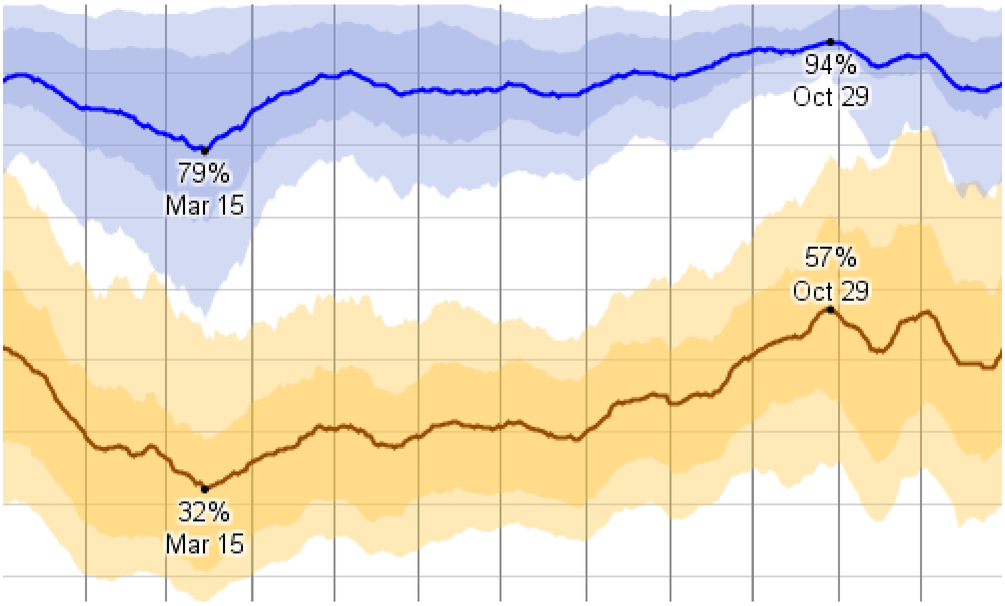
3.2.3 Precipitation

The precipitation are quite usual in spring and summer (thunderstorms). Next graph shows the probability of precipitation along the year.

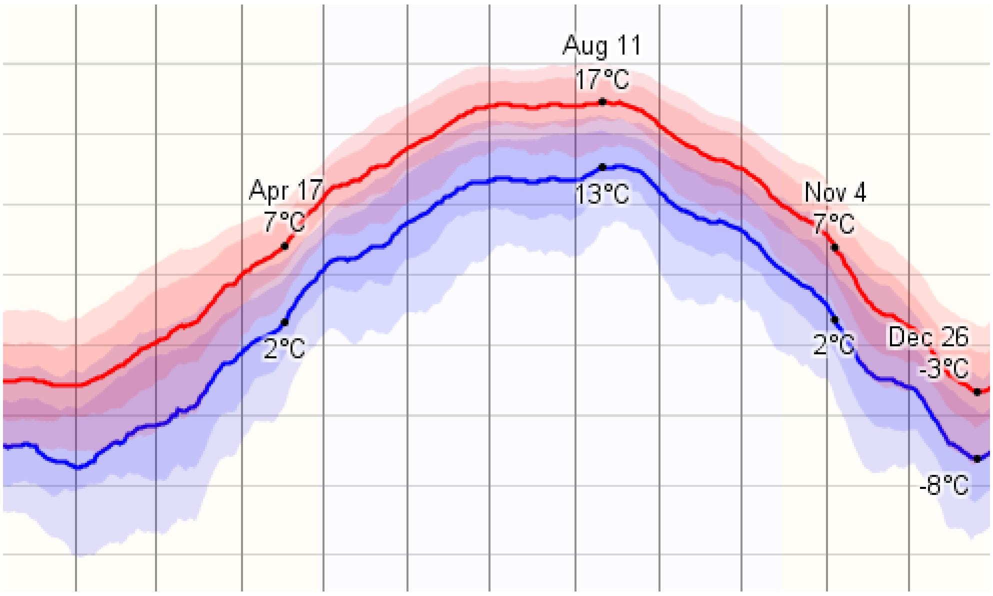


3.2.4 Humidity

Next graph show minimum and maximum humidity ratio per day.



It can be observed how the humidity is quite high. This is much more important in summer, when de dew point is very high (close to 17ºC). We will like to highlight that this is considering only mean values. Therefore, the maximum dew point will be higher (maximum light pink area will be close to 19ºC).



3.2.5 Conclusions

The winter will show quite low temperatures and moderate rain with partly cloudy or cloudy days.

The summer will show moderate-warm temperatures with sunny or partly cloudy days. Precipitation probability up to 40% and around 17ºC of dew point will cause a mean relative humidity around 55% in summer days.

3.3 Architectural Solutions.

Main Use: Office Building, Meeting Rooms, and Place of Assembly

This building has 6 floors (one basement and 5 floors).

On basement there are mainly several meeting or conference rooms and a theatre. Besides this there are several storage areas.

On ground floor there is the main entrance and an expo area. The other floors will have entrance halls and offices.

Those are typical spaces for this type of buildings and the space distribution is similar to any other building. No special energy considerations are observed, besides those described in passive solutions,

3.4 Envelope Solutions Implemented

The main envelope solutions are described and commented.

- **Insulation.** The Umax values have been defined after several dynamic simulations considering the internal use. We have not received those simulations. We would be interested about having them for better analysis.
- **Shading systems.** We understand that the shading devices will be further detailed in detail design. We do not know in detail what are those RETROlux shielding plates that are designed. On the other hand we suggest improving the type of glazing in the south façade, as a 0,632 solar factor seems to be very high. In tender design it is proposed to add a reduction factor of 0,6 in those façades. We are interested about more information about this reduction.
- **Use of thermal mass.** Seem to be a good idea to avoid the false ceiling. We understand that the slab will be exposed to occupied areas.

We will like to receive the next simulation results, in order to analyze them:

- Total Heating Load and the percentage of each load component.
- Total Cooling Load and the percentage of each load component (walls conduction, roof conduction, glass conduction, glass radiation, people, lighting, miscellaneous, etc).
- Month by month cooling and heating demand with every component spread.
- Each façade thermal behaviour detailed for every month. Using this simulations we would be able to find and analyze the daily and seasonal behaviour of each surface in order to find if the sun exposure should be increase or reduced.
- Shading systems simulations and optimizations.

Once we have those simulations we will be able to suggest modifications and/or optimizations. In the documents we have now the most important information is related to envelope compositions.

We have found the internal gains considered in the simulation. We mostly agree with those.

3.5 Passive Solutions

Regarding passive solutions we can distinguish two different aspects: lighting and HVAC (heating, ventilation and air conditioning).

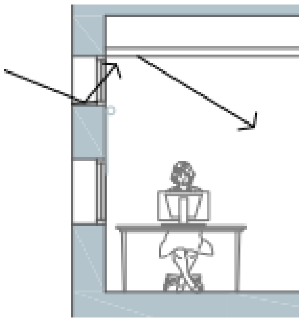
3.5.1 Daylighting

A deep analysis for daylighting has been done in this first description document.

The illuminance requirements considered rise from DIN5034-1:1999, similar in those values to the European Norm (12464-1:2011). We suggest reviewing calculations according to last standard.

Design requirements for natural lighting shown on report's table 5 are well defined and work properly.

We are worried about possible glaring in east and west façade caused by the lower ribbon window (placed at 1,2 m height). A good option could be install curtains inside the rooms that could be manually operated.



To guaranty good reflection factors, the reveal will be in aluminium. Depending on the upper surface finish (the finally selected product), the reflectivity may vary between 80% and 98%. The ceiling is covered with plaster.

Talking about the roof and the indoor garden we suggest making a thermal simulation of such garden. It could have problems on summer due to greenhouse effect. We have seen there are openings on the sides of the skylight but those should be sized after a simulation. We recommend analyzing the interior temperature in summer and winter.

After observing the daylighting simulations we understand they are well defined and we agree with the main conclusions of EURAC report.

Therefore, we can assume that the annual daylight autonomy for each floor are:

Floor	area (150lux)	area (350lux)	area (500lux)
Ground floor	28.10%	42.10%	46.83%
1st floor	22.39%	43.18%	62.67%
2nd floor	30.98%	13.26%	23.29%
4th floor	27.38%	15.59%	36.72%

The main problem becomes when glaring is analyzed. As it was expected there are certain problems on south, east and west façades. We agree with the report: a shading device is required. But we think there might be problems in east and west façades as well as well. That is why an internal curtain might be installed.

3.5.2 Natural Ventilation

Several natural ventilation systems have been designed for the Black Monolith.

- Use of patio. The small offices zone will use the next patio for ventilation. There are windows facing toward the patio from the central offices zone ("small offices zone") but they cannot be opened. To ventilate the central offices/avoid a greenhouse effect, there is, apart from the skylight openings, a void zone as can be seen on the floor 2 plan view. This zone directly connects to outdoors.
- Stack effect ventilation system. It has been designed a stack effect ventilation system as the main way of refresh air. We would like to check calculation or simulation models as this is not a tall building (only 3 stores difference for ventilation proposals). It is described that the floor grilles will close in working hours because acoustical problems.

Natural ventilation simulations were carried out in EnergyPlus (using Trnflow). They showed that wind direction and speed has a substantial influence on the effectiveness of nightly natural ventilation. We contacted the design team to propose and discuss solutions where the actual strategies don't work that well all the time during the night because of stronger winds. Future detailed simulations should be undertaken.

In such simulation is has been defined that the ventilation system will not work whenever outside dew point temperature is above 17ºC. We agree with that condition.

The ventilation system will act with windows and grilles according to indoor and outdoor temperatures and humidity. Considering winter weather in Bolzano the natural ventilation will not open almost any day in December or January at working time. In such period cooling demand is negligible.

This is an expensive solution and it will not work whenever the building is occupied, as the grilles are closed. We suggest the use of more simple and proved solutions based on typical equipment but considering very high efficiencies. On the other hand that equipment shall be installed to guaranty proper sanitary ventilation.

It is expected that this ventilation systems reduce cooling by 10%. This reduction can be achieved with most effective equipment and ventilation systems, as very high efficiency heat recovery systems combined with ventilation according to IAQ sensors, etc. But as this is a demonstration building maybe the designer is more interested in try new solutions to see if they are working or not.

3.6 Conclusions and Expected Results

- The winter will show quite low temperatures and moderate rain with partly cloudy or cloudy days.
- The summer will show moderate-warm temperatures with sunny or partly cloudy days. Precipitation probability up to 40% and around 17ºC of dew point will cause a mean relative humidity around 55% in summer days.
- We will like to receive several thermal simulations as they are detailed in 5.4.
- Interior garden thermal simulation is recommended.
- We might propose to add new shading devices on east and west façades.