PROJECT MANUAL #4

ZAGREB, MARCH 11th, 2014

DELIVERABLE #4

team UNIZG

2 SUMMARY OF CHANGES

section	new	modified
5. CONTEST SUPPORT DOCUMENTS		
5.1 Urban Design, Transportation and Affordability Report		•
5.2 Architecture Design Narrative		•
5.3 Engineering and Construction Design Narrative		•
5.4 Energy Efficiency Design Narrative		•
5.5 Innovation Report		•
5.6 Sustainability Report		•
5.7 Communications Plan		•
6. DINNER PARTY MENU		
7. CONTEST WEEK TASKS' PLANNING		
8. COST ESTIMATE AND PROJECT FINANCIAL SUMMARY		•
8.1 Business and Fund Raising Plan		
8.2 Cost Proposal Form		•
9. SITE OPERATIONS REPORT		
9.1 General Data		•
9.2 Site Operation Teams		•
9.3 Logistic outside of LaCité du Soleil®	•	
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9.6 Equipment requirement Chart	•	
9.7 Assembly and Disassembly Chart		•
9.8 Site Operation Chart		•
10. HEALTH & SAFETY REPORT		
10.1 Health and Safety Checklist	•	
10.2 General Data of the Project		•

10.3 Health and Safety Plan Objectives		●
10.4 Conditions of the site where construction will take place, and interesting data related to the prevention of risks during the construction process		●
10.5 Activities for risk prevention		●
10.6 Risk identification and efficacy evaluation of the adopted protections		●
10.7 Critical work phases for risk prevention	●	
10.8 Collective protections to use		●
10.9 Individual protection resources to use		●
10.10 Safe working procedures of every Team member		●
10.11 Machinery and auxiliary resources	●	
10.12 Planned Measures in case of accident		●
10.13 Risk identification for possible later works	●	
10.14 Useful plans and information about health and safety		●
10.15 Adopted system for the level of health and safety control during works	●	
10.16 Formation and information about health and safety		●
10.17 Emergency evacuation plan during assembly and disassembly periods	●	
10.18 Annex 1– Identification of risk and evaluation of the efficiency of the adopted protections	●	
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11. DETAILED WATER BUDGET		
12. CONSTRUCTION SPECIFICATIONS		
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13.1 SECTION A: Technical description		●
13.2 SECTION B: Material description		●
13.3 SECTION C: Load analysis		●

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4 RULES AND BUILDING CODE COMPLIANCE CHECKLIST

Rule Description		Content Requirement(s)	Drawing(s)/ Report(s)
3,2	Team Officers and Contact Information	Team officer's contact information completely fulfilled in Table 1 (SDE WAT)	PM - 1. Team Officers
4,3	Lot Conditions and attribution	Drawing(s) showing the storage and unloading areas and corresponding load's calculations	AR - 002
4,3	Lot Conditions	Calculations showing the structural design remains compliant even if there is a level difference, and drawing(s) showing shimming methods and materials to be used in case.	PM – 5.2.1. Structural Design ST-001 14. Structural Calculations PM – 13.7 5 ST drawings
4,4	Footings	Drawing(s) showing the locations and depths of all ground penetrations on the competition site	we don't have any ground penetration system
4,4	Footings	Drawing(s) showing the location, contact area and soil-bearing pressure of every component resting directly on the ground	ST – 001
4,7	Construction Equipment	Drawing(s) showing the assembly and disassembly sequences and the movement of heavy machinery on the competition site and specifications for heavy machinery	SO – 201 -245
5,1	Solar Envelope Dimensions	Drawing(s) showing the location of all house and site components relative to the solar envelope	AR – 011 AR – 101 AR – 102

6,1	Structural Design Approval	Structural drawings and calculations signed and stamped by a qualified licensed professional	ST – 001 ST - 304
6,1	Electrical and Photovoltaic Design Approval	Electrical and Photovoltaic drawings and calculations signed and stamped by a qualified licensed professional	PV - all drawings EL - all drawings
6,1	Codes Design Compliance	List of the country of origin codes complied, properly signed by the faculty advisor	PM – 13.1.3
6,2	Architectural Footprint	Drawing(s) showing all the information needed by the Rules Officials to digitally measure the architect footprint	AR – 014
6,2	Architectural Footprint	Drawing(s) showing all the reconfigurable features that may increase the footprint if operated during contest week	AR – 041
6,3	Measurable Area	Drawing(s) showing the Minimum & Maximum Measurable Area.	AR – 051
6,4	Entrance and Exit Routes	Drawing(s) showing the accessible public tour route, specifying the entrance and exit from the house to the main street of La Cite du Soleil	AR – 001 PT – 001 PT - 101
7,3	PV Technology Limitations	Specifications and contractor price quote for photovoltaic components	PM – 5.3.5
7,4	Batteries	Drawing(s) showing the location(s) and quantity of stand-alone, PV-powered devices and corresponding specifications	PD PV – 005 PV - 015
7,4	Batteries	Drawing(s) showing the location(s) and quantity of hard-wired battery banks components and corresponding specifications	PD PV – 005 PV - 015

7,6	Thermal Energy Storage	Drawing(s) showing the location of thermal energy storage components and corresponding specifications	To be determined
7,7	Desiccant Systems	Drawing(s) describing the operation of the desiccant system and corresponding specifications	To be determined
7,8	Humidification systems	Specifications for humidification systems and corresponding certifications of the different elements	To be determined
8,1	Containers locations	Drawing(s) showing the location of all the water tanks	To be determined
8,2	Water Delivery	Drawing(s) showing the fill location(s), quantity of water requested at each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s)	To be determined
8,3	Water Removal	Drawing(s) showing the quantity of water to be removed from each fill location, tank dimensions, diameter of opening(s) and clearance above the tank(s)	To be determined
8,5	Grey water reuse	Specifications for grey water reuse systems	To be determined
8,6	Rainwater Collection	Drawing(s) showing the layout and operation of rainwater collection systems	To be determined
8,8	Thermal Mass	Drawing(s) showing the locations of water-based thermal mass systems and corresponding specifications	ME - 201 ME - 211 ME - 221
8,9	Grey Water Heat Recovery	Specifications for grey water heat recovery systems.	To be determined

9,1	Placement	Drawing(s) showing the location of all vegetation and, if applicable, the movement of vegetation designed as part of an integrated mobile system	AR – 011 AR – 021 AR – 201, 202, 211, 212
9,2	Watering Restrictions	Drawings showing the layout and operation of grey water irrigation systems	To be determined
10,2	SDE Sensors' Location and wire routing	Drawing(s) showing the location of bi-directional meters, metering box, sensors, cables and feed-through to pass the instrumentation wires from the interior to the exterior of the house	To be determined
11,2	Use of the Solar Decathlon Europe Logo	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	PM 5.7.4
11,3	Teams' sponsors & Supporting Institutions	Drawing(s) showing the dimensions, materials, artwork, and content of all communications materials, including signage	PM 5.7.6. PM 5.7.5.2.
11,4	Team Uniforms	Drawing(s) showing the artwork, content and design of the team uniform	PM 5.7.4.
12,4	Public Tour	Drawing(s) showing the public tour route, indicating the dimensions of any difficult point, complying with the accessibility requirements	PM 5.7.3. PT – 001 PT - 101
20,0	Contest 6: Drying Method	Drawing(s) showing the clothes drying method and the place where the clothes wire will be dried	AR - 021

20,0	Contest 6: House Functioning	Appliances and corresponding technical specifications (Appliances and Home Electronics Equipment specifications and user Manuals, Rule 49.1)	PM – 5.3.4
36,5	Photovoltaic systems design	Specifications of PV generators, inverters, wiring, cables, protections, earthing systems, interface with the electricity distribution network.	PM – 5.2.5. PD PV – 001, PV – 002 PV – 031
36,5	Photovoltaic systems design	Inverters' certificates	PM 12
36,5	Photovoltaic systems design	Maintenance plan for PV generators, supporting structure, inverters, wiring, cables, protections, circuit breakers in case of fire and earthing system. Fire protection systems for PV DC wiring	PM – 5.2.5. 5.3.
36,5	Photovoltaic systems design	The corresponding table "design summary" must be filled out	To be determined
51,3	Fire Safety	Specifications for Fire Reaction of Constructive elements, extinguishers and fire resistance of the house's structure	FP - 001
51,3	Fire Safety	Drawings showing compliance with the evacuation of occupants' requirements and fire extinguishers location	FP - 001
51,4	Safety against falls	Specifications of compliance with the slipperiness degree classes of floors included in House tour	To be determined

51,4	Safety against falls	Drawing(s) showing compliance with conditions for uneven flooring, floors with different level, Restricted Areas stairs, Public Areas Staircases, Restricted Areas Ramps and Public Areas Ramps	PT – 001 PT – 101 AR – 003 AR - 021
51,4	Safety for avoiding trapping and impact risk	Drawing(s) showing compliance with conditions for avoiding trapping and impact risk	To be determined
51,4	Safety against the risk of inadequate lighting	Specifications for level of illumination of house tour areas light fittings	To be determined
51,5	Accessibility	Interior and exterior plans showing the entire accessible tour route	AR – 003 PT – 001 PT – 101
51,6	Structural Safety	Specifications for the use of dead loads, live loads, safety factors and load combinations in the structural calculations	PM – 13.3
51,7	Electrical and PV Systems	Complete the "Electrical System Design PV Chart and Checklist" Rule 48	PM 12
51,7	Electrical and PV Systems	Specifications of the wiring, channels, panels and protections of the electrical installation	PM – 5.3.5 PD - PV
51,7	Electrical and PV Systems	One-line electrical diagram and drawings showing the grounding, execution and paths	PD – PV EL

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5 CONTEST SUPPORT DOCUMENTS

5.1 Urban Design, Transportation and Affordability Report

5.1.1 Urban Design Strategy

Croatia's rather diverse geographic and cultural context implies a simple and adaptable strategy of urban planning. Though comparatively small, the country spreads through several biomes and climate zones and covers a historically, demographically and economically diverse space. The history of this space contains different types of settlements - from campestral and rural to highly urban and industrial.

In order to respond to such a multifarious context, one must approach urban planning with a simple, adaptable and modular concept – one which is inherent to the Mem**brain's** main principles. In form of a single detached unit, an assembly of units, a matrix or a complex structure, our house can meet a large variety of demands and issues found in Croatia's historically and geographically perplexed space.

5.1.1.1 Geography and climate

Croatia is located in Central and Southeast Europe - it lies mostly between latitudes 42° and 47° N and longitudes 13° and 20° E. The territory covers 56,594 square kilometres, consisting of 56,414 square kilometres of land and 128 square kilometres of water.

The climate is moderately warm and rainy - mean monthly temperature ranges between −3 °C (27 °F) (in January) and 18 °C (64 °F) (in July). The coldest parts of the country are Lika and Gorski Kotar where snowy forested climate is found at elevations above 1,200 metres. The warmest areas of Croatia are at the Adriatic coast. Mean annual precipitation ranges between 600 millimetres and 3,500 millimetres. Prevailing winds in the interior are light to moderate northeast or southwest, and in the coastal area prevailing winds are determined by local area features. Higher wind velocities are more often recorded in cooler months along the coast, generally as bura or less frequently as sirocco. The sunniest parts of the country are the outer islands, Hvar and Korčula, where more than 2700 hours of sunshine are recorded per year, followed by the southern Adriatic Sea area in general, northern Adriatic coast, and Slavonia, all with more than 2000 hours of sunshine per year.

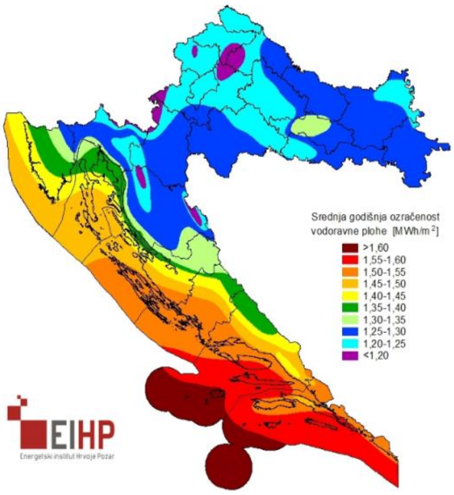


Figure 1 - Map of Croatia with average annual irradiation on horizontal plane with total solar radiation (source: Energy institute Hrvoje Požar)

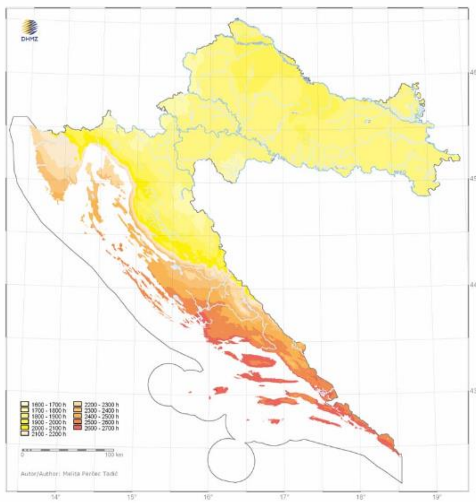


Figure 2 - Map of Croatia with mean annual absolute duration of sunshine in hours (source: Meteorological and hydrological service of Croatia)

5.1.1.2 Demographic analysis

The population density of Croatia is 75.8 inhabitants per square kilometer, and the overall life expectancy in Croatia at birth is 75.7 years. The known demographic record shows that the population rose steadily (with the exception of censuses taken following the two world wars) from 2.1 million in 1857 until 1991, when it peaked at 4.7 million. Since 1991, Croatia's death rate has continuously exceeded its birth rate; the natural growth rate of the population is currently negative.

Croatia is currently in the fourth or fifth stage of the demographic transition. In terms of age structure, the population is dominated by the 15–64 year old segment. The median age of the population is 41.4, and the gender ratio of the total population is 0.93 males per 1 female.

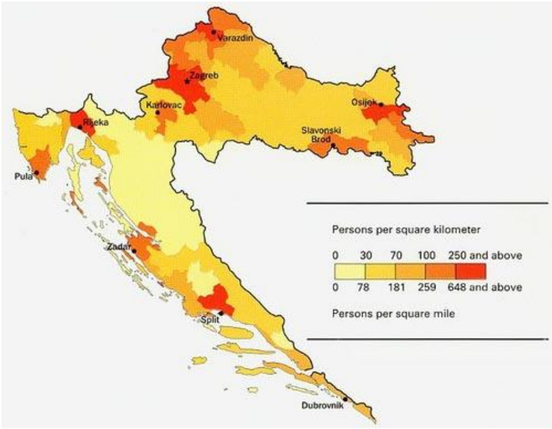


Figure 3 - Map of Croatia with mean annual absolute duration of sunshine in hours (source: Wikipedia)

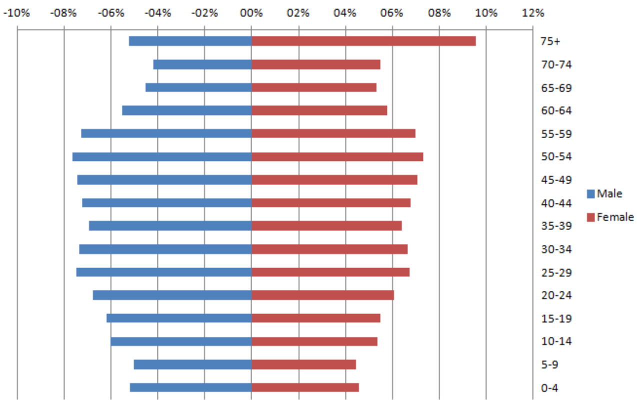


Figure 4 - Croatian population pyramid 2009 (source: Croatian Bureau of Statistics 2010 Yearbook data)

Considering the low population density of the most part of the Croatian territory, our Mem**brain** concept can be applied as a low-cost and highly prefabricated solution to the needed commercial, agricultural, educational and infrastructural facilities. It can easily be fabricated (using local materials and production means), transported (modular elements), assembled and disassembled (user-friendly technology) and adjusted to function as a local school classroom, a small store or infrastructural facility.

In more densely populated areas, the Mem**brain** unit can be multiplied and adapted to form larger and more complex structures, and respond to the issues of larger urban areas. A number of these issues are to be found in the urban fabric of Zagreb - our capital city, and the parent-town of our University.

5.1.1.3 Zagreb – a brief history of the urban context

The urban development of Zagreb through the centuries can be traced in its stratified relation with the Sava River. The original city, consisting of two centers, had no ambition to involve the frequently flooding river in its plan. It claimed its position high above the tides, on the sunny southern slopes of the Medvednica Mountain.

With the arrival of industrialization and the railway the city gradually descended from its high position and formed a grid of enclosed housing blocks, common for mid-European cities. This plan generated a large set of park-surrounded public spaces called the "Green Horseshoe" (Zelena potkova), for its enclosing shape. The river was still far away, while the railway - with its complementary functions - created problems with further expansion which are present today, in the form of unarticulated and often derelict spaces.

The rise of modern architecture sparked a new wave of large urban projects, mostly for the purpose of housing a growing population. These large scale urban types started a conflict with the semi-rural smaller scale housing types developed previously in the Trnje neighborhood. With the construction of its embankment, Sava was dealt with. The next stages of urban planning (New Zagreb) skipped the river and its wide new embankment, creating another, detached city – just across Sava.

The newest large-scale urban plan for Zagreb considers the river as a much more valuable resource. The establishment of three hydroelectric power plants alongside the Sava River narrows the existing riverbank and frees up a vast space at the heart of the city, enclosing it with a variety of potential highly-urbanized areas, containing public spaces, river ports, housing areas as well as workspaces.

5.1.1.4 Zagreb's stages – a workshop

By carrying out an urban/architectural workshop, we were able to gather information for the next phase of urban design in which we decided to focus on the key problems of several stages of Zagreb's urban development, thereby offering site-specific solutions and exploring the adaptable "cellular" urbanism of our Mem**brain** units. The selected stages are the Lower town grid, the Railway wastelands, the Trnje neighbourhood the Sava Riverbank and the slopes of Medvednica.

Several groups of architecture students were formed to design solutions for the application of our units in the urban contexts of the selected stages. Simultaneously, since the architecture team was planning to expand, the authors of the workshop's best solutions were welcomed as new team members.

Case study#1 | Lower-town grid

Consisted of similar types of blocks and green areas that form the famous Zelena potkova, the lower-town grid makes the ideal location for the addition of small pavilion units (functioning as markets, storages, playhouses or greenhouses).

A simple orthogonal grid forms different types of city blocks. One is a closed block with an incomplete inside (unregulated space, terrain, greenery), while the other is a closed block with built inside but unregulated space and different contents (storages, workshops, living, shops, garages). Penetration into the block is very common for this area, so there are two types with that same mark. The first type has unfinished inside with different, mostly utility services, while second type has simply unregulated terrain.

The first example of these types of blocks is the Gundulićeva - Žerjavićeva - Preradovićeva – Hebrangova block with penetration and built, but chaotic and disorganized inside. Consisting of unregulated shops, storages, garages, residential buildings this area forms a common ground for simply exchanging existing contents with small pavilion units by adding them into the block or by closing penetration.

The second analysed example is the Branimirova - Erdodyeva - Bornina – Domagojeva block, viewed as an open block, with several penetrations and an unregulated terrain. In this case we used units to fill free spaces by closing the block on each side so that we gained a closed structure with business or residential spaces. The other way to use pavilion units in this block is by adding them on rooftops, or inside of the block to get interesting public spaces or greenhouses that can function as public or private.

In terms of flexibility and modularity, the lower-town grid is a good example how to multiply our module and form smaller units applicable to specific locations.

Case study#2 | Railway wastelands

Industrialization and the arrival of the railway ended the orthogonal lower-town grid and formed unarticulated industrial areas which are largely unused today. Because the railway has cut off the connections between the old town in the north and the new settlements in the south, the revitalization of these derelict spaces needs to be managed in accordance with the underground railway plan.

In this particular withered industrial area we have chosen two interesting sites. The first one is the old "Paromlin" (flour mill) - an empty space at the city center which is in need of revitalization. The required approach here is to form temporary structures such as hostels and redevelop the old buildings into the social (cultural) spaces. Using modules and making different units by merging them horizontally and vertically it's easy to get interesting units that can be lightly assembled or disassembled. In case more or less space is required, one may add or subtract modules, always getting distinctive structures.

The other site is the "Gradska plinara" (old city gasworks) that is today an unregulated lot with some office buildings in the west. This area is perfect for development of residential, business and social content. In this case using modules also gives us the possibility of having multi-storey units. Other concepts for this location include residential combined with business, or utility services located in ground area of the buildings.

This railway area is ideal for the development of small settlements and redevelopment of old industrial buildings because of the unused spaces. In this specific location, residential is often not the most common content, and using modular units is one way of revitalization that doesn't have to be entirely residential.

Case study#3 | Trnje neighbourhood

A great example of an incorporation of a modernist urban plan to an existing semi-rural smaller scale housing is the Trnje neighborhood. The significance of Trnje is the fact that it is defined by the center - old nucleus in the North and the river Sava from the South. The place consists of vast, green, unbuilt spaces which edge the planned, regular multi residential buildings and the organic, irregular urban space formed by family housing, with the sole exception of the Cvjetno settlement in which the houses are designed and built in an orthogonal grid. For this part of the town, in the differing typology of the existing development we used the housing unit in different modules to imitate or complete the existing environment.

1) The location consists of a high density development of family houses spread in an unorganized, irregular, organic urban site. The site is completed by adding detached family houses - units that become one with the existing houses.

2) The location consists of a row of high-rise housing developments. By continuing the row we added a housing unit created by vertically adding the units in 3 stores.

3) So far we have completed the housing zone filling in the wholes with a similar typology and content.

Besides filling in the existing housing tissue, the unit also offers the possibility of containing public and utility services such as cafe, kiosk, library, etc. The unit contains as much modules as needed to fulfil its utility purpose.

Case study#4 | Sava Riverbank

As mentioned before, the space alongside the river Sava was historically considered as not applicable for settlement because of frequent inundation. Like many other riverside cities, Zagreb never managed to use its most valuable resource, and its latest urban strategy (New Zagreb – a huge modernist urban plan consisted of several communities, housing several hundred thousand inhabitants) was to simply skip the river using an embankment to control its water-level.

Today this is changing, as the public is realizing that the Sava River is a much more valuable resource and could be utilized for wanted additional public spaces, river ports, housing areas and recreation. Through narrowing the riverbank a new linear city alongside the Sava will be formed and interesting possibilities will be opened for the benefit of the city and its surrounding region.

In the context of this large-scale urban plan, our units can be applied as prefabricated pavilions for serving functions as well as for temporary residential structures (in case of disaster scenarios). These pavilions can be used to create sport and recreation centers (due to the fact that this site is today used as a recreation area), art and exposition spaces, cultural centers, playground facilities or supporting structures for water activities. Besides providing flexibility, modulation creates field conditions different from the urban grid of Zagreb, thereby forming a new landmark for our city.

Case study#5 | Medvednica

As a natural boundary on North side of Zagreb, Medvednica has been limiting the growth of the urban tissue of Zagreb throughout history. Linear green areas famously known as the "Green fingers", spread in the North-South direction penetrate the consolidated urban area, creating interesting fusions of greenery and housing. The fact that the mountain is mostly a nature park, makes Medvednica the main destination for recreation, sports and family gatherings.

An interesting site is the "Činovnička livada", a beautiful and wide meadow that hosts many different sporting and recreational events such as skiing, sledding, snowboarding in the winter; hiking, mountain biking; or a simple family get together on the vast, peaceful greenery that has a diner and a clerk's house nearby. The meadow was named after the clerk's house, formerly known as "Dom gradskih činovnika".

Due to the fact that this site accommodates mentioned activities it creates a common ground for mounting lodge. The transparency of our modules enables the interior to merge with the surrounding nature by providing interesting sights. By adding our ground floor modules in a linear way we accommodate different public contents and by placing them vertically we divide public from sleeping spaces.

5.1.2 Market Viability of the product

As we've defined it in the communications plan, our main target group will be the one between 25 and 35 years of age.

According to Croatian Bureau of Statistics there are 582 424 people in total in that target group, which is composed of 285 714 women and 296 170 men.

With the help of different promotion activities explained earlier we are planning to reach a large number of that population, and encourage them to consider the option of building the solar house. There are many aspects that must be evaluated in order to create the best possible strategy which will attract potential consumers and make them rethink about alternative housing solutions.

Important factor in realizing the project is the average net wage which was 5478 HRK or 735.17 EUR in 2012. There are some indications that average net wages will increase in the following 5 years, due to the fact that Croatia is joining European Union.

This is very important information for setting future pricing strategy, because people will become less price sensitive, their budget will increase, so there will be more space for choosing generally more expensive but eco-friendly solution.

There are many negative aspects that need to be reviewed in order to define the market in the right way.

Number of permits issued for buildings and civil engineering works shows negative trend in the past couple of years, decreasing from 12801 in 2007 to 9601 in 2011. Croatian government is working on resolving various bureaucracy problems which are very often the main reason why people are skeptical when they are considering house construction.

Residential construction is also moving at a negative rate, from 2007 it halved to a total number of 12 390 residential constructions in 2011.

Regarding the geographical aspects, Croatia has 4 equally divided seasons and the average temperature is 13.7 Celsius. Average temperature is following the trend of global warming, which is the thing that must be emphasized throughout the project development with the aim of educating people and raising their awareness about the current ecological problems.

5.1.3 Individual or collective housing building characteristic

In creating the urban development, our goal was to produce a simple and efficient solution - one that wouldn't follow a formative conceptual idea, but give way to the specific needs and individual creativity of the users and their communities, thus becoming enriched by the users whom it serves.

Following the idea of houses as single-cell organisms defined by their membranes, the urban development is conceived as an organism of **urban cells.**

These urban cells are the basic units (housing, educational, recreational, sanitary, etc.) while the blood vessels - or capillaries - that connect the cells are the traffic network. As the network of capillaries supplies the cells and needs to be as efficient as possible, so does the traffic network function as a circulatory transport system, and requires to work as a simple grid to assure the commodity and equality of every unit, or cell. The grid is a simple perpendicular one, for it is used primarily by vehicles. It forms square fields, inside which the cells can differentiate into the required types, choosing an arbitrary shape.

This idea is important because it is compatible with any cultural matrix. It provides the basic infrastructure, but does not suggest a specific way of life. The life of the communities inside the urban cells can be arranged according to their requirements, and can evolve through time.

The space between the cell and the vessels - the membrane - serves as a selective barrier, allowing some particles to pass through, but not others. The vehicles are stored into it (in forms of parking spaces), the cells excrete their waste through it (in forms of municipal waste), the cells are protected by it (in forms of protective vegetation) and matter is selected and supplied through it (in forms of commerce units). Hence, the urban development distinguishes three space fields - the outside vessels, the membrane, and the inside of the cell. The inside is always pedestrian, and is shielded by the membrane. It can form structures of different units, creating a closed environment for the users, who can choose to travel from cell to cell, thus changing their environment. In so doing, they can use their own vehicles or public transport, both connected to the outer transport network.

Also, the network of roads itself can evolve through time. As the urban cells around them differentiate and choose their function, some roads accumulate more traffic (becoming the main vessels of the organisms) while others serve merely as links between them (remaining small capillaries). Some may also disappear - forming larger cells, or even groups of cells, that serve a bigger urban settlement, facility or natural area.

The sustainability of the solution is most expressed by its versatility and variability, for it can adapt to any given condition, and support any given population. The urban development can be integrated into any urban network or landscape, and can embrace into its grid the values and traits of its natural and cultural heritage.

5.1.4 Mobility strategies

Zagreb is served by a multifold network of transport, relying on a combination of city-managed mass transit and individual transportation. Mass transit is composed of 19 inner-city tram lines and 120 bus routes, both managed entirely by "Zagrebački električni tramvaj – ZET". Croatian Railways manages the parallel Zagreb Commuter Rail system. The city is served by the Zagreb Airport, which carries more than 2,000,000 passengers per year.

The proposed urban design solutions are implemented in Zagreb's transport network. The five stages of the case study are considering existing city areas served by the mentioned forms of public transport.

The Borongaj campus is approachable by tram (lines 2, 3 and 13), bus (lines 236 and 215) and train (currently the "Maksimir" and "Trnava" stations).

5.1.5 Affordability strategies

Affordability will be updated in Deliverable #5.

5.2 Architecture Design Narrative

5.2.1 Architectural Concepts

5.2.1.1 Introduction

Starting from the very source of life - the cell, the UNIZG team developed the idea of a future house – the Mem**brain**. The name is a portmanteau, combining a membrane (the passive/selective envelope of the house) and a brain (a smart system controlling that same membrane and through it the void inside). By observing the cell and its parts, we used the idea of a membrane - which protects the cell and regulates the conditions between the exterior and the interior – as the skin of the house, regulating the physical properties of the building (temperature, humidity and indoor air quality) as well as the sense of the space inside (light, openness, relation to the exterior).

Also, the membrane contains all the services/utilities: kitchen, bathroom, storage, engine room, entrance and greenhouse, thereby freeing the interior space of service areas and creating a flexible void space. Thus, the membrane doesn't simply protect its costumer, it hosts various functions by itself, and in combination with the void space provides with a wide range of possible uses of the house.

The membrane is located on all six sides of the cell, and it adapts to the location, access, orientation and other conditions (it can function inside a city block, in the suburbs, on a southern mountain slope, etc.). It is completely prefabricated and modular, and can easily be assembled / disassembled. To ensure modularity and achieve a high degree of flexibility, a rectangular layout has been chosen.

The simplicity of the idea generates an efficient, comfortable, adaptable and modern design – creating more than a house – a principle, or concept – applicable to all kinds of architectural tasks.

5.2.1.2 Concept Terminology

In order to make our project easily understandable, we will describe its basic components and their properties in this section.

The two key components are the membrane and the void. The membrane encloses the void, and can be further divided into three spatial subcomponents accommodating different functions – service group, greenhouse and winter garden (as shown in the figure below). The membrane functions as a set of layers which are combined into a single smart unit, enveloping (thus protecting) and contributing to the flexibility and commodity of the void – the Mem**brain**.

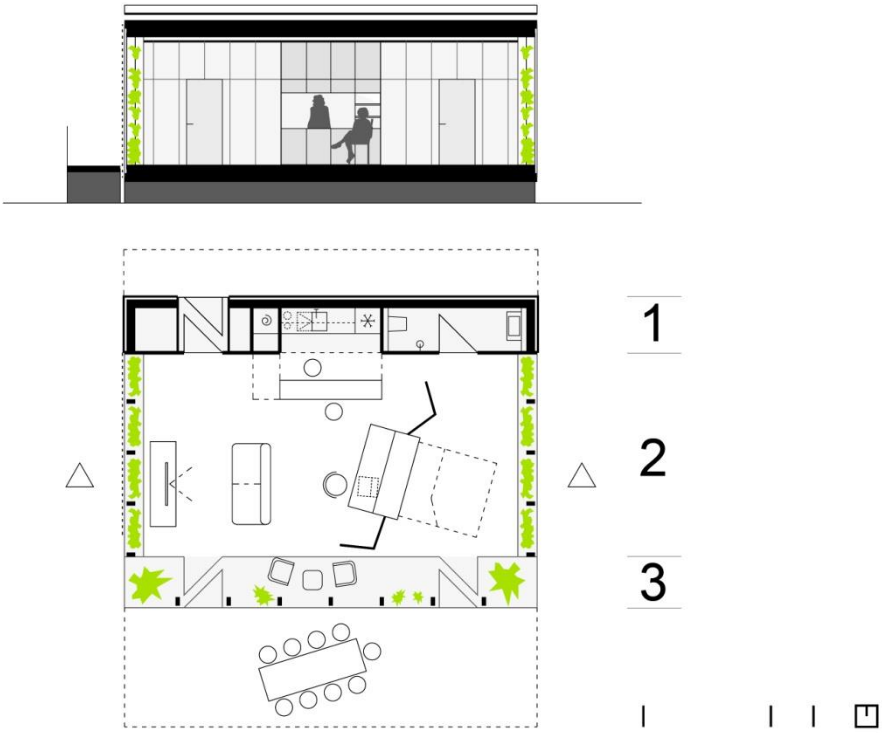


Figure 5 - Spatial division of the Mem**brain** (hatched grey area): 1 service group; 2 greenhouse; 3 winter garden

5.2.1.3 Mem**brain** layers

In this section we will describe the Mem**brain** as a multi-layer system consisting of three basic layers – load bearing structure, insulation and infra layer.

<u>Load bearing structure</u>

Wood, as a major element of the project materialization, was selected for its availability on the Croatian territory - 42% of the area is covered by forests. This is why we wish to explore the possibilities of laminated wood and other wood products used in house construction. The load bearing structure is made of cross–laminated wooden slabs and columns. It is conceived through a modular system, the basic modular measure being 120cm. The columns are arranged around the perimeter of the floor plan. Each column measures 300cm in height, its cross section measuring 12x20cm. The slabs are 18cm thick, spanning a total distance of 680cm. Each slab is, in accordance to the modular grid, 120cm wide.

The horizontal forces, as a result of wind or earthquake impact, are taken over by cross – laminated plywood walls, which are placed between the columns of the northern side of the house, and transduced to the footings. These plywood panels are placed on the non-translucent side of the Mem**brain** (service group), and can be arranged in a variety of suitable positions (enabling the modular design of the house). The footings are made of precast reinforced concrete, with added polystyrene granulate, to reduce density, and thereby their weight.

Mem**brain** layers – insulation

There are two types of insulation used in this project – sheep wool and glazing, the advantages of the first being its cost efficiency and local availability, while the second is translucent, thus enabling sunlight and heat exploitation. By means of the Mem**brain**, we want to define and protect the void, by maintaining a visual connection with the outdoor space. This proposal required us to find the adequate ratio of sheep wool and glazing used to insulate the void space properly.

Three sides of the façade, the southern, the eastern, and the western, consist of an outer and inner layer, made of triple and double glazed panels respectively, providing a high daylight factor. The two layers enclose the greenhouse (to the east and west) and winter garden (to the south) space. All glazing panels are fixed by aluminum profiles attached to the roof and floor slabs. The panels are detached from the columns, and placed adjacently to one another. The narrow space left between two panels is filed up with durable elastic silicone. Air in the greenhouse and winter garden is used to warm up the void space during winter, or serve as a buffer to prevent overheating during summer, becoming an integral part of the insulation.

By making three sides of the façade translucent, we also had to think of ways to provide appropriate sunshade, avoiding overheating during summer. The eastern and western façades are partially protected by plants grown in the greenhouse. They also ensure privacy to some degree, as they serve as a visual barrier, still enabling the customer's view to the outside. In order to ensure complete shading and outside view protection if needed, there are roll up shades on each side. Their shades are placed outside the outer glazing layer, and are rolled up horizontally. The south façade is protected by an innovative building integrated PV tracking system (which will be explained in more detail in a separate section below).

The northern façade is non-translucent, and is enclosing spaces that do not have high or any daylight requirements. It consists of panels that are attached between columns. Each panel is made of several layers, the innermost being cross-laminated plywood, followed by a vapor barrier, a 20cm thick sheep wool layer and finally the outermost façade layer fixed on a secondary wooden construction. The outermost layer depends on the surroundings the house is placed in and can vary in thickness and material. For the purpose of this competition we chose a wood batten wall, with vertical batten alternating in two planes – this type of façade is common in the traditional building of the continental parts of Croatia. Insulation atop the roof and beneath the floor slab is also provided by a sheep wool layer of 16cm thickness, covered with a plywood panel to the outside.

The roof is additionally protected by a single surface synthetic waterproofing, made out of a single piece. The insulation is simply placed atop the roof and bent down over the roof edges into the gutter. Then, it gets additionally fixed on the bent over parts. Every time the house is adjusted in any way (adding or reducing the number of modules) or moved to a different location, the insulation is removed and placed again in one single piece, preventing any harm to it.

All the façade panels (glazing and composite ones containing sheep wool) are made in accordance to the basic modular system (120 cm). The current design of our house determines the previously described distribution of translucent (glazing) and non-translucent (composite panels) elements, but because of the modularity they can be rearranged to adapt to various demands and given sites.

Membrain layers – infra layer

The infra layer contains all the systems that provide a flawless functioning of the whole Membrain and thereby the void space as well. This layer will be described here briefly, and be dealt with in more detail in the respective teams' section of this project manual.

The air temperature is regulated by an under floor heating and cooling system. Underfloor heating systems work with warm water circulating through pipes which are laid under the floor covering. The heat from the water is absorbed by the floor surface and transferred to the rest of the space, mainly through radiation. This type of heating system allows lower operating temperatures, while maintaining the thermal comfort of the space. Lower operating temperatures are of great importance, as they allow us the use of renewable energy sources - during the exhibition in Versailles we will use an air to water heat pump. Underfloor cooling uses the same infrastructure and equipment as underfloor heating, but in this case cold water is circulated through the pipes. The flowing water absorbs the heat from the floor; simultaneously the chilled floor absorbs sensible heat from the air, people, equipment and other objects. In our case, the ventilation system has the task of regulating relative humidity within a safe interval in order to avoid condensate formation on the chilled floor. The ventilation system also regulates the humidity of the greenhouse and the winter garden space, enabling the transfer of warmth from these spaces into the void to benefit from the greenhouse effect during the winter.

Sustainable construction goes hand in hand with the dematerialization of constructional elements, which are made of materials with a lower thermal capacity. This leads to the reduction of heat accumulation and indirectly to increased energy consumption for air conditioning. In order to solve this problem, we use phase-change materials (PCM), which have a much greater ability to store heat than conventional building materials. The PCM is placed beneath the roof slab and covered by a dropped ceiling.

All the plumbing is placed in the northern part of the Membrain. By keeping it all compact, we avoid high plumbing costs, complicated technical solutions and increase the safety in terms of leaking installations. It can be easily accessed, checked or fixed by removing the floor panels.

There are many sensors placed within the Membrain which gather information not only regarding the environment and the conditions around and inside the house, but also regarding the user's behavior and habits. This data is used to provide a maximum level of commodity and safety to the costumer, while saving energy and reducing the ecological impact of the house at the same time.

5.2.1.4 Functional division of the Membrain

This section describes the Membrain by analyzing its functional subcomponents – the service group, greenhouse and the winter garden.

Service group

The service group can be further divided into four components – entrance, engine room, kitchen and bathroom.

The engine room flanks the entrance on both sides, from where it can be accessed. All the infra layers originate from the engine room. The kitchen is configurable – a whole block can be slid from the northern wall, forming a bilateral kitchen. The part slid away into the void is also used for everyday dining, while there is a table for formal dinner stored away in the storage space. The bathroom consists of a toilet, a sink and a shower. Grey water is collected from the kitchen, bathroom sink and shower, and further stored and processed in order to be reused as water for washing the toilet. Because of the rules, the previously described water reuse system will not be applied during the competition in Paris, but we are planning to set it up at the Borongaj university campus.

Winter garden

Located in the southern part of the Mem**brain**, the winter garden serves not only as a space for leisure and relaxation, but also plays an important role in maintaining an optimum climate inside the house, as shown in the figure below. During summer, the winter garden space is a buffer, and the warm air inside is ventilated outside, preventing the inner glazing, and thereby the void, from overheating. At night, all air inside the void is exchanged with fresh air from outside through the winter garden, cooling the whole house in the process.

During winter, the winter garden is used to generate the greenhouse effect – the warmed up air is used to contribute to the warmth of the void and isolate it from the outside cold air - it serves as a buffer during day and night. It can be seen in the figures below, that the PV tracker is operating synergistically with the previously described use of the winter garden.

Greenhouse

The urban greenhouse is based on the principles of sustainable building which we can connect to permaculture - as a movement based on creating sustainable human societies while applying existing nature's schemes, primarily in agriculture and later in other forms and aspects of human activities such as design.

The idea is to add on modern causes for revitalizing urban community gardens and the use of abandoned parts of the city land for organic farming, growing herbs, vegetables and fruit independently within the house, neighborhood, district or a city where it's even possible to plan community garden zones modularly consisting of one or more Mem**brain** cells. It is possible to add a productional dimension to the whole sustainable settlement after which the local population would basically consume self-produced food.

In accordance with the concept, whose final goal and product is a house which satisfies the needs of its inhabitants, we plan a greenhouse which will, though modest in its size and variation of plant species, fulfill the basic needs of a household. In this case, the so called greenhouses would be formed in the east and west parts of the Mem**brain** and would imply a wooden structure made out of vertical poles (with floor foundations) and a horizontal system of green pockets made of waterproof fabric in which the plants are grown. The greenhouses would also include a number of wooden plant pots for bigger plants. The eastern and western orientation of the greenhouses ensure a sufficient amount of sunlight required for such ‘farming’. The needs for humidity and warmth can be calculated using average needs of the planned species and the control of these values would be a part of the house’s smart system. Depending on the climate conditions outside the house and the season, the conditions would be more or less corrected. In the winter bigger efforts would be put into ensuring suitable conditions and in the summer with convenient weather opening the greenhouses to the insides of the house would be possible, creating a greener ambience, giving an additional dimension to the membrane and creating a more translucent space and the contact of inside and outside spaces.

The problems with this type of urban farming are surely the insects, because permaculture and organic farming rules strongly forbid any use of chemical insecticides. This problem is solved avoiding the species which are known to attract swarms of unwanted bugs, using organic insecticides available in agricultural pharmacies and, if needed, using sound devices that create different frequency sounds which fend off the insects.

Irrigation is planned within the horizontal structure. Water needs can be satisfied from the greywater tanks (under the condition that it is purged and filtered from all unwanted microorganisms, phytotoxin etc.). In a system where this kind of water is collected in several containers throughout the house with a simple pump system this water can be brought to the plants and irrigate each green pocket separately. Using a faucet the irrigation is controlled and it can vary from N times a day or drop by drop irrigation. It's important to note that the lower parts of the planting construction can be watered manually thus avoiding additional complications and simplifying the system but also reducing the amounts of electricity used for running the water pumps.
With this concept of urban farming the house is given an additional, productive component and, as a sustainable system, seems more complete satisfying a part of the needs for food. The goal is avoiding the use of imported groceries and food produced thousands of kilometers away. Instead, we offer the advantage of organic farming, the freshness and proximity it offers.

5.2.1.5 Interior Concept

Having previously described the concept of the Mem**brain**, this section will focus on the functioning of the void.

The basic requirement for the void is flexibility - reflected in the ability to easily move objects (such as furniture) inside it, so the house can be arranged depending on the number of users, activities, time of day, etc. The moving of furniture is provided by casters. Every piece of furniture in the void is completely movable and can be folded, stacked or pulled out of another part of the furniture, to meet the user's requirements. With the flexibility and these various functions a fully adaptable space is created.

By configuring the interior elements, the void can be divided into several areas or rooms – living room, dining area, kitchen, bedroom or working space. The kitchen, for example, consists of mobile units that can be pulled out from the northern wall of the Mem**brain**, and form an operational space for preparing and serving food. The living room and dining space are divided from the more private sleeping area by a flexible partition wall, which can form various positions depending on the user's requirements. The bed is also mobile and can be moved to a vertical position in order to free extra space for work, play or exercise.

5.2.2 Summary of Reconfigurable Features

There is a building integrated PV tracker placed atop the roof. It adjusts mechanically to the angle of the solar beams to maximize the efficiency of PV panels. This system has the secondary function of being a dynamic roof for providing shade during summer and to let daylight inside during winter in order to optimize the amount of passive solar gains throughout the year. The tracker is completely modular, so as many units as desired may be attached. The tracker will move daily in order to be in the ideal position for both – power production and shade providing. These two requirements are in correlation, so it is possible to fulfill both simultaneously. The tilt/angle of the tracker will be controllable manually (via a home automation system) or automatically (via an intelligent algorithm).

As mentioned before, the kitchen is reconfigurable – one part of it can be slid away, forming a bilateral kitchen. It is conceived to be used as a bilateral kitchen most of the time, the exceptions being when there is a temporary need to extend the void space. The house-keeping elements work in a similar manner.

5.2.3 Lighting Design Narrative

The home is a world of family relationships, surrounded by objects and furniture revealing the taste of the people who live there. At the same time, the home is a place for socializing, where we meet with friends, somewhere we can indulge in our hobbies. All of this must be considered in a project for lighting.

The various indoor and outdoor areas that determine the home need residential lighting that adopts specific solutions not just through traditional lamps but also using more technical products, able to create lighting that adapts the spaces to the conditions in which they are used. The living room may serve for reading a book, but also for organizing a party with friends.

The rapid development in LED lighting technology over the last few years has changed the dynamics of the global lighting market. Improved brightness, lower energy consumption and longer life spans offered by LED lights have encouraged industrial, commercial and even residential consumers to increasingly adopt LED lights.

LED lights are light emitting diodes compared to incandescent bulbs which are based on filaments. LEDs are highly efficient as they offer brightness of up to 150 lumens per watt compared to CFLs (compact fluorescent), which offer brightness of around 60-70 lumens per watt and incandescent bulbs which offer below 30 lumens per watt. This highly improved quality of light offers advantages in multiple applications like street or parking lot lights where improved brightness enhances safety and security.

In addition, LED lights are more environmentally friendly as they consume less power than either CFLs or incandescent bulbs. These lights require about 8-12 watts of power compared to around 15 watts required by comparable CFLs and 60 watts required by incandescent bulbs. Lower power consumption and a consequent decline in the cost of lighting one’s home or office space is a significant advantage especially in the case of commercial buildings where a significant portion of the total energy consumption comes from lighting.

LEDs also have much larger life spans, which along with their lower maintenance costs ensure that the higher upfront investment in them gets compensated during their lifetime. In all, the improved quality of light, reduced energy consumption and higher return on investment offered by LED lights will grow their market. LED creates individuality and that is exactly what the world needs, today and in the future. So, we can conclude that LED is the technology of the future.

The most sustainable lighting is natural daylight. It is not only a free renewable resource but it also has well-documented health benefits. Careful architectural design is required to maximize natural light in a building while maintaining indoor temperature regulation and reducing direct light glare. The strategic placement of windows, skylights, light shafts, atriums and translucent panels in harmony with other building components, such that light is reflected evenly throughout internal spaces, is known as day lighting design.

Along with technological solutions and using renewable energies for their electricity source, simple practices such as turning lights off, using dimmers and timing switches can help in making lighting more environmentally friendly.

The detailed layout of the lights in the house is shown in the drawing EL – 401 Lighting plan.

Our lighting plan is listed in the Table 1. Total power amounts to 547.7 W.

Table 1 Total lighting power

Light	Power	Quantity	Total power	Dimming values
LED strip 1	7.2 W/m	36 m	259.2 W	10-100%
LED strip 2	4.5 W/m	5 m	22.5 W	0%
KORA 16	15 W	3 pcs	45 W	0%
KORA 7	7 W	6 pcs	42 W	10-100%
Tab 2 GU5.3	6 W	4 pcs	24 W	10-100%
KEA 180	11 W	2 pcs	22 W	0%
JAGO	7 W	3 pcs	21 W	0%
LIAM	7 W	13 pcs	91 W	0%
NEMEA 6	7 W	3 pcs	21 W	0%

5.2.3.1 Indoor lighting

Indoors, indoor recessed luminaires, indoor ceiling-mounted luminaires and LED strips are used. When the ceilings do not allow installation and people decide to put luminaires on the walls, indoor wall-mounted luminaires and wall-recessed luminaires can be used. Standard LED lamps with indirect light have optics designed to direct the light flow onto the ceiling, giving light that is evenly diffused around the room.

LED Strip 1 is used in the kitchen, greenhouse and main room as a direct and indirect lighting because of wide light spectrum, Figure 6 (left). LED strip 2 is used only in the bathroom around the mirrors as indirect lighting, Figure 6 (right). With that kind of dimmable lighting, the house can be adjusted to every daily situation and also creativity can be expressed. Technical information is listed in the Table 2 – Technical sheet for LED Strip 1 and LED strip 2, the simulation is presented in the Figure 8.

Figure 6 – LED strip 1 and LED strip 2

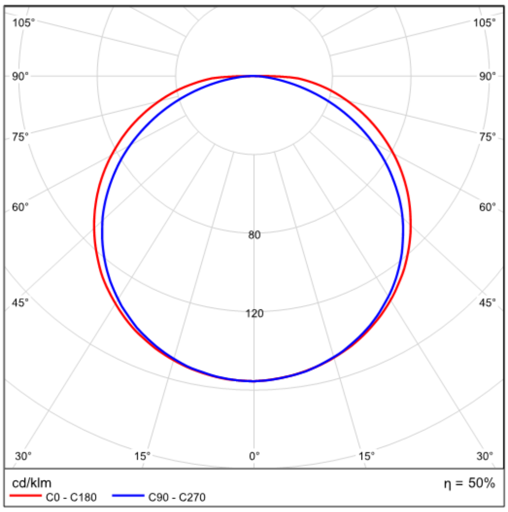


Figure 7 – Distribution of illumination for LED strip

Table 2 – Technical sheet for LED Strip 1 and LED strip 2

CODE	LED Strip 1	LED strip 2
Light colour	3000 K	3000 K
Total luminous flux [lm/m]	400	180
Colour rendering index (CRI)	>75	>75
LED lifetime [h]	>50 000	>50 000
IP Protection	IP65	IP65
Insulation class	II	II
Voltage input	12 DC	12 DC
Power [W]	7.2 W/m	4.5 W/m

Figure 8 – Simulation of light in green house

KORA7 is used in main room to complement LED Strip and also to light up specific part of house, when that is needed, Figure 9. Technical information is listed in the Table 3, the simulation is presented in the Figure 10.

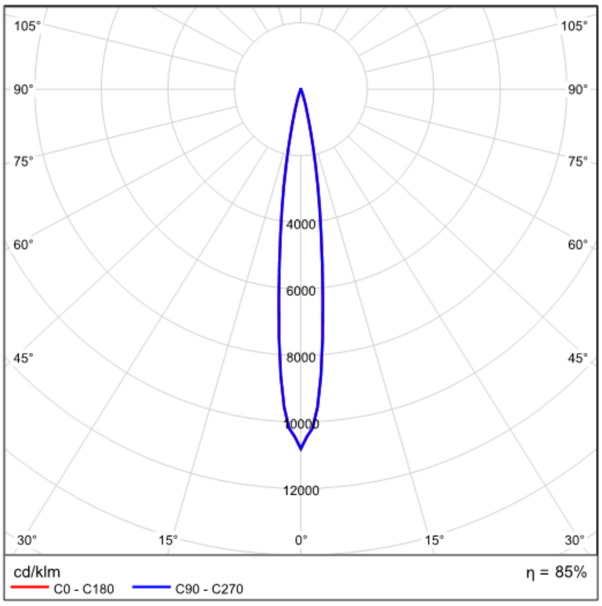


Figure 9 – KORA 7 distribution of illumination

Table 3 – Technical sheet for KORA 7

CODE	KORA 7
Light colour	Warm white 2800-3200 K
Total luminous flux [lm]	310
Colour rendering index (CRI)	70-80
LED lifetime [h]	>25 000
IP Protection	IP54
Voltage input	230 AC 50 Hz
Power [W]	7

Figure 10 – Simulation of light in the main room

KORA 16 is used in the bathroom, Figure 11. The bathroom is a room with presence of water and moisture, so the chosen light needs a high IP protection factor. According to the latest issue of IEE wiring regulations minimal IP protection factor for the lights chosen in the bathroom is IP44. Technical information is listed in the Table 4, the simulation is presented in the Figure 12.

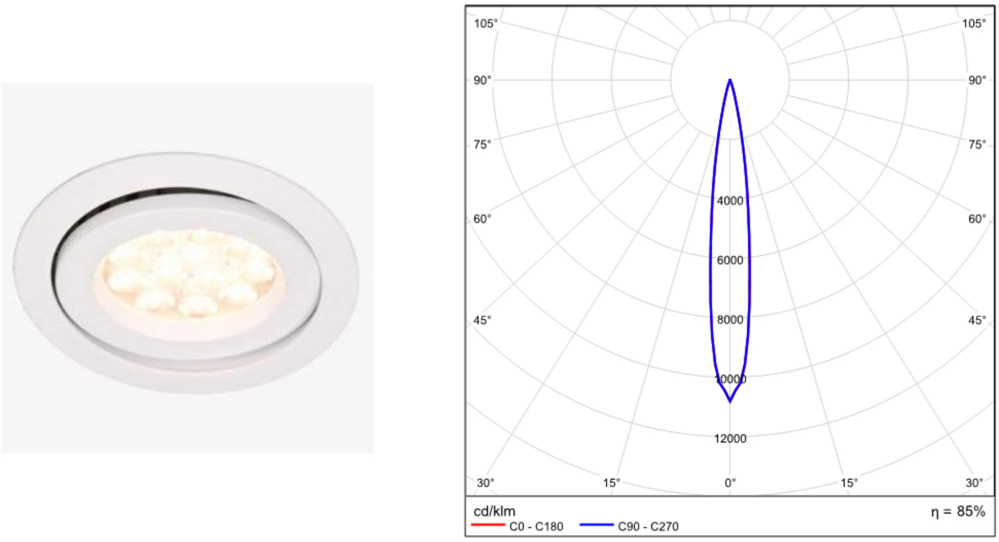


Figure 11 - KORA 16 distribution of illumination

Table 4 – Technical sheet for KORA 16

CODE	KORA 16
Light colour	Warm white 2800-3200 K
Total luminous flux [lm]	410
Colour rendering index (CRI)	70-80
LED lifetime [h]	>25 000
IP Protection	IP44
Voltage input	230 AC 50 Hz
Power [W]	15

Figure 12 – Simulation of light in bathroom

KEA 180 is used in storage and engine room, Figure 13. This lamp is chosen because that kind of light needs to have very good luminance and wide light spectrum. Technical information is listed in the Table 5, the simulation is presented in the Figure 14.

Figure 13 – KEA 180 distribution of illumination

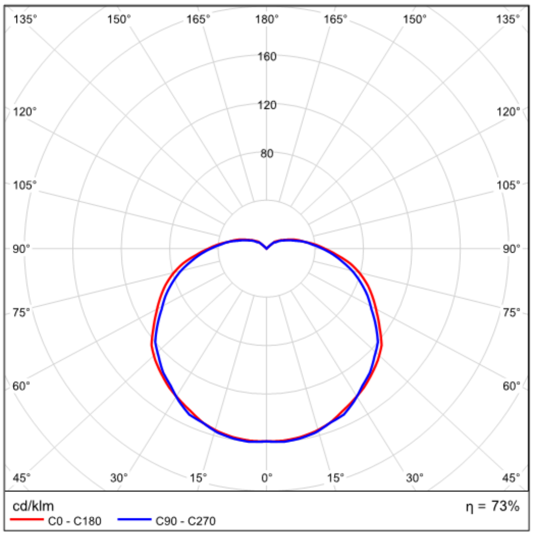


Table 5 – Technical sheet for KEA 180

CODE	KEA 180
Light colour	Warm white 2800-3200 K
Total luminous flux [lm]	525
Colour rendering index (CRI)	>75
LED lifetime [h]	>50 000
IP Protection	IP40
Voltage input	230 AC 50 Hz
Power [W]	11

Figure 14 – Simulation of light in storage and engine room

Tab2 GU.5 is used in kitchen and lobby, Figure 15. This lamp has low power consumption and very good color rendering index, so that could be very useful in kitchen. Technical information is listed in the Table 6, the simulation is presented in the Figure 16.

Figure 15 – Tab 2 GU.5 distribution of illumination

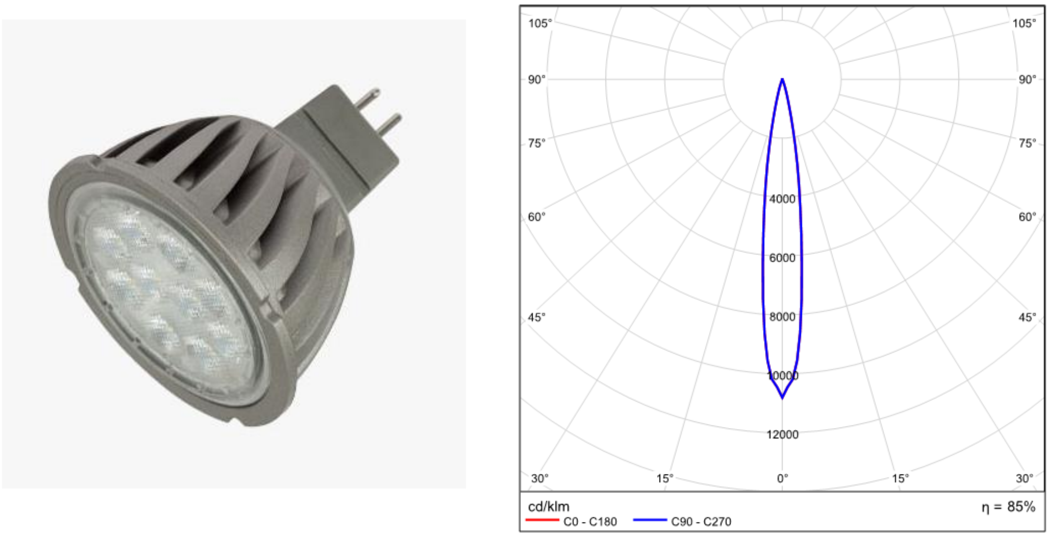


Table 6 – Technical sheet for Tab 2 GU.5.

CODE	Tab2 GU.5
Light colour	Warm white 2800-3200 K

Total luminous flux [lm]	320
Colour rendering index (CRI)	>70
LED lifetime [h]	>25 000
IP Protection	IP40
Voltage input	230 AC 50 Hz
Power [W]	6

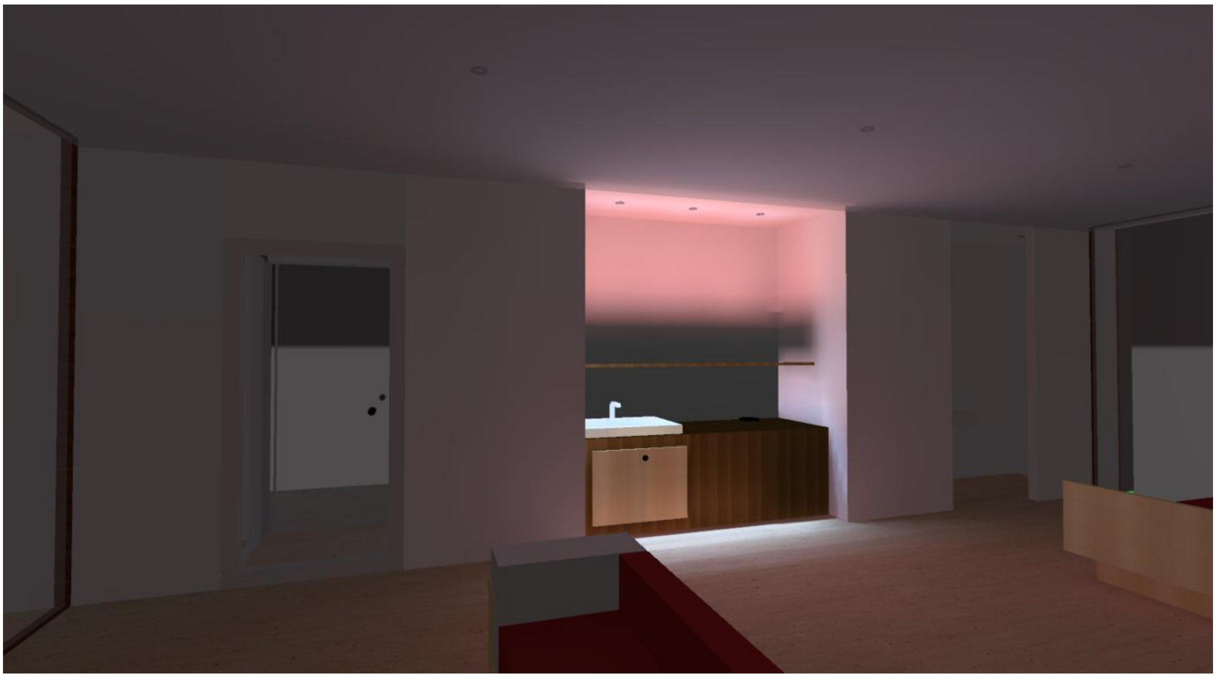


Figure 16 - Simulation of light in kitchen

5.2.3.2 Outdoor lighting

For residential lighting of the gardens, the luminaires used are the same as those for public areas, such as outdoor floodlights and pathway luminaires. Installation of ground and floor-recessed luminaires is designed to create guide lights which highlight the paths in the outdoor garden and building areas, as well as making the most of greenery by reducing the size of the luminaires, whose technical components disappear under the surface, with just the light coming out.

Outdoor lighting is subject to certain wiring regulations and must be selected and erected so as to be suitable for external influences likely to occur at the particular point of installation. Such influences are likely to include: spraying and splashing water, water from jets and immersion in water. The required IP rating for outdoor lighting depends on the influences it is subjected to.

LIAM is used to light pathway, Figure 17. Technical information is listed in the Table 7, the simulation is presented in the Figure 18.

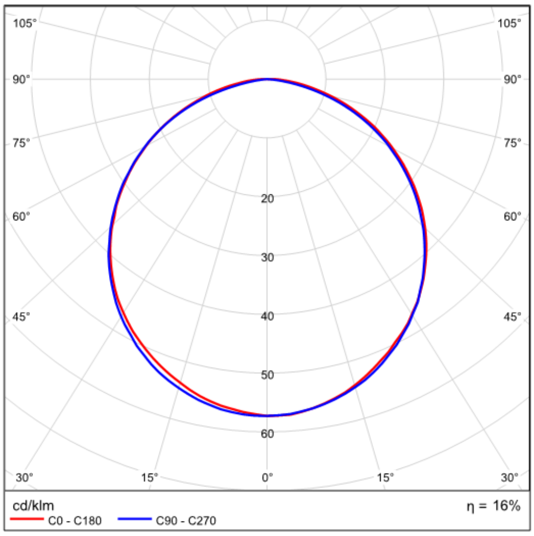


Figure 17 – LIAM distribution of illumination

Table 7 - Technical sheet for LIAM

CODE	LIAM
Light colour	Warm white 2800-3300 K
Total luminous flux [lm]	160
Colour rendering index (CRI)	>75
LED lifetime [h]	>50 000
IP Protection	IP65
Voltage input	230 AC 50 Hz
Power [W]	7

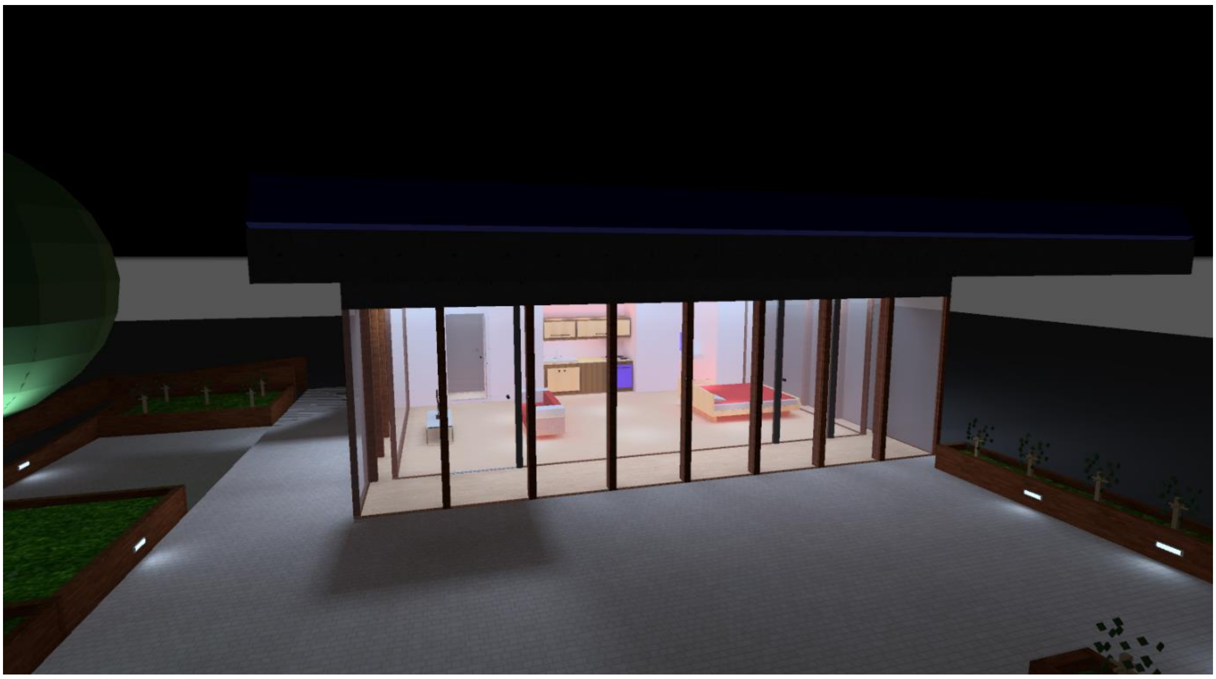


Figure 18 – Simulation of light outdoors

NEMEA 6 is used to light tree and to contribute outdoor light design, Figure 19. Technical information is listed in the Table 8, the simulation is presented in the Figure 20.

Figure 19 – NEMEA 6 distribution of illumination

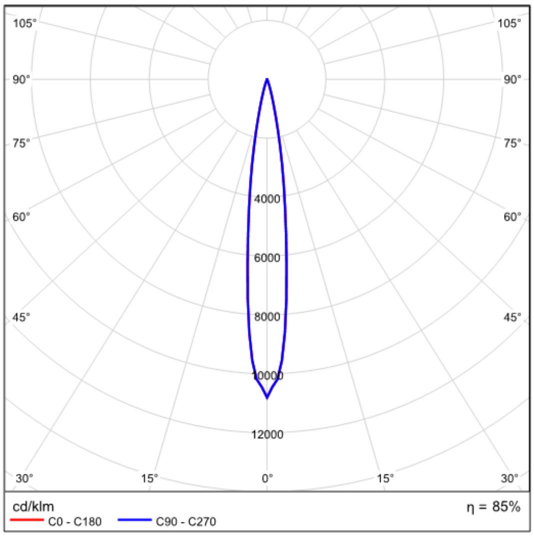


Table 8 - Technical sheet NEMEA 6

CODE	NEMEA 6
Light colour	Cool white 5500-6000 K
Total luminous flux [lm]	500
Colour rendering index (CRI)	>70
LED lifetime [h]	>40 000
IP Protection	IP67
Voltage input	230 AC 50 Hz
Power [W]	7

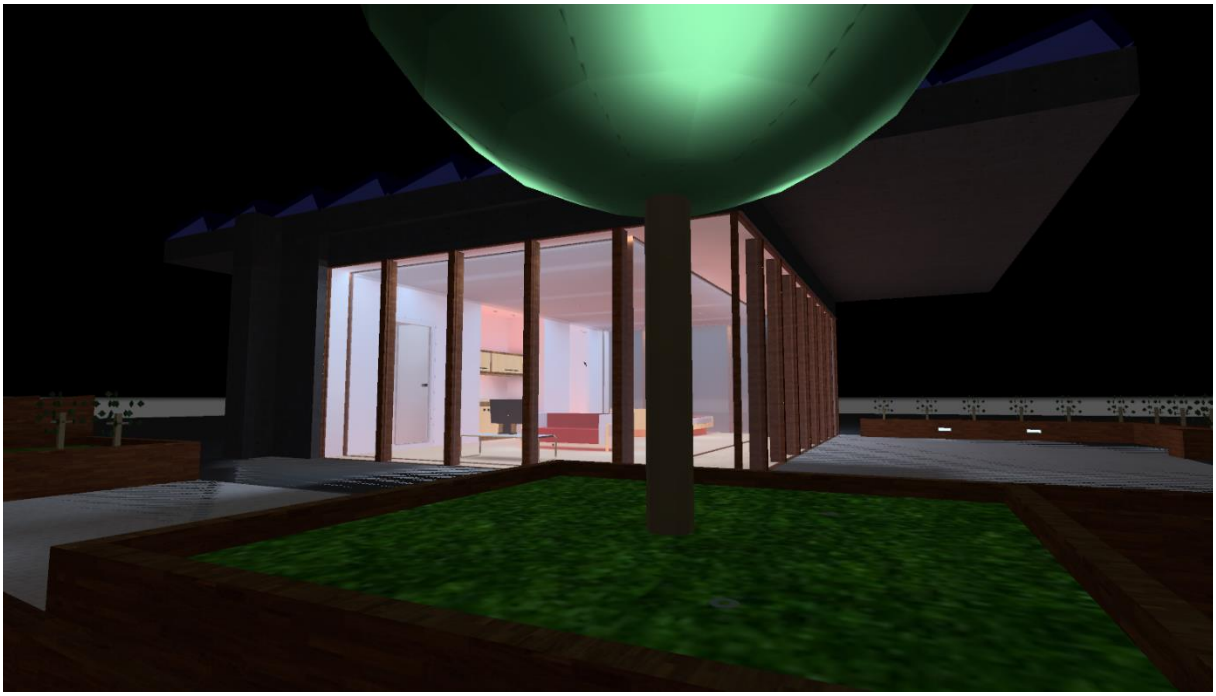


Figure 20 – Simulation of tree lighting

JAGO is used to light northern facade and also to contribute outdoor lighting design with specific light rays, Figure 21. Technical information is listed in the Table 9Table , the simulation is presented in the Figure 22.

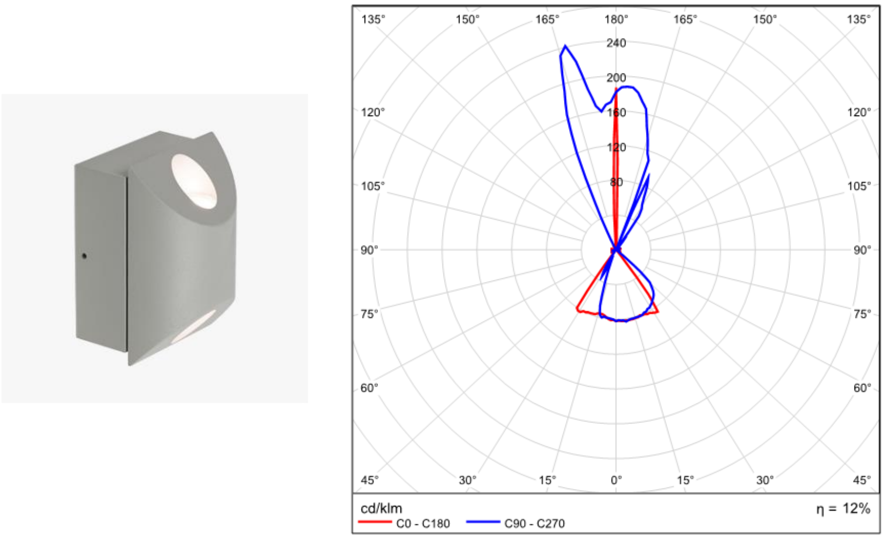


Figure 21 – JAGO distribution of illumination

Table 9 – Technical sheet for JAGO

CODE	JAGO
Light colour	Warm white 2800-3200 K
Total luminous flux [lm]	2 x 80
Colour rendering index (CRI)	>70
LED lifetime [h]	>50 000
IP Protection	IP54
Voltage input	230 AC 50 Hz
Power [W]	7

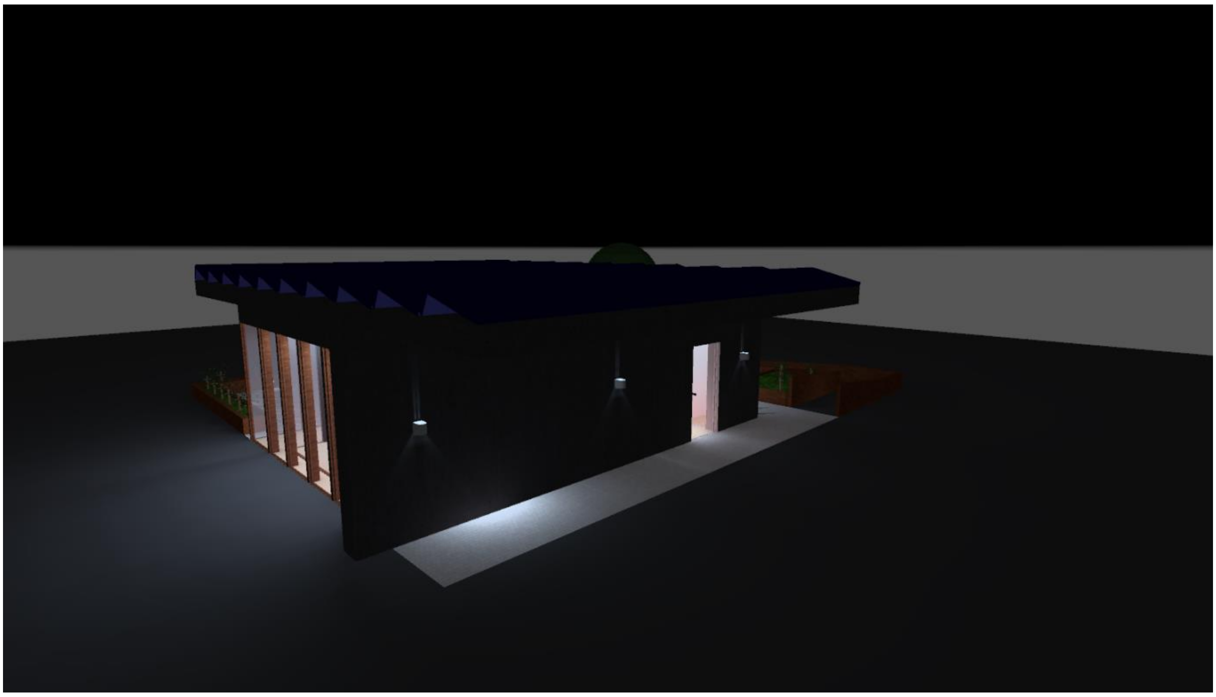


Figure 22 - Simulation of northern facade lighting

5.2.3.3 Lighting calculation

The lighting calculations were made in DIALux evo, free software developed for professional light planning. The software calculates the light exchange between luminaires and any other surfaces (direct lighting) and also the light exchange between illuminated surfaces (indirect lighting).

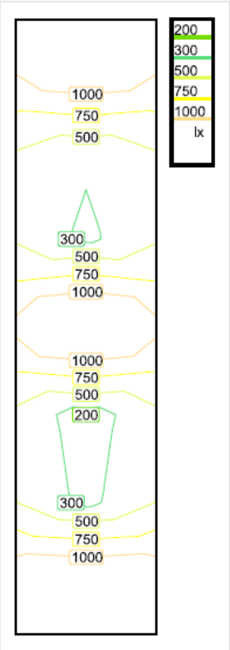
The method applied for the calculation is so-called photon shooting method. According to its distribution, light is projected on the visible surfaces. From these surfaces photons are, depending on the material properties, sent out, diffusely passed on, transmitted or absorbed. The photons are gathered on the surfaces, affected and an evaluation of the density is made. From the number of photons per surface and their energy content the luminance or luminance is determined. It is possible not only to visualize mirroring surfaces but also to take them into account exactly and sufficiently in photometric planning and calculation in a time frame which is acceptable in practice.

Lighting calculation of each object in house is represented through several different parameters.

For more information about DIALux and calculation method please visit official DIALux webpage.

Lighting calculation (bathroom)

Bathroom / Isolines/Horizontal illuminance

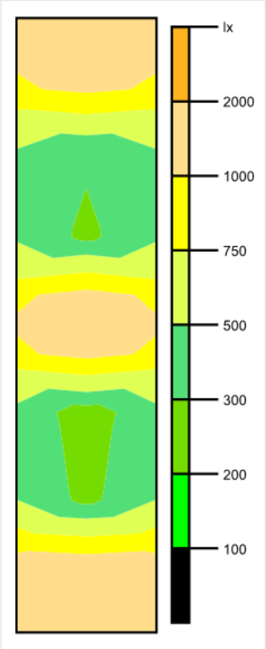


Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 765 lx, Min: 199 lx, Max: 1494 lx, Min/average: 0.260, Min/max: 0.133, Points: 1 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Bathroom / False colours/Horizontal illuminance

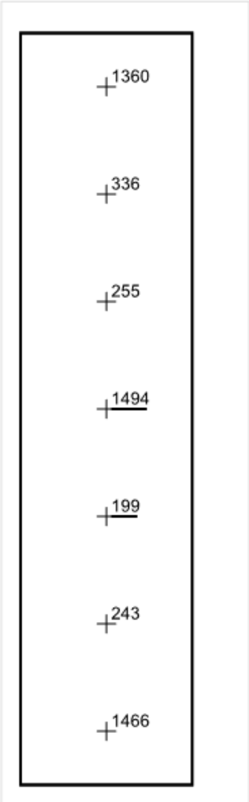


Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 765 lx, Min: 199 lx, Max: 1494 lx, Min/average: 0.260, Min/max: 0.133, Points: 1 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Bathroom / Value chart/Horizontal illuminance



Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 765 lx, Min: 199 lx, Max: 1494 lx, Min/average: 0.260, Min/max: 0.133, Points: 1 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Bathroom / Table/Horizontal illuminance

Value chart [lx]

m	0.000
1.314	1360
0.876	336
0.438	255
0.000	1494
-0.438	199
-0.876	243
-1.314	1466

Horizontal illuminance (Grid)
Average: 765 lx, Min: 199 lx, Max: 1494 lx, Min/average: 0.260, Min/max: 0.133, Points: 1 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Bathroom / Results overview

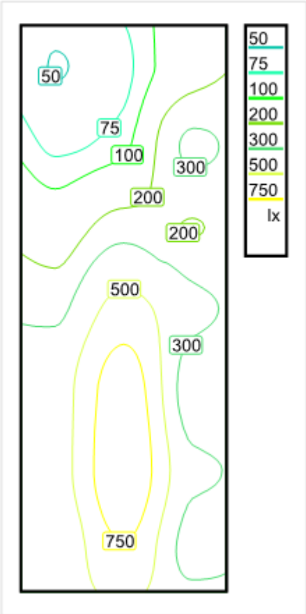
Results overview (Grid)

Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Horizontal illuminance [lx]	765	199	1494	0.260	0.133	1 x 7 (all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (kitchen)

Kitchen final / Isolines/Horizontal illuminance

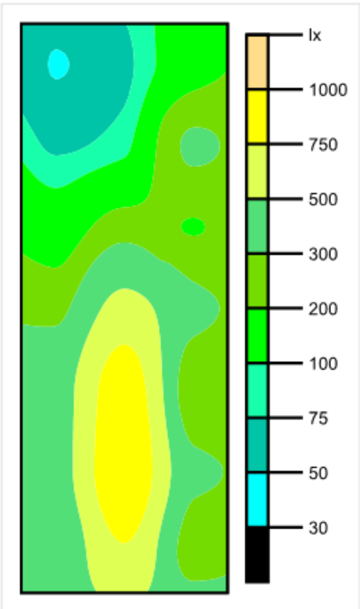


Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 336 lx, Min: 49 lx, Max: 979 lx, Min/average: 0.146, Min/max: 0.050, Points: 3 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Kitchen final / False colours/Horizontal illuminance

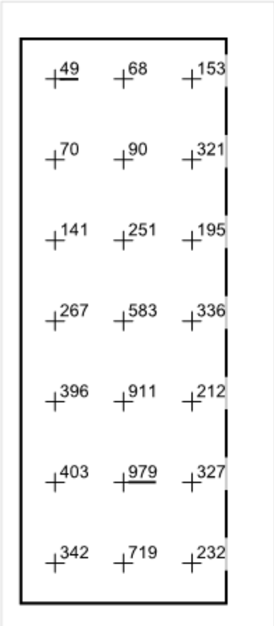


Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 336 lx, Min: 49 lx, Max: 979 lx, Min/average: 0.146, Min/max: 0.050, Points: 3 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Kitchen final / Value chart/Horizontal illuminance



Scale: 1 : 25

Horizontal illuminance (Grid)
Average: 336 lx, Min: 49 lx, Max: 979 lx, Min/average: 0.146, Min/max: 0.050, Points: 3 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Kitchen final / Table/Horizontal illuminance

Value chart [lx]

m	-0.276	0.000	0.276
0.977	49	68	153
0.651	70	90	321
0.326	141	251	195
0.000	267	583	336
-0.326	396	911	212
-0.651	403	979	327
-0.977	342	719	232

Horizontal illuminance (Grid)
Average: 336 lx, Min: 49 lx, Max: 979 lx, Min/average: 0.146, Min/max: 0.050, Points: 3 x 7 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Kitchen final / Results overview

Results overview (Grid)

Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Horizontal illuminance [lx]	336	49	979	0.146	0.050	3 x 7 (all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (greenhouse)

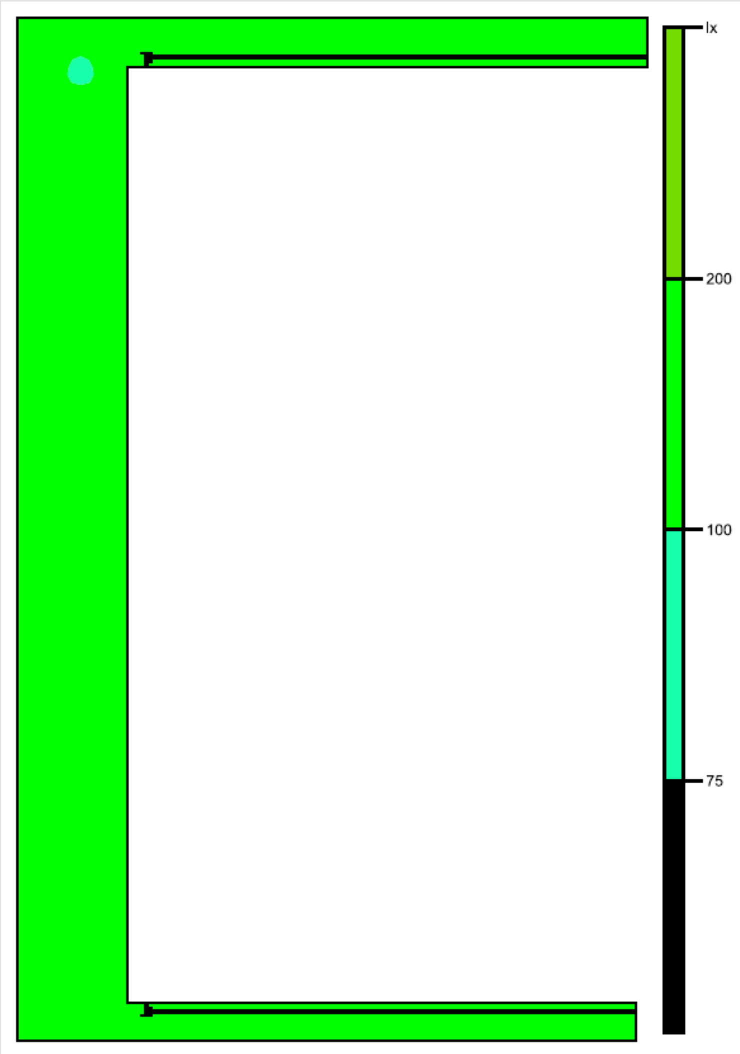
Greenhouse / Isolines/Horizontal illuminance

Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 154 lx, Min: 99 lx, Max: 179 lx, Min/average: 0.644, Min/max: 0.554, Points: 5 x 9 (Relevant: 9)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Greenhouse / False colours/Horizontal illuminance



Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 154 lx, Min: 99 lx, Max: 179 lx, Min/average: 0.644, Min/max: 0.554, Points: 5 x 9 (Relevant: 9)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Greenhouse / Table/Horizontal illuminance

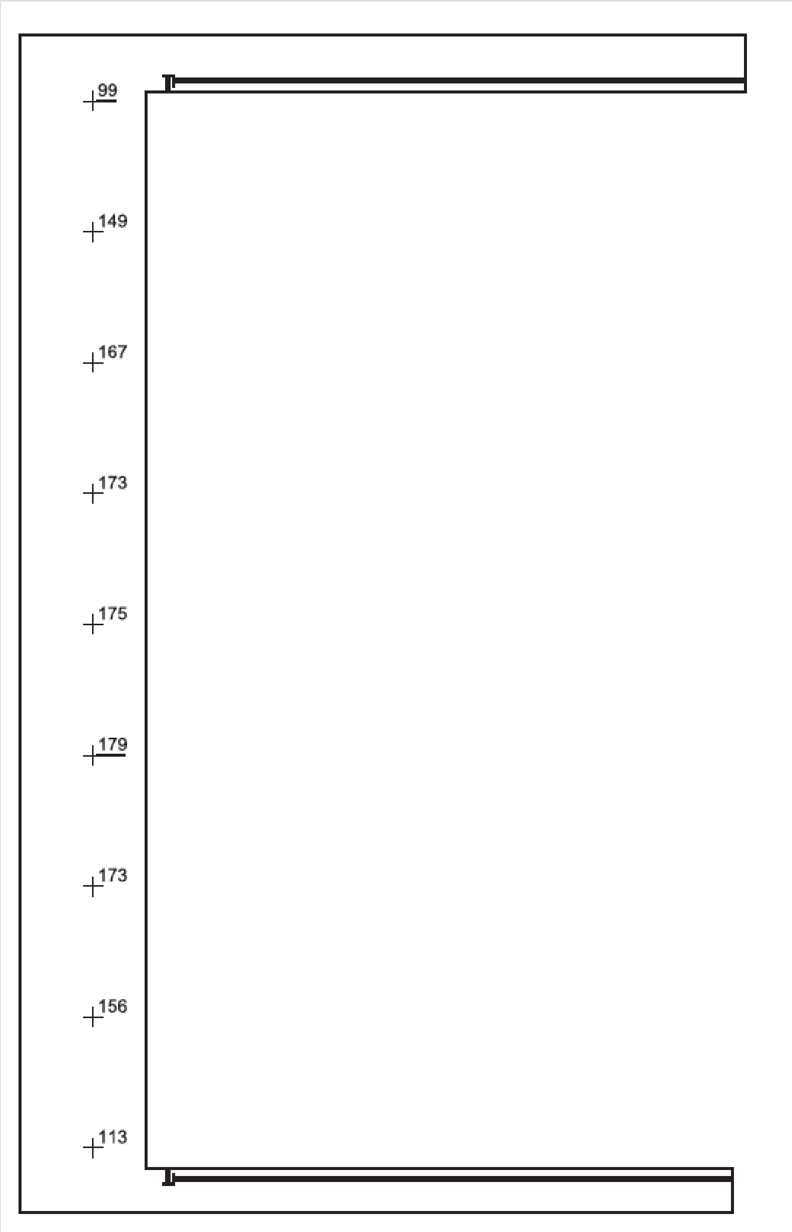
Value chart [lx]

m	-2.525	-1.375	-0.225	0.925	2.075
4.182	103	/	/	/	/
3.143	149	/	/	/	/
2.104	165	/	/	/	/
1.064	174	/	/	/	/
0.025	177	/	/	/	/
-1.014	180	/	/	/	/
-2.053	172	/	/	/	/
-3.092	155	/	/	/	/
-4.131	113	/	/	/	/

Horizontal illuminance (Grid)
Average: 154 lx, Min: 103 lx, Max: 180 lx, Min/average: 0.668, Min/max: 0.571, Points: 5 x 9 (Relevant: 9)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Greenhouse / Value chart/Horizontal illuminance



Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 154 lx, Min: 99 lx, Max: 179 lx, Min/average: 0.644, Min/max: 0.554, Points: 5 x 9 (Relevant: 9)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Greenhouse / Results overview

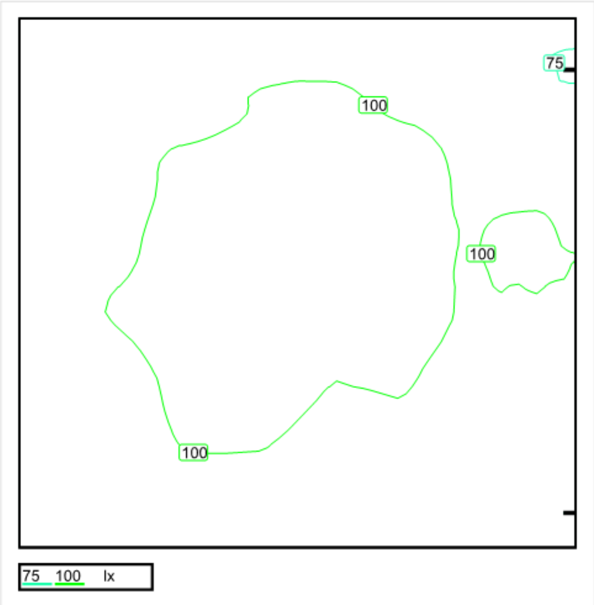
Results overview (Grid)

Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Horizontal illuminance [lx]	154	103	180	0.668	0.571	5 x 9 (9)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (engine room 1)

Engine room 1 / Isolines/Perpendicular illuminance (adaptive)



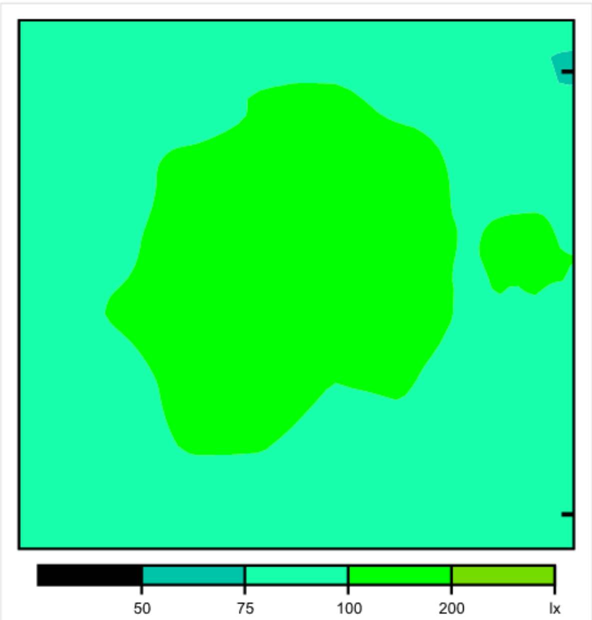
Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 98 lx, Min: 66 lx, Max: 104 lx, Min/average: 0.677, Min/max: 0.638, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 1 / False colours/Perpendicular illuminance (adaptive)



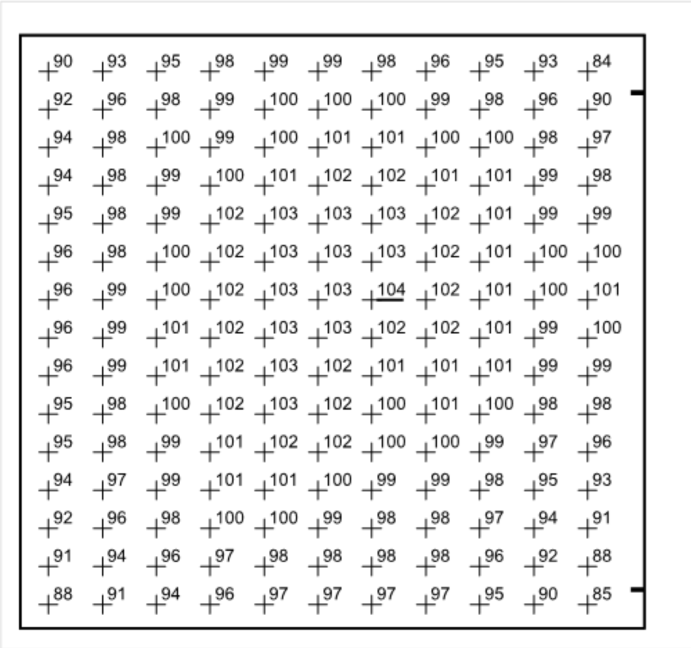
Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 98 lx, Min: 66 lx, Max: 104 lx, Min/average: 0.677, Min/max: 0.638, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 1 / Value chart/Perpendicular illuminance (adaptive)



Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 98 lx, Min: 66 lx, Max: 104 lx, Min/average: 0.677, Min/max: 0.638, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 1 / Results overview

Results overview (Surface)

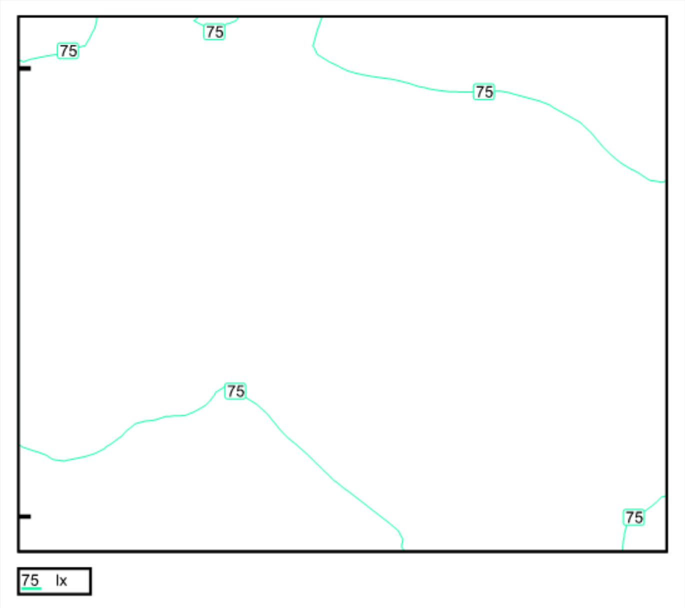
Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Perpendicular illuminance [lx]	98	66	104	0.677	0.638	64 x 64 (all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (engine room 2)

Engine room 2 / Isolines/Perpendicular illuminance (adaptive)



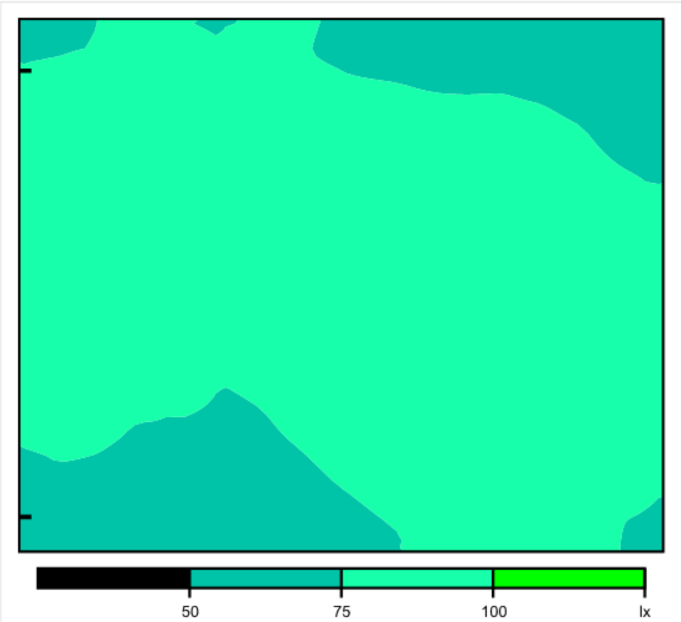
Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 79 lx, Min: 61 lx, Max: 94 lx, Min/average: 0.772, Min/max: 0.650, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 2 / False colours/Perpendicular illuminance (adaptive)



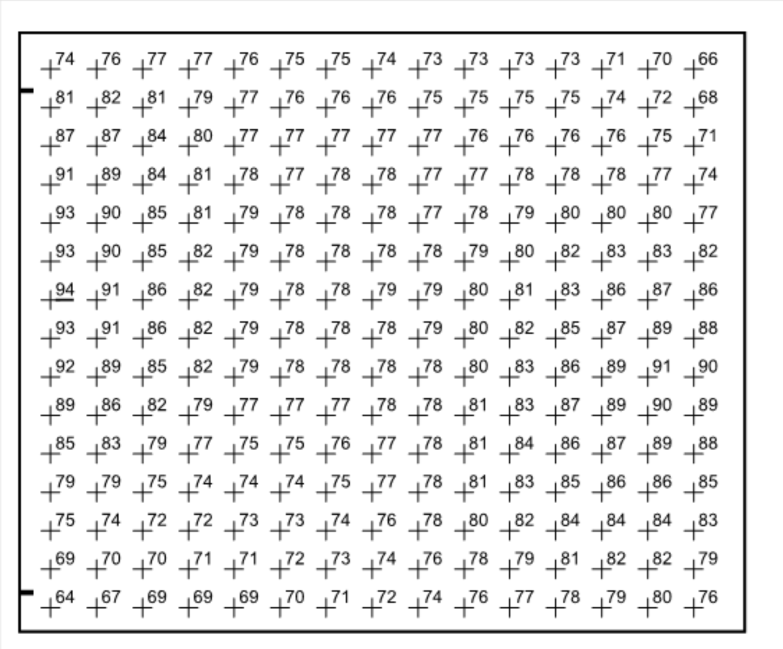
Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 79 lx, Min: 61 lx, Max: 94 lx, Min/average: 0.772, Min/max: 0.650, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 2 / Value chart/Perpendicular illuminance (adaptive)



Scale: 1 : 10

Perpendicular illuminance (Surface)
Average: 79 lx, Min: 61 lx, Max: 94 lx, Min/average: 0.772, Min/max: 0.650, Points: 64 x 64 (Relevant: all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Engine room 2 / Results overview

Results overview (Surface)

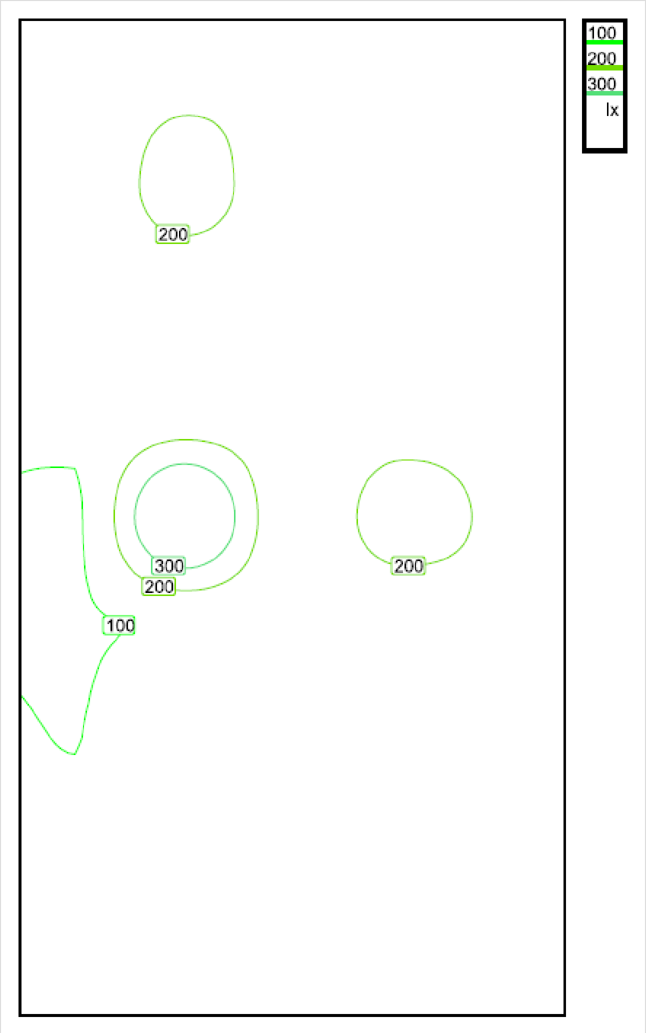
Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Perpendicular illuminance [lx]	79	61	94	0.772	0.650	64 x 64 (all)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (main room)

Main room final / Isolines/Horizontal illuminance

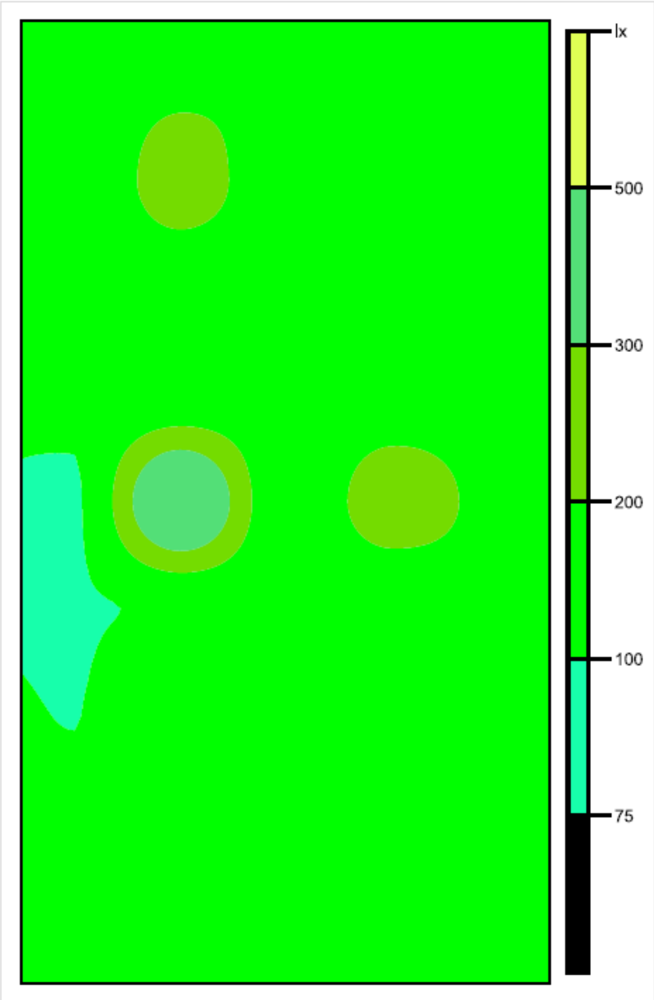


Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 162 lx, Min: 95 lx, Max: 451 lx, Min/average: 0.584, Min/max: 0.210, Points: 5 x 9 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Main room final / False colours/Horizontal illuminance



Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 162 lx, Min: 95 lx, Max: 451 lx, Min/average: 0.584, Min/max: 0.210, Points: 5 x 9 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Main room final / Table/Horizontal illuminance

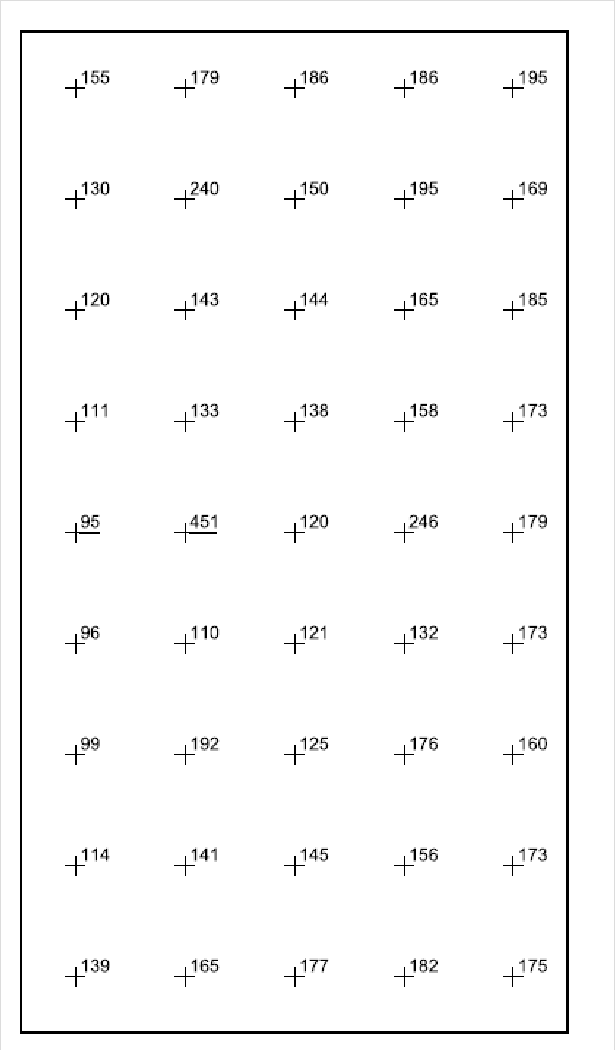
Value chart [lx]

m	-1.740	-0.870	0.000	0.870	1.740
3.533	155	179	186	186	195
2.650	130	240	150	195	169
1.767	120	143	144	165	185
0.883	111	133	138	158	173
0.000	95	451	120	246	179
-0.883	96	110	121	132	173
-1.767	99	192	125	176	160
-2.650	114	141	145	156	173
-3.533	139	165	177	182	175

Horizontal illuminance (Grid)
Average: 162 lx, Min: 95 lx, Max: 451 lx, Min/average: 0.584, Min/max: 0.210, Points: 5 x 9 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Main room final / Value chart/Horizontal illuminance



Scale: 1 : 50

Horizontal illuminance (Grid)
Average: 162 lx, Min: 95 lx, Max: 451 lx, Min/average: 0.584, Min/max: 0.210, Points: 5 x 9 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Main room final / Results overview

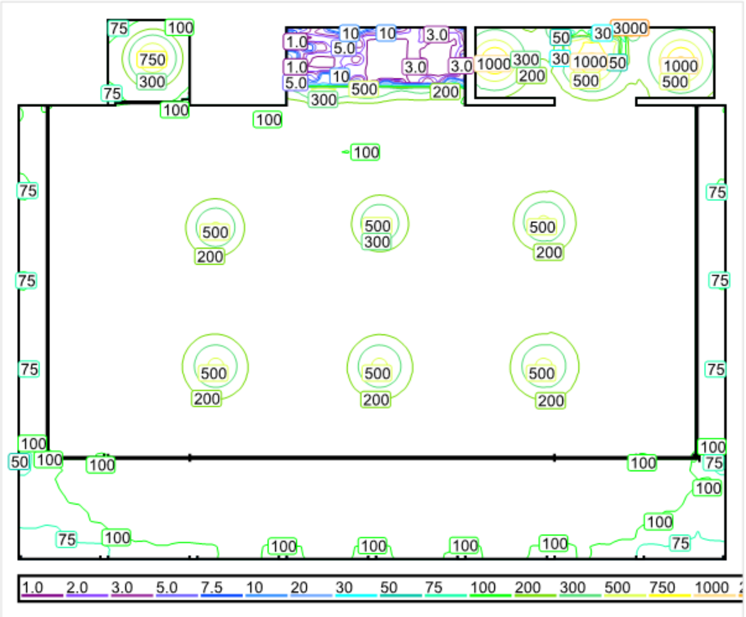
Results overview (Grid)

Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Horizontal illuminance [lx]	162	95	451	0.584	0.210	5 x 9 (all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

<u>Lighting calculation (workplane3)</u>

Workplane 3 / Isolines/Perpendicular illuminance (adaptive)



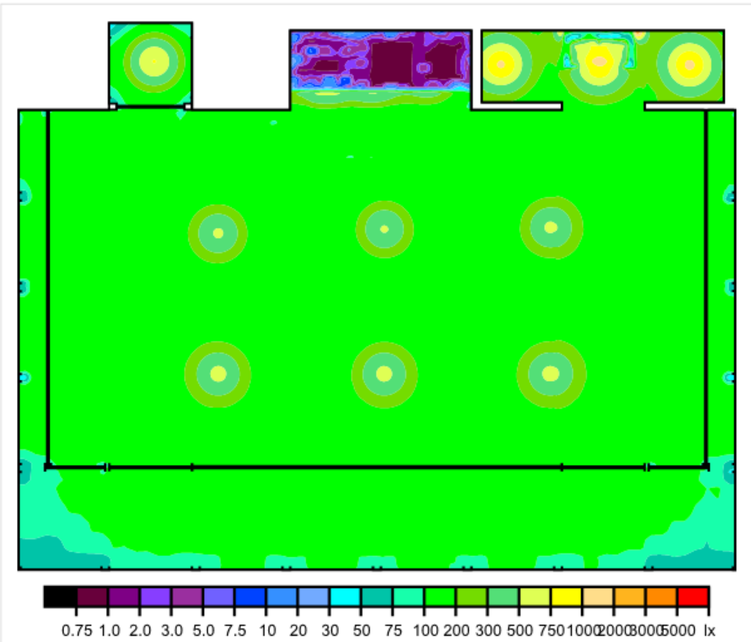
Scale: 1 : 75

Perpendicular illuminance (Surface)
Average: 157 lx, Min: 0.83 lx, Max: 3027 lx, Min/average: 0.005, Min/max: 0.000, Points: 512 x 512 (Relevant: 244560)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Workplane 3 / False colours/Perpendicular illuminance (adaptive)



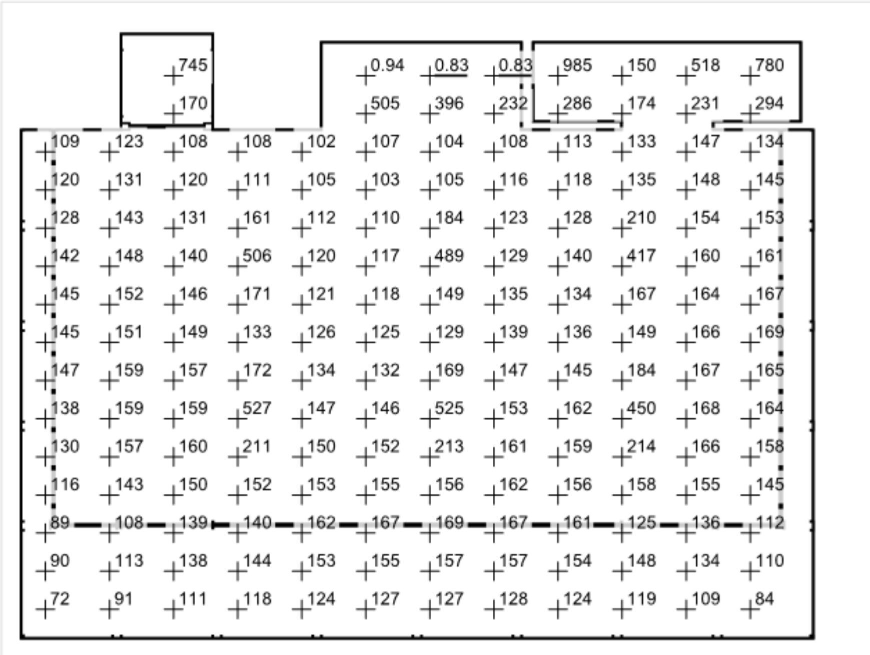
Scale: 1 : 75

Perpendicular illuminance (Surface)
Average: 157 lx, Min: 0.83 lx, Max: 3027 lx, Min/average: 0.005, Min/max: 0.000, Points: 512 x 512 (Relevant: 244560)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Workplane 3 / Value chart/Perpendicular illuminance (adaptive)



Scale: 1 : 75

Perpendicular illuminance (Surface)
Average: 157 lx, Min: 0.83 lx, Max: 3027 lx, Min/average: 0.005, Min/max: 0.000, Points: 512 x 512 (Relevant: 244560)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Workplane 3 / Results overview

Results overview (Surface)

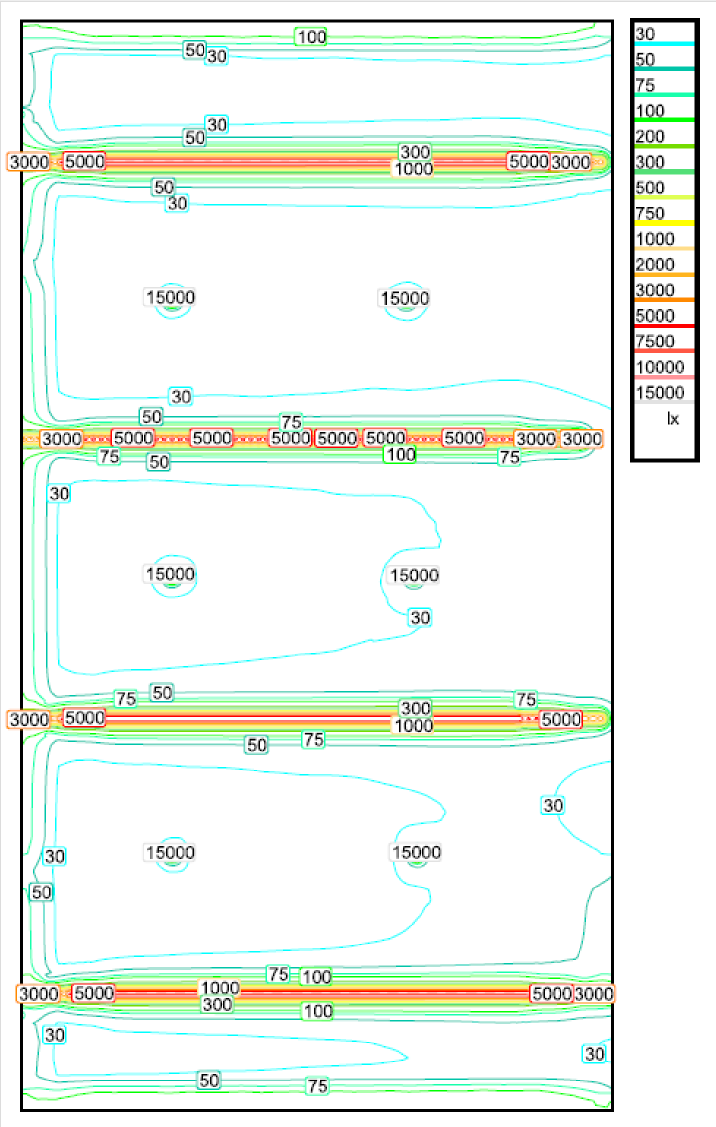
Result type	Average	Min	Max	Min/average	Min/max	Points (Relevant)
Perpendicular illuminance [lx]	157	0.83	3027	0.005	0.000	512 x 512 (244560)

Height of working plane: 0.800 m, Wall zone: 0.000 m

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Lighting calculation (surface)

Surface result object 1 (Furniture) / Isolines/Perpendicular illuminance (adaptive)

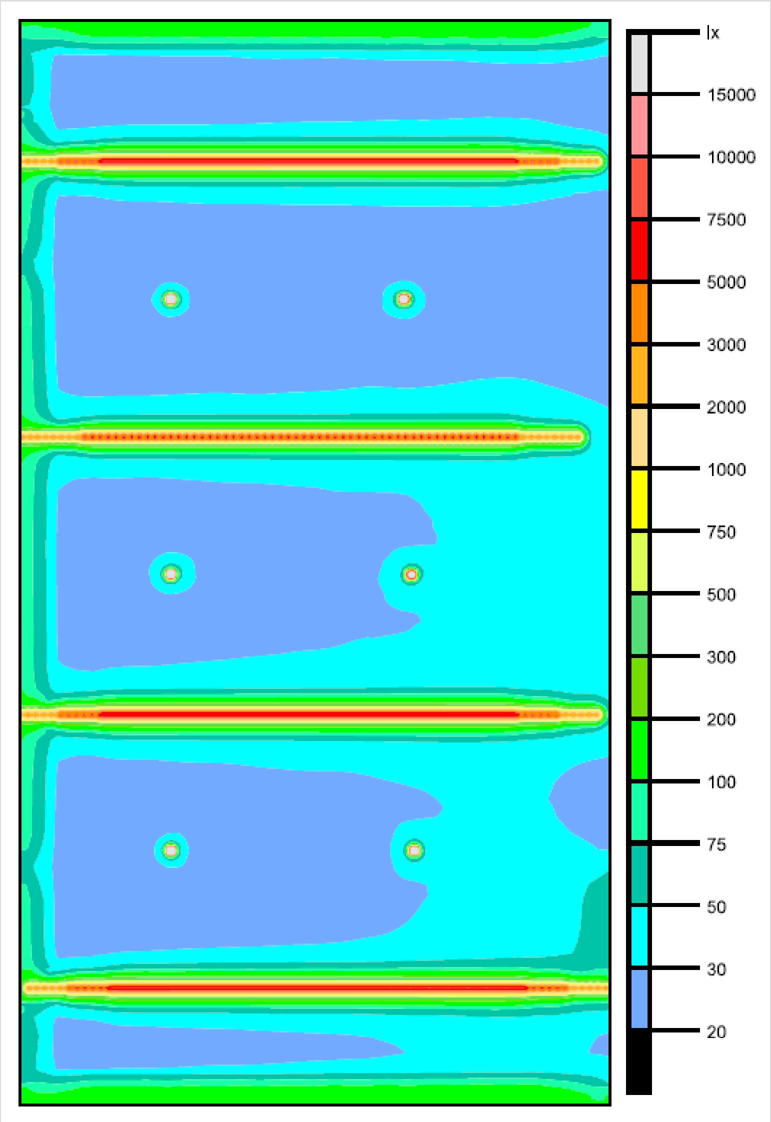


Scale: 1 : 50

Perpendicular illuminance (Surface)
Average: 247 lx, Min: 22 lx, Max: 371784 lx, Min/average: 0.087, Min/max: 0.000, Points: 512 x 256 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Surface result object 1 (Furniture) / False colours/Perpendicular illuminance (adaptive)



Scale: 1 : 50

Perpendicular illuminance (Surface)
Average: 247 lx, Min: 22 lx, Max: 371784 lx, Min/average: 0.087, Min/max: 0.000, Points: 512 x 256 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

Surface result object 1 (Furniture) / Value chart/Perpendicular illuminance (adaptive)

48	37	35	40	40	41	42
49	22	23	25	24	25	27
61	34	36	36	38	39	35
394	1568	982	980	983	983	656
70	27	29	29	30	30	28
61	23	24	25	25	26	25
62	23	25	24	25	26	24
69	24	24	25	26	26	25
71	25	25	26	27	27	28
74	31	31	32	33	34	33
1590	4531	3719	3700	3775	4624	2194
76	32	33	34	35	36	37
73	26	28	28	29	31	34
74	26	27	27	28	30	34
74	26	27	27	29	31	34
73	26	27	28	29	31	33
73	29	31	32	33	34	35
137	178	211	183	185	187	136
80	50	49	54	51	53	49
71	26	27	29	30	32	31
70	24	25	26	28	30	31
55	23	25	25	27	31	35
64	22	23	25	27	32	39
68	24	25	27	29	34	41
91	81	80	80	82	87	79
62	68	77	74	82	85	71
55	25	26	27	29	32	35
78	93	94	96	97	99	100

Scale: 1 : 50

Perpendicular illuminance (Surface)
Average: 247 lx, Min: 22 lx, Max: 371784 lx, Min/average: 0.087, Min/max: 0.000, Points: 512 x 256 (Relevant: all)

Relevant points are points that are within the respective surface and are not covered by furniture or other elements. The summarized results are based exclusively on these points, as all other points would falsify the results, in some cases significantly.

5.2.4 Acoustic Design

In the acoustic design narrative, we will describe how Mem**brain** deals with noise transmission from building exterior to interior and vice versa, as well as the technological means of solving the interior noise and reverberation.

As previously described, the envelope of our house – or Mem**brain** – consists of two basic groups of layers – one being solid walls and slabs and the other glazed panels. The transmission of exterior noise through the solid parts of our house is prevented by the solid layers (wood panels or slabs) and the insulation layers (sheep wool), and is reduced to a minimum. The glazed parts of the envelope are designed in two layers – a triple-glazed exterior facade, and a set of double glazed interior panels. The difference between the thickness of glazing and the voids between the glass panels increase the sound impermeability of the envelope. The space between the two glazed surfaces also contributes to the decrease of sound transmission from exterior to interior.

Since glazing constitutes a large portion of our interior (the eastern, western and southern 'walls'), we had to address the problem of reverberation. This is solved by using fabric as the cover material of our ceiling. It is compatible with the PCM material above it since it hardly absorbs any energy at all, but improves the absorption of sound that would otherwise be reflected towards the glazed surfaces, causing high reverberation times. The material of the fabric is cotton, and it is fire-protected by a covering layer. It also serves as the final covering of our ceiling, and is a good light diffusor.

Another problem regarding acoustics is the noise produced by the machines in the engineering room. The engineering room is placed next to the living room, and separated by a wooden panel. To avoid transmission of noise between the two spaces, the engineering room is completely insulated from the inside, using wood-fiber insulation boards. Also, the machinery is placed on rubber pads, to avoid direct transmission of sound through the load-bearing materials.

Thusly, we avoid transmission of noise from the exterior to the interior and vice versa, but also control the interior transmission and reverberation of sound.

5.3 Engineering and Construction Design Narrative

5.3.1 Structural Design

5.3.1.1 Introduction

The planned structure for concept Mem**brain** by uniZG Team is a fully timber house. Load bearing structure of our house is a combination of several systems that are usually used in design of timber structures.

The load bearing structure of our house is a combination of several systems that are usually used in design of timber structures. The system consists of glued laminated element for floor, ceiling, walls and vertical columns. Glued laminated wall structures on the northern side of the house have different properties, like good insulation and good location of any closed storage, same as the bearing system. The wooden columns on the periphery of house are the main vertical bearing structure.

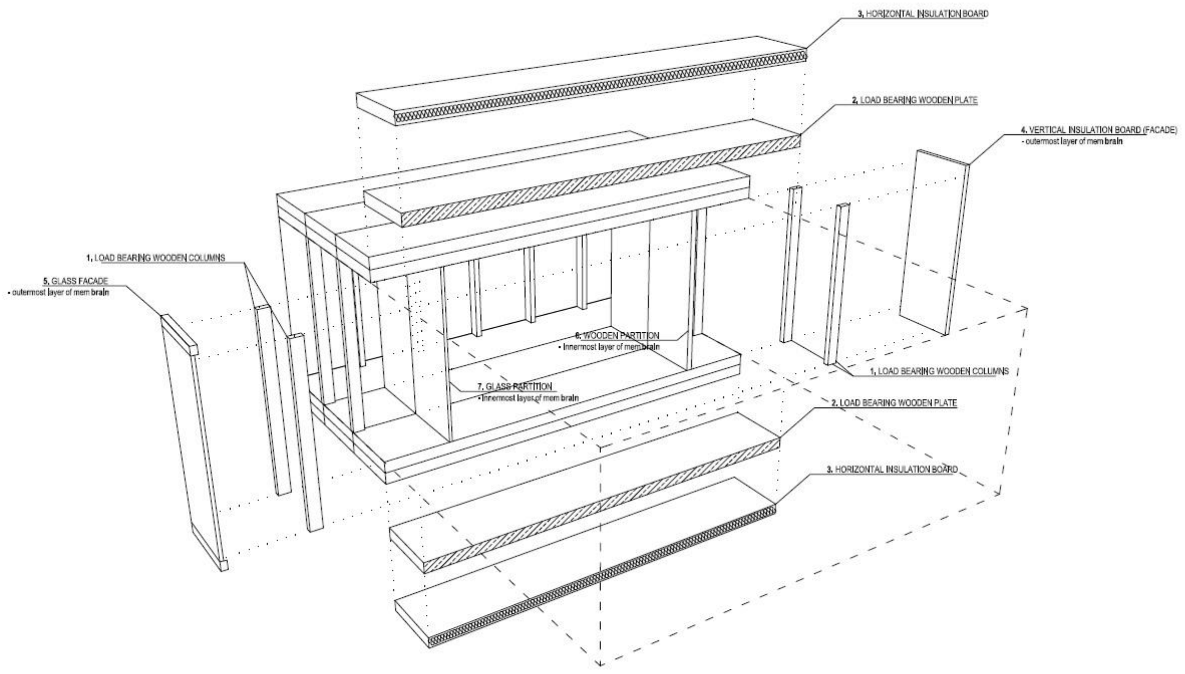


Figure 23 - Load bearing structure of Mem**brain** house

The bearing system of the floor structure is identical as the ceiling, that is, glued laminated wooden slab. Ground plan dimensions are 7.2 x 9.6 m, it will be made in segments, and will be joined the same way as the ceiling panel. Roof and floor glued laminated timber slabs are designed equally thick. That’s because of our pursuit of modularity and easy design of a multiple floor house.

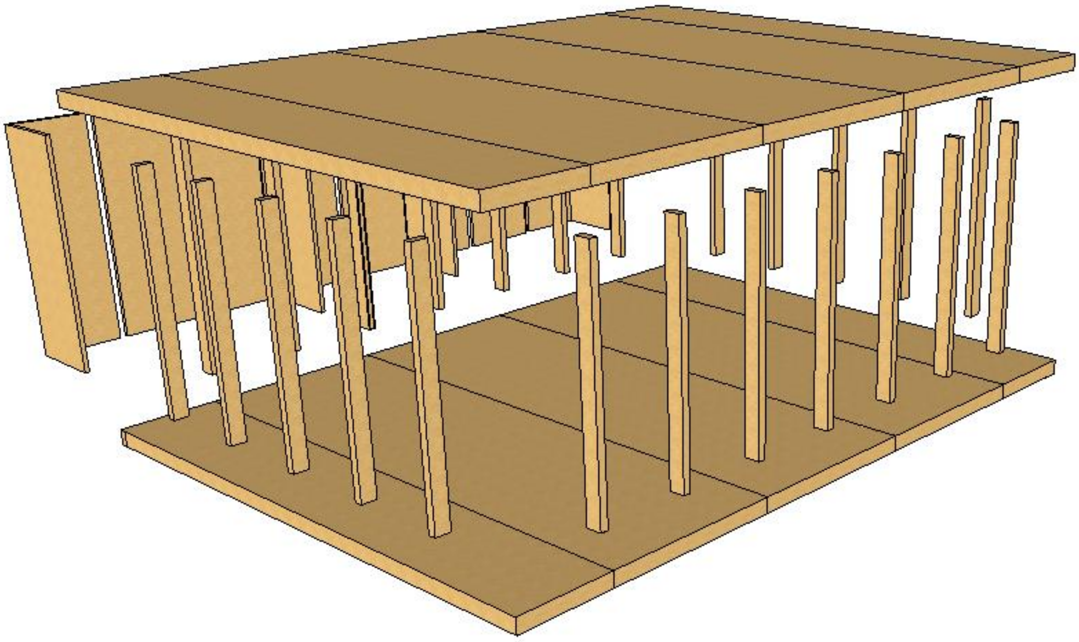


Figure 24 - Modular structure of Mem**brain** house

The ceiling structure is a glued laminated slab whose dimensions along the two main axes are much greater than its thickness. Thickness of the ceiling slab is 18 cm, as provided by the design calculations. It has the function of a load bearing slab and a diaphragm. Total dimensions of this panel are 9.6 x 7.2 meters. However, due to transport issues, it will be made in smaller segments. Three 2.4 x 7.2 and two 1.2 x 7.2 meter segments will be joined together on the construction yard according to the manufacturer instructions. We will use wood screws to ensure their connections.

Vertical loads are carried from the ceiling to the glued laminated wooden columns built along the perimeter of the house. These columns are 3.0 meters high. The cross section area is a rectangle, b x h = 12 x 20 cm. Axial spacing of columns is 1.2 meters, with the note that there are no columns in the four corners of the house. Total number of columns in the house is 24.

Carrying horizontal loads (wind, earthquake etc.) and stiffening of the house is achieved with the assistance of stiffening shear walls which, combined with floor and ceiling slabs create a rigid three dimensional structure. Shear walls are located on the north facade of the house. Their dimensions are 1.1 x 3.0 meters and they will be assembled on the columns and the floor and ceiling slab.

Inside the membrane on the northern side, partition walls are placed. They are also glue laminated panels with the purpose of stiffening the house along the north - south axis. They are placed in the kitchen and bathroom. A minimum of four shear walls must be constructed, two in each direction and placed symmetrically. That way it is ensured that there are no torsion influences on the structure.

Three sides of the façade, the southern, the eastern and the western, consist of an outer and inner layer, made of glass panels. The two layers enclose the greenhouse (to the east and west) and winter garden (to the south) space. The northern façade consists of panels that are attached between columns.

Some of the advantages of this bearing system are:

- Wooden skeleton bears all vertical loads, while walls do not, and they are therefore independent of the skeletal structure
- Walls are designed so that they can be moved and transferred easily
- Freedom in organization of the living space
- Stability of the house is achieved with ceiling and wall diaphragms, and shear walls made of glued laminated wood
- Possibility of both single floor and multi floor structures
- Prefabrication of elements in factories
- Quick construction time
- Simple assembly and erection on the construction spot

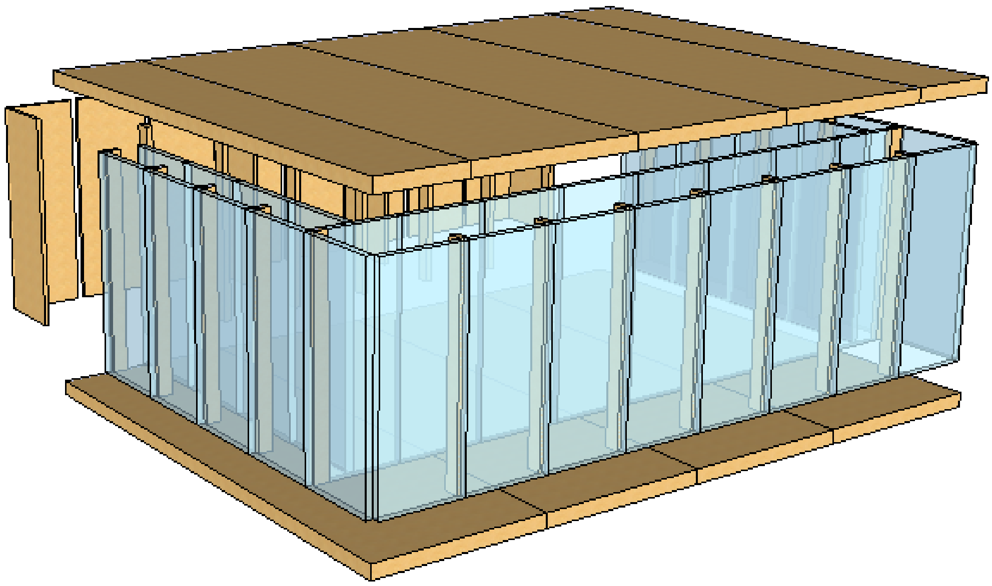


Figure 25 - 3D model of the house

Glued Laminated Timber

The most of our structural elements are made of Glued Laminated Timber GTL. Glued laminated timer, or commonly called glulam, is a timber product manufactured of individual timber laminations, specifically selected and positioned based on their performance characteristics, and then bonded together with durable, moisture-resistant adhesives. By gluing thin layers of timber, imperfections in the original timber, such as knots, can be removed in the factory to reduce variability and enhance structural performance. The grain of all laminations runs parallel with the length of the member, so it can be used in horizontal applications as a beam, or vertically as a column. Because of its composition, glulam provides the strength and versatility of large wood members without relying on the old growth-dependent solid-sawn timbers. Glulam is one of the strongest structural materials per unit weight. Depending on specific loading conditions, a structural steel beam may be 20% heavier, and a reinforced concrete beam 600% heavier than an equivalent glulam beam of the same load-carrying capacity. GLT is an innovative building material that permits fast and efficient construction of single or multi-residential type buildings and it fits perfectly in our concept.

Figure 26 - Glued Laminated Timber

5.3.2 Constructive Design

Our idea is to build a fully customizable, fully modular, self-sustainable passive house, by using modern technologies and design.

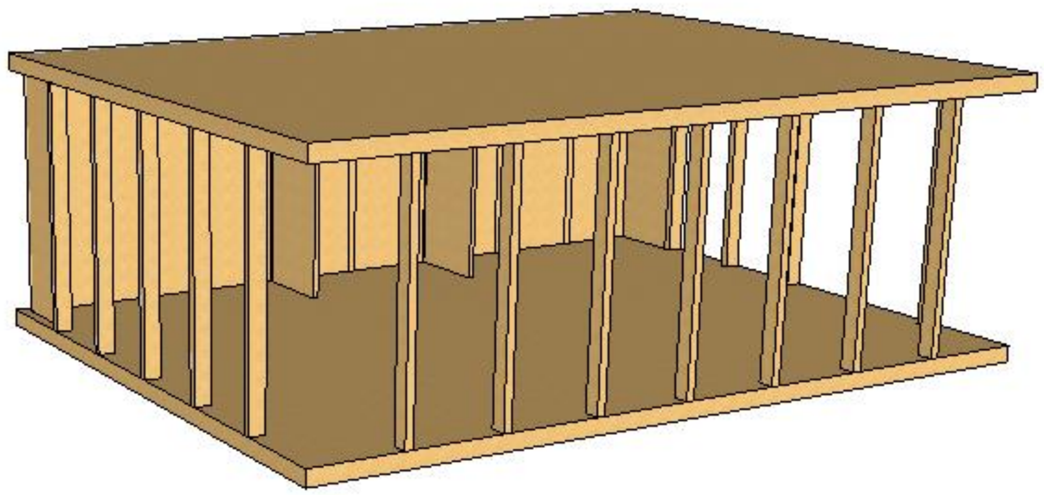


Figure 27 - Load bearing structure of Mem**brain** house

The center of the house is a living area, the so called cell. It is protected by the membrane which also represents the brain of the house. It regulates the temperature, humidity and indoor air quality and contains all the utilities (engine room, kitchen, bathroom, storage, entrance and greenhouse). By separating the envelope and living area we managed to achieve a flexible void space inside the house which offers many different options for usage and furnishing. Three sides of the membrane, the southern, the eastern, and the western, enclosed by glass panels, form a winter garden and greenhouse inside them. The northern façade consists of wooden panels that are attached between columns.

Advantages of this bearing system are high level of functionality of space (utilities are separated from the living space which also allows freedom in organization of the space) but also quick and simple assembly on the construction spot. Another advantage is possibility of both single floor and multi floor structures with no complication due to applied modularity.

<u>Modularity</u>

Modularity is achieved with construction raster, which is 1.2 x 1.2 meters, and repetition of construction elements.

Roof and floor glue laminated timber slabs are designed with the same thickness, from more relevant load combination. This way we can easily design a new house with one or two additional floors, or add them to an existing structure, without making significant changes in bearing elements.

Glued laminated timber walls are primary in construction to ensure stability of house, and bear horizontal forces produced by wind. They can be placed in various positions on the outer surfaces, but there are some rules of placing them. There must be a minimum of 4 GLT walls, two in each direction. All four wall directions must not be intersected at the same point. If the building consists of more floors all floors must have the same wall placement pattern. Preferably they are placed symmetrically through the structure. That way it is ensured that the mass center and stiffness center of the house are close to each other and there are no torsion influences on the structure. On taller buildings it is preferred to have more walls, depending of the seismic or wind loads of that area. In the Figure 28 there are some of various placement positions.

Figure 28 - Variations of GLT walls placements

The columns are placed on 1.2 meters of distance from each other, with an exception on the corners of the building where they are removed.

The house is not limited to spread into height, it can also be widened by placing more house modules next to each other. In the Figure 29 there are some of the various combinations that can be achieved.

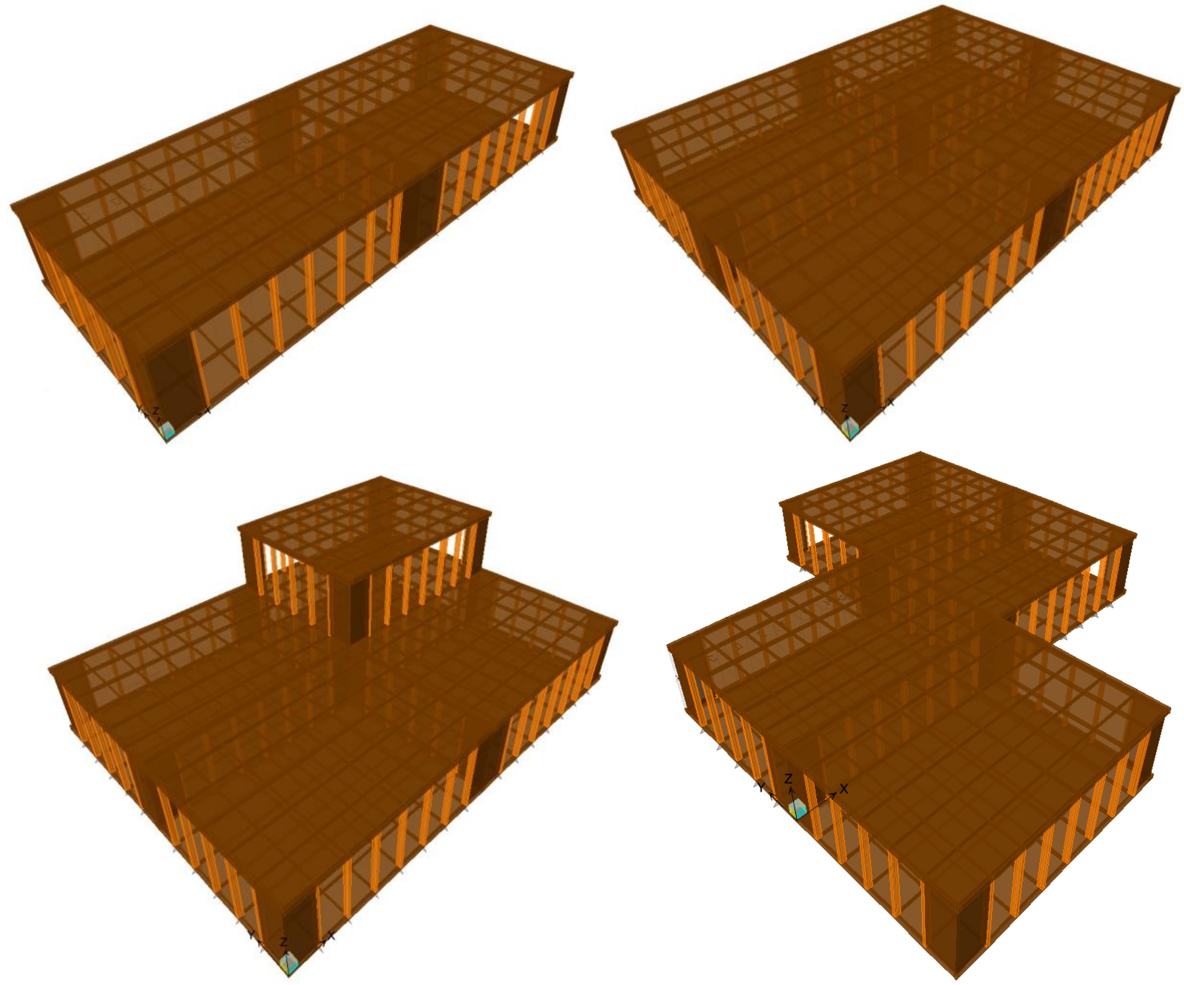


Figure 29 - Variations of connecting house modules

<u>Materials used</u>

Sheep Wool as an Insulation Material

Using sheep wool as an insulating material has many advantages. Above all, it's a natural, renewable and sustainable material, easily installed and it presents no hazard to human health. Wool fibers are breathable, meaning they can absorb and release moisture without reducing thermal performance unlike fiberglass based products. It does not support combustion and will extinguish itself in the event of fire. Also, sheep wool insulation does not settle due to the high elasticity of the wool fibers ensuring no loss of performance over time and it can be reused or recycled as compost.

Figure 30 - Sheep wool insulation

Wool has a natural ability to regulate temperature and moisture. Wool is hygroscopic material and absorbs and releases moisture from the surrounding air without any effect on thermal efficiency. During cold weather, wool absorbs warmth from moisture in air, which enables building to reduce warmth losses. During warm periods, releasing absorbed moisture has performance of cooling and stopping warmth to get into a building. That keeps building cooler during the day and warmer during the night, so heating and cooling requirements are minimized. This property improves state of comfort, saves energy and contributes to healthier microclimate.

Table 10 - Sheep wool specification

ρ	Depending on compression, 20 – 30 kg/m³
c	about 1100 J/kgK
λ	about 0,040 W/mK
μ	1 - 2

Wood wool panels as an acoustic insulation

As an acoustic insulation material and secondary thermal insulation material in engine room we will use wood fiber insulation. Wood is thermally more efficient than competing building materials, thus conserving energy over the lifetime of a building. Thermal-insulating properties of wood are about 15 times better than those of concrete, 400 times better than steel and 1700 times better than aluminum. 5 cm thick wooden panel insulates as well as five times thicker brick wall. To make a wood wool panel wood fibers are first impregnated, then interrelated with cement and in a continuous production process, by pressing, are formed into panels. In Croatia, light insulating panels made of wood wool fibers from soft conifers jointed with cement have been produced since 1942. Even today there are companies that continue this tradition and produce wood wool insulation panels.

Figure 31 - Wood Wool Cement Board

As described in Innovation report, (5.5.6 Innovation in Sustainability), we are researching production and performance of wood wool and planning to produce wood wool insulation for our house by ourselves. We will use cement with only 30% clinker and 70% slag. Slag is a byproduct of iron production and its disposing represents a huge environmental problem in Croatia and our area. Estimated amount of slag on landfills is few million tons and with that being said it’s clear there is a need of reusing it somehow.

Figure 32 - Our efforts to produce wood wool insulation by ourselves

Technical Specifications – Building engineering physics

Wood wool balances humidity in a space where it is placed as it absorbs and releases moisture into air in the room as needed. This contributes to a convenient inner climate that is good for the comfort and health of people. High pH prevents the growth of mold and rot. It stores heat from the air and releases it when the air temperature falls.

Table 11 - Wood wool specification

ρ	about 420 kg/m^3
λ	about 0,070 W/mK
μ	3 - 6

Also, due to the large share of pores in the material, it reduces sound reflection, muffles the noise and contributes to a pleasant and peaceful atmosphere of sound. Relevant frequencies for designing the interior space are taken 100 – 5000 Hz.

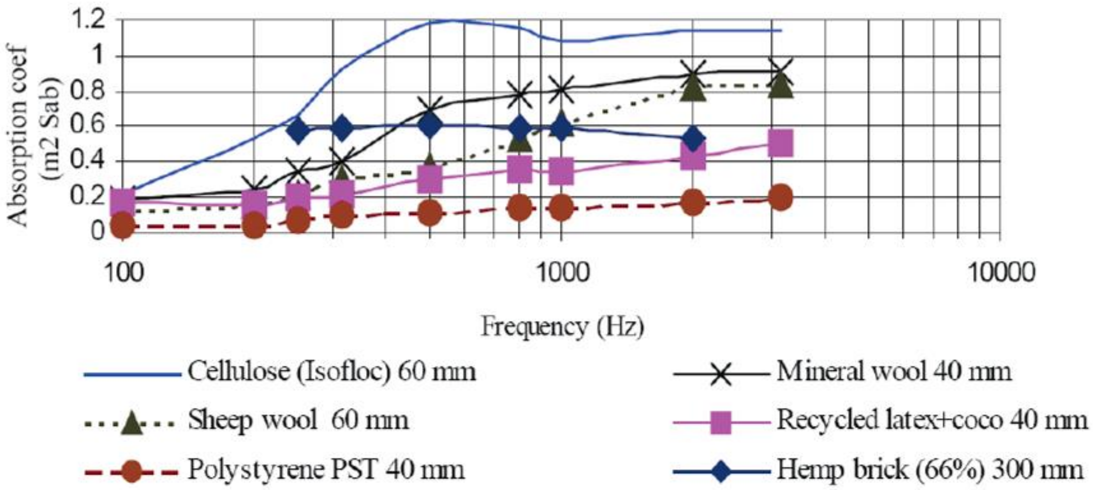


Figure 33 - Absorption coefficient

5.3.2.1 Acoustic performance

Introduction

Housing-rooms enclosure constructive solution is analyzed here regarding its acoustic performance and its noise insulation.

Acoustic performance

Noise insulation house has a main objective of ensuring internal acoustic comfort in order to achieve this, we must verify that the existing sound field will not disturb the residents' home. Aspects normally related with acoustic comfort in a space, where the main source for noise is the spoken word, are reverberation, sound distribution, the definition and intelligibility of the word. In this case, considering the reduced space of the house and spaces which compose, it is only necessary to control the main magnitude for acoustic comfort: reverberation time, the only really representative value.

Reverberation time estimation

The reverberant sound in an auditorium dies away with time as the sound energy is absorbed by multiple interactions with the surfaces of the room. In a more reflective room, it will take longer for the sound to die away and the room is said to be 'live'. In a very absorbent room, the sound will die away quickly and the room will be described as acoustically 'dead'. But the time for reverberation to completely die away will depend upon how loud the sound was to begin with, and will also depend upon the acuity of the hearing of the observer. In order to provide a reproducible parameter, a standard reverberation time has been defined as the time for the sound to die away to a level 60 decibels below its original level. The reverberation time can be modeled to permit an approximate calculation. A reverberation, or reverb, is created when a sound is produced in an enclosed space causing a large number of echoes to build up and then slowly decay as the sound is absorbed by the walls and air. This is most noticeable when the sound source stops but the reflections continue, decreasing in amplitude, until they can no longer be heard. To avoid those echoes we are analyzing this area (highlighted in the drawing below) to find some significant internal coating materials with as high as possible absorption coefficients.

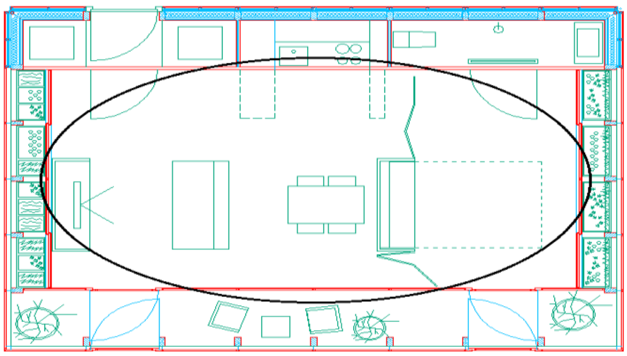


Figure 34 - Area where we do the calculation of reverberation time

Reverberation time (RT) is a measure of the amount of reverberation in a space and equal to the time required for the level of a steady sound to decay by 60 dB after the sound has stopped. The decay rate depends on the amount of sound an absorption in a room, the room geometry, and the frequency of the sound. RT is expressed in seconds. This decay is usually measured over the first 10, 20 or 30 dB and then extrapolated to the full 60 dB range. The frequency dependent reverberation time of a room is usually given for the canter of a third octave band filter frequency of 500 Hz or 1 kHz or a frequency dependent response curve of the reverberation time of the frequency, but this is not a "frequency response" of the reverberation.

Methodology

Our calculations are based on Sabine's reverberation equation. That established a relationship between the RT60 of a room, its volume, and its total absorption.

$$RT_{60} = k \cdot V / A = 0.161 \cdot V / A \quad \text{(V and A in meter)}$$

$$k = (24 \times \ln 10) / C_{20} = 0.161 \text{ (meter)}$$

- RT_{60} = reverberation time in second (reverb time)
- V = room volume in m^3
- A = $\alpha \times S$ = equivalent absorption surface or area in m^2
- α = absorption coefficient or attenuation coefficient
- The terms "attenuation coefficient" and "absorption coefficient" are used interchangeably
- S = absorbing surface area in m^2
- A = $\alpha 1 \times S1 + \alpha 2 \times S2 + \alpha 3 \times S3 + \ldots$
- C_{20} = speed of sound is 343 m/s or 1126 ft/s at 20°C

Internal Materials Description

Materials of the interior surfaces:

- **Floor:** wood on joists Floor
- **Wall:** Plaster (gypsum or lime, on masonry)
- **Windows:** Glass, large panes
- **Ceiling:** Plaster (gypsum or lime, rough finish or timber lath)
- **Doors:** coated in linen canvas

Results

Table 12 - Absorption coefficients for interior surfaces

AREA	ABSORPTION COEFFICIENTS						
	m²	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000Hz
FLOOR	39,1	0.15	0.11	0.10	0.07	0.06	0.07
WALL	20,5	0.14	0.1	0.06	0.05	0.04	0.04
CEALING	39,1	0.14	0.1	0.06	0.05	0.04	0.04
WINDOWS	53,1	0.18	0.06	0.04	0.03	0.02	0.02
DOORS	4,4	0,04	0,10	2,50	3,60	4,10	4,10

Statistical acoustics

Optimum RT (500Hz - Speech): 0.58 s

Optimum RT (500Hz - Music): 1.12 s

Volume per Seat: 32.308 m³

Minimum (Speech): 3.941 m³

Minimum (Music): 7.680 m³

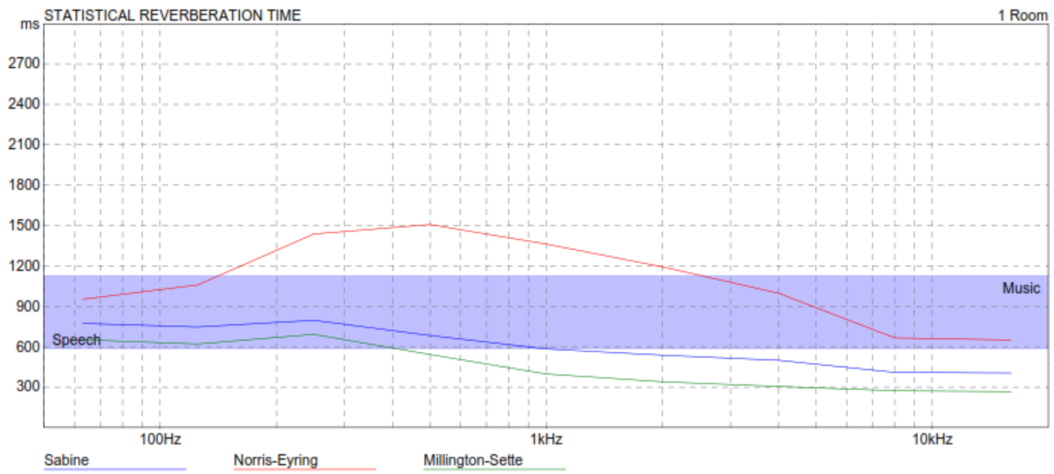


Figure 35 - Result of statistical reverberation time

Table 13 - Reverberation time RT_{60}

	TOTAL	SABINE	NOR-ER	MIL-SE
FREQ.	ABSPT.	RT(60)	RT(60)	RT(60)
63Hz:	39.328	0.77	0.95	0.65
125Hz:	40.364	0.75	1.06	0.62
250Hz:	36.523	0.80	1.44	0.69
500Hz:	42.709	0.68	1.51	0.54
1kHz:	49.086	0.58	1.36	0.40
2kHz:	50.812	0.54	1.19	0.34
4kHz:	49.766	0.50	1.00	0.30
8kHz:	48.791	0.41	0.67	0.27
16kHz:	48.246	0.40	0.65	0.27

5.3.3 Plumbing System Design

Water saving and efficient consumption is one of the main aspects to consider when talking about sustainability. The goal is to implement water efficiency measures in Mem**brain** and still deliver an unchanged or improved water service while reducing overhead costs. Improving water efficiency reduces operating costs (e.g., pumping and treatment) and reduces the need to develop new supplies and expand our water infrastructure. It also reduces withdrawals from limited freshwater supplies, leaving more water for future use and improving the ambient water quality and aquatic habitat. Water usage in per person is shown in figure below. As it can be seen, measures for more efficient water consumption increase savings dramatically.

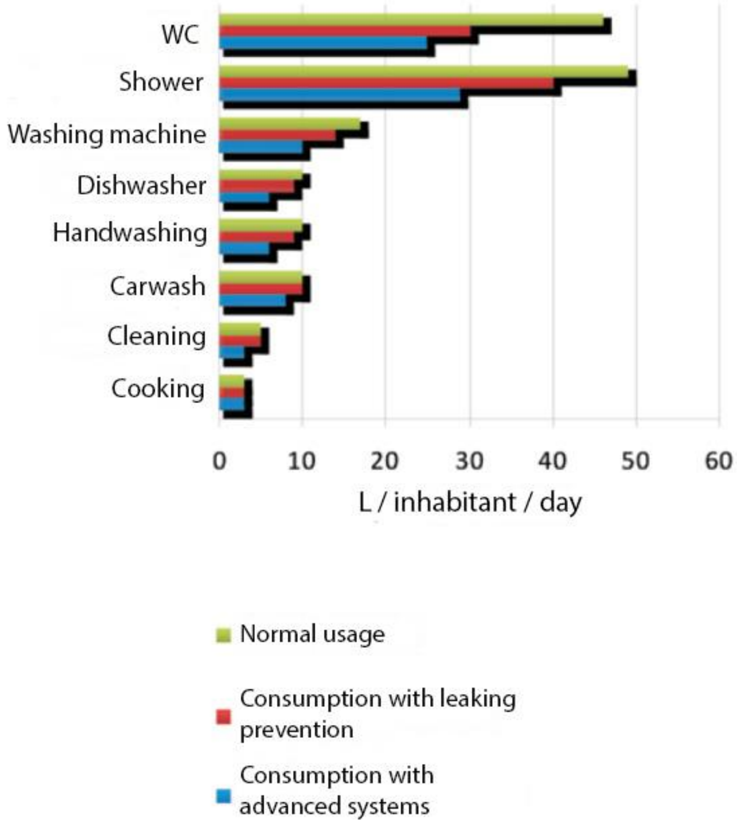


Figure 36 - Water consumption distribution

The daily water consumption of a house can be efficiently reduced by the appropriate selection of the integrated devices. Apart from the electrical and household systems, the selection of the water taps is also of great importance. It's very important to choose systems that are best in promoting the reduction of water consumption.

Consumption habits play a very important role in water saving. To reduce water consumption and create awareness, water saving units will be used in the bathroom and kitchen. It is advised to reduce showering time from average 9 min. to 7 min. because showering and dishwashing are one of the biggest water consuming activities. Water saving measures (WSM) are shown in the tables below. By using simple basic measures it's possible to save about 210 EUR per year on water consumption. Mem**brain** will have the most efficient water supply and piping system made by

Geberit. Savings are calculated for water price of 11.09 HRK/m3 (based on actual water price in Zagreb, 2013).

Table 14 - Seals installation

WSM 1.	Seals installation - leaking prevention
Annual savings	10 €
Investment	0,7 €
Return on investment	0,9 years
Lifetime	3 years
Lifetime savings	30 €

Table 15 - Water saving flusher

WSM 2.	Water saving flusher installation
Annual savings	60 €
Investment	40 €
Return on investment	0,7 years
Lifetime	10 years
Lifetime savings	607€

Table 16 - Water saving laundry washer

WSM 3.	Water saving laundry washer installation
Annual savings	47 € (water) / 9 € (electricity)
Investment	480 €
Return on investment	8,5 years
Lifetime	11 years
Lifetime savings	523 € (water) / 100 € (electricity)

Table 17 - Water saving shower

WSM 4.	Water saving shower installation
Annual savings	72 €

Investment	54 €
Return on investment	9 months
Lifetime	5 years
Lifetime savings	362€

Waste water

Waste water cannot be used for appliances unless it is filtrated through expensive purification systems. They are not economically viable for small households unless there are several of them connected to the same purification system. A 1500 L tank will be located beneath the decking of the house for waste water collecting and storage.

Grey water

In design phase it's necessary to consider every possible option to reduce overall water consumption. Collecting and using the grey water is one of most important things in sustainable designing. There are several possible usages of grey water. During the contest period grey water will be collected in the tank, but not used for household appliances. When built on Borongaj site, Mem**brain** will use filtered grey water for flushing and plants watering which will improve efficiency in water consumption. As is the case with the waste water, it would be more efficient and cost effective if several houses are connected to the same grey water collection system.

5.3.4 Electrical System Design

5.3.4.1 General description

The input for the electrical system is an IEC single-phase 230V-125 A plug socket with pilot contact.

The system characteristics for the housing unit installation are as follows:

• System classification according to CEI 64/8	TT
• Nominal voltage	230 V AC
• Distribution	single-phase
• Short-circuit current	6 kA
• Maximum absorbed power	15 kW

The system starting point is the Master Electrical Panel, fed by an IEC single-phase 230 V – 125 A plug socket.

5.3.4.2 System design and characteristics

Connecting to Grid

Connection to the grid will be done with the cable FG07R 3x16 mm^2, according to the requirements of the contest. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90°C.

For the connection to the grid, the request of the competition is to use main circuit breaker with breaking capacity of 6 kA minimum and rated current 63 A maximum together with the RCD with medium sensitivity 300 mA. The calculation for the circuit breaker and RCD that will be installed is showed below:

Circuit-breaker to the grid (Q3)

Maximal current that can come from the grid or can be delivered to the grid is maximal output current of the Quattro inverter/charger and that is: $I_{max}=I_{maxout}=$ 50 A, so the circuit breaker appropriate for this position is circuit breaker with nominal current 50 A, 1P+N, with short-circuit current capacity 10 kA and C characteristic.

Residual current device toward the grid, RCD2

Maximal current that can come from the grid or can be delivered to the grid is maximal output current of the Quattro inverter/charger and that is: $I_{max}=I_{maxout}=$ 50 A, so nominal current of the RCD will be 63 A. Leakage current that will be used is $I\Delta n=300$ mA. So, for this position (see the drawing EL - 001 Grid interconnection) the RCD 300mA, 63 A will be used.

Figure 37 - RCD 300 mA, 63 A

<u>Distribution board and circuits</u>

Main distribution board for house appliances will be mounted in the engine room in the entrance of the house. There will be 30 electrical circuits in the house, divided according to the appliances used in each circuit.

In the following text, there is list of appliances used in the house and their individual consumption (nominal power).

The main loads are:

Load	Power	Voltage	Current
1. Clothes washer and dryer	3300 W	230 V	14.35 A
2. Lighting	548 W	230 (24 DC)	2.38 A
3. Stove	2900 W	230 V	12.61 A
4. Oven	2700 W	230 V	11.74 A
5. Dishwasher	2400 W	230 V	10.44 A
6. Refrigerator + freezer	160 W	230 V	0.70 A
7. TV	31 W	230 V	0.14 A
8. Laptop	75 W	230 V	0.33 A
9. BluRay	8,8 W	230 V	0.04 A
10. Heat pump	2000 W	230 V	8.70 A

For each circuit, it's necessary to calculate circuit breaker and appropriate cable.

Circuit breakers are calculated according to the maximal current that can appear in each circuit:

$$I_{max}=\frac{Pmax}{U\ nominal}$$

Cables are calculated according to the following criteria:

Current carrying capacity criteria

$$I_{ac}=\frac{Pmax}{U\ nominal}$$

Appropriate current capacity for AC cable is approximate 6A/mm².

Voltage drop

For AC cable, voltage drop is calculated by the following formula:

$$V_{ac}= \frac{2xIx(R_c xcos\varphi + X_c xsin\varphi)xL}{1000}$$

where

V_{dc} is AC voltage drop (V);

I is the nominal full load or starting current as applicable (A);

Rc is the AC resistance of the cable (Ω/km)

Xc is the ac reactance of the cable (Ω/km)

cosφ is the load power factor (pu)

L is the length of the cable (m)

If the voltage drop is less than 3% for the nominal voltage 230 V, the cable cross-section satisfies the criteria.

If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc{,}mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod}$$

Short circuit temperature

The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm²*)

i is the prospective short circuit current (A)

t is the duration of the short circuit (s)

k is a short circuit temperature rise constant.

Distribution circuits and corresponding circuit breakers and wiring is shown in the following table:

Table 18 - Distribution circuits

LOAD	POWER (W)	POWER CURRENT (A)	CIRCUIT NUMBER	CIRCUIT BREAKER	CABLE (mm²)
Clothes washer and clothes dryer	3300	14.35	S1	20 A, 1 p, 10 kA, B	4
Socket		16	S2	16 A, 1 p, 10 kA, B	2.5
Stove	2900	12.61	S3	13 A, 1 p, 10 kA, B	2.5
Oven	2700	11.74	S4	13 A, 1 p, 10 kA, B	2.5
Socket (2 sockets in circuit)		16	S5	16 A, 1 p, 10 kA, B	2.5

Lighting - Kitchen	18	0.08	S6	1 A, 1 p, 6 kA, C	1.5
Lighting – Kitchen (DIM)	7.2	0.03	S7	1 A, 1 p, 6 kA, C	1.5
Dishwasher	2400	10.44	S8	13 A, 1 p, 10 kA, B	2.5
Refrigerator + freezer	160	0.70	S9	16 A, 1 p, 10 kA, B	2.5
Socket (2 sockets in circuit)		16	S9	16 A, 1 p, 10 kA, B	2.5
Lighting - Bathroom	67.5	0.30	S10	1 A, 1 p, 6 kA, C	1.5
Socket (3 sockets in circuit)		16	S11	16 A, 1 p, 10 kA, B	2.5
Socket (6 sockets in circuit)		16	S12	16 A, 1 p, 10 kA, B	2.5
Socket (4 sockets in circuit)		16	S13	16 A, 1 p, 10 kA, B	2.5
Lighting – Bedroom (DIM 1)	14	0.06	S14	1 A, 1 p, 6 kA, C	1.5
Lighting – Bedroom (DIM 2)	28.8	0.13	S15	1 A, 1 p, 6 kA, C	1.5
Lighting – Main room (DIM 1)	28.8	0.13	S16	1 A, 1 p, 6 kA, C	1.5
Lighting – Main room (DIM 2)	28.8	0.13	S17	1 A, 1 p, 6 kA, C	1.5
Lighting – Main room (DIM 3)	28.8	0.13	S18	1 A, 1 p, 6 kA, C	1.5
Lighting – Main room (DIM 4)	14	0.06	S19	1 A, 1 p, 6 kA, C	1.5
Lighting – Main room (DIM 5)	14	0.06	S20	1 A, 1 p, 6 kA, C	1.5
Lighting – Greenhouse (DIM 1)	36	0.16	S21	1 A, 1 p, 6 kA, C	1.5
Lighting – Greenhouse (DIM 2)	36	0.16	S22	1 A, 1 p, 6 kA, C	1.5
Lighting – Greenhouse (DIM 3)	36	0.16	S23	1 A, 1 p, 6 kA, C	1.5
Lighting – Greenhouse (DIM 4)	36	0.16	S24	1 A, 1 p, 6 kA, C	1.5
Socket (4 sockets in circuit)		16	S25	16 A, 1 p, 10 kA, B	2.5
Home electronics	114.8	0.50	S26	3 A, 1 p, 6 kA, C	1.5
Heat pump	2000	8.70	S27	10 A, 1 p, 10 kA, B	2.5

Lighting – Engine room	28	0.12	S28	1 A, 1 p, 6 kA, C	1.5
Lighting – Outdoor	133	0.58	S29	1 A, 1 p, 6 kA, C	1.5
Socket (3 sockets in circuit)		16	S30	16 A, 1 p, 10 kA, B	2.5

Wiring

All wiring must be laid in either flexible or rigid PVC conduit or steel channels, suited for the application. The internal diameter of PVC conduits must be a minimum of 20 mm and at least 1.4 times greater than the diameter of the wire or wire bundle contained. Steel channels must allow free space of not less than 50 %. Cable for lines at different nominal voltage must be installed in separate conduits or separated by appropriate barriers. Metal channels must be provided with the necessary ground and equipotential connections.

Cabling will be implemented in a manner that minimizes the probability of propagating or igniting any fire under the various installation conditions. The electrical lines will be dimensioned that limit voltage drops to 3 % of the nominal input voltage. Selected cable cross-sections for each circuit are shown in the table above.

Electrical box

The electrical distribution boxes will contain all necessary switching, measuring, protection and control equipment necessary for system function, according to the circuit diagram included with this project document. The electrical boxes will confirm to CEI norms for the particular type of the product.

The boxes will be built in galvanized sheet steel, finished in thermoset epoxy resin polymer powder coating.

Lighting system

The interior and exterior lighting will be LED units, switched by the motion detectors and dimmered in function of natural light detected by low-light sensors. The light system is divided in various lines and circuits, so in case of any kind of disturbance or fault, the whole house wouldn't be in dark. Description of the lighting can be found in the section 5.1.2. Detailed layout of the lighting can be found in the drawings EL-401 Lighting plan and EL-402 Lighting plan details.

Lighting in the bathroom and shower is chosen according to the latest copy of the IEE wiring regulations minimal IP protection factor for the lights chosen in bathroom is IP44. Selected luminaire KORA 16 compiles the standard IEC 60364-7-701 with IP protection factor 44.

Outdoor lighting is subject to certain wiring regulations and must be selected and erected so as to be suitable, for the external influences likely to occur at the particular point of installation. Such influences are likely to include: spraying and splashing water, water from jets and immersion in water. The required IP rating for outdoor lighting depends on the influences it is subjected to. Selected luminaires satisfy IP protection code, LIAM IP65, NEMEA6 IP67 and JAGO IP54.

Protection against overcurrent

In accordance with the section of the conductor, rated current of the protection is specified. Selected circuit breakers have short circuit current capacity of minimum 6 kA.

Protection against electric shock (direct and indirect contact)

There is the risk of direct contact and accidental contact of the person with active parts of the installation and indirect contact with metallic mass which can get accidentally under the voltage due to the decreased isolation. All electrical equipment have minimum IP protection code 2. IP protection codes for sockets are listed in the following table. Each socket have protective shutter. The installation of the socket can be seen in the drawing EL-301 Power plan.

After main circuit breaker toward the house appliances, residual current device will be used as protection against direct contact.

Maximal current that can supply house appliances is defined with maximal possible house load
$I_{maxload}=\frac{Pmax}{U}=\frac{9\ kW}{230\ V}=39\ \text{A}$

so the nominal current of the RCD will be 40 A.
Leakage current that will be used is $I\Delta n=30$ mA. So, for this position (see the drawing EL-601 AC wiring diagram) the RCD 30mA, 40 A will be used.

Data and telephone system

The system plan includes specifications for installation or provision for the future installation of a data and telephone transmission system. The plan also provides WiFi coverage of the entire house.

Grounding system

The housing unit grounding system will be attached to the grounding system already present in the building and the new system will serve the existing one. The type of the grounding system will be TT and according to the norms, in TT systems where differential breaker is used to ensure protection from the indirect contact, the earth resistance must satisfy the following formula:

$R_t \le \frac{U}{Idn}$

In the housing unit system the maximum value of I_{dn} is 1 A, so the value of resistance to earth is:

$R_t \le \frac{50\ V}{1\ A} \le 50\ \Omega$

Protective conductor will connect the earthing-pin contact in each socket outlet with the main earthing terminal at the origin of the installation.

All metallic masses of the receiving devices, general heating and plumbing system, TV and radio aerials will be connected will be connected to the grounding with the protective conductor.

5.3.4.3 Electrical System Management

Today there are two major challenges which electrical power engineering is trying to address. The first one is to reduce the electricity consumption peaks. The electricity consumption significantly varies over time. In order to ensure reliable delivery of electricity, every part of the grid (transmission lines, transformers, circuit breakers...) has to be dimensioned to withstand the peak load. However, during the off-peak hours the grid is usually underutilized. Shifting the electricity demand from peak to off-peak hours would reduce the need to upgrade the existing grid because of the increasing demand. In addition to the obvious financial benefits, this is important because the grid upgrades, i.e. new transmission lines, are very difficult to integrate in populated areas such is most of the Europe. The second challenge is the integration of the renewable sources, namely wind and solar. Electricity is difficult to store in significant amounts (with exception of pumped hydro), so the electricity generation and demand + losses have to be in balance at all times. We cannot rely on the production of renewable sources due to their intermittency (stochastic behaviour of the wind is exceptionally challenging), which means that reserve in conventional power plants is required to enable safe operation of the power system. In order to enable a larger share of renewable integrated into the power systems, demand side will have to become more active. Households make up for the significant part of total electricity demand, and our goal is to make our house a “model citizen“ in the electricity grid with demand side management ability. That means that the house will be able to adjust its consumption throughout the day in order to achieve different objectives.

A peak demand in Croatia and also in the global system is between 7 and 10 p.m., so if the house will be able to remove from the grid in that period, it could relieve the power grid. Furthermore, it is well known that the power plants which produce electricity in the peak period implement production technologies that emit CO_2 and besides, they are increasing the energy price.

Our energy strategy encompasses the promotion of electricity generation from the sun and promoting energy efficiency at the micro level. This strategy is an opportunity to improve people behaviour, who have to learn to minimize electricity consumption and which benefit they have from it. So we propose a prospective method of energy management, which will encompass several different scenarios of the house behaviour.

The idea we had in mind when designing the electrical system of our house was to enable high level of control over all electricity related systems. That will enable energy efficient house management while providing high level of comfort for residents.

Electrical equipment in our house will be connected to AC bus.

The loads in used in the house are will be either flexible or non-flexible. Flexible loads are those that have the possibility to operate at different times of the day without reducing the comfort level. The example of such a load is the electric heat pump, which can take advantage of the high thermal capacity of the house to operate at different times of the day. For example, heat pump will warm up the house during the night when the electricity is cheaper. The heat will be stored in the walls and phase changing materials and emitted throughout the day. The fridge will be used in a similar way, on a smaller time scale. Those loads will be monitored and controlled from the central computer in a way to modify the daily consumption curve of the house. Non-flexible loads cannot be used in that way, such as TV, because the users require immediate response. However, some of the non-flexible loads, such as clothes dryer or dishwasher will warn the user if they are used during peak consumption hours. The user will have the option to disregard the warning and use those appliances anyway.

Batteries will be connected to the DC bus via controllable inverter/charger. Its role is to enable control over energy flow to and from the batteries, according to the optimal charge/discharge strategy determined by the central controller. In addition to that, this will be used to regulate the charging process of the battery, adjusting charging voltage depending on the state of the battery. Battery power flow would be controlled by switching the charger and the inverter on and off. The additional benefit is that the battery inverters are designed to keep voltage and frequency when the house operates off-grid. Battery state of charge will be calculated by measuring and integrating the current flow.

The batteries and the flexible loads, namely the electric heat pump, will be used to modify the daily load profile of the house. To ensure the desired behaviour we will use model predictive control (MPC). In a nutshell, this method is used to determine the current behaviour of the system (in discrete steps) while taking into account the future behaviour. In our case this method will use the detailed mathematical model of the house and different forecasts (weather, electrical load, thermal load, house occupancy) to determine the optimal operating schedule of the controllable loads and the battery system. The operating schedule will be done for a certain time horizon, i.e. 24 hours. The control actions will be implemented in the current discrete control period, i.e. 1 minute. In the beginning of the next control period the optimal schedule is calculated again, with updated forecasts and measurements as input parameters.

PV panels are also going to be connected to the DC bus, via DC/DC maximum power tracker. The reasoning behind this is similar to the one with the battery system: to reduce the amount of energy that has to go through DC/AC conversion and to increase overall efficiency of the system. Since the entire PV array will be tilted at the same angle and there will not be any shadowing, the maximum power point will be the same for all solar panels. This will enable the use of only one MPPT device.

Electricity consumption or generation for every piece of electrical equipment will be monitored and those measurements will be used to determine real time electricity balance of the house. That data will be used by the central controller to determine the optimal operating schedule for batteries and flexible loads.

The layout of the design of the Mem**brain** electrical system is shown on the following figure.

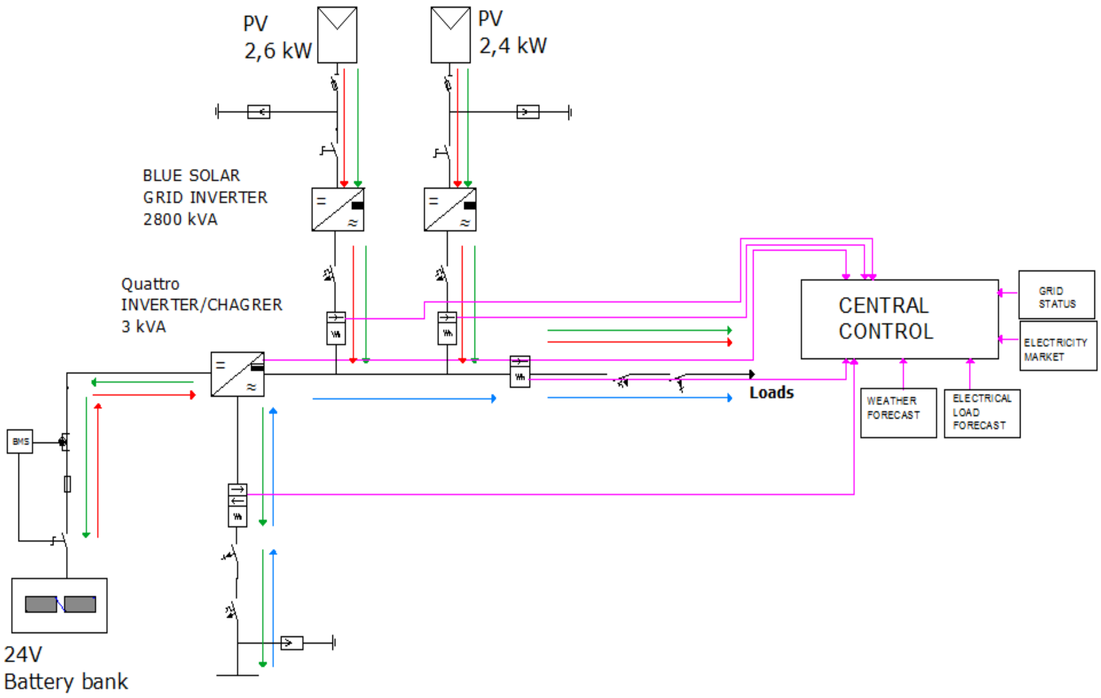


Figure 38 – Membrain electrical system design layout

5.3.5 Photovoltaic System Design

5.3.5.1 Introduction

A photovoltaic system consists of:

- **PV module** or PV generator converts sunlight into DC electricity.
- **Grid inverter** that converts DC current coming from the PV panels into a clean AC current for AC appliances, regulates the voltage and current coming from the PV panels going to battery and prevents battery overcharging and prolongs the battery life.
- **Inverter/charger** is the core of the system, which regulates power flow in various directions: in the battery, from the battery, from the grid, in the grid etc.
- **Battery** that stores energy for supplying electrical appliances.
- **AC and DC loads** that consume electricity produced from PV modules or distributed from the grid.

A simplified model of this grid-connected PV system is shown in the Figure 39.

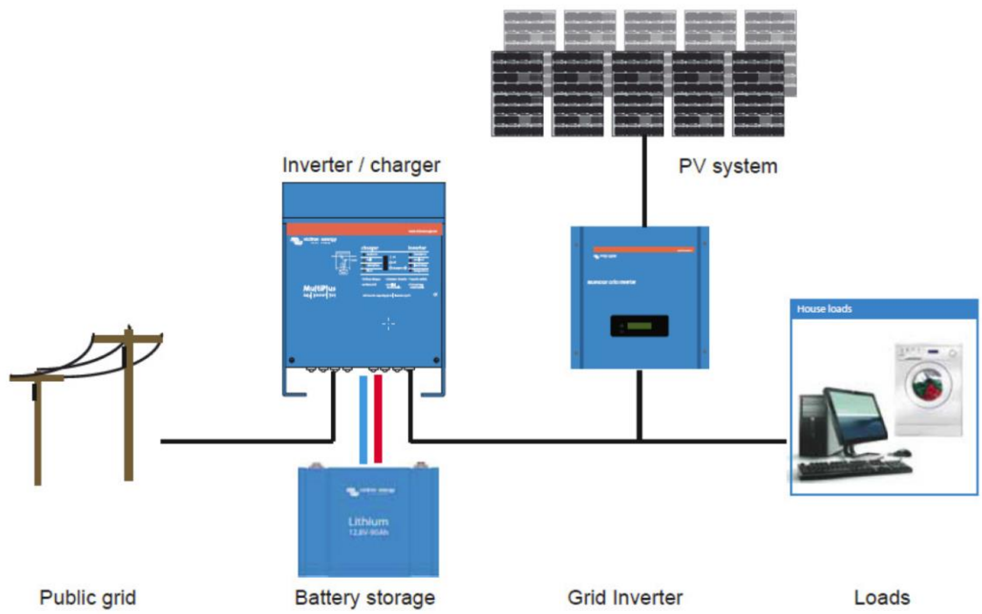


Figure 39 - Simplified model of grid-connected PV system

If we consider characteristics of the current in the described system, the system can be divided in two parts:

- **DC part** covering the part of the described system from PV modules to grid inverter and also from inverter/charger to batteries. PV modules, batteries, supporting structure, DC connection boxes, DC conductors and DC protection devices are included in this part.
- **AC part** covering the part of the described system from the grid inverter to the public grid and appliances. Grid inverter, wires, appliances, AC protections and metering devices are included in this part.

The graphical representation of the division of the AC and DC parts (components) is shown in Figure 40.

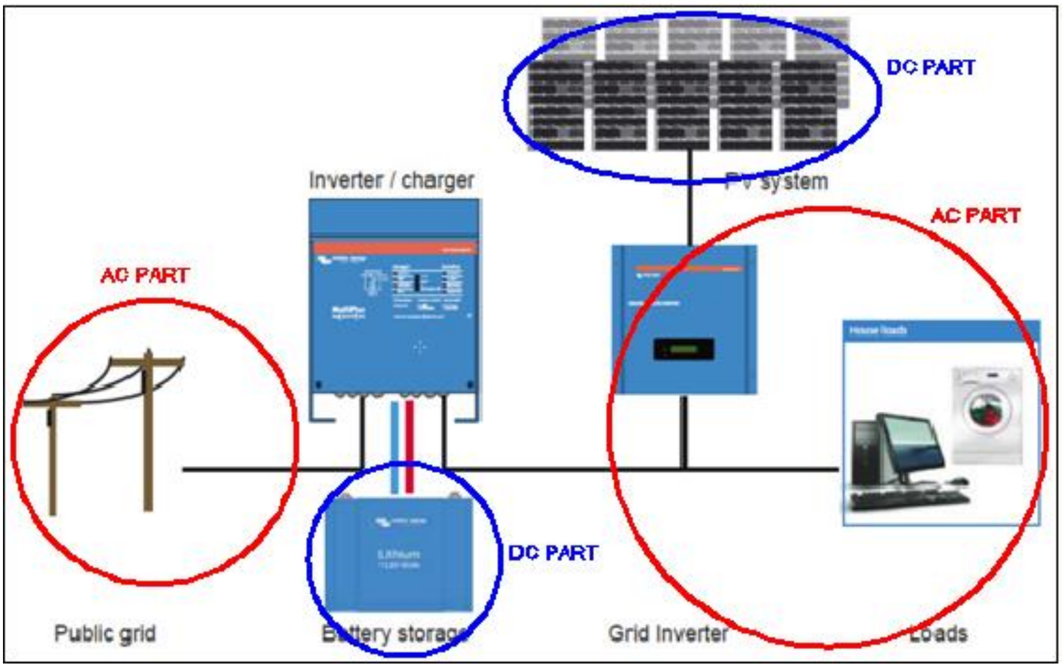


Figure 40 - The graphical representation of the division of the AC and DC parts

5.3.5.2 General description

Central parts of our photovoltaic system are building integrated photovoltaic modules which are located in the envelope of the membrane. Since our goal is to design the concept that would suit the two geographic locations, Zagreb and Paris, the photovoltaic system also has to be adjusted to these objectives. Therefore, our decision, in terms of the design of the photovoltaic system construction, is construction of the furling panels on the roof. Furling panels can adjust mechanically to the angle of the solar beams and contribute to the maximum electricity production. This way, our system, is one-axis tracker that has the ability to change its angle over the year as the height of the sun above horizon changes. Since the entire PV array will be titled at the same angle and there will not be any shadowing, the maximum power point will be the same for all solar panels.

To increase overall system efficiency and usability, we are using batteries and flexible loads, namely heat pump. Batteries will be controlled via controllable inverter/charger, which will enable control over energy flow to and from batteries, according to the optimal strategy determinate by the central controller. Flexible loads will have possibility to operate at different times of the day without reducing the comfort level.

Batteries and flexible loads together will be included in the flexible electrical system, which is the main objective of the Mem**brain** energy strategy. The basis of this strategy is flexibility in the context of the electricity production and consumption.

A conceptual layout of the described PV system is shown in the figure below. Each part of the system will be described with further detail later.

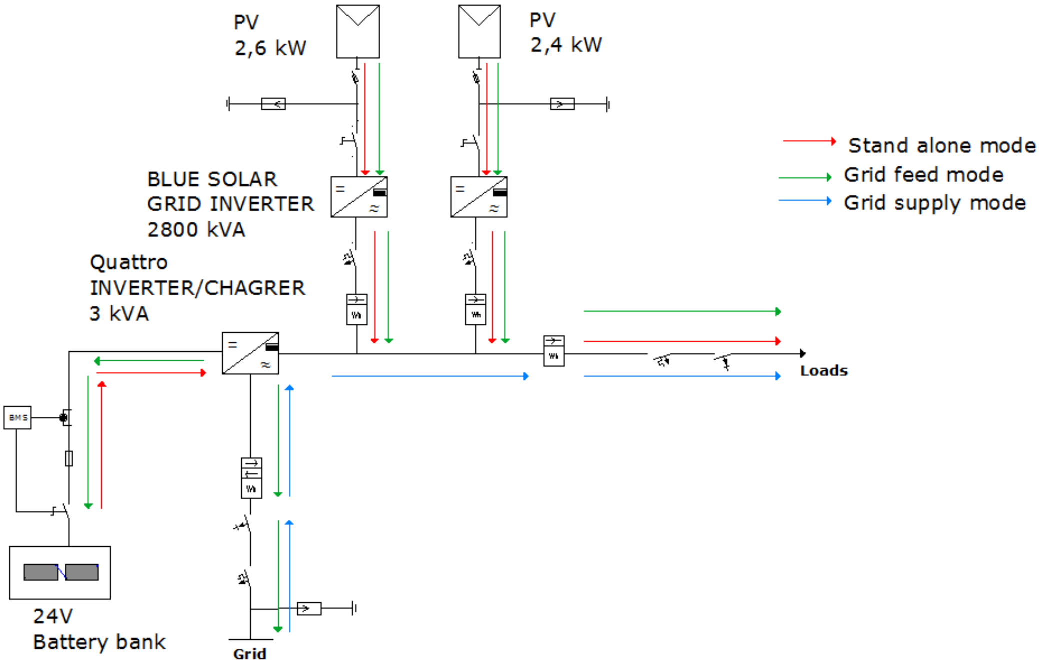


Figure 41 - Conceptual layout of the described PV system

5.3.5.3 Design and specifications

Photovoltaic generator

The photovoltaic installation consists of six rows of photovoltaic modules arranged in the horizontal orientation (roof). Chosen photovoltaic modules are commercially available, manufacturing brand Victron energy. We defined necessary photovoltaic modules based on architectural requirements (module dimensions that suit the structure) and electrical requirements (power, open circuit voltage, etc.). Main characteristics of the chosen photovoltaic module, BlueSolar Monocrystalline Panels SPM101-12, are presented in the following table.

Table 19 - BlueSolar module specifications

DIMENSIONS	1210x540x35 cm
GLASS SIZE	1205x535 cm
WEIGHT	8 kg
POWER	100 W
MAX POWER VOLTAGE (U_{MPP})	18 V
MAX POWER CURRENT (I_{MPP})	5.56 A
OPEN CIRCUIT VOLTAGE (V_{OC})	22.4 V
SHORT CIRCUIT CURRENT (I_{SC})	6.53A

Additional characteristics and data sheet can be found in the appendix Victron energy Solar panels.

The layout and the dimensions of each row are shown in the figure below.

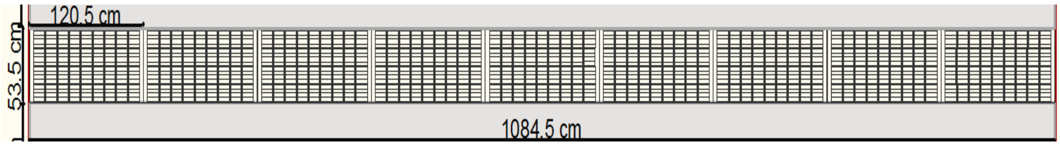


Figure 42 - Layout of the one row of PV modules

The PV panels are connected to the four strings. Two strings consist of 13 panels and two of 12 panels. The detail layout of the PV module design is shown in the drawing PV – 011.

In the string with 13 panels, maximum voltage (open circuit voltage) is 291.2 V and the maximum short-circuit current that can appear in the circuit is 6.53 A.

In the string with 12 panels, maximum voltage (open circuit voltage) is 268.8 V and the maximum short-circuit current that can appear in the circuit is 6.53 A.

The figure below represents the real layout of the BlueSolar Monocrystalline Panels SPM101-12.

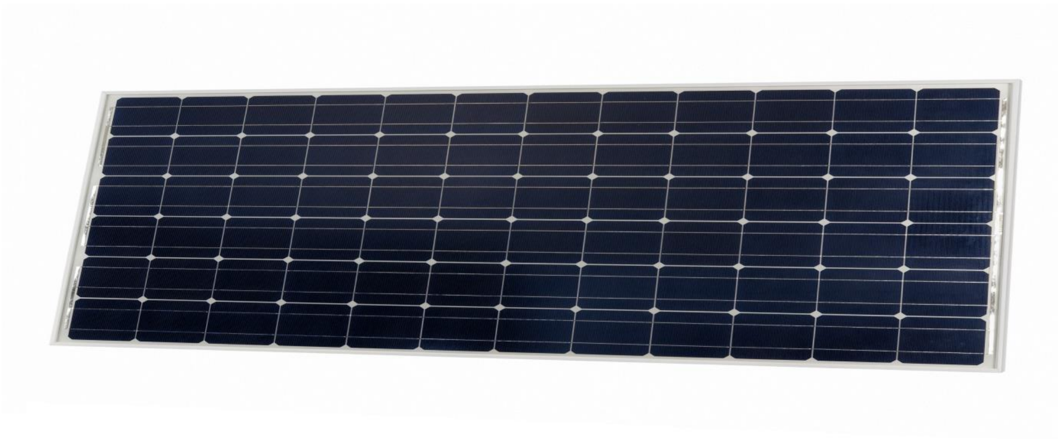


Figure 43 – BlueSolar Monocrystalline Panels SPM101-12 layout

Grid inverter

The 5 kW BIPV system of Mem**brain** consists of custom made monocrystalline PV modules that are combined in four equally powered strings. Maximal output power of the first two strings connected is 2.4 kW, maximum output voltage (open circuit voltage) is 268.8 V and the maximum short-circuit current that can appear in the circuit is 6.53 A. Maximal output power of the second two strings connected is 2.6 kW, maximum output voltage (open circuit voltage) is 291.2 V and the maximum short-circuit current that can appear in the circuit is 6.53 A. Two same-numbered strings are brought in parallel to the input of the solar grid inverter. According to the available inputs for grid inverter, two Blue Solar Grid Inverters 2800 will be installed. Maximum input power of the grid inverter is 2.8 kW, maximum voltage is 550 VDC and maximum current is 13 A, so it accomplishes all conditions referring input parameters (solar output values). Detail specifications of the solar grid inverter are shown in the figure below.

BlueSolar Grid Inverter

BlueSolar Grid Inverter	1500	2000	2800
GRID OUTPUT (AC)			
Nominal output power	1500W	2000W	2800W
Maximum output power	1650W	2200W	3000W
Nominal output current	6.52A	8.7A	12A
Maximum output current	7.2A	9.5A	13A
Maximum fuse protection	16A	16A	16A
Harmonic distortion of output current	<3% at nominal power	<5% at 50% power	
Nominal AC output voltage	220V - 230V - 240V		
Power factor	>0,99% at nominal power		
Operating AC voltage range	190-260V		
Nominal AC frequency	50Hz		
Operating AC frequency range	45.5-54.5Hz		
Internal consumption at night	<0,1W		
Short circuit proof	Yes		
SOLAR INPUT (DC)			
Maximum Input voltage	450V	500V	500V
Input Voltage MPPT range	110-430V	110-480V	110-480V
Maximum input current	9A	10A	13A
Maximum input power	1750W	2280W	3160W
Number of MPPT trackers	1	1	1
Number of strings	1	1	2
Start-up power	7W	7W	7W
Ground fault monitoring	RCMU (residual current monitoring unit)		
Reverse polarity protection	Yes, with short circuit diode		
EFFICIENCY			
Maximum efficiency	95.5%	96.4%	96.4%
European standard efficiency	94.5%	95.4%	95.5%

Figure 44 - Solar grid inverter specifications

Because the power generated from PV module varies with solar radiation, ambient temperature and solar cell temperature the solar grid inverters are equipped with MPPT trackers to extract maximum available power from PV module under certain conditions. The major principle of MPPT is to extract the maximum available power from PV module by making them work at the most efficient voltage.

Inverter/charger

Central part of the PV system is inverter/charger. Since there are two generators, PV modules and public grid, battery and appliances, and given that there are lot of different energy flow directions, this implies that it is necessary to use device that will easily control all mentioned energy flow directions. Therefore, Quattro inverter/charger 24/3000/70-50/30 is chosen. The basis of the Quattro is an extremely powerful sine inverter, battery charger and automatic switch in a compact casing. The Quattro features two AC inputs for connecting two independent voltage sources and automatically selects the input where voltage is present. If voltage is present on both inputs, the Quattro will select the generating set.

The Quattro also has usual uninterruptable output and one auxiliary output that disconnects its load in the event of the battery operation. The Quattro is very powerful battery charger. It will draw a lot of current from the generator or shore side supply. A current limit can be set on each AC input. The Quattro can be used in off grid as well as grid connected PV and other alternative energy systems.

Quattro inverter/charger allows the power system of Mem**brain** to work in three power modes: Grid-Feed, Grid-Charge and Stand-Alone. In Grid-Feed mode if the batteries are fully charged and the loads demands are satisfied, the inverter can feed the power generated by the PV to the grid, in Grid-Charge mode the power saved in battery is insufficient to satisfy demands of connected loads and is therefore supported up by the grid power. In Stand-Alone mode the micro grid of Mem**brain** can be powered only by the batteries or in combination with the PV modules. Following figures presents each of these power modes.

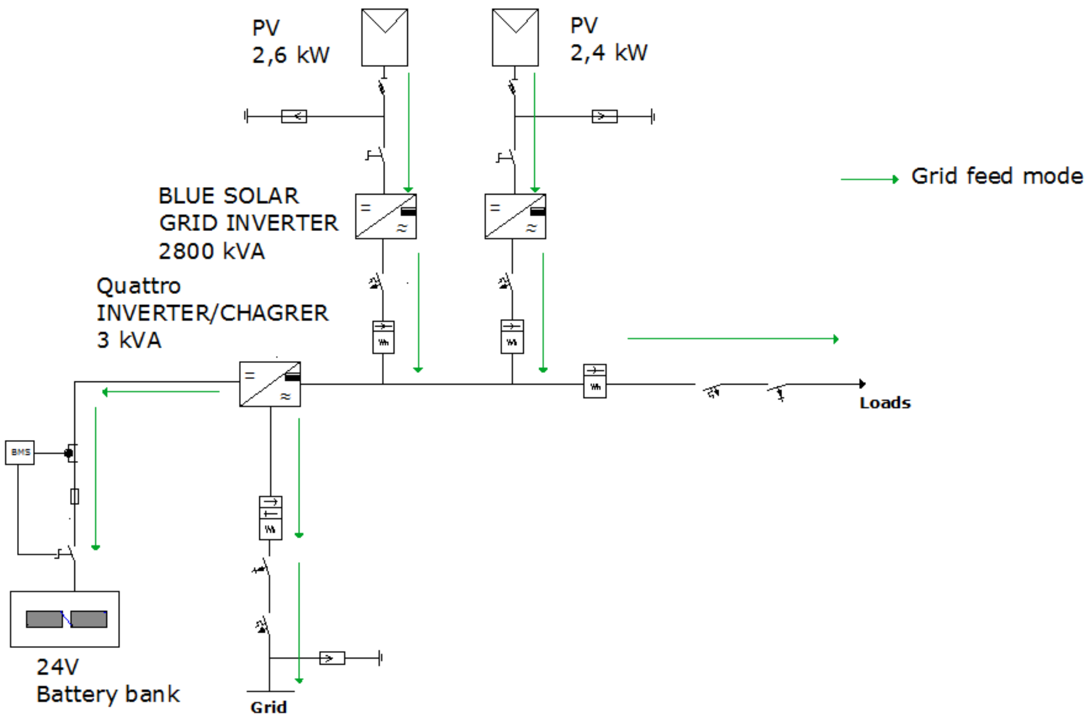


Figure 45 – Grid feed mode

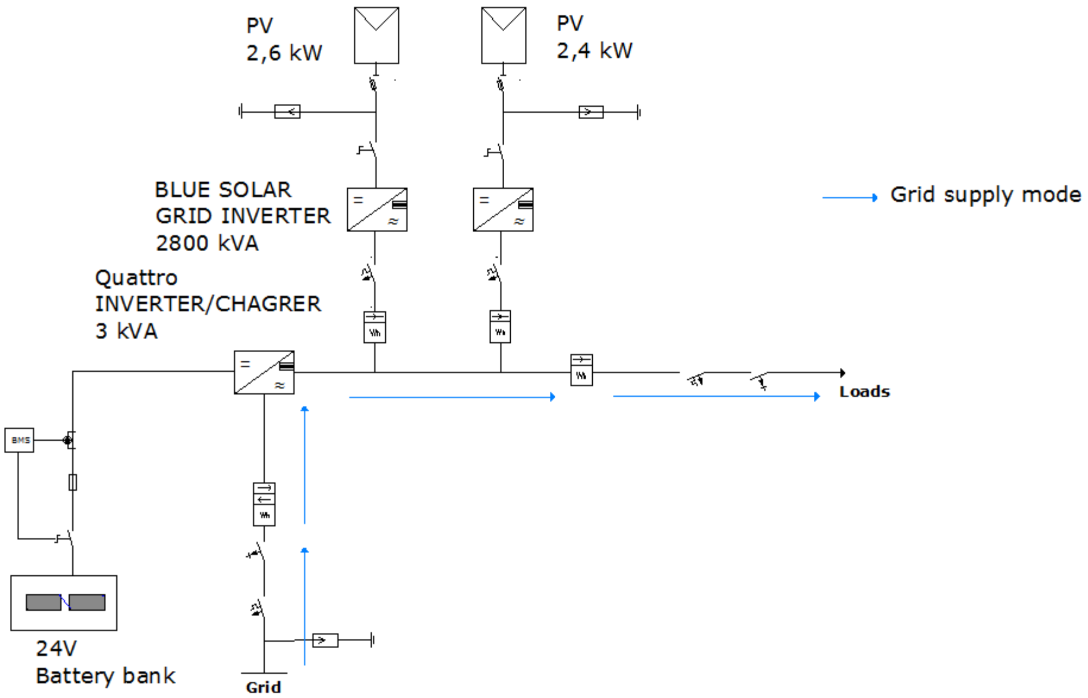


Figure 46 – Grid charge mode

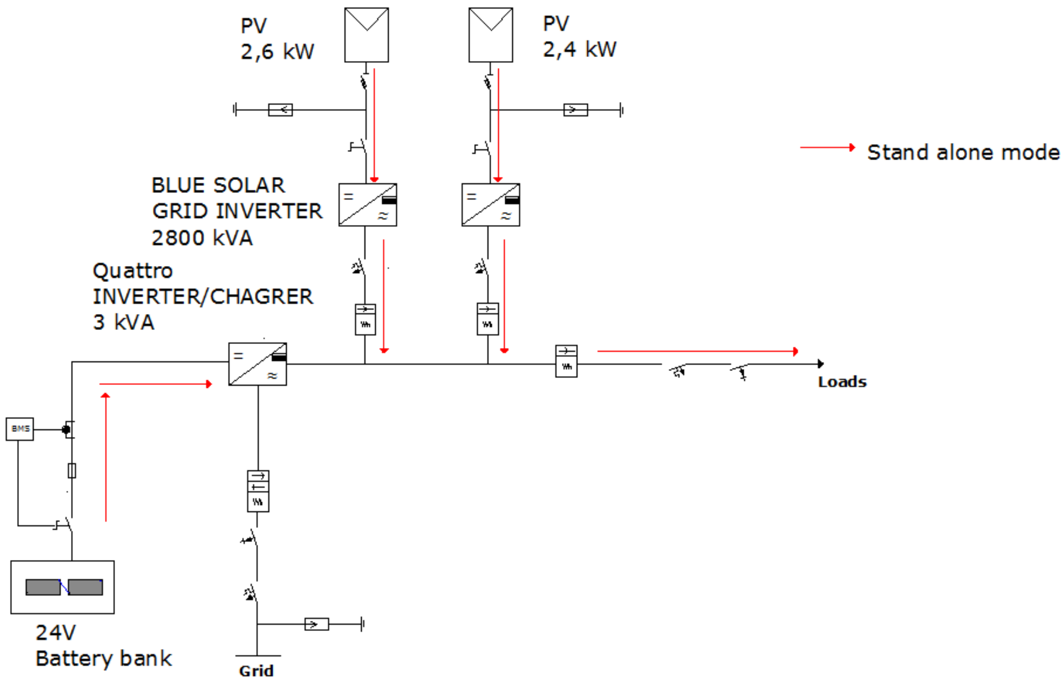


Figure 47 – Stand-alone mode

Detail description of the mentioned power modes is in the section 5.3.6. Electrical Energy Balance Simulation.

Batteries

Type of battery integrated in the PV system of Membrain is sealed Gel Valve Regulated Lead Acid (VRLA). This type of batteries is also known as maintenance free and don't require ventilation, and can be mounted in any orientation. The electrolyte in the batteries is immobilized as gel (sulfuric acid is mixed with silica fume), the pressure relief activates when the battery starts building pressure of hydrogen gas as result of being recharged at excessive voltage. In comparison to Absorbent Glass Mat (AGM) batteries they have a longer service life and better cycle capacity. Usage of lead calcium grids and high purity materials allows Victron VRLA batteries to be stored during long periods of time without recharge; rate of self-discharge is less than 2% per month at 20°C. The batteries are compliant with both CE and UL specifications in ABS fireproof containers.

The battery bank consist of two series connected 12V batteries with capacity of 220 Ah. In total the capacity of the entire bank reaches 220 Ah which equals the power of 5280 W considering the voltage value of 24 V. Detail specifications of each 12 Volt Deep Cycle GEL battery are shown in the table below (for more details see Appendix Victron energy GEL Batteries).

Table 20 - Characteristics of the battery

Type of battery	Deep Cycle GEL VRLA
Nominal voltage	12 V
Capacity	220 Ah
Dimensions [L x W x H]	522x238x240 mm
Weight	66 kg

Quattro inverter/charger will provide the optimum protection and long service life through temperature-compensated battery charge, control of electrolyte circulation and ventilation of the battery box. In event of slight battery discharge, absorption is kept short to prevent overcharging and excessive gas formation. After deep charging, the absorption time is automatically extended in order to fully charge the battery. Because of the use of lead calcium grids and high purity materials, Victron VRLA batteries can be stored during long periods of time without recharge. The rate of self-discharge is less than 2% per month at 20°C. The self-discharge doubles for every increase in temperature with 10°C. Victron VRLA batteries can therefore be stored during up to a year without recharging, if kept under cool conditions. Victron VRLA batteries have exceptional discharge recovery, even after deep or prolonged discharge. It should however be stressed that repetitive deep discharge and prolonged discharge have a very negative influence on the service life of all lead acid batteries, Victron batteries are no exception. The rated capacity of Victron AGM and Gel Deep Cycle batteries refers to 20 hour discharge, in other words: a discharge current of 0.05 C. The rated capacity of Victron Tubular Plate Long Life batteries refers to 10 hours discharge. The effective capacity decreases with increasing discharge current. Please note that the capacity reduction will be even faster in case of a constant power load, such as an inverter.

The layout of the battery is shown in the figure below. Connections of the batteries are shown in the drawing PV-005 Battery bank.

Figure 48 - 12V 220 Ah GEL battery

Wiring system

There are four different criteria for sizing the wiring system:

- maximal admissible current, according to IEC 60364-7-712 Standard, the cables must allow 1.25 times the maximum current in the standard test conditions
- maximum voltage drop, according to the Croatian National Electrical Code, maximal admissible voltage drop is 5% and according to the French National Electrical Code, maximal admissible voltage drop is 3%
- short circuit temperature rise within the cable
- earth fault loop impedance

Our calculation for all cables will be carried for first three mentioned criteria, maximal admissible current, maximum voltage drop and short circuit temperature rise since earth fault loop impedance will be calculated in Earthing section. Voltage drop calculation will be carried out according to the French standards and the results will also be valid according to the Croatian standards.

PV Module interconnections
Photovoltaic modules are arranged in the four parallel connected strings, two with 12 modules in series and two with 13 modules in series. Calculation for each strings are as follows:

String with 12 serial connected modules
Expected cable length - L=0.5 m
Current carrying capacity criteria: $I_{MAX} = I_{SC} = 6.53$ A
This is maximal current that can appear in the serial connected string. According to this criteria, cable with cross section 4 mm2 with current capacity 2A/mm^2 will be appropriate.
Maximum voltage drop criteria For DC cable, voltage drop is calculated by the following formula:
$V_{dc} = \frac{2xIxRxL}{1000}$
Where:
V_{dc} is DC voltage drop (V);
I is the nominal full load or starting current as applicable (A);

R is the DC resistance of the cable (Ω/km), calculated for cable 4 mm² and 0.5 m length

R= $\frac{\rho x l}{A}$ = $\frac{0.0172x0.5}{4}$ = 0.00215 Ω;

L is the length of the cable (m)

V_{dc}= $\frac{2x5.56x0.00215x0.5}{1000}$=0.0001 V

which is for nominal voltage of 216 V less than 3% voltage drop, so 4 mm² satisfies this criteria.

Short circuit temperature rise

The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

A = $\frac{\sqrt{i^2 t}}{k}$

Where:

A is the minimum cross-sectional area of the cable (*mm*²)

I is the prospective short circuit current (kA)

t is the duration of the short circuit (s), t=5 s for cables

k is a short circuit temperature rise constant.

A = $\frac{\sqrt{5.56^2 * 10^{-6} * 5s}}{1}$=0.012 mm²

so our chosen cross-section is sufficient.

According to all three criteria and to the manufacturer recommendations, for the connections between PV modules in string with 12 modules, cable FG70R with 4 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with isolation HEPR/PVC , for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according PV-014 DC circuit: PV modules cabling.

String with 13 serial connected modules

Expected cable length - L=0.5 m

Current carrying capacity criteria: I_{MAX} = I_{SC}= 6.53 A

This is maximal current that can appear in the serial connected string. According to this criteria, cable with cross section 4 mm2 with current capacity 2A/mm² will be appropriate.

Maximum voltage drop criteria For DC cable, voltage drop is calculated by the following formula:

V_{dc}= $\frac{2xIxRxL}{1000}$

Where:

V_{dc} is DC voltage drop (V);

I is the nominal full load or starting current as applicable (A);

R is DC resistance of the cable (Ω/km), calculated for cable 4 mm² and 0.5 m length

R= $\frac{\rho x l}{A}$ = $\frac{0.0172x0.5}{4}$ = 0.00215 Ω;

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where:
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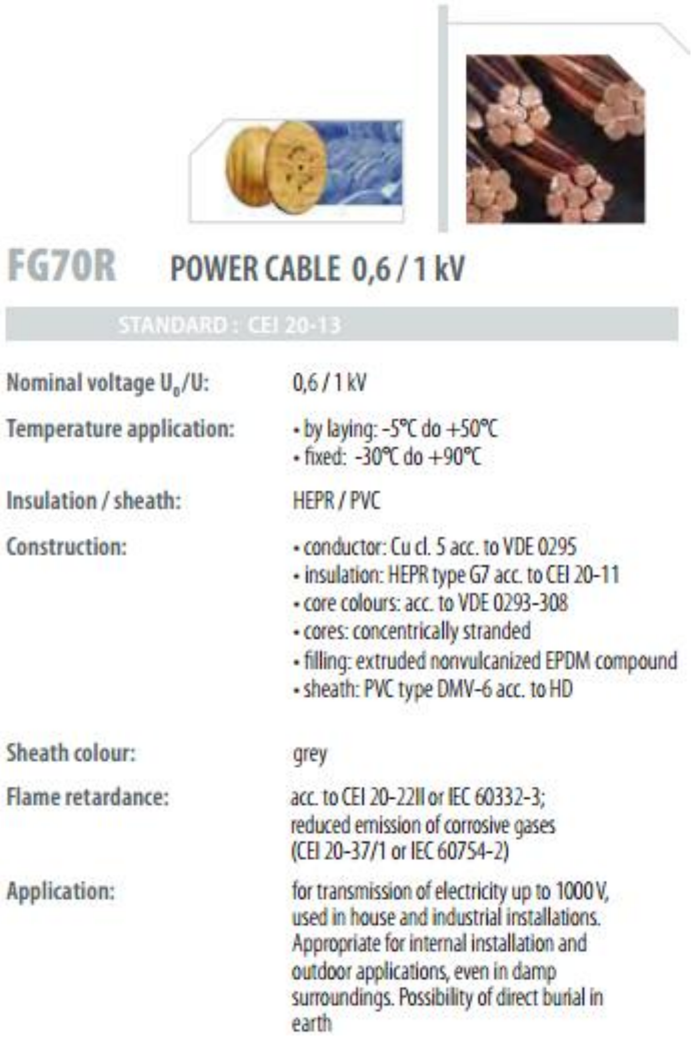
t is the duration of the short circuit (s), t=5 s for cables
k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{5.56^2 * 10-6 * 5s}}{1} = 0.012 \text{ mm}^2$$

so our chosen cross-section is sufficient.
According to all three criteria and to the manufacturer recommendations, for the connections between PV modules in string with 13 modules, cable FG70R with 4 mm^2 will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according PV-014 DC circuit: PV modules cabling.



FG70R POWER CABLE 0,6 / 1 kV

STANDARD : CEI 20-13

Nominal voltage U_0/U:	0,6 / 1 kV
Temperature application:	• by laying: -5°C do +50°C • fixed: -30°C do +90°C
Insulation / sheath:	HEPR / PVC
Construction:	• conductor: Cu cl. 5 acc. to VDE 0295 • insulation: HEPR type G7 acc. to CEI 20-11 • core colours: acc. to VDE 0293-308 • cores: concentrically stranded • filling: extruded nonvulcanized EPDM compound • sheath: PVC type DMV-6 acc. to HD
Sheath colour:	grey
Flame retardance:	acc. to CEI 20-22II or IEC 60332-3; reduced emission of corrosive gases (CEI 20-37/1 or IEC 60754-2)
Application:	for transmission of electricity up to 1000 V, used in house and industrial installations. Appropriate for internal installation and outdoor applications, even in damp surroundings. Possibility of direct burial in earth

Figure 49 - Characteristics of the PV interconnection cable

Detail information about this cable can be found in the Appendix - Eurocable specifications.

Connection of the first string with 12 modules and the first Blue solar grid inverter

Expected cable length - L= 8 m
Current carrying capacity criteria
Maximal current that can appear in the cable connecting PV strings and solar grid inverter is maximal short current of two parallel connected strings:
$I_{MAX} = 2*I_{sc} = 2*6.53\ A = 13.06\ A$
According to this, cable with cross section 6 mm² with current capacity 2A/mm² will be appropriate.
Voltage drop
For DC cable, voltage drop is calculated by the following formula:
$V_{dc} = \frac{2xIxRxL}{1000}$
where
V_{dc} is DC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
R is DC resistance of the cable (Ω/km), calculated for cable 6 mm² and 8 m length
$R = \frac{\rho xl}{A} = \frac{0.0172x8}{6} = 0.022\ \Omega$;
L is the length of the cable (m)
$V_{dc} = \frac{2x13.06x0.022x5}{1000} = 0.0029\ V$
which is for nominal voltage of 234 V less than 3% voltage drop, so 6 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2 \times Lmod \times Isc{,}mod}{\Delta Vmod \times Vsc \times Nmod \times \sigma}$$

$$L_{mod} = \frac{Smin \times \Delta Vmod \times Voc \times Nmod \times \sigma}{2 \times Isc.mod} = \frac{6 \times 0.03 \times 22.4 \times 12 \times 56}{2 \times 2 \times 6.53} = 103.7\ m$$

Short-circuit temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:
$A = \frac{\sqrt{i^2 t}}{k}$
where A is the minimum cross-sectional area of the cable (mm²)
i is the prospective short circuit current (kA)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.
$A = \frac{\sqrt{13.06^2 * 10^{-6} * 5s}}{1} = 0.029\ mm^2$
so our chosen cross-section is sufficient.
According to all three criteria, for the connections between the first string with 12 modules and the first solar grid inverter, cable FG70R 6 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-014 DC circuit: PV modules cabling.

Connection of the second string with 12 modules and the first Blue solar grid inverter
Expected cable length - L= 14 m
Current carrying capacity criteria:

Maximal current that can appear in the cable connecting PV strings and solar grid inverter is maximal short current of two parallel connected strings:

$I_{MAX} = 2*I_{sc} = 2*6.53A = 13.06$ A

According to this, cable with cross section 6 mm² with current capacity 2A/mm² will be appropriate.

Voltage drop

For DC cable, voltage drop is calculated by the following formula:

$V_{dc} = \frac{2xIxRxL}{1000}$

where

V_{dc} is DC voltage drop (V);

I is the nominal full load or starting current as applicable (A);

R is DC resistance of the cable (Ω/km), calculated for cable 6 mm² and 14 m length

$R = \frac{\rho x l}{A} = \frac{0.0172x14}{6} = 0.04\ \Omega;$

L is the length of the cable (m)

$V_{dc} = \frac{2x13.06x0.04x14}{1000} = 0.0146$ V

which is for nominal voltage of 234 V less than 3% voltage drop, so 6 mm² satisfies this criteria.

If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc,mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod} = \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod} = \frac{6\times0.03\times22.4\times12x\times56}{2\times2x6.53} = 103.7 \text{ m}$$

Short circuit temperature

The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm*²)

i is the prospective short circuit current (A)

t is the duration of the short circuit (s)

k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{13.06^2*10-6*5s}}{1} = 0.029\ mm^2$$

so our chosen cross-section is sufficient.

According to all three criteria, for the connections between the second string with 12 modules and the first solar grid inverter, cable FG7OR 6 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-014 DC circuit: PV modules cabling.

Connection of the first string with 13 modules and the second Blue solar grid inverter

Expected cable length - L= 5 m

a) CURRENT CARRYING CAPACITY:

Maximal current that can appear in the cable connecting PV strings and solar grid inverter is maximal short current of two parallel connected strings:

$I_{MAX} = 2*I_{sc} = 2*6.53A = 13.06$ A

According to this, cable with cross section 6 mm² with current capacity 2A/mm² will be appropriate.
Voltage drop
For DC cable, voltage drop is calculated by the following formula:

$$V_{dc}= \frac{2xIxRxL}{1000}$$

where
V_{dc} is DC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
R is DC resistance of the cable (Ω/km), calculated for cable 6 mm² and 5 m length

$$R= \frac{\rho xl}{A} = \frac{0.0172x5}{6} = 0.014\ \Omega;$$

L is the length of the cable (m)

$$V_{dc}= \frac{2x13.06x0.014x8}{1000}=0.00481\ V$$

which is for nominal voltage of 216 V less than 3% voltage drop, so 6 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc,mod}{\Delta Vmod\times Vsc\times Nmod\times \sigma}$$

$$L_{mod}= \frac{Smin\times \Delta Vmod\times Voc\times Nmod\times \sigma}{2\times Isc.mod}= \frac{6\times 0.03\times 22.4\times 13\times 56}{2\times 2\times 6.53}=112.4\ m$$

c) SHORT CIRCUIT TEMPERTURE
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (mm²)
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{13.06^2 * 10^{-6} * 5s}}{1}=0.029\ mm^2$$

so our chosen cross-section is sufficient.
According to all three criteria, for the connections between the first string with 13 modules and the second solar grid inverter, cable FG70R 6 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-014 DC circuit: PV modules cabling.

Connection of the second string with 13 modules and the second Blue solar grid inverter

Expected cable length - L= 11 m
Current carrying capacity criteria:
Maximal current that can appear in the cable connecting PV strings and solar grid inverter is maximal short current of two parallel connected strings:
I_{MAX} = 2*I_{sc} =2*6.53A= 13.06 A
According to this, cable with cross section 6 mm² with current capacity 2A/mm² will be appropriate.

Voltage drop
For DC cable, voltage drop is calculated by the following formula:

$V_{dc}= \frac{2xIxRxL}{1000}$

where
V_{dc} is DC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
R is DC resistance of the cable (Ω/km), calculated for cable 6 mm² and 11 m length

$R= \frac{\rho x l}{A} = \frac{0.0172x11}{6} = 0.031\ \Omega;$

L is the length of the cable (m)

$V_{dc}= \frac{2x13.06x0.031x11}{1000}$=0.0089 V

which is for nominal voltage of 216 V less than 3% voltage drop, so 6 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$S = \frac{2\times Lmod\times Isc,mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$

$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod} = \frac{6\times0.03\times22.4\times13\times56}{2\times2\times6.53}$=112.4 m

Short circuit temeprature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$A = \frac{\sqrt{i^2 t}}{k}$

where A is the minimum cross-sectional area of the cable (mm²)
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$A = \frac{\sqrt{13.06^2 * 10^{-6} * 5s}}{1}$=*0.029 mm²*

so our chosen cross-section is sufficient.

According to all three criteria, for the connections between the second string with 13 modules and the second solar grid inverter, cable FG70R 6 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-014 DC circuit: PV modules cabling.

Connection of the first Blue solar grid inverter with Q1 and the second Blue solar grid inverter with Q2

Firstly, it's important to observe solar grid inverter information in order to calculate cables:

Nominal output power	2800 W
Maximum output power	3000 W
Nominal output current	12 A
Maximum output current	13 A

Maximum fuse protection	16 A

Expected cable length between solar grid inverter and Q1/Q2 - L= 1 m
Current carrying capacity criteria
Maximal current that can appear in the cable connecting solar grid inverter and Q1/Q2 is maximal output current of solar grid inverter:
$I_{MAX} = I_{maxout} = 13$ A
According to this, cable with cross section 2.5 mm² with current capacity 6A/mm² will be appropriate.
Voltage drop
For AC cable, voltage drop is calculated by the following formula:

$$V_{ac}= \frac{2xIx(Rcxcos\varphi+Xcxsin\varphi)xL}{1000}$$

where
V_{dc} is AC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
Rc is the AC resistance of the cable (Ω/km)
Xc is the ac reactance of the cable (Ω/km)
cosφ is the load power factor (pu)
L is the length of the cable (m)

$$V_{ac}= \frac{2x13x(7.41x1)x1m}{1000}=0.192 \text{ V}$$

which is for nominal voltage of 230 V less than 3% voltage drop, so 2,5 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc,mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod}= \frac{2{,}5\times0.03\times230\times56}{2\times13}=37.1 \text{ m}$$

Short circuit temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm*²)
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{13.06^2*10^{-6}*5s}}{1}=0.029\ mm^2$$

so our chosen cross-section is sufficient.

According to all three criteria, for the connections between solar grid inverter and Q1/Q2, cable FG70R 2,5 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-001 PV system: general.

Connection of the Blue solar grid inverter output (Q1/Q2) and measuring device

Expected cable length L=0.5 m
Current carrying capacity criteria:
Maximal current that can appear in the cable connecting two inverter's output and measuring device P3 is:
$I_{MAX} = 2*I_{maxout} = 26$ A
According to this, cable with cross section 6 mm² with current capacity 6A/mm² will be appropriate.
Voltage drop
For AC cable, voltage drop is calculated by the following formula:

$$V_{ac}= \frac{2xIx(Rcxcos\varphi+Xcxsin\varphi)xL}{1000}$$

where
V_{dc} is AC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
Rc is the AC resistance of the cable (Ω/km)
Xc is the ac reactance of the cable (Ω/km)
cosφ is the load power factor (pu)
L is the length of the cable (m)

$$V_{ac}= \frac{2x26x(7,41x1)x0.5m}{1000}=0.19 \text{ V}$$

which is for nominal voltage of 230 V less than 3% voltage drop, so 6 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc,mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod}= \frac{6\times 0.03\times 230\times 56}{2\times 26}=44.58 \text{ m}$$

Short-circuit temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm*²)
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{26^2 * 10^{-6} * 5s}}{1}=0.058 \, mm^2$$

so our chosen cross-section is sufficient.
According to all three criteria, for the connections between solar grid inverter output and measuring device P3, cable FG70R 6 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-001 PV system: general.

Connection of Quattro inverter/charger input and circuit breaker Q4
Firstly, it's important to observe Quattro inverter/charger information about AC inputs (solar generator input):

Nominal input power	3000W
Input voltage range	187-265 VAC
Input frequency	45-65 Hz
Power factor	1
Maximum feed through current	50/30 A

Expected cable length between Quattro inverter/charger and circuit breaker Q4 -L= 2 m
Current carrying capacity criteria
Maximal current that can appear in the cable connecting Quattro inverter/charger and circuit breaker Q4 is I_{acinv} =I_{maxin}= 50 A. According to this, cable with cross section 10 mm^2 with current capacity 6A/mm^2 will be appropriate.
Voltage drop
For AC cable, voltage drop is calculated by the following formula:

$$V_{ac}= \frac{2xIx(R_c xcos\varphi+X_c xsin\varphi)xL}{1000}$$

where
V_{dc} is AC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
Rc is the AC resistance of the cable (Ω/km)
Xc is the ac reactance of the cable (Ω/km)
cosφ is the load power factor (pu)
L is the length of the cable (m)

$$V_{ac}= \frac{2x50x(7{,}41x1)x2m}{1000}=1.48 \text{ V}$$

which is for nominal voltage of 230 V less than 3% voltage drop, so 10 mm^2 satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc{,}mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod}= \frac{10\times0.03\times230\times56}{2\times50}=38.64 \text{ m}$$

Short circuit temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm*^{2})
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$$A = \frac{\sqrt{50^2*10^{-6}*5s}}{1}=0.11 \, mm^2$$

so our chosen cross-section is sufficient.

According to all three criteria, for the connection between Quattro input and circuit breaker Q4, cable FG70R 10 mm^2 will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-001 PV system: general.

Connection of the Quattro inverter/charger and battery bank
Firstly, it's important to observe Quattro inverter/charger charging information:

Charge voltage 'absorption'	28.8 VDC
Storage mode	26,4VDC
Charge current	70 A

Expected cable length between Quattro and battery bank -L= 0-5 m

Current carrying capacity criteria:

Maximal current that can appear in the cable connecting Quattro and battery bank is I_{ac} = I_{Bat}=70 A. According to this, DC cable with cross section 70 mm^2 with current capacity 2A/mm^2 will be appropriate.

Voltage drop
For DC cable, voltage drop is calculated by the following formula:

$$V_{dc}= \frac{2xIxRxL}{1000}$$

where
V_{dc} is DC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
R is is DC resistance of the cable (Ω/km), calculated for cable 70 mm^2 and 2 m length

$$R= \frac{\rho x l}{A} = \frac{0.0172x2}{70} = 0.00049\ \Omega;$$

L is the length of the cable (m)

$$V_{dc}= \frac{2x70x0.00049x2}{1000}=0.00014\ \text{V}$$

which is for nominal voltage of 24 V less than 3% voltage drop, so 70 mm^2 satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2\times Lmod\times Isc{,}mod}{\Delta Vmod\times Vsc\times Nmod\times\sigma}$$

$$L_{mod}= \frac{Smin\times\Delta Vmod\times Voc\times Nmod\times\sigma}{2\times Isc.mod} = \frac{70\times 0.03\times 24\times 56}{2\times 70}=20.2\ \text{m}$$

Short circuit temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:

$$A = \frac{\sqrt{i^2 t}}{k}$$

where A is the minimum cross-sectional area of the cable (*mm*^{2})
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)
k is a short circuit temperature rise constant.

$A = \frac{\sqrt{70^2 * 10^{-6} * 5s}}{1}$=*0.16 mm*²
so our chosen cross-section is sufficient.

According to all three criteria, for the connections between Quattro and battery bank, cable FG70R 70 mm² will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-001 PV system: general.

Connection of the Quattro inverter/charger output and electricity meter toward the grid

Expected cable length between Quattro and electricity meter toward the grid -L= 0.5 m

Current carrying capacity criteria

Maximal current that can appear in the cable connecting Quattro output and electric meter toward the grid is $I_{ac} = I_{maxout}$=50 A .
This is the maximal current that can appear in this cable from both directions; from PV system to the grid and from the grid to the Quattro. According to this, AC cable with cross section 10 mm² with current capacity 6A/mm² will be appropriate.
Voltage drop
For AC cable, voltage drop is calculated by the following formula:
$V_{ac} = \frac{2xIx(R_c xcos\varphi + X_c xsin\varphi)xL}{1000}$
where
V_{dc} is AC voltage drop (V);
I is the nominal full load or starting current as applicable (A);
Rc is the AC resistance of the cable (Ω/km)
Xc is the ac reactance of the cable (Ω/km)
cosφ is the load power factor (pu)
L is the length of the cable (m)
$V_{ac} = \frac{2x50x(7{,}41x1)x1m}{1000}$=0.74 V
which is for nominal voltage of 230 V less than 3% voltage drop, so 10 mm² satisfies this criteria.
If we would like to obtain maximal cable length to satisfy voltage drop beneath 3 %, the calculation is as follows:

$$S = \frac{2 \times Lmod \times Isc{,}mod}{\Delta Vmod \times Vsc \times Nmod \times \sigma}$$

$$L_{mod} = \frac{Smin \times \Delta Vmod \times Voc \times Nmod \times \sigma}{2 \times Isc.mod} = \frac{10 \times 0.03 \times 230 \times 56}{2 \times 50} = 38.64 \text{ m}$$

Short Circuit Temperature
The minimum cable size due to short circuit temperature rise is typically calculated with an equation of the form:
$A = \frac{\sqrt{i^2 t}}{k}$
where A is the minimum cross-sectional area of the cable (*mm*²)
i is the prospective short circuit current (A)
t is the duration of the short circuit (s)

k is a short circuit temperature rise constant.

$A = \frac{\sqrt{50^2 * 10^{-6} * 5s}}{1}$=0.11 mm^2

so our chosen cross-section is sufficient.

According to all three criteria, for the connections between Quattro output and electricity meter toward the grid, cable FG70R 10 mm^2 will be installed. This cable is used for nominal voltage 0.6/1 kV, with HEPR/PVC isolation, for indoor and outdoor installation, for outdoor temperatures from -30°C to +90 °C. The cables will be mounted according to the drawing PV-001 PV system: general.

5.3.5.4 Safety and security measures

Protection against short circuit and overload

Protection on the DC side

gPV fuses

According to the standard IEC 60269-6 ed 1.0 (2010-9), for all strings in parallel, gPV fuses are compulsory. In order to define its characteristics (current), the following calculation is made:

Determination of the fuse rated voltage U_N

$$U_{P\,MIN} \geq U_{OC\,ARRAY} \times \left(1 + \left(\Delta\vartheta \times temp.coeff.of\ U_{OC\,ARRAY}\right)\right)$$

$$U_{P\,MIN} \geq (13 \times 22{,}4) \times \left(1 + (50 \times 0{,}0034)\right)$$

$$U_{P\,MIN} \geq 340{,}704$$

$$U_N = 1000\ VDC$$

Determination of the fuse rated current I_N

K_{TH}=0.84 – ambient air temperature of 60°C

A_2=0.9 – alternating load factor for full range fuse

K_{ZS}=1 – derating by high numbers of closed fuse-holders

$$I_{N\,MIN}' = I_{MPP}/K_{TH}/A_2/K_{ZS}$$

$$I_{N\,MIN}' = 5{,}56/0{,}84/0{,}9/1$$

$$I_{N\,MIN}' = 7{,}35\ A$$

Chosen I_N=8 A

$$I_{N\,RED} = I_N \times K_{TH} \times A_2 \times K_{ZS} = 8 \times 0{,}84 \times 0{,}9 \times 1 = 6{,}048\ A$$

Calculation of I_{SC} at 70°C

$$I'_{SC} = I_{SC_{MOD}} \times \left(1 + \left(\Delta\vartheta \times temp.coeff.of\ I_{SC_{STRING}}\right)\right)$$

$$I'_{SC} = 6{,}53 \times \left(1 + (45 \times 0{,}00037)\right)$$

$$I'_{SC} = 6{,}638\ A$$

Allowance for max irradiance to be assumed I_{SC} at 1200 W/m²:

$$I_{SC} = 6{,}638\ \times 1{,}2 = 7{,}966\ A$$

Requirement: $I_N > I_{SC}$

$6{,}048 > 7{,}966$ -> not fulfilled, further iteration step required

Selection of the next higher rated current: I_N=10A

$$I_{N_{RED}} = I_N \times K_{TH} \times A_2 \times K_{ZS} = 10 \times 0{,}84 \times 0{,}9 \times 1 = 7{,}56\ A$$

$7{,}56 > 7{,}966$ -> not fulfilled, further iteration step required

Selection of the next higher rated current: I_N=12A

$$I_{N_{RED}} = I_N \times K_{TH} \times A_2 \times K_{ZS} = 12 \times 0{,}84 \times 0{,}9 \times 1 = 9{,}072\ A$$

$9{,}072 > 7{,}966$ -> fulfilled, no further iteration step required

The fuse rated current chosen is 12A, so 8 Photovoltaik-fuse-characteristic gPV, 10x38, 12A, 1000V will be installed.

Figure 50 – gPV fuse

Fuse F1 on the battery bank (F1)

Maximal current that can appear in the cable connecting Quattro and battery bank is $I_{max}=I_{maxout}$=70 A.

According to the manufacturer recommendations, the DC fuse 300 A should be installed, in order to prevent the damage of the battery.

4.2 Connecting the battery cables

In order to use the full potential of the Quattro, batteries of sufficient capacity and battery cables with the correct cross-section should be used.

See table:

	12/3000/120	24/3000/70	48/3000/35
Recommended battery capacity (Ah)	400–1200	200–700	100–400
Recommended DC fuse	400A	300A	125A
Recommended cross-section (mm2) per + and - connection terminal			
0 – 5 m*	2x 50 mm2	50 mm2	35 mm2
5 -10 m*	2x 70 mm2	2x 50 mm2	2x 35 mm2

Figure 51 – Manufacturer recommendations for connecting battery bank

Protection on the AC side

Circuit-breakers after solar grid inverter (Q1 and Q2)

Maximal current from the solar grid inverter is:

$I_{max}=I_{maxout}=13$ A

so the appropriate circuit breaker for this position is circuit breaker with nominal current 16 A, 1P+N, with short-circuit current capacity 10 kA and C characteristic.

Figure 52 - Circuit breakers Q1 and Q2

Additional characteristics of these circuit breakers can be found in appendix and its position in the PV system can be found in the drawing. PV-001 PV system: general.

Circuit-breaker to the grid (Q3)

Maximal current that can come from the grid or can be delivered to the grid is maximal output current of the Quattro inverter/charger and that is $I_{max}=I_{maxout}=$ 50 A so the circuit breaker appropriate for this position is circuit breaker with nominal current 50 A, 1P+N, with short-circuit current capacity 10 kA and C characteristic.

Circuit-breaker to the house appliances (Q4)

Maximal current that can supply house appliances is defined with maximal possible house load:

$I_{maxload} = \frac{Pmax}{U} = \frac{9\ kW}{230\ V} = 39$ A

Pmax is defined in the section Electrical System Design.

According to the maximal current that can supply appliances, circuit breaker with nominal current 40 A, 1P+N, with short-circuit current 10 kA and C characteristic will be installed.

<u>Protection against electric shock (direct and indirect contact)</u>

There is the risk of direct and accidental contact of the person with active parts of the installation and indirect contact with metallic mass which can get accidentally under the voltage due to the decreased isolation.

In DC grid, the floating generator configuration is a security measure against direct and indirect contacts. It consists of metallic mass of the installation connected to the protection ground, so under normal performance conditions, DC grid is insulated from the ground.

The battery system has a nominal voltage of 24V, so it doesn't need protection against direct or indirect contact. Another protection measure against direct contact will be: isolated wire and covered battery terminals, protected and with restricted access. Complementary protection measure against faults is included in the battery inverter itself.

The battery cell container doesn't have metallic parts, so it is not ground connected.

The DC/AC inverter has some protection elements against DC reverse polarity protection, total discharge protection, AC short-circuit, AC overload, grid monitoring etc.

In AC grid, as a complementary protection, residual current device will be used toward the grid and appliances.

Residual current device toward the grid, RCD2

Maximal current that can come from the grid or can be delivered to the grid is maximal output current of the Quattro inverter/charger and that is:

$I_{max} = I_{maxout} = 50$ A

so nominal current of the RCD will be 63 A.

Leakage current that will be used is $I\Delta n = 300$ mA.

So, for this position (see the drawing PV-001 PV system: general) the RCD 300mA, 63 A will be used.

Figure 53 – RCD 300 mA, 63 A

*R*esidual current device toward house appliances, RCD1

Maximal current that can supply house appliances is defined with maximal possible house load:

$I_{maxload}=\frac{Pmax}{U}=\frac{9\ kW}{230\ V}=39\ A$

so the nominal current of the RCD will be 40 A.

Leakage current that will be used is IΔn=30 mA.

So, for this position (see the drawing PV-001 PV system: general) the RCD 30mA, 40 A will be used.

Breaking and isolation devices

For the emergency and maintenance cut-off of the PV modules, cam switches will be used.

Input values for dimensioning these cam switches are PV modules output current - 13 A for each inverter and output voltage - max 292 V. So for the installation on this position (according to the drawing PV-001 PV system: general) cam switch 0-1/2P/32A/1 kV DC will be used for each pair of strings (S1 and S2).

Figure 54 – Cam switch 0-1/2P/32A/1 kV DC

For the emergency and maintenance cut-off of the battery bank, cam switch will be used. Input values for dimensioning this cam switch is battery input current, 70A, and battery voltage 24 V DC. Since the battery fuse, according to the manufacturer recommendations is 300 A, cam switch 2 kA, 80 VDC will be installed.

In the case of Quattro inverter/electrical grid fault or any other fault in the PV system, there is possibility of supplying the house directly from the grid without including any part of the PV system. To ensure that possibility, rotary cam switch S4 with 3 positions 80 A and 4 contacts.

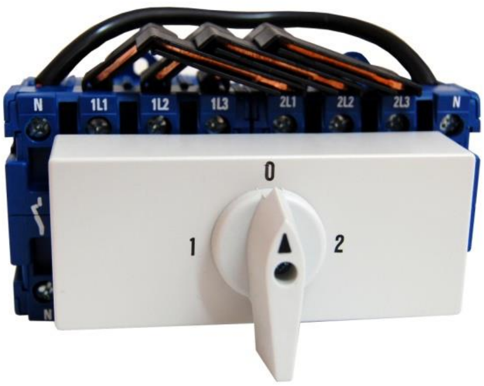


Figure 55 – Cam switch, 3 positions, 80 A

Protection against electromagnetic interference in buildings

The overvoltage in the house grid is mostly caused by the lighting or by the grid itself (connection and disconnection of switched, short-circuits etc.). To avoid overvoltage we will use equipotential connection and installation of voltage surge arresters.

We will use two voltage surge arresters before the inverter and two after the inverter. They will be connected to the ground electrode.

Surge arrester on DC side

For protection of PV system from lighting and overvoltage, surge arresters on the DC side should be used. Appropriate protection should include protection against direct and indirect lighting contact and overvoltage. In our system, Vartec surge arrester will be installed. This is special series of surge arresters, produced by Schrack Technick, type T1+T2. These surge arresters are tested and certificated according to IEC/EN 61643. Since maximal voltage from each pair of strings is 292 V, surge arresters 550 VDC will be used. Surge arresters will be connected with the FG07R 6 mm^2 cable that is used in that part of the system (see calculation in the sub-section above). With the 16 mm^2 cross-section cable it will be connected to the earthing busbar. They will be installed according to the drawing PV-001 PV system: general.

Surge arrester on AC side

For the protection of the whole electrical system in the house, there should be installed surge arrester on the line coming from the grid to the house. Since our system is adjusted to the TT distribution earthing system, it is necessary to choose surge arrester that will be compatible with this system. In this system Powertec surge arrester, manufactured by Schrack Technik will be used. The serial combination of two surge arresters will be used; RV1 which is surge arrester 25 kA, T1/T2 and RV2 50 kA. For optimal operation of these two surge arresters, fuse F11, 63 A will be installed. This fuse will prevent response of surge arresters on minor faults. Surge arresters will be connected with the FG07R 16 mm^2 cable that is used in that part of the system (see calculation in the sub-section above). With the 16 mm^2 cross-section cable it will be connected to the earthing busbar. They will be installed according to the drawing PV-001 PV system: general.

<u>Earthing</u>

Concerning the safety aspects of PV system installation, both DC and AC parts have conductive metal works which may be accessible to people.

A TT connection scheme will be used, as prescribed by the SDE 2014 Rules. In this connection scheme, the neutral conductor of the installation and the metal works will be grounded independently, directly and without protection elements.

We will use the earth electrode in order to prevent these metal works from causing electric shocks to person so all the metal works of the PV installation must be connected to the earth electrode. This way, if insulation fault appears, the earth electrode would play the role of drain that avoids the risk of electric shock. Earth electrode will be installed in the depth according to the type of the soil and value of the earth resistance.

Figure 56 – Earth electrode

In order to connect all metal parts to the earth electrode, copper cable with the cross section 16 mm^2 will be used. It includes the metallic parts of the PV modules and their structure, metallic parts of inverters and battery chargers, DC voltage surge arresters, AC voltage surge arresters.

One of the terminals of the surge arresters will be also connected to the earth electrode, avoiding the overcurrent carried through them. All the metal works and the earth electrode will be easily visible and accessible in order to check system safety.

The complete location and design of the AC and DC conductors grounding is shown in the drawing PV-031 Photovoltaic system: Grounding system.

5.3.5.5 Maintenance plan

PV modules

Installing - work on location

Potential hazards

Installing a PV system is a combination of risks which the installer is facing during installation and construction work. This includes physical work, work at height and electrical shock risk. European and national requirements for safe operation in the workplace are available at www.hse.gov.uk and http://osha.europa.eu.

It should be noted that due to frequent changes in the installation of PV systems list of the information and guidance is not final and that their use has no legal grounds and responsibilities.

The importance of risk assessment

Before using practical information it is very important to make a good assessment of the risks in the workplace. Such an assessment should consider all risks in order to avoid exposure to injury in the workplace. Below is a simple description of the risk assessment procedure: "A risk assessment is nothing more than a careful consideration of all steps in the job that may lead to injury or illness of employees with a description of the steps that must be made to reduce that risk or completely eliminate it. The result of systematic implementation of risk assessment is the nomination of the most appropriate measure that the user must take. "

Security work with electrical installations

Working with circuits

The prevention of all types of injuries related to electric shock is a basic safety measure. Further to the above, check the following:

- Always disconnect the power supply circuits.
- Disconnected circuit is generally harmless - CAUTION! - Lots of accidents happened with disconnected circuits as a result of irregularities. Careful work with disconnected circuits is mandatory.
- Use a voltage tester or other type of device as a safety measure.
- Use the main switch / circuit breaker rules and locking systems.
- Locking systems rules are used for systems where the main switch locks physically.
- Lock all the circuits that can be activated during operation.

The electric part of the PV system

Electricians are generally familiar with the power of classical systems. However, in PV systems there are two power sources - from the grid and from the PV system. Ending the main supply does not interrupt the PV side. Electricians also need to separate two systems in order to have a safe operation. With the least sun, FN side can cause electric shock or sparks may fall off a roof or ladder and injuries of a serious nature. The following precautions must be followed when working with PV circuits:

1) Follow the procedure outlined in the previous section - notice that PV systems have large capacitors that may remain charged after disconnecting circuit - always follow the manufacturer's instructions and specific information on the operation and safety.
2) The only safe method is to eliminate the primary energy source - the sun. If needed, should be covered with opaque coating to prevent electricity generation.

3) Even small amounts of light can produce energy - voltage may be present in low -light. Although it is not sufficient for the inverter, it can certainly hurt the electrician - not directly with electricity attack, but from falling off a roof or ladder. Before starting work with PV array, electricity supply should be disconnected with the DC disconnection switch. The circuit should be designated and locked according to the procedure.
4) Systems connected to the network have two energy sources – it is necessary to turn off the main circuit. The switch does not necessarily disconnect the PV field - although the inverter is off. Wires with FN sides remain energized and received little illumination. Disconnection switches can isolate the PV system but do not rule out the entire power system. It should be remembered that if the DC switch is in the ON position, it might be possible that the line from the PV field may still have potential. This is the same as the grid potential when the main switch is turned on - the risk is equal on both sides. Small PV system can have a DC voltage on the terminals that is greater than 600 V.
5) The risk of sparking arises when changing or adding modules - NEVER connect / disconnect system or part of the system under load. When added modules spark or an electric arc is created, they can be so strong to cause major burns or destabilize the installer resulting in a fall from the roof and serious consequences. Always keep an open circuit using a DC switch. Before working always use a voltage tester or related equipment to establish the status of the PV system.

NEVER disconnect the PV module connectors or other wiring if the PV field is connected to the load.

- When adding or modifying a series of PV modules, if the circuit is not interrupted and if a string is under voltage, there is danger of starting an electric arc. The strength of the electric arc is enough to cause burns, as well as current or permanent loss of vision.
- It is required to turn off the DC switch when working on the PV system.

Use a current clamp to check the installation before work.

Security measures working at height

The law does not recognize elimination of all risks, but they boil down to "reasonably practical" measures. If work at height must be inevitable:

- Use an existing safe place to work
- Use work equipment to prevent falls, such as mobile platforms, scaffolding, ropes, etc.
- Minimize the distance from the consequence of the fall - for example, using the appropriate ladder, a short time working in the risk zone, etc.

Safety equipment

The purpose of personal protective equipment is to protect workers from the risk of injury by creating a protective barrier of job risk.

Personal protective equipment includes the following:

- Face and eyes protection (glasses, shades, visors, etc.)
- Head protection - (helmets, caps, etc.).

This type of protection is mandatory in the case of fulfilling opportunities objects falling from heights or work at height:

- Protecting the extremities - gloves, shoes, knee protection, etc.)
- Respiratory protection (respirators, masks, etc.). This protection is particularly important if a worker is in contact with asbestos or paint
- Hearing protection (ear protection, earplugs, etc.)
- Protective clothing

Fire protection

PV systems installation in the building may have an impact on fire safety:

- In the case of the roof assembly, the PV system needs to be placed above the flame-retardant cover which is suitable for application
- Do not install a PV system near risky locations with flammable gases.
- In the event of a fire in the building PV modules can produce dangerous DC voltage even in case of:
- Low-intensity illumination - when the modules are disconnected from the inverter
- The modules are partly destroyed
- Wiring which is partially damaged during and after the fire should stay away from elements of the PV system and inform the fire department about potential risks.

Other risks:

- The glass surface of the roof or facade PV modules are made of solid glass. This means that in case of a fall it will not break into small pieces, but will fall in one piece which is a threat.
- The edges of the PV modules can be very sharp
- PV modules generate electricity with minimal light and cannot be quenched. This means that work on electrical circuits often means under voltage work.
- When connecting the conductor, it should bear in mind that the PV modules produce DC voltage and the DC arc short circuit greater length and lasts until the power supply is interrupted.
- Short-circuit and other failures is slightly larger than usual and fuses and switches often cannot provide adequate protection.
- PV installation can develop lethal DC voltage if not properly grounded
- PV systems are called low even though they generate up to 1500 V. About 20 V is enough for a risk of injury.
- The risk of injury is greater as the installation is more damaged
- To maximize productivity, the PV modules are installed on untreated surfaces. Rain and wind can significantly increase the risk during installation and maintenance
- Parts of the system may have a temperature greater than 80°C.
- The surfaces of PV modules can reflect significant amounts of sunlight, which can be the cause of visual impairment.

After selecting the appropriate components for photovoltaic systems, it is important that they are installed in accordance with manufacturer's recommendations, particularly with regard to the necessary fixings, ventilation, temperature range and security. Failure to follow proper operating conditions can lead to poorer system performance, shorter life span, and in some cases affect the final cost-effectiveness of building a photovoltaic system. Attention should be paid to reducing the length of the cable and, in particular, properly executed and protected compounds. Poor connections do not affect the initial performance of the system, but over time have become increasingly influential, either to generate electricity, or the occurrence of failures.

Production losses due to poor connections can be significant, and for their recognition and detection takes time, especially if you are within the PV field. It is much better and easier to perform high-quality compounds in the phase of the installation, than to find and correct malfunctions and defects during system operation. Excess cable should be avoided wherever possible. Where needed a small surplus, the excess shouldn't be rolled, such as performance dissipating reduces heat in the environment, which may lead to the creation of inductive voltage spikes, which are passed on to a series, the photovoltaic field and exchanger. Although it may not directly affect the initial level of system performance, the quality of the physical installation of the system, particularly the photovoltaic field, can affect the long-term effectiveness of the system and the costs associated with it. Poor fixing component fields can cause damage over a number of adverse weather conditions, which will result in a loss of power, and repairing or replacing damaged parts. This failure could lead to damage to other parts of the roof, and impair water tightness of the roof.

The sequence of works

The installer should follow the sequence of work, and the start of the planning and procurement of all necessary materials, tools and ensuring a sufficient number of personnel for proper installation. The process of installing the site consists of the following steps

1. Setting girders and substructure
2. Setting up of photovoltaic modules
3. Connecting the photovoltaic modules
4. Set the connection and junction boxes
5. Set the channel and cable
6. Connecting components
7. Commissioning and testing systems

Tools and Equipment

Tools and equipment that the installer of photovoltaic systems uses in this paper are not significantly different from those used by licensed electricians. In any case, it is necessary to strictly follow the relevant local legislation. All necessary components for installation on roofs and facades of buildings, as well as all the necessary safety equipment must be available to the installer, who is trained for their use. It is advisable to have access to tools and machinery necessary for the transmission and raise photovoltaic modules and other materials on roofs, so that no unnecessary physical burden is put on the installers. Finally, installer should have a compass and inclinometer for the correct positioning of photovoltaic modules.

Installation of electrical equipment

Installing the grounding system

Linking parts of a PV system with grounding affects:

- risk of electric shock to people in the vicinity of the plant,
- risk of fire under fault conditions,
- transfer induced surges
- electromagnetic interference

Properly performed grounding is an important element of security for the proper installation of the PV system. If the maximum system voltage is greater than 50V, it is usually necessary to ground the conductive parts of the system. The key is to use the "photovoltaic cable" or "photovoltaic guide" that meets the requirements for grounding the unearthed network wiring. A variety of manufacturers offer modules with excerpts from these kinds of guides. Two design types of circuit to ground to consider:

- grounding of exposed conductive parts (e.g. frame modules)
- system Grounding - one of the outputs of the photovoltaic field is connected to ground.

In normal conditions, the fixing of photovoltaic modules on the mounting substructure takes place in two stages: setting up modules in the proposed formation and physical attachment to the structure.

Mechanically connecting the modules involves contact between two different metals (aluminum and steel frame modules in connectors), which entails a risk of electric shock. To prevent contact between the two metals, it is possible to use insulating materials such as nylon or rubber. This ensures the proper installation and seating area frames and avoids possible damage to the module (such as damage due to overuse of glass). Setting module should be designed in such a way as to prevent any damage, such as leaning module to loose elements (such as e.g. Packaging Module) and the storage module to a desk or similar element. Once the modules are arranged in a regular schedule, they need to consolidate within the supporting structure. This task should be performed using a sufficient number of operators without proper mechanical devices such as cranes, pulleys, etc., especially when the system is installed at a considerable height from the ground.

Electrical connection of PV modules

After the mechanical installation and fixing the module, they must be electrically connected. The main objective of preparing components for electrical installation is preparing terminal modules, and the positive and negative terminals, which defines the main circuit of PV string / field. Voltage and current at these terminals will depend on the current radiation exposure, and should be determined during the design phase.

To avoid potential errors when connecting modules, especially when there are more strings of modules which are connected in a parallel, it is necessary to use technical drawings and consider the position, label and module performance. Connecting the modules needs to be done via the existing connectors, connected to the terminal box modules. The most commonly used connectors look like plastic tubes, and are flexible.

Parallel connection

Combining several modules in parallel is increasing the power of such a compound. All components connected in a parallel must have the same characteristics, and it is necessary to carefully select, based on their tolerance. Since the output current of this compounds as many times as big as the number of connected modules, it is necessary to dimension the outgoing circuit to the increased current.

Serial connection

By connecting several serial modules higher output voltage is achieved, while the current of this compound remains the same as for one module. It is vital that a number of modules in series are identical, to have the same current- voltage characteristic. Photovoltaic modules can be selected according to their tolerances. Since the output current remains the same as in a single module, it is necessary to increase the cross section, but it is necessary to select lines of sufficient rated voltage.

Cables

Cables used in photovoltaic installations, as well as all other electrical installations, must have a sufficient cross section and be properly sized to avoid warming and higher voltage drops (losses) in the lines. Guides used in the DC area divorce must be Class II (double insulated). Installer to use cables RZ1 (insulation performed interlaced polyethylene), designed for operating in the temperature range of 90 ° C or higher, and the voltages between 750V and 1000 V.

Guides used in the AC of the divorce must correspond to the electrical installation regulations on low voltage.

Batteries

A battery bank is a group of batteries wired together using series and/or parallel wiring.

A series connection is made by connecting one pair of opposite terminals of different batteries together (i.e. positive to negative). This increases the total voltage (the voltages of the two or more batteries are simply added together) while keeping the amperage capacity the same as just one of the batteries that are wired in series.

A parallel connection is made by connecting terminals of two or more batteries together (i.e. positive to positive and negative to negative). This increases the amperage of the circuit (the Ah capacities of the batteries are simply added together) while keeping the total voltage the same as one of the batteries in that bank.

The battery bank in the photovoltaic system of Mem**brain** is made of two equal sealed Gel Deep Cycle Valve Regulated Lead Acid batteries 12V/2200 Ah C20, where batteries are wired into series strings. String has a voltage of 24 V (12 V x 2) and 220 Ah. In total the capacity of the entire bank reaches 24VX220 Ah which equals the power of 5280 W.

The same voltage drops must be realized from each string to end connector regardless if a string consists of one unit or several unit. This is achieved by proper choice of cable lengths and cable diameters. The connector cables for positive and negative terminals of each battery string have the same length. The minimum cable size for the end connectors of a string is 25mm²/100 Ah string capacity and the end-connector must be placed on a copper bar with at least 100mm²/100 Ah string capacity with the lowest possible distance. Each string contains appropriate fuse and positive pole of the battery bank is connected to appropriate circuit breaker.

Gel Valve Regulated Lead Acid batteries do not require ventilation and can be mounted in any orientation. It is very important that the battery racks are stable and horizontal. Air safety distance of at least 10 mm between insulated cables and electrically conductive parts must be kept. Also, the battery bank must be protected against any overheating risk induced by direct exposure to the sun radiation or by their amplification through glass walls.

The battery cell container does not have metallic parts, so there is no need for grounding.

For more information about batteries please see sub-section 5.3.5.3. For better understanding battery bank connection please see PV-015 DC circuit: Battery connections.

5.3.5.6 Maintenance plan

<u>PV modules</u>

PV system requires little maintenance. It is recommended to check the status of the modules at least once each six months. However, if the system output drops at any time during sun hours, a check should be performed to remove any dust, tree leaves or other dirt from the modules.

To clean the modules, the maintenance agent can simply use a ladder and climb safely up the roof. Once up, the agent can use water and a non-abrasive detergent to wash them.

The visual inspection also includes checking possible broken glass. Then those broken glass should be replaced.

<u>Solar grid inverter and Quattro inverter/charger</u>

The inverters should be checked every three months for any visual signs of external damage. The status indicators can be cleaned also with a cloth. In case of any inverter shutdown, the module branch belonging to that inverter should be checked and cleaned to remove shadowing and a reset should be done on the inverter.

The housing has to be mechanically sound. In case of damage (cracks, holes, missing covers) that endanger the operating safety, the device needs to be immediately deactivated. Larger particles of dirt are removed from the device with a soft brush while dust is removed with a damp cloth. Depending on the ambient conditions it is necessary to clean the fans only at a standstill either with a vacuum cleaner or a soft brush. The control elements can also be cleaned with soft, damp cloth without the usage of solvents, abrasives or corrosive liquids. It’s important to regularly check whether error messages are present.

Batteries

Type of batteries integrated in the Membrain PV system do not need water replacement and no residues of electrolytes appear in the battery contacts. That is the reason why they were called maintenance-free. Pressure valves are used for sealing and cannot be opened without destruction. Therefore, they are defined as “Valve-Regulated” lead-acid batteries (VRLA-batteries).

To ensure the reliability and longevity of the battery bank, regular maintenance is required.

Work to be performed every six months

Take the following measurements and record the measurement values:

- Voltage of the complete battery bank.
- Voltage of a few selected batteries in the battery bank.
- Surface temperature of a few selected battery in the battery bank.
- Temperature in battery room.

If the battery voltage deviates from the average float charge voltage by more than +1.2 V/battery or -0.6 V/battery and/or if the surface temperature of selected battery in battery bank differs by more than 5 °C, contact customer service.

Work to be performed annually

Take the following measurements and record the measurement values:

- Voltage of the complete battery bank.
- Individual voltage of all batteries in the battery bank.
- Surface temperature of all batteries in the battery bank.
- Temperature in battery room.
- Perform a visual check of all screwed connectors.
- Check all screwed connectors to make sure that they are firmly secured.
- Visual check of battery racks or battery cabinets.
- Check to make sure that the battery room is properly ventilated.

Cleaning of the battery

Cleaning the batteries on a regular basis is necessary to maintain battery availability and to meet accident prevention regulations.

Before cleaning is carried out, each component of the system should be isolated. This would involve switching off circuit breakers to and from the battery bank.

While cleaning the batteries you must wear safety goggles and safety clothes.

Plastic battery components must be only cleaned with pure water. After cleaning the battery surface has to be dried with appropriate measures, like antistatic cleaning cloth (e.g. cotton).

Batteries should be cleaned at least once per year.

Wiring and protections

An inspection should be taken every six months. Following should be checked:

- terminals; check if they are loose, overheated or burned out. If any wire is burned it should be replaced
- the wiring skin; to detect any possible defects and to be fixed with self-adhesive tape
- oxidation in welding and circuits of PV modules (caused by the entrance of humidity across the enclosures)
- the connecting pin wiring of the PV modules to check for failures in pressure
- the connection between the other equipment, checking power values
- the sealing of the PV modules, to replace any affected elements, avoiding future malfunctions
- the protection equipment, including all the relays, following the instructions of the manufacturer

In case of any inconvenience or doubt, the manufacturer's datasheet should be checked for further instructions concerning the maintenance.

5.3.6 Electrical Energy Balance Simulation

5.3.6.1 Electrical PV generation

Concerning the Energy balance which corresponds to the grid connected photovoltaic system that is going to be integrated in the house; the main characteristics are the following:

Final power of the system: 5 kW

Final power of the inverter: 5.6 kW

To develop the production energy balance, the analytical method has been and will be used. This method is based on ambient temperature and irradiance data for two locations that our system has been designed, Zagreb and Paris. Since Mem**brain** PV system is designed in the shape of the furling panels i.e. the one-axis tracker that will change its tilt daily in the north-south direction.

Firstly, optimal tilt for two geographical locations, Zagreb and Paris, should be calculated, according to irradiance data that we have collected. Following figures present irradiation in Paris for January and July.

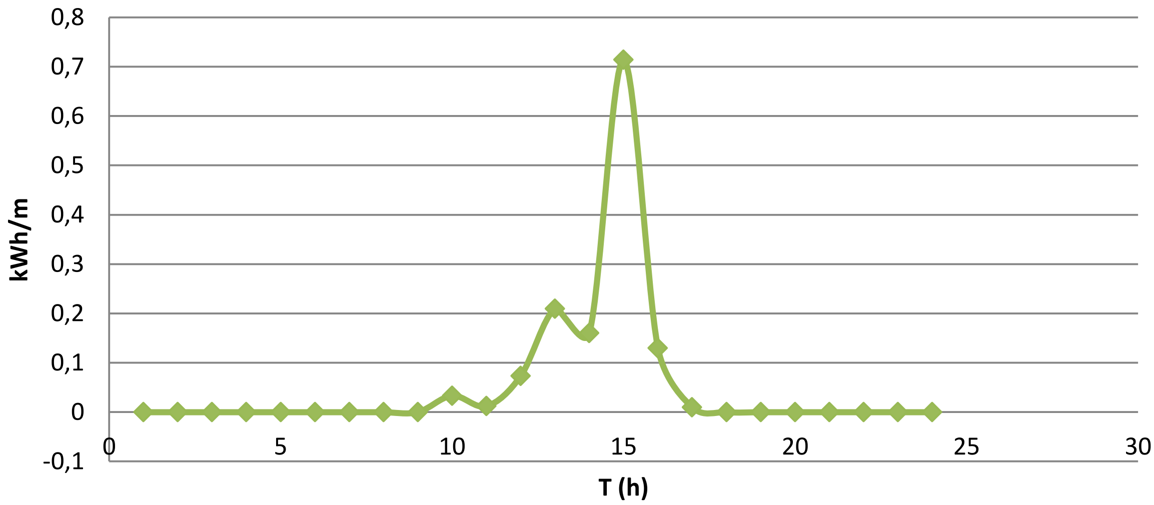


Figure 57 - Irradiation in Paris in January

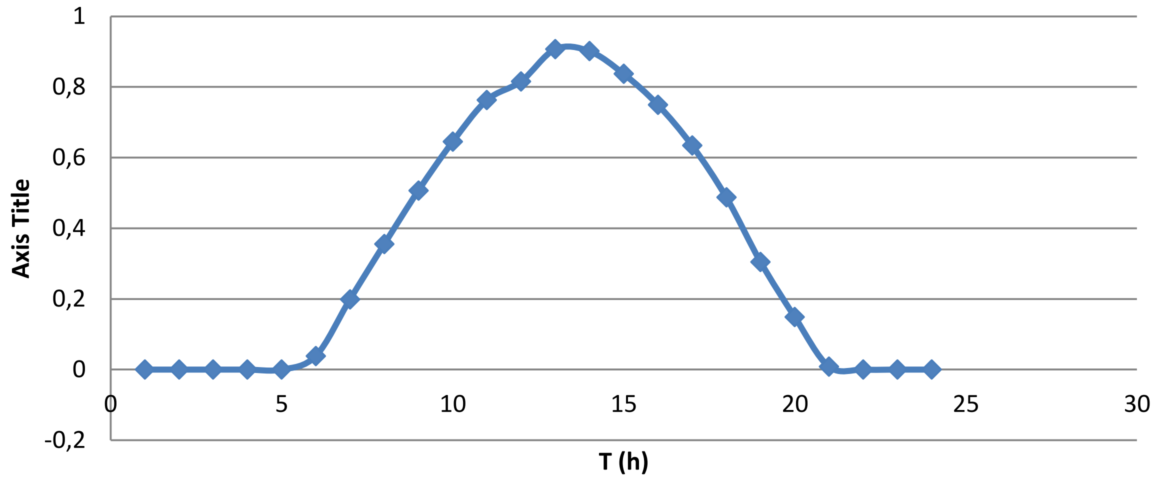


Figure 58 – Irradiation in Paris in July

According to the information about the irradiation in Paris for each month, we calculated the maximum power that can be generated by this system and optimal tilt of PV modules working under these operation conditions. For this calculation we have used PV Sol software. The following figures show optimal tilt of PV modules for two seasons.

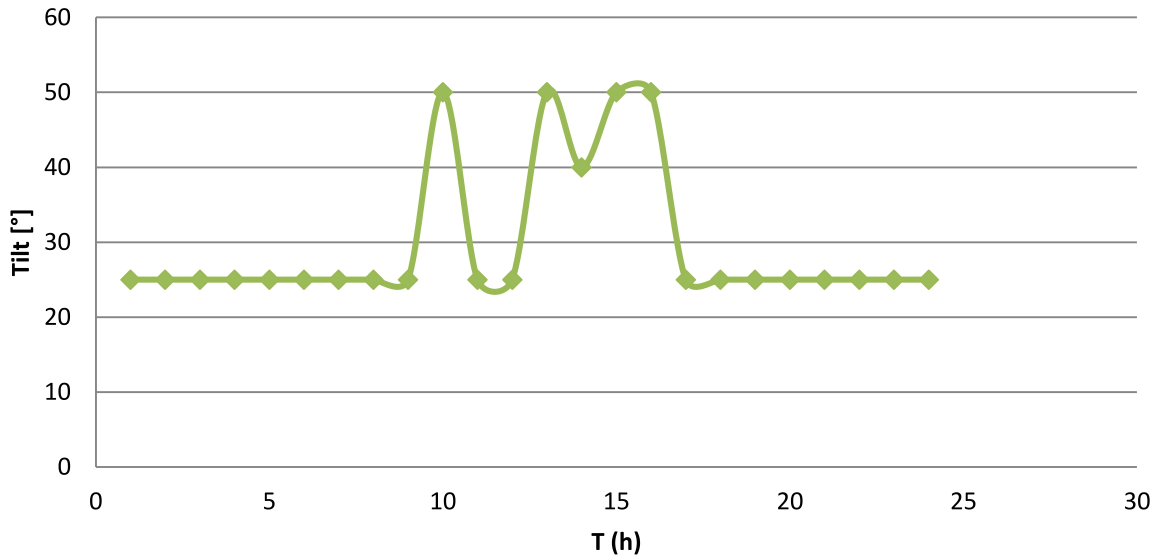


Figure 59 – Optimal tilt of PV modules in winter season

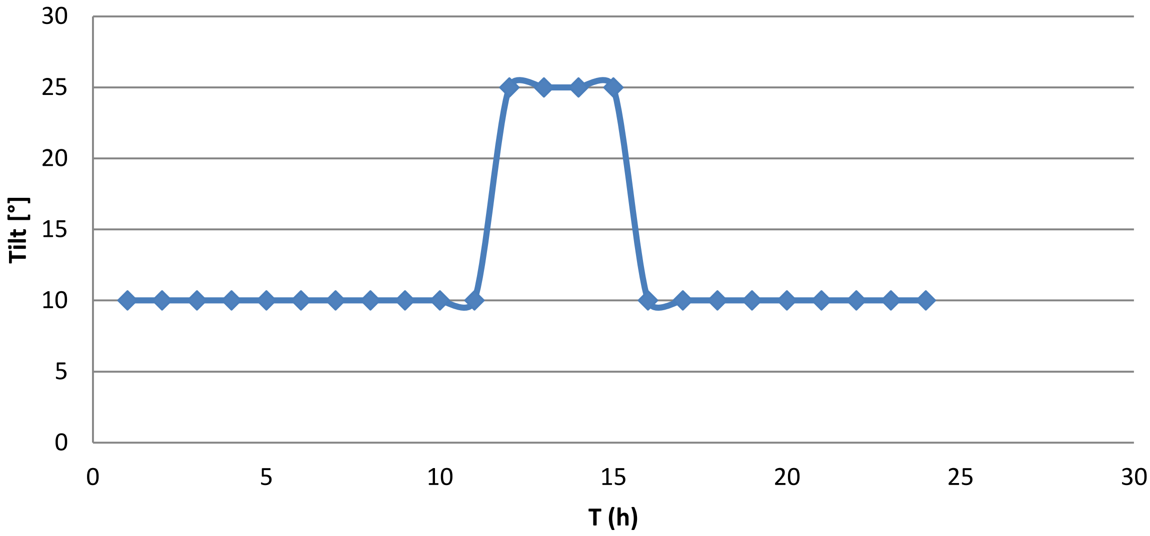


Figure 60 – Optimal tilt angle of PV modules in summer season

In winter, when the sun is low in relation to the Earth, furling panels will collect (furl) and their optimal angle to the Sun will be between 20° and 50° depending on the location and mechanical strength. In summer, when the Sun is high in relation to the Earth, furling panels will stretch (extend) to achieve almost a right angle to the Sun and additionally to get protection from the Sun in the form of shelter. The optimal angle in the summer will be between 10° and 25°. This way we can increase production throughout the year depending on the position of the Sun.

5.3.6.2 Results of the PV production simulation

In order to obtain as accurate and qualitative results of the PV production simulation, advanced algorithm[1] has been used, which has been developed by researchers at the University of Zagreb. In cooperation with them, this algorithm is used to obtain a forecast of production of our PV system and to be able to predict the optimum tilt angle for a particular month.

The model is predictive control algorithm for photovoltaic panel orientation with the aim to maximize the photovoltaic system net power production. Thereby we take into account local weather forecast with its uncertainty, thermal behaviour of the panel, and the positioning system energy consumption with its technical constraints. The model predictive control synthesis procedure comprises two basic steps: identification of solar irradiance model and development of the photovoltaic system model and development of predictive control algorithm for the photovoltaic panel active surface orientation, based on the obtained models. Performance of the developed algorithm is verified through year-scale simulations based on a large number of solar irradiance and other weather data patterns. It turns out that the proposed algorithm is fully competitive with the mostly used sun tracking or maximum irradiance seeking controls, and that it outperforms them. The other advantages of the proposed algorithm are: the positioning system is controlled smoothly and prediction of energy yield one day ahead is available together with its uncertainty for easier photovoltaic system integration into the electricity distribution network. For more details

[1] M. V. N. P. Marko Gulin, »Dynamical optimal positioning of a photovoltaic panel in all weather conditions,« *Applied Energy,* vol. 108, pp. 429-438, 2013

about proposed algorithm, see the article Gulin, Vašak, Perić: Dynamical optimal positioning of a photovoltaic panel in all weather conditions, Applied energy, August 2013.

Results for annual production prediction

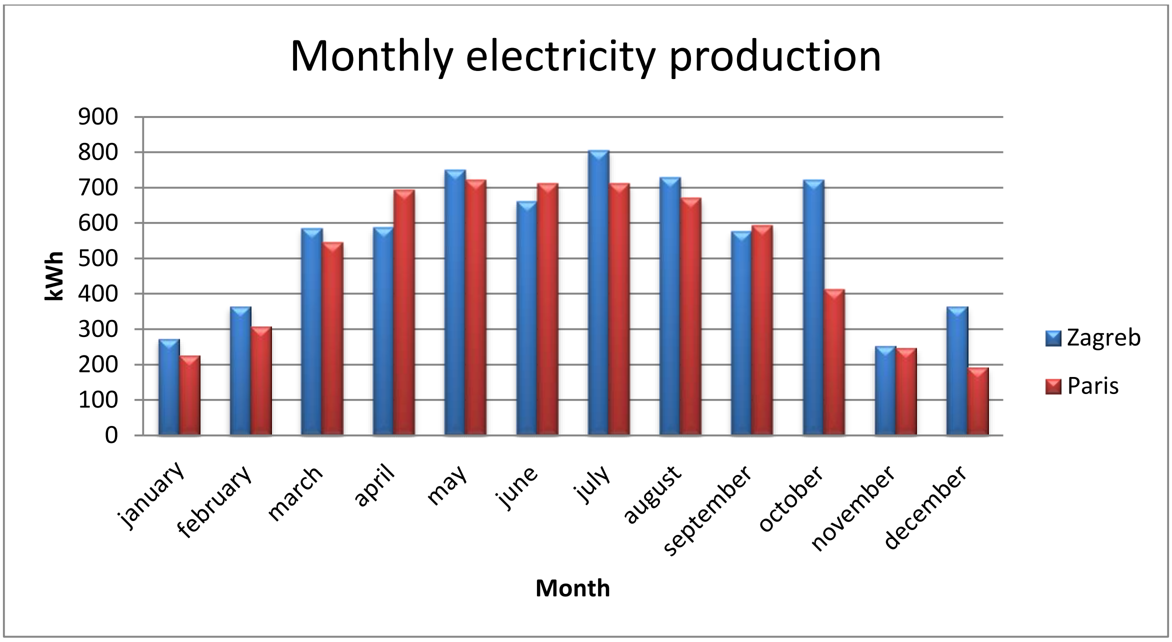


Figure 61 – Annual electricity production with fixed angle

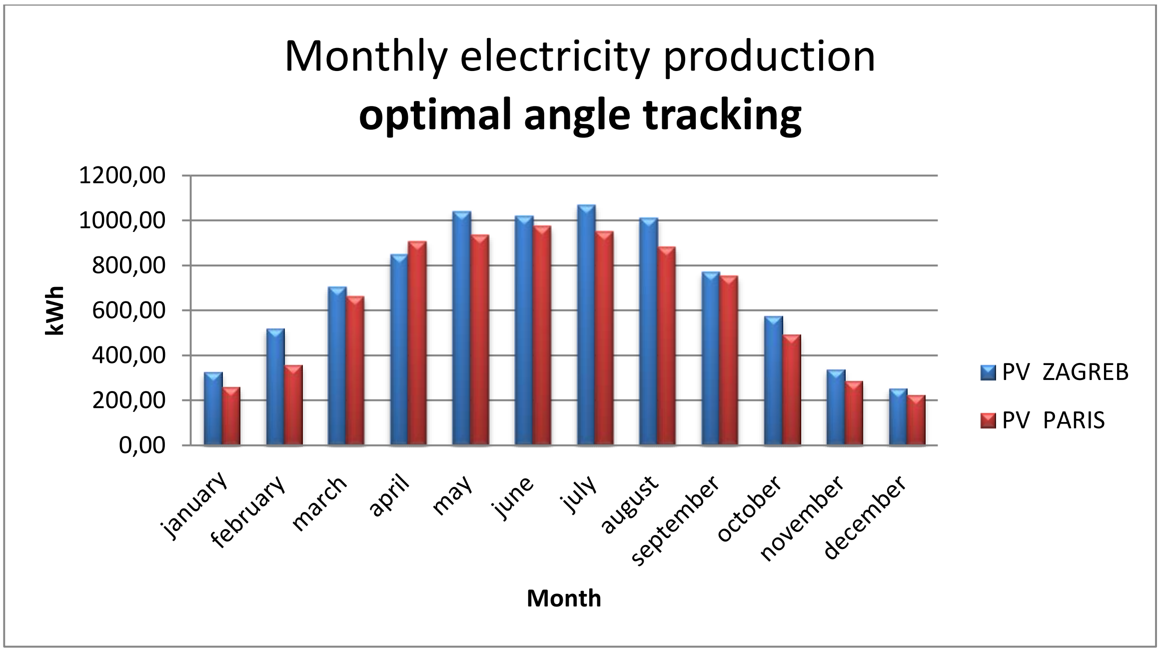


Figure 62 – Annual production with optimal angle

Results for weekly production prediction

Simulation of the production for the competition week is presented below:

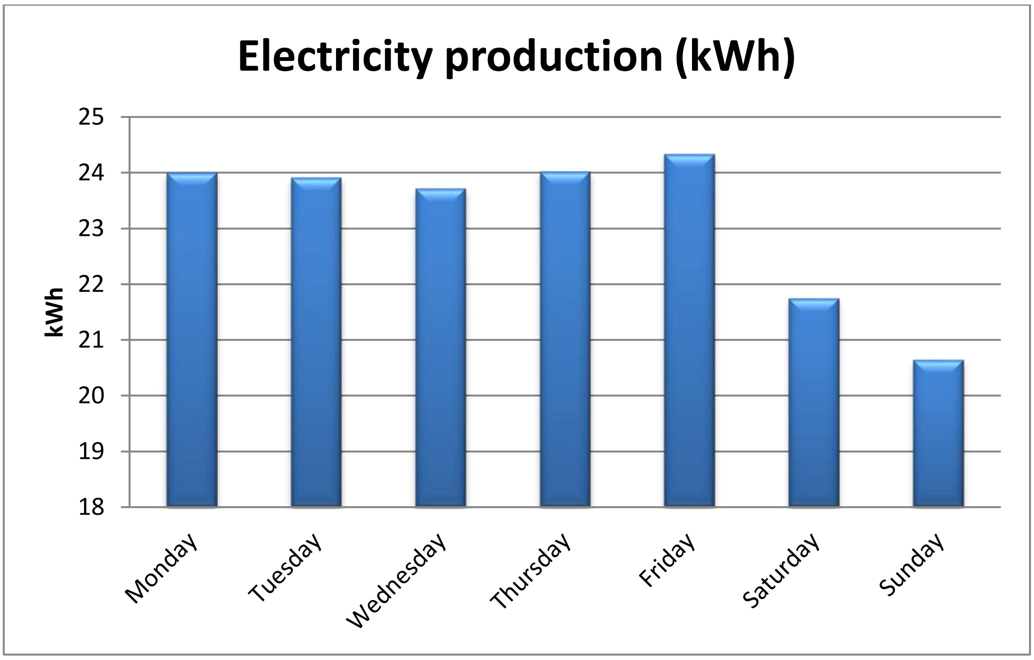


Figure 63 – Weekly production with optimal angle

Results for daily production prediction

For characteristic week day in the summer season (13.06.)

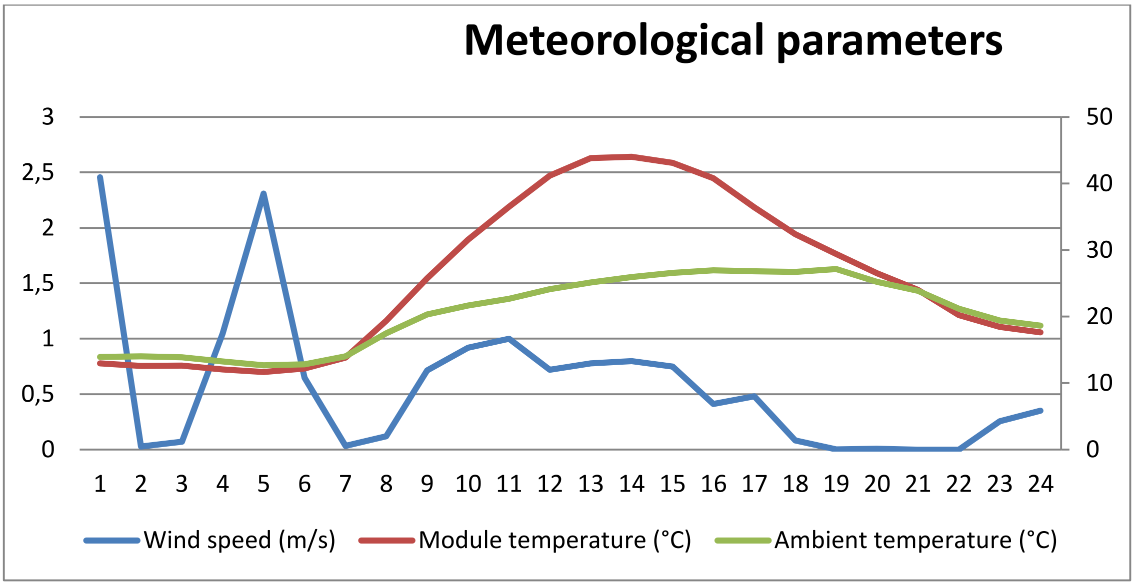


Figure 64 – Meteorological parameters

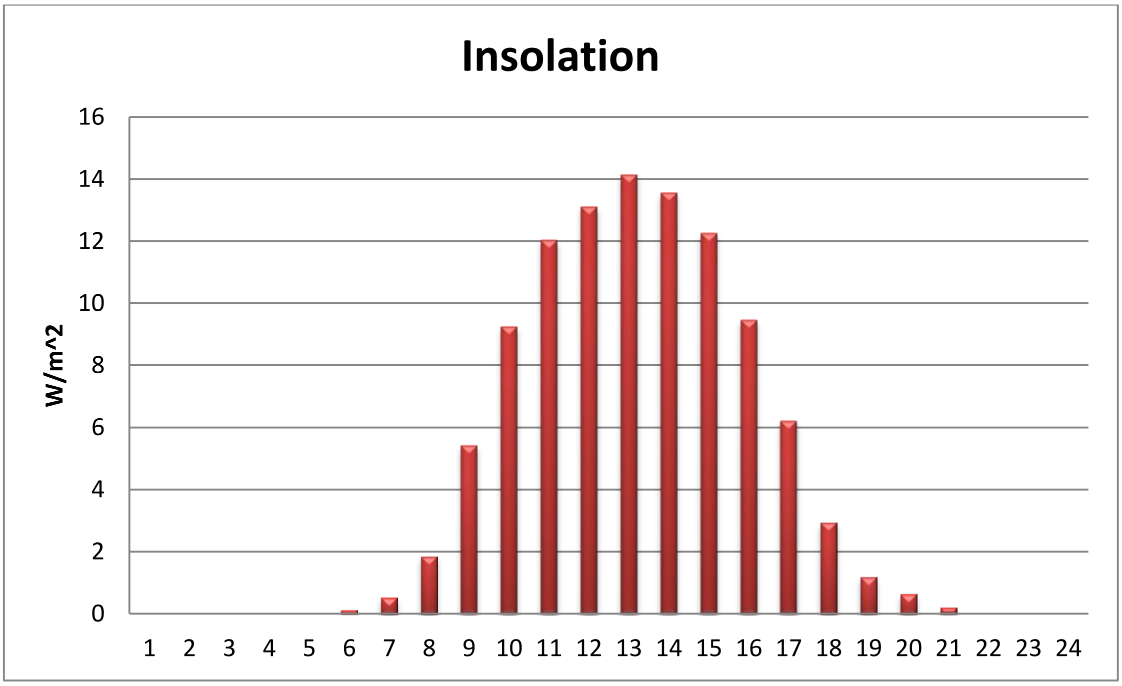


Figure 65 – Insolation

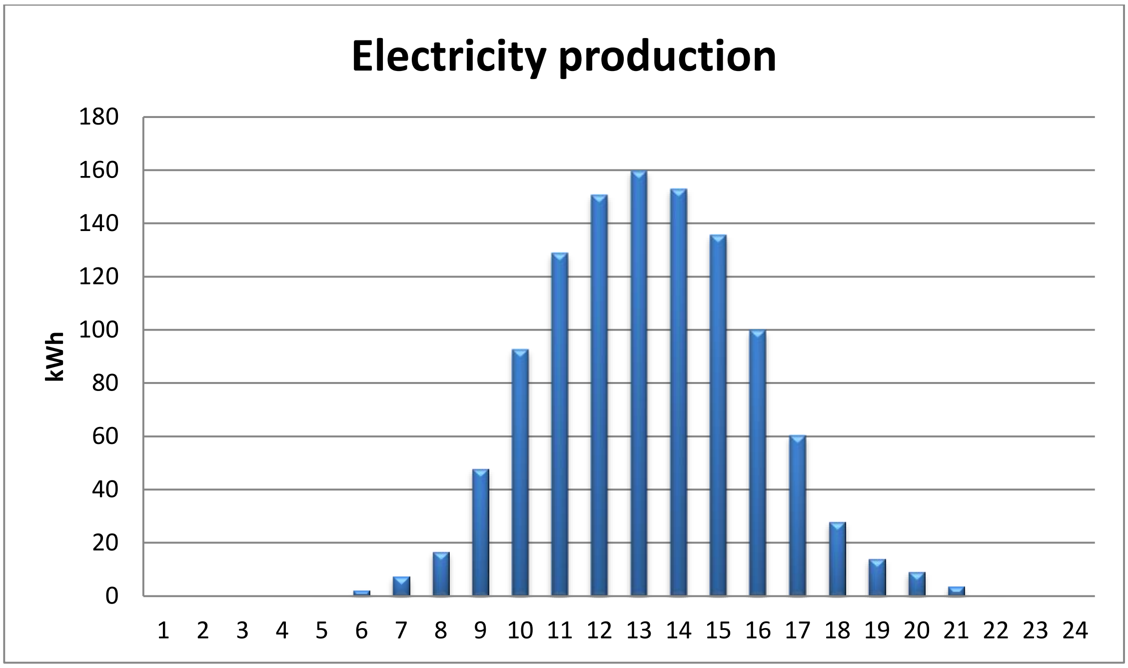


Figure 66 – Electricity production

For characteristic weekend day in summer season (15.06.)

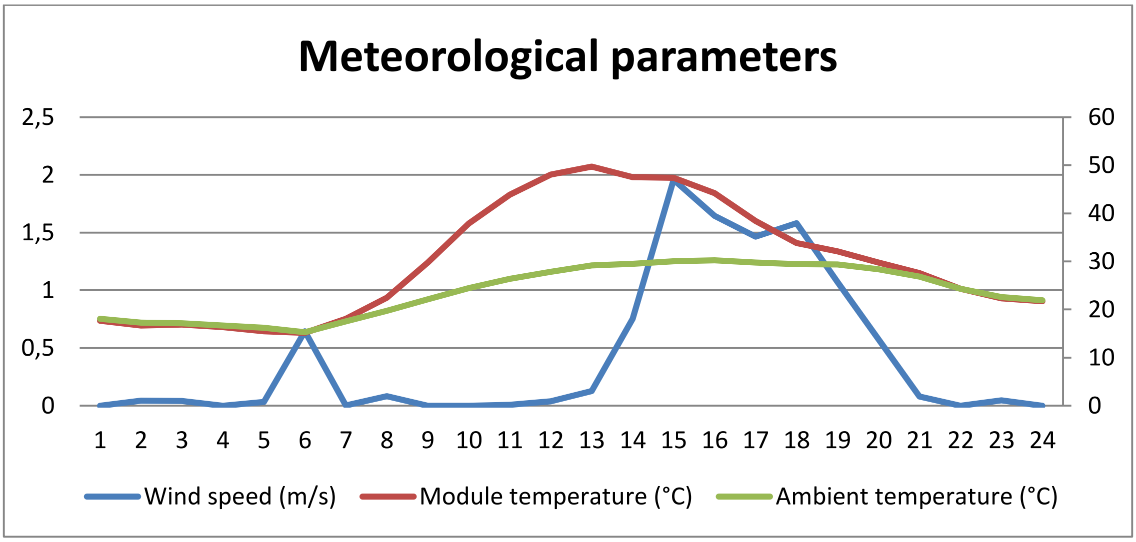


Figure 67 – Meteorological parameters

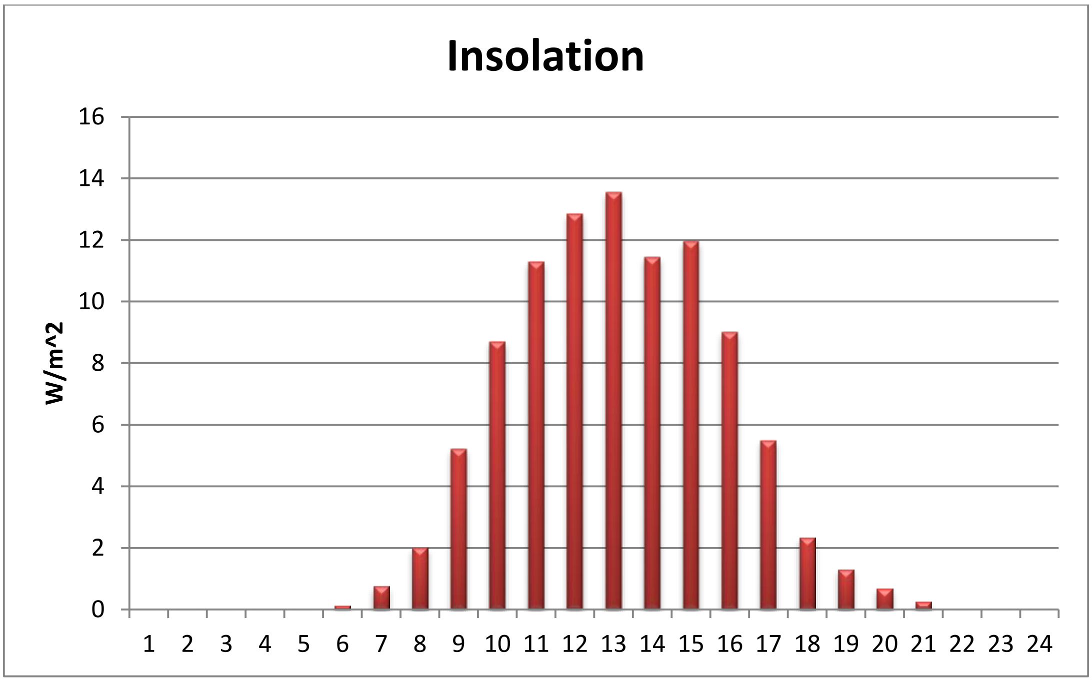


Figure 68 – Insolation

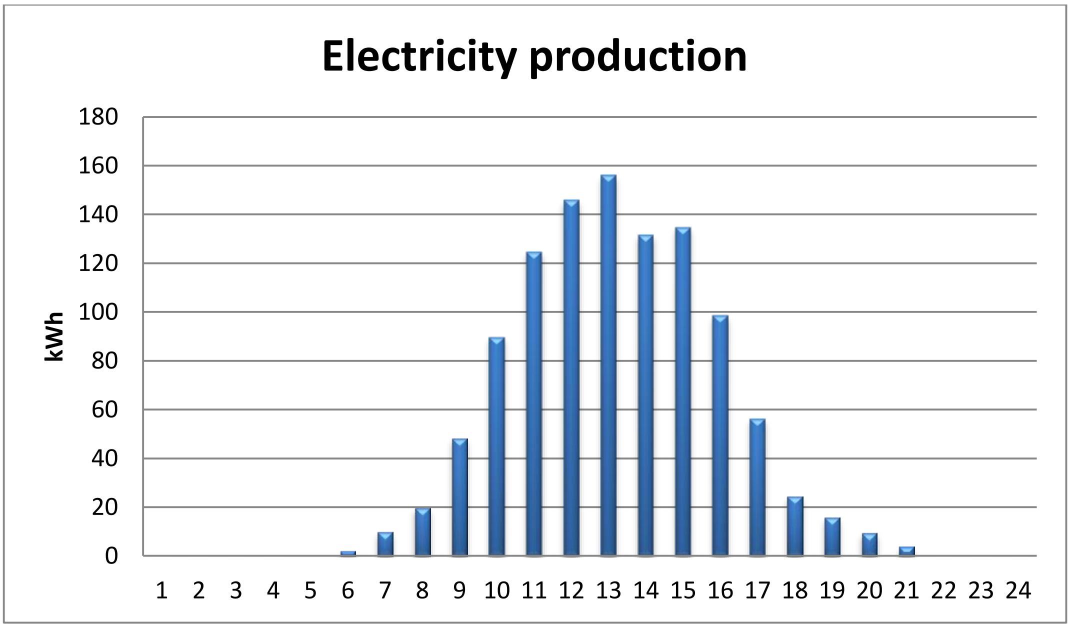


Figure 69 – Electricity production

For characteristic week day in winter season (10.01)

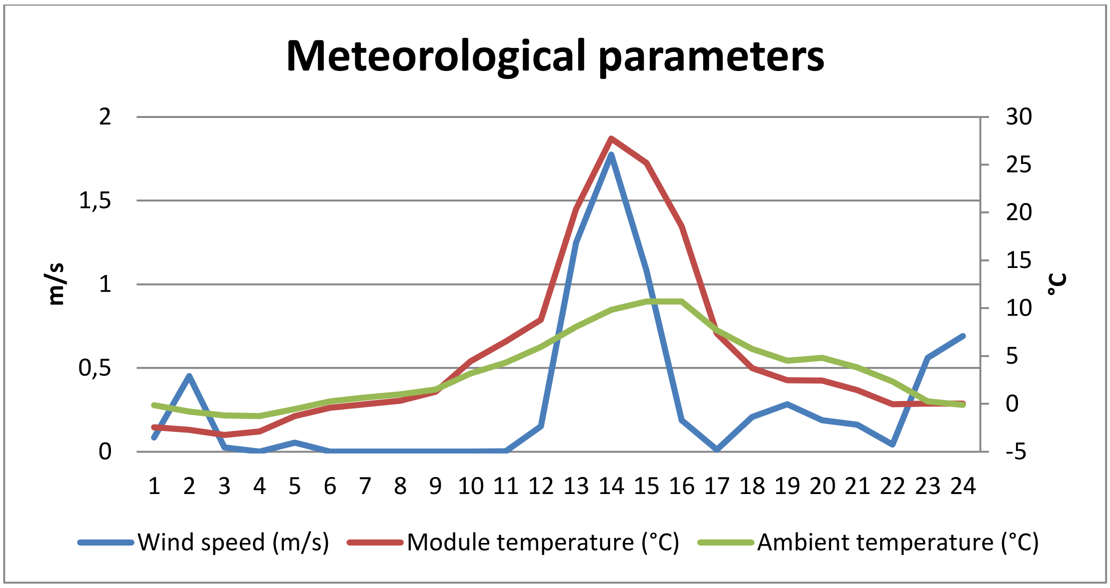


Figure 70 – Meteorological parameters

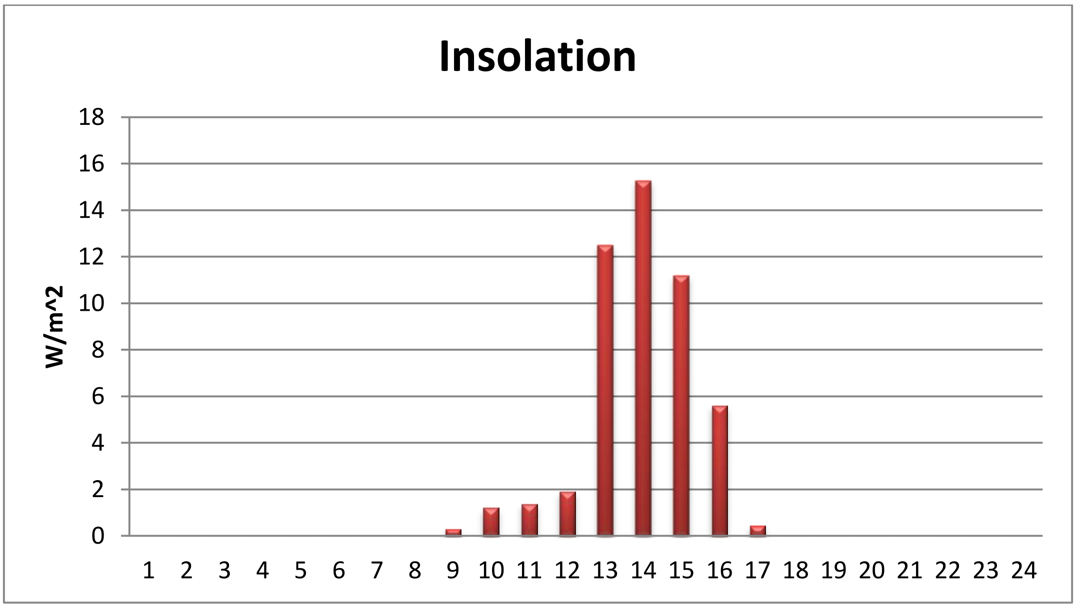


Figure 71 – Insolation

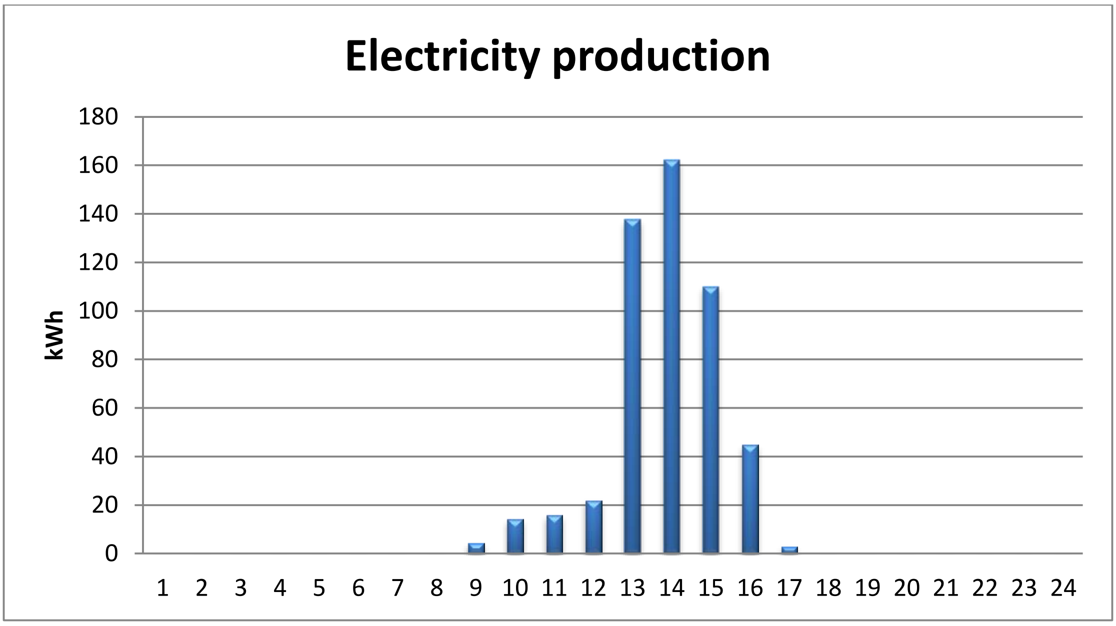


Figure 72 – Electricity production

For characteristic weekend day in the winter season (12.01.)

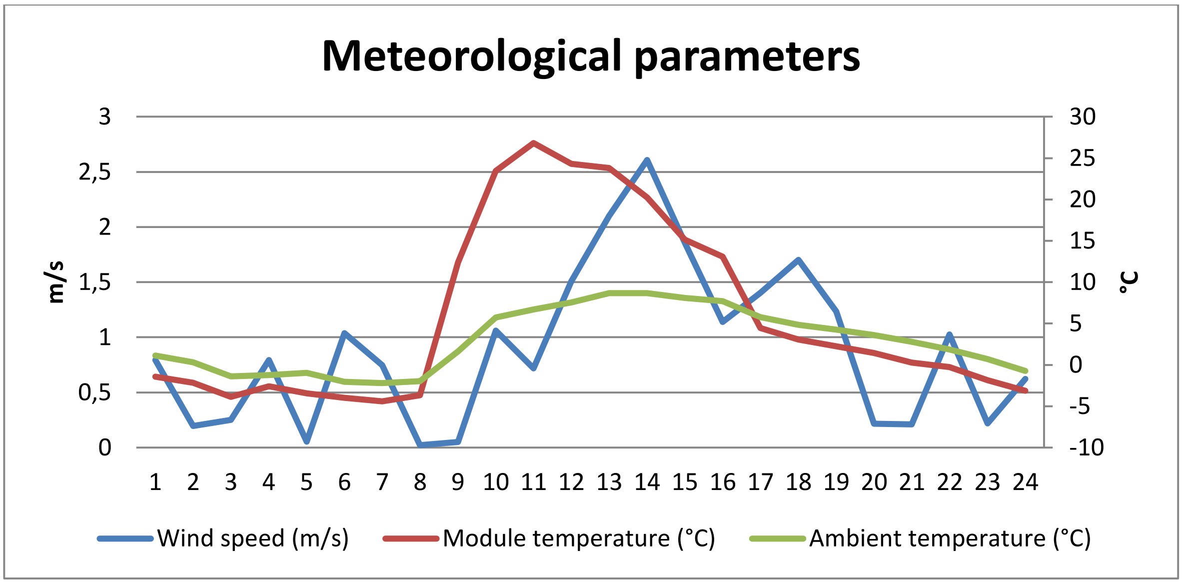


Figure 73 –Meteorological parameters

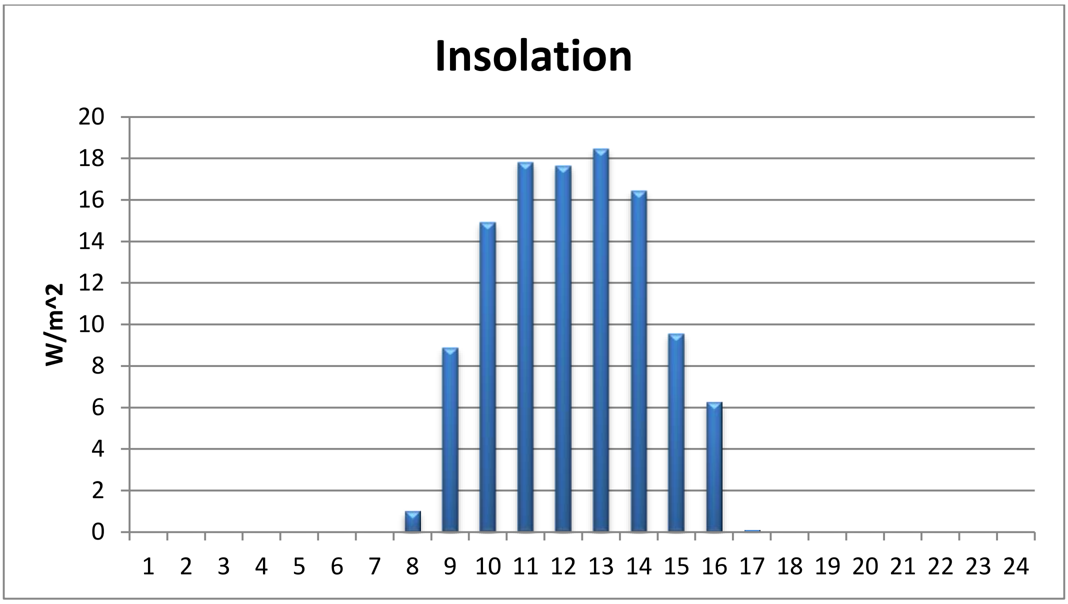


Figure 74 – Insolation

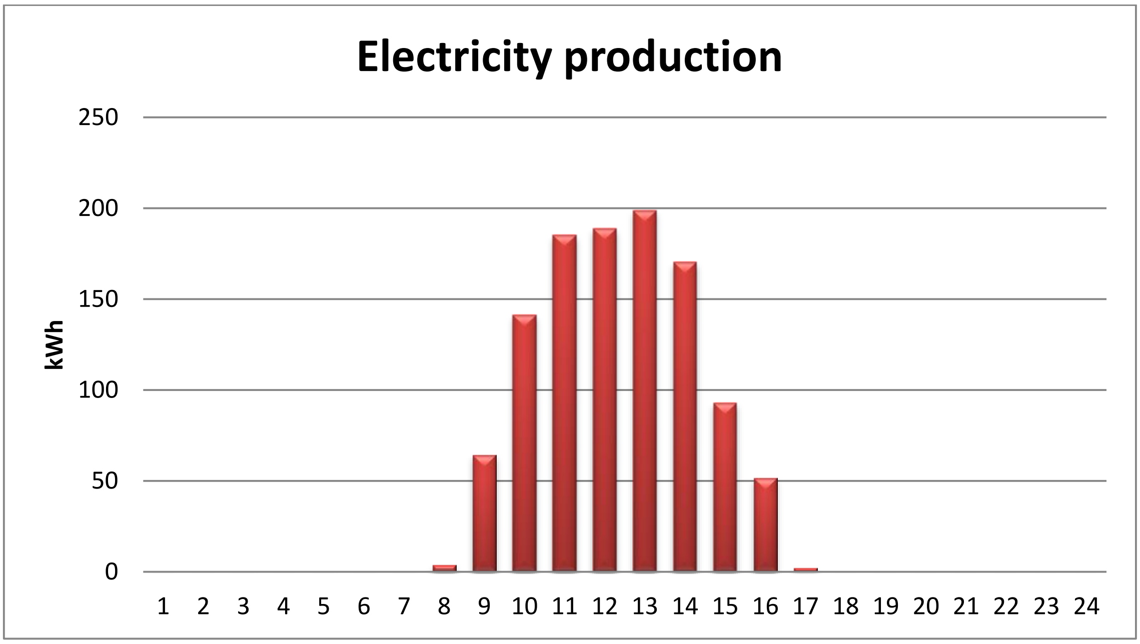


Figure 75 – Electricity production

Based on daily electrical production calculation around 1108.99 kWh for summer season and 514.49 kWh for winter season is obtained.

5.3.6.3 Electrical Loads

In accordance with the rules of the competition, our goal is to meet the needs of consumers in the modern households. In order to make calculation and simulation of appliances and devices consumption in the house, we made a list of appliances and devices that are necessary for normal functionality. The list includes the current market available appliances of the highest energy class, and their power in normal operation and stand by.

Table 21 – List of the electric loads

	Appliance type	Model	Maximum power (W)	Working hour (h)	Consumption (kWh)
Engine room	Clothes washer	BOSCH WAS32890EU	2300	3,41	0,69
	Clothes dryer	BOSCH WTB66200BY	1000	1,42	1,02
	Lighting	KEA 180	2x11	0,5	0,011
	Inverter		25	24	0,6
	Regulator		5	12	0,084
Bathroom	Lighting	KORA 16	3x15	1	0,035
Kitchen	Stove	KONČAR UKE2920KD.CKT	2900	1,5	1,75
	Oven	GORENJE BO5103AX	2700	0,5	0,384
	Dishwasher	BOSCH SMS69N28EU	2400	3,25	0,93
	Refrigerator +freezer	BOSCH KGE36AW40	160	24	0,41
	Lighting	GU.5	5x6	1	0,03
Main room	TV	PANASONIC TX-L32B6	31	4	0,031
	Laptop	17 inch	75	10	0,764
	Bluray player	SAMSUNG BD-F5100	8,8	2	0,024
	Lighting	LED	30x7,2	2	0,3
		KORA7	5x7	2	0,05

Simulations of individual appliances on a daily basis were performed according to available data for the appliances consumption for an average household.

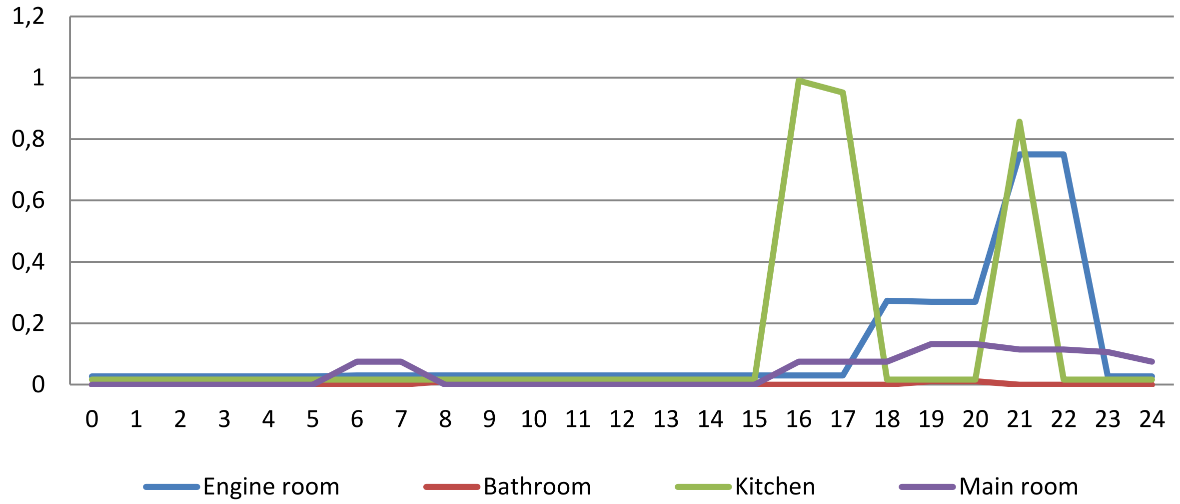


Figure 76 – Simulation of the individual appliances on a daily basis

Starting from house energy loads prediction, a weekly and annual electricity demand simulation was performed.

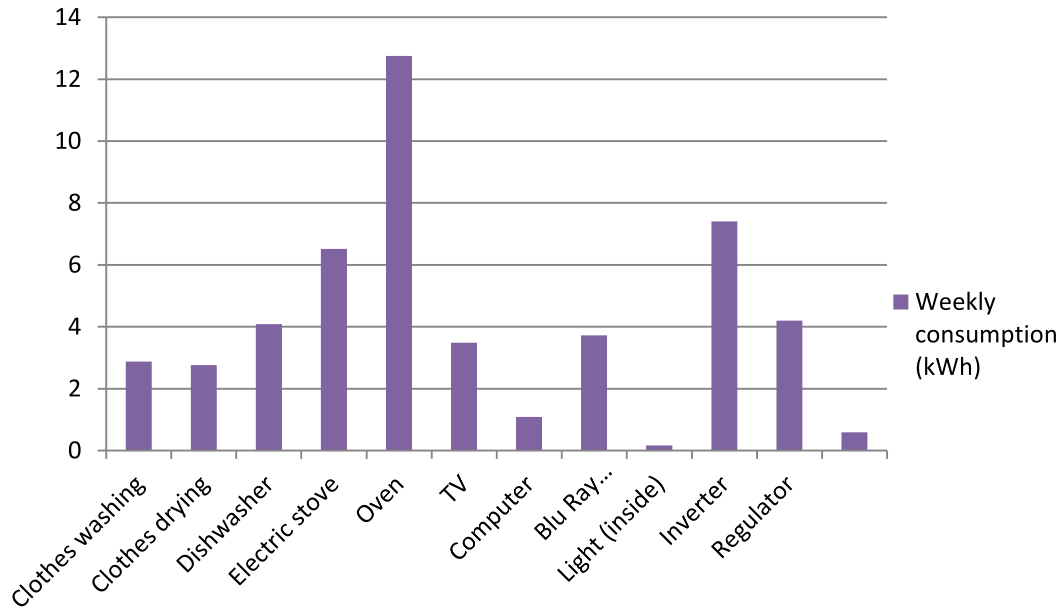


Figure 77 – Weekly electricity consumption

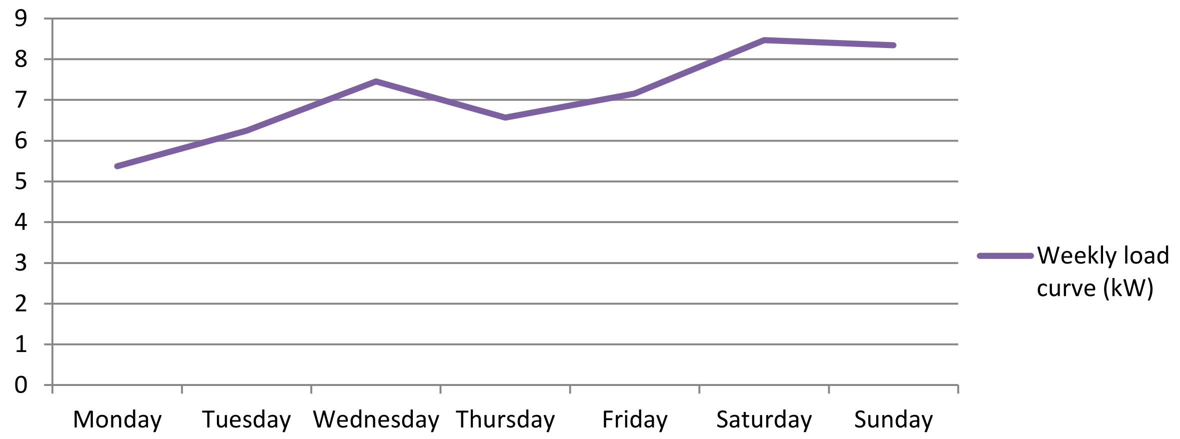


Figure 78 – Weekly load curve

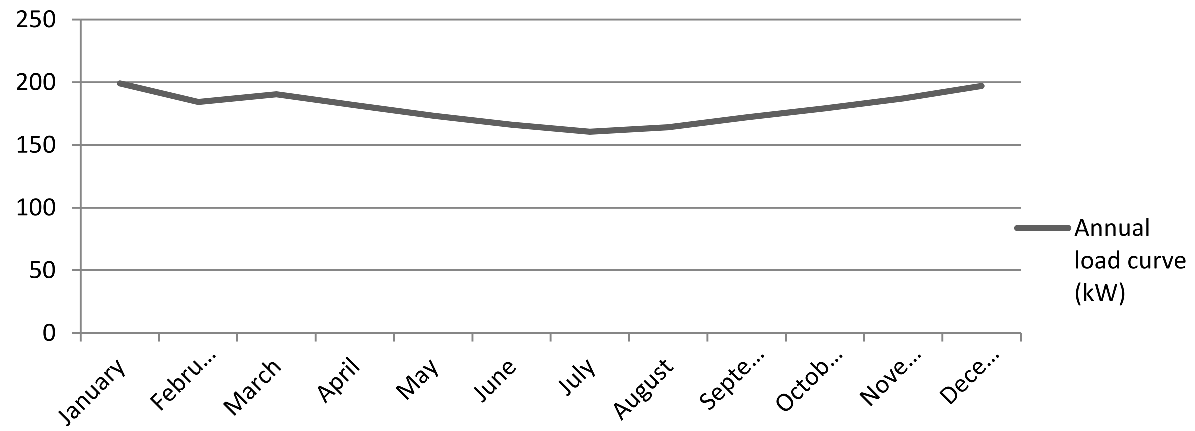


Figure 79 – Annual electricity consumption

According to the simulation results for electricity production and consumption, energy balance simulation was performed. Lighting and appliances electrical demand and PV production have been calculated according to design strategies by an hourly detailed simulation for Paris climate context.

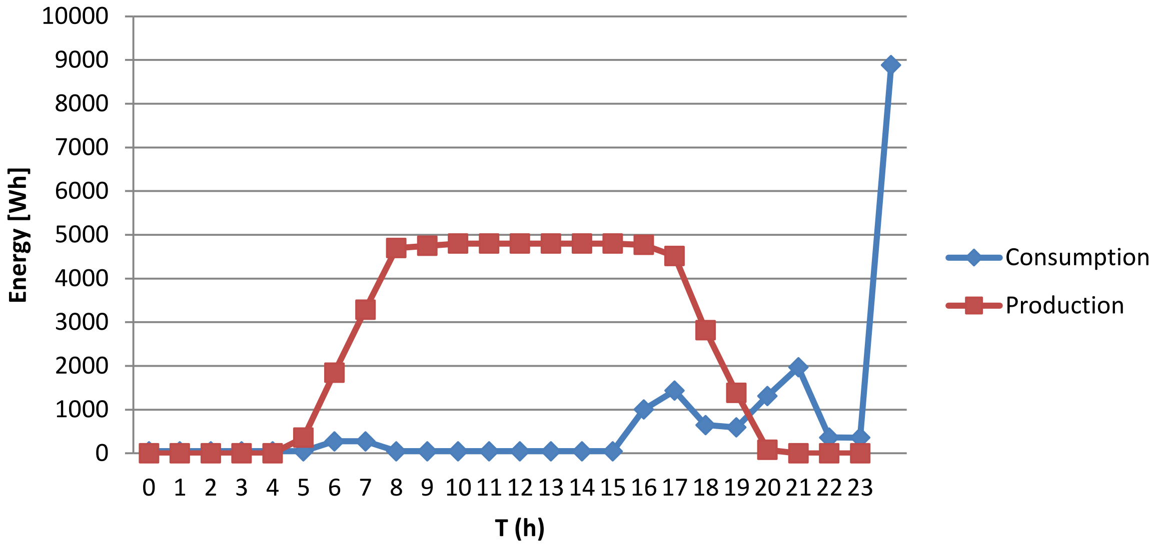


Figure 80 – Daily electricity balance

Peak load is between 20 and 23h, which is also peak load in the global power system in Croatia (in France the situation is bit different due to the different structure of the power system). Since households make up for the significant part of total electricity demand, our goal is to make our house a “model citizen“ in the electricity grid.

In order to optimize the consumption, our house will have a software implementation of the algorithms whose task will be to monitor users' home habits and budget forecasting and control daily consumption. This implies that the house will be able to adjust its consumption throughout the day in order to achieve different objectives. One of the possible control strategies is to reduce electricity import and export peaks, as well as reducing electricity import during power system peak hours (late afternoon). This is achieved by managing flexible loads (heat pump, fridge…) and using the batteries.

An example of control strategy is shown in the Figure below. There are two cases shown:

Case I, where the electrical balance towards the grid is shown by the green line. Import and export of the energy with the grid are determined by the difference between PV generation and consumption of the loads in the house.

Case II shows the desired behaviour of our house. All of the flexible loads are shifted into periods with high PV generation, reducing the load in the upcoming hours. Batteries are charged during sunny hours, and discharged several hours later, when the grid peak load occurs. The orange curve is more beneficial for the grid, as less energy is imported (some energy is even exported) during the peak, late afternoon hours. One more benefit is the overall reduction of import/export peaks. This example is not based on the real data, but it illustrates the principles that will be implemented.

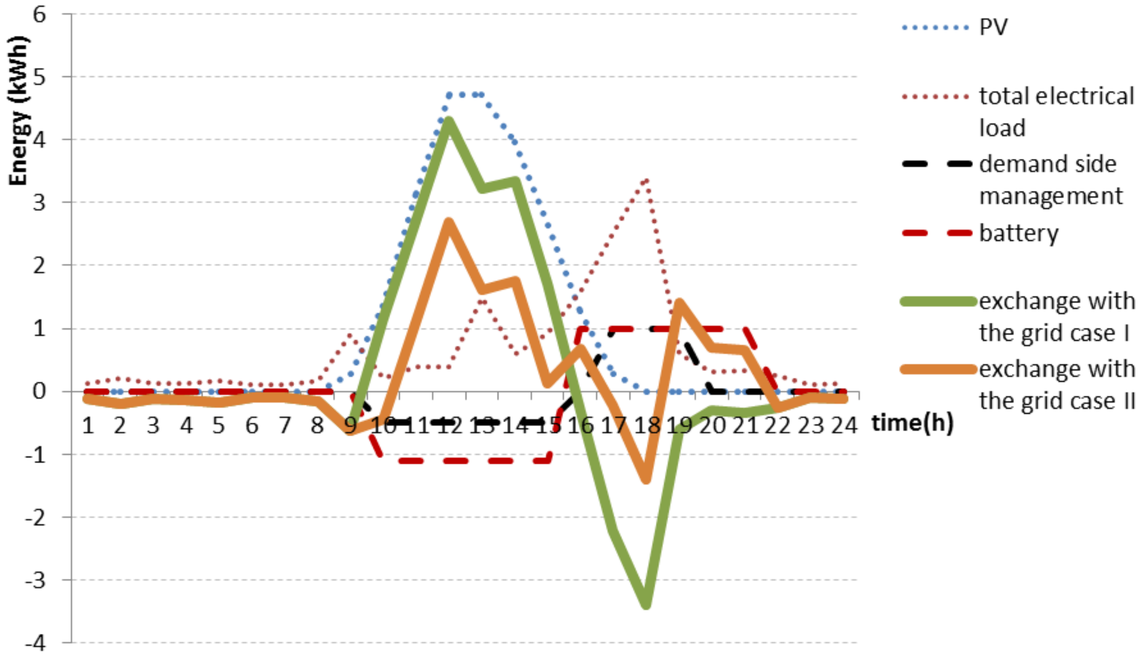


Figure 81 – Example of modifying the consumption curve

This kind of system behaviour will be enabled by the high level of control over the electrical equipment. Control algorithms will be implemented in the central control unit, which will simplify changes in the desired behaviour.

Part of Mem**brain** control algorithm, is control of the power flow through the house electrical system. In order to fully exploit the possibilities of the inverters and inverter/charger, we will use HUB-2 algorithm for controlling the usage of all parts of PV system.

The Victron MultiPlus (or Quattro) is more than just an inverter/charger. It will manage the energy flow in a PV system with battery back-up. This is accomplished by intelligent software which can be set up to do exactly what is needed in a specific environment.

The following situations are possible in a self-consumption system with grid tied PV:

Situation 1: enough solar power to supply the loads.

Situation 2: not enough solar power to supply the loads

Situation 3: no solar power available

Enough solar power to supply the loads

In this situation the grid is present and connected to the loads. The Quattro will see that the PV system is producing more energy than needed by the loads, resulting in a surplus of solar power. The surplus is used to charge the battery. All energy that is not absorbed by the battery, because it is fully charged or already being charged with the maximum charge current, is fed back into the grid. A simplified model of this situation is shown in the figure below.

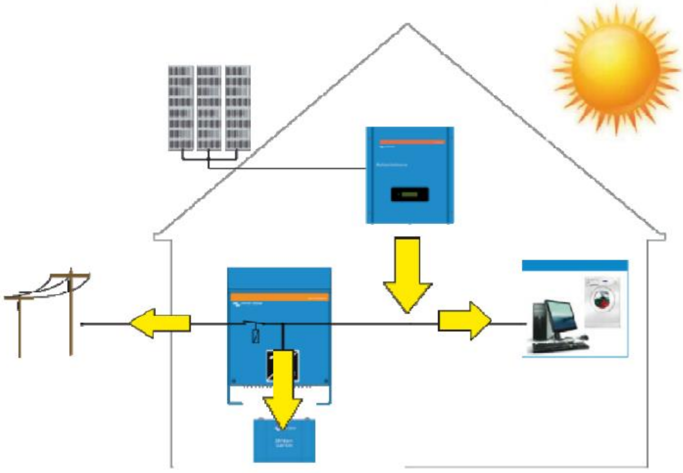


Figure 82 – Situation with enough solar power

Not enough solar power to supply the loads
Limited shortages of power will be drawn from the grid, and larger shortages will be drawn from the battery. A simplified model of this situation is shown in the figure below.

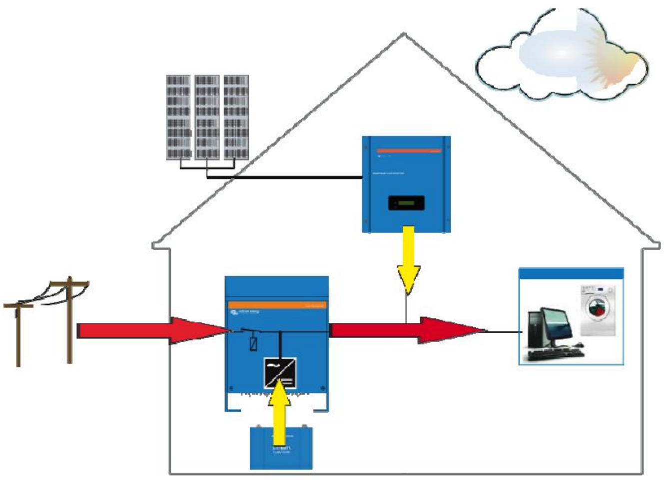


Figure 83 – Situation without enough solar power

Night time, no solar power available
After a couple of days of monitoring PV power, the Quattro inverter/charger will synchronize its internal clock to the day/night rhythm. The Quattro inverter/charger will, without interrupting the AC supply, disconnect from the grid during the night and all energy for the AC loads will be drawn from the battery storage. The grid will remain disconnected until one of the following two major events occurs:

- Charge current starts to flow into the battery. This means that a new day has dawned, and that sufficient sunlight is available to provide power to the loads, with some surplus to charge the battery. The Quattro inverter/charger will then reconnect to the grid.
- The battery has been discharged to a present state of charge or a present voltage, whichever comes first. The Quattro inverter/charger will then reconnect to the grid and

switch to standby: it will not charge the batteries from the grid, nor power the loads from the battery storage. The loads are powered from the grid. It will start charging the battery storage with surplus PV power as soon as it is available and remain in charger only mode until a present battery storage voltage has been reached.

A simplified model of this situation is shown in the figure below.

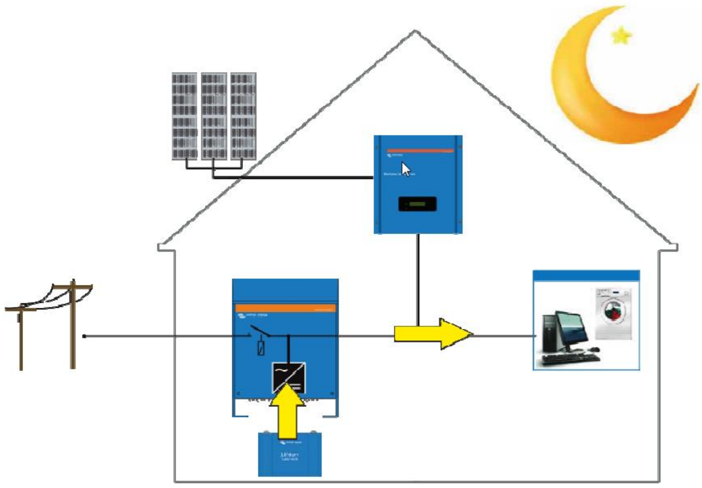


Figure 84 –Situation without solar power

5.3.7 Solar Thermal Design

Solar collectors are widely used for domestic hot water production. Essentially they use sun radiation and heat transfer medium that heats the water through the heat exchanger. Even though solar collectors are effective way to produce hot water they are not always necessary asset. Initially, idea was to put solar collectors in one row of the tracking system. In our case, taking the features of the house and tracking system into account, installation of a solar thermal collector system implies an excessively long time for the economic returns, for it has a low utilization level and definitely needs an alternative heat producer. There is no valid reason to put solar collectors on the roof and to justify their installation economically Due to solar tracking construction limitations and sufficient amount of hot water produced by heat pump, decision is made that solar collector will not be used in this project. Considering the fact that water will be effectively heated by heat pump at this point no other source of energy is needed to provide house with hot water. Custom made heat pump with expected power of 5 kW will be the source of heat production with the priority for domestic hot water. MPC (model predictive control) will, through various algorithms and predictions of inhabitants' behavior, ensure that every time there is need for hot water it will be available. This way system will be more efficient and more economically viable.

5.3.8 Building integrated Solar Active Systems

Aesthetics

Our photovoltaic integration philosophy is based on both maximizing electricity production and creating the shadow for the house. For this reason we decided to design PV structure in the shape of the furling panels, where the tilt of the solar panels will be automatically adjustable as the height of the sun changes over the year.

The PV tracking system undergoes a very strict set of criteria in the design process, one of it being its aesthetic value regarding the system itself, as well as its integration in the building as a whole. The system is conceived as a light filigree structure forming the final roof construction layer. It is cantilevered to the south, and provides sun and rain protection when needed. For it not to be very massive, PV modules are only installed on the sides oriented to the sun, whereas the opposite sides are covered with fabric. Initially there were 3 aluminum profiles serving as the load bearing structure, but that was changed to 5 in order to emphasize the overhang on the south and to reduce the profiles' cross section. The aluminum profiles slightly detach the tracker from the solid body of the house providing a levitating effect of the system. Apart from being used as a solar tracker our system is very effective in channeling rainwater and acting like a real dynamic roof.

Maintenance Plan

PV system requires little maintenance. It is recommended to check the status of the modules at least once each six months. However, if the system output drops at any time during sun hours, a check should be performed to remove any dust, tree leaves or other dirt from the modules.

To clean the modules, the maintenance agent can simply use a ladder and climb safely up the roof. Once up, the agent can use water and a non-abrasive detergent to wash them. The visual inspection also includes checking possible broken glass. Then those broken glass should be immediately replaced.

In order to ensure constant efficiency of the PV system over its total operating period, it is necessary to provide periodic checks and maintenance: regular technical checks, regular maintenance and irregular maintenance. Regular technical checks encompasses monthly check for front panel glass damage, monthly check of cleanliness of the modules and monthly visual examination and test of the terminal boxes. Regular maintenance encompasses removal of the soil using water and non-abrasive detergent twice yearly. Irregular maintenance is system manufacturer obligation for any defect or breakdown within 36 hours of its observation or report.

Construction and additional properties

Because this is very innovative tracking system with primarily function to improve efficiency of PVs and there is no such thing available on market, precise calculations and dimensioning are needed for the main construction. There were several things to consider before choosing size of the construction such as demand for specific area to be covered with PVs and need for sunlight. This system has secondary function to be a dynamic roof that will be used to provide shade in the summer and to let the sunlight in at the winter in order to optimize solar gains and losses throughout the year. Figure below show what the basic element looks like. Idea is for tracker to be completely modular so you can attach as many units as demanded.

Figure 85 - Basic tracking element

Total length of the system and its change in dimensions are determined by demand for sun radiation and most efficient angle relative to roof in specific time span. Tracker will move daily in order to be at the ideal position for both power production and providing shade. These two requirements are in correlation so it will be possible to fulfill both at the same time. Tilt/angle of the tracker will be possible to control via home automation system manually or in the automatic mode where intelligent algorithm will determine the best possible solution.

Dimensions had to be chosen very carefully in order to improve efficiency of the PV elements. Calculations were made to see what is the optimal min. and max. angle for the tracker. As input we used Paris weather data and sun angles throughout the year to get optimal tilt for PVs. Even though chosen angles are not ideal there is no significant loss in power production compared to the ones got by calculation. Maximum angle will be 50 degrees and minimum angle will be 10 degrees due to the construction requirements.

5.3.9 Membrain Home Security and Automation System

Mem**brain's** home security and automation system will be an interactive and simple to use, custom made control system. There are many advantages of developing our custom system instead of implementing commercially available solutions:

1. Our system's main goal will be to save energy not just through smart control, but through user education. Modern methods of home control will be implemented to provide users with more flexibility (mobile apps, web interface…).
2. Our control algorithm will be based on Model Predictive Control. It is a modern mathematical method for minimizing energy waste.
3. Software controlling the heat pump will implement machine learning principles to improve energy efficiency. This way, as time passes our heat pump will become more efficient.

To implement smart control and it's feedback, accurate sensors must be used. All of our sensor modules will be custom developed, low power, wireless or wired solutions. In addition to all of these goals, we will especially consider system affordability. Mem**brain**'s home security and automation system consists of three independent stand-alone but networked systems:

- Central Processing unit
- Wireless sensor network
- "littlePLC" – HVAC control system
- "littlePLC" – PV and light control system

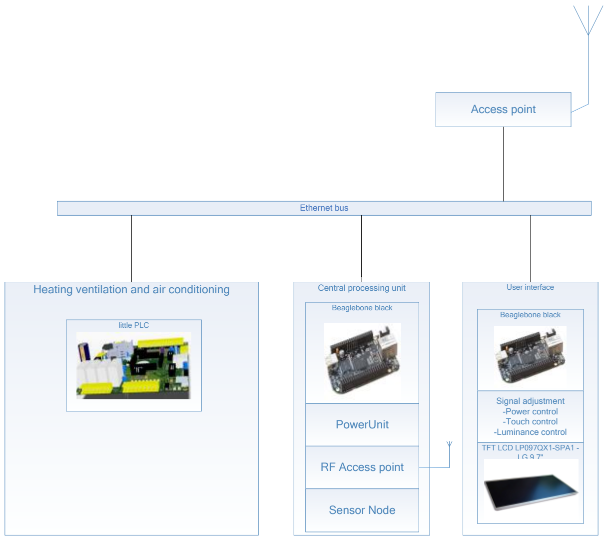


Figure 86 - Mem**brain** home security and automation system block diagram

5.3.9.1 Central processing unit

The central processing unit implemented in Mem**brain** is based on Beaglebone Black, a Texas instruments embedded Linux platform. Functions it needs to provide for Mem**brain** are listed below:

- MPC algorithm calculations.
- Interface between wireless sensor network, littlePLC and user interface panel.
- Fire, burglary and health care reports to local emergency services.

- Web server for remote user remote access to home control systems.

Beaglebone Black was chosen because it has a much higher computational power than standard microcontroller systems, providing enough resources and CPU speed to implement advanced algorithms, such as MPC. An overview of the device given by the developer is shown in the picture below.

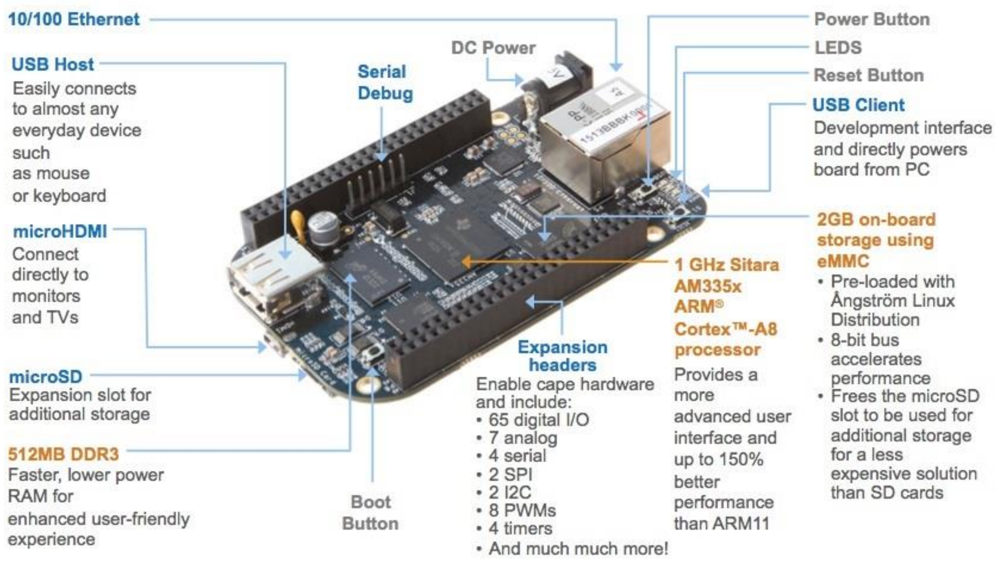


Figure 87 - Beaglebone Black overview

5.3.9.2 Model Predictive Control

In accordance to the prototype of Mem**brain** concept and the general idea of sustainability and energy efficiency, the thermal efficiency of the heating control system stands in one of the focuses of the entire Mem**brain** concept.

Relying on the advanced custom made sensing system which is to be developed and used in the Mem**brain** concept as well as a custom made heat pump which will be used as an actuator within the heating system, this system is a fully custom made one with some parts having already gained contribution in the research area of interest. Apart from various information gathered using the sensing system inside and outside the house (e.g. temperature, pressure, insolation, humidity, CO_2, etc.), this control method has some forecast information available as well. Mainly, thanks to Croatian Meteorological and Hydrological Service (DHMZ), the predicted temperature and insolation for at least a few hours up to a day in advance are at disposal.

The part of the project oriented to control system synthesis is consisted of several main segments and can be presented as follows. Firstly, an accurate high complexity model of the house is to be implemented. For this task, commercial software is to be used (IDA Indoor Climate and Energy – IDA ICE). This serves as a validation reference for mathematical modeling of the house using representation with much lower complexity. Acquiring a simple as possible model, which still guarantees accuracy of the processes description, will create a basis for the control scheme implementation. Usually, such a control scheme is firstly developed within simulation software, and afterwards, is implemented on the hardware to be used in the exact object. Once having built the building, it is possible to carry out an identification of the real system improving accuracy of the model which is usually used in the control scheme. Within this report we are still focused on the control scheme, rather than implementation on a real hardware system where the control algorithm is to be executed. The entire development process is presented in the figure below.

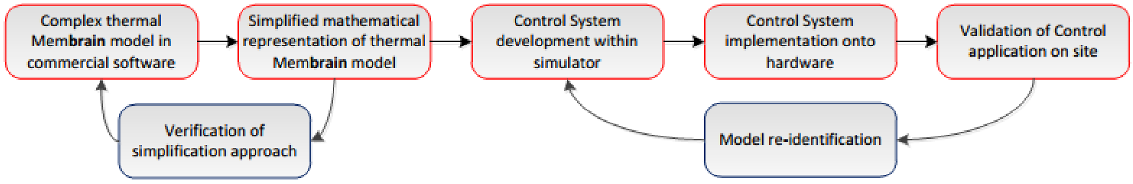


Figure 88 - Flow Chart for the objectives of the Control system design task

The majority of simple and well-established control techniques (e.g. PID controller, hysteresis controller etc.) do not consider energy consumption optimality but rather consider only satisfaction of the demand on the temperature level in an object. In contrary, herein we plan to implement an advanced control technique which ensures optimality in heat management with respect to given constraints of our systems, regarding to compromise between a price of energy, amount of spent energy as well as any other thing that can be interesting to be taken into account. Namely, this control technique is called Model Predictive Control (MPC) and it is explained into more details further below.

MPC has developed considerably over the last few decades, both within the research control community and in industry. Four major aspects of MPC framework make the design methodology attractive to both practitioners and academics. The first aspect is the design formulation, which uses multivariable system framework naturally where performance parameters are easily understood and can be tuned by engineers. The second aspect is the ability of the method to explicitly take into account both soft and hard constraints. This allows operation closer to constraints (compared with conventional control), which frequently leads to more profitable operation. The third aspect is the ability to perform on-line process optimization. The fourth aspect is the simplicity of the design framework in handling all these complex issues.

The basic concept of MPC is to use a dynamic model of the process and current measurements to forecast system behavior and optimize the prediction to produce the best decision – the control move at the current time. Therefore, the control action is obtained by solving online, at each sampling instant, a finite horizon optimal control problem in which the initial state is the current state of the plant. The result of this optimization is a finite control sequence and only the first action in this sequence is applied to the plant. This method, also known as receding horizon control, implicitly introduces the feedback to the control design. The control scheme for an MPC is shown in the figure below.

As mentioned previously, MPC has the ability to take into account a wide range of constraints, which is highly desirable feature. These constraints commonly include physical limitations of the actuators (e.g. heaters, valves, etc.) but even economic or ecological constraints can be dealt with. This makes the system operation efficient and prevents the damage to equipment.

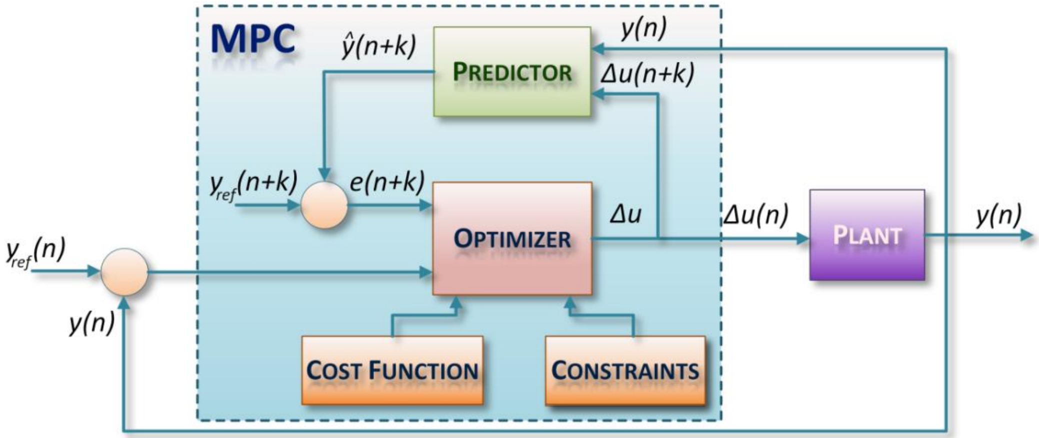


Figure 89 - Flow Chart for the objectives of the Control system design task

MPC is considered to be mature technique for rather slow systems because slow process dynamic leaves a plenty of time for online optimization at each sampling instant. In our project the controller is to be used for the control of a custom made heating/cooling system, which itself is not very dynamically demanding. This coupled with the ability to explicitly incorporate constraints in the controller design (e.g. physical limitations of a heat pump), thereby taking advantage of the measurements and predicted trends of a temperature in a house correlated with forecasted variables (e.g. outdoor temperature, sunlight irradiation, etc.) and demands of the occupants, to secure comfortable environment at minimum cost and usage of energy, makes the decision to use MPC pretty straightforward.

To use MPC within our project, firstly we will have to develop a mathematical model of thermal behavior of our house. In general, this would not stand as a problem since often thermal behavior of materials used in buildings can be considered as linear. Nevertheless, in the case of a phase change material (PCM) which is to be used within our house, the characteristic has very nonlinear behavior, which is described in detail earlier in this paper. However, considering the behavior of PCM in different areas of state space, it can be considered as piece-wise affine model. In particular, we distinguish the cases when PCM acts as a container of sensible heat and the case when the PCM solidifies or melts. Modeling in a way described above is possible using the hybrid models.

Hybrid models allow the interaction between continuous dynamics described by differential or difference equations, and logical components described by finite state machines, if-then-else rules, propositional and temporal logic. Such heterogeneous models switch among many operating modes, where each mode is associated with a different dynamic law, and mode transitions are triggered by events, like states crossing pre-specified thresholds. In particular, in order to generate a mathematical representation suitable for optimization solver which stands for vital part of MPC algorithm, the model of the house is utilized as mixed logical dynamical (MLD) system. Furthermore, matrix representation of the optimization problem will be realized using a programming language HYSDEL (Hybrid Systems Description Language), which is an integral part of the Hybrid Toolbox implemented in Matlab, high-level programming language.

5.3.9.3 Wireless sensor network

Membrain is equipped with a highly reliable and extremely energy efficient wireless sensor network. The sensor network consists of various types of sensor nodes that communicate with the central station using a 2.4 GHz wireless connection. 2.4 GHz band was chosen because it is worldwide license-free, error-tolerant, and has low power characteristics. Today 2.4 GHz networks are widely used in households, its applications ranging from microwave ovens up to wireless local area networks. Membrain's wireless sensor network distinguishes each connected sensor node by its unique address. Apart from the wireless connectivity solution, industry standard digital communication interface (RS232/RS485) is available on all sensor nodes. This interface adds another degree of freedom for sensor nodes which require fast response times and have high current consumption. This allows for a wired interface connection, for sensor nodes located near the central processing unit. An abstract scheme is shown in the Figure below.

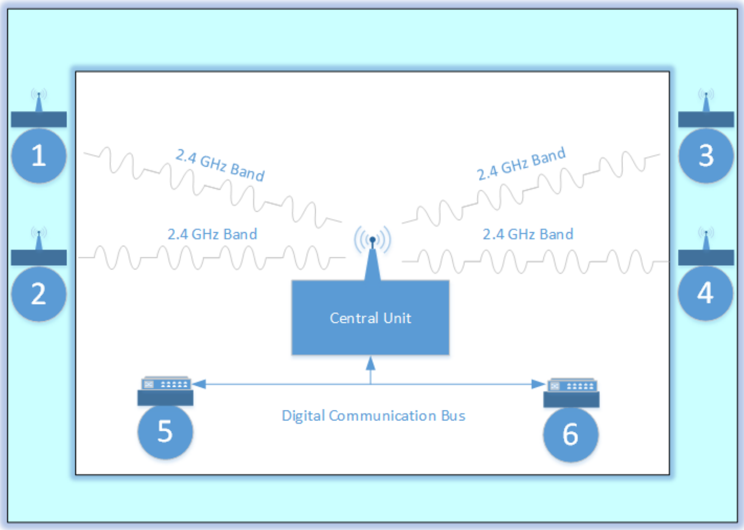


Figure 90 - Abstract sensor network scheme

Membrain's sensor network is modular and adaptable, which allows the user to quickly and easily add and remove sensor nodes. Sensor nodes are recognized as abstract objects with strictly specified communication interfaces rather than actual hardware objects. This allows automatic configuration, making our sensor network completely hardware independent as long as the communication interface for the new sensor is designed following the specified rules. Primary benefit of this approach is that new types of sensors can be added more quickly without affecting the integrity of the existing sensor network. Sensor market is developing faster and faster every day and we want to be able to quickly integrate new sensor solutions depending on the customer's needs.

New sensor integration is carried out in three simple steps:

1. New type of sensor is chosen
2. Membrain wireless or wired sensor interface is connected to the sensor and properly configured
3. Integrated solution is placed within Membrain which adapts to the newly introduced sensor node

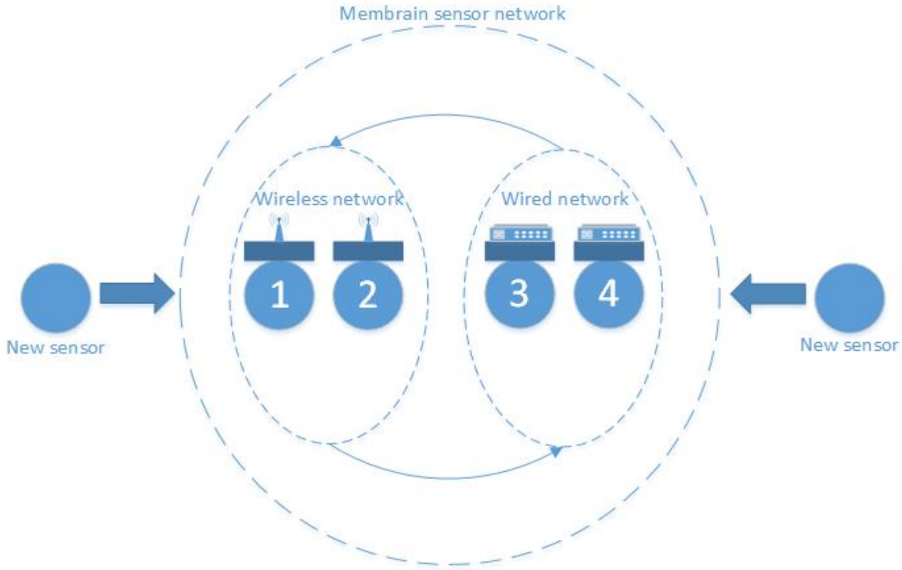


Figure 91 - First step in integrating a new sensor

Developed smart sensor interface automatically detects sensor type and starts collecting data

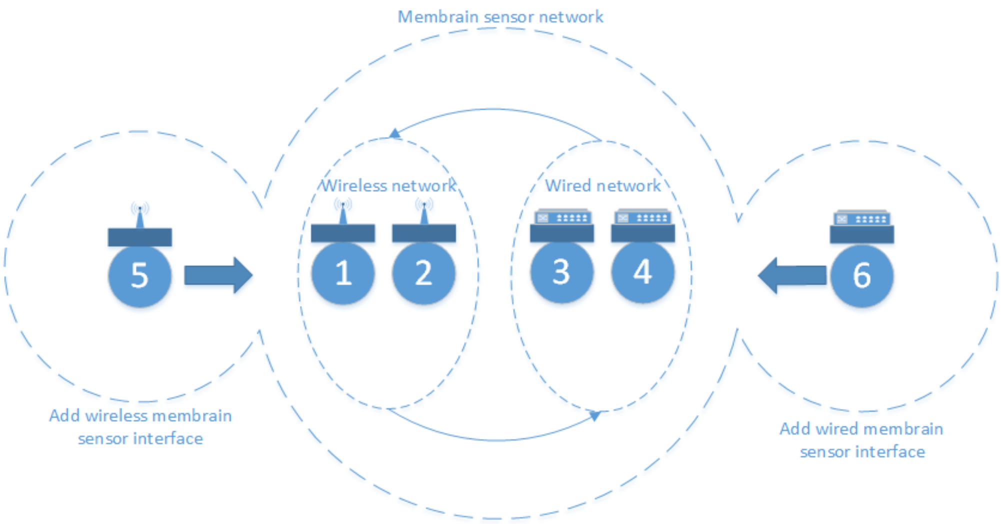


Figure 92 - Second step in integrating a new sensor

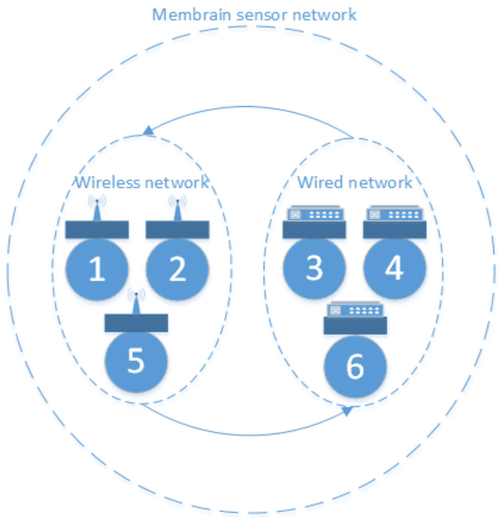


Figure 93 - Third step in integrating a new sensor

A single sensor node consists of following units: power unit, processing unit, sensor unit and communication unit. To ensure minimal energy consumption, special care was taken in order to choose most energy efficient solution for each unit. A microcontroller with extreme low power consumption was chosen for the processing unit. These microcontrollers offer several low power consumption modes in which it consumes even less than 500 nA of current. The chosen variant offers all of the required analog and digital peripherals that are required on a sensor node (SPI, UART, I2C, GPIO, etc.). The general consumption characteristics of the chosen processing unit solution are shown in the Table below.

Table 22 - Processing unit power consumption

	Consumption
Sleep mode	500 nA
Active mode - Typical	500 uA
Active mode - Maximum	10 mA

Wide range of sensor units has to be integrated into the sensor network. Since different sensor types have different power consumptions, in order to ensure minimal energy waste, processing unit redirects power to sensor units only when needed. The time needed for collection of measurements is estimated to be no longer than 10 milliseconds and consuming a maximum of 20 mA.

The complete list of proposed sensor units is explained later. As we mentioned earlier, sensor units can be connected to central unit using a wired or wireless connection. Power unit in wireless sensor nodes consists of a battery unit and energy harvester such as Peltier thermoelectric. Wired sensor node is directly powered from the communication bus. For the communication unit interface in wireless sensor nodes, 2.4 GHz RF modules were chosen. These solutions are perfect for short range, high speed communication reaching up to 2 Mbit/s while offering an overall 82% less power consumption than most of commercially available solutions in transmitting or receiving mode. The general consumption characteristics for the chosen wireless communication unit are shown in the Table below.

Table 23 - Wireless communication unit power consumption

	Consumption
Sleep mode	900 nA
Active mode - Transmit	11.3 uA
Active mode - Recieve	13.3 mA

The typical sensor node configuration is illustrated by block diagram shown in the Figure below.

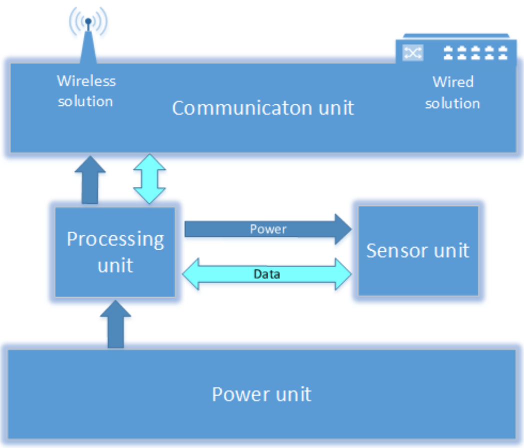


Figure 94 - Sensor node block diagram

Sensor nodes can be configured to report measured data in fixed time intervals. Every time a sensor node collects measurement data, it is immediately reported to Mem**brain's** central unit. In order to make sure central unit has received the data, each sensor node waits for confirmation. Sensor nodes can operate in one of the following states:

- Sleep state – Lasts for T_s
    - Sensor node waits for an appropriate time to start collecting data
- Measurement collection state – Lasts for T_{mc}
    - Sensor node acquires all measurements from selected sensors
- Measurement report state – Lasts for T_{mr}
    - Sensor node initiates the communication unit to transfer mode
    - Sensor node sends acquired measurement data to Membrane's central unit
    - This state ends after sensor node receives confirmation from the central unit
- Node configuration state – Lasts for T_{nc}
    - Sensor node initiates the communication unit to receive mode

- Node waits a short time for incoming packets that are used to configure its behavior such as data collection interval
- After a fixed time interval the node automatically goes to sleep state, ceasing all communication with central unit

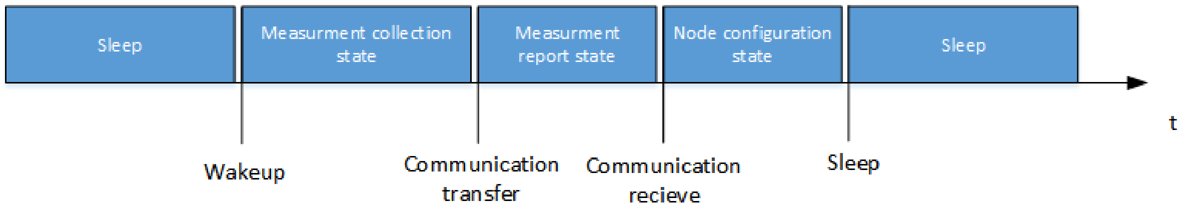


Figure 95 - States of operation

Since wireless sensor nodes need to be as energy efficient as possible to insure long battery life, special care is taken to minimize consumption. Consumption greatly depends on chosen measurement collection and reporting interval. We can summarize sensor node consumption by diagram shown in the Figure below.

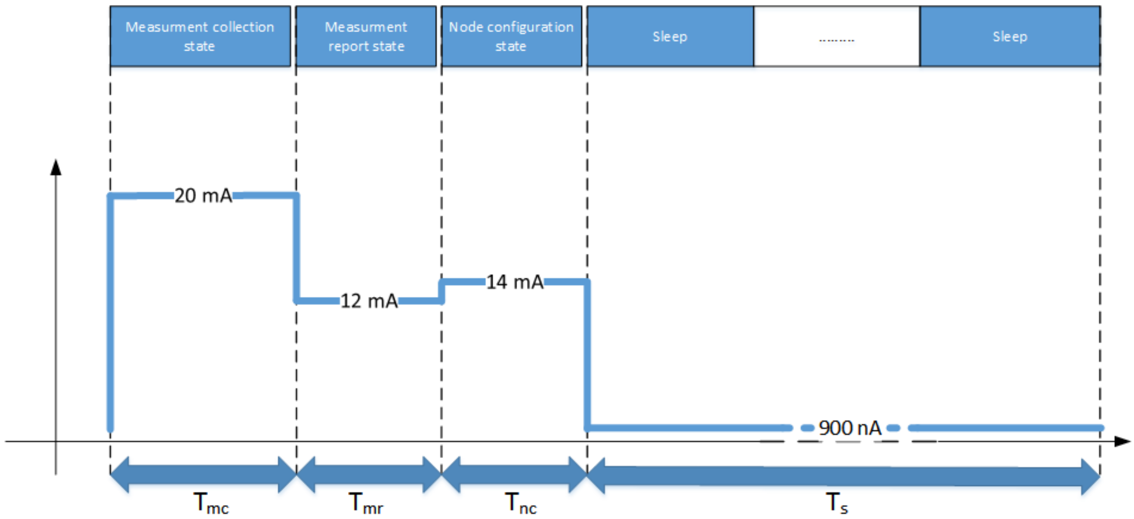


Figure 96 - Current consumption in various states

If sensor nodes use a 2200 mAh battery and the time values: T_{mc}=10 ms, T_{mr}=20 ms, T_{nc}=20 ms, we get the following average lifetime of a sensor node in relation to data collection interval T_s as shown in the Figure below.

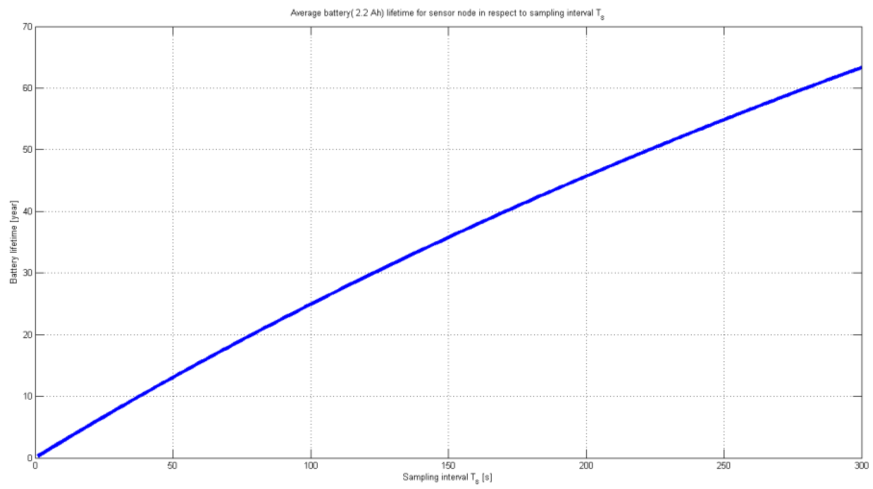


Figure 97 - Average battery lifetime in respect to sampling interval Ts

Membrain's sensor nodes are able to constantly report measured values in the specified sampling period T_s or they can be configured to only report when specified measured variable drifts outside of user specified boundaries. This way we distinguish two types of sensor node behavior as shown in the figure below time triggered and event triggered behavior. By configuring sensor nodes with for event triggered behavior, we can choose a shorter sampling interval T_s, while completely eliminating measurement report and node configuration state and thus saving additional energy. This option is useful for implementing alarm type sensor nodes which should only notify central unit in case of potentially hazardous events, such as: gas leak, fire or burglary. If a sensor node is preforming more than one measurement, different behaviors can be specified for every measurement.

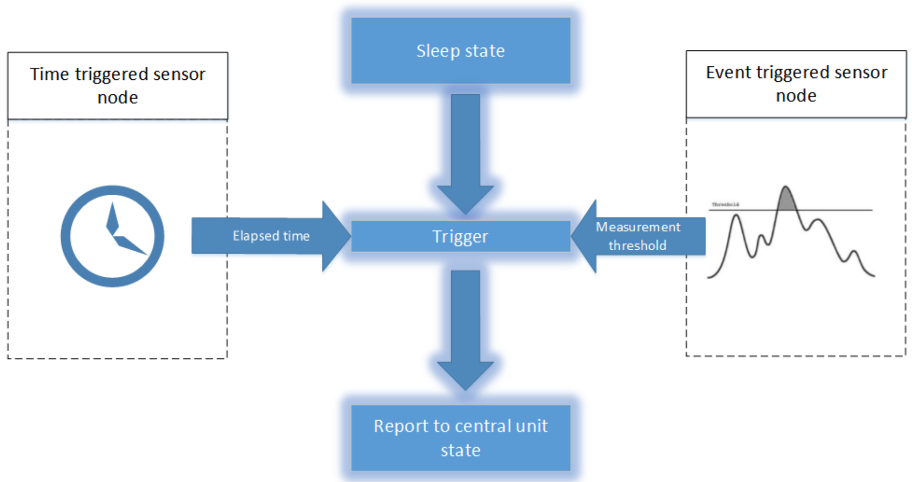


Figure 98 - Sensor node behavior options

Special care was taken to make sensor nodes as reliable as possible. Each node is equipped with a fault detection system which ensures reliable operation by restarting the processing unit in case of error. Sensor nodes are completely configurable using wireless or wired communication which eliminates the need for removal of nodes from Mem**brain** in order to make configuration changes. Sensor nodes are part of the Mem**brain** and they will be completely integrated in Mem**brain**, so they won't be visible.

The most important aspect of a sensor node apart from communication is the actual sensors used. Mem**brain** will be equipped with 6 or more types of sensor nodes. We have to point out the fact that the basic design of Mem**brain's** sensor network is motivated by easy integration of any type of needed sensor. We will develop a range of needed sensor solutions, but the concept of Mem**brain's** sensor network is not strictly limited to the sensors described in the following overview.

5.3.9.4 Type 1 sensor node – Temperature measurement node:

This sensor node is equipped with the following temperature sensors:

- Single high precision, factory calibrated, digital temperature sensor
    - Offers a highly reliable temperature measurement with digital interface, directly at node location
    - Special attention has been put to ensure that heat produced from electrical components do not influence sensor readings
    - Sensor resolution: 0.0625 ^{o}C
    - Sensor accuracy: ± 0.25 ^{o}C between -40 and 125 ^{o}C
- Up to four precision analog temperature sensors
    - Can be used to measure temperature at locations near the sensor station
    - Each sensor is calibrated to ensure precise measurements
    - Sensors are connected to the sensor node using quality shielded cable
    - Readings are acquired using 12 bit analog to digital converter
    - We can ensure accuracy of ± 1 ^{o}C after calibration, over temperature range of -55 and 150 ^{o}C

These sensor nodes will be used as a feedback measurement for HVAC system, general temperature monitoring within Mem**brain**, and for monitoring temperature of various vital parts of Mem**brain** such as PCM material, floor, ceiling, inner air, etc. Temperature measured by these nodes will be used as a primary feedback signal for model predictive control (MPC) algorithms. This node is a highly precise but price friendly solution for wireless temperature measurement.

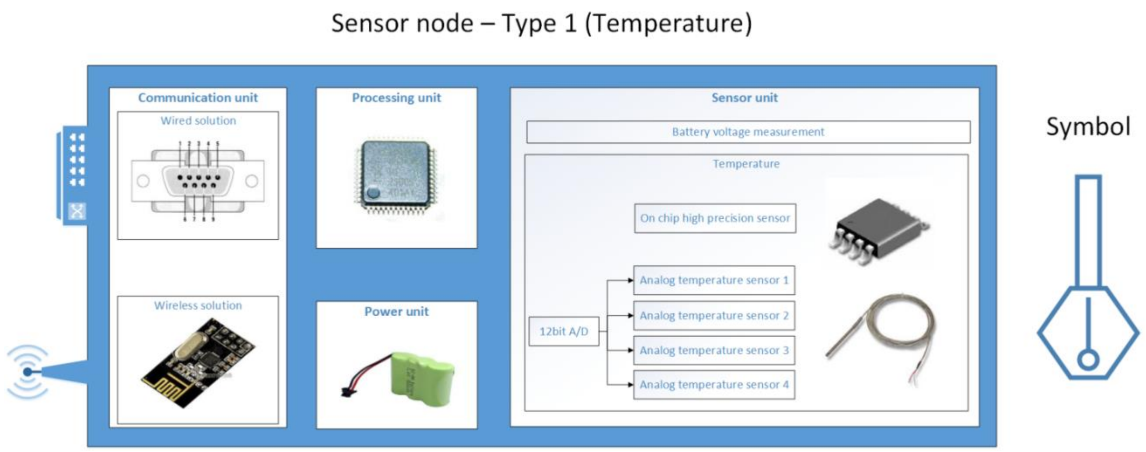


Figure 99 - Type 1 sensor node block diagram (Temperature)

5.3.9.5 Type 2 sensor node – Ambient light measurement node:

This sensor node is equipped with sensors for measuring luminosity and ambient light:

- Single high precision, factory calibrated, digital ambient light sensor
  - High precision 16 bit light sensor
  - Measures light up to 64 000 Lux at peak wavelength of 540 nm
  - Rejects UV and IR light, and reduced 50/60 Hz noise
- Up to four photodiodes can be connected in order to measure directed light
  - Can be used to measure luminosity in wanted direction near sensor station
  - Highly linear characteristic simplifies integration
  - Photodiodes are connected to sensor node using quality shielded cable
  - Readings are acquired using 12 bit analog to digital converter

These sensor nodes will be used as a feedback signal for controlling light intensity inside or outside of Mem**brain**. We can save energy by controlling light intensity using light dimmers, smart glass or window shutters. Directed light intensity sensors will be used to ensure proper lighting on different surfaces, such as working desks or dining tables. By controlling the lighting in such subtle way we can make Mem**brain** a very intelligent, energy efficient and user adaptable home. The block diagram for Type 2 sensor node is shown in the Figure below.

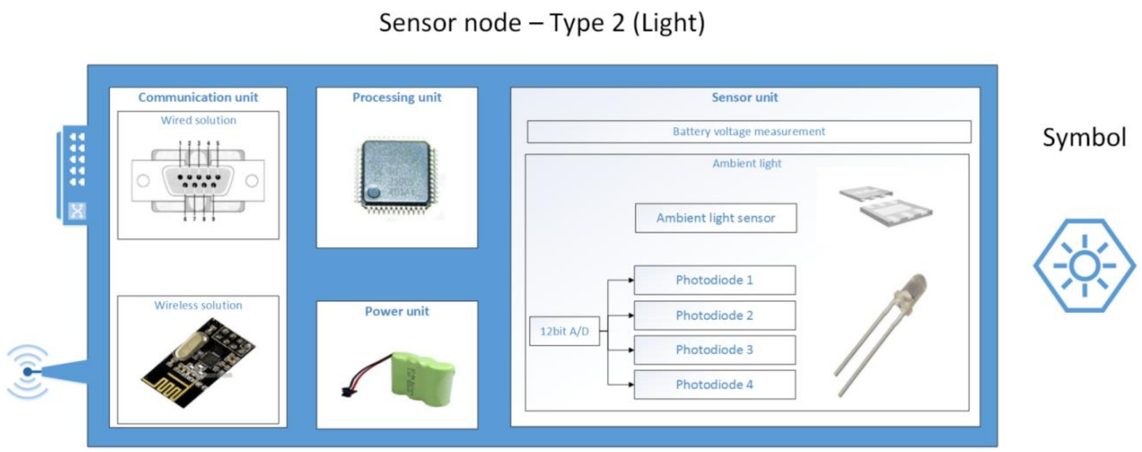


Figure 100 - Type 2 sensor node block diagram (Light)

5.3.9.6 Type 3 sensor node – Pressure and humidity measurement node:

This sensor node is equipped with sensors for measuring pressure and humidity. This node is also equipped with temperature measurement to ensure proper temperature compensation for humidity and pressure measurement.

- One high precision, factory calibrated, digital pressure sensor
  - High precision 19 bit pressure sensor
  - User adjustable resolution
  - Sensor resolution: 0.01 hPa, 0.01 ^{o}C
  - Sensor accuracy: ± 1 hPa between 300 and 1100 hPa, $\pm 1\,^{o}C$ between -40 and 125 ^{o}C
- Factory calibrated, digital humidity sensor

- Good for measuring RH from 0 to 100%
    - Temperature compensated
    - Sensor resolution: 0.1 %
    - Sensor accuracy: ±1 %
    - Low cost solution
- Temperature sensor is present in the digital pressure sensor for internal calibration purposes

Pressure and humidity sensor node will be used for measuring inside and outside of Mem**brain**. This way we can keep inside air humidity level at an optimum and make Mem**brain** a pleasant home to live in. Using the pressure sensor, we can detect a possibility of rain so proper measures can be taken (closing the window). This way we can control the irrigation process by using predicting algorithms. Low power consumption, great measurement precision and affordable price makes this sensor node an excellent solution. The block diagram for Type 3 sensor node is shown in the Figure below.

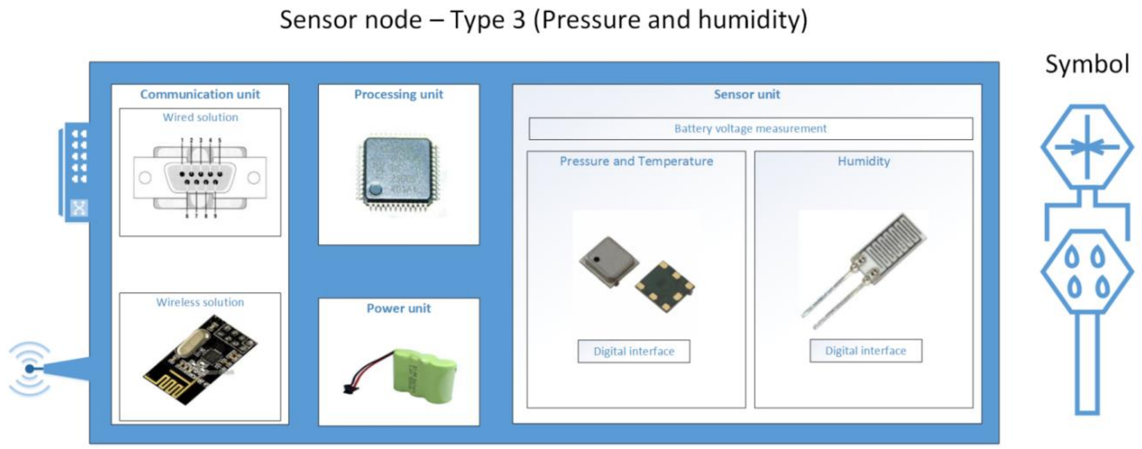


Figure 101 - Type 3 sensor node block diagram (Pressure and humidity)

5.3.9.7 Type 4 sensor node – Strain measurement node:

This sensor node is equipped with strain gauges for measuring wooden structure stress. This node is also equipped with temperature measurement to compensate it' s influence on precise strain gauge measurement. Sensor unit for Type 4 sensor node consists of:

- 12 bit analog to digital converter
    - Used for precise measurement of strain gauges resistance
- Instrumentation amplifier array
    - Used for signal conditioning to maximally exploit full A/D converter resolution
- Analog and digital temperature sensors
    - Used for measurement compensation due to temperature influence
- Up to 4 strain gauge configurations can be connected to single Type 4 sensor node. Sensor node supports many configurations:
    - Quarter-Bridge Type I, II
    - Half-Bridge I, II
    - Full-Bridge I, II, III, etc.

Since Membrain's structure is made of wooden beams, we want to be able to measure any possible displacement or defects due to: heavy structure loading or beam humidity influence, and report if there is possibility of structural damage. The block diagram for Type 4 sensor node is shown in the Figure below.

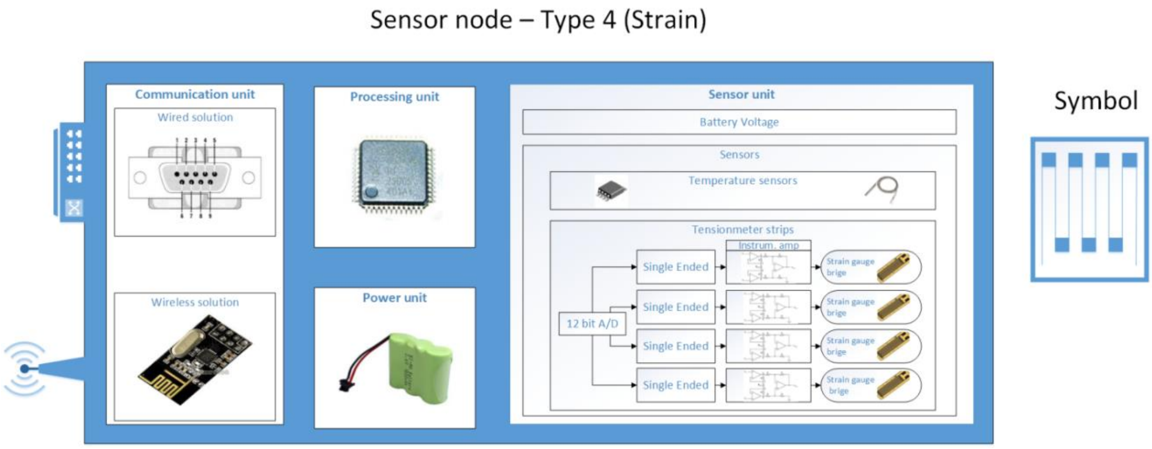


Figure 102 - Type 4 sensor node block diagram (Strain)

5.3.9.8 Type 5 sensor node – Air quality sensor node:

This sensor node is equipped with sensors for measuring air quality within Membrain. This node plays an important role in safety, since it's equipped with sensor solutions used to detect smoke and dangerous or potentially lethal gas substances. This node consists of following sensor solutions:

- CO2 sensor
- CO sensor
- Formaldehyde sensor
- Smoke detector
- Air quality - Ammonia, Sulfide and Benze steam

We want to ensure superb air quality within Membrain. This is achieved by constantly monitoring and controlling mentioned air substances with air ventilation and filtering system. This node combines all the necessary sensor solutions. The node is made modular so sensors can be added and replaced on the fly. Since this type of sensor is used for very important measurements that require quick reaction (fire detection, hazardous gas detection) the sampling period has to be set to a rather short time interval. Due to the high current consumption of air quality sensor node, this node is intended to be connected using wired communication interface. This way we get fast response times and in the same time we provide constant power supply to provide 100% uptime. This node is set to operate in event triggered mode. The block diagram for Type 5 sensor node is shown in the Figure below.

Sensor node – Type 5 (Air quality)

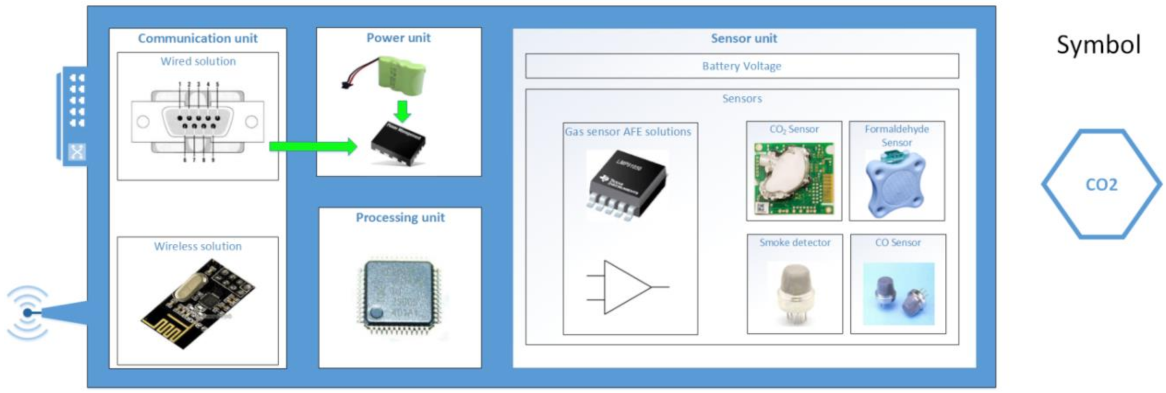


Figure 103 - Type 5 sensor node block diagram (Air quality)

5.3.9.9 Type 6 sensor node – Wood humidity node:

Mem**brain** structure is entirely made of wooden beams and panels. Wood, as a water absorbing material, requires humidity measurements to ensure that structural integrity of our building lasts as long as possible.

Wood humidity will be detected by using impedance spectroscopy. In the future months a sensor node will be developed to measure amplitude and phase frequency characteristics of wood. These characteristics change with the percentage of water in wooden beams and will give accurate readings of wood humidity after laboratory calibration of sensor nodes.

5.3.9.10 littlePLC

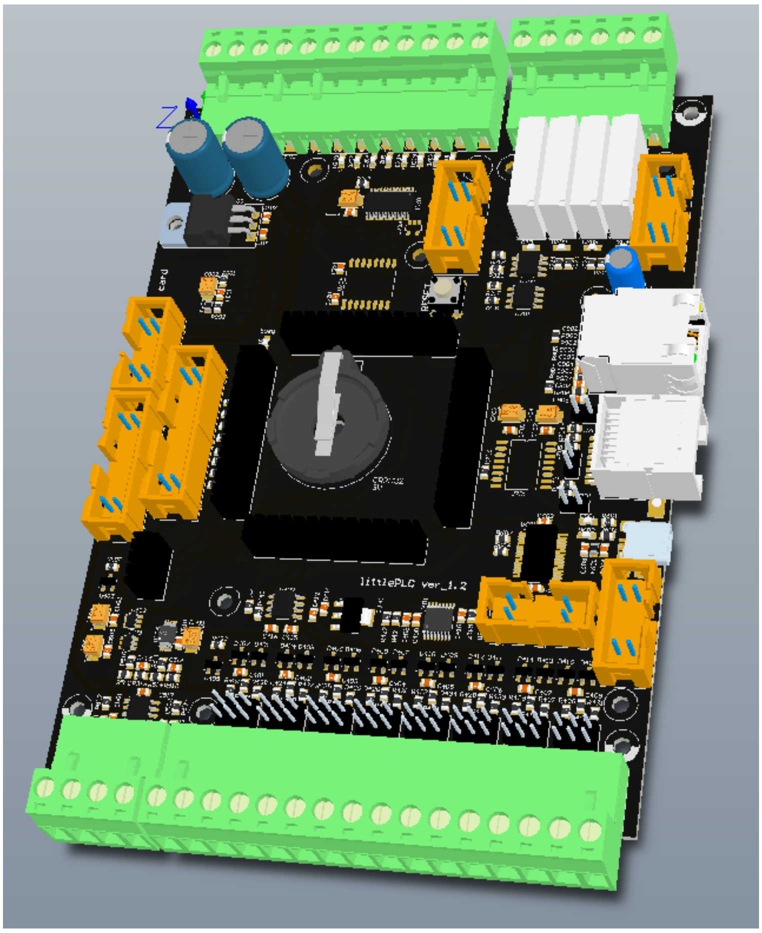


Figure 104 - LittlePLC

Programmable Logic Controller or PLC is an electronic system, basically a digital computer used for automatization of electromechanical processes in hazardous environment. From the beginning our team wanted to develop a custom system so we could implement complex algorithms such as machine learning. This type of control is not used for industrial applications and therefore there is no support for implementing these algorithms in a standard, commercially available PLC. We were encouraged by the results of the preliminary analysis which proved that our system will be faster and still have significantly lower price than a commercial PLC. Although it still does not satisfy some of the industrial regulations, it is not a problem for this purpose.

We developed a programmable logic controller from scratch! It's small size and price gave it a name: "littlePLC". Its main purpose in Mem**brain** is to control operation of the HVAC system. littlePLC must be robust, meaning that any external disturbances such as vibrations, EM interference, over voltage, etc. must not disrupt regular operation of the system. Steps were taken to ensure system operation under extreme conditions. These include electrical insulation of all peripheral connections. We made sure that any fault will not affect stability of the whole system, thus making our system a perfect solution for controlling Mem**brain's** essential operations.

Basic characteristics of littlePLC are:

- ARM based central microcontroller, up to 180MHz operation
- Communications: USB, Ethernet, RS485, USB-UART, Wi-Fi, GSM, 2.4GHz wireless
- Digital inputs (configurable: 8 or 16 channel): 12V-24V (30V tolerant)
- Digital (relay) outputs (configurable: 4, 8, 12 or 16 channel): 0-250V AC, 0-120V DC, 10A max
- Analog inputs (configurable: 8, 16, 24 or 32 channels @ 16bit):
    - Temperature: RTD, KTY, thermistor, Pt50, Pt100, Pt1000…
    - Current: 4-20mA, 0-20mA
- Analog outputs (2 channel):
    - 0-10V @ 12bit
- microSD card for data storage up to 64GB

LittlePLC is autonomous system, meaning that it's capable of controlling a given process without external interference of man or other computer systems. It also provides interface for high level external control and monitoring. littlePLC is modular; we can easily connect expansion boards if there's need to connect a large amount of sensors or control a large amount of peripheral devices. Block diagram of littlePLC is shown in the Figure below.

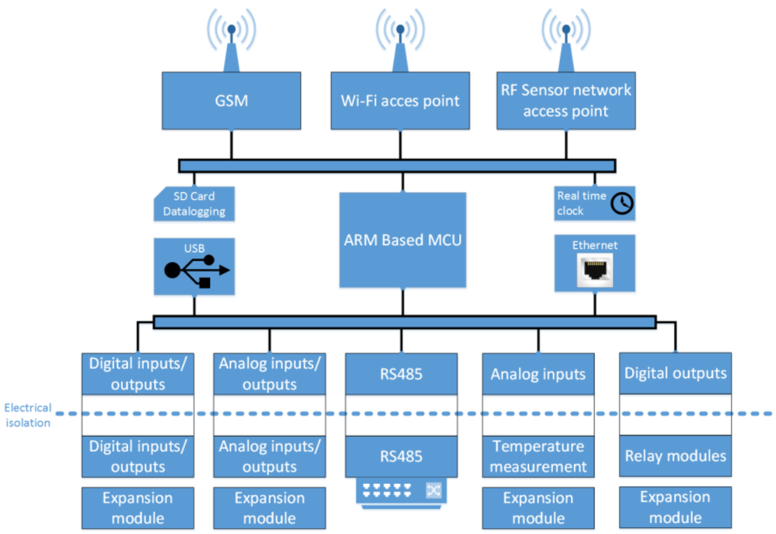


Figure 105 - littlePLC block diagram

LittlePLC has a wireless interface for our custom made wireless sensor modules described above. In configurations where wired sensors can't be installed or their location is not close to littlePLC, we will use wireless sensors.

Machine learning will be implemented on littlePLC. We will collect energy consumption data over time. In addition, the mathematical model of the heat pump will be improved over time by machine learning. The heat pump is a difficult system to model completely accurately in theory. Therefore, by applying machine learning concepts greatly improves the efficiency of the pump. Our system will be able to learn the daily routines of its' inhabitants so it can make smart, energy saving decisions, such as heating the water with lower power for longer time.

All the interfaces listed above are integrated into littlePLC to ensure great flexibility and future compatibility. It isn't important whether Mem**brain** has one, two or even more floors, or whether it has an air-water or water-water heat pump, littlePLC can control all HVAC configurations. In our configuration, littlePLC works in unison with Mem**brain's** central computer to achieve even better results in energy efficiency.

5.3.9.11 User interface

Mem**brain's** main user interface is a wall mounted tablet computer. It is connected to Mem**brain's** local area network. An Android application will be developed to give the user access to functionalities of the system. Readings from the wireless sensor network will be available through measurement interpretation software to the end user, as well as all control options and notifications. Use of Android allows for the application to be easily portable to a smartphone device, providing remote access.

Data from the sensor nodes, gathered and stored in a database on the Central Processing Unit, will be displayed through interactive graphs. This will serve an educational purpose as the application will advise the user how to achieve higher energy efficiency.

The user will be able to control the system parameters through the application or select high efficiency modes; in high efficiency mode the system takes full control to optimize energy consumption.

5.4 Energy Efficiency Design Narrative

5.4.1 Technical Project Summary

5.4.1.1 Project Dimensions

<u>House Geometry Characteristics</u>

Surface area of heated part of the house:

Table 24 - Facade elements

Facade	West	East	North	South
	(m^2)	(m^2)	(m^2)	(m^2)
Total	29,2	29,2	38,7	38,7
Openings (windows and doors)	17,4	17,4	2,5	27,9
without openings	11,8	11,8	36,2	11,8

Table 25 - Floor and roof area

Element	(m^2)
Floor according to ground	72,5
Roof	72,5

Table 26 - Geometric characteristics of house

Element	
The volume of the heated part of the building (Ve)	286,4 m^3
Heated area of the building (A)	280,8 m^2
Form factor (f=A/ Ve)	0,98 m^{-1}
Usable area (Ak)	45,0 m^2

<u>Heating and cooling of house</u>

The building is for residential purposes, i.e. family home. The whole building will be in one heat zone. Heating the house will be central, with the use of 100% renewable energy. Heat from the environment will be used as a source of renewable energy. Because of high temperatures during the summer the building will be air-conditioned. Average monthly temperature ext. of air in the coldest month on the building site $\Theta_{e,mj,min}$=5.3°C. Average monthly temperature ext. of air in the hottest month on the building site $\Theta_{e,mj,max}$=23.2°C. Number of air changes, n=0.5 (h1).

5.4.1.2 House Envelope

Buildings elements

1. External wall _1 : **A= 28,2 m²**

Table 27 - External wall_1 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	Internal linings of the wall (plaster)	1,0	0,3	900
2	GLT	6,0	0,15	550
3	Insulation (sheep wool)	20,0	0,035	50
4	OSB panel	2,0	0,13	650
5	Waterproof barrier	0,015	0,2	900
6	Ventilated layer of air	4,0	-	-
7	Wood (facade wall element)	3,0	0,18	800

2. External wall _2 (section through the pillar) : **A=4,2 m²**

Table 28 - External wall_2 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	Internal linings of the wall (plaster)	1,5	0,3	900
2	GLT	6,0	0,15	550
3	Insulation (sheep wool)	4,0	0,035	50
4	OSB panel	2,0	0,13	650
5	Waterproof barrier	0,015	0,2	900
6	Wood (substructure facades)	4,0	0,15	550
7	Wood (facade wall element)	2,0	0,18	800

3. Roof_1(above the heated space) : **A= 58,0 m²**

Table 29 - Roof_1 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	Suspended ceiling (PCM)	5,0	0,18	785
2	GLT	18,0	0,15	550
3	LD 100	0,015	0,5	980
4	Insulation (sheep wool)	16,0	0,035	50
5	OSB panel	2,0	0,13	650
6	Synthetic waterproofing	0,5	0,15	900

4. Roof_2(above greenhouse): **A= 14,5 m²**

Table 30 - Roof_2 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	GLT	18,0	0,15	550
2	LD 100	0,015	0,5	980
3	Insulation (sheep wool)	16,0	0,035	50
4	OSB panel	2,0	0,13	650
5	Synthetic waterproofing	0,5	0,15	550

5. Floor_1 (section through the wool) : **A= 58,0 m²**

Table 31 - Floor_1 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	Wood (parquet)	1,5	0,15	550
2	OSB panel	4,5	0,13	650
3	Insulation (sheep wool)	9,0	0,035	50
4	GLT	18	0,15	550
5	Insulation (sheep wool)	16,0	0,035	50
6	OSB panel	2,0	0,13	650
7	Waterproof barrier	0,015	0,2	900

6. Floor_2 (section through the beam) : **A= 14,5 m²**

Table 32 - Floor_2 layer

Layer	Material	d[cm]	λ[W/mK]	ρ[kg/m³]
1	Wood (parquet)	1,5	0,15	550
2	OSB panel	3,0	0,13	650
3	Wood (floor structures)	5,0	0,15	550
4	GLT	18	0,15	550
5	Insulation (sheep wool)	16,0	0,035	50
6	OSB panel	2,0	0,13	650
7	Waterproof barrier	0,015	0,2	900

Openings:

1. Windows:

Fixed window frames for passive and low energy houses. Designed in an open and flexible way in which it is possible to meet all the needs of passive solar buildings in terms of insulation and static properties. Innovative joints of wooden and aluminium parts enabled the unique flow isotherms. This design can be made fixed walls, facades and vertical cliffs winter gardens. Surface of a window is **A=3,48 m²**.

Internal windows:

Table 33 - Technical characteristic of internal windows

LIGHT CHARACTERISTICS (EN410) EN 410	
Bandwidth light τv (%)	78
Reflection of light ρv (%)	13
Interior reflection of light ρvi (%)	13
Compliance colors RD65-Ra (%)	97
ENERGY CHARACTERISTICS EN 410 ISO 9050	
Solar factor g (%)	49
Reflection energy ρe (%)	24
Direct energy permeability τe (%)	45
Solar absorption of glass 1 αe (%)	28
Solar absorption of glass 2 αe (%)	3 3
Total energy absorption αe (%)	31
Shading coefficient (g) SC 0.6	0.56
UV Permeability UV (%)	0
Solar factor g (%)	49
THICKNESS AND WEIGHT	
Nominal thickness (mm)	26
Weight (kg/m²)	25.0
HEAT CHARACTERISTICS (EN 673) EN 673	
Ug- value - W/(m².K)	1,1

External window:

Table 34 - Technical characteristic of external windows

LIGHT CHARACTERISTICS (EN410) EN 410	
Bandwidth light τv (%)	66
Reflection of light ρv (%)	17
Interior reflection of light Ra (%)	94
Compliance colors RD65 - Ra (%)	94
ENERGY CHARACTERISTICS EN 410 ISO 9050	
Solar factor g (%)	40
Reflection energy ρe (%)	25
Direct energy permeability τe (%)	32
Solar absorption of glass 1 αe (%)	33
Solar absorption of glass 2 αe (%)	66
Solar absorption of glass 3 αe (%)	65
Total energy absorption αe (%)	44
Shading coefficient (g) SC 0.6	0.46
UV Permeability UV (%)	0
THICKNESS AND WEIGHT	
Nominal thickness (mm)	52
Weight (kg/m^2)	50
HEAT CHARACTERISTICS (EN 673) EN 673	
Ug- value - W/(m^2.K)	0,6

2. Front door:

Door + front door with its thermal conductivity reaching up to U_D = 0.46 W/m²K. Intended for passive and low energy houses with technical features and design in line with the same name from the windows "Bluegreen" lines. Using the technique of wood–aluminium. Outside the coated aluminium panel, weatherproof. Interior, wooden part of the door that will suit your interior provides a natural and comfortable atmosphere in your home, good thermal insulation and provides exceptional residential climate. Door + the door open for modern design demands of the customer. Door surface is A=2,5 m².

Table 35 - Technical characteristic of front door

Opening name	U [w/m²K]	Orientation	n
Front door	0,80	North	1,00

5.4.2 Comprehensive Energy Analysis and Discussion

Introduction

Heat concept Mem**brain** house are well insulated roof, floor and wall, insulated with sheep's wool, and membrane of two layers of the sandwich windows. From energy conservation point of view, increasing heat insulation is important to reduce heat load of the house. Therefore, we calculate air conditioning heat load of Mem**brain** House in Paris by using “Autodesk Ecotect Analysis”. “Autodesk Ecotect Analysis” is the simulation software for model energy consumption and air conditioning heat load.

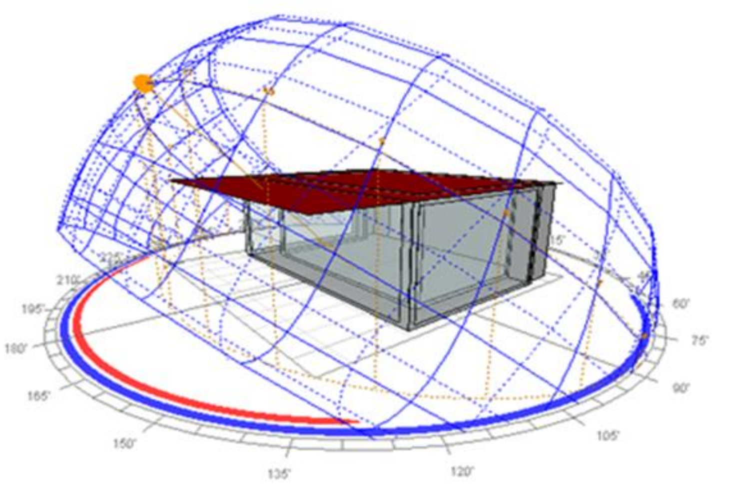


Figure 106 - Model for the thermal calculation – allows to view the intrusion of sunlight at any time of the day and year

Information about the software “Autodesk Ecotect Analysis”:

Ecotect is a building analysis program that gives its users an array of tool that helps in the design of a more energy efficient building. The feedback received from Ecotect helps in both the conceptual stages of design and helps validate the final design. Among its many features Ecotect does shadows & reflections, shading design, solar analysis, thermal analysis, ventilation & airflow, etc. The feedback received from Ecotect shows results in 3D, which help visualize the data. Many of these calculations are easily done through the calculation wizards. These are step by-step guides that help the user through the calculation analysis. Ecotect has a steep learning curve. Learning the program starts slow but quickly accelerates.

Even though Ecotect has its own 3D modeling interface, it gives its users a wide range of import options such as 3DS and DXF formats. Importing geometry into Ecotect could be quite cumbersome and may require editing.

The program sometimes does not understand all the geometry being imported and different results may occur. To reduce this problem it's necessary to only import what you need.

The student version of the program is available as a free download through the Autodesk website and has all the same features of a commercial version. In addition to Ecotect, the download comes with Solar Tool & Weather Tool, which compliment Ecotect. Because of its flexibility, Ecotect is by far the most useful program in its category. As of today, Ecotect is only available for window base platforms.

House and Systems Description

The goal of Mem**brain** house is to provide the balance between energy consumed and produced renewable energy. Because openings area of Mem**brain** house is larger than standard detached house, heat loss from openings affects whole heat loss coefficient of the house. Therefore we ensure membranes heath around the house. The membrane is made of two layers of windows separated by useful space.

U value of house elements

Calculation of building components

Table 36 - U value of house elements

Name of the construction part	A[m^2]	U[W/m^2K]	U_{max}[W/m^2K]	OK
External wall_1	28,20	0,15	0,35	✔
External wall _2	4,20	0,29	0,45	✔
Floor _1	58,00	0,13	0,50	✔
Floor _2 :	14,50	0,15	0,30	✔
Roof _1	58,00	0,15	0,30	✔
Roof _2	14,50	0,16	0,30	✔

Meteorological Parameters

Paris has an oceanic climate and is influenced by the North Atlantic Current, which rare delivers extremely high or low temperatures. Paris has warm and pleasant summers with average high temperatures of 25 ° C and low of 15 ° C. Winters are cold, but the temperature is approximately 3°C to 8°C, and rarely drops below zero. For our calculation of energy use for heating and cooling the house, we used a file “FRA_Paris.Orly.071490_IWEC.epw” with weather data for Paris.

Location: PARIS_ORLY, FRA (48.7°, 2.4°)
Data: 1st January- 31. December
Time: 00:00 – 24:00
Weather Manager

Weekly Summary

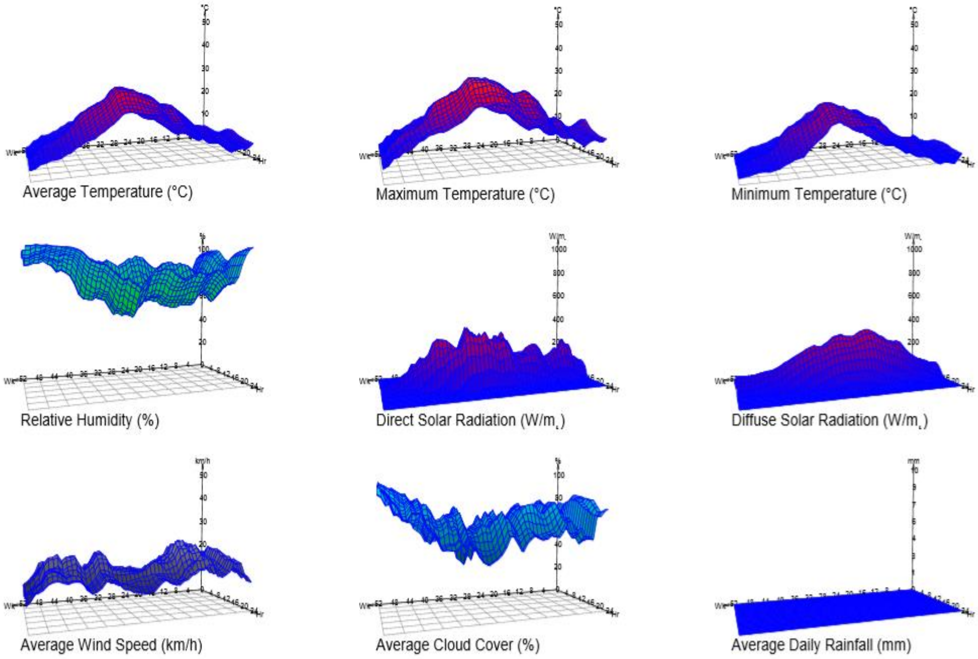


Figure 107 - Weekly Summary

Wind frequency

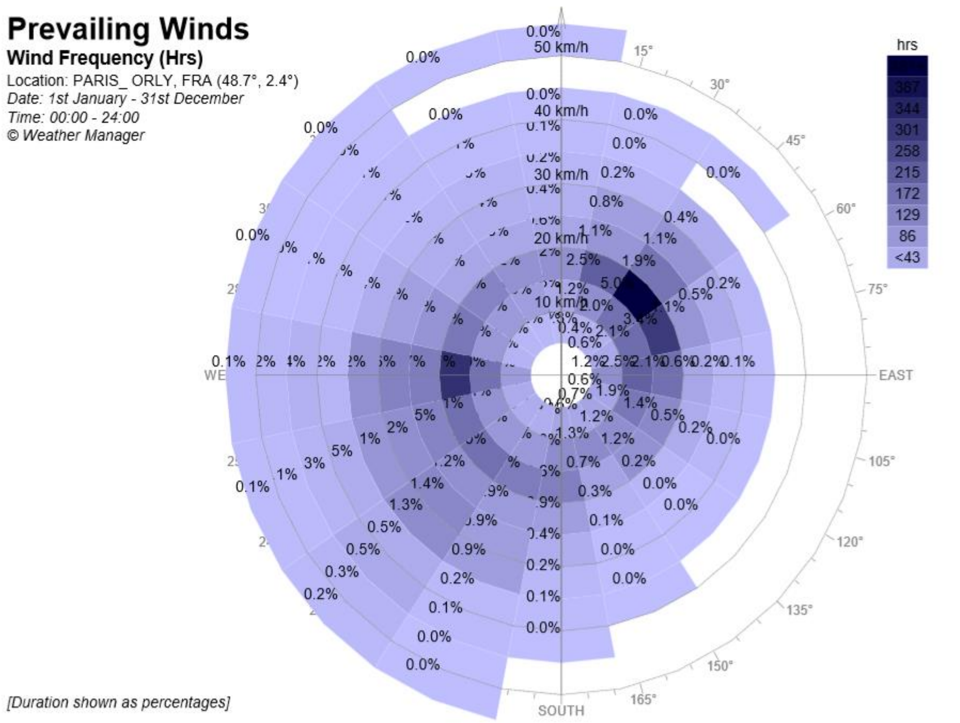


Figure 108 - Wind frequency- shows the frequency, average and maximum winds speed for given orientation

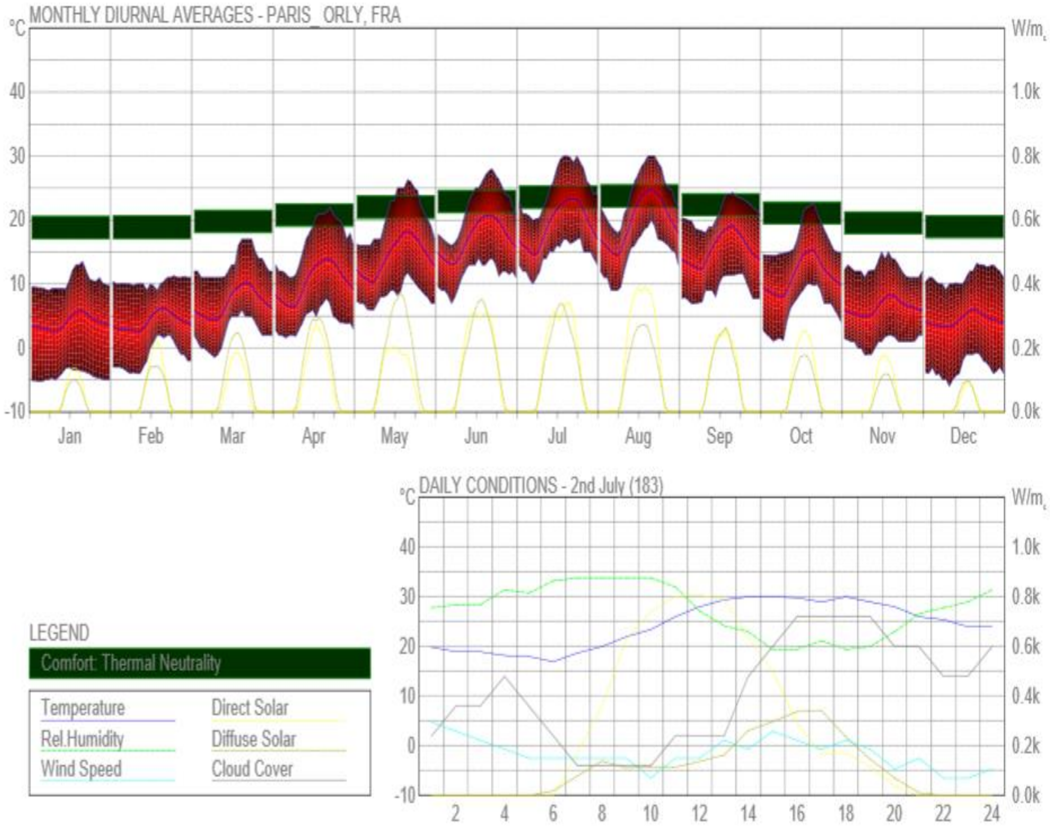


Figure 109 - Monthly diurnal averages

Climate Summary

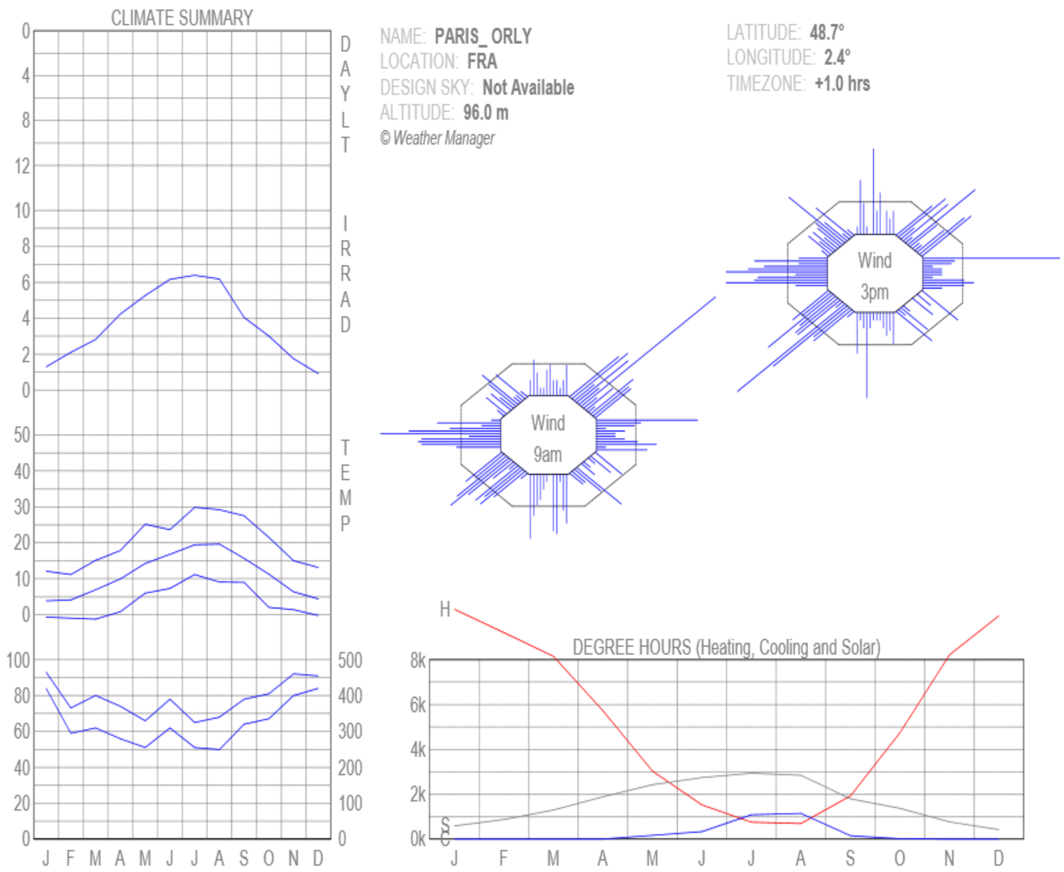


Figure 110 - Climate summary- overall climatic data for the energy efficiency calculation

Results and Discussions

Result of solar access analysis:

The results are shown areas of the house that are most exposed to sunlight as shown in the figures below.

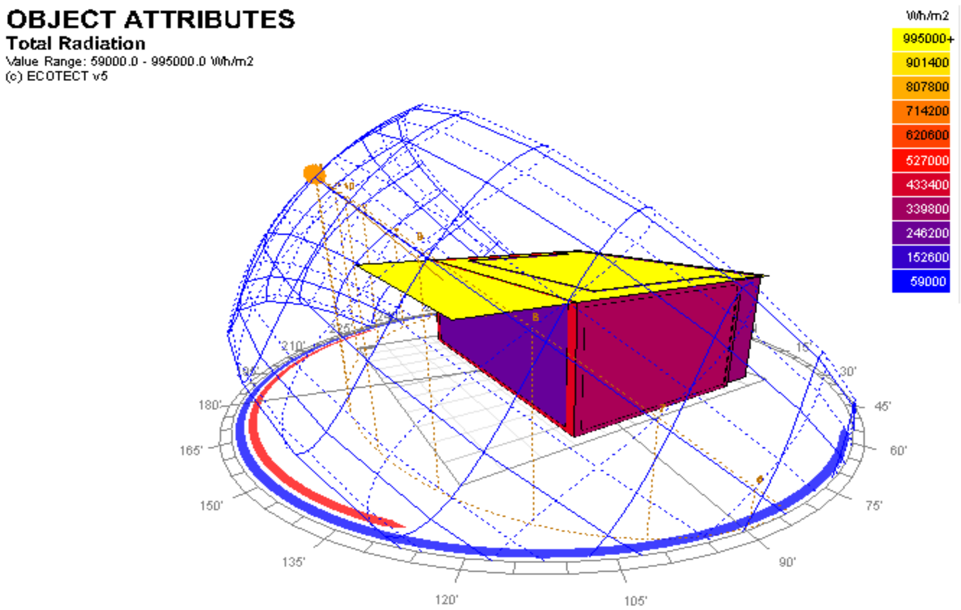


Figure 111 - Model of total radiation

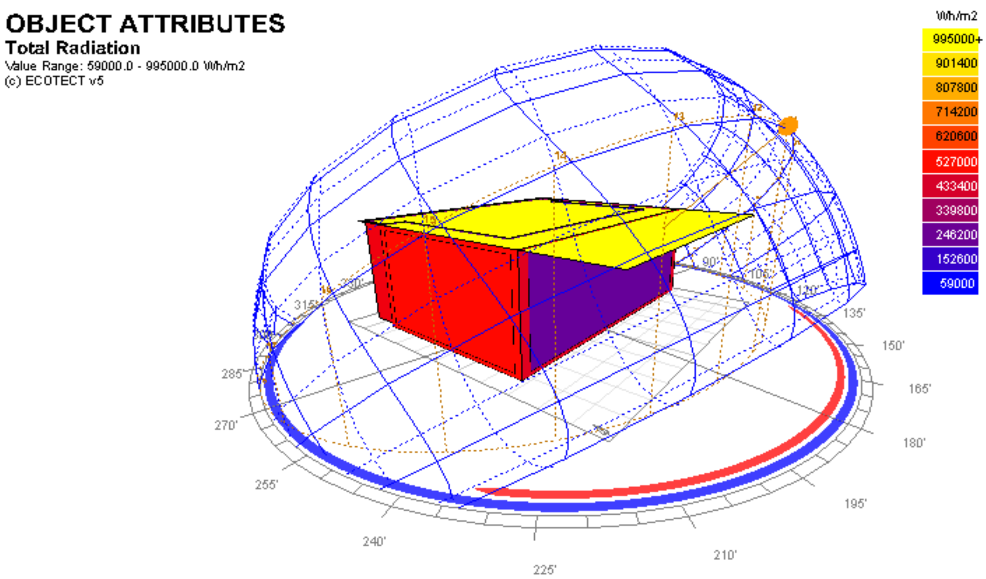


Figure 112 - Model of total radiation

Result of annual load calculation (cooling load + heating load):

Positive values show heat load and negative values shows heating load in result of cooling load calculation.

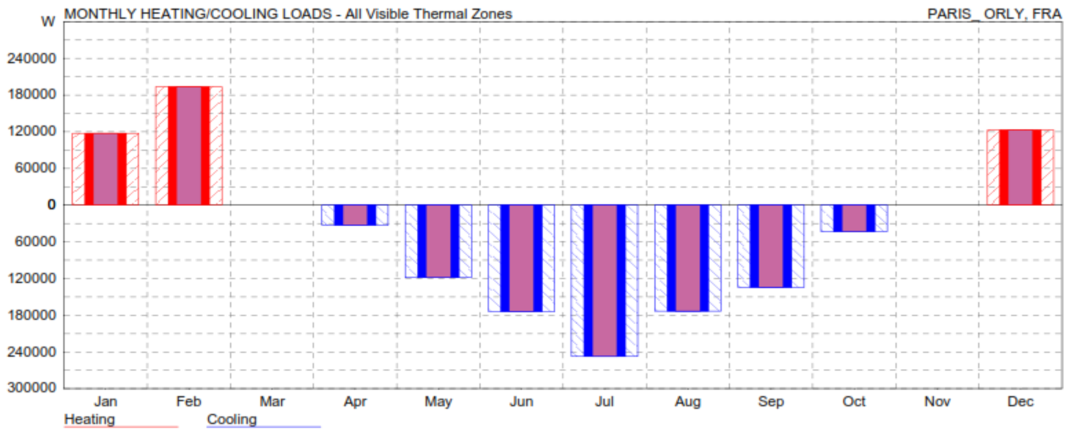


Figure 113 - Cooling and heating load- results are shown in the annual energy for heating and / or cooling by month

Monthly heating/cooling loads

All visible thermal zones

Comfort: zonal bands

Max Heating: 2369 W at 22:00 on 26th January

Max Cooling: 2715 W at 15:00 on 20th August

Table 37 - Monthly heating and cooling load in Wh

MONTH	HEATING (Wh)	COOLING (Wh)	TOTAL (Wh)
Jan	117316	0	117316
Feb	193369	0	193369
Mar	0	0	0
Apr	0	33107	33107
May	0	118805	118805
Jun	0	174094	174094
Jul	0	247552	247552
Aug	215	173497	173712
Sep	0	134611	134611
Oct	0	43719	43719
Nov	0	0	0
Dec	122722	0	122722
TOTAL	433621	925385	1359007
PER m²	5979	12759	18737

The results of the annual energy consumption for heating are shown below in the Figure 114, it can be seen that house belongs to the energy class A +.

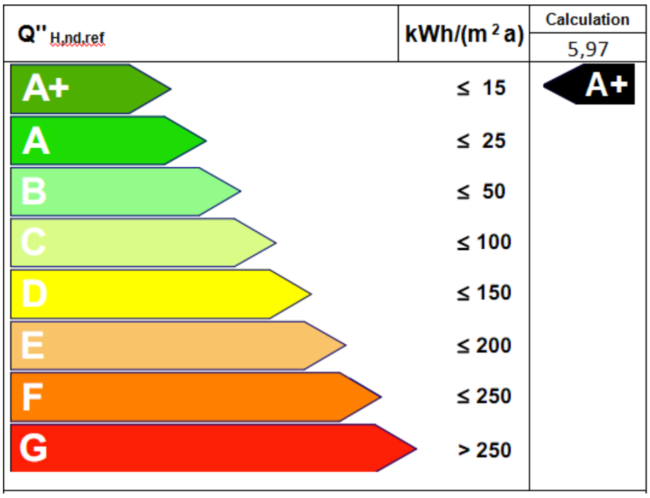


Figure 114 - House energy class

Annual temperature distribution

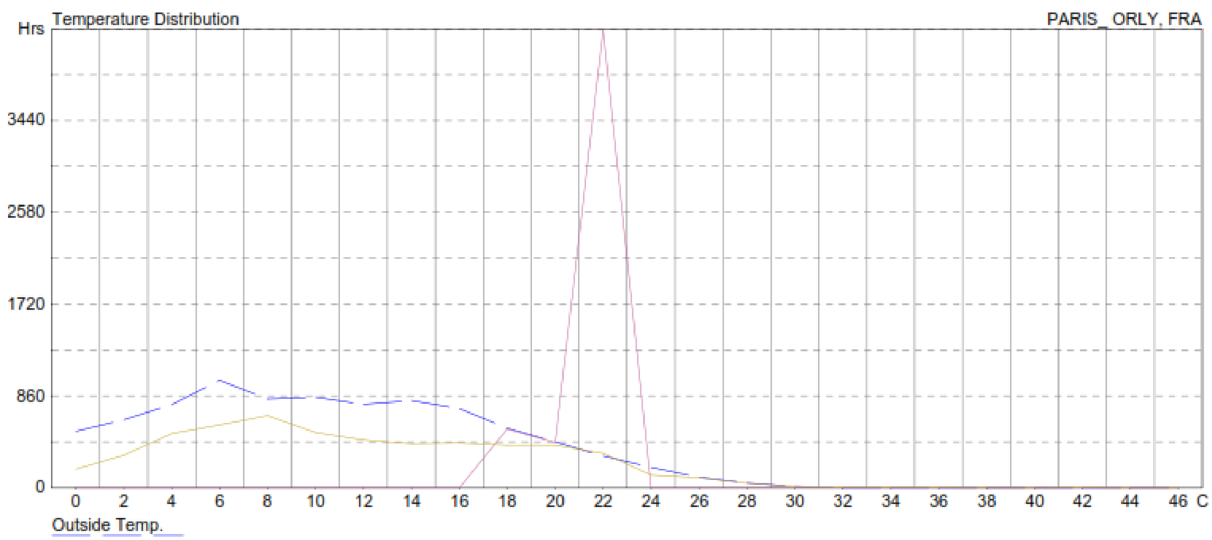


Figure 115 - Annual temperature distribution

Fabric Gains: Qc + Qs

Fabric gains will be most pronounced in June, July and August, what you can see below in the Figure 116.

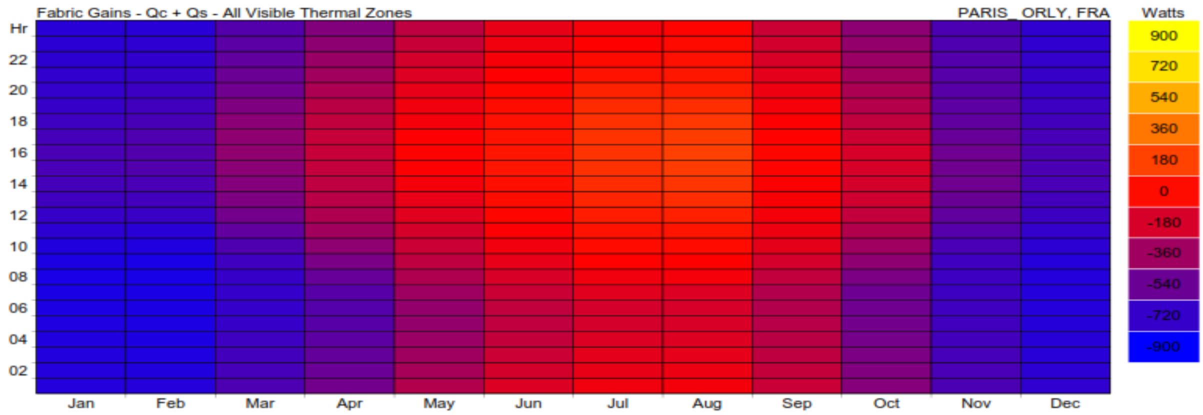


Figure 116 - Fabric Gains

Annual loads table

All Visible Thermal Zones – Monthly Averages

Table 38 - Annual loads table

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)
00	-779	-774	-640	-511	-299	-160	-89	-79	-227	-450	-645	-741
01	-780	-788	-664	-541	-338	-191	-119	-102	-240	-467	-653	-750
02	-784	-796	-677	-565	-364	-217	-133	-127	-255	-486	-664	-763
03	-791	-800	-691	-590	-378	-241	-159	-151	-273	-506	-673	-766
04	-796	-804	-714	-605	-400	-253	-184	-171	-283	-512	-681	-770
05	-805	-807	-722	-614	-404	-248	-184	-180	-296	-524	-688	-776
06	-811	-810	-720	-607	-368	-218	-142	-155	-301	-531	-692	-779
07	-814	-818	-715	-556	-309	-172	-89	-76	-247	-482	-693	-782
08	-804	-814	-687	-489	-258	-120	-39	-40	-186	-421	-683	-773
09	-789	-792	-638	-416	-216	-84	-3	-6	-129	-361	-654	-749
10	-751	-760	-573	-352	-182	-53	22	27	-98	-298	-614	-724
11	-714	-707	-515	-310	-143	-26	54	67	-78	-242	-571	-695
12	-683	-676	-474	-277	-114	-2	82	110	-58	-201	-545	-672
13	-665	-652	-456	-261	-76	9	106	138	-48	-189	-521	-652
14	-652	-627	-430	-243	-46	28	124	159	-30	-175	-521	-643
15	-648	-622	-414	-233	-39	30	132	175	-23	-175	-524	-642
16	-665	-632	-417	-233	-46	23	130	161	-35	-208	-553	-661
17	-689	-656	-432	-250	-76	13	124	143	-49	-248	-576	-676
18	-713	-678	-476	-273	-89	-2	104	115	-72	-292	-591	-694
19	-724	-698	-521	-316	-121	-19	74	64	-99	-321	-604	-708
20	-734	-715	-538	-354	-156	-45	22	33	-132	-349	-610	-713

Indirect Solar Gains: Qs

In the Figure 117 can be seen that for Paris weather conditions, indirect solar gains will be most pronounced from May to August, in a range from 14 to 20 hours.

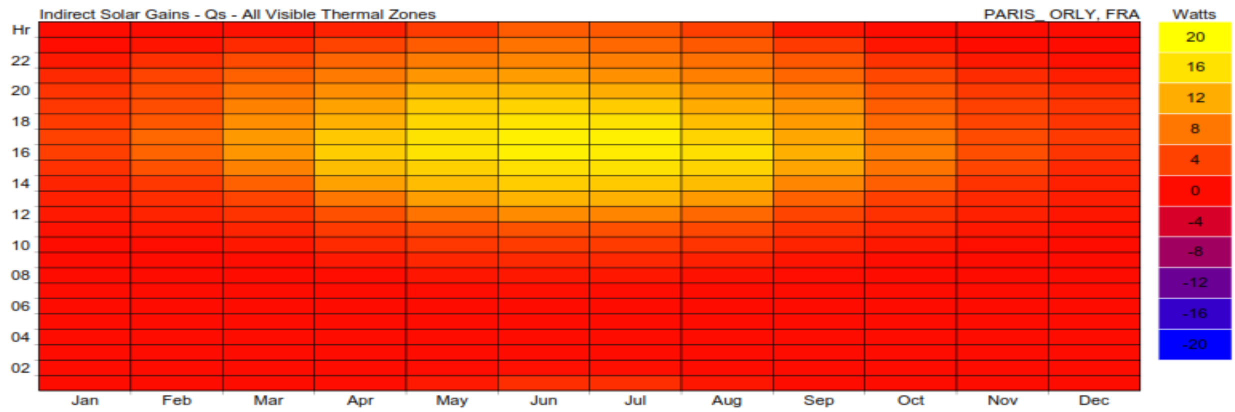


Figure 117 - Indirect solar gains

Annual loads table

All Visible Thermal Zones – Monthly Averages

Table 39 - Indirect solar gains result

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)
00	0	0	0	0	1	2	3	1	0	0	0	0
01	0	0	0	0	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0	0	0	0	0
05	0	0	0	0	0	0	0	0	0	0	0	0
06	0	0	0	0	0	0	0	0	0	0	0	0
07	0	0	0	0	1	1	1	0	0	0	0	0
08	0	0	0	1	2	2	2	1	1	0	0	0
09	0	0	1	2	3	4	3	3	2	1	0	0
10	0	1	2	3	4	5	5	4	3	2	1	0
11	1	2	3	5	8	10	9	7	4	3	2	1
12	1	2	4	8	11	13	12	11	6	4	2	1
13	2	3	6	11	13	14	14	13	9	6	3	1
14	3	5	9	13	15	16	16	15	11	8	4	2
15	4	7	10	14	16	17	17	16	12	8	5	3
16	4	7	11	14	16	17	17	15	12	8	5	3
17	4	6	10	12	15	16	16	13	11	7	4	3
18	3	5	9	11	14	15	14	12	10	6	4	3
19	3	5	8	10	13	13	12	10	8	5	3	2
20	2	4	6	8	10	11	10	9	7	4	2	1

21	1	3	5	7	8	9	8	7	6	3	1	0
22	0	1	2	4	6	8	7	6	3	1	0	0
23	0	0	0	2	3	6	6	4	1	0	0	0

Direct Solar Gains: Qg

Direct solar gains are significant throughout the whole year in the time period from 12 to 16 hours, what can be seen in the Figure 118.

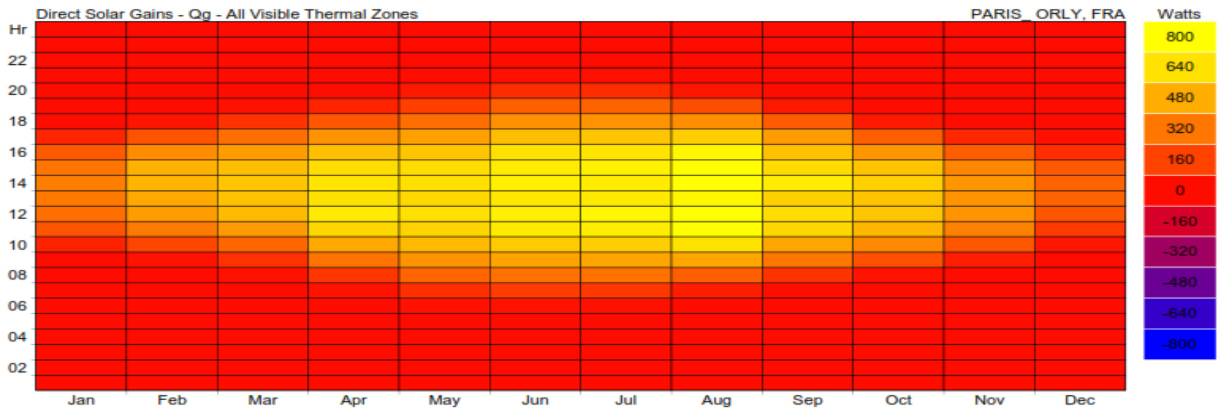


Figure 118 - Direct solar gains

Annual loads table

All Visible Thermal Zones – Monthly Averages

Table 40 - Direct solar gains result

HOUR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)
00	0	0	0	0	0	0	0	0	0	0	0	0
01	0	0	0	0	0	0	0	0	0	0	0	0
02	0	0	0	0	0	0	0	0	0	0	0	0
03	0	0	0	0	0	0	0	0	0	0	0	0
04	0	0	0	0	0	0	0	0	0	0	0	0
05	0	0	0	0	10	20	13	0	0	0	0	0
06	0	0	0	18	105	145	129	51	3	0	0	0
07	0	0	15	124	261	300	303	247	112	19	0	0
08	1	17	109	307	403	451	457	462	318	200	55	0
09	64	173	269	466	515	568	578	639	458	373	222	28
10	213	329	428	602	593	662	669	749	605	506	348	134
11	296	428	521	662	632	678	699	769	624	552	402	215
12	324	466	541	635	609	655	660	701	584	546	406	255
13	341	501	553	646	632	681	670	727	669	584	412	261
14	314	492	530	624	622	667	684	745	614	546	363	225
15	233	381	434	535	553	636	643	697	539	409	244	98
16	72	212	293	399	438	528	551	579	423	244	79	12

17	2	26	114	219	292	395	402	391	238	37	0	0
18	0	0	14	68	148	248	258	193	36	0	0	0
19	0	0	0	6	38	94	95	30	0	0	0	0
20	0	0	0	0	1	11	8	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0	0	0

Ventilation Gains: Qv

Results show that the ventilation gains be the most significant in June, July and August, as can be seen in the Figure 119.

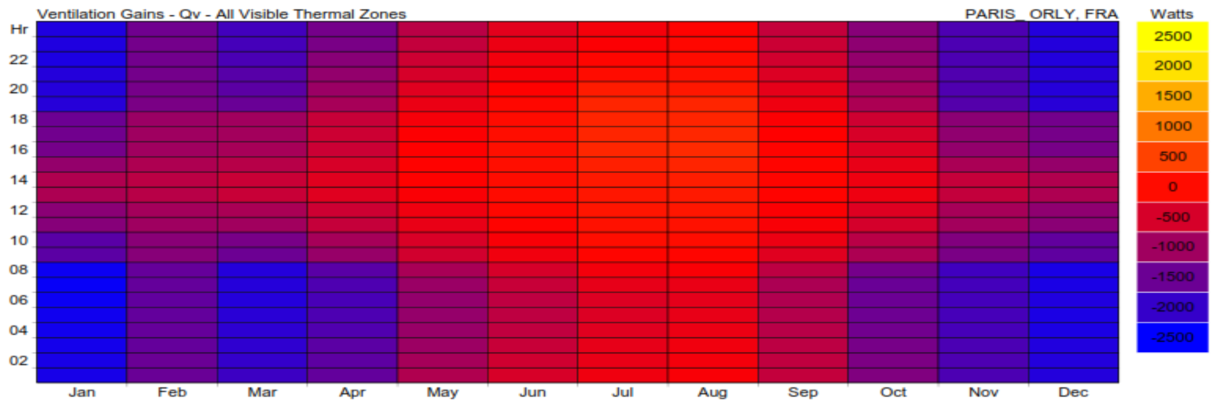


Figure 119 - Ventilation gains

Annual loads table

All Visible Thermal Zones – Monthly Averages

Table 41 - Ventilation gains result

HOU	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	(Wh)	(Wh)	(Wh)	(Wh)	(Wh)	(Wh	(Wh	(Wh	(Wh	(Wh)	(Wh)	(Wh)
00	-	-	-	-	-855	-	-	-	-	-	-	-
01	-	-	-	-	-947	-	-	-	-	-	-	-
02	-	-	-	-	-	-	-	-	-	-	-	-
03	-	-	-	-	-	-	-	-	-	-	-	-
04	-	-	-	-	-	-	-	-	-	-	-	-
05	-	-	-	-	-	-	-	-	-	-	-	-
06	-	-	-	-	-	-	-	-	-	-	-	-
07	-	-	-	-	-916	-	-	-	-	-	-	-
08	-	-	-	-	-544	-	-70	-65	-	-880	-	-
09	-	-	-	-948	-469	-	5	-1	-	-769	-	-
10	-	-	-994	-653	-321	-83	44	43	-	-512	-969	-
11	-	-962	-904	-583	-255	-46	85	94	-	-423	-938	-
12	-880	-779	-631	-404	-160	-13	89	123	-82	-269	-676	-869

13	-849	-752	-616	-393	-109	-2	119	154	-77	-261	-660	-842
14	-	-867	-784	-484	-100	21	179	218	-76	-328	-904	-
15	-	-	-940	-605	-115	26	238	281	-82	-422	-	-
16	-	-	-976	-594	-134	8	235	252	-	-492	-	-
17	-	-	-990	-633	-203	-9	218	222	-	-567	-	-
18	-	-	-	-940	-305	-48	230	229	-	-890	-	-
19	-	-	-	-	-406	-	139	99	-	-978	-	-
20	-	-	-	-	-498	-	2	32	-	-	-	-
21	-	-	-	-	-585	-	-70	-11	-	-	-	-
22	-	-	-	-	-671	-	-	-47	-	-	-	-
23	-	-	-	-	-762	-	-	-92	-	-	-	-

Internal Gains: Qi

The Figure 120Figure 120 - Internal gains below shows that the internal heat gains are present throughout the year, but will be most pronounced in February and August.

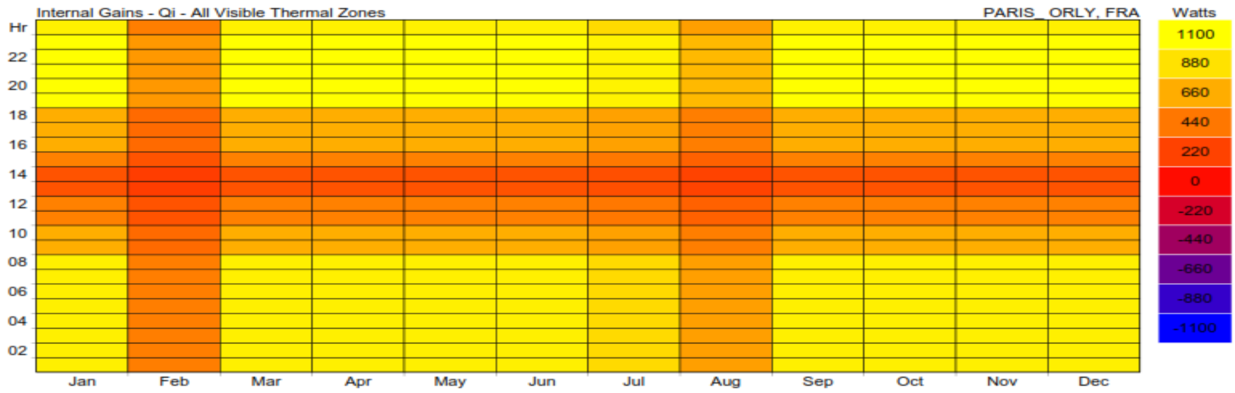


Figure 120 - Internal gains

Annual loads table

All Visible Thermal Zones – Monthly Averages

Table 42 - Internal gains result

HOU	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	(Wh)	(Wh	(Wh)	(Wh)	(Wh)	(Wh)	(Wh	(Wh	(Wh)	(Wh)	(Wh)	(Wh)
—	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
00	936	468	936	936	936	936	845	604	936	936	936	936
01	936	468	936	936	936	936	845	604	936	936	936	936
02	936	468	936	936	936	936	845	604	936	936	936	936
03	936	468	936	936	936	936	845	604	936	936	936	936
04	936	468	936	936	936	936	845	604	936	936	936	936
05	936	468	936	936	936	936	845	604	936	936	936	936
06	936	468	936	936	936	936	845	604	936	936	936	936
07	936	468	936	936	936	936	845	604	936	936	936	936

08	666	385	666	666	666	666	612	467	666	666	666	666
09	666	385	666	666	666	666	612	467	666	666	666	666
10	479	292	479	479	479	479	443	346	479	479	479	479
11	479	292	479	479	479	479	443	346	479	479	479	479
12	292	198	292	292	292	292	274	225	292	292	292	292
13	292	198	292	292	292	292	274	225	292	292	292	292
14	479	292	479	479	479	479	443	346	479	479	479	479
15	666	385	666	666	666	666	612	467	666	666	666	666
16	666	385	666	666	666	666	612	467	666	666	666	666
17	666	385	666	666	666	666	612	467	666	666	666	666
18	104	573	104	104	104	104	950	708	104	104	104	104
19	104	573	104	104	104	104	950	708	104	104	104	104
20	104	573	104	104	104	104	950	708	104	104	104	104
21	104	573	104	104	104	104	950	708	104	104	104	104
22	104	573	104	104	104	104	950	708	104	104	104	104
23	936	468	936	936	936	936	845	604	936	936	936	936

Gains breakdown:

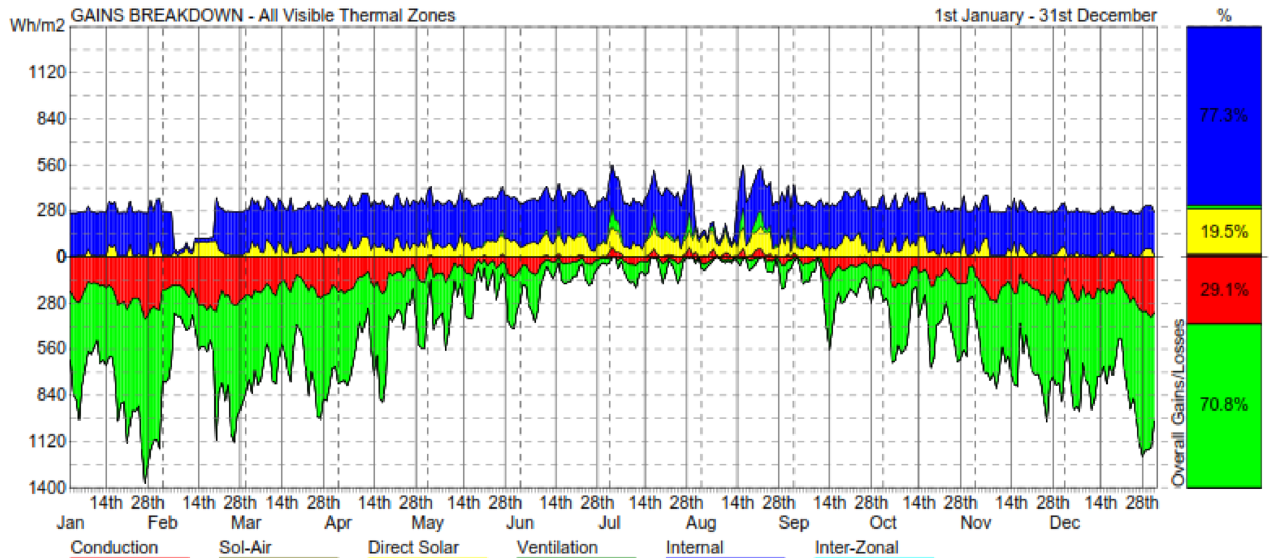


Figure 121 - Gains breakdown

GAINS BREAKDOWN – All Visible Thermal Zones

FROM: 1st January to 31st December

Table 43 - Gains breakdown result

CATEGORY	LOSSES	GAINS
FABRIC	29.1%	1.0%
SOL-AIR	0.0%	0.4%

SOLAR	0.0%	19.5%
VENTILATION	70.8%	1.7%
INTERNAL	0.0%	77.3%

Passive adaptability index: 0,19

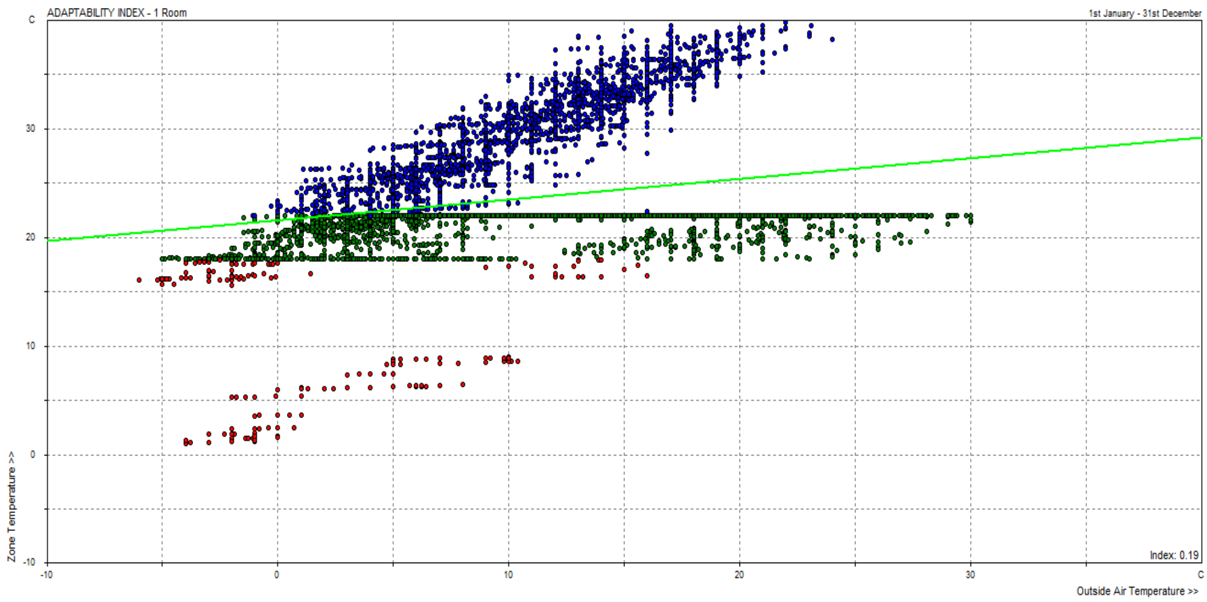


Figure 122 - Passive adaptability index

Temp/gains comparison:

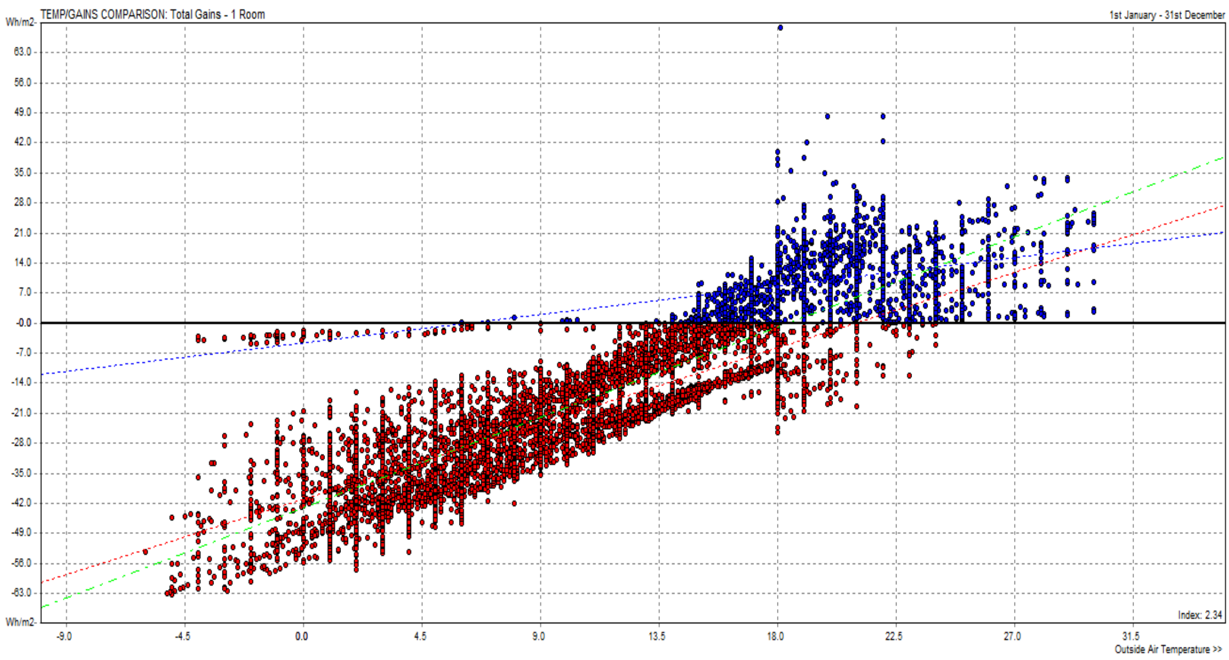
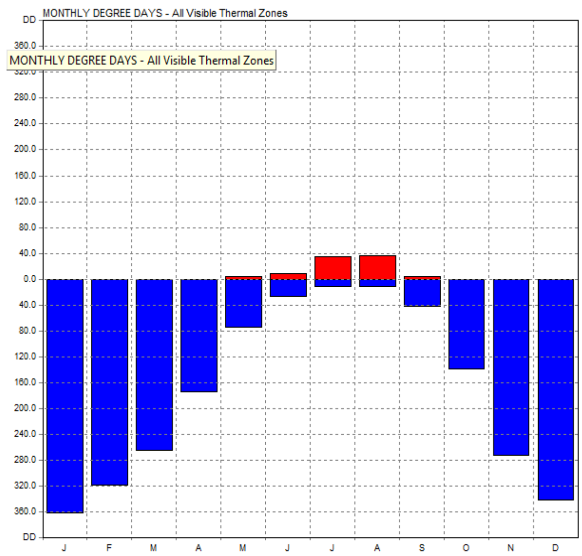


Figure 123 - Temp/gains comparison

Monthly degree days:



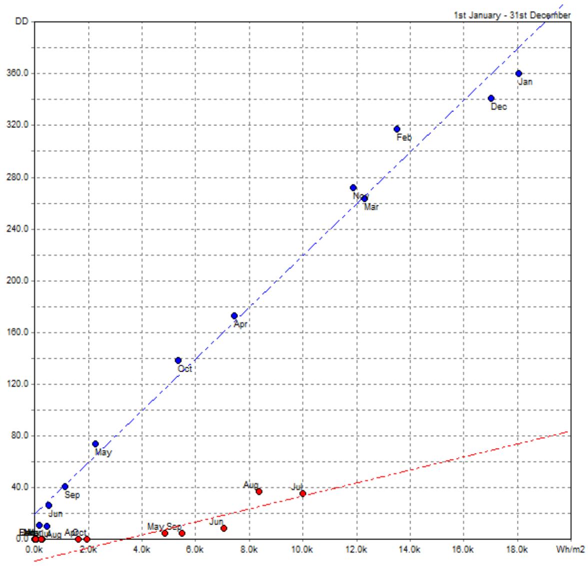


Figure 124 - Monthly degree days

Table 44 - All Visible Thermal Zones

MONTH	HEATDD	COOLDD	LOSSES	GAINS
	(dd)	(dd)	(Wh)	(Wh)
Jan	360.5	0.0	18045	75
Feb	317.6	0.0	13510	3
Mar	263.8	0.0	12292	282
Apr	173.3	0.1	7427	1624
May	74.0	4.8	2246	4858
Jun	26.6	8.9	505	7054
Jul	11.3	35.3	163	9985
Aug	10.6	37.2	444	8348
Sep	41.2	4.7	1134	5490
Oct	138.4	0.4	5360	1925
Nov	272.2	0.0	11886	226
Dec	341.2	0.0	17026	6

5.4.2.1 Influence of Energy Analysis on House Design and Competition Strategy

The passive/selective envelope of the house and a smart system controlling the outer membrane and inner environment. We used the idea of a membrane - which protects the cell and regulates the conditions between the exterior and the interior – as the skin of the house, regulating the physical properties of the building (temperature, humidity and indoor air quality).

The membrane is located on all six sides of the cell, and it adapts to the location, access, orientation and other conditions (it can function inside a city block, in the suburbs, on a southern mountain slope, etc.). It is completely prefabricated and modular, and can easily be assembled / disassembled. The membrane doesn't simply protect its costumer, it hosts various functions by itself, but it's the combination with the void space that results in a wide range of possible uses of the house.

The Mem**brain** as a multi-layer system consisting of three basic layers – load bearing structure, insulation and infra layer. Two types of insulation are used in this project - sheep wool and glazing.

Advantages of sheep wool are low cost and local availability. Wool is hygroscopic material and absorbs and releases moisture from the surrounding air without any effect on thermal efficiency. During cold weather, wool absorbs warmth from moisture in air, which enables building to reduce warmth losses. During warm periods, releasing absorbed moisture has performance of cooling and stopping warmth to get into a building. That keeps building cooler during the day and warmer during the night, so heating and cooling requirements are minimized. This property improves state of comfort, saves energy and contributes to healthier microclimate.

Table 45 - Sheep wool specification

Density ρ (kg/m^3)	30-50
Specific heat capacity c (J/kgK)	1100
thermal conductivity coefficient λ (W/mK)	0,035

A benefit of window is transparency, which enables a high level of solar gains in winter period. Three sides of the façade, the southern, the eastern, and the western, consist of an outer and inner layer, made of triple and double glazed panels respectively, providing a high daylight factor.

Table 46 - Technical characteristic of double glazed panels

LIGHT CHARACTERISTICS (EN410) EN 410	
Bandwidth light τv (%)	78
Reflection of light ρv (%)	13
Interior reflection of light ρvi (%)	13
Compliance colors RD65-Ra (%)	97

HEAT CHARACTERISTICS (EN 673) EN 673	
Ug- value - W/(m².K)	1.1

Table 47 - Technical characteristic of triple glazed panels

LIGHT CHARACTERISTICS (EN410) EN 410	
Bandwidth light τv (%)	66
Reflection of light ρv (%)	17
Interior reflection of light Ra (%)	94
Compliance colors RD65 - Ra (%)	94
HEAT CHARACTERISTICS (EN 673) EN 673	
Ug- value - W/(m².K)	0,6

This proposal was required to find the adequate ratio of sheep wool and glazing used to insulate the void space properly.

Air in the greenhouse and winter garden can be used to warm up the void space during winter, or serve as a buffer to prevent overheating during summer, becoming an integral part of the insulation.

By making three sides of the façade translucent, we also had to think of ways to provide appropriate sunshade, avoiding overheating during summer. The eastern and western facades are partially protected by plants grown in the greenhouse. They also ensure privacy to some degree, as they serve as a visual barrier, still enabling the customer's view to the outside. In order to ensure complete shading and outside view protection if needed, there are roll up shades on each side. They shades are placed outside the outer glazing layer, and are rolled up horizontally. The south façade is protected by an innovative building integrated PV tracking system (which will be explained in more detail in a separate section below).

5.4.2.2 Projected Performance of Final Housing unit Design

The two layers enclose the greenhouse (to the east and west) and winter garden (to the south) space.

The winter garden and greenhouse serves not only as a space for leisure, relaxation, organic farming but also plays an important role in maintaining an optimum climate inside the house, as shown in the Figure 125. During summer, the winter garden space is a buffer, and the warm air inside is allowed to escape outside, preventing the inner glazing, and thereby the void, from overheating. At night, all air inside the void is exchanged with fresh air from outside through the winter garden, cooling the whole house in the process. During winter, the winter garden is used to generate the greenhouse effect – the warmed up air is used to contribute to the warmth of the void. At night, this space serves as a buffer again.

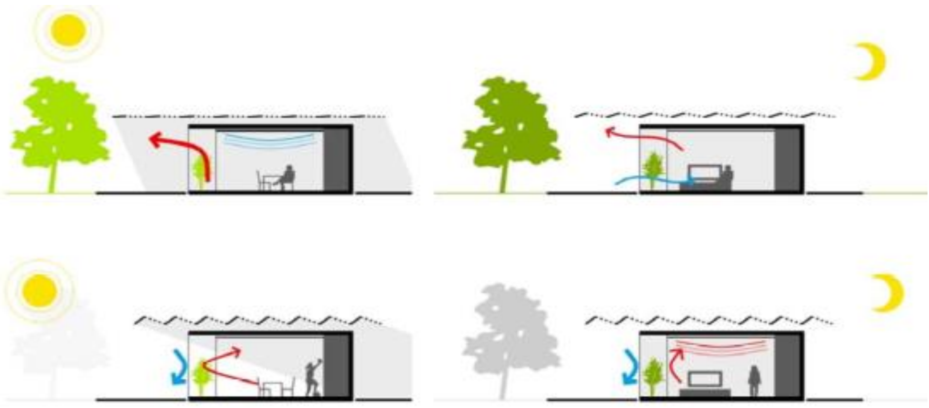


Figure 125 - Use of winter garden and greenhouse for maintaining an optimum indoor climate during summer and winter

The northern facade is non-translucent. It consists of panels that are attached between columns. Each panel is made of several layers, the innermost being cross-laminated plywood, followed by a vapor barrier, a 20 cm thick sheep wool layer and finally the outermost façade layer fixed on a secondary wooden construction. The outermost layer depends on the surroundings the house is placed in and can vary in thickness and material.

Insulation atop the roof and beneath the floor slab is also provided by a sheep wool layer of 16 cm (for the roof) and 21 cm (for the floor) thickness covered with a plywood panel to the outside.

The roof is additionally protected by a single surface synthetic hydro insulation. The insulation is simply placed atop the roof and bent down over the roof edges into the gutter. Then, it gets additionally fixed on the bent over parts. Every time the house is adjusted in any way (adding or reducing the number of modules) or moved to a different location, the insulation is removed and placed again in one single piece, preventing any harm to it.

The air temperature is regulated by an under floor heating and cooling system. Underfloor heating systems work with warm water circulating through pipes which are laid under the floor covering. The heat from the water is absorbed by the floor surface and transferred to the rest of the space, mainly through radiation. This type of heating system allows lower operating temperatures, while maintaining the thermal comfort of the space.

Underfloor cooling uses the same infrastructure and equipment as underfloor heating, but in this case cold water is circulated through the pipes. The flowing water absorbs the heat from the floor; simultaneously the chilled floor absorbs sensible heat from people, equipment and other objects.

The ventilation system also regulates the humidity of the greenhouse and the winter garden space, enabling the transfer of warm from these spaces into the void during to benefit from the greenhouse effect during the winter.

In order to solve problem reduce heat accumulation, we use phase-change materials (PCM), which have a much greater ability to store heat than conventional building materials. The PCM is placed beneath the roof slab and covered by a dropped ceiling.

5.4.2.3 Adaptations made by the Team in the house for the prototype in Versailles

Mem**brain** basic idea is to be adaptable to every environment, therefore although primarily intended for use in Zagreb, we are not made significant adjustments for house prototype in Versailles.

The only adjustment that we will do during the exhibition in Versailles is that we will use an air to water heat pump. Due to the SDE rules teams are unable to drill the collector in the ground, but in Borongaj campus site heat pump will be converted to water source in order to increase its efficiency.

5.4.3 HVAC Systems

HVAC system is the main house system designed for achieving thermal comfort in conditioned spaces. System designed as part of Mem**brain** project will satisfy needs for heating, cooling, dehumidification, domestic hot water preparation and ventilation of the house. Central unit of the system is heat pump which produces thermal energy for heating and cooling and is also used in ventilation system for dehumidification. Heat exchange with air inside the house and occupants is achieved via floor panel heating and cooling. More detailed information about the system itself and specific components of the system will be thoroughly explained in the following text.

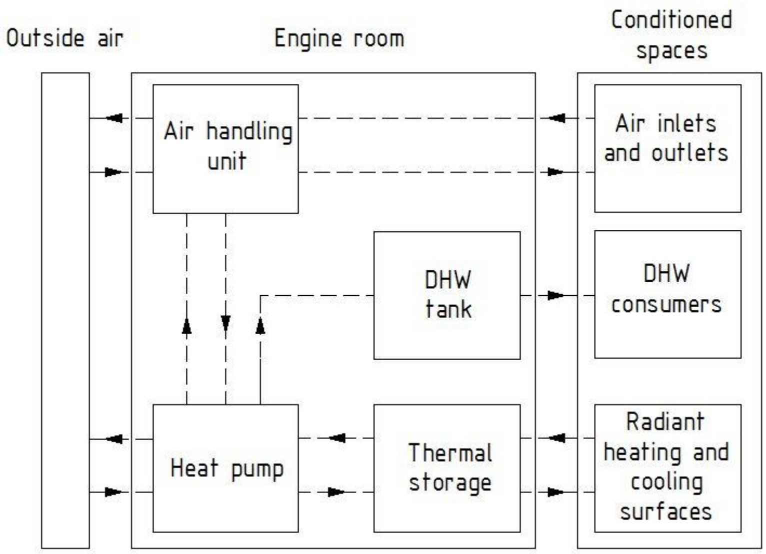


Figure 126 - Main HVAC components

5.4.3.1 Heat pump

A heat pump is a device that transfers heat energy from a heat source to a heat sink. In order to do so heat pump uses some amount of external high-grade energy. Therefore, use of heat pump allows moving thermal energy opposite to the direction of spontaneous heat flow to accomplish the desired transfer of thermal energy from heat source to heat sink. External energy can be mechanical or thermal energy. More often mechanical energy is used by means of compressor that compresses refrigerant from evaporation pressure to condensation pressure.

In Mem**brain** concept such compression heat pump will be designed by students, produced by project partners Dalmacija klima d.o.o. and in the end used in assembled house. As a heat source and heat sink outside air and indoor hydronic system will be used. Heat pump connected to ground or water heat source will have greater seasonal performance factor and coefficient of performance than one with outside air but due to competition rules and regulations air will be used as heat source and sink (depending on heating and cooling season).

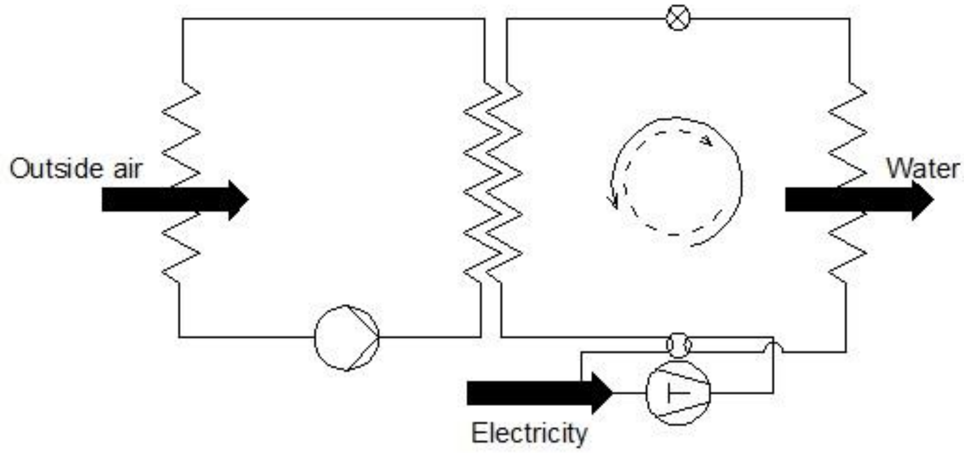


Figure 127 - Compression heat pump

Outdoor air is a universal available heat source and sink medium for heat pumps and is widely used in residential systems. Extended-surface, forced-convection heat transfer coils transfer heat between the air and refrigerant. During heating, the temperature of the evaporating refrigerant is generally 6 to 11 K less than the outdoor air temperature; while during cooling refrigerant's temperature is 5 to 11 K more than the outdoor air temperature. It has low installation costs, and moderate operation and maintenance cost in comparison to other heat sources. Main disadvantage of air as heat source are air temperature variations during 24 h period and during whole year. As the outdoor temperature decreases, the heating capacity of an air-source heat pump decreases but also it overall efficiency decreases. Therefore, more energy is needed for lesser heating capacity. Same refers for cooling season. This makes equipment selection for a given outdoor heating design temperature more critical for an air-source heat pump. Second problem referred to air is frost formation. On lower air temperatures, even above 0 °C frost may form on the coil surface (since the temperature of coil surface is even lower to allow heat transfer). If allowed to accumulate, frost inhibits heat transfer; therefore, the outdoor coil must be defrosted periodically. The number of defrosting operations is influenced by the climate, air-coil design, and the hours of operation. In order to make hot-gas defrosting effective much closer fin spacing will be used and the system's size and bulk will be reduced. In current practice, fin spacing's of 1.3 to 2.5 mm are widely used.

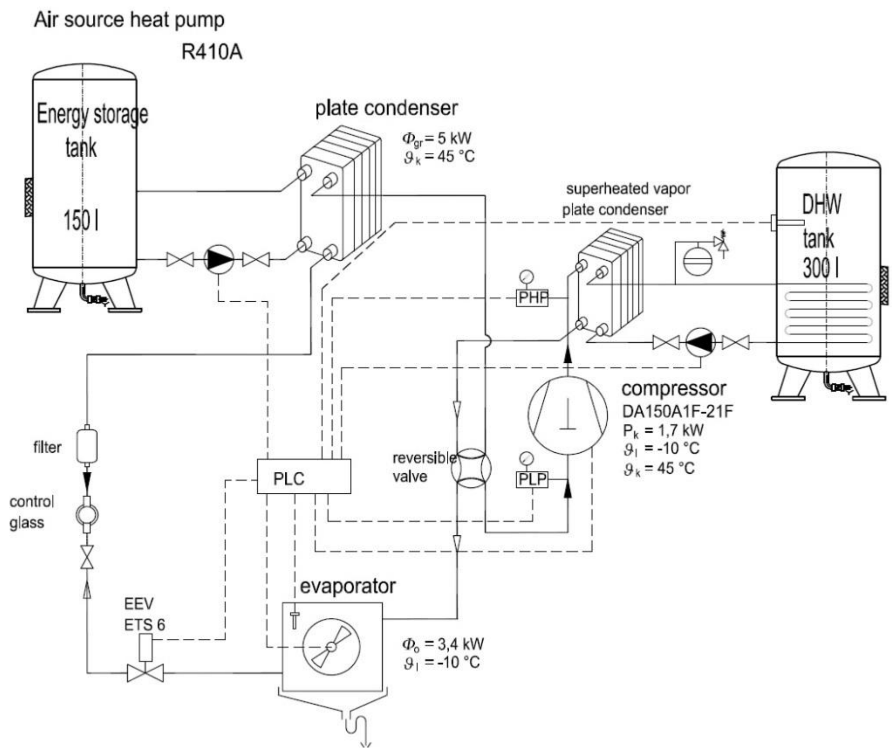


Figure 128 - System scheme

In order to increase seasonal energy efficiency of heat pump (known as SCOP and SEER) team will use thermal storage tank as can be seen from scheme of the system. In that way, if the conditions allow it, thermal energy preparation (regarding of season) can be shifted to period of day when outside conditions are more favorable regarding efficiency of heat pump. As shown in figure below (daily temperature changes for two months expressed in °C) during May heat needed for heating during night will be produced during the day, when for same condensation temperature higher evaporation temperature will be achieved and heat pump will work with higher COP. Same idea applies for July, only the cooling energy is needed then and greater difference between night and day temperatures is also beneficial. The greatest efficiency increase will be achieved in parts of the year like spring and autumn when heating or cooling is needed in only one part of day. To make the best use of system careful dimensioning of thermal storage and heat pump capacity is needed and they will be optimized based on building and HVAC simulation results. Also control of the system must be developed to satisfy the needs of the house. That is why the MPC (model predictive control) will be used which will through various algorithms and predictions of inhabitants behaviour ensure that every time there is need heating or cooling energy will be available.

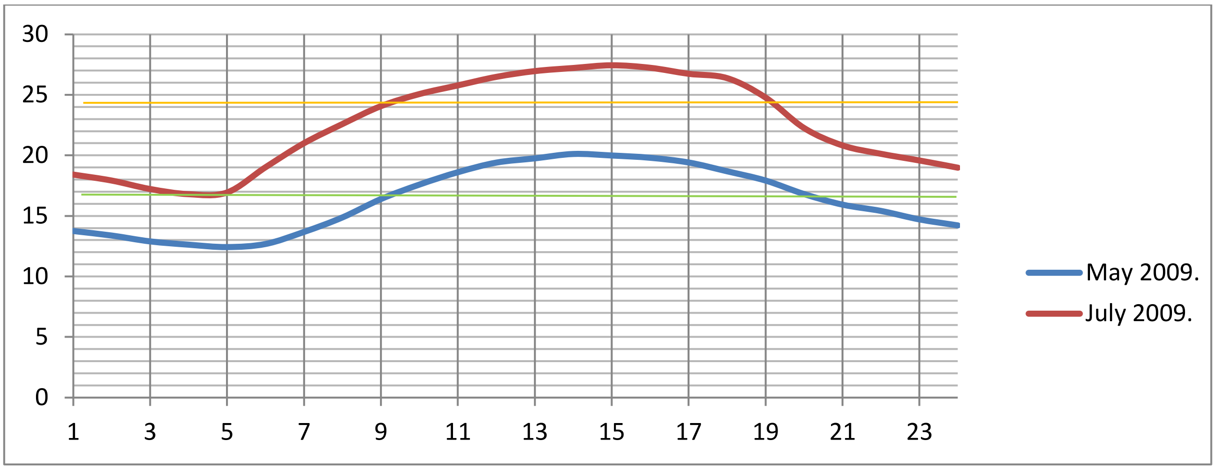


Figure 129 - Hourly temperatures of two months in year 2009.

Heat pump will also be used for preparation of domestic hot water (DHW). In winter period heat pump will heat the DHW directly and in summer period refrigerant will condense inside DHW tank (so in certain time heat pump will work as water/water HP) when possible and provide simultaneous production of DHW and cold water for cooling. If condensation is insufficient HP will shift to winter mode in order to heat DHW.

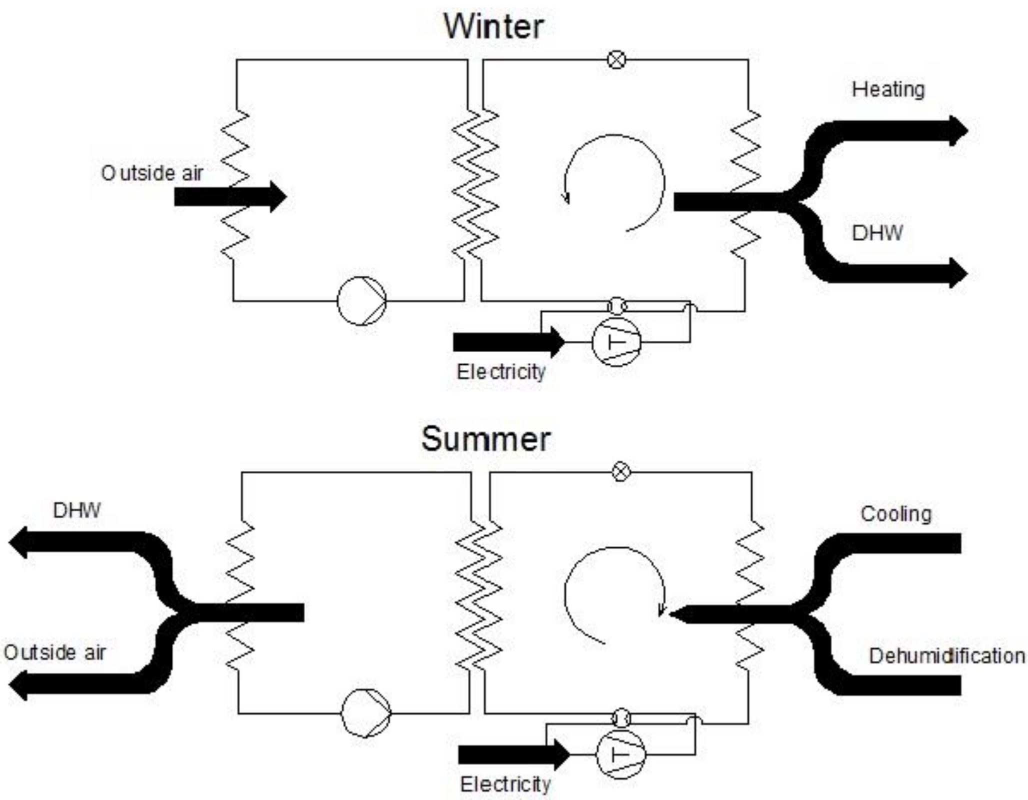


Figure 130 - Use of heat pump in heating and cooling period

Heat pump will also be connected to air handling unit and ventilation system with DX evaporator inserted in ventilation duct. Main purpose of this evaporator is dehumidification of outside air in summer period to minimize the risk of water condensation on floor due to floor cooling. Second measure against condensation will be thermometers inside floor surface that stops water circulation if floor temperature is 19 °C or less (in cooling mode only).

Compressor

There are several requirements from compressor to make the system more efficient. It has to be scroll compressor, frequency operated and suitable for use with R410A refrigerant. This type of compressor with small input power is very hard to find because usage of R410A in households is relatively new on the market. R410A is chosen because for the same volume as other refrigerants its more effective (as described in text further below) and whole system is smaller in dimensions. Only drawback is that operating pressures are higher compared with ones that we get from other refrigerants. Frequently operated compressor gives us the opportunity to intelligently operate with the heat pump because it's one of the systems vital parts, and to operate with its parameters means to increase overall efficiency of the system and coefficient of performance.

Figure 131 - Scroll compressor

Thermal storage

Inside the house water unit will be used coupled with floor heating and cooling. As already mentioned, heat pump will not be directly connected to coils for surface heating/cooling. It will heat or cool the water in storage tank, depending on season. Stratification of temperature in the tank is to be used and to sets of connections to tank are predicted, one for heating season, when floor heating is in need of hot water (water outlet is in upper part of the tank) and one for cooling season when there is need for cold water in cooling season (outlet is on lower part of the tank). Two 3 way valves allow the use of same pump and same direction of water inside floor installation regardless of which set of water outlet and inlet of storage tank is used. Using thermal storage also enables more stable work for circulation pump because temperature in tank is more stable than one that would be directly form evaporator/condenser. This also results in longer service life and lowers energy consumption.

Electronic expansion valve

Electronic expansion valve (EEV) operates with a much more sophisticated design than the standard thermo expansion valves. EEVs control the flow of refrigerant entering a direct expansion evaporator. They do this in response to signals sent to them by an electronic controller (Mem**brains** littlePLC). A small motor is used to open and close the valve port. The motor is called a step or stepper motor. Step motors do not rotate continuously. They are controlled by an electronic controller and rotate a fraction of a revolution for each signal sent to them by the electronic controller. The step motor is driven by a gear train, which positions a pin in a port in which refrigerant flows. A cutaway of an EEV with step motor and drive assembly is shown in the Figure below.
Step motors can run at 200 steps per second and can return to their exact position very quickly. The controller remembers the number of step signals sent by the controller. This makes it possible for the controller to return the valve to any previous position at any time. This gives the valve very accurate control of refrigerant that flows through it.
Mem**brains** EEV will be two way PLC operated unit. Using this type of valve allows smaller overall dimensions of heat pump and also in synergy with compressor manages to fine tune pressures in the system.

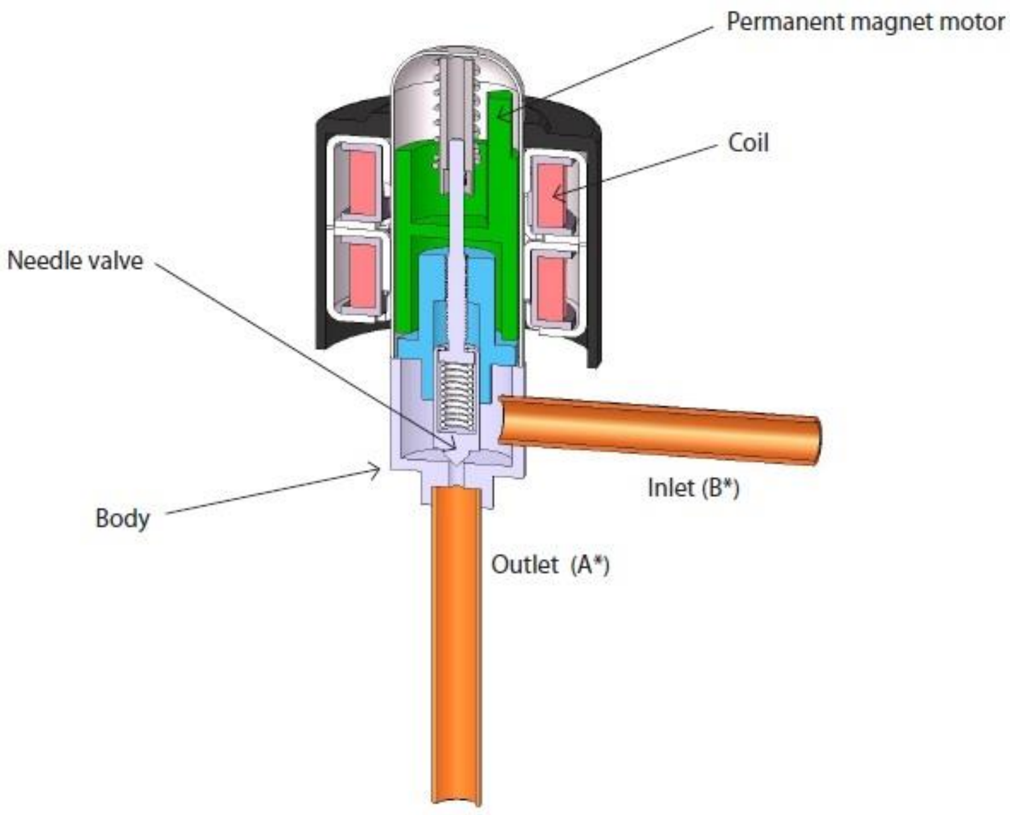


Figure 132 - EEV section view

Plate heat exchanger

A plate heat exchanger is a type of heat exchanger that uses metal plates to transfer heat from a hotter fluid to a colder. Metal plates form a very large heat transfer surface which enables transfer of great thermal power inside relatively small space. High heat transfer efficiency of such small devices made great impact on HVAC systems and domestic heating and hot water. Plate heat exchangers are well suited for transferring heat between medium and low pressure fluids.

Figure 133 - Plate heat exchanger

<u>Refrigerant</u>

R410a is also known as AZ-20, Puron, EcoFluor R410, Genetron R410A and Forane 410A. This refrigerant is a mixture of pentafluoroethane (CF_3CHF_2, called R-125) difluormethane (CF_2H_2, called R-32).

It is now being used as a replacement for **difluoromonochloromethane** (**HCFC, called** R-22) in air conditioning applications. R410a is a better and more acceptable option than R-22 because of his zero ozone depletion potential and similar global warming potential. Since R410a introduces higher system efficiencies than R-22 (and other comparable refrigerants) it reduces power consumption. Consequently the global warming impact and carbon footprint of such systems are considerably lower.

Table 48 - R410a properties

ODP (Ozone Depletion Level)	0
GWP100 (Global Warming Potential)	1725
Molecular mass	72.59
Critical temperature, °C	70.17
Critical pressure, bar	47.7
Evaporating temperature (1 bar), °C	-51.6

Evaporating pressure (-15 °C), bar	4.82
Saturated liquid density (30 °C), kg/m3	1035
Saturated vapor density (-15 °C), kg/m3	18.43
Latent heat vaporization (-15 °C), kJ/kg	237.6
Volumetric refrigerant effect, kJ/m3	3243.7
Specific Heat capacity at constant pressure (1 bar i 0°C), kJ/kgK	0.793
Specific Heat capacity at constant volume (1 bar i 0°C) , kJ/kgK	0.667
Adiabatic index	1.189

Value of volumetric effects of refrigerants R410a, R717, R404a, R22A and R407C are comparable with each other as it's given in the Figure below. Compared to others, refrigerant R407C has the lowest volumetric cooling capacity. It means that for the same capacity of the system it will have the largest volume of compressor cylinder. For low-temperature ranges, volumetric cooling effect is reduced (lower density at the inlet of the compressor and lower specific refrigerant effect). This means that at lower evaporating temperatures, to get the same refrigerating effect, volume of compressor cylinder should be higher.

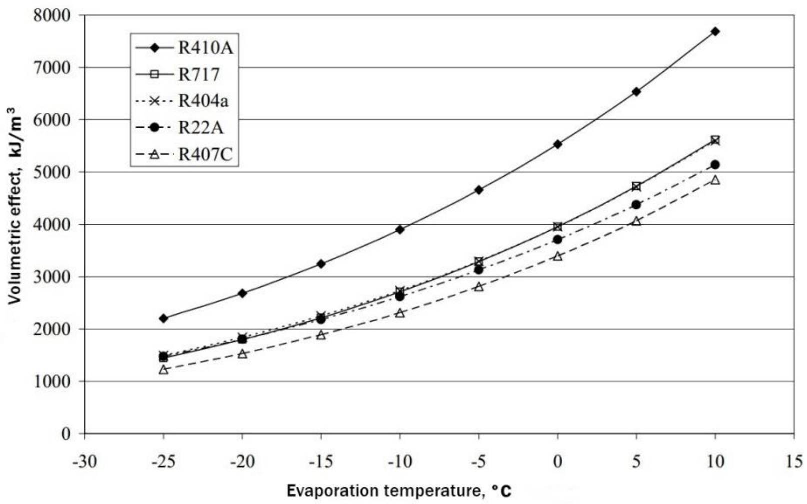


Figure 134 - Volumetric refrigerating effect

R410a has a higher latent heat of vaporization than R404a. That means it will have lower mass flow of the refrigerant under the same operating conditions for the same capacity of the system. A smaller mass flow rate of refrigerant and lower density of liquid and vapor phase compared to the refrigerant R404a, means smaller diameter of liquid and vapor line. Evaporation temperature of refrigerant at -51.6 °C means that at room temperature and under atmospheric pressure it's in the gaseous state. Despite lower latent heat of vaporization compared to R717, R410a has the highest volumetric cooling effect because of its high density. Higher volumetric cooling effect results in smaller compressor working volume, for the same cooling capacity of the system usage of R410a allows 30-50% smaller compressors.

5.4.3.2 Floor heating and cooling

Mem**brain's** indoor climate control is achieved through underfloor heating and cooling. This type of heat exchanger is chosen because of its various advantages but we also took into account the complications and problems which come with usage of this type of exchanger.

Underfloor heating

Underfloor heating (UFH) systems work on a very simple principle, just circulate warm water through pipes which are laid under the floor covering, the heat from water is absorbed by the floor surface from which the heat is transferred to the rest of the space, mainly through radiation. This form of heat transfer gives us the opportunity to considerably reduce the amount of energy which is required for maintaining the thermal comfort of the space. These benefits are achieved through lower operating temperatures, which allows us to use renewable energy sources (during the competition we will use an air to water heat pump). Despite lower operating temperatures the comfort level remains the same (or even gets higher) because the main goal of radiant heating systems is to heat the occupants via radiation which suppresses body heat losses and results in high thermal comfort level also the internal air mass is heated to a lower temperature.

UFH establishes an almost theoretical temperature profile (height-temperature distribution) which is much more favorable that the profiles provided by radiators (convection heat exchangers). Even in esthetical sense UFH is far ahead from the competition because there are no visible parts in the room consequently the user enjoys greater freedom in decorating the room according to his wishes and the walls are much more cleaner because there is no equipment mounted on them. Lower operating temperatures and lack of visible equipment reduce the risk of injuries, e. g. the floor is too cold to get burned and there is no danger of tripping on heating equipment. Scientific studies show that UFH is allergy friendly; it doesn't stimulate strong air circulations so allergens aren't blown throughout the space and the warmth of radiant floors speeds up the evaporation of wetted floors which kills bacteria, dust mites, mold, etc. On the other hand installation of UFH system introduces some complications, for instance the system has a slow response which makes the process harder to control, but our automation team is developing a MPC (Model predictive control) control algorithm which will take into account the behavior of users (and other equipment) and the newest meteorological data so the system will be given a heads up to prepare for yet to come events. For even better control, house will be divided in several heating zones, e. g. warmer zone near external walls, an individual bathroom zone and the main zone for the central living space in the house.

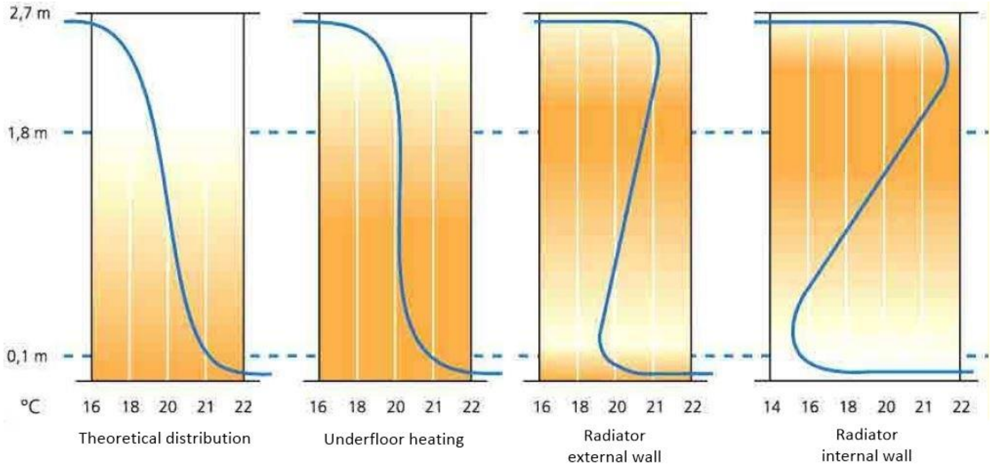


Figure 135 - Heating types comparison

Figure 136 - Distribution system

Underfloor cooling

Underfloor cooling (UFC), or a bit broader term, radiant cooling is a system that uses the same infrastructure and equipment as radiant heating but in this case cold water is circulated through pipes which are laid beneath the floor covering. The flowing water absorbs the heat from the floor, simultaneously the chilled floor absorbs sensible heat from people, equipment and other objects (mainly transferred via thermal radiation), but in a small portion the floor cools down the nearby air particles via convection.

Since most of the heat is transferred through thermal radiation this type of system achieves the desired comfort level despite higher indoor air mass temperature, with this information in mind it is obvious that underfloor cooling offers great potential in energy consumption reductions. UFC and UFH share the same infrastructure and equipment consequently they share the same advantages (energy efficiency, renewable energy sources, great temperature profile, aesthetics, etc.) and disadvantages (slow response) but UFC systems have one additional and very important problem, which is condensation. Because of the condensation underfloor cooling systems seldom come alone, rather they come in pair with an HVAC system. As mentioned above, UFC systems absorb only sensible heat which leaves the problem of latent portion unsolved. HVAC systems must deal with that remaining portion; in our case the ventilation system has the task of regulating relative humidity within a safe interval so there is no threat of condensate formation on the chilled floor. Our fresh air supply system has an integrated refrigerative dehumidifier which can control the humidity of the supply air and that gives us the ability to control the relative humidity of the indoor air mixture. During our elaboration of the cooling system fan coil units were also considered but due to their lacks the UFC solution prevailed. In comparison with UFC fan coil cooling is cheaper and simpler but greater air speeds, lower heat comfort level and lower hygiene standards (complicated cleaning) were compromises we simply could not agree to.

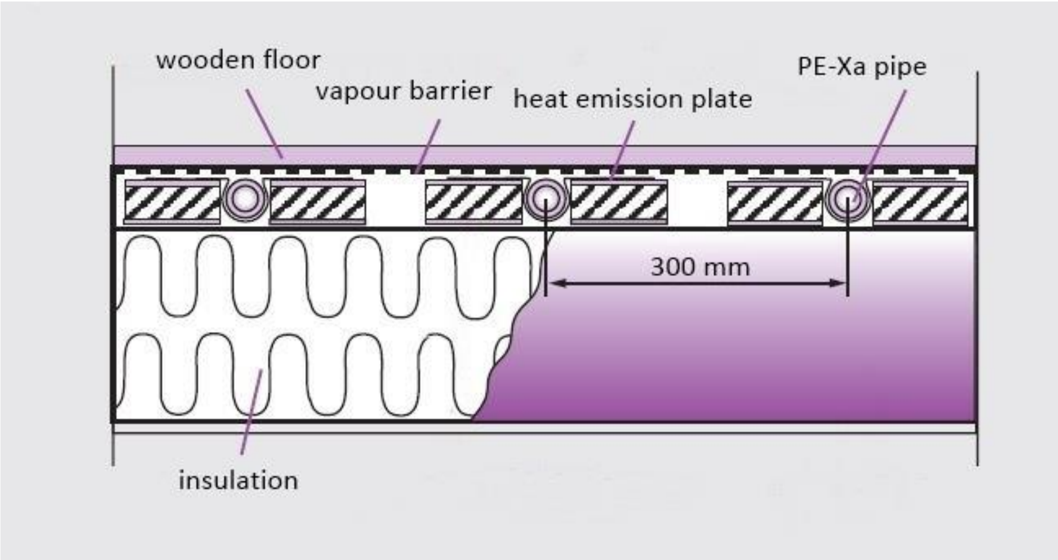


Figure 137 - Floor construction with heating pipes

Because of the mobility and modularity of the house we couldn't choose the system in which pipes are casted in concrete floor slab (commonly named poured floor systems) so only reasonable solution was to go with the sub floor version. As shown on the picture, the whole construction lies on an insulation layer (reduces heat loses to the ground and maximizes the heat output), the PE pipes are fitted between floor joists which carry the load and keep the pipes save from damage. Apart from the vapor barrier there is one additional layer between the pipes and the wooden floor and that is the heat emission plate (HEP). The heat emission plates will be made from aluminum or graphite due to good thermal conduction properties.

We included this layer because timber suspended floors don't conduct heat as good as screed floor, but when HEP are included the evenness of the floor temperature is significantly increased.

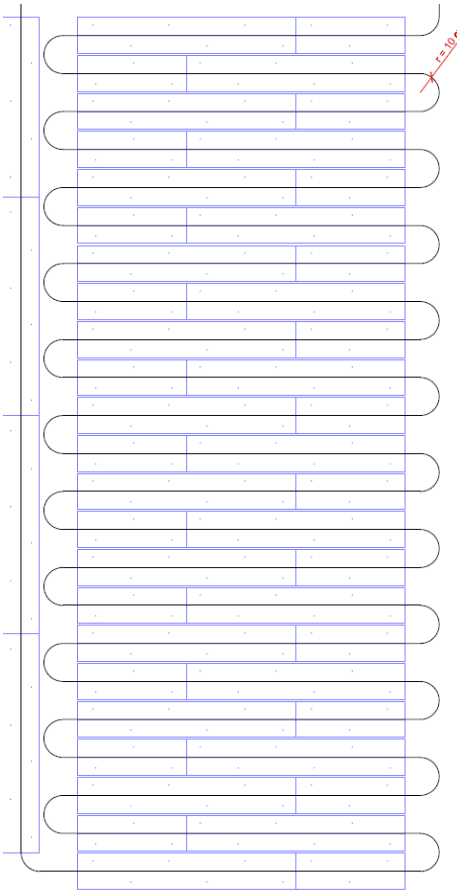


Figure 138 - Floor heating and cooling panel

For greater mobility, modularity and easier reassembly of the house, our team developed custom made panels for underfloor heating and cooling. The panels will be preassembled and ready for mounting. Preassembled panels include floor joints, thermal insulation, piping, heat plates and parquet. As shown on the figure above, during assembly of the floor the panels only require connection of the inlet and outlet on the main (heating and cooling) system of the house. The house heat exchanging system consists of three panels and a separate exchanger for bathroom. The bathroom is a separate zone because of its special demands related to floor temperature and floor material (frequent contact with water).

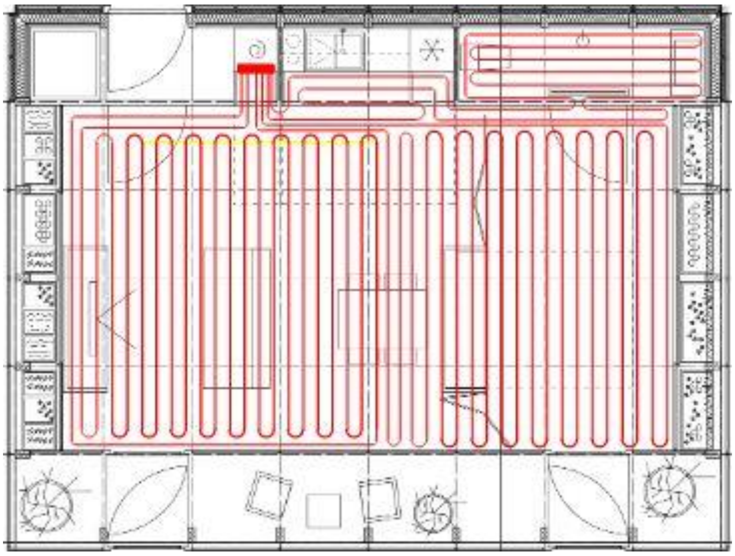


Figure 139 - Floor heating and cooling distribution

5.4.3.3 Ventilation system

Ventilation system is of great importance for achieving satisfactory indoor comfort conditions for occupants. Air temperature, air speed inside occupied area, humidity and inside air quality (IAQ) in general have high impact on thermal comfort which is analytically described using PPM and PVD indices described in ISO 7730 standard. In general terms, main ventilation purpose is transfer of fresh and healthy outdoor air to inside of the house and the transfer of used inside air to the outdoor environment. When outside air is conditioned (heated, cooled, dehumidified...) than the used system is air-conditioning system.

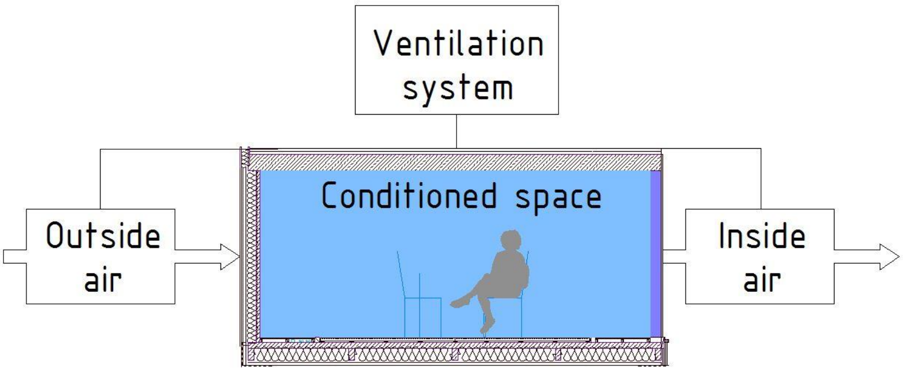


Figure 140 - Air transfer by ventilation system

In 1970's new term received public attention - sick building syndrome (SBS). Term describes buildings that due to poor indoor conditions result in increasing number of illness and efficiency reduction of its occupants. Poor indoor conditions are mainly result of undersized, unmaintained and, due to running costs, misused ventilation and AC systems. As more and more time people spend indoors, it is critical to secure healthy and adequate conditions inside working and living area. Because the indoor air quality (IAQ) is closely related to the health of occupants and thermal comfort in general, one of the main focuses of the design of the HVAC systems is exactly the IAQ.

Adequate quantities of outside air, air filters and absorbents, air distribution and air conditioning must be secured and used. On the other hand, supplying the indoors with required amounts of supply air and conditioning requires certain amount of energy. Over sizing the system and bad choice of system control (or absence of one) can result in unnecessary increase in energy consumption. Therefore, efficient ventilation and air-conditioning system that can easily adapt to the needs of the house is of great importance.

For small residential houses three main types of ventilation exists: natural ventilation, forced exhaust ventilation and mechanical ventilation. In our house three different types of spaces exist: living space, bathroom and sunspaces envelope that surround living space. Each part will be addressed independently regarding the type of ventilation system.

Therefore, forced exhaust ventilation will be used in specific parts of our house, such as bathroom and east and west sunspace, while the main living space and southern sunspace will be ventilated with mechanical ventilation system and natural ventilation when possible. Natural ventilation is as this moment predicted for sunspace only, but simulations are being made, and additional numerical analysis, coupled with building simulation, will be made to clarify potential and energy savings of natural ventilation of living space also (resulting in hybrid system with mechanical system as base system).

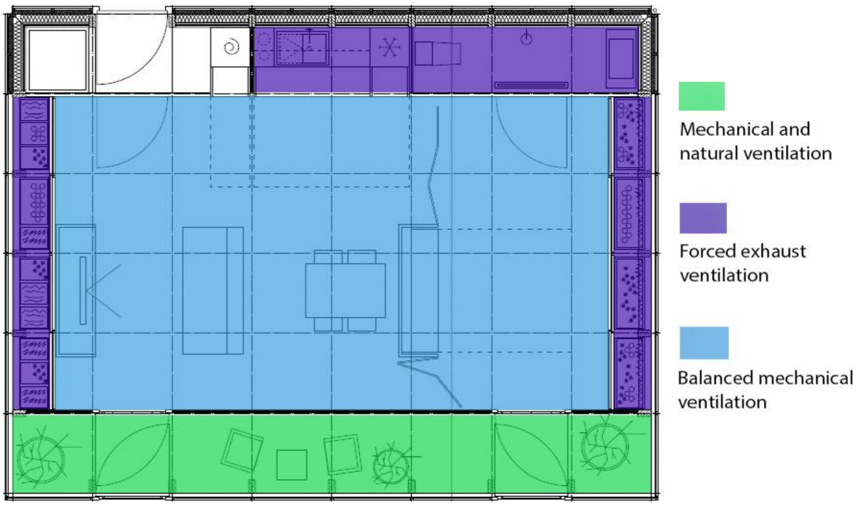


Figure 141 - Ventilation zones

Ventilation system and ventilation rate will be based on CO_2 content. CO_2 is one of the most common compounds in our atmosphere. It is also cited by many as a general indicator of the buildup of greenhouse gases and global warming. In urban areas outdoor CO_2 levels typically range from 360 up to as high as 450 to 500 ppm due to the presence of localized sources of CO_2 which can include any combustion device or process. Higher outdoor levels can also be measured when in close proximity to a source of CO_2 such as an idling vehicle or a furnace or combustion exhaust. Because of its low molecular weight CO_2 will readily diffuse and equalize within an open space. As a result, outside CO_2 levels tend to be ubiquitous and fairly constant over large geographic regions. Because of this consistency, it is possible to use CO2 as a baseline reference for outside air for the purpose of measuring and controlling ventilation.

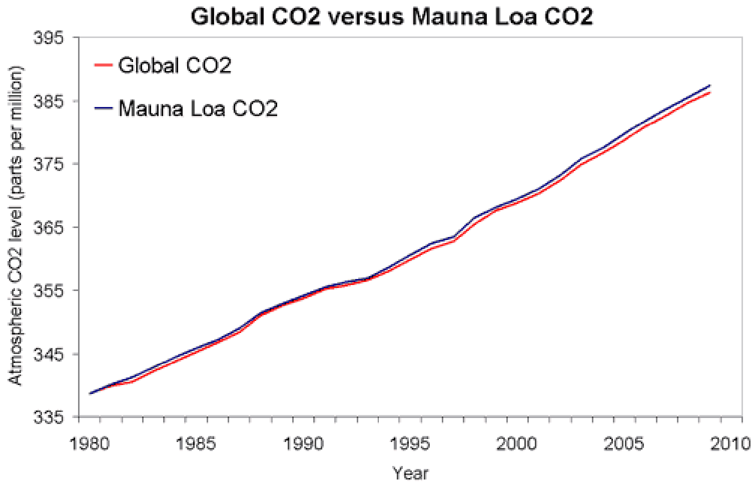


Figure 142 - CO_2 content in ppm in atmosphere

Indoors in residential buildings people are the primary source of CO_2. Plants, due to their low level of metabolic activity contribute an insignificant amount of CO_2 to indoor spaces. Highly elevated levels of CO_2 (e.g., 3000 to 5000 ppm) can indicate the presence of potentially dangerous combustion fumes as $CO_2$is one of the most plentiful byproducts of combustion and can account for 8% to 15% by volume of the content of a combustion exhaust and one can be used as fire warning system that will trigger ventilation shut down procedure in case of fire.

Table 49 - Approximate carbon dioxide emission per person

Activity	Respiration per Person (m^3/h)	Carbon Dioxide Emission per Person (m^3/h)
Sleep	0,3	0,013
Resting or low activity	0,5	0,02
Normal work	2 - 3	0,08 - 0.13
Hard work	7 - 8	0,33 - 0.38

For ventilation control people as a source of CO_2 are interesting starting point. People exhale predictable quantities of CO_2 in proportion to their degree of physical activity. Because CO_2 production is so consistent and predictable, it can be used as a good indicator of general occupancy trends. For example, if the number of people in the space is doubled, the amount of CO_2 produced will double (if their activity is similar). If one or two people leave a space the CO_2 production will decrease correspondingly. It is important to note that an indoor CO_2 measurement does not provide enough information to actually count people (quantity of exhaled CO_2 depends on age, gender, size and activity of each person) but it can be used in combination with outside air concentrations to calculate, measure and control ventilation rates. An indoor CO_2 measurement is a dynamic measure of the number of people in a space (exhaling CO_2) and the amount of outside air at baseline CO_2 concentration that is being introduced for dilution via mechanical ventilation. The result is that it is possible to determine ventilation rates in a space by measuring the CO_2 differential.

*18 l/h is CO_2 emission for light office work or low activity

Table 50 - Calculation for total ventilation

Calculation of needed ventilation rate based on CO_2 content		
Number of occupants	4	-
CO_2 exhaled per person	18*	l/h
Requested indoor CO_2 content	750	ppm
Outdoor CO_2 content	390	ppm
Ventilation rate per person	13,51	l/s
Total ventilation rate	200	m^3/h

Calculation for total ventilation rate is based on few assumptions which include four occupants with low activity and outdoor CO_2 content of 390 ppm (as shown in the Figure above). Indoor CO_2 content is set on 750 ppm as 800 ppm is defined as set point by competition rules and regulation. Calculated total ventilation rate is worst case scenario for living area (colored in blue in the Figure above) in everyday house use.

Each assumption made in above calculation is for steady-state situation, but in real house use all values have dynamic character and have different impact on ventilation rate needs. Effect of change of each value was looked into and results are represented in diagrams below. Cumulative effect of different values can also happen in real house use and can be displayed in diagrams but are interesting only for presenting certain scenarios of house use and effect on CO_2 content.

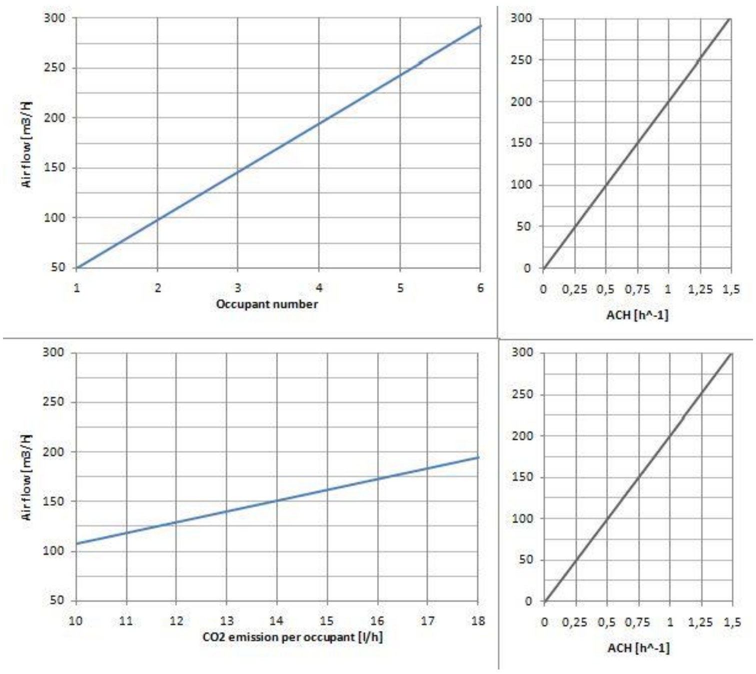


Figure 143 - Required ventilation rates based on number of occupants and CO_2 emission

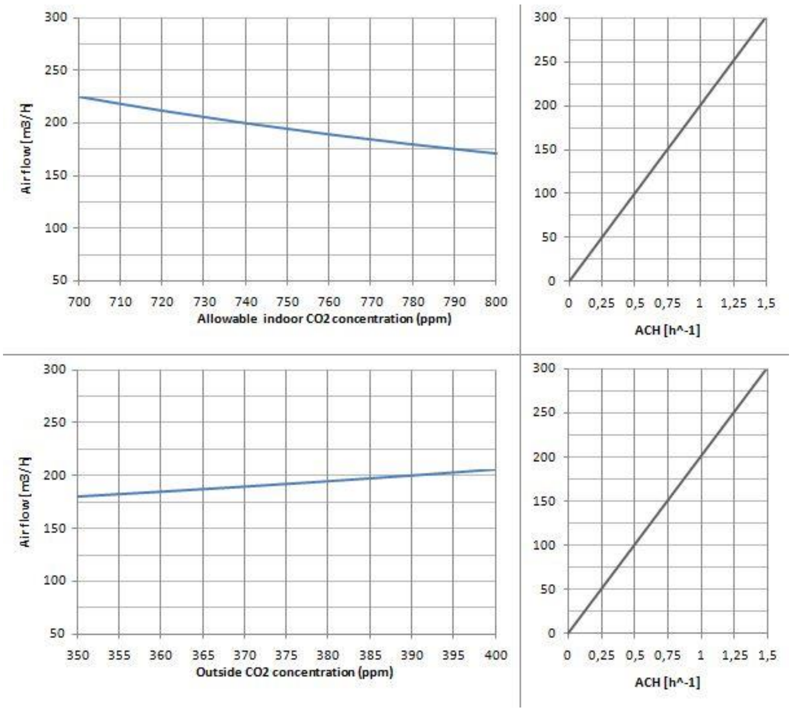


Figure 144 - Required ventilation rates based on indoor and outdoor CO_2 content

Since the occupants are source of CO_2 it's obvious that CO_2 content won't be constant. Rather, it will build up inside ventilated space when people enter it. Level of CO_2 will continue to increase until the amount of CO_2 produced by the space occupants and the dilution air delivered to the space are in balance. This is called the equilibrium point. The relationship between indoor/outdoor CO_2 differential and ventilation rate is independent of occupants' density. However, occupants' density will affect the time it takes for CO_2 to build up to an equilibrium level. Following two diagrams represent this. On first diagram minimum needed ACH are calculated in order to stay under the 800 ppm content for different number of occupants. Lower ACH also increases time required to reach equilibrium level.

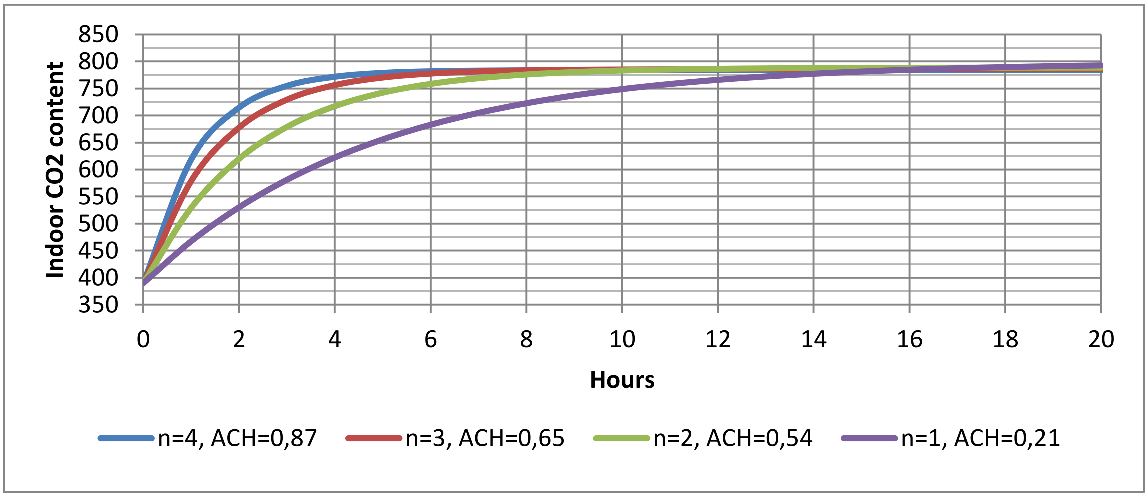


Figure 145 - Air change per hour

On second diagram same number of occupants was kept while ACH was changed. It is clear that in these conditions 0.8 or more ACH is needed.

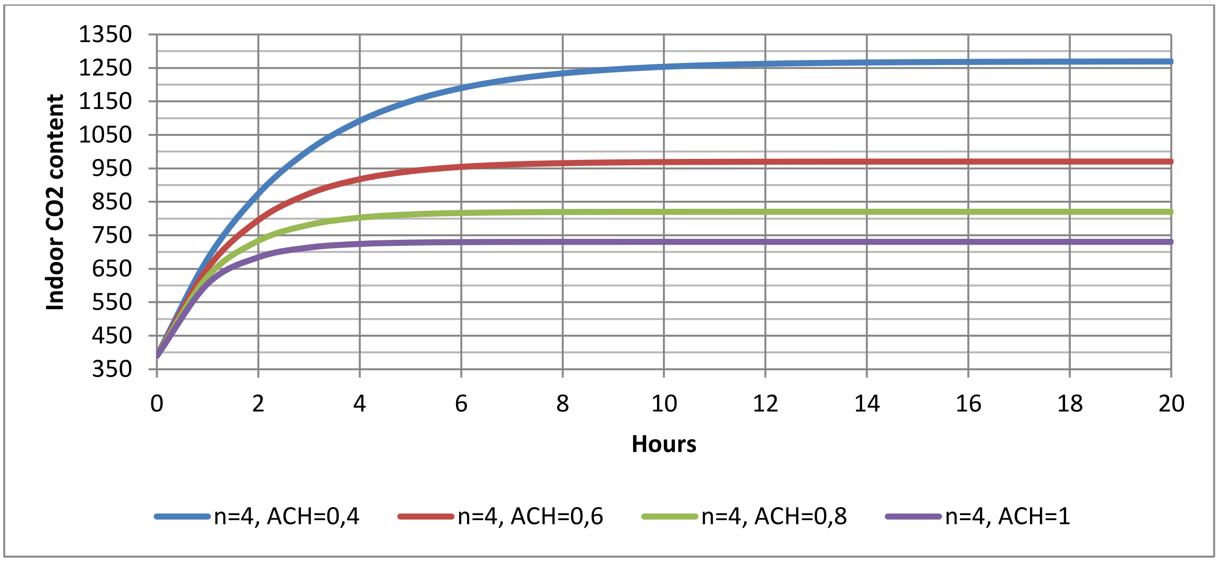


Figure 146 - Air change per hour

Demand control ventilation (DCV) concept based on CO_2 will ensure energy consumption only if indoor and outdoor CO_2 content is measured. Based on scenarios of use and occupant behavior it is possible to allow MPC (model predictive control) to predict needs for ventilation and its effect on heating and cooling needs (outside air needs to be conditioned in AHU unit before it is transfered to conditioned space). DCV system is designed in five main steps, first two steps are described above, minimum ventilation rate is determined in step 3 depends on house interior and must be determined in coordination with other teams, and steps 4 and 5 will be defined with Automatization team.

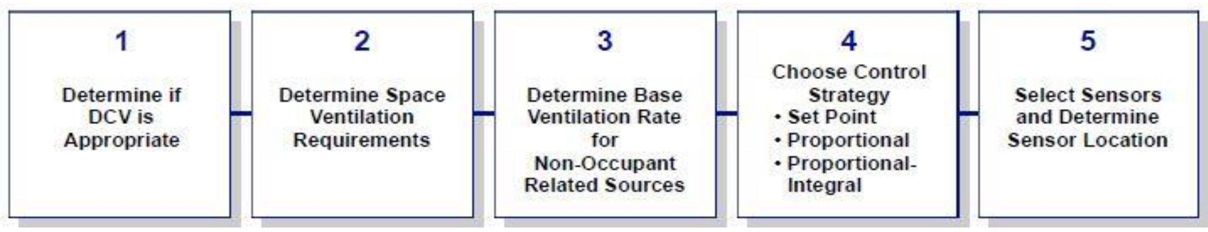


Figure 147 - Ventilation control scheme

Ventilation rates of sunspaces and bathroom will be calculated based on number of air changes per hour and scenarios of use. Total rates will finally be defined after evaluation of potential of natural ventilation. At this moment ventilation rates are taken account as:

Table 51 - Ventilation rates

Calculation of needed ventilation rate based ACH		
Greenhouse SOUTH volume	8,2	m³
Greenhouse WEST and EAST volume combined	32	m³

Bathroom volume	6,2	m³
Greenhouse SOUTH ACH	0,25	h-1
Greenhouse WEST and EAST ACH	0,25	h-1
Bathroom ACH	0,4	h-1
Greenhouse SOUTH Ventilation rate	2,05	m³/h
Greenhouse WEST and EAST Ventilation rate	9,5	m³/h
Bathroom Ventilation rate	2,4	m³/h

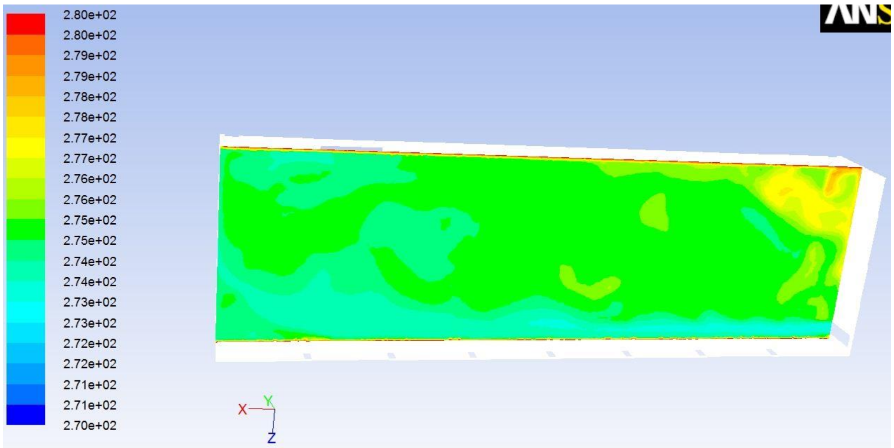


Figure 148 - Greenhouse temperature (K) distribution

System of mechanical ventilation will be equipped with heat recovery unit, in order to minimize heat losses and heat gains, depending on season, and will be equipped with DX evaporator that will act as cooler and dehumidifier in cooling season.

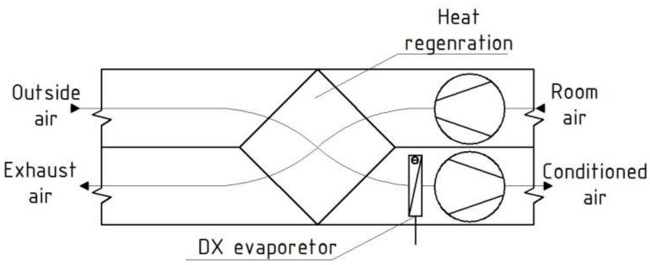


Figure 149 - Ventilation scheme

Product that will be used as AHU unit described as above is one offered by project partner Systemair designated as SAVE VTR 150. It is heat recovery unit designed for dwellings where ventilated area is up to 100 m². The SAVE VTR 150 is double skinned, fully insulated and with complete control functions, high efficiency rotating heat exchanger, thermostat operated re-heater battery and filters. Energy efficient fans with EC motors will reduce energy consumption for transportation of ventilation air by approximately 50% compared to traditional AC motors. Modern technology is contributing to a low SFP factor (Specific Fan Power) as well as an efficient design of the unit.

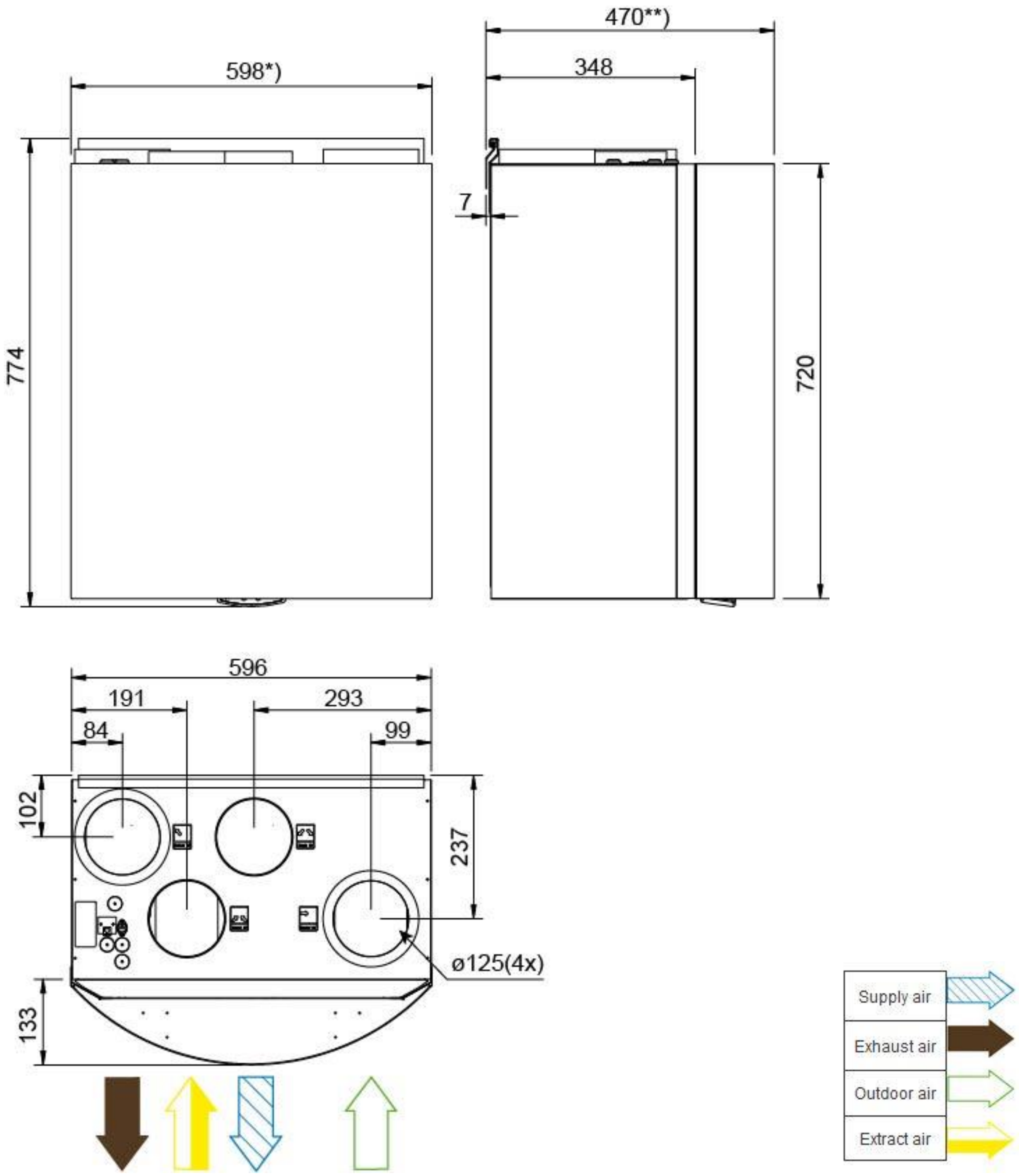


Figure 150 - VTR 150 scheme

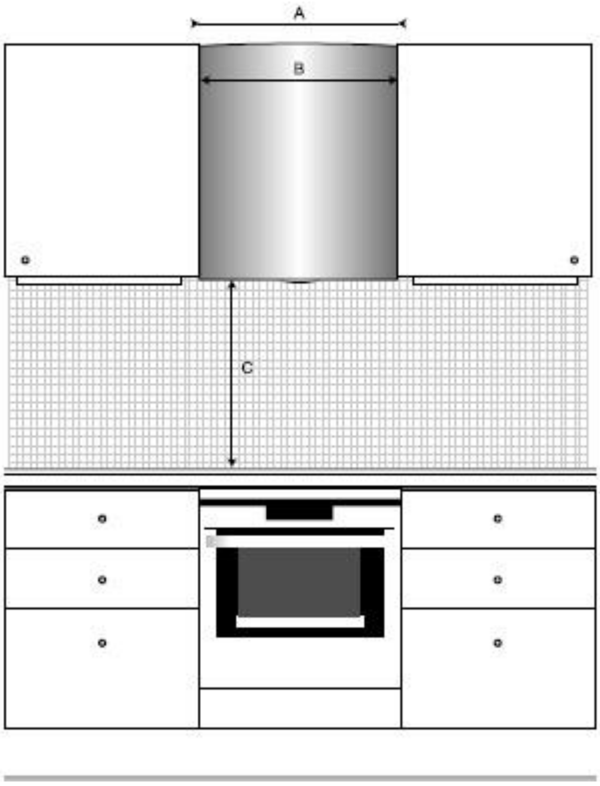


Figure 151 - Save VTR 150 in kitchen environment

A	Minimum distance between cabinets (mm)	600
B	VTR150/K unit width (mm)	598
C, Electrical stove	Minimum distance between stove surface and cooker hood (mm)	450 (Recommended 500)
C, Gas stove	Minimum distance between stove surface and cooker hood (mm)	650

Figure 152 - Dimensions

EC fans are motors with electronic control which ensures optimal operating efficiency. They are highly adoptable to ventilation systems with variable demand and run more silently. Also, EC-motors have longer service life due to lower wear and tear.

As air distribution type mixing distribution using high side outlets is chosen. A high side outlet may be a sidewall outlet mounted at the high level of a conditioned space, or an outlet mounted directly on the supply duct. As the air jet discharges from the high sidewall outlet, the surface effect tends to keep the air jet in contact with the ceiling (Coanda effect). The air jet induces the ambient air and deflects downward when it strikes on the opposite wall and flows along the opposite wall. The induction of space air from the occupied zone into the air jet forms the reverse airstream and fills the occupied zone. Mentioned Coanda effect is particularly interesting in Mem**brain** project because the team plans to install PCM material in the ceiling and air streaming along the PCM surface will improve heat transfer.

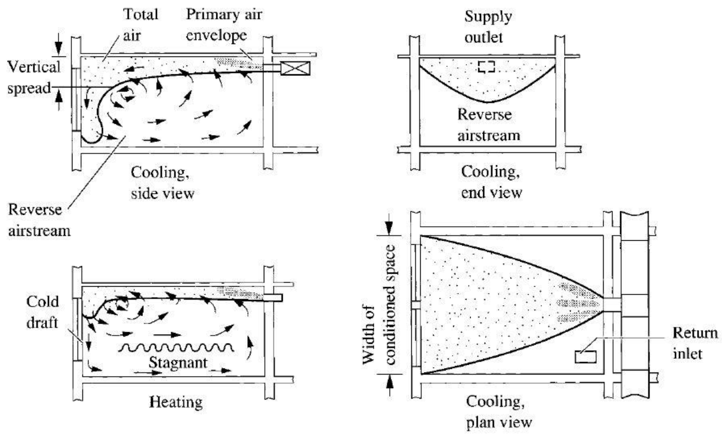


Figure 153 - Mixing air distribution (Ashrae Fundamentals 1989)

It is important that the throw of high sidewall outlet is no longer than the sum of the length of the room and the height of the opposite wall. Because of jet deflection air jet and the reverse airstream fill the occupied zone with a higher air velocity and greater temperature difference. On the other side, if the throw is too short, the air jet drops and this too causes higher air velocity in occupied zone. During heating, warm air tends to rise and results in a shorter throw. As the induced airstream rises, a stagnant zone may form between the floor and the induced airstream. A warm air jet with sufficient velocity and a longer throw can reduce or even eliminate the stagnant zone. Ducting and exhaust vents will be placed in northern part of the house and air will be distributed under the ceiling toward opposite wall. This allows higher speed of jet before it drops into occupied zone. Flexible ducting should be used to connect exhaust and intake vents to central ducting.

Greenhouse ventilation

Greenhouse will be equipped with separate ventilation system that has function to condition air for plants. Ventilation is designed in a way that enables air supply to come to greenhouse from the floor and the air exhaust vent placed in the ceiling. Air flow will be achieved with axial duct fans placed in the engine room. There will be two supply and two exhaust vents in winter garden and one supply and exhaust vent per greenhouse. Air exchange will be carried out in heat exchanger unit that will provide air properties suitable for greenhouse plants.

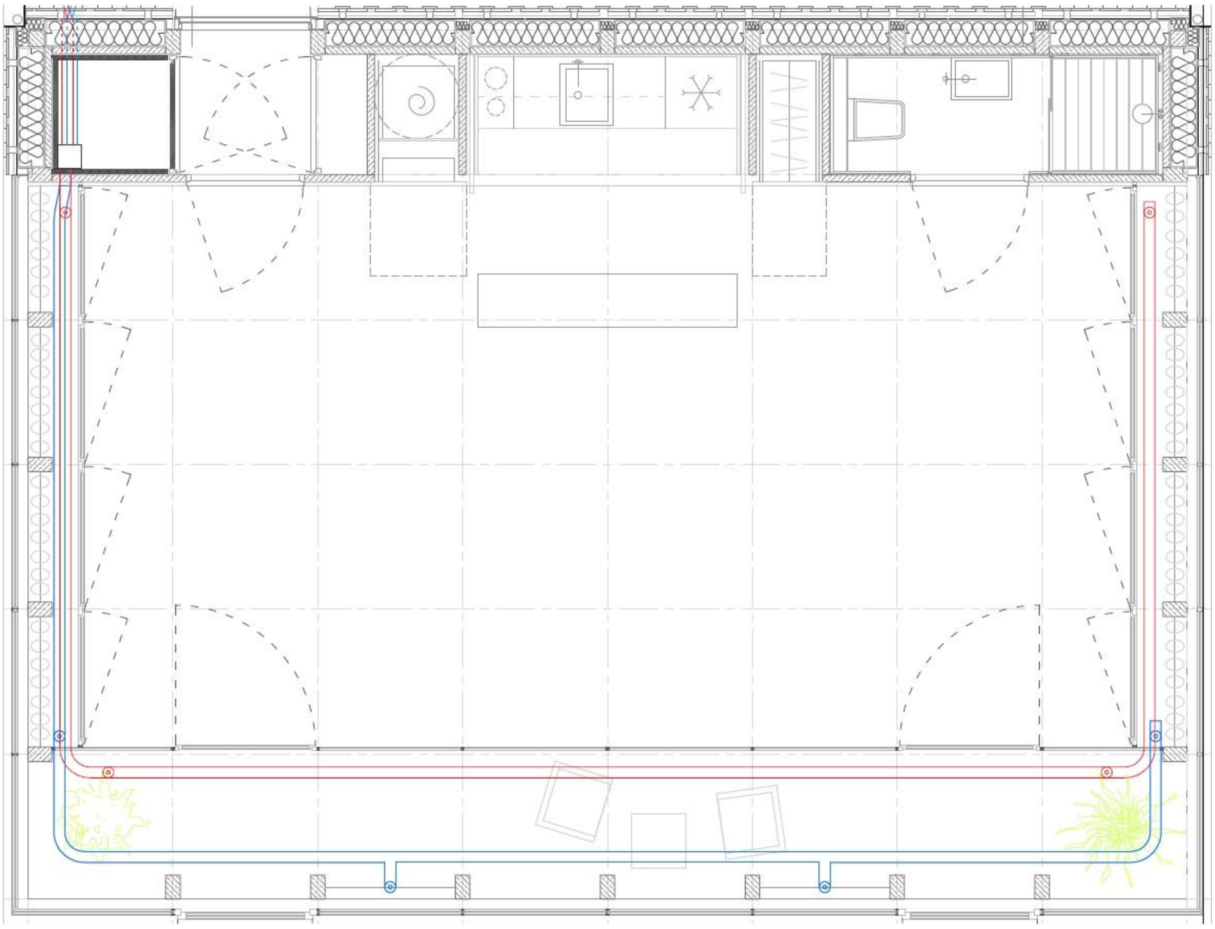


Figure 154 - Greenhouse ventilation scheme

Figure 155 - Flexible greenhouse duct

5.4.3.4 PCM (Phase change materials)

Today's practice of sustainable construction requires quick and rational construction of energy efficient buildings. The tendency during construction is to dematerialise construction elements, which leads to the reduction of heat accumulation of building and indirectly to the increased consumption of energy for heating, cooling and air conditioning. The problem of heat capacity, especially notable in lightweight structures, is increasingly solved using phase-change materials (PCM), which have much greater ability to store heat than conventional building materials.

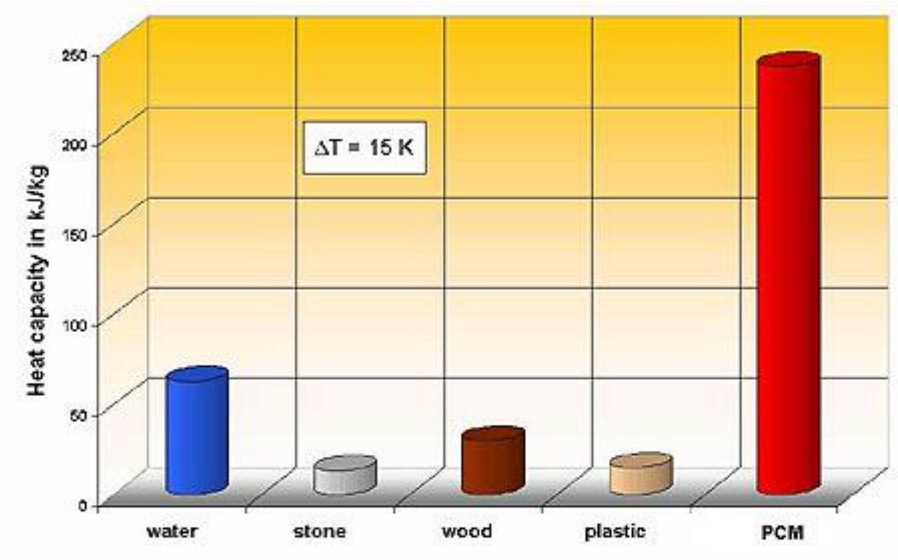


Figure 156 - PCM heat capacity compared to other conventional materials

This feature allows them to pass from one to another physical condition in the temperature interval of 20-30°C, and at the same time to store or release large amounts of latent heat usable for room temperature control. At temperatures lower and higher than the temperature of the melting point they behave like other construction materials; however, their specific heat capacity is usually much higher, and with sensible heat, they contribute to better thermal performance of buildings in use.

A large number of phase change materials (organic, inorganic and eutectic) are available in any required temperature range. A classification of PCMs is given in the Figure below.

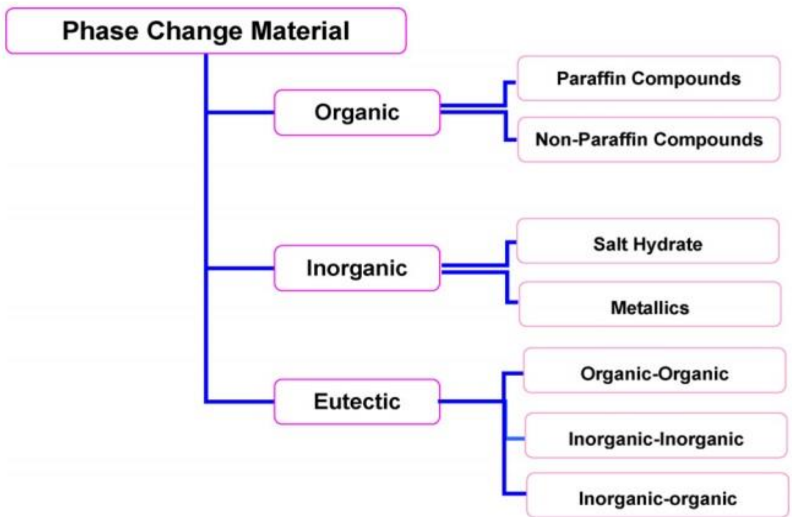


Figure 157 - Phase change materials

There are a large number of organic and inorganic chemical materials, which can be identified as PCM from the point of view melting temperature and latent heat of fusion. However, except for the melting point in the operating range, majority of phase change materials does not satisfy the criteria required for an adequate storage media. As no single material can have all the required properties for an ideal thermal-storage media, one has to use the available materials and try to make up for the poor physical property by an adequate system design. For example metallic fins can be used to increase the thermal conductivity of PCMs, supercooling may be suppressed by introducing a nucleating agent or a 'cold finger' in the storage material and incongruent melting can be inhibited by use of suitable thickness.

In general inorganic compounds have almost double volumetric latent heat storage capacity (250–400 kg/dm3) than the organic compounds (128–200 kg/dm3). As organic material have been chosen for project, only their thermal and chemical behavior will be discussed below.

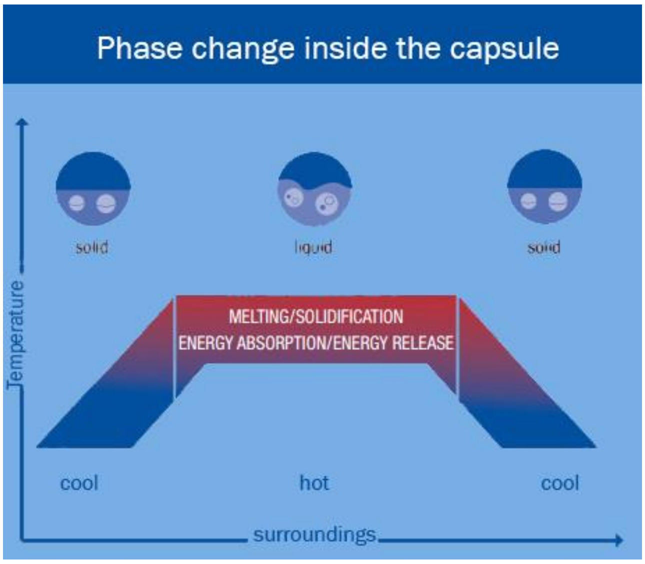


Figure 158 - Phase change

Paraffin wax consists of a mixture of mostly straight chain n-alkanes CH_3–(CH_2)–CH_3. The crystallization of the (CH_3)-chain release a large amount of latent heat. Both the melting point and latent heat of fusion increase with chain length. Paraffin qualifies as heat of fusion storage materials due to their availability in a large temperature range. Due to cost consideration, however, only technical grade paraffins may be used as PCMs in latent heat storage systems. Paraffin is safe, reliable, predictable, less expensive and non-corrosive. They are chemically inert and stable below 500°C, also they show little volume changes on melting and have low vapor pressure in the melt form.

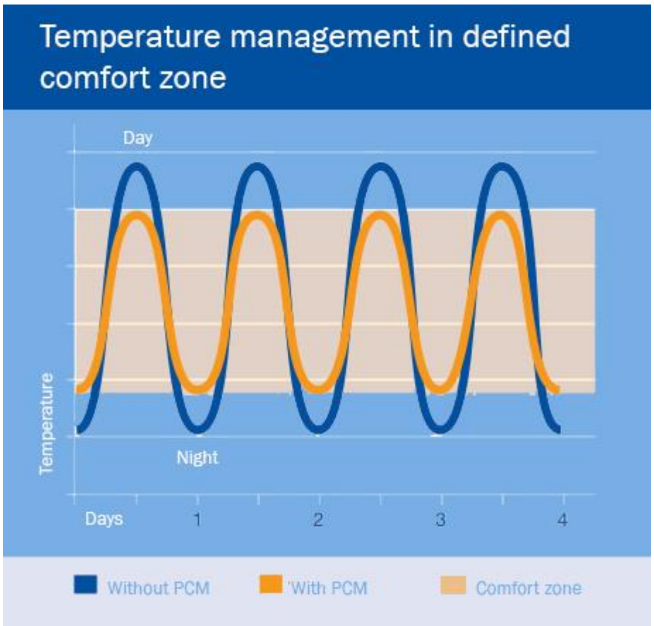


Figure 159 - Temperature management with PCM usage

For these properties of the paraffins, system-using paraffins usually have very long freeze–melt cycle. The melting point of alkane increases with the increasing number of carbon atoms. Apart from some several favorable characteristic of paraffins, such as congruent melting and good nucleating properties, they show some undesirable properties such as: low thermal conductivity, non-compatibility with the plastic container and they are moderately flammable. All these undesirable effects can be partly eliminated by slightly modifying the wax and the storage unit. Some selected paraffins are shown in the Figure below along-with their melting points and latent heat of fusion.

Table 52 - Paraffins with different melting points

No. of carbon atoms	Melting point (°C)	Latent heat of fusion (kJ/kg)
14	5.5	228
15	10	205
16	16.7	237.1
17	21.7	213
18	28.0	244
19	32.0	222
20	36.7	246
21	40.2	200
22	44.0	249
23	47.5	232
24	50.6	255
25	49.4	238
26	56.3	256
27	58.8	236
28	61.6	253
29	63.4	240
30	65.4	251
31	68.0	242
32	69.5	170
33	73.9	268
34	75.9	269

Due to the solar gains and well dimensioned HVAC system there is no need for additional passive heating of conditioned space. Since only floor cooling is used to achieve comfort temperature range in the summer, it is advised to use PCM as part of passive cooling system in the summer. In passive cooling, storage medium is used to store cold when exterior temperature is lower compared to the room temperature and the stored cold is extracted from the storage medium whenever it is needed using the ventilation system. Storage medium for free cooling is normally in the form of sensible and latent energy type. The main difference between free cooling and the nocturnal ventilation cooling is that in later the house structure (like walls) act as the storage medium while in passive cooling technique, a separate thermal storage unit is used for the storage of the cold and a mechanical device like fan is used to store and extract the cold from the storage unit. Advantage of passive cooling over the nocturnal ventilation cooling is that the accumulated cold can be extracted whenever it is needed by circulating exterior or room air through storage unit.

Thermal energy storage is the vital part of the free cooling system which is used to store the ambient cold to be used later during hot day time. Generally thermal energy, for free cooling, is stored either by changing the internal energy of the storage material (sensible heat storage), by changing the phase of the storage material (latent heat storage) or the combination of these two. Latent Heat Thermal Energy Storage (LHTES) by Phase Change Materials (PCMs) is preferred over other storage techniques due to its high energy storage density and isothermal storage process. Phase Change Materials (PCM) are substances with high heat of fusion, melting and solidifying at a certain temperature and are capable of storing and releasing large amount of thermal energy at a certain phase change temperature. Thermal energy is absorbed or released as the material changes its phase from solid to liquid or from liquid to solid.

Passive cooling

Solidification (Charging): This process is carried out during night time when ambient temperature is lower compared to room temperature. The cool ambient air flows through storage unit and takes away heat from liquid PCM which starts solidifying at certain constant temperature. An electrically driven fan is used to remove the heat from PCM. Charging process continues until the ambient temperature is lower enough than the melting/solidification temperature of PCM.

Melting (Discharging): Cold stored in PCM is discharged when room temperature rises above the comfort limit. Hot air which is to be cooled passes through the PCM storage unit and PCM (which is in solid state after charging operation) absorbs heat from the air. The air thus cooled to comfort temperature from the storage is delivered to the living space. PCM absorbing heat from air, starts converting from solid to liquid phase at certain constant temperature.

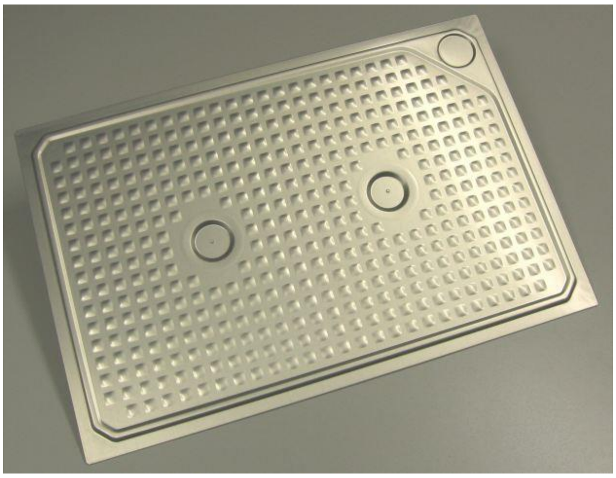


Figure 160 - CSM aluminium panel

One of the most important criteria to consider while choosing PCM type is that the melting point is set to appropriate value. This means melting point of the PCM should be in the center of the comfort zone in order to maximize efficiency. Last thing to consider, but not less important, is a suitable quantity of PCM in use. While doing research it was found that the optimal PCM quantity for ceiling mount is around 6.5 kg/m^2. Ceiling mounted PCM will be used as main part of ventilation system in order to increase its efficiency. Surface covered with PCM will be around 36 m^2, which implies that around 200 kg is going to be used. To maximize its effect, phase change temperature should be chosen carefully.

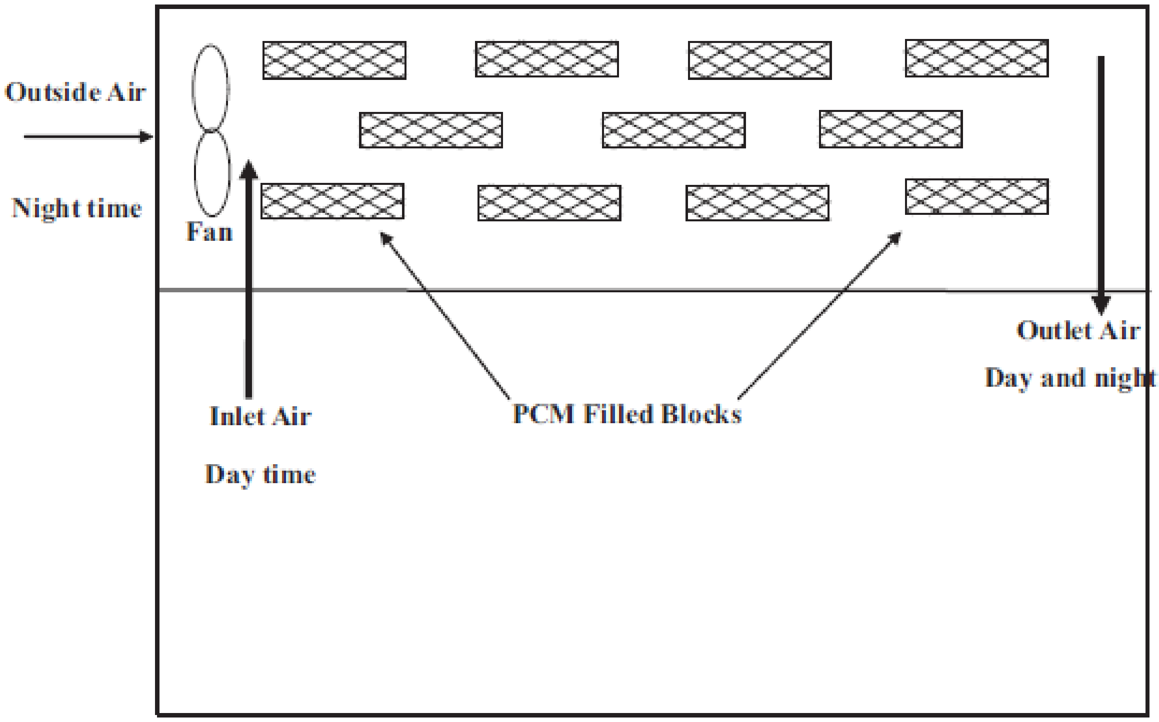


Figure 161 - Ventilation scheme

In Membrain project Rubitherms RT25 HC organic PCM will be used, properties are shown in figure below. Biggest challenge is to make "heat exchanger" that would enhance phase change and improve its efficiency. Rubitherm has pre-fabricated aluminium blocks that are filled with desired material as shown in figure above. Aluminium blocks will be placed in ceiling where ventilation supplies fresh outside air that flows under and over the blocks thus allowing them to fully charge/discharge depending on the exterior-interior temperature. Optimal air flow rate is 0.7 m^3/h which is easily achievable with Membrains ventilation system output.

RT25HC

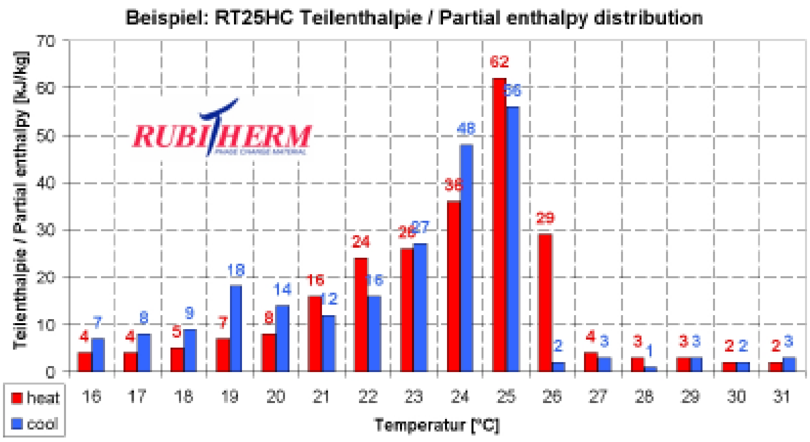
RUBITHERM® RT is a pure PCM, this heat storage material utilising the processes of phase change between solid and liquid (melting and congealing) to store and release large quantities of thermal energy at nearly constant temperature.
The RUBITHERM® phase change materials (PCM's) provide a very effective means for storing heat and cold, even when limited volumes and low differences in operating temperature are applicable.

We look forward to discussing your particular questions, needs and interests with you.

Properties:
- high thermal energy storage capacity
- heat storage and release take place at relatively constant temperatures
- no supercooling effect, chemically inert
- long life product, with stable performance through the phase change cycles
- melting temperature range between -4 °C and 100 °C

The most important data:

	Typical Values	
Melting area	22-26 main peak: 25	[°C]
Congealing area	26-22 main peak: 25	[°C]
Heat storage capacity ± 7,5%	230	[kJ/kg]*
Combination of latent and sensible heat in a temperatur range of 16°C to 31°C.	64	[Wh/kg]*
Specific heat capacity	2	[kJ/kg·K]
Density solid at 15 °C	0,88	[kg/l]
Density liquid at 40 °C	0,77	[kg/l]
Heat conductivity (both phases)	0,2	[W/(m·K)]
Volume expansion	12,5	[%]
Flash point (PCM)	150	[°C]
Max. operation temperature	65	[°C]



*Measured with 3-layer-calorimeter.

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The product information given is a non-binding planning aid, subject to technical changes without notice. Version: 23.07.2013

Figure 162 - RT25 HC properties

5.4.4 Domestic Hot Water

Primary source of energy for preparation of domestic hot water (DHW) will be heat pump. Process of preparation of DHW will be regulated with water circle between HP and storage tanks during heating period and with refrigerant circle during cooling period by means of two motorized 3 way valves and two different heat exchangers. In winter period heat pump will heat the DHW or water in thermal storage tank with DHW preparation as priority. In summer period refrigerant will condense inside DHW tank when possible and provide simulation production of DHW and cold water for cooling (and/or dehumidification if needed). If condensation is insufficient HP will shift to winter mode in order to heat DHW and revert back to cooling mode when done. In this way basic needs for production of DHW is satisfied and any additional system, such as hybrid PV/Thermal collectors, can be easily connected and decrease energy consumption.

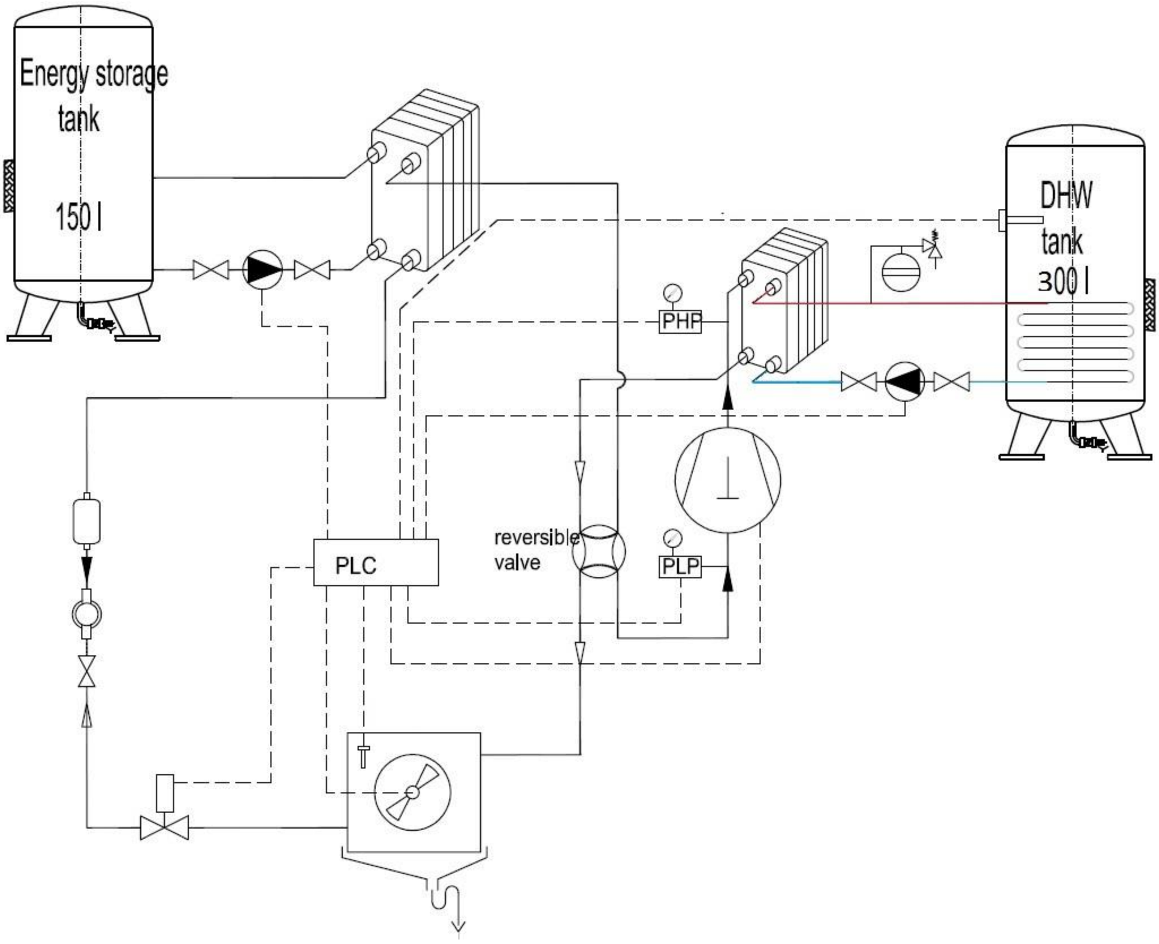

Figure 163 - DHW preparation

The design of a domestic hot water system follows the procedure below:

Table 53 - DHW data

Laundry washing machine [l]	30	From manufacturer specifications
Dish washer [l]	7	From manufacturer specifications
Daily consumption per individual [l]	40	From VDI 2067-12, model 1 (sink, shower cabin, dish washer)
Other (cooking, etc...)	10	
Number of individuals	4	-
Daily need for DHW [l]	169	It is necessary to choose a bigger tank capacity if this value fits between two similar capacities

Due to solar tracking construction limitations we are not able to put sufficient amount of solar collectors to justify their installation economically. Considering the fact that water will be effectively heated by heat pump, conclusion is made at this point that no other source of energy will be needed to provide house with hot water. Hot water will be stored in 200L tank.

Custom made heat pump with expected power of 5 kW will be the source of heat production with the priority for domestic hot water. MPC (model predictive control) will, through various algorithms and predictions of inhabitants' behavior, ensure that every time there is need for hot water it will be available. This way system will be more efficient and more economically viable.

Suitable growth temperatures and the accumulation of sediments of organic material and corrosion products at the bottom of hot water storage vessels provide an environment that is especially conducive to the accumulation of biofilm and legionella bacteria. In order to eliminate legionella bacteria thermal disinfection will be used once a day. Legionella pneumophila requires on average 3.2 minutes exposure to 60°C to inactivate 90% of the bacteria but where the water contains 100,000 cfu/l, the bacteria needs to be held at 60°C for approximately 10 minutes to reduce numbers to below the action level of 100 cfu/l. Hot water storage cylinders that maintain a temperature of 60°C throughout the whole storage vessel for a period of one hour daily should achieve satisfactory control of Legionella bacteria, so we will act accordingly.

Approximate dimensions of the tank:

b = 700 mm

H = 1500 mm

Addition: To reduce hot water consumption water saving units will be used in bathroom and kitchen with reminder for saving water that will increase our inhabitants awareness of its importance.

Preparation of DHW

Domestic hot water production is part of home HVAC system. DHW tank has integrated heat exchanger (spiral) that allows water to circulate through condenser and back to the tank. DHW heating will be operated with intelligent MPC system that ensures significant savings in energy expenditure. DHW tank will be equipped with electric spiral in order to support HVAC system if needed, and also to ensure water heating for hygiene purposes. DHW will be connected to water supply unit and to HVAC system water cycle. Daily need for hot water is roughly 170 L but to be sure it will always be available it's necessary to consider bigger tank. There are several tank requirements. It needs to have good insulation, electric spiral heater and heat exchanger. Viessmann tanks meet all of those requirements so one from the Vitocell V line will be used. Energy storage tank (EST) doesn't have high hygiene requirements so it will be custom made based on required dimensions of the engine room. Capacity of the EST will be 150 L based on norms that advise 20-35 L volume per kW heat pump provides.

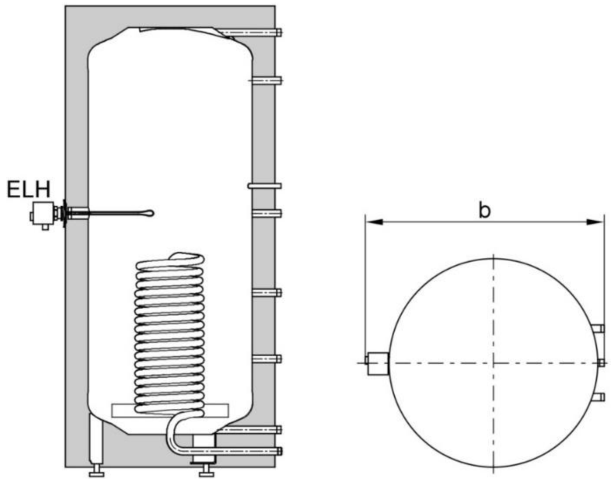

Figure 164 - DHW tank section view

Figure 165 - Vitocell 300L tank

5.5 Innovation Report

5.5.1 Innovation in Architecture

Architecture is primarily important, because with careful design of shapes, volumes, materials and use of light, we can achieve the maximum energy savings and consumption reduction. Throughout the development of the concept, we have been implementing the basic principles of bionic architecture. We have combined modern technology with natural science ideas thus achieving the synthesis of conventional engineering and natural principles. We aim on reducing energy consumption and transport-induced pollution by using natural and recycled materials from the region (such as wood and sheep wool).

In addition, we have a huge emphasis on urban planning and the use of different variants of our house. The development of such a concept only for the competition and building only one building would not be sustainable. It is vital that the entire project emphasizes all the possibilities of our concept and our house. Versatility is our strongest advantage and the most important innovation. The concept of the facility will be used, as shown already, in many different varieties and in different environments. The idea that we are exploring is that our house – conceived as a membrane and interior void - can be converted into different spaces and for different usages.

In any implementation, the membrane will still keep all the necessary systems for the functioning of the building, and the interior space will accommodate the user and can be used for housing, office space, shops, schools, etc. Classic stories for housing, offices and a variety of miscellaneous smaller objects will be produced. The facility has been prepared for the merger in breadth, in depth and in height. In this way you can get a smaller or larger blocks of residential or office space. What is particularly interesting is education. In Croatia, the tradition is that the schools for the first four years in the smaller villages have one teacher. They are mostly small, two-storey houses, where the ground floor a classroom, and the top floor is the teacher's apartment. Our concept answers this request, and provides a more sustainable and feasible solution.

5.5.1.1 Innovation in Interior

The biggest innovation in interior design is the ability to easily move the furniture inside the void. Having no fixed walls inside the void, the furniture was made self-standing and flexible (movable). Moving of furniture inside the void is provided with casters. To fully increase the flexibility of the void and to insure extra storage space, furniture had to have increased functionality with functions like folding, stacking or pulling out of another part of the furniture. For example, the kitchen consists out of one fixed segment and three movable segments. The first segment is a kitchen cabinet, the second is a kitchen counter and the third is a foldable dining table. All three combined create a kitchen island. The fixed segment is placed inside the Mem**brain** (northern wall), and the movable segments are placed inside the void when used. When not in use, all three movable segments can be stored into the Mem**brain**, and the whole kitchen can be closed with folding doors. In that way, the user can clear the void for more space and hide the kitchen if needed – for example, when having a larger number of guests.

5.5.1.2 Innovation in Materials

Materials used for the furniture are solid oak wood, particleboard and MDF. For some furniture parts and details we used willow wicker, which is local, traditional and safe for environment product. These materials are chosen for their affordability and availability in Croatia.

The basic principle of Croatian forestry is sustainable management in order to preserve the natural structure and diversity of forests and permanently increase the stability and quality of economic and beneficial functions of forests. The Forest Management Plan for the area is determined on ecological, economic and social basis for biological enhancement of forests and the increase forest production. The aim of forest management in Croatia is sustainable and harmonious use of all functions of forests and continuous improvement of their situation. Having in mind that the area of forests in Croatia is 2 688 687 ha, which is 47% of Croatia's land mass, wood and wood based materials are a logical choice for the structural material of our house.

Quercus robur (commonly known as Slavonian oak) is internationally known as a high quality material because of its aesthetic, physical and mechanical properties. This is a highly sustainable product because of the principles of sustainable management which are conducted in Croatia.

When it comes to wood based materials like particleboard and MDF, there are many questions concerning the sustainability of these materials. Most wood based product manufacturers emphasize the sustainable use of raw materials in its core values. Their actions focus on the closed material cycle. In this way, they use wood which is not suitable for production of solid wood products and also recycled wood for production of wood based boards. When these boards are not suitable for use, they are recycled and used for biomass fuel. When wood is burned, CO_2 is released, which would remain locked in if the wood was used to make materials and products. This CO_2 is then absorbed by forests and the cycle closes.

With these materials we wanted to show that traditional and local Croatian materials, such as oak wood and willow wicker, can be combined with contemporary materials such as particleboard and MDF to create a perfect minimal, yet warm and visually interesting modern interior. The use of these local, traditional and contemporary materials in the void space is also a link to the use of materials in the Membrain.

5.5.2 Innovation in Engineering and Construction

The approach to Mem**brain** concept design and development introduces certain innovations. The basic concept of the house's membrane that separates living space from environment is innovative. Emphasis in this project is in sustainability and efficiency of the systems. House parts and systems are not innovative per se, but synergy and the idea of them functioning together to provide inhabitants with a comfortable living experience is what we are after. For example, PCM is a known element in passive building design, but in Mem**brain** it works along with the central ventilation system in a way enhancing both and providing better living space air conditioning. Heat pump operates with R410A refrigerant because compared to others it has higher volumetric effect and that allows smaller dimensions of parts with increased efficiency. With electronic valves and frequency operated compressor connected to littlePLC altogether operated by the MPC algorithm, efficiency of the HVAC system is highest possible for this type of HVAC distribution. MPC is a relatively new technology mostly used and tested in big infrastructures, nevertheless, it is one of the key elements in efficient HVAC system operation so including it in Mem**brain** concept is expected. Innovation is a key part of Mem**brain's** control system as the team has developed a functional PLC unit and a wireless sensor network instead of using industrial components; it is a feature that greatly reduces system costs and provides a system of automation financially viable for small building design.

5.5.3 Innovation in Energy Efficiency

5.5.3.1 Electrical system innovation

One of the innovative aspects of the Team UNIZG house is its flexibility in the context of electricity consumption and production. To appreciate the importance of that flexibility it is necessary to understand the recent developments in the electrical power grids. Today there are two major challenges which electrical power engineering is trying to address. The first one is to reduce the electricity consumption peaks. As show on the figure below, the electricity consumption significantly varies over time. In order to ensure reliable delivery of electricity, every part of the grid (transmission lines, transformers, circuit breaker, etc.) has to be dimensioned to withstand the peak load. However, during the off-peak hours the grid is usually underutilized. Shifting the electricity demand from peak to off-peak hours would reduce the need to upgrade the existing grid because of the increasing demand. In addition to the obvious financial benefits, this is important because the grid upgrades, i.e. new transmission lines, are very difficult to integrate in populated areas such is most of the Europe.

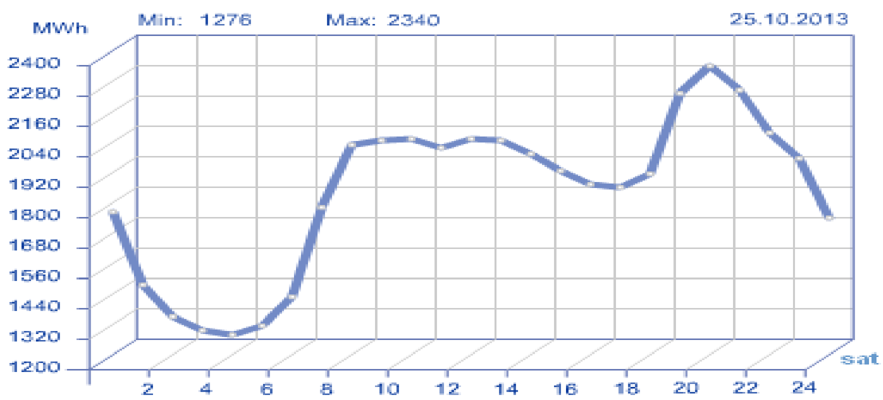

Figure 166 - Croatian power system daily load profile

The second challenge is the integration of the renewable sources, namely wind and solar. Electricity is difficult to store in significant amounts (with exception of pumped hydro), so the electricity generation and demand + losses have to be in balance at all times. We cannot rely on the production of renewable sources due to their intermittency (stochastic behaviour of the wind is exceptionally challenging), which means that reserve in conventional power plants is required to enable safe operation of the power system. In order to enable a larger share of renewable integrated into the power systems, demand side will have to become more active. Households make up for the significant part of total electricity demand, and our goal is to make our house a “model citizen” in the electricity grid with demand side management ability. That means that the house will be able to adjust its consumption throughout the day in order to achieve different objectives.

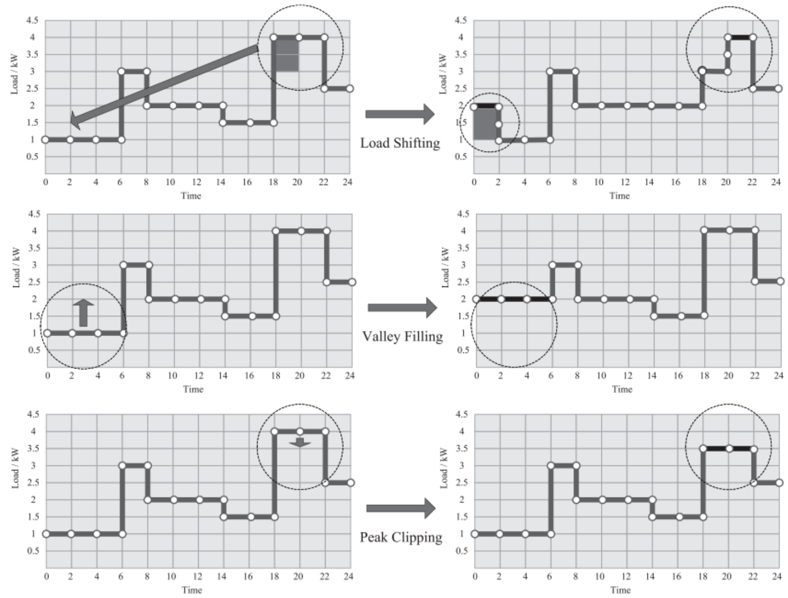

Figure 167 - Different demand side management services

One of the possible control strategies is to reduce electricity import and export peaks, as well as reducing electricity import during power system peak hours (late afternoon). This is achieved by managing flexible loads (heat pump, fridge, etc.) and using the batteries with the help of sensors and communication technology. The Team UNIZG house will have several flexible loads, listed in table below, which will be fully or partly controllable when needed:

Table 54 - Flexible loads in Team UNIZG house

Load	Average daily consumption [kWh]
Dishwasher	0,93
Washing machine	0,69
Clothes dryer	1,02
Refrigerator with deep freezing	0,41
Electric stove	2,65
Oven	0,348
TV	0,158
Blue ray	0,764
Lighting – inside	1,3

An example of control strategy is shown on the figure below. There are two cases shown:

Case I, where the electrical balance towards the grid is shown by the green line. Import and export of the energy with the grid are determined by the difference between PV generation and consumption of the loads in the house.

Case II shows the desired behaviour of our house. All of the flexible loads are shifted into periods with high PV generation, reducing the load in the upcoming hours. Batteries are charged during sunny hours, and discharged several hours later, when the grid peak load occurs. The orange curve is more beneficial for the grid, as less energy is imported (some energy is even exported) during the peak, late afternoon hours. One more benefit is the overall reduction of import/export peaks. This example is not based on the real data, but it illustrates the principles that will be implemented.

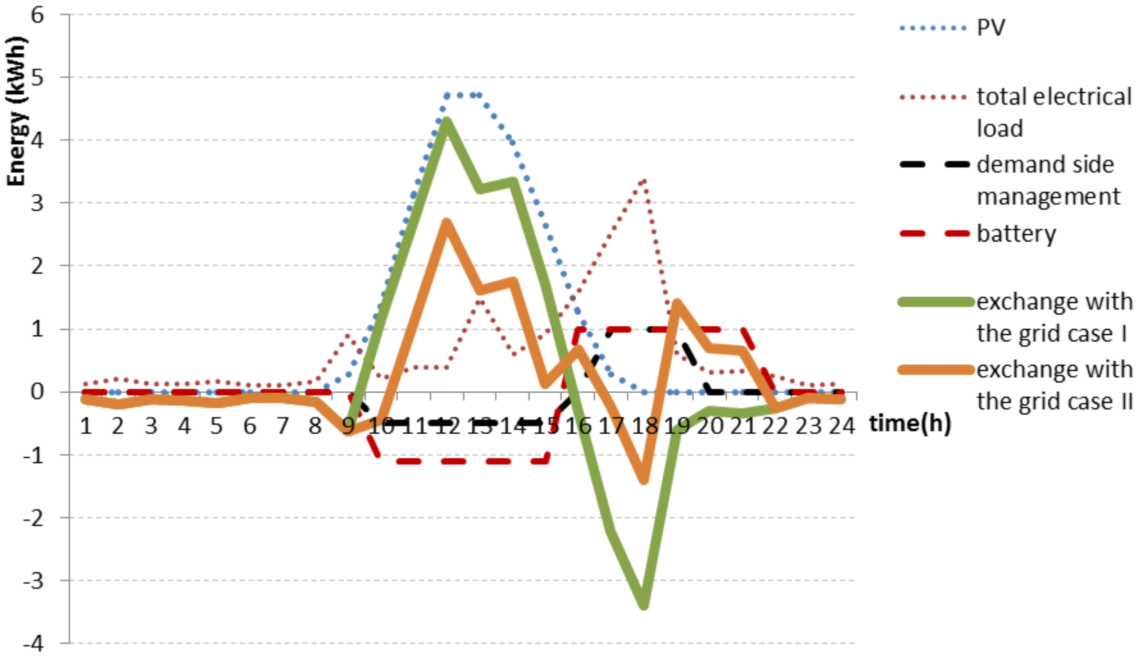

Figure 168 - Example of modifying the consumption curve

This kind of system behaviour will be enabled by the high level of control over the electrical equipment. Control algorithms will be implemented in the central control unit, which will simplify changes in the desired behaviour. The introduction of control algorithms and DSM has a series of short-term and long-term benefits for the customers, energy suppliers and the network operator. A short overview of the benefits for the customer is given in the table below. These benefits have to be thoroughly explained to the customers via various educational programs and media who have incalculable effect on the public.

Table 55 - Overview of customer benefits from smart metering

Customer's benefits		
Short term	Energy savings as a result of improved information	Variable pricing schemes
	More frequent and accurate billing	Better customer service
Long term	Simplification of payments for distributed generation output	Additional payments for wider system benefits
	More reliable energy supply and reduced customer complaints	Facilitating adoption of home area automation for more comfortable life

In addition, implementation of DSM has various other objectives such as achieving the specific trade schedule with the grid, maximization of the profit depending on varying electricity prices or CO2 emission minimization (taking into account varying CO2 emissions from the grid).

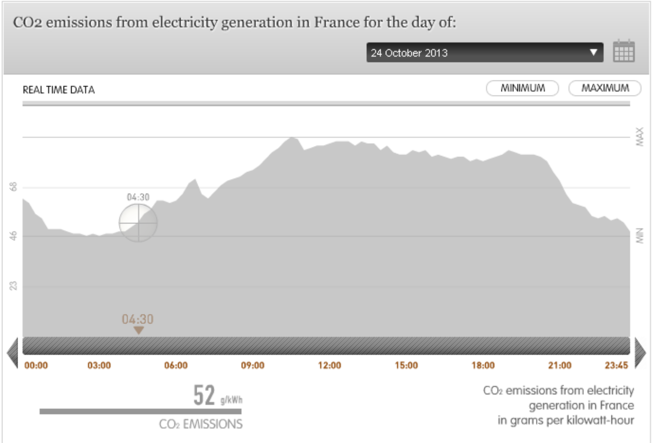

Figure 169 - Varying CO_2 emissions in French power system over time

5.5.3.2 PV system innovation

Innovative approach is also used in control of the tilt of the solar panels. Solar panels installed will have the ability to change their slope from roughly 10 to 50°. The obvious way to utilize that ability is to change their angle over the year as the height of the sun above horizon changes. However, the change in the slope can be used to take advantage of the diffuse radiation during cloudy weather. In that case, slope of the solar panels should be minimal, as that position captures most of the diffuse radiation. During the very sunny or very cloudy days it is obvious how to control the solar panel's tilt: sunny days require solar panels facing the sun, and the cloudy weather requires them to be horizontal. The question is how to deal with days with partial cloud cover. It is not efficient to constantly adjust the solar panel tilt as the moving mechanism might use up more energy than it would be gained. To address that issue, researchers at the University of Zagreb have developed an advanced algorithm[2] which will be used in the operation of Team UNIZG house (see figure below).

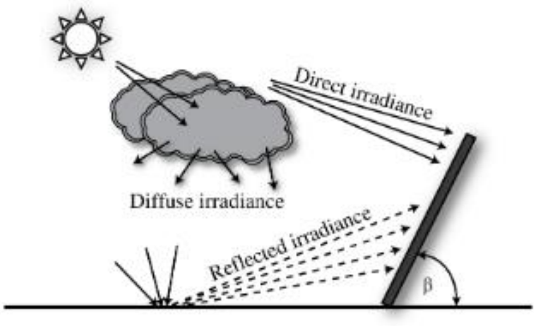

Figure 170 - Tracking different irradiances

[2] M. V. N. P. Marko Gulin, »Dynamical optimal positioning of a photovoltaic panel in all weather conditions,« *Applied Energy,* br. 108, pp. 429-438, 2013

5.5.4 Innovation in Communication and Social Awareness

In order to approach general public more efficiently our intention is to be as creative as possible. Since this project is unique in Croatia, it is important to mention that the Mem**brain** concept is not only an exhibition house. After the exhibition in Paris, it will be rebuilt in Zagreb as a part of future Campus Borongaj project and used in educational, promotional and informational purposes. That fact makes this project unique. Furthermore, our main mission is to inform and awake people about ecological problems which are more and more expressed. We can accomplish that task by resumption of representation the Mem**brain** concept as a house which cares about nature.

An initiative planned to attract the attention of all people is the Mem**brain** Flash mob. It will be held in May at Ban Jelacic square, Zagreb's main square. Details about the Flash mob will be determined in the next few weeks.

For the purpose of introducing the Mem**brain** concept to the other universities/faculties in Croatia, we are planning a tour through all bigger cities and universities in Croatia in spring 2014. There will be held presentations about the Mem**brain** concept on courses which are related to our project.

To mark The Day of Renewable Energy, we will organize a 'City Center One' event in one of our many national shopping malls, which is located in two cities, Zagreb and Split. We will exhibit the Mem**brain** setup and organize an art workshop for children 'Draw your sustainable house'. Also we will exhibit materials which are used in construction process. Other details and activities will be determined in the next few weeks.

Even though business cards do not have big influence in social awareness, we are proud to distinguish with unusual business card form, as shown in the Material for the Project Dissemination.

5.5.5 Innovation in Urban Design, Transportation and Affordability

Flexibility is not a completely new subject in urban design, but in our opinion it hasn't been exploited enough. Furthermore, there haven't been any attempts on flexible urbanism in Croatia yet.

The house can be built anywhere, but there can also be a group of houses (varying in their layouts) grouped together to form specific urban combinations. Elements (housing units) can be added or withdrawn from a certain group in order to create different relations between the units. Also, a unit can change the function it accommodates. For instance, half of the units in a housing cluster can become workstations thus combining the habitants living and workplace.

The cluster can be expanded and reduced in size horizontally and vertically, it can even be divided and relocated. All the units can be transformed individually in size and function. This wide range of changes allows the cluster to adjust to its habitant's needs live a living organism.

5.5.6 Innovation in Sustainability

5.5.6.1 Wood wool

During our research and designing we have noticed an interesting material – wood wool. It is already used throughout Europe, United States, Russia and S.E. Asia, mainly for roofs, floors and walls. To make wood wool insulation panel wood fibers are jointed with cement mixture. Material possesses countless advantages compared to panels produced with organic resins: high durability, good dimensional stability, acoustic and thermal insulation properties and low production cost. It has both the advantages of inorganic and organic materials. Compared to most other materials, it could be said it is environmentally friendly and sustainable; however, we believe it could be much more and have decided to make a real improvement to production process, sustainability, price and social impact the material could have.

Figure 171 - Main components of Wood Wool panels: wood fibres, cement and water

Today, wood wool is made in large plants, using different kinds of wood and cement. Material itself is quite easy to make – mixing water and cement creates a cement paste which is then poured over wood fibers, mixed and set into a mould in order to dry. The problem is that good and healthy trees are cut down in order to get wood fibers by shaving the logs and the production of cement is one of the most environmentally unfriendly processes known. The main problems affecting the manufacture and use of wood wool are the inhibitory effects of wood on the setting of cement and the high specific gravity of the final product. That is why industry has turned to use of an array of chemicals and additives in order to negate those inhibitory effects.

To solve inhibition problems, it is common to add inorganic chemicals, known as accelerators, to accelerate the cure of cement or use pre-treatment such as aqueous extraction to remove inhibitory substances from wood. Cement chemicals accelerators usually improve the properties of wood wool. There are many papers concerning the use of cement curing accelerators such as $SnCl_2$, $FeCl_3$, $AlCl_3$ and $CaCl_2$ and pre-treatments of wood particles to improve the properties of wood wool.

This is where we have decided to improve at first but afterwards expanded even more. Our goal is to produce wood wool insulation for the engine room in Mem**brain** house and we want it to be as 'green' as possible.

Croatia has a lot of forests and wood and timber industry has a real importance in our economy and society. Timber is the ultimate "green" construction material. During a tree's lifetime, it removes tonnes of carbon dioxide from the atmosphere. Wooden materials in the building industry have always been popular worldwide as a result of their excellent properties. However, the process of wood production generates considerable amounts of waste. Wood appears in numerous waste streams, from such diverse sources as domestic furniture to construction and demolition waste. Wood waste represents a significant proportion of the general waste stream. In recent years, wood wastes have caused environmental concerns and the topics of recycling systems and reuse techniques of wood wastes are widely discussed and are becoming increasingly important. Deposing that waste at the landfills is quite costly since our waste management centres are still in the process of being designed and built.

Figure 172 - Croatian forest

Our wood wool is made as environmentally friendly as possible. We wanted it to have everything which all the other mass produced wood wool does not have. Wood shavings taken from waste instead of healthy trees, no additional chemical and cement which has less than 30% of clinker and 70% of slag (another by-product considered to be waste) and low specific gravity. A perfectly acceptable material practically created from "waste".

Wood is a naturally renewable house building material, and is significantly more environmentally friendly than other materials such as steel or PVC. We have decided to use "wood waste" in making of our material. You can get wood shavings practically for free because to sawmill it represents extra cost due to it being of no use to them and considered waste. Wood is chemically heterogeneous and its components can be divided into two groups: structural components of high molecular weight - natural polymer substances (cellulose, hemicelluloses and lignin), which are the major cell wall components; and non-structural components of low molecular weight (extractives and inorganic components). The content of polymer substances: cellulose 40-42 %, lignin 26-28 %, hemicelluloses 29-34 % and extractives 5-10 %. Cellulose is insoluble in water, organic solvents and alkaline solution. It does not mediate under the influence of these materials. Lignin is the most complex polymer among naturally occurring high molecular weight materials. It does not disintegrate under the influence of various organic solvents, alkaline solutions and water. Hemicelluloses differ from cellulose by containing various sugar units with much shorter chains. It is a group of different polymers made up of 5 and 6 carbon sugars. They are soluble in alkali and some hard wood polyoses are even soluble in water. Disintegration of hemicelluloses to the constituents in the alkaline solution increases the amount of extractives. Hemicelluloses are more reactive than cellulose. The extractives are non-polymeric (except pectin sand condensed tannins) and may be separated from the insoluble cell wall materials by solving them in water or organic solvents. The presence of extractives results in corrosion of metals in contact with wood, inhibition of setting of concrete, glue, and finishes, etc. Cement is an alkaline inorganic composite containing a surface hydroxyl group. Wood, in general, inhibits the setting of cement with hardwood fibers, being the most inhibitory. Wood extractives were found to adversely affect the exothermic hydration characteristics of Portland cement, which in turn affects the wood cement compatibility. The main inhibitor of cement hydration is wood fibre soluble sugars and part of hemicelluloses, which under certain conditions can be resolved in these sugars. It has also been found that along with sugars, starches and tannins can inhibit cement setting. Other extractives that cause problems in cement wood compatibility are resins and fatty acids, terpenes and terpenoids, simple sugars and salts. Sugars in concentration as low as 0.03-0.15 wt. % in cement retard the setting time and affect the strength of the cement. The main saccharides of different wood species are glucose and gallactose, arabinose and xylose with mannose. Pozzolanic material added to the cement stimulates combination of free $Ca(OH)_2$ and active silica giving water-insoluble silicate hydrates. Set-retardation may be primarily due to retarding of the hydration of tricalcium silicate through the adsorption of organic admixtures onto calcium hydroxide.

Wood fibers which were used were made from fresh shavings of various wood species (fir, ash, hornbeam, birch etc.).

Figure 173 - Wood fibers

Cement is a hydraulic binder, that is a finely ground inorganic material that is mixed with water to create a paste, which by hydration reactions and processes links and solidifies, and that after curing retains strength and stability under water. Cement, compliant with norm HRN EN 197-1 and HRN EN 97-1, designated as CEM cement, if properly mixed with adequate proportions of aggregates and water, has the ability to create concrete or mortar, which retains workability long enough to shape, and after a certain time period achieves certain grades of strength and maintain long-lasting volume.

Manufacturing cement is an energy-intensive process. It requires 3 to 6 million kilojoules of energy and 1.7 tons of raw materials to make one ton of clinker. The process is a significant source of carbon dioxide emissions, in addition to nitrogen oxides, sulphur oxides, and particulate matter. Concrete manufacturing is one of the most significant sources of CO_2 emissions from manufacturing sources.

Considering the fact that cement production heavily burdens the environment we came to the conclusion that in need of this material being environment friendly cement must be replaced with another binder. Some natural binders, such as magnesite (which is also commonly used in wood wool industry), may not be the perfect solution for this problem. Even though such binders do not require damaging manufacture, they are natural resources, which means we have to be careful exploiting them. Another flaw, specifically for our project, is heavy impact of the transport, since these resources are not local. Solution we came up with is cement with high percentage of slag. Slag is a by-product of iron production and its disposing represents a huge environmental problem in Croatia and our area. Estimated amount of slag on landfills is few million tons and with that being said it's clear there is a need of reusing it somehow. Croatian cement factory "Cemex" produces cement with 66% - 80% of slag and 20% - 34% of clinker. That is a very high amount of slag being used in and we believe that by using that cement as a wood wool binder we can contribute greatly to reducing slag waste in Croatia without exploiting natural resources or burdening the environment with excessive clinker production.

Cement of choice in the making of the material was Cemex CEM III/B 32,5N SR-LH. It is a sulphate resisting slag cement with low hydratation heat and consisting mainly of slag (66-80%) and clinker (20-34%). Unlike traditional Portland cement it utilises a very high quantity of slag – another metal industry by-product considered to be waste. Also, its chemical composition has certain benefits which enable easier hydratation of cement and mitigate to a certain extent the aforementioned negative effect that wood has on cement hydratation.

Table 56 - Properties and composition of CEM III/B 32

TYPICAL PROPERTIES OF CEM III/B 32,5N SR-LH	
%SO_3	2,8±0,2%
%C3A	2,5±0,5%
Chlorides	0,12±0,02%
Binding start time	180±25 min
Early strength (7 days)	27±2 Mpa
Normal strength (28 days)	41±2 MPa
Heat of hydration	<220 J/g
TYPICAL COMPOSITION	
Clinker + Plaster	30%
Slag	70%
Other	0%

Characteristics of the cement:

- high sulphate resistance owing to a substantial proportion of slag
- low heat of hydration and reduced tendency of shrinkage and cracking
- significantly increase the strength of concrete at a higher age (after 28 days)
- longer start bonding

- possible thermal treatment at an early stage in order to raise early strength
- significantly slowed diffusion of aggressive ions
- resistance to impact and aggressive clean water

Recommendations for use:

- construction in wet and aggressive environments rich in sulphates
- works in road construction, development of the foundations of bridges
- marine and coastal facilities
- underground works and soil stabilization and grouting
- systems for wastewater treatment
- sewage and drainage systems
- irrigation Systems

Properties of this cement, aside from being more sustainable than the usual Portland cement, made our job easier due to its longer start of bonding and chemical composition.

In order to determine the best way of mixing we decided to try the three technologies. We used three moulds – dimensions 0,45 x 0,45 x 0,05 m, nine weights – each weighing 9 kg, wood fibers, cement and water.

In the first method of mixing the wood fibers are sprayed with water to such an extent until they reach glow, then evenly strewn with cement through a sieve material (Figure 174).

Figure 174 - Spraying wood fibres with water and distributing cement over the wood fibres

In the second mixing method, we first put cement in a bowl, then kneaded the wood fibers into cement (Figure 175) and finally sprayed with water.

Figure 175 - Mixing the dry wood fibres with the cement

In the third method, we separately mixed cement and water in order to get the cement slurry in which we kneaded the dry wood fibers (Figure 176).

Figure 176 - Mixing the dry wood fibres with cement slurry

Mixtures were then put into molds and left to dry for three days in a room which has air temperature of 22 °C (Figure 177).

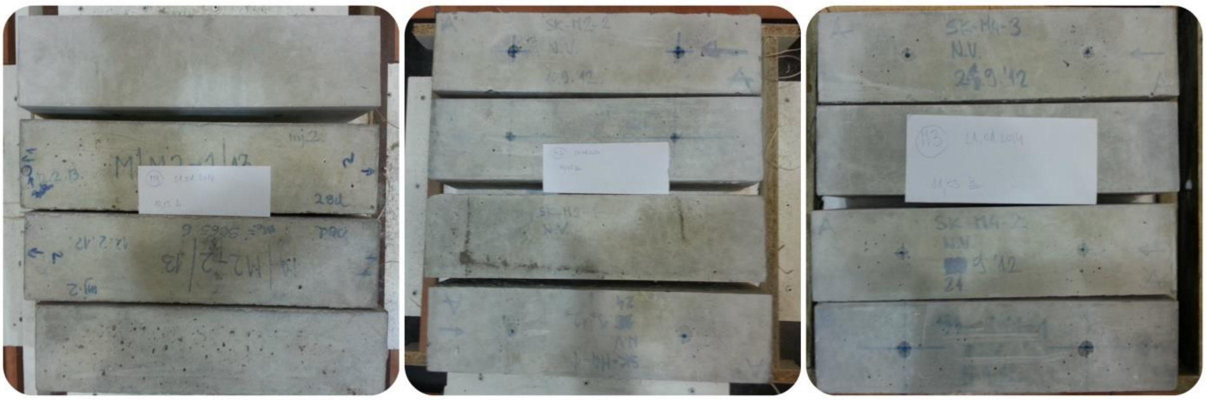

Figure 177 - Wood wool in moulds under a load

After that we had to determine the correct mass ratios of wood fibers, cement and water. We also wanted to test if it was possible to achieve consistency of the material without using any additives. Following mixtures were made:

Table 57 - 6 different wood wool mixtures

	w/c	mwf (g)	mc (g)	mw (g)	d (cm)	V (m³)	r(kg/m³)
M1	0,60	300	2500	1500	2,725	0,005518	535,9973
M2	0,65	300	2500	1625	3,125	0,006328	444,7921
M3	0,70	300	2500	1750	2,950	0,005974	353,4128
M4	0,60	400	2500	1500	3,875	0,007847	400,6691
M5	0,65	400	2500	1625	3,800	0,007695	392,9695
M6	0,70	400	2500	1750	3,813	0,00772	361,0476

w/c – water/cement ratio, mwf – mass of wood fiber, mc – mass of cement, mw – mass of water,
d – thickness of specimen, V – volume of specimen, r- density of specimen

These samples were left under a load of 36 kg to settle down for three days. After that, we took them out and put to dry. We found that all the samples had excellent consistency and achieved a certain level of rigidity (Figure 178).

Figure 178 - Samples after drying

Samples with highest water-cement ratio achieved the least density. Given that less dense materials have better absorption properties (for frequencies lower than 2000 Hz) we have selected samples M3 and M6 (same water-cement ratio of 0.7, but different amounts of wood fiber) for further testing.

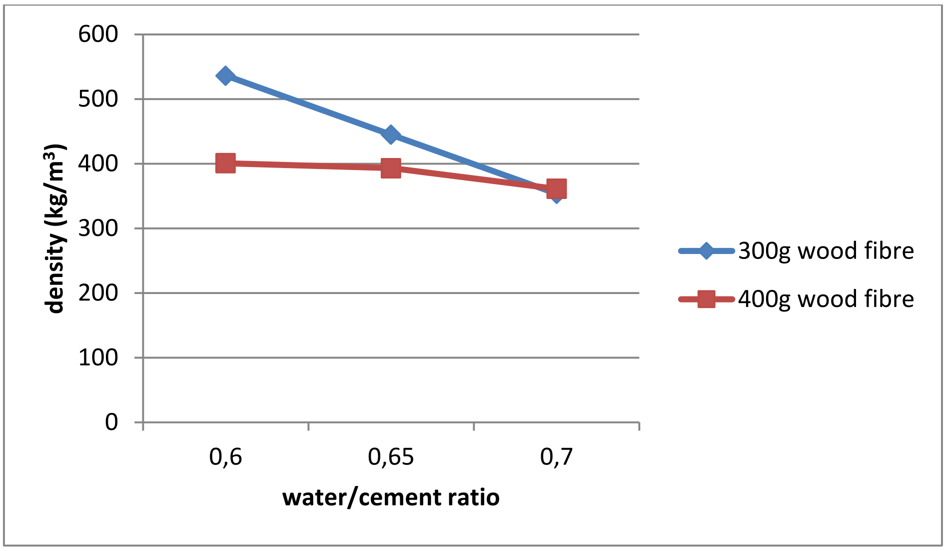

Figure 179 - Densities of samples after drying

We have decided to perform further tests on samples M3, M6 and DRVOLIT AKUSTIK DA (Figure 180) by using Kundt's tube to get an approximate sound absorption coefficient for all three products. Kundt's tube (Figure 181) is used today only for demonstrating standing waves and acoustical forces. DRVOLIT AKUSTIK DA will be used as the reference product, therefore we will use its absorption coefficient as a guideline for the selection of the sample that we will produce for insulation of the engine room in Mem**brain** house.

Two samples were prepared for testing in Kundt's tube:

Table 58 - Samples prepared for testing in Kundt's tube

	w/c	mwf (g)	mc (g)	mw (g)	d (cm)	V (m^3)	r(kg/m^3)
M3	0,70	300	2500	1750	3,5	0,007088	355,5728
M6	0,70	400	2500	1750	3,5	0,007088	391,0835

w/c – water/cement ratio, mwf – mass of wood fiber, mc – mass of cement, mw – mass of water, d – thickness of specimen, V – volume of specimen, r- density of specimen

Figure 180 - Samples: DRVOLIT AKUSTIK DA, M3 and M6

Table 59 - Densities of samples M3, M6 and DRVOLIT AKUSTIK DA

	d (cm)	r(kg/m³)
M3	3,5	355,5728
M6	3,5	391,0835
DRVOLIT AKUSTIK DA	3,5	414,2857

d – thickness of specimen, r- density of specimen

Figure 181 - Kundt's tube apparatus

We plan to perform many further tests on this new material such as testing in a reverberation chamber, flammability testing, permeability to water, thermal conductivity, tensile and pressure strength tests, in order to observe its behavior and how it compares to other available products. Even so, wood wool offers obvious environmental and sustainability benefits. Material is very cheap to produce. Two most expensive items are cement and manpower. Since it wasn't made in a big facility or plant it significantly reduces the carbon footprint and embedded energy used in the production.

Our goal was not to make a material which has high load capacity, but a porous and light one, which can be used for covering the façade and provide better thermal and acoustic insulation. It is highly resistant to humidity, pests, insects and fire. We are currently testing all of those properties in a certified laboratory and will soon be able to compare the performance of wood wool with other similar materials on the market. When done with all the testing, we are going to produce insulation panels for the engine room in our house.

Figure 182 - Engine room 3D model

Wood wool is very easy to handle. It is light and can be cut with a saw into any shape you wish. We haven't observed any problems while dyeing it and we are planning to dye it in three different colors to create some sort of mosaic in our engine room. At first glance it looks scruffy, but it can easily be transformed and become aesthetically pleasing. Installation of wood wool is another easy thing about it. Gluing works extremely well and offers a lot of flexibility.

Figure 183 - Cutting and mounting idea

Another interesting and useful thing is that this is a material that practically anyone can produce at home with very little effort and knowledge. Croatia has a lot of problems with the insulation of buildings. Most of them were built a long time ago when insulation was unheard of or uncommon practice. Also, a lot of people after building their homes don't have the financial ability to insulate the facade. This could be a viable method of achieving that. It could also be used in third world countries to accomplish the same goal since this material is not too dependent on the type of wood used.

5.6 Sustainability Report

Mem**brain's** sustainability report is based on the motive that technological optimism in collaboration with environmental standards is the response to problems of environmental capacity and the impact on the environment.

The environment is a complex set of physical, geographic, biological, social, cultural and political conditions that surround an individual or organism and this set of conditions have influence on our way of living and behaving. Carrying capacity is a term that stands for the highest density of species that may occupy a habitat or ecosystem without degrading the ability of that habitat for future species. Sustainable development is the concept of using resources while preserving them for future generations, and having no irreversible impact on ecosystems. There are two views in achieving this goal:

- Technocentrism, which is identified with anthropocentric view of the world where there are no limits for development and unlimited commitment to economic growth and scientific and technological optimism that will give an answer to every environmental problem.
- Ecocentrism is the second view where there are ecological and social limits to growth, reducing the use of natural resources at the level of the bearing capacity of the ecosystem, and respecting the complexity of ecosystems, as well as the limits of human understanding and elitist expertise.

Technological optimism is a vision that will increase the number of technological improvements in areas such as food production, environmental quality and energy and facilitate the sustainability of human life and existence as a response to the increasing number in the total population of people in the world. But some experts do not support this vision because they find that technological optimists can deceive mankind with anticipation of continuing occurrence of technological advances with increasing estimation of prices. They promote the idea of a stable politics that will enable mankind steady state of using resources in response to the possibility that technological innovations fail. On the other hand, by educating people in lifelong cultural behavior and rational use of resources, optimists believe that the idea of technological developments can take hold in sustainable development.

Since the world can't be all black and white, through the development of project the team decided to use the best of both directions and offer society the Mem**brain**.

5.6.1 General Concept of the project and Sustainability

If one were to explain the general concept of our house in few terms, it would more likely be the absence of a specific concept or context. The concept of Mem**brain**, though clear and simple, is hardly a concept in the conventional meaning – in a way, the concept itself is to avoid a specific concept, and embrace a principle, one very present in all aspects of life and behavior.

It is the principle of a membrane and its content – which is similar to the relation of a house to the life which occupies it. Physically, the house is not a volume, but a membrane – a thin envelope which defines the difference between in and out, safe and uncertain, livable and unsuitable.

Our concept, so to say, was to create such a membrane which would implement the very principles of sustainability which we described previously. The integration of technological innovation (heat pump, PV tracking systems, smart house, PCM), usage of sustainable materials (wood, sheep wool), rainwater collection, treatment of wastewater and reduction of waste in general, reduces the ecological "footprint" of the envelope and the life inside it to a minimum – but also increases the level of awareness and consciousness of its inhabitants towards their environment.

To put it briefly – our principle is the envelope, the Mem**brain**, which defines the living space of the user, and our concept is to make it highly sustainable and comfortable for the user, with the local resources in our disposition.

5.6.2 Urban Design, Transportation and Urban Design

Mem**brain's** adaptable urban strategy (described previously in the chapter of the Urban Design, Transportation and Affordability Report), is based on the same principles as the house itself - simplicity, modularity and adaptability. These principles are implemented through modular planning inside an urban grid, developing complex social, economic and cultural spaces through the usage of simple Mem**brain** units. The units themselves are adaptable to a wide variety of purposes, thus serving as “transformable cells” of a complex urban organism.

The horizontal modularity gives way to endless possibilities for forming different urban layouts, inside a variety of grids formed by transportation lines, while the vertical modularity (stacking several units to form a higher building) provides a relatively high density – applicable to different ranges of urban zones - low-rise and medium-rise housing, services, tourism, etc. – the key contents of the Croatian urban context.

Of course, the urban design also implies solutions in not-so-urban contexts, which constitute a large portion of Croatian territory. The rural parts of Croatia (in the continental regions as well as the Mediterranean) frequently require small service structures such as schools, local communities and self-governments, libraries, post offices and shops – which usually imply an expensive and inefficient construction process, often not using the local materials but transporting from distant sites and constructing by expensive technologies.

The Mem**brain**, in this case, would serve as a cheap and effective solution – offering quick, inexpensive, locally based and easily manufactured structures with high energy standards and minimal ecological impact. In some cases, almost all of the material could be provided locally and the working force would be the local community. The technology and material would be adapted to the local resources (for instance – the insulation may be sheep wool, as well as wood wool, straw bale and other local resources) and the usage of the space defined by the modular grid of the Mem**brain**.

5.6.3 Bioclimatic Strategies: Passive design strategies

There are several aspects of passive design strategies to be considered in the Mem**brain** concept:

There are two types of insulation used in this project – sheep wool and glazing, the advantages of the first being its cost efficiency and local affordability, while the seconds is translucent, thus enabling sunlight and heat exploitation. By means of the Mem**brain**, we wanted to define and protect the void, by maintaining a visual connection with the outdoor space. This proposal required us to find the adequate ratio of sheep wool and glazing used to insulate the void space properly.

Three sides of the façade, the southern, the eastern, and the western, consist of an outer and inner layer, made of triple and double glazed panels respectively, providing a high daylight factor. The two layers enclose the greenhouse (to the east and west) and winter garden (to the south) space.

During summer, the winter garden space is a buffer, and the warm air inside is allowed to escape outside, preventing the inner glazing, and thereby the void, from overheating. At night, all air inside the void is exchanged with fresh air from outside through the winter garden, cooling the whole house in the process. During winter, the winter garden is used to generate the greenhouse effect – the warmed up air is used to contribute to the warmth of the void. At night, this space serves as a buffer again. It can be seen in the figures below, that the PV tracker is operating synergistically with the previously described use of the winter garden, as shown in the Figure 184.

Sustainable construction goes hand in hand with the dematerialization of constructional elements, which are made of materials with a lower thermal capacity. This leads to the reduction of heat accumulation and indirectly to increased energy consumption for air conditioning. In order to solve this problem, we use phase-change materials (PCM), which have a much greater ability to store heat than conventional building materials. The PCM is placed beneath the roof slab and covered by a dropped ceiling, as shown in the Figure 184.

By having three façades translucent, we also had to think of ways to provide appropriate sunshade, avoiding overheating during summer. The eastern and western facades are partially protected by plants grown in the greenhouse. In order to ensure complete shading and outside view protection if needed, there are roll up shades on each side. They shades are placed outside the outer glazing layer, and are rolled up horizontally. The south façade is protected by an innovative building integrated PV tracking system (which is explained in more detail in a separate section). The three translucent facades provide a large portion of daylight, while previously described means of shading enable a fine control of the daylight factor.

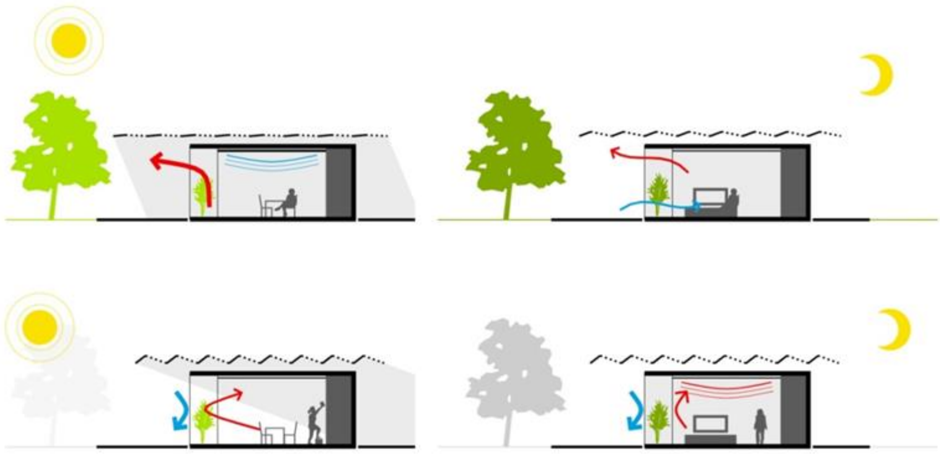

Figure 184 - Use of winter garden for maintaining an optimum indoor climate during summer and winter (top and bottom, respectively)

5.6.4 Construction system

Manufacturing of the house elements will be performed under controlled conditions in which they will be easily monitored for energy, time and materials consumption. Elements of the house will be produced in dimensions that will allow the optimal number of trucks required for transport. Total of eight trucks are predicted to transport the construction elements from Zagreb to Versailles. On the other hand the dimensions of the elements and their assembly methods are designed to perform quick and energy-efficient construction of the house. The main construction machines that will be used in building process are tower crane, forklift and cherry picker. Team UNIZG will also hire a truck mounted crane that will be also used for transporting the elements from Zagreb to Versailles. This truck will be set up as an additional machine on the site that will be also used as a crane to avoid unnecessary organizational delays and to speed up the process of assembling the house as well as to save time and energy. House Membrain consist of completely prefabricated elements so there will be small amount of waste, which will be sorted and recycled.

5.6.5 Materials

5.6.5.1 Materials Selection

For the main material of our house we selected wood for its availability in Croatia. Forests in Croatia have a long history of serving the nation's survival and for economic recovery. It gives a man the necessary materials for life from the cradle to the grave (cradle, lumber, paper, furniture, woodwork, floors, ceilings, wall coverings, fuel wood, coffin, etc.) so that life without the wood can't be imagined. Croatian forests in the history of our nation enabled its economic progress (especially Slavonian oak) and because of their exploitation and sales, many railways, roads, bridges and even entire cities were built. Croatia is in the wooded countries in Europe with more than 0.50 ha per capita, and the forests are one of the biggest Croatian national wealth.

Total area of forests and forest land in Croatia amounts to 2, 688. 687 ha which is 47% of its total land area. Forests are classified according to their purpose as well. The Forest Act states that according to their purpose, forests can be:

- Commercial
  - used for the production of forest products, next to the preservation and improvement of their welfare functions
- Protective
  - serve for the protection of soil, waters, settlements, etc.
- Forests with special purpose:
  - protected nature areas (reserves, national parks, nature parks, nature monuments, important landscapes, park forests)
  - forests and parts of forests registered for production of forest seed (seed stands)
  - forests for scientific research
  - forests for defense of the state

Figure 185 - Croatian forest

The term "growing stock" depicts the total volume of wood mass in a certain forest, which indirectly defines the quality of that forest, too. The term "increment" shows the quantity by which this volume is increasing every year, which is again a figure that depicts the availability of wood for usage by men.

“Hrvatske šume” are applying the principles of sustainable management for hundreds of years already. Significantly less wood is taken from the forest than it is growing every year, and as trees of lesser quality are constantly cut, it is clear that our forests are the more beautiful the longer they are managed.

Some people are worried when passing through some wooded parts of country and seeing parts of forests cut, thinking that foresters cut the trees clear. They are wrong. What looks like a clear cut, is actually a young forest only a few years old. And when one oak falls down, that should be looked on like birth of a few thousand of them, who cannot live in the shadow of their ancestors and can't wait for their chance. That is why some tree species simply have to be managed in a regular way, as foresters say. It is important to notice that felling, which looks like clear cut, happens only on small areas, whereas at the level of a management unit the total growing stock is either the same or even higher with time.

In the forests of Gorski kotar forest management is different. In that region the selection management is applied, so that every couple of years, individual ripe trees are taken out, opening in that way space for young growth. Beech and fir are species that enable such kind of management. Looked at from the outside, it seems as the forest is not changing at all, although by this method the same quantity of wood is exploited as in the regular forests. As the selection forests cannot be classified by age, they are classified in tables according to their diameter class.

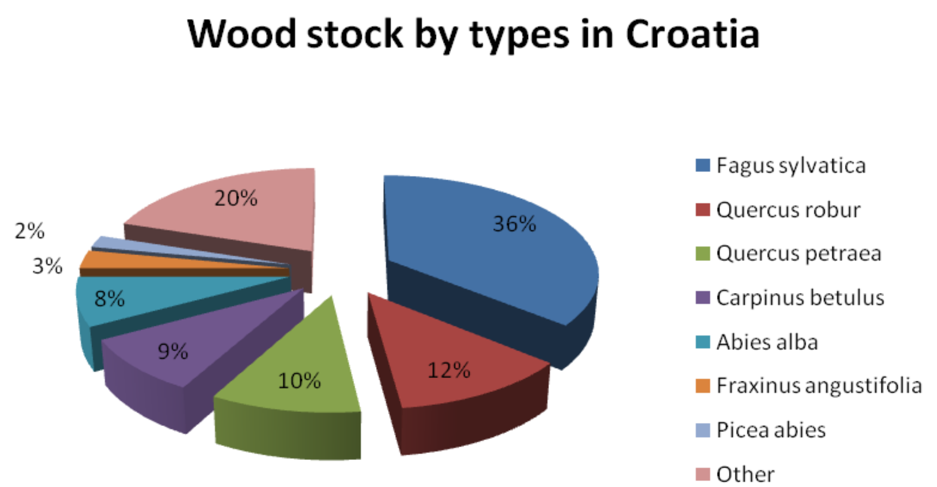

Figure 186 - Wood stock by types in Croatia

Pedunculate/English oak (*Quercus robur*) is a deciduous tree of the genus oak family Fagaceae. It is a tree with height of 40 m (exceptionally up to 50 m), and the tree can reach a diameter of up to 3 m. This is a tree that can reach an age of 500 – 800 years. Its treetop is broad, irregular and well branched.

Pedunculate oak requires deep, clay or sandy, fertile, mostly wetlands, with a high level of groundwater. Less thrives on shallow dry soil. Because of that, pedunculate oak habitat is predominantly in illuvial – lowland soils or slightly hilly terrain. There he is represented in the pure pedunculate oak forests or in combination with hornbeam, ash etc.

Figure 187 - Pedunculate oak (Quercus robur)

Silver fir (*Abies alba Mill.*), Coniferous tree species of temperate regions of the Northern Hemisphere, the third most widespread forest tree species in Croatia, after beech and oak tree. Silver fir is represented with 50% in coniferous forests Croatian. Silver fir is the only Abies genus native in Croatia. In Gorski Kotar fir has exceptionally favorable conditions and achieves high quality. It grows up to 40 m (in the jungles of up to 60 m), reaches a thickness greater than 1.5 m in diameter at breast height. The trunk is cylindrical. Treetop is initially conical, and can be straightened in the later age, as cut off. It is very sensitive to winter cold and frost, requires high air humidity and tolerate well snow and hail. It is threatened due to the effects of acid rain.

Figure 188 - Silver fir (Abies alba)

Spruce (*Picea albies*) is a coniferous wood species of the family Pinaceae. It grows in northern Europe and mountainous regions of central and southern Europe. It is grown outside the natural habitat because it grows quickly, provides high-quality wood and is commonly used as a Christmas tree. In Croatia it is an indigenous species. Spruce is 50 meters high and 2 meters thick wood. Its trunk is straight and slender, up to 1 m in diameter. Treetop is tight and columnar. In our country it is populated in the areas of northern Velebit. We distinguish its two ecotypes with respect to resistance to the frost. It loves areas with plenty of rainfall and it is very sensitive to summer drought. However, is one of the most adaptable species and is easily grown beyond the boundaries of its habitat.

Figure 189 - Spruce (Picea albies)

Penduculate oak

For hardwood floor we chose oak, a native Croatian species of lowland area. It is the most aesthetically valued species with great physical and mechanical properties and high durability. Pedunculate oak is the most common choice in floor making because its lively texture. Its color enriches both traditional and modernly decorated spaces. Because of its durability Pedunculate oak is used to build houses since ancient times that are now protected and make the cultural heritage of the area.

Table 60 – Technical properties of pedunculate oak

TECHNICAL PROPERTIES	
density (g/cm^3)	0,390 - 0,790
tangential stability	9,4
hardness (daN/cm^2)	470 - 1140
speed of sound in the grain direction (m/s)	3381 – 4310
color stability	Medium
change of water	Slow
possibility of setting in the kitchen, bathroom and on underfloor heating	Medium

Silver fir and spruce

For structural and wall elements we chose fir and spruce, a native Croatian species of mountainous regions. With beech and oak these are the most common wood species. They are mostly used in making structural elements where they are irreplaceable. Main advantage of these wood species are low density, easy and fast drying, easy processing and gluing, as well as relatively low cost compared to wood species such as larch or pine. Although these are poorly durable wood species, they can be used on wooden facades with appropriate constructional and physical protection, surface treatment. They have the possibility of maintaining and restoring in order to achieve aesthetic effect, environmental standards and low cost.

Table 61 - Technical properties of spruce and fir

TECHNICAL PROPERTIES		
	SPRUCE	FIR
density (g/cm³)	0,300 - 0,640	0,320 - 0,710
bending strength (daN/cm²)	490 - 1360	470 - 1180
compressive strenth (daN/cm²)	310 - 590	350 - 790
compressive strenth (daN/cm³)	210 - 2450	480 - 1200
shear strength (daN/cm²)	40 - 120	37 - 63
modulus of elasticity (daN/cm²)	73000 - 214000	66000 - 172000
work to maximum load (KJ/m²)	10 - 110	30 - 120
natural durability rating	4 (poorly durable)	

Glued Laminated Timber (Glulam)

Of the structural building materials, wood has the lowest energy requirements for its manufacture, significantly reducing the use of fossil fuels and pollution of our environment compared to other materials. As part of a structure, wood's natural insulating properties (many times higher than steel or concrete) reduce the energy required to heat and cool the structure for its lifetime. Wood is reusable, easily recycled, and 100% biodegradable. Advantages of these materials in particular are that they can be harvested from second- and third-growth forests and plantations. Glulam elements provide the strength and versatility of large wood members without relying on the old growth-dependent solid-sawn timbers because they are made by gluing individual thin timber layers together. They reduce the overall amount of wood used when compared to solid sawn timbers by diminishing the negative impact of knots and other small defects in each element. Wood has a greater tensile strength relative to steel – two times on a strength-to-weight basis – and has a greater compressive resistance strength than concrete. Glulam wood is naturally durable and robust. Glulam offers excellent fire resistance, unlike other alternatives, and provides a known charring rate bringing safety and integrity to our structure. Glulam is chemically stable and suitable for aggressive and humid environments. The layers are bonded together using formaldehyde-free and environmentally-friendly adhesive which makes up less than 1% of the entire product.

Figure 190 - Glued laminated timber slabs

Wood Wool

Wood wool panels for acoustic insulation of the house are made by binding wood fibers with cement. Wood fibers are a completely organic product that has very good technical properties, while the cement mixture is used for fiber bonding; it also strengthens the element and increases its fire and moisture resistance. Important property of wood wool panels is that debris from the timber, i.e. out of all wood parts which remain unused after the production of structural elements, beams, columns and the like, can be used for fibers. Therefore, for the production of such insulating boards it is not required to procure new raw material since all healthy and acceptable wooden remains can be utilized.

Figure 191 - Wood wool

Considering the fact that cement production heavily burdens the environment we came to the conclusion that in need of this material being environment friendly cement must be replaced with another binder. Some natural binders, such as magnesite (which is also commonly used in wood wool industry), may not be the perfect solution for this problem. Even though such binders do not require damaging manufacture, they are natural resources, which means we have to be careful exploiting them. Another flaw, specifically for our project, is heavy impact of the transport, since these resources are not local. Solution we came up with is making wood wool panels with cement which has high percentage of slag (as described in chapter 5.5.6.). Slag is a byproduct of iron production and its disposing represents a huge environmental problem in Croatia and our area. Estimated amount of slag on landfills is few million tons and with that being said it's clear there is a need of reusing it somehow. Croatian cement factory "Cemex" produces cement with 66% - 80% of slag and 20% - 34% of clinker. That is a very high amount of slag being used and we believe that by using that cement as a wood wool binder we can contribute greatly to reducing slag waste in Croatia without exploiting natural resources.

Sheep Wool

For thermal insulation of the house we choose sheep wool. Croatia is a country with long tradition in sheep breeding and farming. Even though sheep farming is developing more and more, nowadays it's focused on production of meat, cheese and milk and not on making products from sheep wool. Sheep are sheared once or twice per year and since there is no organized collecting system in Croatia the wool is being left in the nature making unregulated dumps. Raw sheep wool is slowly biodegradable and hard flammable material, which causes difficulties with its disposal. The discarded wool does not allow plants to grow, smells and becomes lair for bacteria and rodents, becoming ecological and health problem.

Figure 192 - Discarded sheep wool

According to the data base, there is about 1200 t of discarded sheep wool in Croatia and the quality of that wool is not good enough to make fine products, but it is acceptable for making carpets and thermal insulation. Using sheep wool as an insulation material leads to unregulated dumps large decrease. Because of their crimped nature, when wool fibers are packed together, they form millions of tiny air pockets which trap air, and in turn serve to keep warmth in during winter and out in the summer. Wool's unique advantage is its breathability. It's ability to absorb and release moisture from the surrounding air, without compromising it's thermal efficiency. When wool fibers absorb moisture, they generate tiny amounts of heat. This warmth acts to prevent condensation in construction cavities by maintaining the temperature above the dew-point in damp conditions. This property creates a natural buffering effect, stabilizing heat changes that occur with relative humidity. Practically, this reduces the need to keep adjusting heating or cooling levels as wool insulation will keep a buildings cooler during the day and warmer during the night.

To make wool insulation panels wool is washed in an environmentally friendly way with soda and soap and moth repellent is added during textile processing, so there is no hazard to human health and panels can be reused or recycled as compost.

Figure 193 - Life cycle of sheep wool

Powder Coated Steel

Powder Coated Steel is used for foundation system. Powder coating is a dry finishing process. Powder coatings are based on polymer resin systems, combined with curatives, pigments, leveling agents, flow modifiers, and other additives. These ingredients are melted, mixed, cooled and ground into a uniform powder similar to baking flour. A process called electrostatic spray deposition (ESD) is typically used to achieve the application of the powder coating to a metal substrate. Representing over 15% of the total industrial finishing market, powder is used on a wide array of products. More and more companies specify powder coatings for a high-quality, durable finish, allowing for maximized production, improved efficiencies, and simplified environmental compliance. Powder coated products are more resistant to diminished coating quality as a result of impact, moisture, chemicals, ultraviolet light, and other extreme weather conditions. In turn, this reduces the risk of scratches, chipping, abrasions, corrosion, fading, and other wear issues. Because powder coating materials contain no solvents, the process emits negligible, if any, volatile organic compounds (VOCs) into the atmosphere. It requires no venting, filtering or solvent recovery systems such as those needed for liquid finishing operations. Exhaust air from the powder booth can be safely returned to the coating room, and less oven air is exhausted to the outside, making powder coating a safe, clean finishing alternative and saving considerable energy and cost. Theoretically, 100 percent of the powder over-spray can be recovered and reused. Even with some loss in the collection filtering systems and on part hangers, powder utilization can be very high. Over-sprayed powder can be reclaimed by a recovery unit and returned to a feed hopper for re-circulation through the system. The waste that results can typically be disposed of easily and economically.

5.6.5.2 Incorporated Energy

The embodied energy of a building material can be taken as the total primary energy consumed. This would normally include (at least) extraction, manufacturing and transportation. Ideally the boundaries would be set from the extraction of raw materials (including fuels) until the end of the products lifetime (including energy from manufacturing, transport, energy to manufacture capital equipment, heating and lighting of factory, maintenance, disposal etc.), known as 'Cradle-to-Grave'. It has become common practice to specify the embodied energy as 'Cradle-to-Gate', which includes all energy (in primary form) until the product leaves the factory gate. The final boundary condition is 'Cradle –to-Site', which includes all of the energy consumed until the product has reached the point of use (i.e. the building site)

"Cradle-to-Gate" - Glued Laminated Timber

1. Transportation

In some cases, the transport of raw and processed materials consumes a significant amount of energy. Logs are harvested in the forest and weight about 1 tone/m^3. A large part of this is water which is removed later in the production process. Logs are transported from the forest in trucks on road built for the purpose. Processed timber is also transported and it is relatively light material and weighs 500 kg/m^3. That is much lighter than the approximate 2,500 kg/m^3 weight of concrete. We also need to considered the transportation from Zagreb to Paris and backwards.

2. Manufacturing structural timber

The conversation of raw resources into a usable product typically uses the most energy and creates the most pollution in the life cycle of a building product. However, compared product such as plastic, timber requires only minor processing. Also, the manufacture of rough sawn timber uses vastly less fossil fuel energy per unit volume than does that of steel, concrete or aluminum. Table shows that the fossil fuel energy required to manufacture rough sawn timber is 1.5 MJ/KG while the manufacture of aluminum requires 435 MJ/kg of fossil fuel energy.

Table 62 - Fossil fuel required to produce four common building materials

Material	Fossil fuel energy (MJ/kg)	Fossil fuel energy (MJ/m^3)
Rough sawn timber	1.5	750
Steel	35	266000
Concrete	2	4800
Aluminium	435	1100000

Also, timber stores up to 15 times the amount of CO_2 released during its manufacture, whereas steel and aluminium store negligible amounts.

3. Dressing and molding

The process of planning the wood surface to a smooth finish is known as dressing. Molding is simply the shaping of timber into forms other than rectangular. Dressing and molding are relatively simple industrial processes and they do not use much energy.

Wood wool

Wood wool panels for acoustic insulation of the house are made by binding wood fibers with cement. Wood fibers are a completely organic product that has very good technical properties, while the cement mixture is used for fiber bonding; it also strengthens the element and increases its fire and moisture resistance. Compared to most other materials, it could be said it is environmentally friendly and sustainable; however, we believe it could be much more and have decided to make a real improvement to production process, sustainability, price and social impact the material could have (as described in chapter 5.5.6.1).

Figure 194 - Main components of Wood Wool panels: wood fibers, cement and water

Today, wood wool is made in large plants, using different kinds of wood and cement. Material itself is quite easy to make – mixing water and cement creates a cement paste which is then poured over wood fibers, mixed and set into a mold in order to dry. The problem is that good and healthy trees are cut down in order to get wood fibers by shaving the logs and the production of cement is one of the most environmentally unfriendly processes known. The main problems affecting the manufacture and use of wood wool are the inhibitory effects of wood on the setting of cement and the high specific gravity of the final product. That is why industry has turned to use of an array of chemicals and additives in order to negate those inhibitory effects.

This is where we have decided to produce our own wood wool for acoustic insulation of the engine room and improve at first but afterwards expanded even more. Our goal is to produce wood wool insulation for the engine room in Mem**brain** house by ourselves and we want it to be as ‘green’ as possible. To achieve that we also needed to replace cement with another binder.

Manufacturing cement is an energy-intensive process. It requires 3 to 6 million kilojoules of energy and 1.7 tons of raw materials to make one ton of clinker. The process is a significant source of carbon dioxide emissions, in addition to nitrogen oxides, sulphur oxides, and particulate matter. Concrete manufacturing is one of the most significant sources of CO_2 emissions from manufacturing sources.

Considering the fact that cement production heavily burdens the environment we came to the conclusion that in need of this material being environment friendly cement must be replaced with another binder. Some natural binders, such as magnesite (which is also commonly used in wood wool industry), may not be the perfect solution for this problem. Even though such binders do not require damaging manufacture, they are natural resources, which means we have to be careful exploiting them. Another flaw, specifically for our project, is heavy impact of the transport, since these resources are not local. Solution we came up with is cement with high percentage of slag. Slag is a by-product of iron production and its disposing represents a huge environmental problem in Croatia and our area. Estimated amount of slag on landfills is few million tons and with that being said it's clear there is a need of reusing it somehow. Croatian cement factory "Cemex" produces cement with 66% - 80% of slag and 20% - 34% of clinker. That is a very high amount of slag being used in and we believe that by using that cement as a wood wool binder we can contribute greatly to reducing slag waste in Croatia without exploiting natural resources or burdening the environment with excessive clinker production.

Croatia has a lot of forests and wood and timber industry has a real importance in our economy and society. Timber is the ultimate "green" construction material. During a tree's lifetime, it removes tonnes of carbon dioxide from the atmosphere. Wooden materials in the building industry have always been popular worldwide as a result of their excellent properties.

However, the process of wood production generates considerable amounts of waste. Wood appears in numerous waste streams, from such diverse sources as domestic furniture to construction and demolition waste. Wood waste represents a significant proportion of the general waste stream. In recent years, wood wastes have caused environmental concerns and the topics of recycling systems and reuse techniques of wood wastes are widely discussed and are becoming increasingly important. Deposing that waste at the landfills is quite costly since our waste management centers are still in the process of being designed and built.

That is why we have decided to use "wood waste" in making of our material. You can get wood shavings practically for free because to sawmill it represents extra cost due to it being of no use to them and considered waste.

Figure 195 - Wood fibers

Our wood wool is made as environmentally friendly as possible. We wanted it to have everything which all the other mass produced wood wool does not have. Wood shavings taken from waste instead of healthy trees, no additional chemical and cement which has less than 30% of clinker and 70% of slag (another by-product considered to be waste) and low specific gravity. A perfectly acceptable material practically created from "waste".

Figure 196 - Our efforts to produce wood wool insulation by ourselves

Another interesting and useful thing is that this is a material that practically anyone can produce at home with very little effort and knowledge. Croatia has a lot of problems with the insulation of buildings. Most of them were built a long time ago when insulation was unheard of or uncommon practice. Also, a lot of people after building their homes don't have the financial ability to insulate the facade. This could be a viable method of achieving that. It could also be used in third world countries to accomplish the same goal since this material is not too dependent on the type of wood used.

Sheep wool

Sheep wool, provided it is not imported from long distances, has a very low level of embodied energy, since unlike many other insulation materials it is a natural product manufactured without any input energy, and is processed with only minimal energy consumption.

Being made from a naturally produced fiber, sheep wool insulation requires less than 15% of the energy required to produce than glass fiber insulation. It can absorb and break down indoor air pollutants, such as formaldehyde, nitrogen dioxide and sulphur dioxide. Wool is a sustainable and renewable resource, that has zero ozone depletion potential and at the end of it's useful life can be remanufactured or biodegraded. Sheep wool insulation is safe and easy to handle and no protective clothing or special breathing apparatus is required to install it. Sheep Wool Insulation also requires only a fraction of the energy to produce compared to that of man made counterparts. This means that Sheep Wool Insulation will pay back its energy costs more than 5 times sooner (only 15 kW of energy are used to produce 1 m³).

Table 63 - Embodied energy

Material	Energy MJ/kg	Density kg/m³	Volume m³	Total (MJ)	MJ/m²
Footing					
Plywood pad	15	600	5.248	47232000	683333.33
Steel	19.8	7860	0.61	94933.08	1373.45
Polypropylene (Buzons)	99.2	950	10.05	947112	13702.43
Superstructure					

Glue Laminated timber (wooden slab)	12	380	26.1	119016	1721.88
Roofing - Waterproofing - Frame					
Panels of oriented fibred (OSB)	15	650	1.45	14137.5	204.54
Glue Laminated timber (wood pillars)	12	350	1.44	6048	87.5
Sheep wool	20.9	50	7685	8030825	116186.70
PVC	77.2	1200	0.1695	15702.48	227.18
Backing wall – Ceiling - Interior Joineries					
Plaster	6.75	900	0.486	2952.45	42.71
Timber	8.5	400	122.419	416224600	6021767.94
Aluminium	214	2700	4.84	2796552	40459.38
Exterior Joineries and Facade					
Wooden facade elements	7.8	800	0.82	5116.8	74.03
GLT (wall)	12	500	2.376	14256000	206250
Glass	15	2900	2.751	119668500	1731315.1
Wood wool	20	90	0.54	972	14.0625
Sheep wool	20.9	50	746	779570	11278.50
Heating – Ventilation – Cooling					
Stainless steel	56.7	7500	0.00064	272.16	3.9375
Aluminum	214	2700	0.004	2311.2	33.4375
Copper	42	8900	0.0012	448.56	6.49
HDPE	76.7	600	0.04	1840.8	26.63
EPDM	89	1000	0.0018	160.2	2.32
PVC pipes	77.2	1100	0.0303	2573.076	37.23
Photovoltaic Panels ; Batteries					
Monocystalline	4750	2330	0.0059	65298.25	944.71
Tempered solar glass	26.2	2420	0.118528	7515.15	108.73
Aluminium	214	2700	1.05	606690	8777.34
Copper	42	8900	0.04	14952	216.32
PVC compound	77.2	1100	110.561	9388840120	135833914
Lead	25.21	11340			

Embodied energy values are usually expressed in energy used per kilogram – but for any useful comparison to be made between materials, thermal performance and material density need to be included.

5.6.5.3 Incorporated CO_2

The embodied carbon of a building material can be taken as the total carbon released over its life cycle and it is subject of rising importance. Modern society is underpinned by an intricate web of economic and social activities; commerce, transport and leisure interwine providing support to not only sustain, but also enhance our way of life. However we have created unprecedented environmental impacts and significant demands upon our natural resources. Clearly concerted action must be taken: not only to limit, but also to reverse any long term damage, and thus ensuring that we live on this planet in a sustainable manner.

Most energy used in the production of building materials is derived from fossil fuels, and embodied energy is a significant indicator of material's impact on the carbon cycle. As timber and other forest products are largely made from atmospheric carbon, they do not have the same relationship between embodied energy and the carbon cycle as other major building materials.

As part of the process of photosynthesis, trees give off oxygen and absorb carbon dioxide from the air and sequester (store or fix) it in woody tissue. To produce 1 kg of wood, a tree takes 1.47 kg of CO_2 and returns 1.07 kg of oxygen to the atmosphere. In effect, the tree acts as a storage sink for carbon. Carbon storage does continue in the ecosystem in, for example, leaf litter in the forest floor. Timber in buildings and wood in other products sequesters carbon from the atmosphere for at least as long as the building stands or the material is used and for much longer if the timber is not burnt. Timber buildings form a considerable carbon sink. Using wood materials in construction ensures that the CO_2 remains fixed for long periods. The embodied carbon of timber products is low relative to many other construction materials. As with all plant-based materials, carbon is stored during tree growth and continues to be stored through its use as a building material. At the end of its life, carbon is released either through natural decomposition, returning other nutrients to the soil, or through the generation of heat/energy by burning it as a fuel, either way providing a comparatively highly efficient end-of-life treatment.

Table 64 - Embodied carbon

Material	Embodied Carbon kg CO_2 per kg	Density kg/m³	Volume m³	Total (kg CO_2)	kg CO_2/m²
Footing					
Plywood	1.07	600	5.248	3369216	48744.44
Steel	1.37	7800	0.61	6518.46	94.31
Polypropylene (Buzons)	2.7	950	10.05	25778.25	372.95
Substructure					
Glue Laminated timber (wooden slab)	0.67	5380	29	104533.4	1512.35
Roofing - Waterproofing - Frame					
OSB (Panels of oriented fibred)	1.12	650	1.45	1055.6	15.27
Glue Laminated timber (wooden slab)	0.67	350	1.44	337.68	4.89
Sheep wool	1.2	50	7685	461100	6671.01
PVC	2.41	1100	0.2175	576.5925	8.34
Backing wall – Ceiling - Interior Joineries					
Plaster	0.12	900	0.486	52.488	0.76
Timber	0.72	400	12.1	3484.8	50.42
Aluminium	8.25	2700	4.84	107811	1559.77
Exterior Joineries and Facade					

Wooden facade elements	7.8	800	0.746	4655.04	67.35
GLT (wall)	0.67	500	2.376	795960	11515.63
Glass	0.85	2900	2.751	6781215	98107.86
Wood wool	0.98	90	0.54	47.628	0.69
Sheep wool	1.2	50			
Heating – Ventilation – Cooling					
Stainless steel	6.15	7500	0.00064	29.52	0.43
Aluminum	8.25	2700	0.004	89.1	1.3
Copper	2.6	890	0.0012	2.7768	0.04
HDPE	1.6	600	0.04	38.4	0.56
EPDM	2.69	1000	0.0018	4.842	0.07
PVC pipes	2.41	1100	0.0303	80.3253	1.16
Photovoltaic Panels; Batteries					
Monocystalline	242	2330	0.0059	3326.774	48.13
Tempered solar glass	1.27	2420	0.118528	364.28	5.27
Aluminium	8.25	2700	1.05	23388.75	338.38
Copper	2.6	8900	0.04	925.6	13.39
PVC compound	2.41	1100	110.561	293097211	4240411.04
Lead	1.57	11340			

Maintenance plan

Table 65 – Maintenance tasks

Ref	Part of building	Maintenance task	Who will do the work?	Frequency
ROOF				
1	Roofs area generally	Inspect roofs areas from the ground and report any loss or damage to the roof coverings	Unskilled or voluntary	1.After a stormy weather 2.Every year
2	Metal parts of roof	Inspect the condition of panels, joints and clips. Make temporary repaints to crack and splits.	Skilled volunteer from team or contractor	Twice a year
3	Weathering's and flashing	Inspect the condition of lead flashings and weathering's.	Skilled volunteer from team or contractor	One a year
EXTERNAL WALLS				

1	External walls generally	Inspect external walls from the ground and accessible high points and report any damage and signs of movement.	Unskilled or voluntary	1.After a stormy weather 2.Every year
2	Ventilation	Make sure that ventilation grilles, air bricks, louvers and so on are free from blockages.	Skilled volunteer from team or contractor	Once a year
3	Windows	Check that roofs and windows are bird-proof before nesting starts.	Skilled volunteer from team or contractor	Twice a year
4	Windows	Inspect window and make essential minor repairs to glazing.	Unskilled or voluntary	Once a year
5	Doors and windows	Check hinges, bolts and locks and lubricate as necessary. Check the security of locks.	Unskilled or voluntary	Twice a year
6	Foliage and large trees close to walls	Check the trees in yard and report any dead branches and signs of ill health, or root damage to the building or below-ground drainage.	Unskilled or voluntary	Once a year
INTERNAL STRUCTURE				
1	Internal spaces generally	Inspect roof voids and internal spaces, particularly below gutters. Report on any evidence of roof or gutter leaks.	Unskilled or voluntary	1.After a stormy weather 2.Every year
2	Internal structure and fabric	Inspect the structure and fabric including roof timbers and bell frames and report any signs of structural movement or damp, fungal growth and dry rot.	Unskilled or voluntary	Once a year
3	Roof and floor spaces	Check roof and floor spaces for signs of vermin and remove. Avoid use poison.	Unskilled or voluntary	Twice a year
HOUSE SERVICES				

1	Lighting protection installation	Visually inspect the lighting-conductor system including spikes, tapes, earth rods and all connections and fastenings.	Lightning conductor engineer	Once a year
2	Heating system	Service the heating system.	Approved code of practice engineer	Once a year
3	Water	Make sure that all exposed water tanks, water pipes and heating pipes are protected against frost.	Unskilled or voluntary	Once a year
4	Fire-fighting equipment	Service fire extinguishers.	Specialist	Once a year
5	Fire protection and smoke alarm systems	Get a qualified engineer to test an service the fire-detection and smoke-alarm systems.	Specialist	Once a year
6	Control system for house	Test the system and inspect the wiring.	Specialist	Once a year
7	Wiring and electrical installation	Inspect all wiring and electrical installations in line with current regulations.	Specialist	Once a year

5.6.6 Active Systems and Equipment

5.6.6.1 HVAC

Global consumption of primary energy to provide space heating/cooling, lighting and other building-related energy services grew up due to growth in population, urbanization and industrialization. These appliances are the main part of the energy consumption in buildings which plays an important role in consumption of energy all over the world. Unfortunately, non-renewable energy sources or electricity, especially fossil fuels, provide for these purposes. Nowadays, most of the energy is used for keeping our living and working spaces at comfortable temperatures to provide better environment. However, low efficient equipment is still used for these purposes. Therefore, energy utilization in an efficient way for space heating and cooling is very important for the development of the energy systems. Although, excessive utilization of non-renewable energy sources leads to several environmental issues, such as acid rain, global warming, ozone depletion due to an intensive increase in the level of carbon emissions.

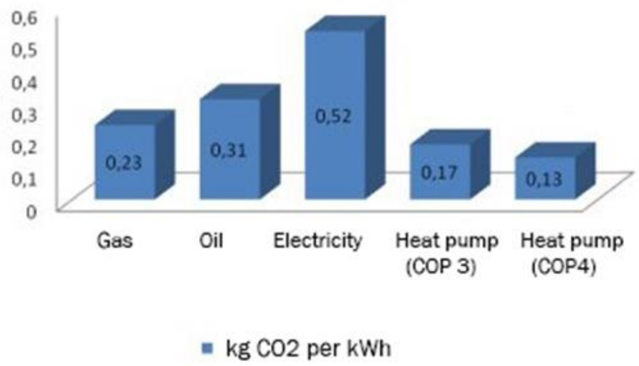

Figure 197 - Carbon footprint comparison

Heat pumps offer the most energy-efficient way to provide heating and cooling in many applications, as they can use renewable heat sources in our surroundings. They also have the smallest CO2 footprint of all today’s energy sources. Even at temperatures we consider to be cold, air, ground and water contain useful heat that's continuously replenished by the sun. By applying a little more energy, a heat pump can raise the temperature of this heat energy to the level needed. There are various types of heat pumps. In our project we will be using Air supply heat pump (ASHP).

Heat pump efficiency is measured by the CoP (Coefficient of Performance). This is a measure of the ratio of useful heat output by the heat pump to the amount of energy input for operation. The CoP is typically between 3 and 5. Efficiency can also be measured by the SPF (Seasonal Performance Factor) which can be regarded as an average CoP for the entire heating season. This takes into account variations in weather and is thus a more accurate measure of efficiency. In house designing one of the goals is to create such environment that will minimize heat losses and thus increase efficiency of whole conditioning system.

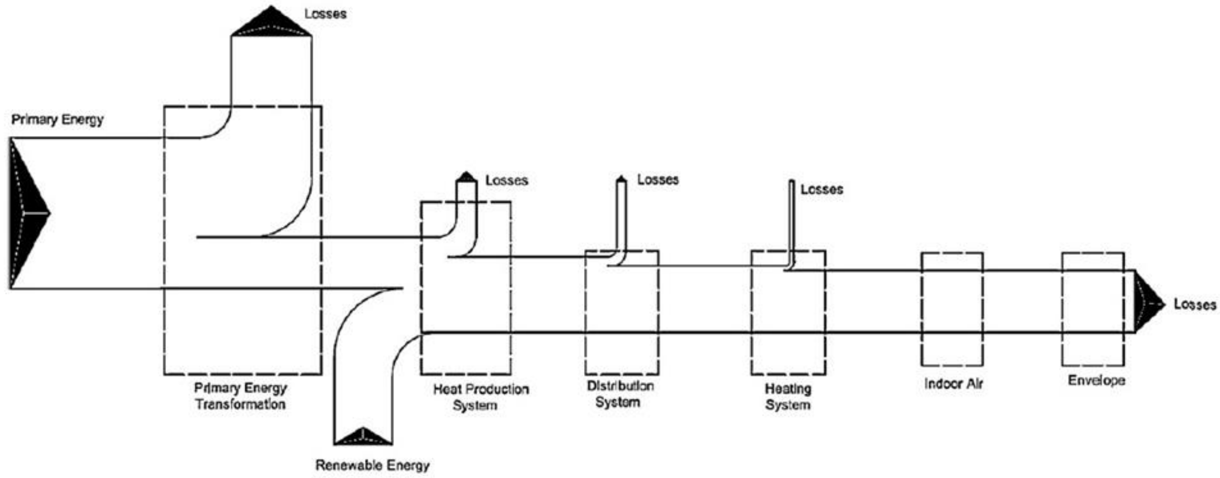

Figure 198 - Energy losses in heat pump operation

The heat pump that will be used in this project is going to be manufactured by local firm so transport costs will be minimized. The compressor and housing are usually made from reinforced steel but the evaporator and condenser are made from low alloyed steel. Other parts of the heat pump such as the pipework, electrical cables and expansion valve are all made from copper. Pipes are insulated with polymeric material (elastomere) and the cables are mostly insulated with PVC. First, we decided that the refrigerant used in heat pump will be R-134a (1,1,1,2-tetrafluoroethane), but after extensive research it was found that R410A refrigerant is more potent and effective. The heat pump will be charged with R-410a refrigerant. R-410a is a high efficiency refrigerant blend of R-32 (Difluormethane CF2H2) and R-125 (Pentafluoroethane CF3CHF2). Many sources say that R-410a is the most efficient refrigerant on the market and it is stated that users may experience energy savings of anywhere from 2% to 5% which leads to significant drop of carbon footprint. R-410a is an environmentally conscious refrigerant because its ozone depletion potential is zero but it has a global warming potential of 2100 which is acceptable in comparison with other refrigerants. The ASHRAE gave R-410a a rating of A1 for safety. R-410a operates at higher pressures which allow use of smaller components and piping.

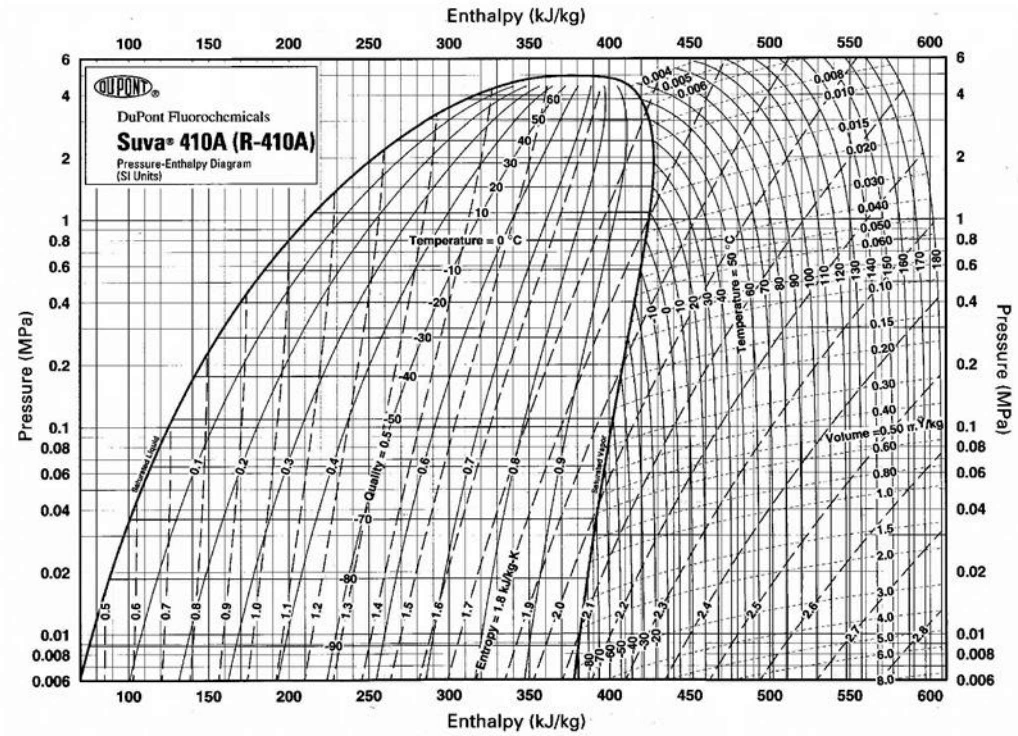

Figure 199 - R410A properties

The units are considered maintenance free, only requiring a top up of refrigerant. Metal and plastic components make a minor contribution to the heat-pump footprint, only 2–3% of the overall value compared to the refrigerant footprint which is significant.

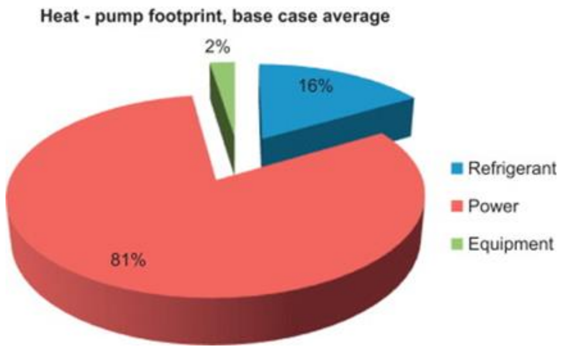

Figure 200 – Heat pump footprint

The installation process for Air source heat pump is minimal compared to the Ground source heat pump which require extensive drilling and/or digging over a large area.

A lifetime of 20 years has been assumed for the heat pumps. At the end of the life cycle, metal components are recycled as are the polymeric parts and insulation materials. The rest of the waste is landfilled. The remaining refrigerant is reused, assuming losses of 20% during extraction process. Life cycle of heat pump is shown on figure below (T meaning transport).

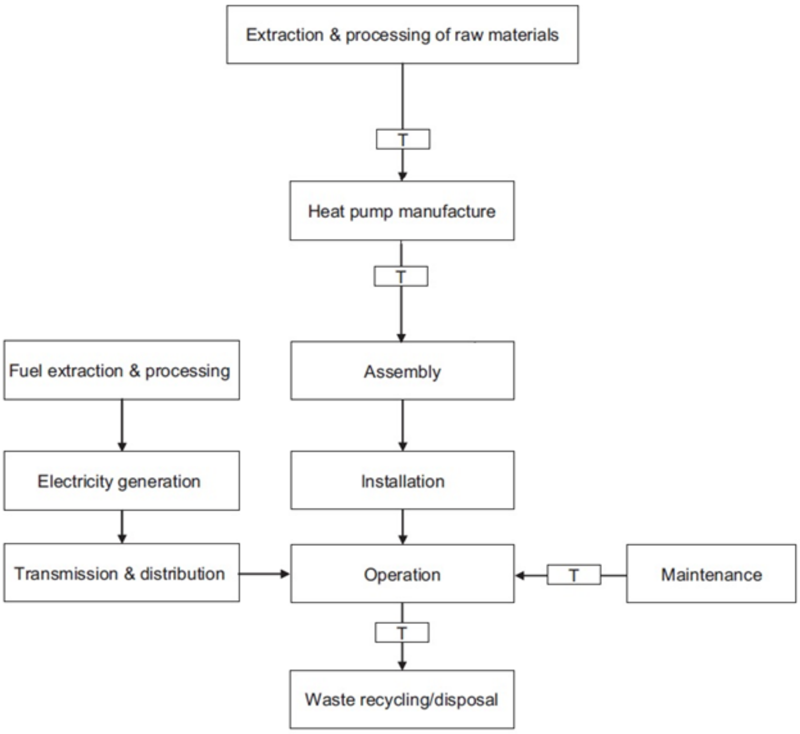

Figure 201 - Heat pump life cycle

As shown in figure below, compared to other countries in Europe, Croatia is in relatively good position regarding CO_2 emission via heat pumps. But are the heat pumps always the best solution? For example, Poland has significantly more heat pumps that Croatia yet CO_2 emissions are sky high. It's because heat pumps use electricity and almost every power plant in Poland uses coal. Because of electricity production mostly from fossil fuels, gas boilers would be better solution for heating when CO_2 emission is considered. In Croatia, heat pumps are very suitable for domestic and industrial use because significant part of electricity is produced from renewable sources and nuclear energy (Krško nuclear plant). Apart from water source heat pumps, Croatia is also very favourable for geothermal heat pumps because geothermal gradient is 30% higher than the Europe average (0,05°C/m vs 0,035°C/m). We can conclude that use of the heat pumps causes no carbon dioxide emission in those countries where only renewables or nuclear power stations produce the electricity. For this reason, Norway or Sweden present nearly almost ideal situations for heat pump usage.

Tracking system

In order to increase efficiency of solar modules they will be placed on tracking system. Membrain solar tracker is unique because it acts like a roof, provides shade, channels rainwater and increases PV efficiency. In order to make it light, cheap and reliable materials had to be chosen carefully. Prefabricated aluminum profiles will be used for tracker construction. Apart from properties, we are using aluminum for our main construction because it is one of the most recyclable materials. To recycle it, we need to use only 5% of energy needed to manufacture new primary aluminum. This construction is designed in a way that part of the load is distributed through our driving mechanism so usage of aluminum is minimized. Even though aluminum production carbon footprint is substantial in this project use of aluminum is justified through merging multiple systems together in the form of PV tracker.

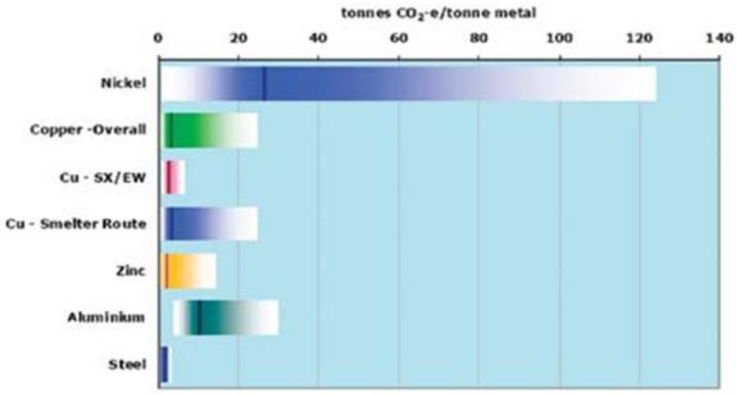

Figure 202 - Metal production CO_2 emission

Compared to steel, aluminum takes more energy to produce and its production emits more CO_2 in the atmosphere. Having that in mind, aluminum was still the first choice over steel. If weight of both is compared for the same construction, and nonexistent corrosion resistance of the steel is taken into account, choice is obvious. In order to make steel corrosion resistant for long period of time toxic coatings and materials would have to be used. Pound for pound steel is more environmentally friendly but weight of the construction if steel is used would be 60% more compared to aluminum. More weight means higher maintenance and transport costs. Sustainability is not about material, it's about final product.

Phase change material

Phase change materials (PCMs) are an innovative technology that can reduce HVAC energy consumption in buildings and houses. PCMs are substances capable of storing or releasing large amounts of energy. Heat is released or stored through phase change, when the material changes from solid to liquid it absorbs latent heat but during phase transition from liquid to solid it releases latent heat.

Significant amount of PCM will be put inside the ventilation channel. The function of this PCM mass is reduction of peak loads. For example during hot summer days the outside air is precooled (PCM melts and absorbs heat) before entering and mixing with inside air which results in decrease of cooling load, consequently the heat pump consumes less electricity and the overall carbon footprint of the house is significantly reduced. During night when the outside air is cooler, PCM is regenerated (it congeals and releases heat).

We will use RUBITHERM® RT25HC as out phase changing material. RUBITHERM® RT25HC is chemically inert and ecologically friendly (organic PCM) and has virtually unlimited product life. The material melts/congeals between 22°C and 26°C with main peak at 25°C. Heat storage capacity varies around 230kJ/kg and the manufacturer indicates that performance remains stable during phase change cycles.

Figure 203 - Phase change material

5.6.7 Solar Systems

5.6.7.1 Energy recovery time

As Mem**brain** is planned for two locations, Zagreb and Paris, it is necessary to calculate the greenhouse gas emissions per produced kWh per year with respect to these two locations. This has been done with program RETScreen. The input data for the calculation are parameters of the PV system as well as of the inverter, location of the system, and transmission and distribution losses. RETScreen contains base cases for average greenhouse gas emissions per kWh of electricity generated in Croatia and in France. Therefore, if we calculate the total emission savings per year, this amounts 1.7 t CO_2/year for Zagreb which is equivalent to 729 litres of gasoline not consumed (Figure 204).

Emission Analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh	
Croatia	All types	0,236	16,0%	0,281	
Electricity exported to grid	MWh	7	T&D losses	16,0%	
GHG emission					
Base case	tCO2	2,0			
Proposed case	tCO2	0,3			
Gross annual GHG emission reduction	tCO2	1,7			
GHG credits transaction fee	%				
Net annual GHG emission reduction	tCO2	1,7	is equivalent to	729	Litres of gasoline not consumed

Figure 204 - RETScreen calculation for Zagreb

For Paris the savings are lower due to the lower base case and amount 0.5 t CO_2/year which is equivalent to 201 liters of gasoline not consumed (Figure 205).

Emission Analysis

Base case electricity system (Baseline) Country - region	Fuel type	GHG emission factor (excl. T&D) tCO2/MWh	T&D losses %	GHG emission factor tCO2/MWh	
France	All types	0,079	5,0%	0,083	
Electricity exported to grid	MWh	6	T&D losses	5,0%	
GHG emission					
Base case	tCO2	0,5			
Proposed case	tCO2	0,0			
Gross annual GHG emission reduction	tCO2	0,5			
GHG credits transaction fee	%				
Net annual GHG emission reduction	tCO2	0,5	is equivalent to	201	Litres of gasoline not consumed

Figure 205 - RETScreen calculation for Paris

To calculate total emissions and savings of the solar system, it is necessary to observe its life-cycle. The life-cycle of solar system (i.e. photovoltaic) covers material production (e.g. mining, smelting, refining, purification), solar cell- and PV module production, system operation and maintenance, system decommissioning, and disposal or recycling. The parameters that determine the life-cycle are initial efficiency, the efficiencies degrade over the system lifetime, the lifetime of the system and performance ratio. We assumed that the initial efficiency of the multi-Si is 14.2 % and the lifetime of a PV system was set at 30 years, as recommended by guidelines from the International Energy Agency (IEA). Total emissions in life cycle for observed solar system is 45 g/kWh. If we include total emissions in life cycle of solar system in calculation of total emissions and savings of the Mem**brain** solar system, total emission savings per year for Croatia are 1,38 t CO_2/year and for France 0,23 t CO_2/year.

In terms of energy efficiency of solar system, an important parameter for observing is the energy pay-back time. A popular belief still persists that PV systems cannot "pay back" their energy investment within the expected lifetime of a solar generator - about 30 years. This is because the energy expended, especially during the production of solar cells, is seen to outweigh the energy eventually generated.

Data from recent studies shows, however, that present-day systems already have an energy payback of 1 to 3.5 years, well below their expected lifetime. Energy payback time depends on the solar cell technology and installation location. According to the data from German Fraunhofer Institute, since geographical conditions for Zagreb and Paris are very similar (irradiation ~1500 kWh/m2/a), we can assume that energy payback time for Mem**brain** solar system will be 2.1 year.

5.6.7.2 CO_2 emissions

Implementing a home solar energy system is a great way to reduce carbon footprint, cut greenhouse gas emissions and help fight global warming (Figure 206). When calculating CO_2 emissions for solar energy system in the house few parameters should be calculated. Firstly, the geographic location and the average greenhouse gas emissions per kWh of electricity produced for the observed country and life cycle of solar system from its production to decommissioning and recycling.

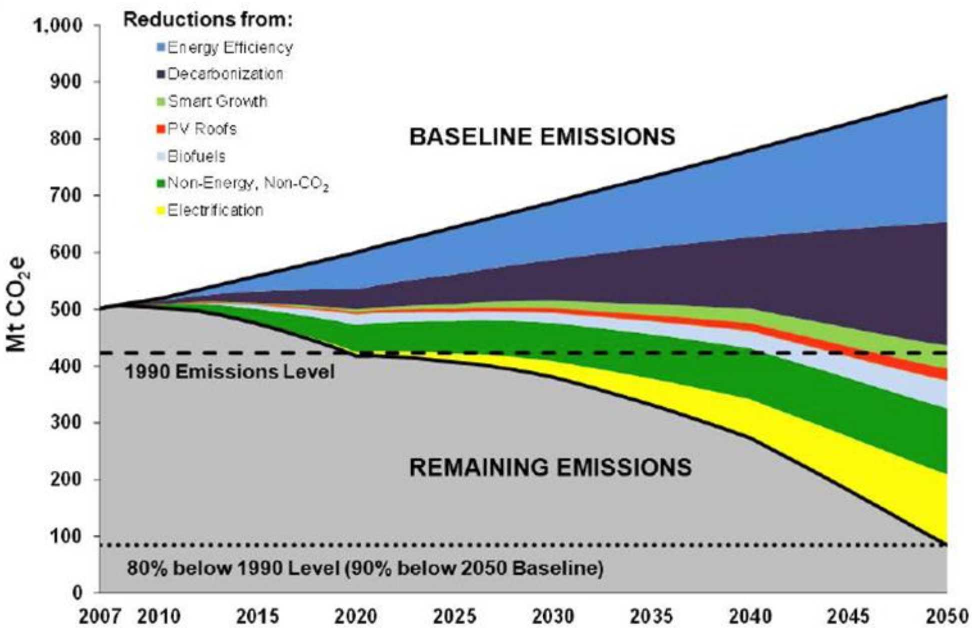

Figure 206 - Prediction of CO_2 emissions until 2050 with several reduction schemes

Accessibility

<u>PV modules</u>

PV system requires little maintenance. It is recommended to check the status of the modules at least once each six months. However, if the system output drops at any time during sun hours, a check should be performed to remove any dust, tree leaves or other dirt from the modules.

To clean the modules, the maintenance agent can simply use a ladder and climb safely up the roof. Once up, the agent can use water and a non-abrasive detergent to wash them.

The visual inspection also includes checking possible broken glass. Then those broken glass should be replaced.

Solar grid inverter and Quattro inverter/charger

The inverters should be checked every three months for any visual signs of external damage. The status indicators can be cleaned also with a cloth. In case of any inverter shutdown, the module branch belonging to that inverter should be checked and cleaned to remove shadowing and a reset should be done on the inverter.

The housing has to be mechanically sound. In case of damage (cracks, holes, missing covers) that endanger the operating safety, the device needs to be immediately deactivated. Larger particles of dirt are removed from the device with a soft brush while dust is removed with a damp cloth. Depending on the ambient conditions it is necessary to clean the fans only at a standstill either with a vacuum cleaner or a soft brush. The control elements can also be cleaned with soft, damp cloth without the usage of solvents, abrasives or corrosive liquids. It's important to regularly check whether error messages are present.

Batteries

Type of battery integrated in the PV system of Mem**brain** do not need water replacement and no residues of electrolytes appear in the battery contacts. That is the reason why they were called maintenance-free. Pressure valves are used for sealing and cannot be opened without destruction. Therefore, they are defined as "Valve-Regulated" lead-acid batteries (VRLA-batteries).

To ensure the reliability and longevity of the battery bank, regular maintenance is required.

a) *Work to be performed every six months*

Take the following measurements and record the measurement values:

- Voltage of the complete battery bank.
- Voltage of a few selected batteries in the battery bank.
- Surface temperature of a few selected battery in the battery bank.
- Temperature in battery room.

If the battery voltage deviates from the average float charge voltage by more than +1.2V / battery or -0.6V / battery and/or if the surface temperature of selected battery in battery bank differs by more than 5°C, contact customer service.

b) *Work to be performed annually*

Take the following measurements and record the measurement values:

- Voltage of the complete battery bank.
- Individual voltage of all batteries in the battery bank.
- Surface temperature of all batteries in the battery bank.
- Temperature in battery room.
- Perform a visual check of all screwed connectors.
- Check all screwed connectors to make sure that they are firmly secured.

- Visual check of battery racks or battery cabinets.
- Check to make sure that the battery room is properly ventilated.

c) *Cleaning of the battery*

Cleaning the batteries on a regular basis is necessary to maintain battery availability and to meet accident prevention regulations. Before cleaning is carried out, each component of the system should be isolated. This would involve switching off circuit breakers to and from the battery bank. While cleaning the batteries you must wear safety goggles and safety clothes. Plastic battery components must be only cleaned with pure water. After cleaning the battery surface has to be dried with appropriate measures, like antistatic cleaning cloth (e.g. cotton). Batteries should be cleaned at least once per year.

<u>Wiring and protections</u>

An inspection should be taken every six months. Following should be checked:

- the terminals; check if they are loose, overheated or burned out. If any wire is burned it should be replaced
- the wiring skin; to detect any possible defects and to be fixed with self-adhesive tape
- oxidation in welding and circuits of PV modules (caused by the entrance of humidity across the enclosures)
- the connecting pin wiring of the PV modules to check for failures in pressure
- the connection between the other equipment, checking power values
- the sealing of the PV modules, to replace any affected elements, avoiding future malfunctions
- the protection equipment, including all the relays, following the instructions of the manufacturer
- In case of any inconvenience or doubt, the manufacturer’s datasheet should be checked for further instructions concerning the maintenance.

5.6.8 Water

At the beginning of the third millennium the United Nations proclaimed the new International Decade for water (2005-2015). Project „Water Life“ determined water from Croatia as very important economic asset. Both foreign and domestic science agrees that Croatian water resource has economic value that exceeds the local and regional significance. In fact, according to a report on the water supply, which is made by UNESCO in up to 188 countries, Croatia is in Europe in the high third position, only two northern countries: Norway and Iceland are richer in water resources. Croatia according to the report has 32,818 cubic meters per year of renewable fresh water per capita and therefore belongs with among 30 richest countries in the world with water supply. In addition, Croatia is among the few countries where the public water supply guarantee and provide drinking water for their citizens. The amount of the assessment of ground water supplies have a total annual capacity of 9,133 million cubic meters, with the majority of stocks (7132 mil/m3) situated in karst - carbonate aquifer and the rest in alluvial area. It is significant because about 90 percent of the water in Croatia is obtained from reserves of groundwater. Today water from the public water supply in Croatia supplies about 80 percent of the population. Till 2015th is planned to finish project of expansion of national water supply where will be achieved goal of 94 percent of the population in Croatia that have access to public water supply and it will be closer to the standards of majority of EU countries.

It is evident from the text above that Croatia does not have a problem with fresh water and supplying the population with such water. But that does not mean we should behave irrationally and neglect and pollute the resource that we have. Of course nobody's follow these principles which is evident from the fact that Croatian average consumption of tap water is 138 liters per capita per day. While in developed countries, water consumption per person is 90-140 l/day and in countries in developing 10 -50 l/day from which we can see that Croatian citizens are very irrational in spending water. Also as we mentioned in the text above that by the end of 2015 is planned to expand the water supply network there is no mention of the problem of deterioration of system. So in Zagreb daily from deterioration water systems drains 178,450 m^3 of unused water compared to a daily all water wells in Zagreb give 430,000 m^3. This means that from the water system every day drains water sufficient to fill 65 Olympic swimming pools.

5.6.8.1 Project’ general water use, management and conservation concept

As we mentioned in text above, in Croatia, there is no problem with the amount of drinking water but with system maintenance and primarily supply water to inaccessible and protected areas. Earlier we mentioned that the public water supply in the Croatia supplies about 80 percent of the population, which means that about one-fifth of people in Croatia still have no access to the public network.

Under inaccessible areas we think primarily of the islands. In the Croatian there is 698 islands, 389 islets and 78 reefs. Of the 698 islands, only 48 are inhabited in the sense that at least one person residing on the island. These islands in the three summer months experienced a huge boom in tourism. This all leads to the problem of water supply on the islands.

The main protected areas in Croatia implies national parks, nature parks and strict reserves. There are 444 protected areas of Croatia, encompassing 9% of the country. Those include 8 national parks in Croatia, 2 strict reserves and 11 nature parks. The strict and special reserves, as well as the national and nature parks, are managed and protected by the central government, while other protected areas are managed by counties. In 2005, the National Ecological Network was set up, as the first step in preparation of the EU accession and joining of the Natura 2000 network. These areas will become a tourist and scientific focus on visiting and research and it will be need to equip this areas with content facilities. Also most of the Croatian national parks and nature parks need to rebuild infrastructure and our concept, Mem**brain**, can be applied because of its simplicity and sustainability.

Water conservation is not simply a matter of using less water through restrictions. It is about careful management of water supply sources, use of water saving technologies, reduction of excessive demand and many other actions. Therefore, during the project team was led by acclaimed design principles in water management: value of water, use water sustainably, develop suitable institutions to manage water, collect and disseminate information, maintain a social and cultural perspective, ensure equitable access to water, use appropriate technology, try to solve causes not symptoms (but accept practical solutions), take an ecosystem approach and work with multidisciplinary teams.

So, during designing we were guided by the idea that our concept of water supply has to be viable and sufficient. We want to achieve a closed circle. We intend to use renewable water feature in the form of rainwater and graywater reuse with minimal discharge of black water into drains. Because our team in this competition has the opportunity to exhibit a house but can not compete and because our house has secured a spot on Borongaj we decided to develop a concept that in designing water concept does not keep to the strict rules of SDE. We want to develop a new system of water purification. In rules of SDE greywater can be used for watering gardens and cleaning. Testing in the lab we want to achieve the graywater from the washing machine, dishwasher, washing machine, kitchen sink (the mesh filter that will trap large particles from entering the system also goes for the dishwasher), shower and sink back again into the system of using water but this time the purified graywater (clean but no potable water) will be used for dishwasher, washing machine, flushing cistern and watering the garden. Purified rainwater would be collected and with water pipes supplied to the kitchen sink, bathroom basin and shower.

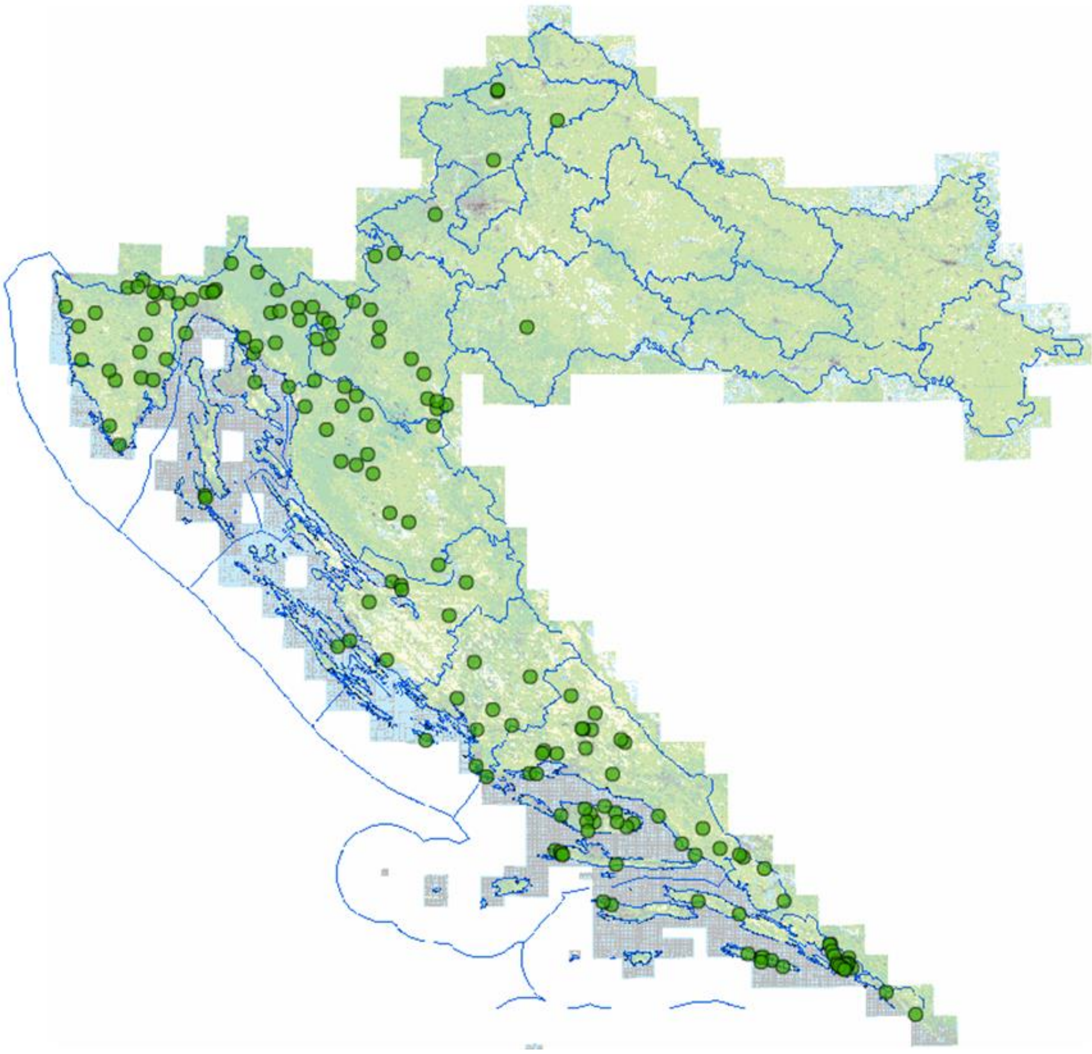

Figure 207 - Natura 2000 in Croatia (http://www.natura2000.hr/)

5.6.8.2 Strategies for the reduction of consumption

In Mem**brain** is planned to install technologies that control the use of water. We will have installed sanitary facilities that saves over 60% of water.

Kitchen

Sink pipe→ 9,5 l/min

Dishwasher → 10 l in one cycle

Bathroom

Wash basin pipe → 3,5 l/min

Shower bath → 9,5 l/min

Flushing cistern →6/3 l/min

Washing machine → 70 l in one cycle

Control the pressure in the pipes

Pressure control is important for preventive care of the appearance of a ruptured pipeline, but has an effect on reducing water consumption (5-15%).

Installation of individual water meters and the distribution of water consumption by actual consumption achieved significant savings - up to 40%. Specifically, in this way each household pays his bill, worries about the state taps, cisterns, etc., and changing their habits and reduced water consumption results in lower bills.

Figure 208 - Individual water meters

5.6.8.3 Treatment of wastewater

Greywater will be treated hybrid in constructed wetlands with activated sludge as a system of purification. And the black water will be diverted with sewage to the public wastewater treatment plant (WWTP). Rainwater will be treated with UV radiation for removal of microorganisms and it will be used as drinking water.

5.6.8.4 Greywater system

Greywater will be treated with hybrid constructed wetlands with activated sludge.

Constructed Wetland (CW)

Wetlands are defined as a half-way world between terrestrial and aquatic ecosystems exhibiting some of the characteristics of each. The proved water purification capability of wetlands has encouraged engineers and scientists to construct artificial wetland systems in order to take advantage of this ability. One of the reasons for the rapid development of constructed wetland (CWSs) is that the processes are seen as both ''green'' ''environmentally friendly,'' ''sustainable' and cost-effective. Another reason for the rapid development of CWSs is that there has been very close national and international cooperation. This is very encouraging at a time of great concern about global warming, but at the end of the day it is important to remember that the primary purpose of the process design is to treat the wastewater such that it meets the standards set down by regulator. Sometimes this is forgotten, or by passed by hope and aspirations. This is where the role of the process engineer is so important. With pressures on potable water (drinking water) supplies continuing to increase worldwide, interest in the use of alternative water sources such as recycled wastewater is also growing. In particular, greywater treatment and reuse is receiving increasing attention. This is because greywater generally has a lower organic pollutant and pathogen content than combined municipal wastewater (a.k.a tap water, running water, city water) which also contains toilet waste. Thus, greywater is considered particularly suitable for on-site (i.e. decentralised) treatment and reuse.

Classification of CW

The CW systems were classified according to the classic nomenclature based on hydrological characteristics (water position and flow direction), distinguishing between: surface flow (SF) systems, horizontal subsurface flow (H-SSF) bed, and vertical subsurface flow (V-SSF) bed. In the first, the majority of flow occurs through a water column overlying a benthic substrate, whereas the flow in the others is through a porous medium (generally gravel), and classed as either horizontal, if the feed is from one side of the bed, or vertical, if the feed is spread over the surface of the bed, crossing it. Additionally, in H-SSF beds the feed is continuous, while in V-SSF beds it is intermittent. To complete the picture, it also include hydroponic gravel beds (HGB) and restoration wetlands (RW), the first referring to systems in which plants may grow using the mineral nutrients dissolved in water, without soil or other media, and the latter to systems generally fed by a river whose water flow is primarily made up of wastewater treatment plant discharges or untreated wastewaters. Surface flow systems investigated include ponds, lagoons, aerated lagoons and free water basins, but we also include a modified SF system. The effluent of this so-called free-flow water system leaves through the bottom of the bed, resulting in a combination of surface and subsurface flow systems. The schematic of each of these types of CW can be seen in Figure 210 - Classification of CW. All the systems are considered and classified according to their size (full-scale, pilot) and the treatment step they represent (primary, secondary, tertiary, or polishing and restoration, see Figure 211 - CW acting as WWTP). It should be noted that a step may include more than one stage (resulting in a multi-stage system) of the same type (monotypic) or of different types (polytypic). These contrast with a hybrid plant, which consists of two or three steps relying on CWs. Moreover, SF treatments often consist of a series of basins. When this series is fed with a secondary effluent, the system acts as a polishing step and the single basins are considered as different stages of the same step (multi-compartment step). In Mem**brain** we will use hybrid constructed wetlands (CWs). In hybrid constructed wetlands (CWs), the advantages of various systems can be combined to complement each other. The design consisted of two stages of several parallel vertical flow (VF) beds (“filtration beds”) followed by 2 or 3 horizontal flow (HF) beds (“elimination beds”) in series. The VF stages were usually planted with Phragmites australis, whereas the HF stages contained a number of other emergent macrophytes, including Iris, Schoenoplectus (Scirpus), Sparganium,Carex, Typha and Acorus. The VF beds were loaded with pre-treated wastewater for 1-2 days, and were then allowed to dry out for 4-8 days. In this system, nitrification, i.e.,oxidation of ammonia to nitrate, takes place in the VF stageand denitrification of nitrate, i.e. reduction of nitrate do N_2O and N_2, proceeds in the HF stage. The oxidation of ammoniain intermittently loaded VF stage is very high but the concentrationof organics in the second stage may not be high enough to support full denitrification.

Advantages and disadvantages of VF and HF wetlands.

Type	Advantages	Disadvantages
Vertical flow wetlands	Smaller area demand. Good oxygen supply, good nitrification, better organics and SS removal, simple hydraulics.	Short flow distances. Poor denitrification, higher technical demand, low nitrate removal.
	Higher purification from the beginning, better than HF beds as water flows from surface to bottom which enhances oxygen mixing.	Loss of performance esp. P removal.
Horizontal flow wetlands	Long flowing distance, nutrients gradients can be established, efficient in the removal of SS, organics.	High area demand, clogging problem is observed, sulphur transformation can affect nitrification sensitivity, loss of P removal performance.
	Denitrification possible.	Careful calculation of hydraulics necessary for optimal oxygen supply, low ammonium oxidation.
	Formation of humic acids for N, P removal.	Uniform passage of wastewater throughout the packed media is complicated (due to possible presence of dead zones).

Figure 209 - Advantages and disadvantages of VF and HF wetlands

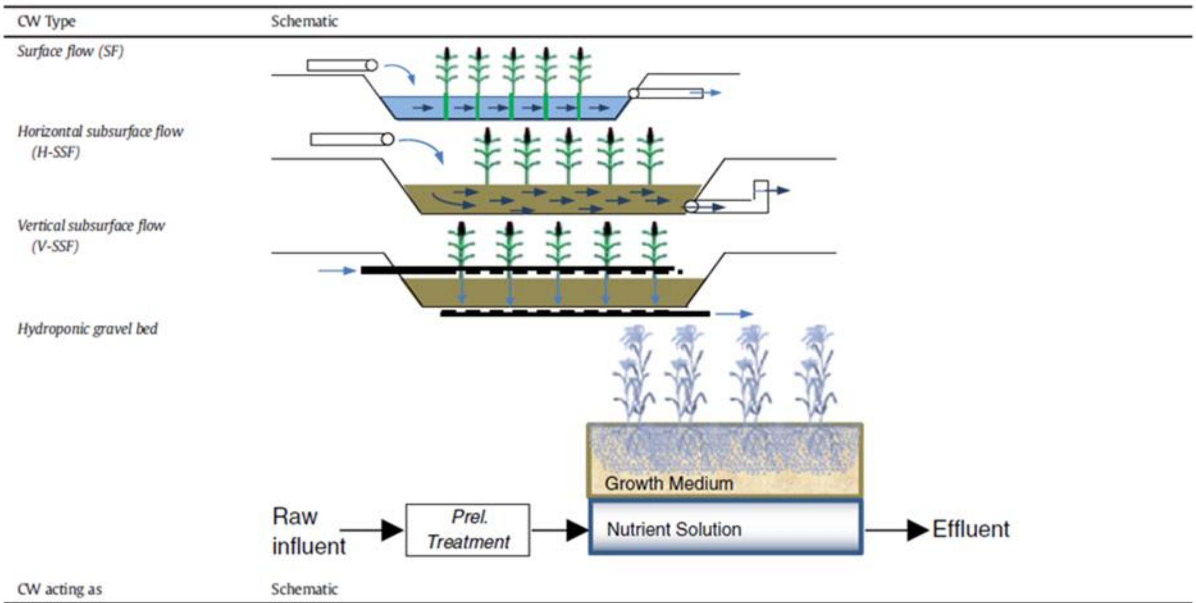

Figure 210 - Classification of CW

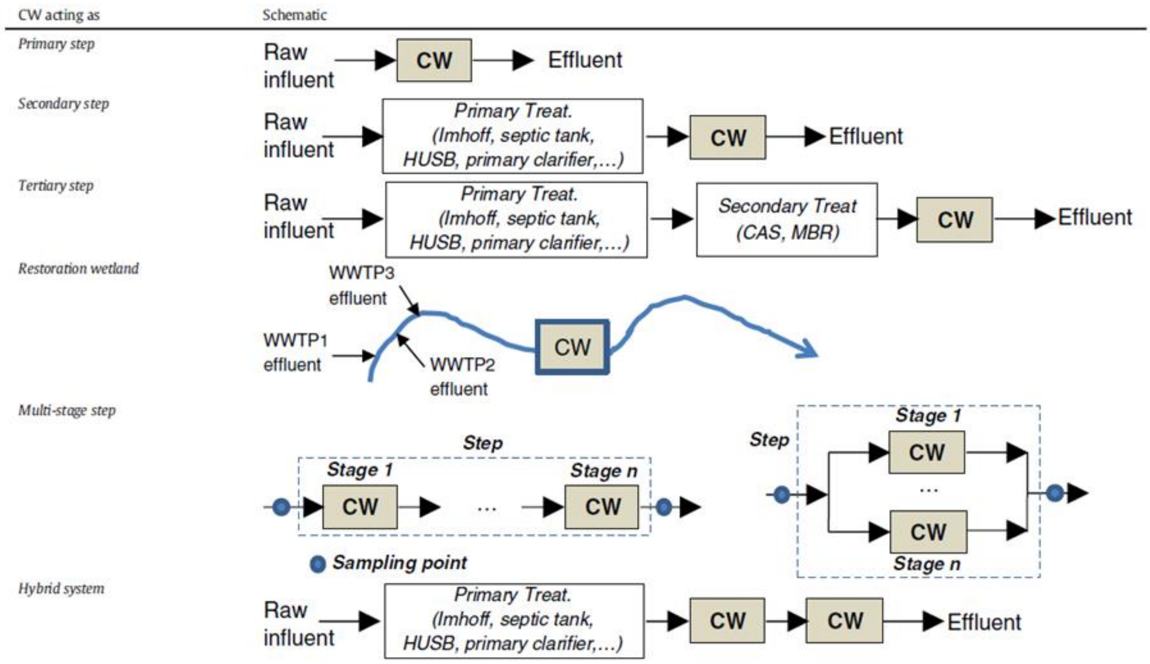

Figure 211 - CW acting as WWTP

Activated sludge

The process involves air or oxygen being introduced into a mixture of screened, and primary treated sewage or industrial wastewater (wastewater) combined with organisms to develop a biological floc which reduces the organic content of the sewage. This material, which in healthy sludge is a brown floc, is largely composed of saprotrophic bacteria but also has an important protozoan flora mainly composed of amoebae, Spirotrichs, Peritrichs including Vorticellids and a range of other filter feeding species. Other important constituents include motile and sedentary Rotifers. Activated sludge we will get from Zagreb wastewater plant.

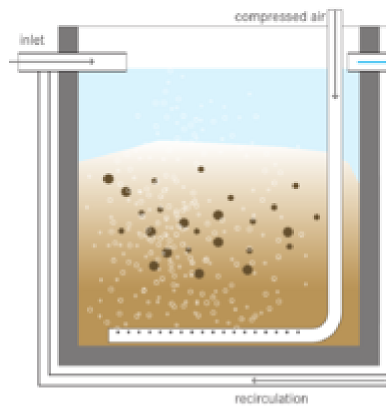

Figure 212 - Activated sludge

Operational parameters and conditions

Water quality analysis

Raw and treated domestic wastewater (DWW) would be sampled every and analyzed for chemical and microbiological parameters including: pH, electrical conductivity, 5-d biological oxygen demand (BOD5); chemical oxygen demand (COD), total suspended solids (TSS), total nitrogen (TN) by phosphate digestion followed by UV analysis, nitrite, ammonia using the Nessler metho, nitrate by second derivative and E. coli by either spread plate or membrane filtration methods using TBX agar.

The current target of wetland performance optimization is heavily dependent on overcoming the conflicting dependency, between nitrogen and organics removal. An in-depth knowledge on the impact of environmental parameters (e.g. pH, oxygen, temperature etc.), and operating conditions (e.g. hydraulic and pollutant loading, detention time, influent feed mode, recirculation, organic carbon addition etc.) can improve the biodegradation routes, associated with nitrogen and organics removal in treatment wetlands.

BOD removal data

Biochemical oxygen demand or B.O.D is the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. The term also refers to a chemical procedure for determining this amount. The BOD value is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days of incubation at 20 °C and is often used as a robust surrogate of the degree of organic pollution of water. BOD is similar in function to chemical oxygen demand (COD), in that both measure the amount of organic compounds in water. However, COD is less specific, since it measures everything that can be chemically oxidized, rather than just levels of biologically active organic matter.

COD removal data

In environmental chemistry, the chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g. lakes and rivers) or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution. The two parameters that express the removal of organic matter in constructed wetlands, i.e., BOD and COD, are widely considered to be correlated with equation COD = 1.8 BOD

Substrate

Wetland substrate (also known as support matrix) often plays a critical role in terms of pollutant removal from wastewater, as the media provides attachment surfaces for microbial communities, and ingredients for bioreactions. The nature of wetland media is also an important factor that determines the environmental condition (such as redox potential) inside the porous spaces. The substrate in constructed wetlands not only provides support for the growth of plants and microorganisms, but also interacts directly with contaminants through sorption processes. Sorption of pollutants onto the surface of substrate involves different mechanisms such as hydrophobic partitioning, van der Waals interaction, electrostatic interaction, ion exchange, and surface complexation. Non-polar organic pollutants can be preferentially adsorbed to the substrate materials that are especially rich in organic matter such as soil, compost and agricultural wastes via hydrophobic process. Polar or ionic pollutants are dominantly adsorbed to the substrate materials (e.g. some kinds of clay) by electrostatic interactions or ionic exchange.

To foster nitrogen and organics removal in engineered wetlands, the media should possess the following characteristics: (i) provide co-existence of aerobic and anoxic/anaerobic pores inside the matrix to enhance nitrification, denitrification and organics removal; and (ii) provide an internal carbon source, to minimize the dependency of denitrification metabolism on the presence of available carbon in wastewater. The commonly implemented gravel substrates in treatment wetlands do not provide carbon, thereby often limiting denitrification.

Microbial community structure

Constructed wetlands provide an ideal environment to support the growth of organisms, which break down the pollutants of the wastewater by biodegradations. Bacteria, fungi, and algae are the common organisms in wetlands. Microbes in constructed wetlands usually play the main role in the processes of transformation and mineralization of nutrients and organic pollutants .The microbial community in constructed wetlands consists of autochthonous (indigenous) and allochthonous (foreign) microorganisms (Figure 213). Autochthonous microbes exhibit adaptive features—they are able to possess metabolic activity, survive and grow in wetland systems participating in purification processes, while allochthonous microbes (including pathogens entering with wastewater) usually do not survive or have any functional importance in the wetland environment. The purification performance of constructed wetlands is based on combined action between microbes and filter material, which may be complemented by plants. The mineralization of organic matter is mainly carried out by microbes both in aerobic and anaerobic conditions. Therefore studies in microbial ecology broaden the knowledge about microbial communities in these systems and help to improve the design and performance of constructed wetlands. Microbial community composition in wetland sediment was found to be relatively stable, demonstrating low bacterial diversity with the prevalence of acidithiobacilli (two dominant species: Acidithiobacillus ferrooxidans and Acidithiobacillus thiooxidans). The total bacterial community composition was dominated by bacteria from phylogenetic clusters related to Bacillus, Clostridium, Mycoplasma, Eubacterium and Proteobacteria. Microbially mediated processes are mainly dependent on hydraulic conditions, wastewater properties, including substrate and nutrient quality and availability, filter material or soil type, plants, and different environmental factors. Microbial biomass is within a similar range in HSSFCW, VSSFCW and SFCWs, and the stratification of the biomass but also the stratified structural pattern of the bacterial community can be seen in subsurface flow systems.

Organic removal

Aerobic degradation of soluble organic matter is governed by the aerobic heterotrophic bacteria according to the following reaction:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 12e^- + \text{energy}$

Insufficient supply of oxygen to this group will greatly reduce the performance of aerobic biochemical oxidation. However, if the oxygen supply is not limited, aerobic degradation will be governed by the amount of active organic matter available to the organisms. In most types of wastewaters with the exception of some industrial wastewaters and runoff waters the supply of dissolved organic matter is sufficient and aerobic degradation is limited by dissolved oxygen concentration. Organic matter is composed of a complex mixture of biopolymers. Some of these compounds, such as proteins, carbohydrates, and lipids are easily degraded by microorganisms (i.e., labile), while other compounds, such as lignin and hemicellulose, are resistant to decomposition (i.e., recalcitrant).

Nitrogen removal

The major removal mechanisms of nitrogen in both h-SSF and v-SSF wetlands are nitrification and denitrification. Volatilization, adsorption and plant uptake play a much less important role in CWs. Nitrogen removal in constructed wetlands has mostly been assumed to be a result of the combination of nitrification–denitrification but newly discovered pathways such as the anaerobic oxidation of ammonium (ANAMMOX) could have potential significance in certain conditions as well. Nitrogen removal occurs within the rhizosphere of the wetland, where large populations of sessile anaerobic and aerobic bacteria grow, adsorbing and breaking down the organic and inorganic components of sewage. Total nitrogen ranges from 20 to 70 mg/l in domestic sewage and is present in four forms: organic nitrogen; nitrite (NO_2-N); nitrate (NO_3-N); and ammonium (NH_4-N). Organic nitrogen, comprising a variety of compounds such as amino acids and urea and NH_4-N are found in the greatest concentrations, the latter being found at about 20 mg/l in sewage. NH_4-N, itself largely derived from organic N through the process of ammonifcation, is oxidised to NO_2-N and NO_3-N (known collectively as total oxidised nitrogen, TON) by nitrifying bacteria which utilise the aerobic conditions found around the roots of wetland plants. Nitrifcation can be slow, and in some cases fails completely, with levels of NH_4-N actually increasing within the wetland as a result of high organic N concentrations in the infuent being aerobically degraded without subsequent oxidation. TON difuses away from the aerobic rhizosphere into the anaerobic water-saturated zone of the wetland and is then permanently lost from the system either through denitrifcation to nitrogen gas, which is released to the atmosphere or through leaching. Removal of total nitrogen in constructed wetlands is often low, 46±72% on average and in many cases is not sufcient to meet discharge consents. Generally poor removal of nitrogen is attributed to nitrifcation being limited by low oxygen and high carbon concentrations derived from the infuent sewage.

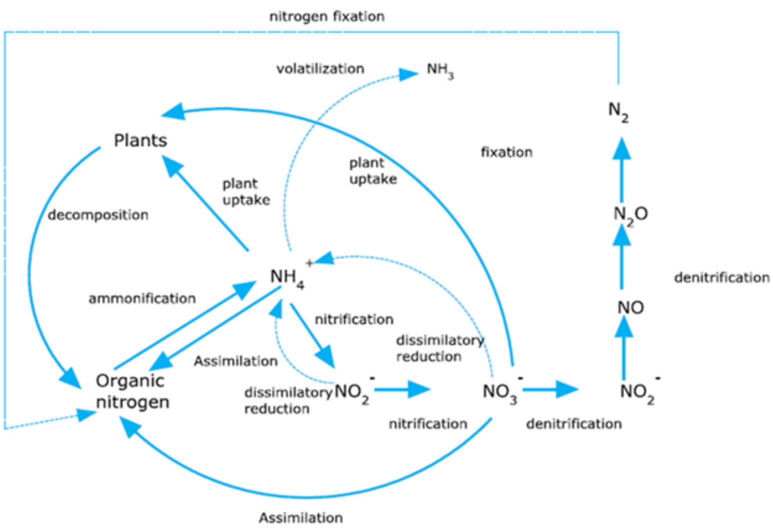

Figure 213 - Major classical nitrogen removal routes in subsurface flow wetlands.

Route	Mode	Significance
Classical removal routes		
Ammonification	Microbiological	Changes the form of nitrogen in wastewater, e.g. from organic nitrogen to NH_4–N. As such, the process does not contribute to net reduction of TN in wastewater.
Nitrification	Microbiological	Transforms NH_4–N to NO_2–N, and NO_3–N. Net quantity of TN remains constant.
Denitrification	Microbiological	Reduces NO_3–N to N_2 gas. The process reduces TN quantity in wastewater, when combined with nitrification.
Biomass assimilation	Microbiological	Adsorbs NH_4–N, thereby reducing nitrogen content of wastewater.
Dissimilatory nitrate reduction	Microbiological	Reduces NO_2–N and NO_3–N to NH_4–N. As such, the quantity of TN remains constant.
Plant uptake	Biological	Removes nitrogen from wastewater.
Volatilization	Physico-chemical	Converts NH_4^+ to NH_3 gas, followed by gaseous strip, thereby eliminating nitrogen from wastewater.
Adsorption	Physico-chemical	Adsorbs NH_4–N from wastewater, thereby reducing TN content. However, aerobic conditions can nitrify the adsorbed NH_4–N, followed by desorption, resulting no net change of TN content in wastewater.
Novel removal routes		
Partial nitrification–denitrification	Microbiological	Allows nitrite removal over nitrate, reducing net TN content of wastewater.
Anammox		

Figure 214 - Significance of classic and novel removal routes on nitrogen removal from wastewater.

Phosphate removal

Although the biota (microbes and plants) are responsible for removing a large proportion of most contaminants, they are not capable of removing significant amounts of phosphorus. Phosphorus is present in sewage at levels of between 6 and 10 mg/l, while less than 10 mg/l in the environment may stimulate algal growth. It has been found however, that the choice of substrate is crucial for maximizing phosphorus removal from waste water, as abiotic interactions between P and sediment particles, including the processes of sedimentation and adsorption, are the major mechanisms for the removal of P. The P-adsorption capacity of a wetland is dependent on two factors: the number of adsorption sites, proportional to the surface area of substrate particles and pH. Phosphorus adsorption is highest in alkaline wetlands, containing large amounts of calcium, and acid wetlands, containing large concentrations of aluminum and iron, phosphorus being precipitated by reactions with these elements. For example, calcium reacts with soluble phosphorus at high pH to form hydroxyapatite, which precipitates out of. Different wetland substrates have different characteristics, and thus different assimilative properties, phosphorus adsorption capacity being determined by a compromise between hydraulic conductivity and surface area. A large hydraulic conductivity, necessary to avoid clogging, often precludes a large substrate surface area, resulting in low phosphorus adsorption capability. Natural soils for example, commonly used as wetland substrates, can remove up to 98% of influent phosphorus, but tend to clog due to low hydraulic conductivity. River gravels are also commonly used as constructed wetland substrates. Gravels have a high hydraulic conductivity, but their capacity for phosphorus removal is generally low; the particles are impermeable, and have a low surface area compared to volume. Figures quoted for the removal of phosphorus by gravel wetlands range from as low as 20% to over 90% with certain types of iron rich gravel. There is a current trend towards the use of novel products as constructed wetland substrates for the removal of phosphorus.

Micropollutants

Over the last few decades, the occurrence of micropollutants in the aquatic environment has become a worldwide issue of increasing environmental concern. Micropollutants, also termed as emerging contaminants, consist of a vast and expanding array of anthropogenic as well as natural substances. These include pharmaceuticals, personal care products, steroid hormones, industrial chemicals, pesticides and many other emerging compounds. Many pharmaceuticals (PhCs) are usually present in raw influent at concentrations in the range of 10−3–102 μg/L and even more, and that common wastewater treatment plants (WWTPs) are not able to efficiently remove all of them. The main route of PhCs brought into water environment is through the municipal wastewater. Many PhCs are not completely metabolized and ingested in the body of humans and animals, as a result, PhCs metabolites, conjugates and their native forms are excreted with urine and feces into sewage system. In households, the unused and expired pharmaceuticals are usually disposed with normal household waste or discarded into sink or toilets. Those pharmaceuticals flushed down the sink or toilets are introduced to the sewage system. Besides, to a minor but relevant extent, the wastewater from hospitals or pharmaceutical manufacturers also contributes to the total loads of pharmaceuticals in municipal wastewater. In the municipal wastewater treatment plants (WWTPs) where the conventional treatment technologies are not specially designed for elimination of pharmaceuticals, it is found that most pharmaceuticals cannot be readily and fully removed. Consequently, various kinds of pharmaceuticals and their metabolites are released into surface water, ground water, coastal water, and even drinking water via WWTPs' effluent. Upon entering the water environment, the pharmaceutical compounds and their metabolites became potential risks to the health of aquatic life and human beings even at trace levels in the water environment. Current WWTPs are not specifically designed to eliminate micropollutants. Thus, many of these micropollutants are able to pass through wastewater treatment processes by virtue of their persistency or/and the continuous introduction. In addition, precautions and monitoring actions for micropollutants have not been well established in most WWTPs. Consequently, many of these compounds may end up in the aquatic environment, becoming threats to wildlife and spelling trouble for drinking water industry. The occurrence of micropollutants in the aquatic environment have been frequently associated with a number of negative effects, including short-term and long-term toxicity, endocrine disrupting effects and antibiotic resistance of. To date, discharge guidelines and standards do not exist for most micropollutants. Some countries or regions have adopted regulations for a small number of micropollutants. For example, environmental quality standards for a minority of micropollutants (e.g. nonylphenol, bisphenol A, DEHP and diuron) have been stipulated in Directive 2008/ 105/EC (European Parliament and The Council, 2008). Nonylphenol and nonylphenol ethoxylates have also been recognized as toxic substances by the Canadian government (Canadian Environmental Protection Act, 1999). Other micropollutants, such as pharmaceutical and personal care products (PPCPs) and steroid hormones, are not included in the list of regulated substances yet. To set regulatory limits for micropollutants, further research on biological responses to these compounds (both acute and chronic effects) is of particular importance. Furthermore, scientific community and regulatory agencies should gain insight into not only the impact of individual micropollutants, but also their synergistic, additive, and antagonistic effects.

Plants

There is misunderstanding of the role of the plants in the treatment process. In the early days there was a widespread belief that the plants themselves carried out the purification. Reeds will take up the nutrients, nitrogen, and phosphorus, but for this to continue would require the plants to be cropped. Even if the plants were cropped, the quantity of N and P would be trivial compared with the design requirement. The biological treatment takes place in the biofilm that grows on the media. Effectively the CWSs are crude, rustic biological filters, which gradually become clogged over an extended period of time. The same treatment mechanisms that took place in the biological filter also takes place within the reed beds. The role that the plants play is to keep the bed from clogging and thus maintaining hydraulic conductivity over a number of years. The mechanisms are believed to result from (1) the growth of roots and particularly the penetration of the rhizomes throughout the bed matrix creating hydraulic pathways and (2) the movement of the stems and leaves of the P. australis in the wind causing small annular holes to be created at the point at which the stems enter the matrix. Plants in constructed wetlands play another important role in stimulating the development and activities of microbial populations which are supported by the rhizodeposition products (exudates, mucigels, dead cell material, etc.), causing various biological processes to occur in the rhizosphere. In addition to the biological processes, certain plant exudates may also function as catalytic agents for the degradation of organic compounds. Most plant species in constructed wetlands are able to release oxygen around their root tips and on young laterals. The oxygen released in rhizosphere can also promote the oxidative chemical processes of contaminants in wastewater and favor the development of aerobic microorganisms in the rhizosphere inducing more efficient biodegradation processes. The continuous release of oxygen from the root zones of plants might counterbalance the chemical and biological oxygen consumption in the rhizosphere. Toxicity to plants caused by pharmaceuticals is an important issue when considering the functions of plants for pharmaceutical removal. Methods of cultivation from seedlings grown from seed in greenhouses was developed; since that time most beds have been planted with seedling, and cover has been rapid such that a bed can be covered in 3 months when planted in spring or summer.

Commonly used aquatic plants in constructed wetlands.

Common name *Scientific name*	Desirable temp. °C	Seed germination °C	Optimal pH	Root penetration cm
Cattail *Typha*	10–30	12–24	4–10	30
Common reed *Phragmites*	12–33	10–30	2–8	60
Rush *Juncus*	16–26	–	5–7.5	–
Bulrush *Scirpus*	16–27	–	4–9	76
Sedge *Carex*	14–32	–	5–7.5	–

Figure 215 - Commonly used aquatic plants in constructed wetlands

Influence of specific surface area (m2/PE)

An interesting parameter to use in comparison between the performances of different CWs is the specific surface area defined as the ratio between the area of a single step and the number of PE corresponding to the applied hydraulic load (assuming specific water consumption per person per day). Unfortunately, this parameter has only been evaluated in a few cases and data is difficult to interpret, as it all refers to the surface of the whole treatment line and not to the specific step under evaluation.

Influence of seasonal variability

Seasonality mainly affects biodegradation processes, and to a lesser extent chemical–physical removal processes like adsorption. This is mainly controlled by interactions governed by isotherms, in which low temperature can have a negative effect.

Experimental design

In the laboratory we will build the whole system and test the effectiveness of the system in water purification.

First greywater will first get to the activated sludge tank then enters in constructed wetland (CW). It will be three stages CW having the HF CW in the middle of the treatment line in between two VF wetlands. The first bed (first stage) without plants, which is a vertical flow-gravel filter (v-GF) bed (1.5 m, 2.0 m, 0.5 m). The second bed (second stage) planted with Iris, which is an h-SSF constructed wetland (1.5 m, 3.5 m, 0.40 m). The third bed (third stage) planted with Phragmites, which is a v-SSF constructed wetland (1.5 m , 3.5 m, 0.32 m). Overall, necessary surface area of the filter bed is 3.2m2/PE. Iris and Phragmites plants were planted at initial densities of 24 and 28 rhizomes for the total surface area, respectively. The filter bed must be enclosed by a tight membrane (minimum 0.5mm thickness). The membrane must be protected by a geotextile on both sides. The drainage layer is built up of coarse gravel (Ø8–16 mm) in which a number of 70 mm diameter drainage pipes are placed. The drainage pipes are connected on one side to a 90–120mm collection pipe that discharges the effluent from the bed to the effluent well. The drainage system is passively aerated by vertical pipes extending 0.3m over the filter bed surface. For single household systems with up to 3 PE, the total volume of the tank must be $2m^3$.

Distribution system

The effluent is distributed evenly over the surface of the bed by a network of pressurised distribution pipes. The distribution pipes should have a diameter of 32–45mm and should have 5–7mm holes placed in the bottom of the pipes for every 0.4–0.7 m. It is important that the whole distribution system is placed under pressure for a period that is long enough to secure an even distribution of water over the entire bed surface. In practice, the volume pumped should be at least three times the volume of the distribution pipe system. If 32mm diameter distribution pipes are used for a single household system, the volume of the distribution system will be approximately 20 l. Therefore, the volume of water pumped to the system at every pulse should be at least 60 l. This means that the loading frequency at a normal loading rate for a household will be 8–12 pulses/day, and when half of the effluent water is recirculated in the system, 16–24 pulses/day. The distribution pipes are insulated against freezing by a 0.2 m layer of coarse wood chips or sea shells placed on the surface of the filter.

Filter medium

First two beds will be filled with gravel and tertiary will be filled with sand. Filter medium will be separated from the drainage layer in the bottom of the bed either by the placement of an open geotextile. It is important not to compact the filter medium during construction. Therefore, the use of heavy machinery is not allowed within the bed during construction.

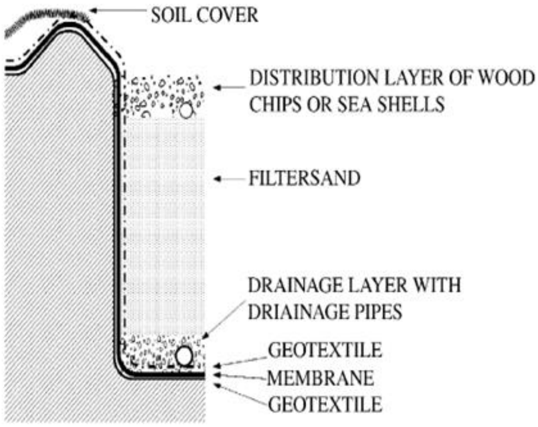

Figure 216 - Detail of the side of the filter bed showing the position of the membrane and geotextiles. The membrane should be covered by soil in order to protect it from UV-radiation.

Planting

The bed is planted with the common reed, P. australis, in a density of approximately 4 plants/m^2. The best planting time is April–May, but planting ca be done all year round except is periods with risks of severe frost. The best result is obtained if potted seedlings are used, but pieces of rhizomes might also be used.

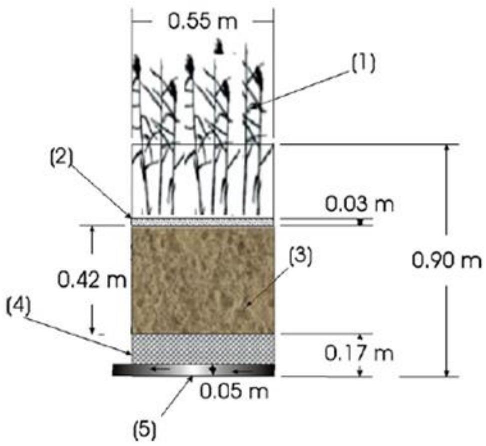

Figure 217 - Schematic diagram of a constructed wetland unit: (1) Phragmites australis; (2) gravel 4–8mm diameter; (3) main substrate; (4) gravel 8–16mm diameter; (5) drainage pipe (outlet).

Scope of the guidelines

The guidelines are to be used for systems up to 3 person equivalents (PE) and only for wastewater with a composition similar to normal household sewage. Rain and storm water may not be discharged into the system together with the household sewage. The hybrid constructed wetland system will fulfil the treatment classes requiring 95% removal of BOD5 and 90% nitrification or effluent concentrations of <10 mg l−1 for BOD5(modified), <5 mg l−1 NH4+-N and 90% removal of phosphorus or a total-P effluent concentration <1.5 mg l−1 if. It is assumed that pollutant loadings per PE are 60 g day−1 of BOD5, 13 g day−1 of nitrogen and 2.5 g day−1 of phosphorus. The water discharge is assumed to be 150 l PE−1 day−1.

Management requirements

Sludge must be emptied from the sedimentation tank once per year to secure a well-functioning removal of settleable and floating material prior to the filter bed. The distribution pipes should be cleaned and flushed once per year to remove sludge and biofilm that might have blocked some of the holes. The V-notch weirs distributing water between effluent and recirculation should be inspected and cleaned at regular intervals, e.g. every third month. During the first growing season, it is important to remove any weeds that might compete with the planted reeds. The reeds should not be harvested during autumn because the plant material will help insulate the filter against frost during winter. It might, however, stimulate the growth of the plants if the above ground dead plant material is removed in the early spring. If it happens that the vertical filter clogs because of overloading, the system should be taken out of operation for a period of several weeks and allowed to dry out.

Operational and maintenance (O&M) problems

Build-and-forget solution

Operational problems are separate into two categories: those resulting from poor maintenance and those associated with parts of the system that were not properly designed or built. Natural treatment systems are too often considered to be a 'build-and-forget' solution not needing any attention at all. When denied the minimal amount of maintenance that even natural systems need, failing treatment systems are often reported. It is noted that in many cases problems with sludge deposition, inlet flow distributor problems, outlet collector problems, weed infestation, and above-ground flow. Especially sludge deposition is important for polishing wetlands, since in most cases it seemed to be caused by wash-out of solids from the preceding secondary treatment step. Despite these problems, all effluents were still compliant with the regulatory consents. Therefore , CWs are known as “very forgiving and abuse tolerant”.

Clogging and flooding

Clogging of SSF is a tangible risk and is principally influenced by loading rates of BOD and/ or SS, the hydraulic loading rate and the particle size and distribution of the matrix material as well as the wastewater particles. Clogging can be counteracted by lowering loading rates or by leaving one or more beds to rest. During this resting period, organic material that blocks the pores can be composted and the hydraulic conductivity thus restored. When most pores are filled with inorganic material and the hydraulic conductivity is too low, the only solution is to excavate the bed and either refill it with new matrix material or refill it with the same matrix material after rinsing.

pH

Wastewater pH is also an important factor that affects anaerobic organic degradation. Methane forming bacteria operate at a pH range of 6.5-7.5, and deviation from that range can stop the function of methane forming bacteria in HF wetlands resulting the generation of odorous compounds.

Capital costs and maintenance costs

Capital costs

As our way of building CW does not occupy any area so there is no other unnecessary ecological print on environment. So the major costs that are usually for CW are unnecessary as the local situation, i.e. soil type, groundwater table height, terrain slope, distance from settlement, discharge criteria, climate etc. land acquisition, earth moving, plastic liners to prevent groundwater contamination or infiltration. Another important factor usually is the economy of scale: larger wetlands tend to be relatively cheaper per PE or per m^3 of wastewater treated. Economic analyses of CWs specifically applied for reuse purposes are rather rare but there seems to be no reason why unit inaAvestment costs would diverge significantly from those of secondary CW. Of course, total costs could be lower because the lower loading rates can be treated with smaller systems. One uncertain cost is the 'removal' cost of the system after its functional life, now estimated at around 20 years.

5.6.8.5 Recycling, reuse

Greywater will be collected from the dishwasher, washing machine, sink, shower and bath basin. Tank with purified greywater (no potable water) will act as a heat exchanger where water that is used in the systems above will, through the piping system, pass the heat to the water already stored in the tank (no potable water, purified greywater). That graywater from piping system enters in the tank with activated sludge and further passes through the constructed wetland. After purification, water goes into the tank (no potable water, purified greywater) from which further is distributes to the dishwasher, washing machine, toilet and pipe for watering the garden (irrigation).

Blackwater will be separated toward sewer system and will be treated in a special facilities known as wastewater treatment plant (WWTP).

5.6.8.6 Rainwater

Rainwater is very soft water, total hardness less than 4°. It is relatively aggressive, because the value of pH of rain from a clean atmosphere is around 5.2 to 5.6 (due to the melting of CO_2). In contaminated atmospheres rain further acidifying with sulfur and nitrogen oxides, and pH value decreases even lower than pH 3 (pH allowed for drinking water is 6.5 to 8.5). So, depending on the purity of the atmosphere and purpose of using rainwater, it will be required to process rainwater. Therefore valid process of rainwater would include bringing the pH value within the set of parameters, which would depend on the use of rainwater. Water quality of rainwater in Mem**brain** can be also ensured by using wetland treatment system as a system of purification.

Collecting rainwater is done directly from the envelope to the tank. In front of the entrance to the reservoir is built protective filter, and tank volume is adjusted to the consumption users. Rainwater will be treated with UV radiation for removal of microorganisms for getting drinking water. Purified rainwater will be lead with piping system to the domestic hot water tank. Before entering of piping system of rainwater in the tank there will be embedded controller to control the duality water system. One system with public water and the other of purified rainwater. So, when there is not enough amounts of rainwater, controller will let water from the public water supply network in the domestic hot water tank. Purified rainwater will be used for kitchen sink, shower and bath basin.

5.6.9 Solid Waste

Waste is a problem of modern civilization and the central problem of environmental protection. According to the Waste Act of Croatia: "Waste is substances or objects that the owner or manufacturer of waste, rejected or postponed and must be disposed of."

Waste in Croatia

The composition of municipal waste

Analysis of municipal waste in major Croatian cities show that the morphological composition is similar to waste from other European cities. Approximately a third of household waste is organic waste and biodegradable waste (food scraps and food items and green waste - flowers, grass, leaves, etc.). About one- quarter is paper and cardboard. Glass waste, mostly remnants of glass packaging make up about 8%, polyester 8% and weight percentage of metal is 2%. Theoretically from household waste can be used 80 weight percent of the waste, or four-fifths. The remaining 20 percent are small waste (dust) but also some potentially usable waste products such as textiles, rubber and wood.

The amount of waste in Croatia

In Croatia each year resulting with 1,2 million tons of municipal solid waste and more than 6.8 million is industrial waste. All of these amounts, for the most part end up in arranged utilities or illegally dumps and occupy every year new acres of land. With large amounts of waste, increasing volume of waste is special issue that must be solved. Annually per capita in Croatia is rejected an average of about 270 kg of municipal waste. For disposal of all waste generated e.g. in Zagreb, every year is permanently occupied an area of 2 hectares.

Situation with waste in Croatia

In the next 20 years, Croatia will have to invest billions of euros to repair damage from uncontrolled waste disposal. It is believed that Croatia should insist on the reduction and recycling of waste, as the most acceptable solution for waste management in Croatia. Also, it is need to make a priority of surveying existing landfills, reduce the number of existing landfills, remediate landfills, increase process of organized waste collection, monitoring and reporting of waste streams, better law regulating surveillance, enforcement and sanctions related to waste management, strictly implement in the monitoring of the waste stream, coordinate Croatian legislation with EU standards, encourage "cleaner production", stronger inspection, provide funding for the development of waste management , pay special attention to education and communication with the public, change the system of payment for waste, involved facilities for handling waste in spatial planning and encourage local governments for mutual cooperation and solving common problem with waste management on economic basis and encourage a regional approach to the problem.

Currently in Croatian cities and counties are organizing the collection and disposal of waste in a manner that can’t be called integrated waste management system.

Problem with waste

The amount of waste disposal is increasing and projections say that this trend will continue, particularly with the further development of tourism. Amounts of separately collected waste is also on the rise, but the waste disposal is still the main option in the management of municipal waste.

Croatia has 146 active (official) landfills and sanation was completed in 107 locations but also there are 512 illegally dumps and sanation was complited in 217 locations. By accepting the agreement of the European Union, Croatia is obliged to reduce the amount of biodegradable municipal waste to three-quarters of the total amount of municipal waste by 31. December 2013 year, or to only a quarter to the end of the 2020 year. Due to delays in the implementation of European standards for waste management Greece pays 60,000 euros and Poland nearly 70,000 per day to European Union. Because of lightly taken conditions, in Croatia is excepted the same. Only sanation of existing landfills in Croatia will cost 2.7 billion. Our economy and agriculture will soon meet with the realization of the impossibility of introducing standards that we have promised and there will be a wave of closings. Cities and municipalities will also be unable to provide promised and will have to pay huge penalties.

Table 66 - Ways of dealing with waste in some European countries

	Austria	Denmark	Slovenia	Croatia
Recycling	34,3%	14%	10%	3,5%
Bioprocessing	21,7%	-	12%	1%
Thermal treatment	14,7%	81%	-	-
Disposal	28,05%	5%	73%	95,5%
Treatment of special waste	0,8%	-	-	-

It is evident from that Croatia has a great problem because 95% of its waste is disposed and it is not effectively and creates a problem in adaptation of European laws and approaching deadlines to comply.

Solution

Developed economies says that waste is not garbage, but a valuable raw material to be treated properly and create new jobs and stimulate economic development. But to gain that society must understood and agree on how they will manage waste. The first step is reducing and avoiding waste through reuse but it remains to solve the „burning „ issue of mixed municipal waste that remains after allocation of separately collected waste. Municipal waste (biodegradable waste from the kitchen and canteen, from gardens and parks, paper and cardboard, glass, plastic, etc.) represents 70% of all greenhouse gas emissions from the sector waste in Croatia. One of the solutions for the disposal of municipal waste is thermal treatment of municipal solid waste, where the rest of the waste that is not recycled becomes energy. Today, many cities are heated with energy obtained from waste. However, thermal treatment of waste in Croatia is currently on negligible level. Experts in the field of waste recently gathered at the Ministry of Environmental Protection, as part of a framework for the „Strategy for low carbon development“ , to choose the most effective measures to reduce greenhouse gas emissions in the waste sector which has a strong growth trend. The majority opinion is that the thermal treatment of waste is acceptable measures that should be encouraged, through the financial support for the construction of such facilities. Of course, taking into account the recycling will eventually grow increasingly and waste will be less. On the other hand, opponents of thermal treatment of waste have their arguments. Case studies show how the prevention of waste, recycling and composting can reduced 70% of waste. Also, recycling saves more energy than burning the same amount of waste and besides recycling produces reduce more emissions than thermal treatment of waste or landfill. After thermal treatment, there is the problem of disposal of ash that is hazardous to the environment and there is need to take it into account. One of the major problem is resistance at the local level because no one wants potentially dangerous objects in their neighborhood. Also, there is the question of credibility and transparency of measuring emissions and it is very important to develop and later maintain trust between experts and citizens. The final conclusion would be that the waste should be viewed holistically and thermal treatment of waste can be taken as only one of the measures together with the prevention of waste, separate collection, recycling and composting.

System of organized municipal waste collection

Recycling yards are intended for sorting and temporary storage of special wastes. Recycling yards have a significant role in the waste management system. Recycling yards or green islands are equipped with tanks and containers with a capacity 1100-5000 liters in which, depending on size and design, are separately collected a dozen different types of reusable waste and hazardous waste from citizens. With selection of microlocation it is particularly important that recycling yards are placed so that citizens could easily reach them. Roughly, it can be assumed that a catchment area of recycling yard is in a radius of two to four kilometers in size from 5000 to 50,000 inhabitants. Densely populated towns and cities should be equipped with a larger number of containers for separate collection - predictably from 30 to 50 vessels 1000 per citizens. Tourist places with marked seasonal oscillations in the number of users of municipal systems and equipment must be prepared for peak load (the proposed number of vessels from 50 to 100 per 1000 visitors). The recycling yards are necessary to organize the collection of bulky waste because it achieves a significant improvement in quality of service and reduce costs. The advantages for citizens are that throughout the year, on all working days, including Saturdays, could dispose their bulky waste. In organization collection system for greater efficiency it is important application of multi-purpose vehicles with more loading mechanisms and several separate loading area. Separately collected material, for economic reasons, is transported only a short distance (up to about 50 km, max. 80 km) to the transfer station. The transfer station is equipped with facilities for further selection and baling waste. Waste collected in the transfer station is transported to the waste management center. The waste management center is a place where are various activities related to the treatment of waste prior to its final disposal of non-hazardous waste at the landfill or prepared waste for thermal treatment.

Centre for Waste Management - location

The strategy envisages the establishment of long-term regional and county Centers for waste management. County and the city of Zagreb shall prepare waste management plans which must define waste management system in a way that more than one Centre for Waste Management is in the county or city of Zagreb. City of Zagreb and Zagreb county is planning the construction of facilities for the thermal treatment of municipal solid waste that would be located in the city of Zagreb, Žitnjak-east, and dump the rest of the heat treatment on the location of the Zagreb county.

5.6.9.1 Waste in Mem**brain**

The concept of waste disposal in Mem**brain** is adjusted to adapting the current situation with waste in Croatia. At present, issue of waste is reduced only on level of voluntary recycling waste. But it will be better regulated when Croatian legislation coordinate with EU standards and of course stronger inspection and penalties due to noncompliance with laws. But, as it was already pointed out owner of the waste decide whether to sell their waste, donate or with financial compensation deliver to the authorized companies for waste management. The Waste Management plan in Membrain relies on so-called "4R" measures of Waste Management and separation of waste:

- Prevention / reduction (Reduction) → buying glass bottles instead of plastic for water, use cloth bags,
- Reuse without treatment (Reuse)→ organic waste as fertilizer (food scraps and food items and green waste - flowers , grass , leaves)
- Recovery, re-use for the same purpose, but with the processing of such returnable packaging (Recovery) → paper, cardboard, plastic bottles, glass
- Recycling and re-use, material and energetic utilization of waste (Recycling) → using recycling yards for disposal oil, batteries, tires, electronic waste

5.6.9.2 System of organized municipal waste collection in Membrain

Part of the waste will be collected by a separate collection system (recycling yards) and the implementation of specific regulations for certain categories of waste (packaging waste, waste tires, waste electrical and electronic equipment). Separately collected waste can be transported directly to material and energy recovery to the transfer station or waste management center and processed for further material or energy recovery. The rest of the mixed municipal waste collected in the collection organized way by companies licensed for municipal waste collection activities and the collected waste transported to the transfer station or a waste management center. Non-hazardous industrial waste is collected separately organized system of collecting waste and transported separately to the transfer station or waste management center. Non-hazardous industrial waste can be collected by licensed collectors who then handed over to the conversion station or a waste management center. The Centre for Waste Management conducted a secondary separation of useful materials, residual waste is treated and then disposed of in a landfill.

5.6.9.3 Construction waste

During construction and after end of use of house it will be need to disposal a waste generated during construction and later after completing the life cycle of materials and house. Construction waste disposal will be depended on the type of waste and thus indirectly stimulates separation by type of waste, waste minimization and sorting of waste in accordance with best practice and EU directives. Predictable fee for accepting construction waste to optimized recycling facilities (excluding transport costs) in Croatia will range from 5-15 euros/t with the major regulator of the amount to be quantitative and qualitative performance of the recycled aggregates.

5.6.10 Life Cycle Analysis

Life cycle analysis is to be developed later.

5.7 Communications Plan

5.7.1 Introduction

Communications plan is a crucial factor of this project. Without spreading the word about our project there would be hardly any chance to gain any material or financial funds.

Being completely aware of economic situation in Croatia, we dedicated time to put a lot of effort in creating long term communication plan. Our plan consists of marketing, promotional and fundraising activities that will be conducted through eight months period.

Promotional and marketing activities presented in this plan are based on innovation, amusement and education. Diversity is another base of our plan. Beside traditional promotional and marketing activities such as leaflets and brochures, we will organize various events, fair and other different activities.

To stand out among tough competition, we will use simple design and creative approach in marketing campaigns.

Considering the whole project is about efficiency, our communications activities will follow those principles – reaching a target group using minimum amount of printed promotional materials.

We are confident that our communication plan, together with sponsorship proposal and sponsorship packages will be a great aid to fundraising.

In the following pages of this chapter we presented our plans for visual identity, communication with target audience and sponsors.

5.7.2 Communications Project

5.7.2.1 Abstract

Our complete communication strategy will be based on various actions and promotions of solar housing and renewable energy in general with the aim of raising social awareness and convincing the public that our solar house is a great choice for safe and prosperous future. We want to inform Croatian citizens that there is an alternative housing solution which is eco friendly and it is in accordance with all the contemporary requirements.

Throughout the project development we will try to set an example with creating nature friendly promotional activities and send a message to the general public that we live what we promote. We are planning to attend environmental conferences throughout the country and try to attract possible sponsors and partners which will help us to accomplish the project in a best possible way by exchanging both knowledge and know-how.

First of all we will emphasize the fact that this house is a project developed by the multidisciplinary team mostly consisted of students with a vision and perspective to create sustainable housing solutions. We will create the house which is different, practical and eco-friendly, but various aspects must be considered to create the house visibility. In creating the house visibility we will constantly observe real estate market and harmonize it with our plans and actions.

In order to spread our message and make people aware about our project, we decided to organize an event in one of our national shopping malls and a Flash mob in the main square of Zagreb, capital of Croatia. More about the events will be explained later.

During the next three months we are planning to hold presentations on various faculties of the University of Zagreb and throughout other universities in Croatia. Our plan is to cover faculties of the University of Zagreb which are participating in the project and a few other faculties in cities Split, Rijeka and Osijek.

Visual identity of the house will be promoted through the logo, designed by our designers, which will follow us to the very end of the promoting activities and differentiate us from the other possibly created solar houses. Logo is created with decent care and concentration on all aspects related with the project (membrane, solar energy, Croatian product, uniqueness etc.).

Presence on the internet will be of great importance in the start of our communication with the general public. Our web page is improved with an English version. We are providing constant Facebook campaign, whose main objective is to educate people about The Mem**brain** concept, Solar Decathlon and renewable energy sources in general.

With all these previous plans and actions we will endure to accomplish them in order to get the attention and attract people to visit the fair in Zagreb that will be organized in the end of our project, in September.

5.7.2.2 Analysis of the Situation

As we said earlier, our multidisciplinary team consists of students with the aim of educating and offering the general public new housing solutions. We are driven by a higher cause and chance to represent our country in the best way possible.

Analyzing the starting point of the situation we came to the conclusion that general public in Croatia is still not aware enough about advantages of renewable energy sources.

A major issue we must handle is overall public concern on the reliability of solar energy followed the skepticism about the quality of self-sustainable houses and renewable energy in general.

Terms like sustainability and market efficiency are particularly new on this geographical area, so we must approach to this problem rationally and carefully study in which way we want to reach the people and convert their opinion regarding previously mentioned terms.

Table 67 - SWOT Analysis

Strengths • Eco friendly • Uniqueness • “Borongaj University Campus” integration	*Weaknesses* • Lack of public awareness • Skepticism • Know-how
Opportunities • Revival of the Croatian economy • A lot of remote areas without electricity • Overall environmental policy	*Threats* • Future competitors • Financial situation • Motivation

From the SWOT analysis table you can see that our main strength comes from the fact that the house is eco friendly and it regards to all sustainable ecological standards.

Following the latest conventions on sustainability and the future of our planet, we want to point out that house is eco friendly in every manner, from the house development to the promotion of the house.

The fact that the house is unique must be emphasized in order to get the public interested into the Mem**brain** concept and to change their view on energy efficient housing.

Great strength of our project comes from the fact that the house will be integrated into Borongaj campus, which will seat 35,000 students in 20 faculties, 15 high institutions and 20 agencies once it is finished.

Previously mentioned lack of public awareness and skepticism about sustainable and energy efficient housing is a weakness in developing the project.

Since there is no project like ours in this region, we are missing the know-how. Many things are done for the first time and there is a problem with the public perception of the project. We will try to overcome this problem by contacting colleagues from Budapest University of Technology and Economics, who were competitors on SDE 2012 in Madrid.

We see the greatest opportunity in the possibility that our project will revive overall Croatian economy. Many ideas in creating the house, brainstorming and initiative to change the present will surely stimulate someone to create something on its own. This project is special because students are those who conduct changes and initiate innovation and they allow Croatian companies to implement their own products into the house and present their products internationally.

From the latest information about areas without electricity, there are 126 settlements where families live and operate without electric power. Our opportunity lies in possible partnership with Croatian government to build houses for them.

Overall global environmental policy goes in our favor. Due to the future predictions, people should change their way of living and think about new and innovative housing solutions.

Threats of future competitors should be considered in the first place. To diminish the possibility for us to be threatened, we need to work harder and create something that will be unique.

Global financial crisis is a threat because people allocate their money carefully and they adjust their preferences according to the crisis.

Motivation is a major issue we must handle until the very end of the project. Within everyday complications with bureaucracy and complex Croatian paperwork, our team strives to stay focused and organized.

5.7.2.3 Communications Objectives and Identification of the Target groups

One of our two identified target groups is stakeholders. Stakeholders are entities, both inside and outside the project, which have an interest in the project and are able to influence its implementation. Seven categories of stakeholders were indentified and they include the project leader, UNIZG team members, the Government, professors and teaching assistants, sponsors/partners, media and faculties. The listed categories are shown in the Table below.

Table 68 - Target group: Stakeholders

Stakeholder	Interests and objectives	Influence	Importance
Project leader	Successful project implementation	Project management and project implementation	High

UNIZG Team members	Task implementation and deliverables creating	Project efficiency	High
Government	New science projects and international cooperation	Legal and regulatory framework, providing consult and project support	High
Professors and teaching assistants	Students' education, task performance support and fullfiling objectives	Advisory role, guidance and problem-solving assistance	High
Sponsors/partners	Realisation of intended benefits in order to create the value forecast in the business case	Organisational support, strategic decision making and successful project implementation	High
Media	Continuous cooperation, informing the public about innovations	Perceived credibility and value of the project, our image	Medium
Faculties	Project publicity and promotion, informing students about the project, use of new and innovative solutions for future projects	Publicity of the project, informing, incenting and recruiting new members	Medium

We have identified each of the stakeholder categories' interests and objectives in this project because we want to fulfill all their expectations. In addition, we have defined the stakeholders' influence, since it can affect the success or failure of an initiative and the project implementation. The aspect of influence was paired with their importance, meaning that the priority was given primarily to satisfying their needs and interests. Only later did we make a decision about the way of communicating and cooperating with them. The goal of communication with stakeholders was set to provide them with information about the project's progress, to increase their awareness, encourage action on their side and, if necessary, to ask for an additional input. The method chosen for communication was e-mail because of the tight schedules of many stakeholders; however, further options such as video-conference, telephone call and presentations were suggested, if an agreeable meeting time was to be arranged.

Second identified target group is general public. General public is the most numerous target group and the most important for spreading the word about The Mem**brain** concept. Five categories of general public were identified and they include students, entrepreneurs, family, professionals, children and teenagers. The listed categories are shown in the Table below.

Table 69 - Target group: General public

General public	**Interests and objectives**	**Influence**	**Importance**
Students	Participation in the project (it leads to raising competitiveness on the labour market), emotional attachment	Spreading voice about the project, raising awareness about sustainable development, the project accomplishment	High
Entrepreneurs	Knowledge about sustainable development (they can use it to improve their businesses), opportunity to find potential workers, cost reduction	Productivity increase	High
Family	Knowledge about saving the energy (cost reduction), potential technology implementation in their own living area	Spreading voice about project, emotional support	Medium
Professionals	Lifelong learning	Spreading voice about The Mem**brain** concept in the business world	Medium
Children and teenagers	Interest about future technology	Indirect influence to spreading voice about The Mem**brain** concept through family	Medium

For each of the general public category were identified their interests and objectives regarding to the project because we desire to fulfill their expectations. In addition, we have defined the general publics' influence, since it is the most important group for spreading voice about the project and raising awareness about sustainable development. The aspect of influence was paired with its importance, meaning that the priority was given to primarily satisfying their needs and interest. In communicating with the general public, our goal was to inform it about the project, easy life (advising how to save the energy) and including The Mem**brain** concept in everyday life.

5.7.2.4 Message/s establishment

Our goal is to raise people's awareness and provide them with the knowledge that there is something different and environmental friendly. Another aim is to implement nature friendly project marketing through attending of different events related to environment awareness and promoting nature friendly ideas made by students throughout our project development.

The Mem**brain** concept will promote quality of living, healthy and sustainable relation with nature and active life.

Main message that we want to establish is that everyone can affect the creation of the safe, sustainable future with making nature friendly choices in everyday life. If we manage to make people think about living efficiently in the present in order to change the future, then we can say that we succeed in our plans.

Our project will set an example that the team composed of students with different education backgrounds, can change the view on something that is not recognized by the general public. Finally, we want to affect people who are currently planning to build the house and people who are planning to build the house in 5 to 10 year period. In general, people think a lot how their houses should look like. Our intention is to make them want a house similar to the Mem**brain** concept. Think in that way, our target groups will continuously visit Mem**brain** house and directly contact our partners contributing to Croatian economy.

5.7.2.5 Action's description

Below are presented our marketing and promotional activities that will be conducted in the next months, until the end of the project. The plan is divided into seven months including, the list of planned activities along with description. At the same time this list will be our guideline in achieving one of our goals – to make our solar house the most popular house in Croatia.

Table 70 - Planned activities

Month	**Activities**	**Description**	**Budget**
March			
Starting on March 17th 2014	Facebook content - presenting other teams from SDE 2014 competition	We will present some teams of the SDE competition. The plan is to get people more interested in the Solar Decathlon but also to show them ideas of other teams.	0 €

Starting on March 17th 2014	Facebook content - presenting UNIZG Team	We will introduce a number of members of our UNIZG Team individually. We will post a picture and a brief interview with a member. The goal is to introduce people behind the project to the public.	0 €
During the month	Presentation on faculties of The University of Zagreb	The Mem**brain** concept will be presented to our colleagues. It will be organized in all faculties that are collaborating on the project.	0 €
April			
Continued	Facebook content - presenting UNIZG Team	We will introduce a number of members of our UNIZG Team individually. We will post a picture and a brief interview with a member. The goal is to introduce people behind the project to the public.	0 €
Starting on April 1st 2014	Building site - opening ceremony	Members of team, partners of the project, sponsors, University professors and Zagreb Mayor will gather for small building site opening ceremony. The budget could not be determined yet.	N/A
From April 9th to April 10th 2014	Tenth Annual International Conference on the Real Estate Market in Croatia	We will present the Mem**brain** concept on the International Conference in Zagreb. Main topics of the 10th Conference are commercial real estate, energy, infrastructure, EU funds, green building and sustainability.	0 €
During the month	Presentation on faculties of The University of Zagreb	The Mem**brain** concept will be presented to our colleagues. It will be organized in all faculties that are collaborating on the project.	0 €
From April 22th to April 25th 2014	Broadcasting announcement of the 'City Center One' event	Announcement of 'City Center One' event on local radio stations. The budget could not be determined yet.	N/A
From April 26th to April 27th 2014	The 'City Center One' event – event in shopping malls	We will present our project to general public in three 'City Center One' shopping malls located in two Croatian cities, Zagreb and Split. The event would last for two days, including exhibition of selected materials used in the construction of the house, a setup of the house, art	3.000 €

		workshops for children and providing information to general public.	
May			
Continued	Facebook content - presenting UNIZG Team	We will introduce a number of members of our UNIZG Team individually. We will post a picture and a brief interview with a member. The goal is to introduce people behind the project to the public.	0 €
During the month	The Mem**brain** flash mob	We will organize the flash mob on the Zagreb main square. It will be published on the Youtube, Facebook etc.	500 €
During the month	Presentations on faculties of other Croatian Universities	Project presentation to students and professors using professional presentations at faculties in larger Croatian cities such as Split, Rijeka and Osijek.	300 €
During the month	Building site – closing celebration	A party will be organized in one of popular Zagreb clubs in order to celebrate the ending of construction. The party will be opened for public.	N/A
June			
During the month	Facebook content - updates from Paris	It will be announced in the next delivery.	0 €
On June 15th 2014	The report for Croatian national television from SDE Paris	We will try to organize the report for our national television from building site in Paris. The budget could not be determined yet.	N/A
On June 28th 2014	The report for Croatian national television from SDE Paris	We will try to organize the report for our national television on opening day of SDE competition. The budget could not be determined yet	N/A
July			
During the month	Press releases in digital media	It includes informing Croatian general public from the house site in Paris.	0 €

During the month	Facebook content - updates from Paris	It will be announced in the next delivery.	0 €
End of July	Webpage and Facebook content	There will be uploaded audio visual presentation from the house site in Paris, as well as results of the SDE competition.	0 €
End of July	Guest on shows	We will share our experience on national television and radio stations. The fair and final presenting of the project Mem**brain** in September will be announced to general public.	0 €
TOTAL			>3.800 €

Some of others actions that we plan to do during the competition are provided in the Public Tour Description.

5.7.2.6 Tracking table of the Communication actions

Project appearances in national media are best visualized through table below. The table shows frequency of articles about the Mem**brain** concept and which national media are interested in it.

Project appearances in national media				
Number	**Media name**	**Date of release**	**Article name**	**Website link**
1	Obnovljivi.hr	13.9.2012	Međunarodno natjecanje sveučilišta – Solar Decathlon	http://www.obnovljivi.com/hrvatska-i-regija/1563-medunarodno-natjecanje-sveucilista-solar-decathlon
2	Limun.hr	20.11.2012	Studenti zagrebačkog sveučilišta na međunarodnom natjecanju	http://limun.hr/main.aspx?id=872943
3	Soundset	20.11.2012	Zagrebački studenti žele na natjecanje sa projektom održive kuće	http://www.soundset.hr/vijesti/zagreb-i-okolica/zagrebacki-studenti-zele-na-natjecanje-sa-odrzivom-kucom

4	Večernji list - učionica	22.11.2013	Studenti Sveučilišta u Zagrebu natječu se na Solar Decathlonu!	http://ucionica.vecernji.hr/vijesti/studenti-sveucilista-u-zagrebu-natjecu-se-na-solar-decathlonu/2586
5	Gradimo.hr	22.11.2012	Studenti Zagrebačkog Sveučilišta na Međunarodnom natjecanju	http://www.gradimo.hr/clanak/studenti-zagrebackog-sveucilista-na-medunarodnom-natjecanju/87912
6	Hrastović inženjering d.o.o.	22.1.2013	Solar Decathlon 2014	http://www.hrastovic-inzenjering.hr/primjena-energije/energetski-clanci/item/534-solar-decathlon-2014.html
7	Zelena zona	N/A	SOLAR DECATHLON EUROPE	http://www.zelenazona.hr/home/wps/wcm/connect/zelena/zona/gospodarstvo/mislim_globalno/solar_decathlon_europe
8	Sveučilište u Zagrebu	N/A	Tim UNIZG Sveučilišta u Zagrebu na natjecanju Solar Decathlon Europe	http://www.unizg.hr/novosti-pojedinacno/tim-unizg-sveucilista-u-zagrebu-na-natjecanju-solar-decathlon-europe/c86a1ad475fc6b20dac208d99d9dc8ca/
9	Webgradnja.hr	22.1.2013	Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje Solar Decathlon Europe 2014	http://www.webgradnja.hr/novosti/studenti-zagrebackog-sveucilista-primljeni-na-prestizno-natjecanje-solar-decathlon-europe-2014/1431/
10	Croenergo.eu	22.1.2013	Hrvatski studenti sudjeluju na Solar Decathlon Europe 2014	http://www.croenergo.eu/Hrvatski-studenti-sudjeluju-na-Solar-Decathlon-Europe-2014-11091.aspx
11	Limun.hr	22.1.2013	Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje	http://limun.hr/main.aspx?id=892362

12	Gradimo.hr	22.1.2013	Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje	http://www.gradimo.hr/clanak/studenti-zagrebackog-sveucilista-primljeni-na-prestizno-natjecanje/88357
13	Poduzetnik.hr	22.1.2013	Studenti Sveučilišta u Zagrebu primljeni na prestižno natjecanje!	http://www.poduzetnik.com.hr/content/view/670/1/
14	Energetika-net	4.2.2013	Zagrebački studenti sudionici su prestižnog međunarodnog natjecanja	http://www.energetika-net.com/specijali/projekt-prica/zagrebacki-studenti-sudionici-su-prestiznog-medunarodnog-natjecanja-16160
15	Mreža tv	7.6.2013	Tim studenata na prestižnom natjecanju	http://mreza.tv/tim-studenata-na-prestiznom-natjecanju/
16	Domosfera.hr	10.7.2013	Znate li što je "sunčani desetoboj“?	http://www.domosfera.hr/wps/portal/domosfera_public/home/kultura_stanovanja/zivim_zeleno/clanak/znate_li_sto_je_suncani_desetoboj
17	Zelena zona		MEMBRAIN – KUĆA BUDUĆNOSTI	http://www.zelenazona.hr/home/wps/wcm/connect/zelena/zona/gospodarstvo/mislim_globalno/membrain_kuca_buducnosti
18	Tportal	23.8.2013	CONCEPT: MEMBRAIN - Studenti grade hrvatsku samoodrživu montažnu kuću	http://www.tportal.hr/scitech/tehno/281848/Studenti-grade-hrvatsku-samoodrzivu-montaznu-kucu.html
19	Srednja.hr	24.8.2013	KAMPUS BORONGAJ: STUDENTI ĆE IZGRADITI SAMOODRŽIVU MONTAŽNU KUĆU	http://www.srednja.hr/Studenti/Vijesti/Kampus-Borongaj-Studenti-ce-izgraditi-samoodrzivu-montaznu-kucu
20	esava	24.8.2013	Studenti grade hrvatsku samoodrživu montažnu kuću	http://esava.info/novosti/studenti-grade-hrvatsku-samoodrzivu-montaznu-kucu/

21	Banka.hr	8.9.2013	Studenti osmislili zeleni projekt Mem**brain**	http://www.banka.hr/hrvatska/studenti-osmislili-zeleni-projekt-membrain
22	Fakultet strojarstva i brodogradnje	10.10.2013	Hrvatski studenti grade kuću budućnosti	http://www.fsb.unizg.hr/atlantis/upload/newsboard/10_10_2013__19643_Objava_listopad_2013.pdf
23	Fakultet elektrotehnike i računarstva	12.10.2013	FER-ovi studenti sudjeluju u gradnji kuće budućnosti	https://www.fer.unizg.hr/?@=2dwwv
24	Građevinski Fakultet	14.10.2013	Hrvatski studenti grade kuću budućnosti	http://www.grad.unizg.hr/?@=2a2ji#news_8980
25	Visoka poslovna škola Zagreb	22.10.2013	Hrvatski studenti grade kuću budućnosti	http://www.vpsz.hr/Page.aspx?categoryId=25&newsId=175
26	esava	23.10.2013	Hrvatski studenti okreću gradnju naglavce	http://esava.info/novosti/hrvatski-studenti-okrecu-gradnju-naglavce/
27	Tportal	23.10.2013	Hrvatski studenti okreću gradnju naglavce	http://www.tportal.hr/scitech/tehno/294288/Hrvatski-studenti-okrecu-gradnju-naglavce.html
28	Zelena zona	30.10.2013.	KUĆA BUDUĆNOSTI KORAK BLIŽE IZGRADNJI	http://www.zelenazona.hr/home/wps/wcm/connect/zelena/zona/gospodarstvo/mislim_globalno/kuca_buducnosti_korak_blize_izgradnji/
29	HRT	31.10.2013.	Solar Decathlon i samoodrživa kuća	http://djh.hrt.hr/dom-i-vrt/9126-samoodrziva-kuca
30	Večernji list	31.10.2013.	Studenti projektirali samoodrživu montažnu kuću s kojom idu u Pariz	http://www.vecernji.hr/moj-kvart/studenti-projektirali-samoodrzivu-montaznu-kucu-s-kojom-idu-u-pariz-900169
31	Nova tv	06.11.2013.	Studenti grade kuću	http://dnevnik.hr/videoteka/studenti-grade-kucu.html
32	Slobodna dalmacija	11.11,2013.	Sinjanin u Versaillesu gradi svoju 'kuću sunca'	http://www.slobodnadalmacija.hr/Mozaik/tabid/80/art

				icleType/ArticleView/articleId/227186/Default.aspx
33	Tportal	16.11.2013.	Pametna kuća na hrvatski način	http://www.tportal.hr/scitech/tehno/299077/Pametna-kuca-na-hrvatski-nacin.html
34	HRT: Eko zona	5.2.2014.	Zagrebački studenti sudionici su prestižnog međunarodnog natjecanja	http://www.hrt.hr/enz/eko-zona/
35	Televizija Student: Akademska četvrt	9.2.2014.	Projekt Mem**brain**	http://vimeo.com/86023528
36	Srednja.hr	13.2.2014.	Upoznajte se s najvećim studentskim projektom u RH i ovom dijelu Europe	http://studentski.hr/studenti/vijesti/upoznajte-se-s-najvecim-studentskim-projektom-u-rh-i-ovom-dijelu-europe/
37	Radio Student: Diskurs	19.2.2014.		
38	Hrvatski radio: Ništa nevažno	20.2.2014.		
39	Hrvatski radio: Oko znanosti	21.2.2014.	Mem**brain**	http://radio.hrt.hr/aod/membrain/55458/

Screenshots of articles in national media

Energetika doživljava korjenite promjene,
to je prilika za
ZAPOŠLJAVANJE I RAZVOJ INDUSTRIJE!

Naslovnica Obnovljivi izvori energije Vijesti Kolumne Struka Info
Aktualno Reakcije Hrvatska i regija Svijet Obavijesti o radu portala Popis svih vijesti

Home ▸ Hrvatska i regija ▸ Međunarodno natjecanje sveučilišta - Solar Decathlon

Vijesti iz regije

Međunarodno natjecanje sveučilišta - Solar Decathlon

Autor Iva Zelenko

Četvrtak, 13 Rujan 2012 22:58

Solar Decathlon jedno je od najvećih međunarodnih sveučilišnih natjecanja, koje se trenutno održava u Madridu u Španjolskoj. Primarni cilj ovog natjecanja je integracija i povezivanje struka u sklopu dvogodišnjeg projekta koji obuhvaća pronalaženje inovativnih i kreativnih ideja prilikom projektiranja i izgradnje niskoenergetskog objekta.

Organizacija Solar Decathlon Europe (SDE) nastala je u suradnji s Odjelom za energetiku Sjedinjenih Američkih Država, koji već dugi niz godina provodi ovo natjecanje.

Prvo natjecanje u Europi održano je 2010. godine, također u Madridu, a natjecanje je započelo slanjem idejnih rješenja i prijedloga sveučilišta iz cijele Europe. Nakon detaljne procjene svih primljenih prijedloga, 20 timova je odabrano za daljnje sudjelovanje u natjecanju. U završnici se objekti montiraju i ocjenjuju u deset kategorija.

Figure 218 - Screenshot – Obnovljivi.hr

Vijesti Tečaj Burze CROBEX® Ekonomske analize Leksikon Nekretnine NOVO Izlog Stanovi After work EU fondovi

Početna > Vijesti > Vijesti dana > Studenti zagrebačkog sveučilišta na međunarodnom natjecanju

Studenti zagrebačkog sveučilišta na međunarodnom natjecanju

20.11.2012 12:11:00 | Autor/Izvor Limun.hr

Studenti Sveučilišta u Zagrebu u završnim su fazama za prijavu na prestižnom dvogodišnjem međunarodnom natjecanju sveučilišta, Solar Decathlon Europe, ističe se u priopćenju.

Solar Decathlon Europe temelji se na izgradnji niskoenergetske montažne kuće, koja svoje potrebe za energijom zadovoljava iz obnovljivih izvora energije, prvenstveno energije Sunca. Natjecanje se održava dugi niz godina i u Sjedinjenim američkim državama te bilježi konstantan porast posjećenosti. Sudionici natjecanja mogu biti sveučilišta i stručni studiji koji sadrže fakultete arhitektonske, elektrotehničke, strojarske, građevinske struke te drugih struka, koje svoje interese pronalaze u području energetske učinkovitosti i održive gradnje.

Do sada na ovom natjecanju nije bilo hrvatskih predstavnika te je inicijativa o prisustvovanju došla iz redova studenata zagrebačkog Sveučilišta. "S obzirom na prethodne studentske projekte koji su bili uspješni, osjetili smo potrebu da iskušamo naše znanje i dosadašnje iskustvo i na ovom svjetskom natjecanju. Naš primarni cilj, tima Sveučilišta u Zagrebu, je projektirati i izgraditi građevinu koja de biti održiva, tj. osim za samo natjecanje, biti de ju moguće koristiti i u obliku informativnog centra, izložbenog prostora pokrovitelja, edukativnog materijala u nastavnim programima fakulteta te brojnih drugih primjena." izjavio je Ivan Ivid, prvostupnik građevine i jedan od članova tima Sveučilišta u Zagrebu.

Od prvih faza projektiranja uključit de se i hrvatske tvrtke i ostali subjekti koji de svojim angažmanom pomoći promidžbi samog Sveučilišta, Hrvatske ali i svojih proizvoda i usluga.

Figure 219 - Screenshot – Limun.hr

soundset Vijesti Science & Business Glazba KULTURA SPORT SKENER FUN Radio

Zagrebački studenti žele na natjecanje sa projektom održive kuće

Utorak, 20. studenog 2012. PODIJELI: 0

INTERVIEW TJEDNA
Privodimo osumnjičene... I one koji to (još) nisu

Vezano

Fakultet dobio 3 milijuna eura iz fondova EU
ZAGREB I OKOLICA Nedjelja, 18. studenog 2012.

Županija stipendira studente
POŽEGA Ponedjeljak, 12. studenog 2012.

Čačić poručio građanima - ulažite u energetiku
RIJEKA Petak, 09. studenog 2012.

TAGOVI: Zagreb i okolica, Znanost, Vijest, montažne kuće, niskoenergetske kuće, zagrebačko sveučilište, međunarodno natjecanje

REBALANS, HOLDING, STANOVI...

Studenti sa Zagrebačkog sveučilišta prijavljuju se na prestižno međunarodno natjecanje Solar Dechatlon Europe koje se temelji na izgradnji niskoenergetske montažne kuće

Studenti Sveučilišta u Zagrebu u završnim su fazama za prijavu na prestižno dvogodišnje međunarodno natjecanje sveučilišta, Solar Decathlon Europe.

Solar Decathlon Europe temelji se na izgradnji niskoenergetske montažne kuće koja svoje potrebe za energijom zadovoljava iz obnovljivih izvora energije, prvenstveno energije sunca. Sudionici natjecanja mogu biti sveučilišta i stručni studiji na kojima su fakulteti arhitektonske, elektrotehničke, strojarske, građevinske struke te drugih struka koje svoje interese pronalaze u području energetske učinkovitosti i održive gradnje.

Figure 220 - Screenshot – Soundset

Studenti Sveučilišta u Zagrebu natječu se na Solar Decathlonu!

Studenti Sveučilišta u Zagrebu u završnim su fazama za prijavu na prestižnom dvogodišnjem međunarodnom natjecanju sveučilišta, Solar Decathlon Europe.

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„S obzirom na prethodne studentske projekte koji su bili uspješni, osjetili smo potrebu da iskušamo naše znanje i dosadašnje iskustvo i na ovom svjetskom natjecanju. Naš primarni cilj, tima Sveučilišta u

Figure 221 - Screenshot – vecernji.hr

Figure 222 - Screenshot – gradimo.hr

Figure 223 - Screenshot – Hrastovic inzenjering

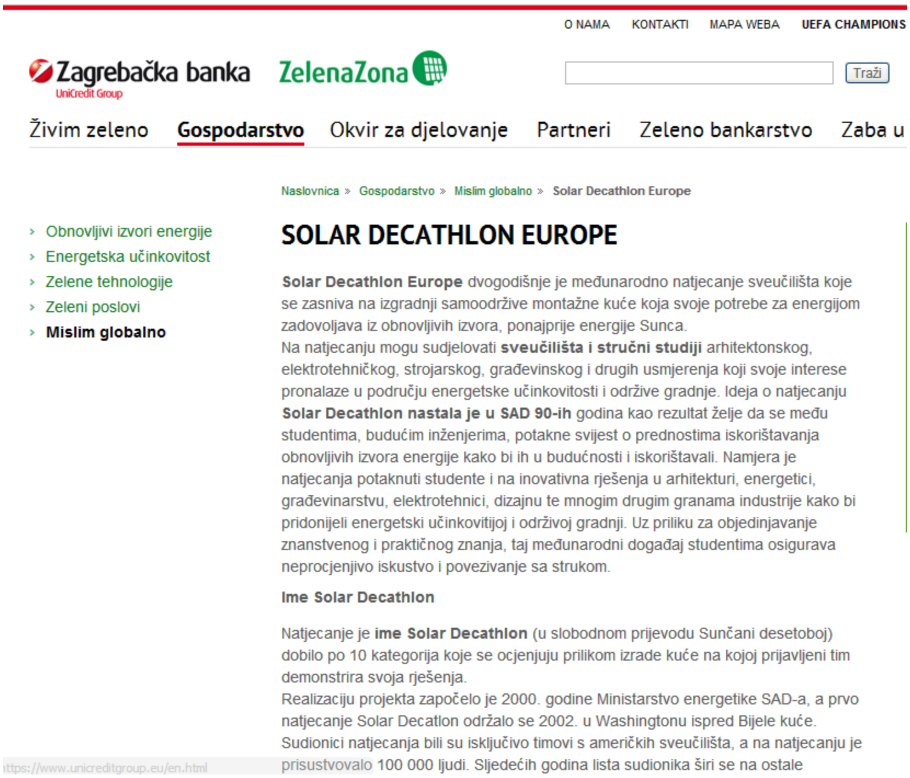

Figure 224 - Screenshot – Zelenazona.hr

Figure 225 - Screenshot – University of Zagreb

Figure 226 - Screenshot – Webgradnja.hr

Figure 227 - Screenshot – Croenergo.eu

Raiffeisen investicijski fondovi 16.07.2013.

Limun.HR FINANCIJE S VITAMINOM C

Početna > Vijesti > Vijesti dana > Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje

Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje

22.1.2013 13:56:00 | Autor/Izvor Limun.hr

Nakon što su krajem 2012. godine predali prijavu za sudjelovanje na prestižnom dvogodišnjem međunarodnom natjecanju sveučilišta Solar Decathlon Europe, studenti Sveučilišta u Zagrebu primljeni su u iduću fazu natjecanja koja traje do studenog ove godine, ističe se u priopćenju.

Solar Decathlon Europe je međunarodno natjecanje sveučilišta koje se temelji na izgradnji samoodržive montažne kuće, koja svoje potrebe za energijom zadovoljava iz obnovljivih izvora, prvenstveno energije Sunca. Sudionici mogu biti sveučilišta i stručni studiji arhitektonskog, elektrotehničkog, strojarskog, građevinskog i drugih usmjerenja, koji svoje interese pronalaze u području energetske učinkovitosti i održive gradnje.

Studenti zagrebačkog sveučilišta imat će priliku predstavljati svoj projekt velikom broju studenata i profesora iz cijelog svijeta, stručnoj komisiji kao i ostalim posjetiteljima kojih se iduće godine u Parizu očekuje oko 400 000. Natjecanje je svakako na visokoj razini uzevši u obzir da su prijave podnijela 44 sveučilišta iz 26 različitih zemalja svijeta. Sveučilište u Zagrebu je zauzelo 25. mjesto što je i više nego uspješan rezultat, budući da je ovo prvi put da su se hrvatski studenti prijavili na Solar Decathlon.

Vrijednost ovakvog pothvata prepoznalo je već u kvalifikacijskoj fazi 24 privatnih tvrtki i državnih institucija, koje su izrazile namjeru svojim sponzorstvima doprinijeti finaliziranju kuće. Budući da se radi o izvorno domaćim tvrtkama mogućnosti za predstavljanje Hrvatske su višestruke. Ovaj projekt osim mogućnosti sudjelovanja na natjecanju, predstavlja i priliku za suradnju između akademske zajednice i hrvatskog gospodarstva, te senzibiliziranje javnosti glede pitanja planiranja i provedbe energetski

Figure 228 - Screenshot – Limun.hr

gradimo.hr od ideje do realizacije

ČLANAK

Studenti zagrebačkog sveučilišta primljeni na prestižno natjecanje

Autor: Silvia Vlakančić | Dodano: 22-01-2013 | Pogledano: 240 put(a)

Kategorije: obnovljivi izvori energije

Zagreb, 22. siječnja 2013. - nakon što su krajem 2012. godine predali prijavu za sudjelovanje na prestižnom dvogodišnjem međunarodnom natjecanju sveučilišta Solar Decathlon Europe, studenti Sveučilišta u Zagrebu primljeni su u iduću fazu natjecanja koja traje do studenog ove godine.

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Figure 229 - Screenshot – gradimo.hr

Figure 230 - Screenshot – Poduzetnik.hr

Figure 231 - Screenshot – Energetika.hr

Figure 232 - Screenshot – Mreža TV

Figure 233 - Screenshot – Domosfera.hr

Figure 234 - Screenshot – Zelenazona.hr

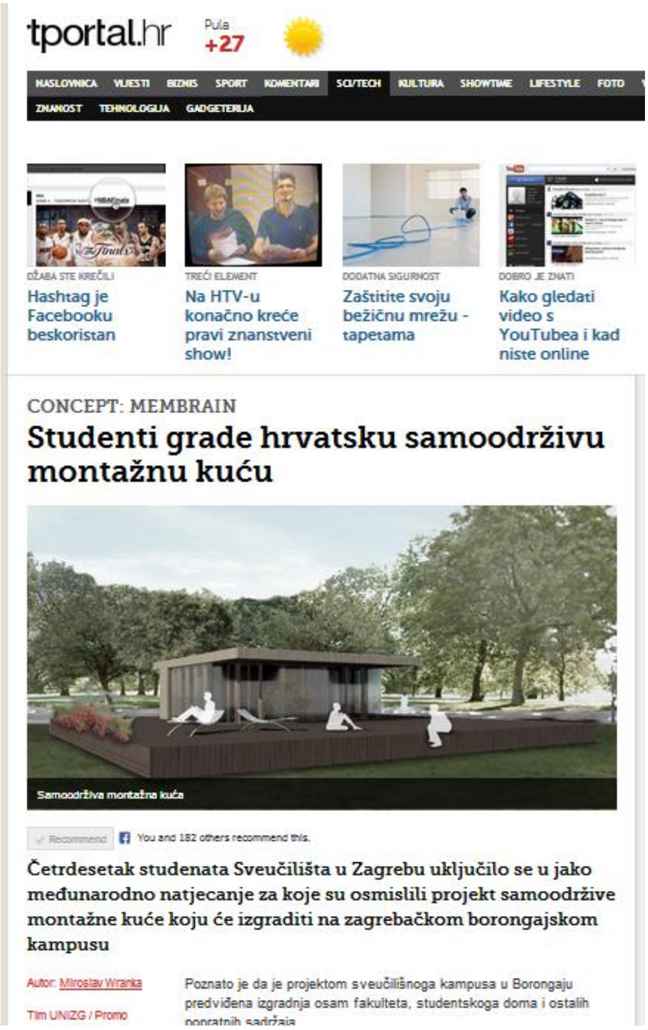


Figure 235 - Screenshot – tportal.hr

VIJESTI

KAMPUS BORONGAJ: STUDENTI ĆE IZGRADITI SAMOODRŽIVU MONTAŽNU KUĆU

Objavljeno 24.08.2013 10:12 piše A.B.

Projekt sveučilišnog kampusa Borongaj koji bi u sljedećih nekoliko godina trebao ugledati svjetlo dana, sadržavati će još jedno iznenađenje. Svima je poznato kako će u sklopu kampusa biti osam fakulteta te studentski dom. Međutim 40-ak studenata zagrebačkog Sveučilišta prijavilo se na međunarodno natjecanje gdje su osmislili projekt samoodržive montažne kuće koju će izgraditi na Borongaju.

www.tportal.hr

Unatoč skepticizmu oko izgradnje sveučilišnog kampusa na Borongaju, Skupština Grada Zagreba je najavila kako će projekt biti završen za četiri godine. Radi se o najvećoj investiciji u Hrvatskoj, a osim osam fakulteta, studentskog doma i brojnih popratnih sadržaja, sadržavat će još jedno iznenađenje - **samoodrživu montažnu** kuću, piše tportal.

Studenti će izgraditi samoodrživu montažnu kuću

Figure 236 - Screenshot – Srednja.hr

Studenti grade hrvatsku samoodrživu montažnu kuću

Administrator   Kolovoz 24, 2013

Četrdesetak studenata Sveučilišta u Zagrebu uključilo se u jako međunarodno natjecanje za koje su osmislili projekt samoodržive montažne kuće koju će izgraditi na zagrebačkom borongajskom kampusu
Poznato je da je projektom sveučilišnoga kampusa u Borongaju predviđena izgradnja osam fakulteta, studentskoga doma i ostalih popratnih sadržaja, piše tportal.

No manje je poznato to da će se među zgradama sveučilišnoga kompleksa naći i jedna neobična zgrada. Riječ je o samoodrživoj montažnoj kući koja svoje potrebe za energijom zadovoljava iz obnovljivih izvora energije, prvenstveno solarne energije.

Tim koji sudjeluje u realizaciji projekta okuplja trenutno četrdesetak studenata Zagrebačkog sveučilišta pod vodstvom 14 sveučilišnih profesora mentora. Izgradnja samoodržive montažne kuće odvija se u sklopu projekta s kojim tim Sveučilišta u Zagrebu (tim UNIZG) sudjeluje na natjecanju Solar Decathlon Europe 2014.

Figure 237 - Screenshot – esava.hr

Figure 238 - Screenshot – banka.hr

HRVATSKI STUDENTI GRADE KUĆU BUDUĆNOSTI

Kao jedini predstavnik sveučilišta iz cijele regije, tim studenata Sveučilišta u Zagrebu sudjeluje na prestižnom međunarodnom natjecanju Solar Decathlon Europe na kojemu će predstaviti hrvatsku samoodrživu montažnu kuću.

Solar Decathlon Europe je međunarodno natjecanje sveučilišta u izgradnji montažne samoodržive kuće koja svoje potrebe za energijom zadovoljava iz obnovljivih izvora energije, prvenstveno Sunca. Na natjecanju sudjeluju sveučilišta iz svih dijelova svijeta. Sveučilište u Zagrebu se po prvi puta prijavilo na ovo natjecanje. Predloženim konceptom Membrain, Sveučilište se uspješno plasiralo u daljnji krug, u kojem je potrebno konceptualno rješenje dovesti do realizacije. Finale natjecanja, tj. dvotjedno izlaganje i bodovanje svih kuća održat će se krajem lipnja 2014. u Parizu pred oko 400.000 posjetitelja.

Tim Sveučilišta u Zagrebu svojim radom pokazao je ozbiljan i stručan pristup cijelom projektu, inovativnost koncepta Mem**brain**, te novi korak u povezivanju akademske zajednice i Hrvatskog gospodarstva. Objedinjujući znanje i sposobnosti studenata koji teže inovativnim i održivim rješenjima unutar struke, ovaj projekt doprinosi cijeloj zajednici ističući važnost energetski učinkovitog planiranja i izgradnje.

Figure 239 - Screenshot - Faculty of Mechanical Engineering and Naval Architecture

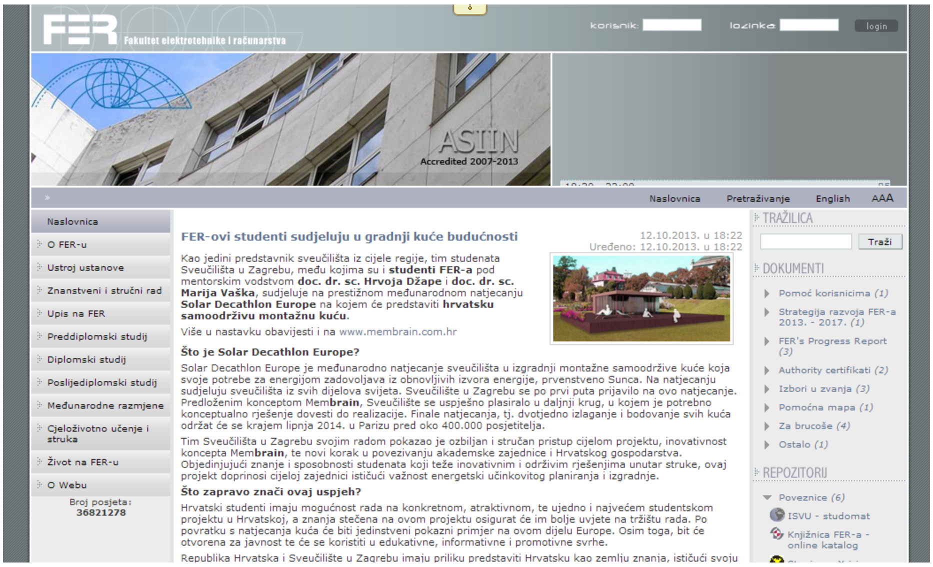


Figure 240 - Screenshot - Faculty of Electrical Engineering and Computing

Figure 241 - Screenshot – Faculty of Civil Engineering

Figure 242 - Screenshot – vspz.hr

Figure 243 - Screenshot – esava.hr

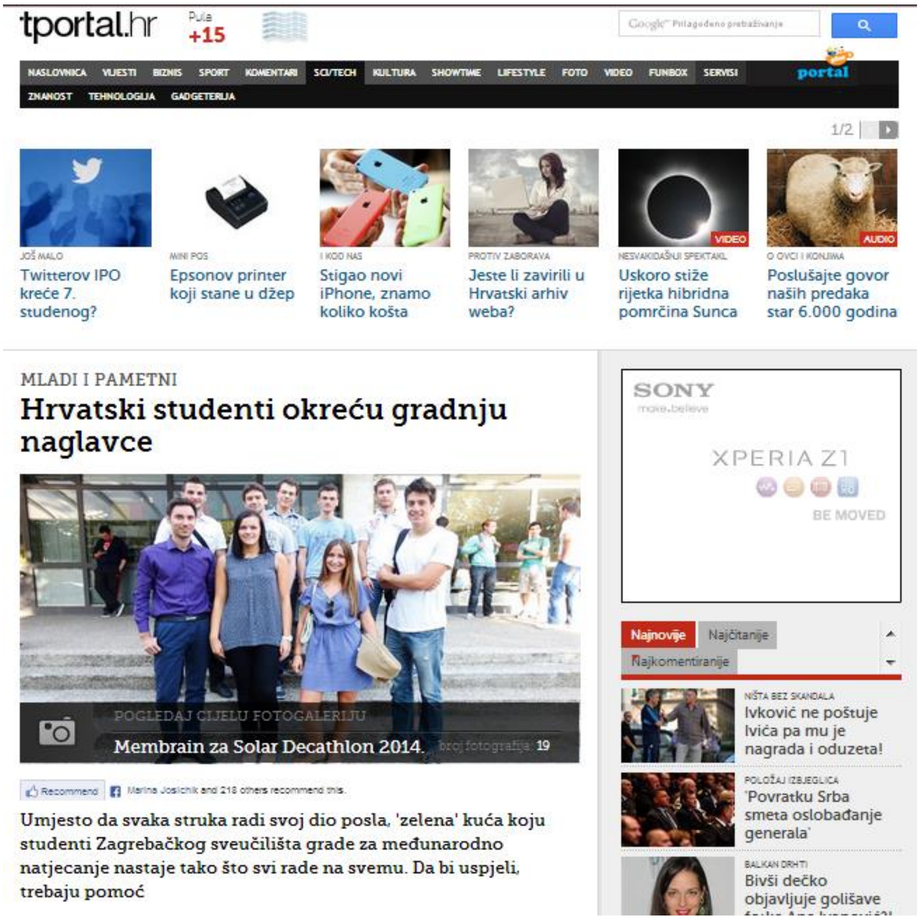


Figure 244 - Screenshot – tportal.hr

Figure 245 - Screenshot – novatv.hr

MOZAIK

Objavljeno 11.11.2013. u 22:50

FRANCUSKA

Sinjanin u Versaillesu gradi svoju 'kuću sunca'

Like 2 Tweet 0 g+1 0

Od 28. lipnja do 14. srpnja sljedeće godine u Parizu će se održati Solar Dechatlon Europe 2014., natjecanje studentskih timova svjetskih sveučilišta u izgradnji energetski samoodrživih montažnih kuća koje sve svoje potrebe za energijom zadovoljavaju iz obnovljivih izvora, prvenstveno sunčeve energije. Na natjecanje u Parizu prijavila su se 44 sveučilišna tima iz 23 svjetske zemlje među kojima i tim Zagrebačkog sveučilišta.

Projekt 60 studenata

Voditelj studentskog projektnog tima Hrvoje Nikola Vučemilo, student zagrebačkog Fakulteta elektrotehnike i računarstva sinjskog podrijetla, prikazao je na Festivalu znanosti Sinj projekt energetski samoodržive kuće koju će graditi u Parizu. Po povratku, Membrain kuća će biti podignuta kao prvi izgrađeni objekt Kampusa na Borongaju. - Ima nas više od 60 studenata s 8 različitih fakulteta.

S nama je i 20-ak mentora, profesora. Pripremamo projekt koji smo nazvali "Koncept Membrain" i s kojim ćemo se predstaviti u Parizu. Radi se o kući koja će u cijelosti imati autonomne izvore energije iz obnovljivih izvora, ponajprije sunca - kazao je Vučemilo dodatno pojašnjavajući o kakvoj se, zapravo, kući radi.

- Nosiva konstrukcija kuće je od drvenih stupova i ploča. Toplinsku izolaciju kuće ostvarili smo na dva načina: na južni, istočni i zapadni zid postavili smo dvostruku staklenu stijenu od vakuumskog stakla. Ono je odličan izolator kroz koji se ne gubi toplina, a solarni dobici kroz njih zimi smanjuju potrebu za aktivnim grijanjem. Osim toga u tom, kako kažete, stakleniku možemo uzgajati biljke za prehranu. Krov ovisno o insolaciji mijenja svoju geometriju i kut nagiba fotonaponskih panela i podešava se za optimalno skupljanje električne energije i istovremeno štiti kuću od prekomjernog osunčanja ljeti.

Maketa 'Membrain' montažne nastambe

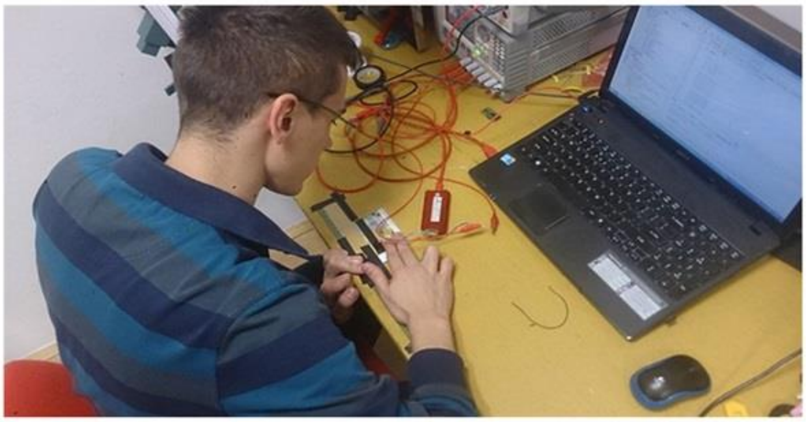
Zimi kada je sunce nisko krov se nabora povećavajući nagib fotonaponskih panela prizvodi više energije i istovremeno propušta više sunčeve energije u unutrašnjost kuće - pojasnio je Vučemilo. Glavni izvor energije je sustav fotonaponskih panela, a pametni sustav kuće odlučuje hoće li tu energiju spremiti u kućnu bateriju, bateriju automobila ili će je predati u elektromrežu.

- Sustavom upravlja centralno računalo koje s korisnikom kuće ostvaruje interakciju preko centralnog panela, tableta ili smart-phonea. Uz spomenuto naša "Membrain kuća" ima pasivno-aktivni strop sa PCM materijalima

Figure 246 - Screenshot – Slobodnadalmacija.hr

OTKRIJTE

Pametna kuća na hrvatski način



Recommend 61 people recommend this. Be the first of your friends.

Zamislite kuću koja zna da se nakon posla volite istuširati. Na osnovu mjerenja zaključit će da se vraćate oko 17 sati. Upalit će grijanje u 16:30 kako bi vas dočekala optimalna temperatura, a u 16:45 zagrijat će vodu...

Autor: Miroslav Wranka

Concept:Membrain / Promo fotografije Concept:Membrain (Foto)

Datum objave: 16.11.2013 9:06
Zadnja izmjena: 18.11.2013 19:07

Like 61
Tweet 1

Komentiraj
Pošalji prijatelju
Ispiši

Tportal Hr
Like You like this.

Gadgeterija
Like 22,716

VEZANE VIJESTI

Znanstvena fantastika? Nemoguće u Hrvatskoj? Krivo, u oba slučaja.

Upravo na razvoju takvog sustava radi 15 studenata zagrebačkog Fakulteta elektrotehnike i računalstva, u sklopu projekta samoodržive montažne kuće *Concept:Membrain*, hrvatskog predstavnika za natjecanje Solar Decathlon, koje će iduće godine biti održano u Parizu. O tom smo projektu već pisali.

Uz studente diplomskog studija, koji čine većinu tima, tu su i diplomirani inženjeri, još donedavno studenti te profesori koji mentoriraju projekt. Zastupljeni su različiti smjerovi, poput automatike, elektroničkog i računalnog inženjerstva, programskog inženjerstva i računalnih znanosti.

U ovoj fazi projekta najveći im je izazov dizajniranje algoritama strojnog učenja. Potrebno je osmisliti algoritam koji - na temelju velikog broja mjerenja - shvaća, pamti, uči i razumije navike svojih stanovnika te prilagođava sam sebe kako bi pružio ukućanima što ugodniji život, uz što manju potrošnju energije.

Glavna ideja sustava automatizacije jest stanaru pružiti ugodnost stanovanja na nenametljiv način. Dio sustava je zadužen za upravljanje dizalicom topline, koja na energetski učinkovit način održava optimalnu temperaturu.

Na temelju matematičkog toplinskog modela kuće, vremenske prognoze, arhivskih podataka i očitanja velikog broja senzora, algoritam MPC (skraćenica za Model Predictive Control, naprednu metodu kontrole procesa - op.ur.) osigurava održanje temperature uz minimalan utrošak energije. Algoritam, kao i toplinski model kuće, u potpunosti su razvili hrvatski studenti. Trenutno je postupku implementacije.

Figure 247 - Screenshot – tportal.hr

Figure 248 - Screenshot – hrt.hr

Figure 249 - Screenshot – televizijastudent.hr

KONCEPT MEMBRAIN

UPOZNAJTE SE S NAJVEĆIM STUDENTSKIM PROJEKTOM U RH I OVOM DIJELU EUROPE

Ovo ime ćete moći vidjeti na ekološkim autobusima, stanicama, po oglasnim pločama i u medijima. Vjerojatno ćete o njemu najviše čitati nakon natječaja Solar Decathlon Europe u Francuskoj, a još vjerojatnije ćete sve biti u prilici vidjeti i ispipati u listopadu kada će se održati prezentacija na kampusu Borongaj.

GALERIJA

Ako niste do sada čuli za projekt Membrain, vjerujte nam – ubrzo ćete čuti, čitali vi ovaj članak ili ne. Ime ćete moći vidjeti na ekološkim autobusima, stanicama, po oglasnim pločama i u medijima. Vjerojatno ćete o njemu najviše čitati nakon natječaja Solar Decathlon Europe u Francuskoj, a još vjerojatnije ćete sve biti u prilici vidjeti i ispipati u listopadu kada će se održati prezentacija na kampusu Borongaj. O čemu se točno radi, pročitajte u sljedećim redovima.

IZBOR UREDNIŠTVA

Oni su jednostavni, mladi, otkačeni, originalni - oni su Silente!

Porezne reforme cara Dioklecijana

NAJNOVIJE VIJESTI

10 zanimljivih činjenica o spavanju koje niste znali!

10 obrazovnih trendova koje treba pratiti

Preko osamdeset studenata i trideset mentora

Koncept Membrain je projekt samoodržive montažne kuće, a projekt je potpuno stasao od strane studenata. **Stipo Dubravac**, voditelj pokroviteljstva Koncepta Membrain, upoznao nas je sa načinom funkcioniranja cijelog projekta i o planovima za budućnost. Ideja o samoodrživim montažnim kućama pojavila se sukladno s idejom o "hrvatskom Harvardu", odnosno o uređivanju Znanstveno-učilišnog centra Borongaj u centar sveučilišne sfere. Po zamišljenim nacrtima, **Borongaj** bi tako trebao zaživiti u skladu sa ekološko prihvatljivim rješenjima, a ideja o kućama se savršeno uklopila u ovu viziju koju je pozdravila i Europska unija. S razvijanjem projekta se širio i broj ljudi koji aktivno radi na njemu, tako da tim sveukupno broji preko osamdeset studenata. Naravno, sve to ne bi bilo moguće bez stručnog nadzora i savjetovanja, tako da su u projekt uključeni i mentori sa dvanaest zagrebačkih fakulteta, koji svojim idejama pripomažu studentima u što uspješnijoj realizaciji.

Projekt je jedinstven u regionalnom dijelu, a po opsegu studenata **jedan i od najvećih**

Figure 250 - Screenshot – srednja.hr

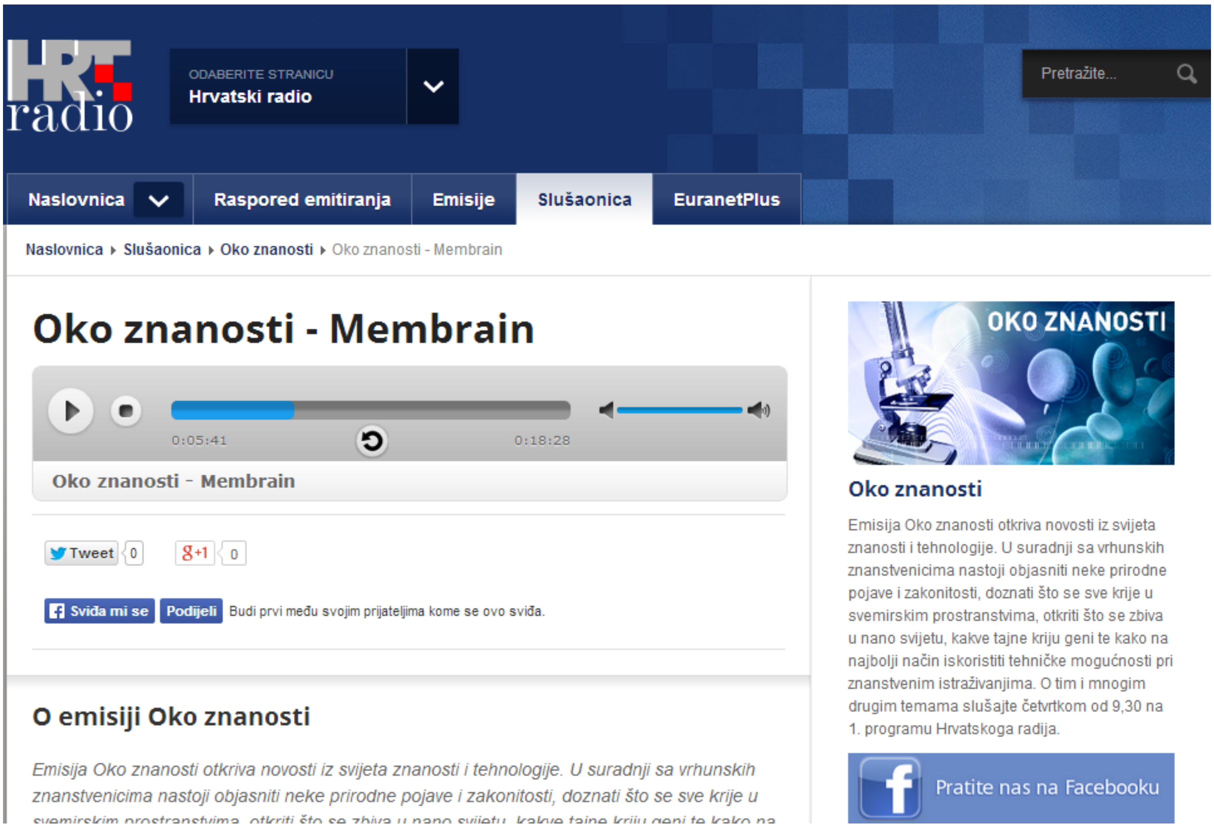


Figure 251 - Screenshot – hrt.hr

All major events that we organized or will organize as well as the conferences that we attended are listed below:

<u>Terraneo workshop</u>

At this year's Terraneo festival in the environmental part of the program, UNIZG team organized interesting workshop “Design your own sustainable house”. Terraneo is a major musical event in the region, which develops the concept of socially responsible and environmentally conscious entertainment. Year after year it attracts more and more visitors from all over Europe. The workshop was held on 8th of August 2013 and was led by team members UNIZG Mate Rupić and Paolo Marenzi.

Workshop consisted of two parts. The first part was related to the presentation of the Solar Decathlon Europe competition, concept Mem**brain** and acquainting the participants with the goals and objectives of the workshop. Participants were given guidelines and materials (paper, scissors, glue, cardboard, etc.) and set about creating their own Mem**brain** sustainable home. In order to explain the mission, workshop leaders brought model home.

The aim of the workshop was to convey to participants the principles of sustainable development which so they remember them when thinking about building sustainable house.

<u>Klima forum</u>

The 4th Forum on Heating, Ventilation and Air-conditioning was held on 3th of October in Zagreb. At this conference project team leader Hrvoje Vučemilo held a lecture about concept Mem**brain**.

The lecture was held in the fourth thematic section called Projects and Solutions, and has induced great interest of gathered experts, especially students. We are proud that the value of the project was recognized at the conference.

Croenergy 2013

Sustainable Energy Finance and Investment Summit CROENERGY 2013 was held from second to forth of October in Tuheljske toplice. Main topic of the conference was financing renewable energy projects using innovative financial instruments. The organizer of the conference was Regional Energy Agency of Northwest Croatia (REGEA). At this conference concept Mem**brain** has demonstrated development stage of the project and presented our plans for the future. Also, for the first time, we have displayed a model of our house. As the Croatian president Josipović already supported the Mem**brain** initiative, after the opening ceremony of the conference he came with his entourage to the showroom to talk to UNIZG team members about project progress. We are extremely happy and proud about the positive reaction from the President.

International Fair of Energy, Energy Efficiency and Renewable Energy

Zagreb Fair hosted the second International Fair of Energy, Energy Efficiency and Renewable Energy, which was held from first to fourth October this year. Our team saw the event and an opportunity to acquire additional knowledge and to present the project to potential sponsors and anyone interested in the project self-sustaining prefabricated houses. In the end, we have set up a stand with promotional items for Mem**brain**, the University of Zagreb and visualization homes that will be built within the campus Borongaj.

Seminar Advertising on Facebook3

In order to improve our internet marketing and promotional activities we attended seminar Advertising on Facebook. The seminar covered topics such as: importance of social networks, general rules when using social networks and Facebook, how to communicate with followers, managing negative comments, creating and managing Facebook adds, organizing giveaways. All topics were shown on real examples.

Greenvest[4] and Ambienta[5]

Even though we did not have an opportunity to be one of exposures we visited fairs and established several contacts that could contribute project dissemination. Greenvest is a fair that gathers companies concerned and dealing about sustainability. Ambienta is international of furniture and interior design, which took place in Croatia 40 years in a row.

10th Annual International Conference on the Real Estate Market in Croatia

The 10th Annual International Conference on the Real Estate Market in Croatia in taking place in Zagreb, in The Regent Esplanade Zagreb Hotel, from April 9th to April 10th 2014. Main topics of the conference will be Commercial Real Estate, Energy, Infrastructure, EU Funds, Green Building and Sustainability. The project manager Ivan Ivic and the marketing team leader Lada Bauer will present the Mem**brain** concept within topic Green Building and Sustainability.

[3] http://www.mapaznanja.hr/hr/arhiva-seminara/oglasavanje-na-facebooku,177.html
[4] http://www.greenvest.com.hr/GREENVEST-INFO/ABOUT-GREENVEST
[5] http://www.zv.hr/?id=65

‘City Center One’ event

The event will be organized anent The Day of Using Renewable Energy, on 26th April 2014. It will be two days event in three large shopping malls, which two of them are located in Zagreb and the third one is located in Split. We are planning to exhibit the setup of the Mem**brain** concept and some materials that we are using in the construction process. An art workshop “Draw your sustainable house” will be held for children and for every painted drawing they will receive a sheep toy. For adults we are planning to get electric bike that will light the setup. Other details and activities during the event will be determined in the next few weeks.

The Membrain Flash mob

The Mem**brain** Flash mob will be organized on the main square in Zagreb. In theory, Flash mob is an unexpected activity which attracts big amount of people who get involved into certain choreography or action planned in advance by performers. Whole performance is recorder with few cameras and then edited in short and attractive video. The participants will be members of UNIZG Team and their friends and kith. Other details of the event will be determined in the next few weeks.

5.7.3 Public Tour Description

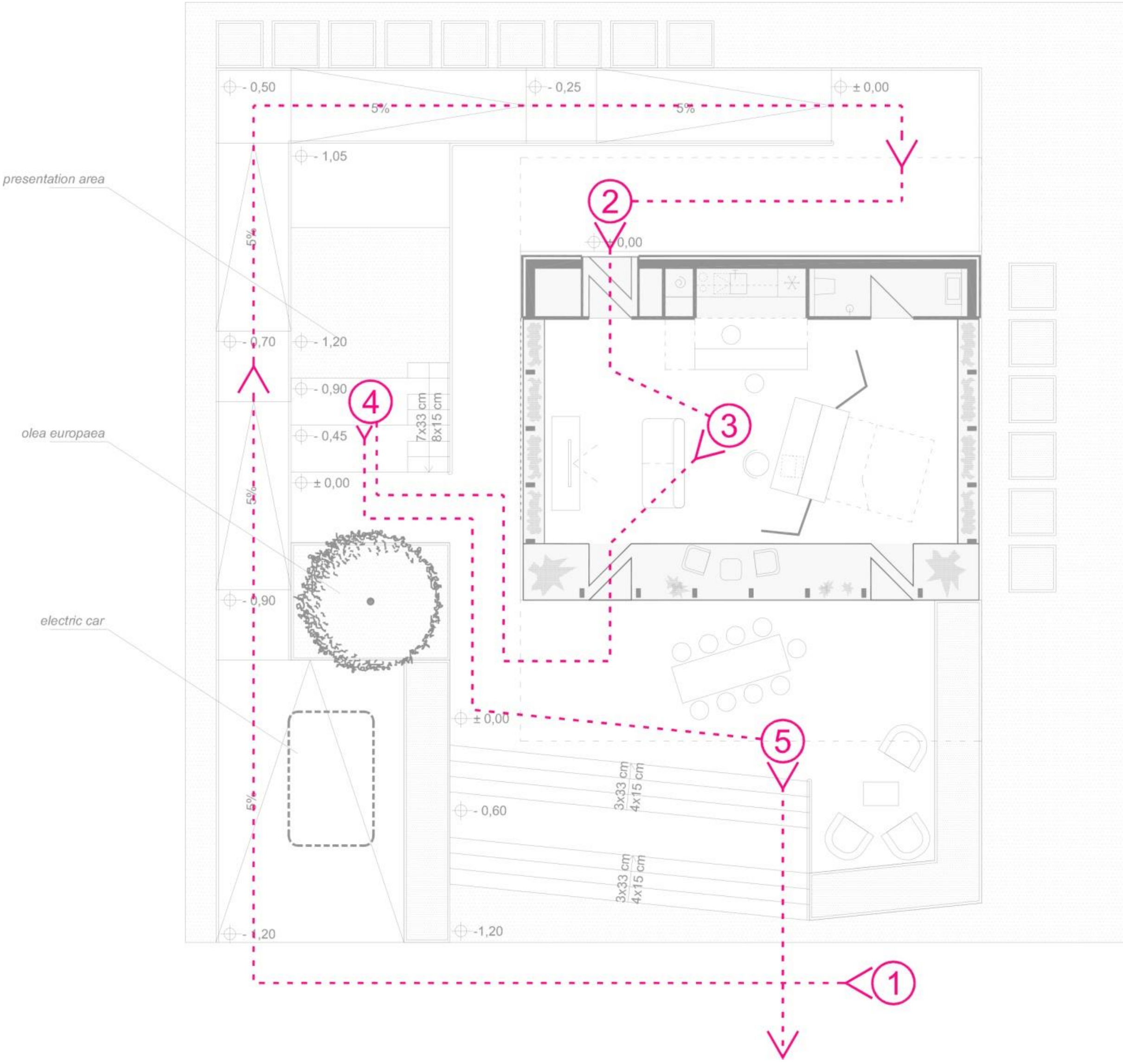


Figure 252 - Public tour description

Public tour of house consists of four spots placed all across the site as presented in the figure above. Each spot, lasting five minutes, explains specific part of unique project, starting with the one in front of the building on Pedestrian Street. To all interested spectators, in optimal sized group of eight people, during 20 minutes long tour, will be presented most important elements and facts, explaining the basic Mem**brain** concept. This organized, eight people groups, at regular intervals, every ten minutes, start their individual tours. By this calculation, the Mem**brain** concept will be shown to approximately fifty people during one hour.

Professionally skilled UNIZG Team members, tour guides, after starting first stop and most memorable and valuable facts, then, lead moving group over west ramps to north designed terrace.

Spot number two gives additional information about components of intelligent membrane, where all technical elements are installed for house function.

The third part of house public tour takes place in its heart, inside of the Membrain concept, at the living space area, explaining modularity and simplicity and nucleus interior space design connected with nature survival configuration of this living sustainable cell principle.

After approximately five minutes, tour moves toward southern entrance terrace and takes place at presentation area in the south. All groups will be informed about bioclimatic function of the Membrain house and its elements adaptability, depending of outside microclimate characters of each unique site, where this modular building can be placed. With this short and last demonstration, public tour ends.

After learning about our house visitors will reach spot number five where they can ask our team members more questions about our project, small talk and network. We will be glad to answer and explain all details and questions our visitors may have in more of informal environment.

5.7.4 Visual Identity Manual

Official name of the team is UNIZG Team, and the name of the project is the Mem**brain** concept.

Several subtle changes have recently been made to the team visual identity. The currently used team logo and the Mem**brain** logo are presented below.

The team logo displays the main characteristic of our university, as well as of our team – multidisciplinary, which is represented using diamond shaped objects. Six of them are placed in order to form a circle, which indicates a compact unit made up of various different parts – just as our University consists of 29 faculties and 4 academies. The sharpest ends of the objects are directed at the center of the circle, indicating a common goal. Our team consists of more than 70 students from 13 different faculties and we all share a common goal: to come up with the best possible solution for future living.

Selected colors represent youth, sustainability and energy efficiency, which are also characteristics of our project and team members. We all are young and ambitious people with a strong sense of environmental problems. In the current version, the colors have been slightly changed to enhance the visual harmony of the logo.

Presented below are the different versions of the team logo according to SDE rules. Vector formats are also included in the deliverable.

Figure 253 - UNIZGteam logo

Colors:
- C: 0% M: 0% Y: 0% K: 100%
- C: 30% M: 0% Y: 100% K: 0%
- C: 50% M: 0% Y: 100% K: 0%
- C: 77% M: 0% Y: 100% K: 0%
- C: 89% M: 28% Y: 100% K: 16%
- C: 93% M: 52% Y: 90% K: 25%
- C: 100% M: 0% Y: 26% K: 67%

Fonts:
team UNI - Lato regular
ZG - Lato bold

Figure 254 - Colors and fonts used in the team logo

Figure 255 - Team logo combined with the SDE logo

U suradnji
In colaboration with

Ured predsjednika RH
Ministry of Economy
FOND ZA ZAŠTITU OKOLIŠA I ENERGETSKU UČINKOVITOST

Partneri
Partners

Partner suradnik
Collaborating partner

Suradnici
Collaborators

Figure 256 - Team logo combined with the team's supporting institutions and sponsors

Figure 257 - Team logo in grayscale

Figure 258 - Team logo in black color

The Mem**brain** concept is a sustainable project and so is its visual identity. The goal is to represent our vision of sustainability and at the same time incorporate the elements of the visual identity of the country we come from. The house logo has been designed in a way that the name of the house is immediately visible to viewers, who get the overall image at the second glance – the combination of solar panels and red cubes that represent Croatia.

We want to establish the young, smart and innovative personality and we will attract the public who recognize the projects potential, as well as disseminate the message of sustainability and energy efficiency.

Figure 259 - The Mem**brain** logo

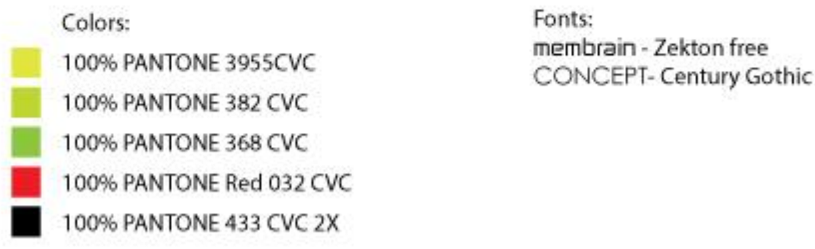


Figure 260 - Colors and fonts used in the Mem**brain** logo

The Mem**brain** logo itself is shown as an intersection of the house, with the roof in three colors which represents the accordion shape that has been used in roof development and design. These three colors, from bright yellow to green, describe the process of heating and cooling, more precisely they indicate the process of heating during the winter and prevention of overheating during the summer.

The line around the text "Mem**brain**" indicates the profile of the house, which is connected with the roof and displays the house intersection. The yellow and green colored elements linked together represent the three elements collecting energy: openings (house intersection), walls and ceiling.

Color and roof layout are turned to the sun, from the top to the bottom, where the hottest color yellow in two steps becomes the coolest color green, the color that represents comfortable living. The two red squares are reminiscent of the chessboard, which is one of the national symbols of Croatia. Apart from that, from the technical side they also represent two concepts linked within the house - energy efficiency and sustainability.

CONCEPT indicates the project of house development according to the defined concept of all project elements:

- Green – represents nature, symbolizes growth and safety
- Red – represents Croatian national color, symbolizes braveness, energy, strength and determination
- Black – represents strength, elegance and success

As a part of the visual identity, team uniforms will be made of bio cotton. The print on the t-shirt was designed with the intention of combining the elements of the projects visual identity with Croatian national symbols. The whole design will be printed in white. The front side of the shirt will contain the team logo and SDE logos. The only additional element is three curved lines at the bottom of the t-shirt, which are meant to evoke the graphic element of the Mem**brain** logo, progressively disintegrating into squares that represent Croatia. The back side of the t-shirt will contain the Mem**brain** logo at the very top and all of the team's supporting institutions and sponsors' logos.

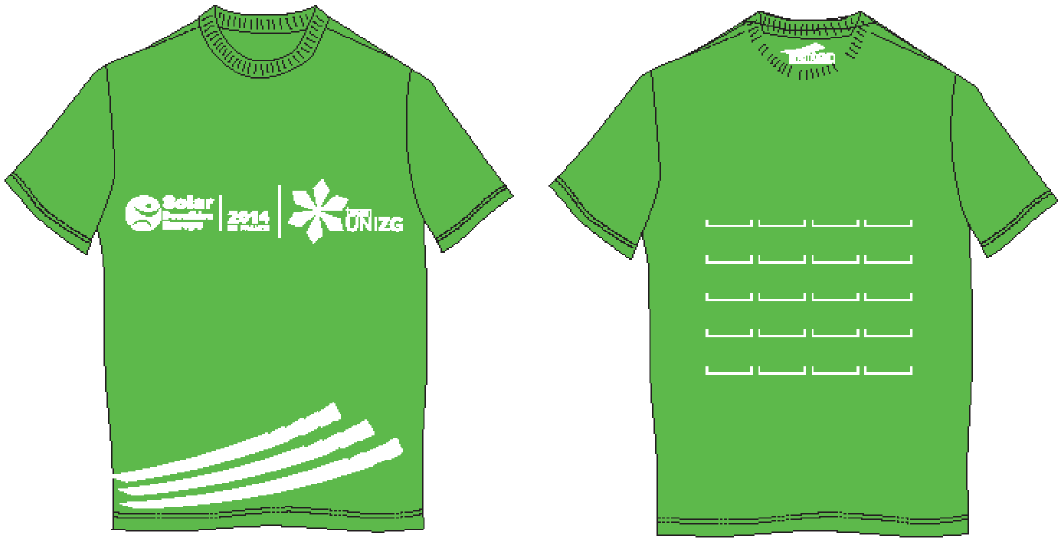


Figure 261 - T-shirt design, the front and the back view

5.7.5 Sponsorship Manual

Aware that without sponsors our project would never reach the assembly phase, we dedicated a lot of time to prepare the sponsorship proposal and the sponsorship package document.

We approach potential sponsors in two ways. The first one is sending an email to the company which includes a short description of the project and a proposal for a meeting. More detailed information about project and sponsorship proposal is attached. The second approach to the potential sponsor is personal networking on various occasions such as meetings, conferences etc. It is important to emphasize that a personal recommendation from someone in this type of situations is much appreciated. With the dissemination of the project and our presence in the public it is expected that potential sponsors will reach out to contact us regarding sponsorship conditions. This new way of raising sponsorship is expected from the end of the 1st quarter of 2014. Considering our position as one of the seven teams selected in the complementary list is still a major obstacle when it comes to signing the sponsorship contract with private companies. This is why we mostly have to rely on national institutions that require complex administration and a lot of time and effort. Despite that, every member of the Team puts a lot of effort and time into this project so that its realization would not be jeopardized.

Despite the fact that we are one of the complementary teams, we are present on various web, news portals and local TV shows and recognized as a promising project. As a result we have signed several new contracts which will be presented in this document.

Our focus in the following months will be finding general partners. In this category we aim for banks and big national companies.

In this period we are going to use two different strategies in seeking sponsorships:

- "Shotgun" strategy for donors
- "Sniper" strategy for sponsors, which is more precise

We have selected two strategies based on the following criteria: exclusively financial ability of companies (in the shotgun strategy) and in the tight resemblance of goals or interests between company and the project (in the sniper strategy).

We decided to approach companies by e-mail. This approach is a little different than the one we have used so far, but we wanted to test this possibility. Today business people receive much more e-mails than standard mail and by doing so we wanted to attract more attention.

The content of mail in the first case is a request for a donation and a project brochure. The second group consists of selected companies to which we send personalized brochures. A personalized brochure contains a request for sponsorship, a short description of the project, opportunities specially designed for each sponsor, press clippings and the proposed amount with a detailed brochure of the project.

The recipients of the mails are general managers of companies or marketing departments.

5.7.5.1 Sponsorship proposal

The search for sponsors and partners is a very tedious process. It consists of several steps that we have established based on the recommendation of the sales representative of the companies we work with. We have primarily divided them into three basic categories of companies we want to convince to be our partners:

- material sponsors of the house
- financial sponsors
- government enterprises and institutions

We had a different approach to each of these groups. For the first group, we proceeded according to the recommendations of professors and experts with whom we have collaborated on the development of the house. We have worked with the majority of them from the very beginning because we wanted to set the foundations for the development of specific systems, but also offer the market new and innovative solutions. Besides the recommendations of professors, we approach them on various professional conferences and meetings, where we presented the Solar Decathlon competition and our work. In most cases companies were enthusiastic about the concept and the results, so with them we had no problem closing the financial structure.

We had to work harder to get financial sponsors and prove them what will they get in return for their sponsorship. We primarily targeted the increasing corporate social responsibility. We would like to accomplish stronger media publicity for them as our partners. We continue to search for financial resources to be able to promote the competition and our project.

Government enterprises, the City of Zagreb and government institutions financially support the realization of this project. We applied for different tenders and due to the fact that this is the largest student project in the Republic of Croatia, we received direct funding of the project. Towards them, we went through of the Rector and the Vice-Rector of the University of Zagreb and their canals.

Sponsorship proposal was based on our marketing plan described in the chapter “Actions Description”. Every sponsorship proposal was and will be personalized for each potential sponsor. The general content of the proposal is translated below and was changed from Deliverable#3.

Sponsorship proposal or Proposal for cooperation was sent according to the company profile:

PROPOSAL FOR COOPERATION

Dear Mr. /Mrs.

Further in this letter is briefly presented the possibility of cooperation between your company and the University of Zagreb as a part of the Solar Decathlon Europe 2014.

The SDE 2014 UNIZG Team is devoted to conceiving, planning and implementing all activities for the participation in the Solar Decathlon Europe 2014 competition. Apart from participating in the competition, our goal is to raise public awareness about the necessity of using renewable energy sources and sustainable development. Our work is guided by joint efforts to find practical solutions for problems and needs we are faced with.

The strategic guidelines of the University of Zagreb's Team include:

- *openness towards all energy, architectural, engineering and construction solutions*
- *creating a stimulating environment for interdisciplinary work and development of every team member*

- *active participation in all aspects of the project environment and the creation of strong ties with the economy, academic community and wider public*

Project values are recognized by many government institutions and private companies:

President of Croatia, Ministry of Economy, Ministry of Construction and Physical Planning, Environmental Protection and Energy Efficiency Fund, HEP, Koncar - Electrical Engineering Institute, Detas Croatia and many others.

Involvement in the project has multiple benefits for the company:

- *through various marketing activities of the project strengthen the company brand in systems for sustainable construction*
- *international publicity - the exhibition in Versailles will visit in two weeks about 350,000 visitors*
- *work with young engineers from different professions and teaching them about your products*
- *further cooperation at the largest university project – Campus Borongaj*

I believe that your company, as one of the leading companies in the field of __________, will recognize the value of our project. We also believe that due to the fact the company develops systems which are environmentally friendly, we can collaborate on a project, Solar Decathlon Europe, but also on a much larger project Borongaj Campus.

Yours sincerely,

5.7.5.2 Sponsorship packages

Besides from the usual space reserved for partners in the promo materials throughout the project, our partners will also have the possibility to advertise them after the competition. As mentioned, our house will be exposed on the Borongaj University Campus and we are offering our sponsors the chance to be a part of the project. In other words, depending on the level of their partnership stake, they will have different possibilities to use the house as an info center and to promote their activities in agreement with our team and University of Zagreb.

Sponsors will be attracted through different actions that we are planning to conduct and a number of advertising possibilities that we will create. Below is the list of sponsorship packages with items for each category. These are also guidelines that are and will be used in negotiations and designing a sponsorship contract.

Table 71 - Sponsorship packages

	Sponsorship amount	General partner	Main partner 150.000,00 kn	Partner-Collaborator 75.000,00 kn	Partner 35.000,00 kn	Collaborator 10.000,00 kn
Membrain house	**Name of a part of the house**	+				
	Opening ceremony	+				
	Tour in Versailles	+				
	Model of the house	+ / mj 1:20	+ / mj 1:100	+ / mj 1:100	+ / mj 1:200	
	Use of house after competition	+ / + 2 days a week	+ / + 1 days a week	+ / + 1 days in 2 weeks	+ / + 1 days a month	
	Press conference and presentations	+	+	+	+	+
	Logo in presentation	+	+	+	+	+
	Press conference	+	+			
	***Banner / Rollup* in the house**	+	+	+	+	
Promo materials	**Logo in promo materials***	+	+	+	+	+
	A7	+	+	+	+	+
	A5	+ / + promo article	+ / + promo article	+	+	+
	A0	+	+	+	+	+
	Billboard	+	+	+	+	
	Citylight	+	+	+		
	ZET bus / tram	+	+	+		
	With every appearance of team	+	+	+		
	** Area in promo materials*	*max. 155,93 cm² (1/4 A4)*	*max 62,37 cm² (1/10 A4)*	*max 41,58 cm² (1/15 A4)*	*max 31,19 cm² (1/20 A4)*	*max 10,40 cm² (1/60 A4)*
	Video					
	For SDE competition	+	+	+	+	+
	For promo activities	+	+	+	+	
	Advertisement	+ / 15 sec	+ / 5 sec			
Web promotion	**Logo on official web page**					
	Static	+				
	Dinamic		+	+	+	+
	Social networks					
	Logo	+	+	+	+	+
	Promo article	+	+	+	+	+
	2x week	+				
	1x week		+			
	1x month			+	+	
	2x in duration of competition					+
Additional benefits	**Right of priority ****	+	+			
	*** The right of priority right among partners from the same field of expertise.*					
	Banquet with general sponsor	+	+	+		

	Media promotion of partners products ***	+	+	+		
	****Publication of an article in the media about a product used in the construction of houses. The would describe the product(s), their specifications, advantages and the method of implementation in the house.*					
	Promotion of company with use of the Membrain name or visual identity	+	+	+	+	
	Partners' lecture at universities					
	Sharing company's promotional materials	+	+			
	Bannera / Rollupa	+	+	+	+	
	Presentation 10 min	+				
	Presentation 45 min	+	+	+	+	
	Fair ****	+	+	+ / registration fee	+ / registration fee	+ / registration fee
	*****Details of the fair, the size of space, the venue of fair, ways of promotion shall be determined by an additional agreement.*					
	Duration of contract *****	+ / until completion of project with annex to fulfillment of certain items	+ / until completion of project with annex to fulfillment of certain items	+ / until completion of project with annex to fulfillment of certain items	+ / until completion of project with annex to fulfillment of certain items	+ / until completion of project with annex to fulfillment of certain items

5.7.5.3 Supporting institutions and companies' tracking

The project is already supported by the companies and institutions listed in the table below.

Table 72 - Sponsors and partners

	Name	Field of Work	Type of collaboration	Contact	Team member in charge
Partners					
1	University of Zagreb	University	Technical support, printing of promotional materials, transport and accommodation costs for deliverables	Prof. PhD. Bojan Baletić – Rector for Development and Regional planning Trg maršala Tita 14, 10000 Zagreb bbaletic@unizg.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
2	Faculty of Electrical Engineering and Computing	Faculty	Working area, laboratories, technical support, working equipment	Prof. PhD. Hrvoje Džapo Unska 3, 10000 Zagreb hrvoje.dzapo@fer.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
3	Faculty of Civil Engineering	Faculty	Technical support, working equipment, laboratories	Prof. PhD. Ivana Banjad Pečur Andrije Kaćića Miošića 26, 10000 Zagreb banjadi@grad.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr

4	Faculty of Architecture	Faculty	Technical support, working equipment, laboratories	Prof. PhD. Mladen Jošić Andrije Kačića Miošića 26, 10000 Zagreb, mjosic@arhitekt.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
5	Faculty of Economics and Business	Faculty	Technical and financial support	Assist. prof. PhD. Vatroslav Škare J.F. Kennedy Square 6, 10000 Zagreb vskare@efzg.hr	Filip Gašpar +385 95 5154 578 fillip.gaspar@membrain.com.hr
6	Faculty of Mechanical Engineering and Naval Architecture	Faculty	Working area, laboratories, technical support, working equipment	Prof. PhD. Vladimir Soldo Ivana Lučića 5, 10000 Zagreb vladimir.soldo@fsb.hr	Marko Mandić +385 91 568 3555 marko.mandic@membrain.com.hr
7	Faculty of Forestry	Faculty	Laboratories, technical support, working equipment, wood material	Prof. PhD. Alan Antonović Svetošimunska 25, 10000 Zagreb alan.antonovic@zg.htnet.hr	Stipo Dubravac +385 91 568 3555 marko.mandic@membrain.com.hr
8	Office of the President of the	President	Reference	Mr. Milodrag Pralas – Head of the Department technical and support activities,	Ivan Ivić

	Republic of Croatia			Pantovčak 241, 10000 Zagreb milodrag.pralas@predsjednik.hr	+385 91 3862 653 ivan.ivic@membrain.com.hr
9	City of Zagreb	City of Zagreb	Financial sponsor, fees	Mr. Marijan Maras - Head of the Department of Energy, Environment and Sustainable Development Trg Stjepana Radića 1, 10 000 Zagreb marijan.maras@zagreb.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
10	Environmental and energy efficiency Fund	Institution for providing additional funding for projects, programs and similar activities in the field of preservation, sustainable use, protection and improvement of environment	Intention to provide certain amount of financial funds	Sven Müller, director Ksaver 208, 10000 Zagreb direktor@fzoeu.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
11	Ministry of Economy	Institution for development and improvement of the	Technical, administrative and financial support	Mrs. Kristina Čelić – Head of the Department for Strategic Planning and Energy	Ivan Ivić

		competitiveness of the Croatian economy, instruments and economic policies		Ulica grada Vukovara 78, 10000 Zagreb kristina.celic@mingo.hr	+385 91 3862 653 ivan.ivic@membrain.com.hr
Sponsors					
12	Detas	LED lighting	Material sponsor of LED lighting, financial sponsor	Mr. Matija Bartoš - Sales manager East and Central region, Matije Gupca 114, 34550 Pakrac mbartos@detas.com	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
13	Tportal	One of the leading web portals in Croatia	Media sponsor	Mrs. Željka Kolak – Sector for developing and managing of content, Savska cesta 32, 10000 Zagreb zeljka.kolak@t-com.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
14	Geberit	Manufacturer and supplier of sanitary parts and related systems	Material sponsor	Mr. Vladimir Kukina - Technical Support & Projects Kutnjacki put 11, 10110 Zagreb vladimir.kukina@geberit.com	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr

15	Schrack Technik	Products for power engineering, building and emergency lighting	Material and financial sponsor	Mr. Josip Zdenković – Director Zavrtnica 17, 10000 Zagreb josip.zdenkovic@schrack.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
16	Dalmacijaklima	Manufacturer of heat pumps	Material sponsor	Mr. Mladen Vučemilo – Director Put Sv. Ižidora 40, 21000 Split mladen.vucemilo@dalmacija-klima.com	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
17	Adriatic Zagreb	Factoring company	Material sponsor	Mr. Mate Marić – CEO Josipa Marohnića 1, 10000 Zagreb mate.maric@azfactoring.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
18	Energetika marketing	One of the leading web portals and professional journal in Croatia dealing with energy topics	Media sponsor	Mr. Boris Labudović - Executive editor Sokolska 25, 10000 Zagreb boris.labudovic@ege.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
19	Klimaoprema	Leading Croatian manufacturer of equipment for ventilation, air-	Financial sponsor	Mr. Branko Duvnjak – Director Gradna 78A, 10439 Samobor bduvnjak@klimaoprema.hr	Ivo Krezić +385 95 802 9062 ivo.krezic@membrain.com.hr

		conditioning and cleanrooms			
20	Systemair	Leading manufacturer of ventilation products	Material and financial sponsor	Mr. Tomislav Kovačević – Sales and Application Engineer Svetonedjeljka 62b, 10431 Sveta Nedjelja tomislav.kovacevic@systemair.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
21	Citroën Savska	Official Citroën dealer	Material sponsor	Mr. Nikola Mustapić, Financial Director Savska cesta 41, 10000 Zagreb nikola.mustapic@citroen.com	Ivo Krezić +385 95 802 9062 ivo.krezic@membrain.com.hr
22	Drvene Konstrukcije	One of leading manufacturer of laminated timber	Material sponsor	Mr. Mario Abramović Josipa Martinca bb, 33522 Voćin info@drvene-konstrukcije.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
23	Soven	Sheep wool manufacturer	Material sponsor	Mrs. Marija Srblin Mariborska cesta 48 2352 Selnica ob Dravi, SLO soven@siol.net	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
24	Gorica Staklo	Glass manufacturer	Material sponsor	Mr. Vinko Huzjak	Ivan Ivić

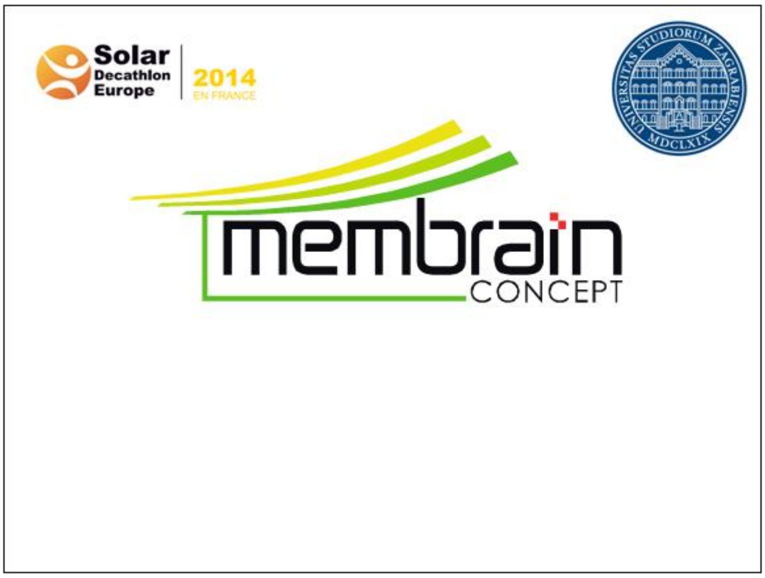
				Sisačka 43, 10410 Velika Gorica vinko@goricastaklo.hr	+385 91 3862 653 ivan.ivic@membrain.com.hr
25	FEAL	Aluminum systems manufacturer	Material sponsor	Mr. Damir Šimunović, director Rudeška cesta 3a 10000 Zagreb damir.simunovic@feal.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr
26	Bramgrad	Civil engineering company	Material sponsor and technical support	Mr. Branko Mihaljević, director Vučak 28 10000 Zagreb uprava@bramgrad.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
27	Ljekarna Mihaljević	Pharmacy	Material sponsor	Mrs. Iva Mihaljević Samoborska cesta 65 10000 Zagreb info@ljekarna-mihaljević.hr	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr
28	ByteLab	Electronic and embedded systems	Material sponsor and technical support	Mr. Matija Puškar Dragutina Golika 63 10000 Zagreb puskar@byte-lab.com	Hrvoje Nikola Vučemilo, +385 98 438 183 hrvoje.vucemilo@membrain.com.hr

29	Fragmat	Wood wool manufacturer	Material sponsor	Mr. Željko Mioković Donja Pačetina 1a, 49223 Sveti Križ Začretje zeljko.miokovic@fragmat.hr	Ivan Ivić +385 91 3862 653 ivan.ivic@membrain.com.hr

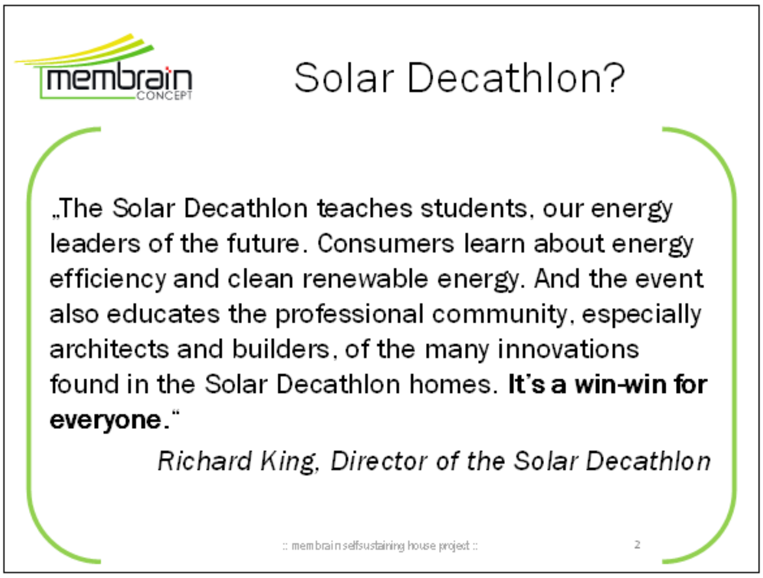
5.7.5.4 Presentations used to raise sponsorships

The presentation helped us to appear in a more professional way and for a better visualization. The estimated duration of the presentation is around 15 minutes. In that short period of time we want the potential sponsor/partner to get general information about the competition, our project and goals, as well as to see their own benefits in sponsoring the project. As planed in Deliverable #2 this presentation was also held on various conferences, containing more technical details.

Translated slides of the presentation are shown below, including comments for each one of them. Compared to Deliverable #2, our presentation is visually and contextually changed and now contains more relevant information.



Comment for slide No. 1 – In most cases the presentation was held by the Project Manager, the Student Team Leader, the Sponsorship Manager or members of the Fundraising Team. If needed, other members of the team were present. Since this approach has proved to be efficient, it will also be used in future presentations.

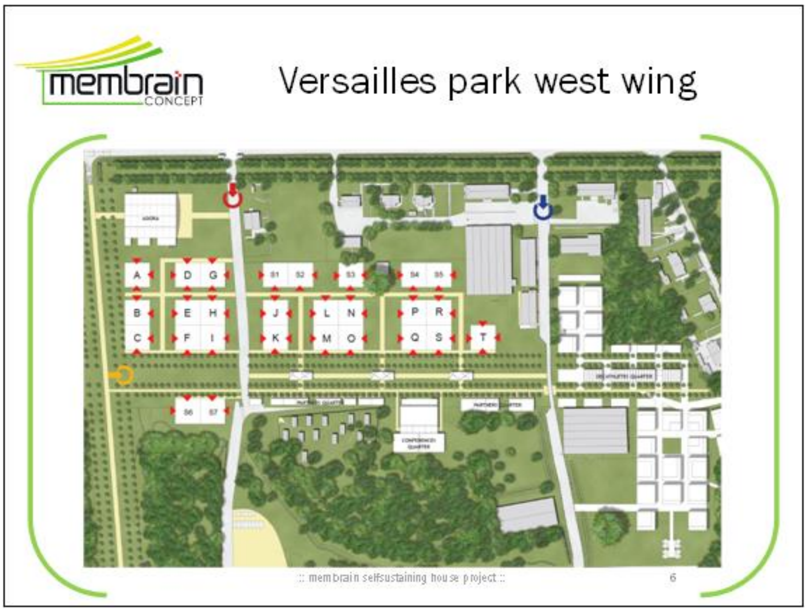


Comment for slide No. 2 – Introduction with definition of Solar Decathlon competition by Richard King.

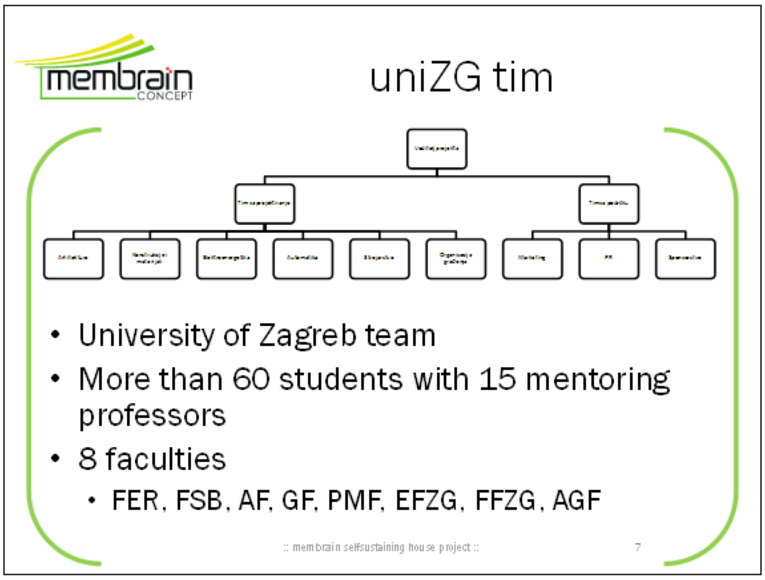
Comment for slide No.3 – Short description of SDE, goals of competition, history; several facts about SDE2012 and SDE2014.

Comment for slide No. 4 – Various examples of houses from the last competition.

Comment for slide No. 5 – Geographical and climate diversity of the competition is presented, which leads to the conclusion that the idea of the competition goes beyond the mere comparison of performance facilities. It is difficult or impossible to compare, e.g. passive systems, designed for a variety of weather conditions. It is more important to raise awareness about sustainable lifestyle, learn about other cultures and about green building in various climates.

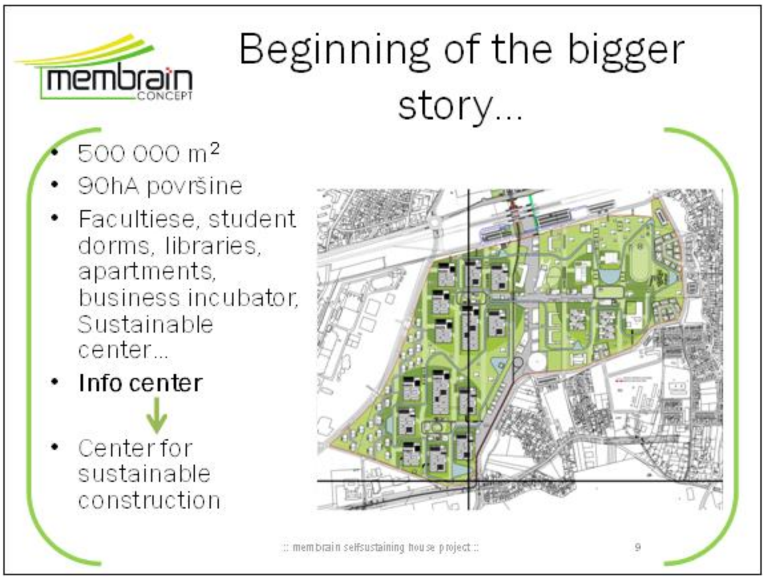


Comment for slide No. 6 – Position of objects in the competition.

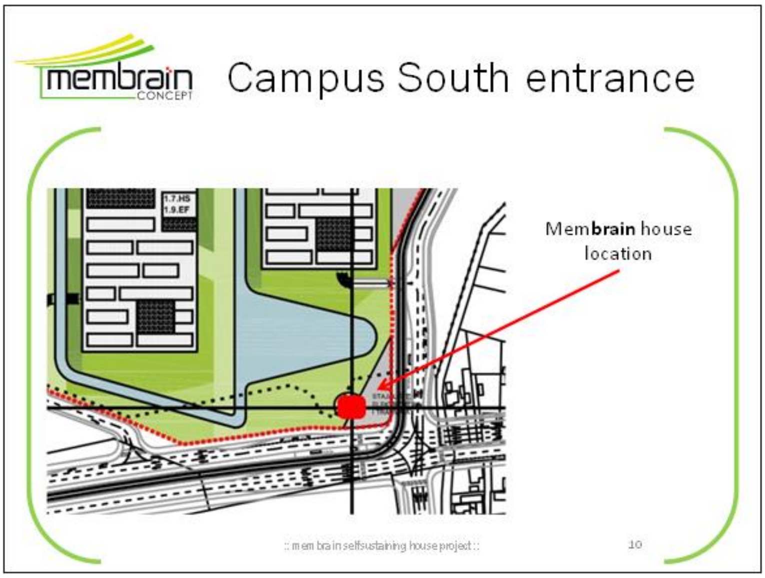


Comment for slide No. 7 – Presenting our team's organization and interdisciplinary

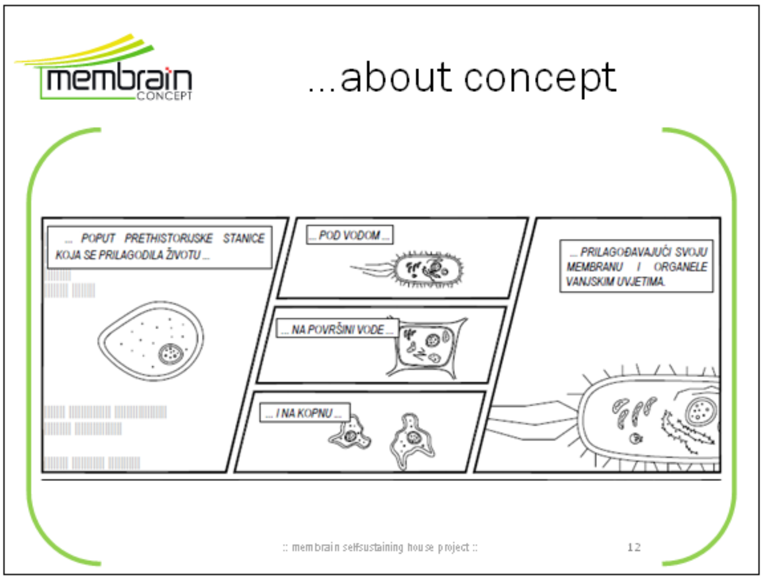
Comment for slide No. 8 – Several Team photos



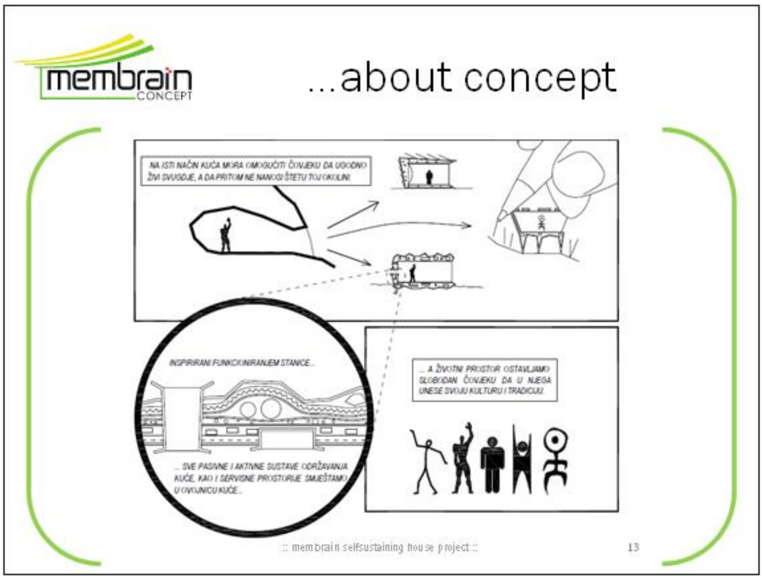
Comment for slide No. 9 – Presenting the large project of Campus Borongaj and our part in it, pointing out scientific, educational and commercial advantages of the house.



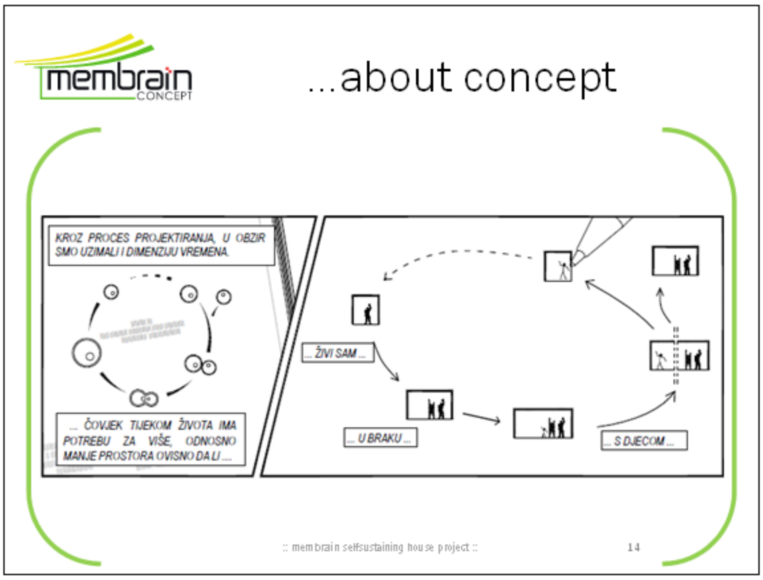
Comment for slide No. 10 – Presenting the large project of Campus Borongaj and the place where the house will be permanently located.



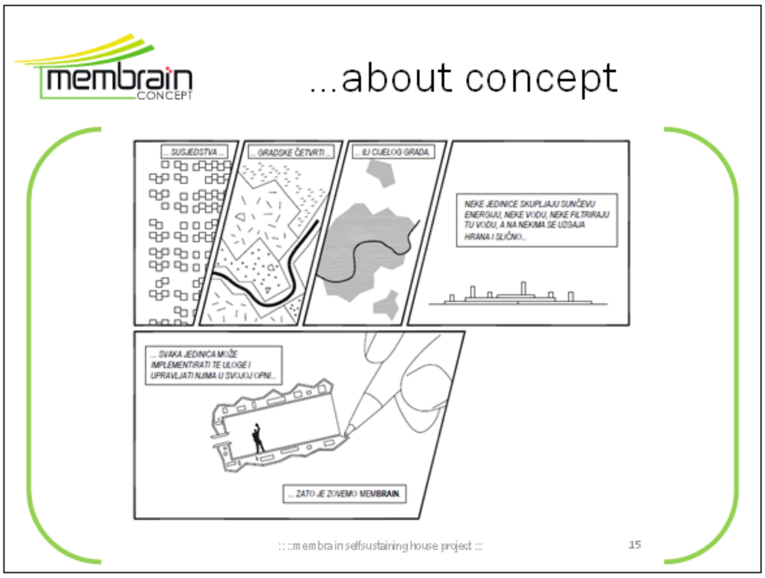
Comment for slide No.12 – Explaining our idea and concept of the house



Comment for slide No.13 – Explaining our idea and concept of the house



Comment for slide No.14 – Explaining our idea and concept of the house



Comment for slide No.15 – Explaining our idea and concept of the house

Comment for slide No.16 – Playing a short audiovisual presentation. Depending of the sponsor or the audience this part is replaced with more technical details of the house.

Comment for slide No.17 – Pointing out benefits for partners and sponsors (usually personalized benefits adjusted for each potential partner). If the presentation is held on a conference or a seminar, general benefits are mentioned.

Comment for slide No.18. - No matter what the outcome of the meeting will be, we always try to express our gratitude for the spectators’ time and patience.

6 DINNER PARTY MENU

Dinner party menu is to be developed later.

7 CONTEST WEEK TASKS’ PLANNING

Contest week tasks’ planning is to be developed later.

8 COST ESTIMATE AND PROJECT FINANCIAL SUMMARY

8.1 Business and Fund Raising Plan

There are several types of sponsors that could have a direct or indirect benefits from participating in the project like this. In the first place there are Croatian companies that have innovative products and systems of extreme quality that we can integrated into our project. With them, we are trying to achieve a partnership, and in cooperation with universities and institutes to develop new and innovative technical solutions. On the other hand, there are companies that have a social responsibility program and their participation in project like this can help to improve society perception of the company. These sponsors are included in this project as financial sponsors. In addition to private companies, different state institutions that have programs for supporting green and sustainable projects have already recognized importance of this prestigious competition. For each of these partners or sponsors we'd use special approach and presentation.

Our desire is to make the Croatian know-how of a project in which we can take advantage of the knowledge and capabilities of Croatian companies, academic and government institutions. Although the cost of this project is very high, especially in the current situation, Croatian companies have shown great interest for cooperation in this project. Material sponsors and partners who agree to develop a new product in cooperation with our team are of special interest to us.

Through consultation we try to reach a common solution that will fulfill our needs and can easily be integrated in our house. Besides this there are universities and their research laboratories working with us and trying to develop and optimize our house systems. We found our partners in a way that part of the team that is responsible for designing a specific system and who is familiar with the references of companies in this field suggests potential partners. Then sponsorship manager negotiate the terms of partnership and leaves further cooperation to the team that is responsible for the design of the system.

Negotiations with financial institutions and companies that are not directly related to the working area of the project, leads directly sponsorship manager. Those companies that don´t have direct connection with the project achieve their promotion through our Marketing Plan. As we dedicated great attention to the project promotion, and the project is unique in Croatia, there is a great interest of companies to sponsoring our project.

Our approach to potential sponsors is mainly divided in two ways.The first one refers to sending an email to the company which includes short description of the project and proposal for the meeting. Attached is more detailed information about project and sponsorship proposal. The second approach to potential sponsor refers to personal networking on various occasions such as meetings, conferences etc. It is important to stress out that personal recommendation from someone is in this type of situations appreciated. With the dissemination of the project material and our presence in the public it is expected that potential sponsors will reach to contact us regarding sponsorship conditions. This new way of raising sponsorship is expected from the end of 1st quarter of 2014.

Detailed information about Sponsorship Proposal and Sponsorship Packages can be found in Communication Plan.

8.2 Cost Proposal Form

Solar Decathlon Europe 2014 EN FRANCE		**SDE 2014 COMPETITION EN FRANCE**			
		Team's Abbreviations	UZG		
		School's Name	University of Zagreb		
		Team's Name	Team UniZG		
Nº	**Name**	**Description**	**Budget**		**% Total**
			ex VAT	**VAT**	**on ex VAT**
A. DEVELOPMENT PHASE_COST ESTIMATE					
A.1	**Personnel**				
	Professors & Researchers	200 h * 10 €/h * 15 professors	30000	7500	3%
	Granted Students	900 h * 4 €/h * 30 students	108000	27000	12%
	Consultants	30 * 70 €/h * 6 consultants	12600	3150	1%
	Accountant	40 * 10 €/h * 1 accountant	4000	1000	0%
	...				0%
		Personnel	**154.600,00 €**	**38.650,00 €**	17%
A.2	**Communication**				
	Architectural Models	5 architecture models for competition, presentation and partners	2500	625	0%
	Videos	7 videos for competition, presentation and partners	2100	525	0%
	Web Page (creation and maintenance)		1000	250	0%
	Communication documentation	broschures, bilboards, citylights, car designs and other documentations	97000	24250	11%
	Exhibitions during the development phase	exhibitions in mall, other universities and cities	7800	1950	1%
	...				0%
		Communication	**110.400,00 €**	**27.600,00 €**	12%
A.3	**First Workshop**				
	Travel & Transport	2 * 500 €/person	1000	250	0%
	Lodging	2 * 150 €/person	300	75	0%
	Expenses Allowance	2 * 140 €/person	280	70	0%
	...				0%
		First Workshop	**1.580,00 €**	**395,00 €**	0%
A.4	**Second Workshop**				
	Travel & Transport	5 * 100 €/person	500	125	0%
	Lodging	5 * 80 €/person	400	100	0%

	Expenses Allowance	5 * 150 €/person	750	187,5	0%
	Miscellaneous Expenses	5 * 40 €/person	200	50	0%
	…				0%
		Second Workshop	**1.850,00 €**	**462,50 €**	0%
A.5	**Administrative and miscellaneous**				
	Consumables and office supplies	paper, printer, office accessories, water, cleaning kit - 200 €/month for 9 months	1800	450	0%
	Administrative expenses	office rent, telephone, internet, gas - 400 €/month for 9 months	3600	900	0%
	Travel expenses for coordination with partners	300 €/months for 9 months	2700	675	0%
	…				0%
		Administrative and miscellaneous	**8.100,00 €**	**2.025,00 €**	1%
		Sub-Total_Development Phase Cost Estimate	**276.530,00 €**	**69.132,50 €**	31%
B. HOUSE CONSTRUCTION_COST ESTIMATE					
B.1	**Direct Materials**				
	Raw Materials		66750	16687,5	7%
	Purchased Materials & Parts		67500	16875	7%
	Purchased Services		12180	3045	1%
	Purchased Equipment		20350	5087,5	2%
	Interior equipment		20474	5118,5	2%
	…				0%
		Total Direct Materials	**187.254,00 €**	**46.813,50 €**	21%
B.2	**Material Overhead**				
	10%	% Estimated Rate * Total Direct Materials	18725,4	4681,35	2%
	…				0%
		Total Material Overhead	**205.979,40 €**	**51.494,85 €**	23%
B.3	**Direct Labor**				
	Professors & Researchers	100 h * 10 €/h * 15 professors	15000	3750	2%
	Granted Students	320 h * 4 €/h * 20 students	25600	6400	3%
	Laborers	300 * 6 €/h * 6 laborers	10800	2700	1%
	Administrative	40 * 10 €/h * 1 accountant	4000	1000	0%
	…				0%
		Total Direct Labor	**55.400,00 €**	**13.850,00 €**	6%
B.4	**Lower - Tier Subcontractors**				
	Subcontractors	subcontractors for special work packages	15000	3750	2%
	…				
		Total Lower - Tier Subcontractors	**15.000,00 €**	**3.750,00 €**	2%

B.5	**Consultants**				
	Supervisors	40 * 10 €/h * 4 supervisors	16000	4000	2%
	…				0%
		Total Consultants	**16.000,00 €**	**0,00 €**	2%
B.6	**Other Direct Costs**				
	General & Administrative Expenses	hall rent, telephone, internet, gas - 1100 €/month for 2 months	2200	550	0%
	Indirect Expenses	various indirect expenses	3000	750	0%
	Transportation	transportation from partners, from specialized shops, factories and etc. - 1000 €/month for 2 months	2000	500	
	Security	security officers and survillance system	9200	2300	1%
	…				0%
		Other Direct Costs	**16.400,00 €**	**4.100,00 €**	2%
		Sub-Total_House Construction Cost Estimate	**496.033,40 €**		#DIV/0!
C. HOUSE DISASSEMBLY IN ORIGIN AND TRANSPORTATION					
C.1	**Disassembly in origin**				
	Personnel	Students and laborers	1600	400	0%
	Material and equipment	Cranes, bonding material, etc.	3000	750	0%
	Other Expenses	Event for start of transportation	1000	250	0%
	….				0%
		Disassembly in origin	**5.600,00 €**	**1.400,00 €**	1%
C.2	**House Transportation**				
	Transport and transport Insurance		22400	5600	2%
	Other Expenses	tracking of the transport	1500	375	0%
	…				0%
		House Transportation	**23.900,00 €**	**5.975,00 €**	3%
		Sub-Total_House Disassembly in Origin Cost Estimate	**29.500,00 €**	**7.375,00 €**	3%
D. FINAL PHASE IN LE CITE DU SOLEIL:COST ESTIMATE					
D.1	**Travels & Costs for Final Phase in Paris**				
	Travel & Transport	40 * 300 €/person	12000	3000	1%
	Lodging	40 * 500 €/person	20000	5000	2%
	Expenses Allowance	40 * 450 €/person	18000	4500	2%
	Miscellaneous Expenses	40 * 450 €/person	18000	4500	2%
	…				0%
		Total Travels & Costs for Final Phase in Madrid	**68.000,00 €**	**17.000,00 €**	8%
D.2	**Assembly and Disassembly Processes**				
	Cranes		8000	2000	1%

	Equipment and machinery		4650	1162,5	1%
	Assembly in Le Cité du Soleil ©		4000	1000	0%
	Disassembly in Le Cité du Soleil ©		4000	1000	0%
	…				0%
		Total Assembly, Transport, Disassembly Processes	**20.650,00 €**	**5.162,50 €**	2%
D.3	**Insurance Policies**				
	Liability Insurance		6000	1500	1%
	Transport and Accident Insurance		2300	575	0%
	Medical Insurance		1600	400	0%
	…				0%
		Total Insurance Policies	**9.900,00 €**	**2.475,00 €**	1%
		Sub-Total_Final Phase in La Cité du Soleil® Cost Estimate	**98.550,00 €**	**24.637,50 €**	11%
E. POST EVENT COST ESTIMATE					
E.1	**House Permanent Assembly**				
	Personnel	TBD			0%
	Materials	TBD			0%
	Machinery and Equipment	TBD			0%
	…				0%
		Sob-Total House permanent Assembly	**0,00 €**	**0,00 €**	0%
E.2	**As built**				
	Professors & Researchers	TBD			0%
	Granted Students	TBD			0%
	Consumables and office supplies	TBD			0%
	Administrative expenses	TBD			0%
	…				
		As Built	**0,00 €**	**0,00 €**	0%
		Sub-Total_Post Event Cost Estimate	**0,00 €**	**0,00 €**	0%
		Total Price / Cost Estimated	**900.613,40 €**	**101.145,00 €**	**100 % Total**
Please CHECK (X) your status >>>		If you benefit VAT Recovering		-101.145,00 €	
	X	If you don't	101.145,00 €		
		Total Price / Cost Estimated included VAT	**1.001.758,40 €**	**900.613,40 €**	

9 SITE OPERATION REPORT

9.1 General Data

This Site Operations Plan complies with the rule 45 of the regulations for Solar Decathlon Europe 2014. Please note that according to the final data such as the lot selection, this site operation plan will change considerably. This Plan is in the initial stage of its development and does not contain all sections required by the regulations for Solar Decathlon Europe 2014.

Table 73 - General Data

Project Name	Mem**brain**
Project Developer	Team UNIZG
Faculty advisor	Mladen Jošić, prof.
Project Manager	Ivan Ivić, univ.bacc.ing.aedif.
Student Team Leader	Hrvoje Nikola Vučemilo
Site Operations Developer	Construction Management Team
Construction Management Team Members	Kristijan Jurić, mag.ing.aedif. (Team Leader)
	Viktor Pernjek, univ. bacc. ing. aedif.
	Velimir Šilec, univ. bacc. ing. aedif.
	Ivan Ivanov, univ. bacc. ing. aedif.
	Nino Kovačić, univ. bacc. ing. aedif.
	Sonja Kolarić, univ. bacc. ing. aedif.
Type of the construction work	Prefabricated housing
Place of the construction work	La Cité du Soleil®, Versailles, France

9.1.1 Precedents and aim

This Site Operations Plan has three main goals:

The first goal of the Site Operations Plan is to guarantee safety during logistics, assembly and disassembly of the Mem**brain** prototype. In order to do this, it will be basic to try to keep order, not only during the activities that will take place where the Mem**brain** prototype will be assembled, but also when assigning the different tasks according to the personnel's training.

The second goal is to assure the assembly of the Mem**brain** prototype is carried out in the least amount of time reserving a couple of days to test the prototype.

The third goal of this Site Operations plan is to anticipate all the machinery and personnel needed for the assembly and disassembly without any injuries. This goal answers to the recyclability of the prototype, designed to be disassembled in one site and assembled on another. All the component of the prototype will be order after its disassembly and reused on the following site, which will be in Zagreb, on the Borongaj University Campus.

9.1.2 Technical description

Idea of this house is to build a fully customizable, fully modular, self-sustainable house. For the Foundation system of the house, Team UNIZG will use patented CP-Anchor Piers. The CP Anchor Pier is a powder coated steel pier on a pressure treated plywood with ground spikes that penetrate 35 centimeters. Team UNIZG will use '10 inch piers' which have height adjustment from ground 30,5 cm to 43,0 cm.

House ceiling structure consists of five massive glued laminated timber segments, covered with prefabricated insulation above and PCM suspended ceiling below. Bearing system of the floor structure is identical as the ceiling structure, except PCM below. The dimensions of the elements are 240/720cm for middle segments, and 120/720cm for lateral segments. Vertical loads are carried from the ceiling to the glued laminated wooden columns built along the perimeter of the house. This columns are 3,0 meters high, and the cross section area is a rectangle, 12/20 cm. Shear walls are located on the north facade of the house. Their dimensions are 110/300 cm, and they will be assembled on the columns and the floor and ceiling slab. Shear walls are also made of glued laminated timber, and their thickness is d = 6 cm. Whole northern facade will be walled, with openings for doors and windows. Inside of the Mem**brain** on the northern side, partition walls are also glued laminated and located in kitchen and bathroom. On the southern, eastern and western side, inside walls and facade will be made of double and triple glazing panels. Dimensions of facade glass panels will be 120/333 cm. Dimensions of inside glass panels will be 120/300 cm. Thermal and acoustic insulation and waterproofing will be integrated in insulation boards. Dimension of vertical insulation board are 120/340 cm, while dimensions for horizontal insulation boards are 240/720 cm.

PV Harmonic will consist from aluminium rails, aluminium structure and 6 PV panels. Final dimensions of the elements will be designated in the next deliverable. For heating and cooling under floor, heating and cooling systems will be used. Final floor covering will be made from wood (parquet) and ceramic.

Decking around the house will be made from wooden covering elements and polypropylene Buzon screw-jack pedestal elements which can be adjusted to compensate the slope. Terrace fence will be made of wooden elements.

9.1.3 Time schedule

The time schedules we have are defined in the manner to fit into the competition´s calendar, and are as follows:

- • max. 10 days for the prototype's assembly.
- • 20 days for maintenance and testing (competition).
- • max 5 days for disassembly.

We will use this defined time schedules as input data for the development of operational schedule.

The Schedule for the transportation to the competition's site is logically not indicated by the competition, because they depend on the distance from the origin to the site.

9.1.4 Staff

The team that will work in Villa Solar during the unloading phase, assembly and disassembly phase will be composed of:

1. Build operators and technicians
2. Workers
3. Site Operations Team Coordinators
4. Health and Safety Team Coordinators
5. Researchers

<u>Build operators and technicians</u>

TASKS: Transport of the elements from Zagreb to Versailles, transport on the construction site and machinery management.

ORGANIZATION: Staff for transport and machinery management will be selected by Team UNIZG. They will stay on the construction site only in time required for transporting all of the house elements to the Operations Area and in the disassembly phase to transport the elements from Versailles to Zagreb. Staff which will manage the crane and forklift will stay on the constructing site depending on the progress of construction, and according to the plan that will be created by Team UNIZG.

<u>Workers</u>

TASKS: assembly and disassembly of the object, help with unloading the house elements from trucks to the lot, taking photographs and storing the information about the process of assembling and disassembling the object.

ORGANIZATION: Workers that form the Site Operation Team will be divided into 2 working sub teams. Workers will be present on the site the whole time during the assembly and disassembly of the house.

<u>Site Operations Team Coordinators</u>

TASKS: Monitoring and control of assembly and disassembly of the house in terms of accuracy and quality of construction. Monitoring, control, and ensuring that all construction processes are carried out in a safety environment by all means.

ORGANIZATION: There will be two Site Operations coordinators. Both will work in a coordinated manner, in order to have at least one of them present in all assembly and disassembly phases.

<u>Health and Safety Team coordinator</u>

TASKS: The HS Team Coordinator will be responsible for solving any kind of risks associated to assembly and disassembly of the object.

ORGANIZATION: There will be two Health and Safety Team coordinators, each of them will be responsible for its sub-team.

Researches

TASKS: Supervising the all components of Membrain prototype that they have researched and developed.

ORGANIZATION: Researches will be present at the construction phases as some component related to them will be finished.

9.2 Site Operation Teams

The Site Operations Team will be in charge of operations derived from transportation, assembly and disassembly of the Mem**brain** prototype in the site La Cité du Soleil® located in Versailles.

This team is made up of:

- 2 Site Operations coordinators, one for each sub-team of workers.
- 2 Site Operations teams, each group counts 12 workers.

9.2.1 Site Operations Coordinators

The Team UNIZG site operation coordinators are:

1. Velimir Šilec, bacc. ing. aedif.

tel: +385989517051

e-mail: velimir.silec@membrain.com.hr

2. Viktor Pernjek, bacc. ing. aedif.

tel: +958855454

e-mail: pernjek@gmail.com

9.2.2 Site Operations sub-team

Names of workers will be defined in deliverable #5.

Working Team A:

Table 74 - Members of Working Team A

Name	Last name	Charge/Position	ID number	Date of birth
Velimir	Šilec	Site Operations Coordinator		
Matej	Mihić	Health and Safety Coordinator		
		Electrician		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		

		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		

Working Team B:

Table 75 - Members of Working Team B

Name	Last name	Charge/Position	ID number	Date of birth
Viktor	Pernjek	Site Operations Coordinator		
Ivan	Ivanov	Health and Safety Coordinator		
		Electrician		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		

9.3 Logistic outside of LaCité du Soleil®

9.3.1 TRUCKS ROUTE

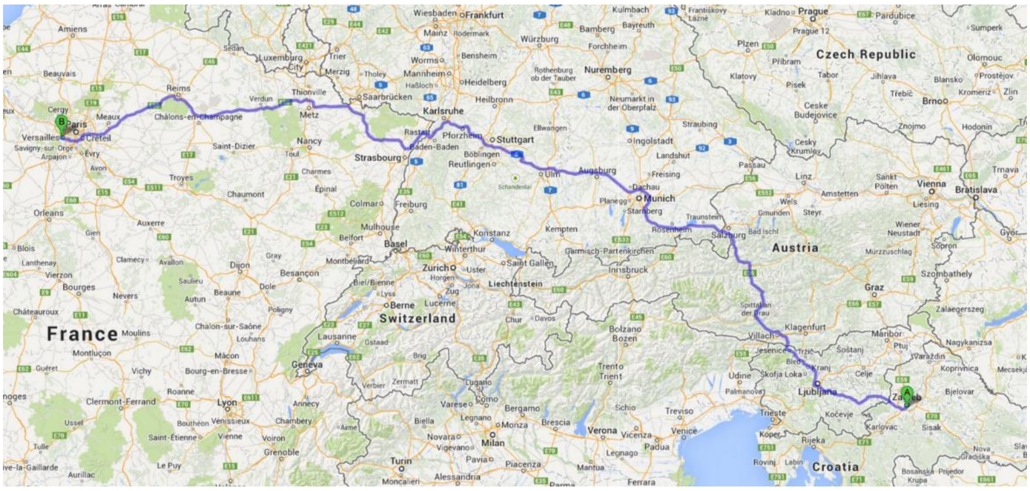


Figure 262 - Trucks route from Zagreb to Versailles

The distance between Zagreb and Paris is approximately 1450 km, and will be covered in two days.

The route will be:

Zagreb – München – Stuttgart – Paris

The components transportation will be carried out by road with trucks. The width and height limitation from the roads and bridges present along the journey does not affect the transportation of the prototype. Detailed truck route is shown in Project Drawings: SO-001

9.3.2 TRUCKS SPECIFICATIONS AND SHIPMENTS

For transportation needs we will use a total of 10 trucks. Trucks will be 5-axle tractor semi-trailers with total dimensions 2,50 x 4,20 x 16,5, and total weight of 40 tons. Internal loading dimensions are: 2,45 x 2,8 x 13,60 m.

Figure 263 - Truck Type 1 (for illustrative purposes only)

9.4 Logistic in La Cité du Soleil®

9.4.1 INFRASTRUCTURES

Infrastructures that will be installed on the stock area during the assembly and disassembly phases are:

- 5 Waste management containers
    - Dedicated containers for the waste materials on the construction site
- Tool storage container
    - Dedicated storage for tools when they are not used
- Cleaning elements
    - Used for cleaning the operation site and Mem**brain** prototype
- Water tank
- Used for water supply of the construction site
- Portable spotlights
- Safety elements
- Euro - Pallets
- Rain cover
    - Used for covering the infrastructures and elements in case of rain
- Electric lines covering elements
- Site boundary fences

9.4.2 TOOLS AND MACHINERY

TRUCKS

The Mem**brain** prototype house will be carried in parts by 10 trucks. The trucks will be loaded with prefabricated elements and leave from Zagreb. They will supposedly arrive a day before the start of the assembly period in Paris. The transport of the house will be organized and realized through collaboration of the Team UNIZG and the transport company. All the necessary paperwork and asks for the required permissions will be handled by a professional transport company.

Specification and characteristics of the trucks are defined in the section 9.3.2. of this document.

MOBILE CRANE

The mobile crane will be provided by the SDE 2014 Organization. We will use the 35 Tn mobile crane for assembly and disassembly tasks of the heavy and large house elements. The mobile crane will be handled at all times by qualified and certified operators.

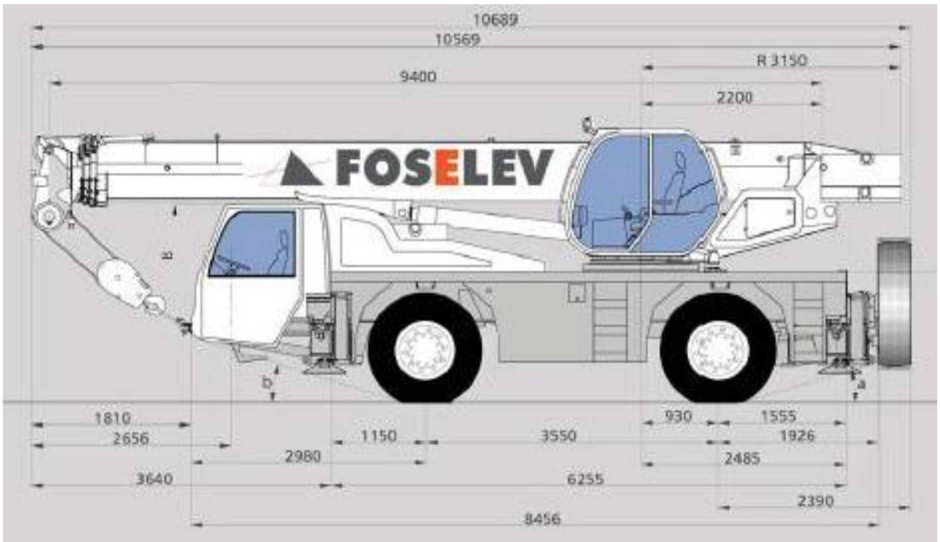


Figure 264 - Mobile Crane - Abaque grue 35 Tonnes

WHEEL FORKLIFT

Wheel forklift will be used for unloading, loading, stocking and construction site transport of the prototype's components.

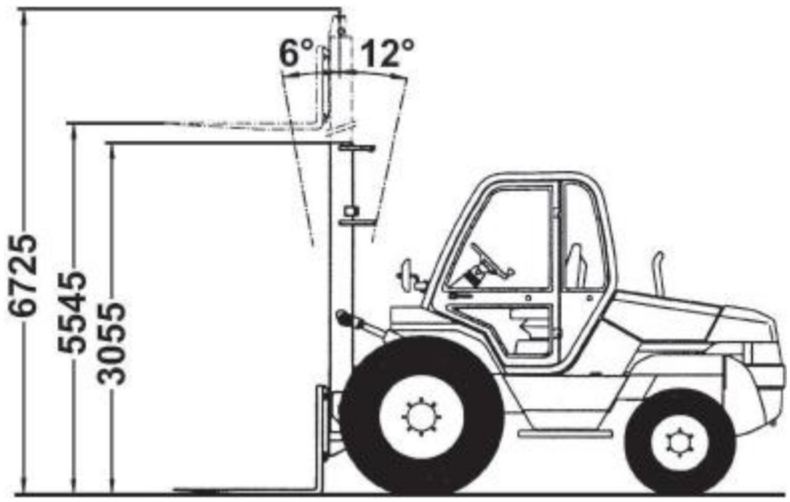


Figure 265 - Forklift - Manitou M26-4

MOBILE SCAFFOLDING

Mobile scaffolding will be used to set in place the roof and for other tasks to be carried out at higher levels on the roof. The tasks carried out on the prototype's roof will have to comply with all the measures that will be established in the Health and Safety plan.

Figure 266 - Mobile scaffolding (for illustrative purposes only)

WORKING STAIRS

Working stairs can be used for small works at higher levels of the house.

Figure 267 - Working stairs (for illustrative purposes only)

PALLET TRUCK

Pallet truck will be used for lifting and moving of heavier pallets during assembly and disassembly phase.

Figure 268 - Pallet truck (for illustrative purposes only)

TOOLS, AUXILIARY MEANS AND SMALL MACHINERY

Tool, auxiliary means and small machinery will be in use during each working day during assembly and disassembly. When using work tools, auxiliary means and small machinery, it is necessary to comply with Health and Safety measures defined in Health and Safety Report.

TRANSPORTATION VEHICLES THROUGH VERSAILLES

For transportation purposes through Versailles Team UNIZG will use Citroen C4 vehicle.

Figure 269 - Transport vehicle through Versailles (for illustrative purposes only)

9.4.3 CONSTRUCTION WORKING TEAMS

Team UNIZG will define two construction working teams which consist of:

1 SO coordinator + 1 HS Officer + 12 workers

9.4.4 PHASES DESCRIPTION

Table 76 - Assembly Phases Description

Assembly phase	Explanation	Corresponding HS Drawing
1. Site preparation	First, we will install the security fence around the construction site. The next step is unloading and placement of tool, safety accessory and storage containers and construction of the base camp. While the work is in progress, the site will be safeguarded by the team members and the electricians will install the electrical distribution cables and spotlights for works performed during night hours. Afterwards, the prototype boundaries will be specified.	SO - 201
2. House foundation placing	After measuring the boundaries of the prototype, the foundation system will be installed using theodolite and laser meter. The 45 height adjustable foundation steel elements of portable weight will be placed by hand at predetermined positions.	SO - 202

3. Floor panels assembly	The 5 prefabricated floor panels, consisting of load bearing wooden plate, thermal insulation and hydro isolation, will be unloaded from the truck and placed during this phase. It's a critical phase because these panels are large and heavy. First, we will implement the central panel and then we will start implementing west and east panels. We will seal these panels with each other mechanically using a steel connection system. Once the floor panels are placed and connected they will be leveled with the adjustable foundations.	SO – 203
4. Vertical structure assembly - columns	In this phase the vertical load bearing columns walls will be unloaded from the trucks one by one and placed in predetermined positions. The order in which the columns will be installed is described in the site operation plan in details. It is critical that the columns are placed with no vertical inclination.	SO – 204
5. Vertical structure assembly – shear walls	After the placement of columns the shear walls will be inserted and connected between the columns on the northern side of the prototype making a compact wall unit that will provide horizontal stability.	SO - 205
6. Plumbing system placement	Unloading and placement of the plumbing system box in position on the northern wall of the prototype. The plumbing system box will assure more precisely placement of the northern wooden partition walls.	SO -206
7. Wooden partition walls assembly	After load bearing columns and shear wall are assembled, the wooden partition walls, which separate the system room and bathroom from residual part of the prototype, will be unloaded from trucks by the crane and placed in numbered order at determined position at the northern side of the prototype.	SO – 207
8. Placing of engine system room	The next phase is placement of the system engine room which is transported as a prebuilt unit to the construction site. Unloading of the system engine room and its placement will be done by the crane at the determined place taking care of safety measures during the process.	SO – 208
9. Roof panels assembly	First, temporary construction support will be installed on some wooden columns to provide safety and stability during this phase. In this phase 5 prefabricated roof panels, consisting of load bearing	SO – 209

	wooden plate, thermal insulation and active roof carriers, will be unloaded from the truck by the crane, taking care of necessary safety measures, and placed in predetermined order. It's also a critical phase because these panels are large and heavy. First, we will implement the central panel and then we will start implementing west and east panels in a similar process described as in Phase 3. We will seal these panels with each other mechanically using a steel connection system. Once the panels are placed and connected hydro isolation will be rolled and sealed on top of the constructed roof. During the assembly of the panels no other work on the prototype should be carried out as a critical safety measure. After roof is assembled, steel braces will be mounted between the wooden columns to provide safety and stability of the house.	
10. Northern wall insulation panels assembly	In this phase the insulation boxes/panels will be unloaded form the truck and placed in determined position accordingly to the site operation plan. The unloading from the truck will be performed using the crane and taking care of necessary safety measures.	SO - 210
11. Glass partition walls assembly	In this phase the glass partition walls, which make the Mem**brain** of the prototype, will be unloaded from trucks by the forklift, carried by pallet trucks to predetermined place and installed one by one in order specified as in the site operation plan. It is imperative to handle with the glass walls with caution using necessary equipment described in the Health and Safety plan. Individual glass partition walls have to be installed without vertical inclination to allow connection with other glass elements.	SO - 211
12. Outer glass facade assembly	In the next phase the outer glass facade will be mounted in place. The singular elements will be unloaded by crane from the truck and placed one by one in determined positions as in the site operation plan. As the elements are hard to manipulate with, necessary safety equipment for handling, as defined in the health and safety plan, will be mandatory to use. The glass elements will be connected with each other by water resistant silicone providing impermeability.	SO – 212

13. Active roof assembly	This phase consists of connecting prefabricated active roof components with preinstalled photovoltaic plates to the carriers on the roof panels. The 6 prefabricated modules will be unloaded from the truck by crane and placed at the determined position. As this phase is carried out at the roof of the prototype, necessary use of height safety equipment will be imperative for the workers.	SO – 213
14. Wooden facade assembly	Outer wooden panels will be unloaded from truck and placed by the crane in predefined positions on the outer side of the northern wall. Prefabrication of the panels is planned to shorten the assembly time and assure safety for the workers.	SO – 214
15. Suspended ceiling assembly	In this phase the fireproof suspended ceiling, which covers the view of the installations and systems set up on the roof of the residual area of the prototype, will be placed and connected to the carriers on the roof panels. The carriers of the suspended ceiling are included in the roof panels assembled in phase 8 and therefore placing and connecting the suspended ceiling will be simpler and safer for workers. For this job safety ladders will be used as a measure of caution.	SO – 215
16. Winter garden works	The Air Duckt will be unloaded manually from the truck and placed on the floor of the winter garden. Then floor under structure will be placed. Gravel will be transported in bags and manually carried and dissipated in place. After the flooring is finished flowerpots with plants will be mounted.	SO – 216
17. Installations and systems setup	The next phase consists of installing and connecting different systems/installations which are required for operability of the prototype. The underfloor heating elements will be installed in the residual area and connected with the engine system room. Electrical systems will be manually connected by certified electricians. Every work phase will be performed by certified workers and necessary safety measures will be assured.	SO – 217
18. Bathroom elements setup	The bathroom elements will be manually unloaded from the truck and carried inside the prototype bathroom where they will be installed as predetermined positions.	SO – 218

19. Floor covering	After the installations are placed and connected, the floor covering will be unloaded from trucks and manually placed on predetermined positions using pallet trucks for help.	SO – 219
20. Interior furnishing assembly and setup	The elements will be manually unloaded from the truck and partially assembled on the assembly zone of the lot. After this step the individual elements will be carried inside the prototype using pallet trucks for help and assembled into finished furniture.	SO – 220
21. Decking assembly	The last constructive phase will be assembly of the terrace construction carriers and placement of the terrace floor panels. The construction carriers will be unloaded from truck manually by hand, as they are made of hard plastic, and placed in determined positions. After this step the terrace floor panels will be unloaded on pallet trucks and driven to assigned position. Placing of the panels will be also done by hand taking care of maximal allowed weight of one panel.	SO – 221
22. Canvas facade assembly	The last phase of assembly of the prototype is mounting of the canvas façade on declared positions using moveable safety ladders. The canvas façade is easy and assembly will therefore be carried out manually.	SO – 222
23. Assembly revision and Site cleaning	Assembly revision and manual cleaning of the site and removal of base camp and equipment container.	SO - 223

Table 77 - Disassembly Phases Description

Disassembly phase	Explanation	Corresponding HS Drawing
1. Canvas facade disassembly	The canvas facade will be manually disassembled using safety ladders as a safety measure. It will be transported and loaded into trucks by hand as the canvas facade is light.	SO - 224
2. Decking disassembly	The first step of the disassembly of terrace, stairways and access ramp is removing of the terrace fences and floor coverings. The transportation of the elements will be done by forklift or manually if the weight of the elements doesn't exceed the maximal allowed carrying	SO – 225

	weight. After this step the construction carriers will be manually removed and loaded into the truck.	
3. Interior furnishing removal	Interior furnishing will be manually disassembled and carried from the prototype using pallet trucks as a help and safety measure. The elements will be packed correspondingly and loaded into the trucks using the crane, forklift or manually. Loading of the elements into the trucks will be performed with caution because of the possibility of falling objects.	SO – 226
4. Floor covering removal	This phase consists of removing and loading of the floor covering elements from the residual area. The individual panels will be transported to the truck using pallet trucks and the loading into the truck will be done by the forklift. It is necessary to take care of falling objects.	SO - 227
5. Bathroom elements removal	Bathroom will be manually disassembled and carried from the prototype using pallet trucks as a help and safety measure. The elements will be packed correspondingly and loaded into the trucks using the crane, forklift or manually. Loading of the elements into the trucks will be performed with caution because of the possibility of falling objects.	SO – 228
6. Installations and systems removal	The systems of the prototype will be disconnected by qualified workers assuring safety.	SO – 229
7. Winter garden works	Gravel will be manually removed and loaded into bags which will be transported to the truck using pallet trucks and loaded into the truck. After this step, the floor under structure will be removed manually from the winter garden and transported to the truck. It will be loaded into the truck by forklift taking care of necessary safety measures. The flowerpots with plants will be also removed by hand and transported to the loading/unloading zone from where they will be loaded into the truck.	SO – 230
8. Suspended ceiling disassembly	Disassembly will be carried out in the same way as in the assembly phase taking care of necessary safety measures using safety ladders.	SO – 231
9. Wooden facade disassembly	Outer wooden panels will be disassembled from the prototype in blocks and loaded to truck by the crane.	SO – 232

10. Active roof disassembly	The phase of disassembly of the active roof will be carried out in several steps. First the individual components will be disassembled from the roof and it will be imperative to use necessary safety equipment as a precaution to work on high ground. After this the single panels will be carried by crane to the trucks and loaded in position. It will be mandatory not to stand below the working crane as a safety measure from falling objects or elements.	SO – 233
11. Outer glass facade disassembly	Outer glass facade will be disassembled from the prototype individually one by one and loaded to truck by crane taking care of necessary safety measures as described in the Health and Safety plan.	SO – 234
12. Glass partition walls disassembly	Glass partition walls will be disassembled from the prototype individually and transported to the trucks using pallet trucks for help. Loading of the individual elements will be carried out by the forklift or crane taking care of the possibility of falling objects/elements.	SO – 235
13. Northern wall insulation panels assembly	The insulation panels will be lifted with the crane and loaded into the truck taking care of safety measures.	SO – 236
14. Roof panel disassembly	As in the section of assembly, the roof panels will have to be transported into the trucks with great caution as the single elements are very heavy. The roof panel connection between panels will be removed one at the time and the single panel will be transported to the truck and loaded taking care of all necessary safety measures described in the section of risk assessment.	SO – 237
15. Engine system room removal	The engine system room of the prototype will be disconnected by qualified workers assuring safety. The individual elements will be transported and loaded into the truck by crane or forklift.	SO – 238
16. Wooden partition walls disassembly	The partition walls will be lifted with the crane and loaded directly into the trucks where workers will reach and position single elements into trucks.	SO – 239
17. Plumbing system removal	The plumbing system box will be carried and loaded manually from the prototype into the truck. The box will be lifted and positioned into the truck with the forklift.	SO – 240

18. Vertical structure disassembly – shear walls	The shear walls will be lifted with the crane and loaded directly into the trucks where workers will reach and position single elements into trucks.	SO – 241
19. Vertical structure disassembly – columns	Columns will be detached from the floor panels by 2 workers and manually carried and loaded into the truck.	SO – 242
20. Floor panels disassembly	Exactly as the disassembly phase of the roof panels, the floor panels will have to be transported into the trucks with great caution as the single elements are very heavy. The floor panel connection between panels will be removed and the single one by one panel will be transported to the truck and loaded taking care of all necessary safety measures described in the section of risk assessment.	SO - 243
21. House foundation disassembly	The foundation system will be manually loaded into the truck by workers because the single element doesn't exceed maximal carrying weight of a worker.	SO – 244
22. Site cleaning	The site will be cleaned and everything will be left as it was at the start of the assembly works. Boundary fencing will be removed, containers will be loaded into trucks by the crane and the base camp will be disassembled and loaded into the truck.	SO - 245

9.4.5 WASTE MANAGEMENT

The waste produced on site will mainly come from the packaging derivatives of the Mem**brain** prototype´s elements and components. Therefore Team UNIZG will assure five containers for separation of recyclable materials:

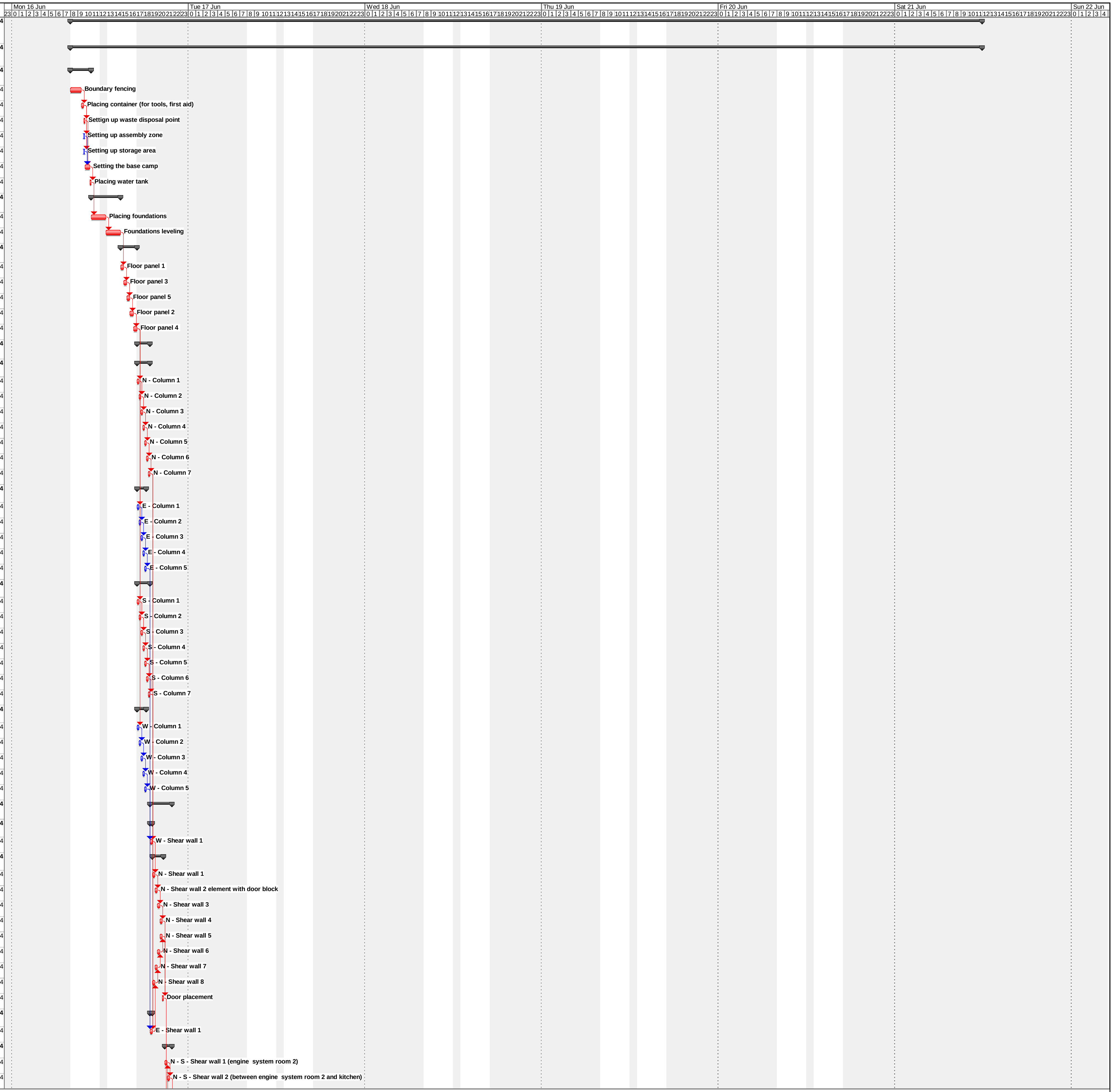
- Timber
- Cardboard and paper
- Plastic
- Residual waste
- Scrap metal

Those containers will be placed close to the access road to facilitate its removal to the disposal areas available in La Cité du Soleil.

9.5 Assembly/Disassembly schedules

Actions	Dates
Planned deadline for wind-and-water tight	20-June-2014
Planned deadline for electrical connection to village grid	21-June-2014
Planned deadline for house delivery	23-June-2014

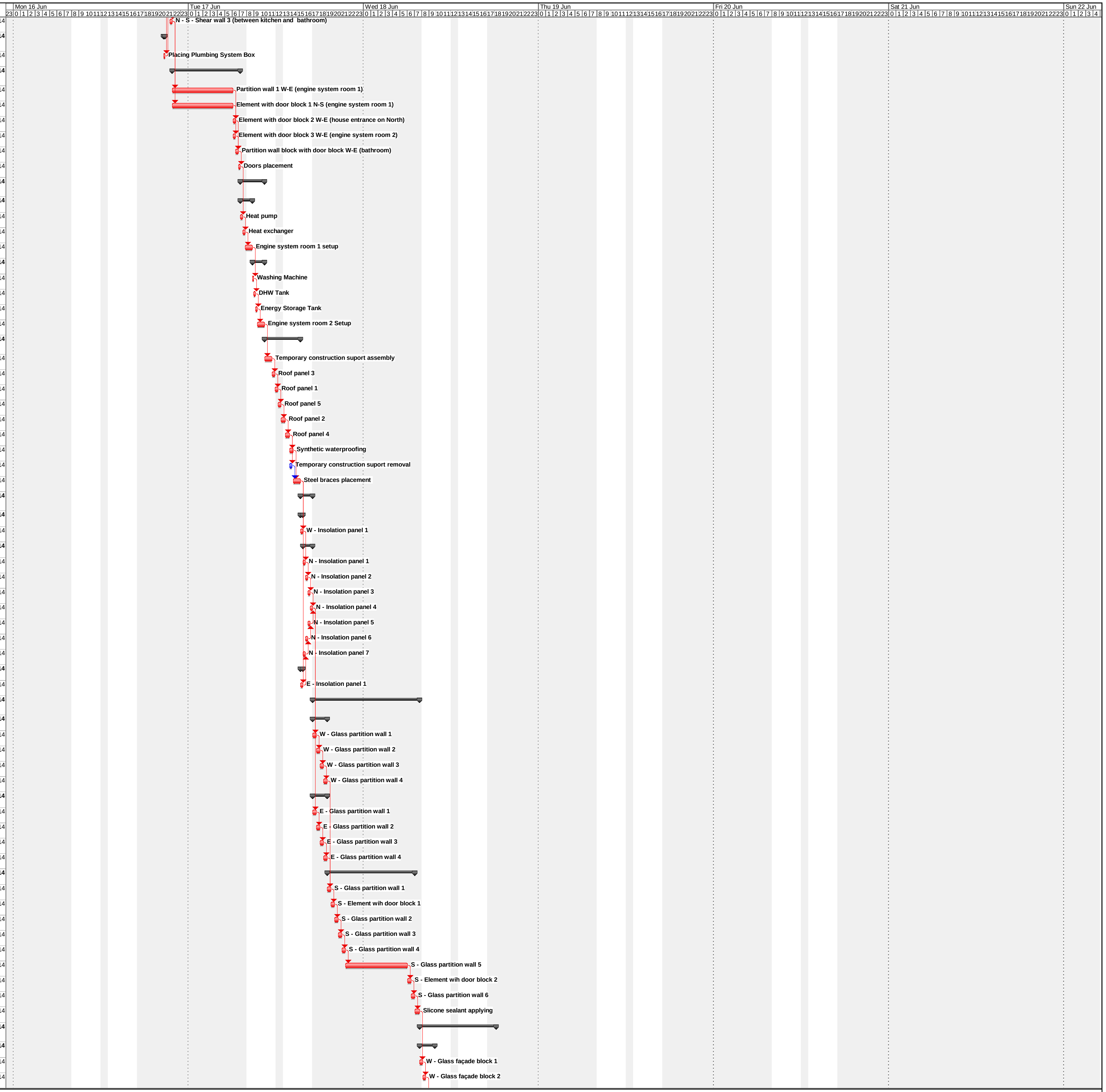
ID		Task Name	Duration	Start	Finish
1		**Concept Membrain**	**5035 mins**	**Mon 16.6.14**	**Sat 21.6.14**
2		***Assembly Phase***	**5035 mins**	**Mon 16.6.14**	**Sat 21.6.14**
3		**Site Preparation**	**170 mins**	**Mon 16.6.14**	**Mon 16.6.14**
4		Boundary fencing	90 mins	Mon 16.6.14	Mon 16.6.14
5		Placing container (for tools, first aid)	20 mins	Mon 16.6.14	Mon 16.6.14
6		Settign up waste disposal point	10 mins	Mon 16.6.14	Mon 16.6.14
7		Setting up assembly zone	5 mins	Mon 16.6.14	Mon 16.6.14
8		Setting up storage area	5 mins	Mon 16.6.14	Mon 16.6.14
9		Setting the base camp	40 mins	Mon 16.6.14	Mon 16.6.14
10		Placing water tank	10 mins	Mon 16.6.14	Mon 16.6.14
11		**House Foundation Placing**	**240 mins**	**Mon 16.6.14**	**Mon 16.6.14**
12		Placing foundations	120 mins	Mon 16.6.14	Mon 16.6.14
13		Foundations leveling	120 mins	Mon 16.6.14	Mon 16.6.14
14		**Floor panels assembly**	**135 mins**	**Mon 16.6.14**	**Mon 16.6.14**
15		Floor panel 1	25 mins	Mon 16.6.14	Mon 16.6.14
16		Floor panel 3	25 mins	Mon 16.6.14	Mon 16.6.14
17		Floor panel 5	25 mins	Mon 16.6.14	Mon 16.6.14
18		Floor panel 2	30 mins	Mon 16.6.14	Mon 16.6.14
19		Floor panel 4	30 mins	Mon 16.6.14	Mon 16.6.14
20		**Vertical structure assembly - Columns**	**105 mins**	**Mon 16.6.14**	**Mon 16.6.14**
21		**North**	**105 mins**	**Mon 16.6.14**	**Mon 16.6.14**
22		N - Column 1	15 mins	Mon 16.6.14	Mon 16.6.14
23		N - Column 2	15 mins	Mon 16.6.14	Mon 16.6.14
24		N - Column 3	15 mins	Mon 16.6.14	Mon 16.6.14
25		N - Column 4	15 mins	Mon 16.6.14	Mon 16.6.14
26		N - Column 5	15 mins	Mon 16.6.14	Mon 16.6.14
27		N - Column 6	15 mins	Mon 16.6.14	Mon 16.6.14
28		N - Column 7	15 mins	Mon 16.6.14	Mon 16.6.14
29		**East**	**75 mins**	**Mon 16.6.14**	**Mon 16.6.14**
30		E - Column 1	15 mins	Mon 16.6.14	Mon 16.6.14
31		E - Column 2	15 mins	Mon 16.6.14	Mon 16.6.14
32		E - Column 3	15 mins	Mon 16.6.14	Mon 16.6.14
33		E - Column 4	15 mins	Mon 16.6.14	Mon 16.6.14
34		E - Column 5	15 mins	Mon 16.6.14	Mon 16.6.14
35		**South**	**105 mins**	**Mon 16.6.14**	**Mon 16.6.14**
36		S - Column 1	15 mins	Mon 16.6.14	Mon 16.6.14
37		S - Column 2	15 mins	Mon 16.6.14	Mon 16.6.14
38		S - Column 3	15 mins	Mon 16.6.14	Mon 16.6.14
39		S - Column 4	15 mins	Mon 16.6.14	Mon 16.6.14
40		S - Column 5	15 mins	Mon 16.6.14	Mon 16.6.14
41		S - Column 6	15 mins	Mon 16.6.14	Mon 16.6.14
42		S - Column 7	15 mins	Mon 16.6.14	Mon 16.6.14
43		**West**	**75 mins**	**Mon 16.6.14**	**Mon 16.6.14**
44		W - Column 1	15 mins	Mon 16.6.14	Mon 16.6.14
45		W - Column 2	15 mins	Mon 16.6.14	Mon 16.6.14
46		W - Column 3	15 mins	Mon 16.6.14	Mon 16.6.14
47		W - Column 4	15 mins	Mon 16.6.14	Mon 16.6.14
48		W - Column 5	15 mins	Mon 16.6.14	Mon 16.6.14
49		**Vertical structure assembly - Shear walls**	**180 mins**	**Mon 16.6.14**	**Mon 16.6.14**
50		**West**	**20 mins**	**Mon 16.6.14**	**Mon 16.6.14**
51		W - Shear wall 1	20 mins	Mon 16.6.14	Mon 16.6.14
52		**North**	**90 mins**	**Mon 16.6.14**	**Mon 16.6.14**
53		N - Shear wall 1	20 mins	Mon 16.6.14	Mon 16.6.14
54		N - Shear wall 2 element with door block	20 mins	Mon 16.6.14	Mon 16.6.14
55		N - Shear wall 3	20 mins	Mon 16.6.14	Mon 16.6.14
56		N - Shear wall 4	20 mins	Mon 16.6.14	Mon 16.6.14
57		N - Shear wall 5	20 mins	Mon 16.6.14	Mon 16.6.14
58		N - Shear wall 6	20 mins	Mon 16.6.14	Mon 16.6.14
59		N - Shear wall 7	20 mins	Mon 16.6.14	Mon 16.6.14
60		N - Shear wall 8	20 mins	Mon 16.6.14	Mon 16.6.14
61		Door placement	10 mins	Mon 16.6.14	Mon 16.6.14
62		**East**	**20 mins**	**Mon 16.6.14**	**Mon 16.6.14**
63		E - Shear wall 1	20 mins	Mon 16.6.14	Mon 16.6.14
64		**North - South**	**60 mins**	**Mon 16.6.14**	**Mon 16.6.14**
65		N - S - Shear wall 1 (engine system room 2)	20 mins	Mon 16.6.14	Mon 16.6.14
66		N - S - Shear wall 2 (between engine system room 2 and kitchen)	20 mins	Mon 16.6.14	Mon 16.6.14



Project: Site Operation Schedule
Date: Sun 9.3.14

Task | Critical Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline

ID	Task Name	Duration	Start	Finish
67	N - S - Shear wall 3 (between kitchen and bathroom)	20 mins	Mon 16.6.14	Mon 16.6.14
68	**Plumbing System Placement**	**10 mins**	**Mon 16.6.14**	**Mon 16.6.14**
69	Placing Plumbing System Box	10 mins	Mon 16.6.14	Mon 16.6.14
70	**Wooden partition walls assembly**	**80 mins**	**Mon 16.6.14**	**Tue 17.6.14**
71	Partition wall 1 W-E (engine system room 1)	20 mins	Mon 16.6.14	Tue 17.6.14
72	Element with door block 1 N-S (engine system room 1)	20 mins	Mon 16.6.14	Tue 17.6.14
73	Element with door block 2 W-E (house entrance on North)	20 mins	Tue 17.6.14	Tue 17.6.14
74	Element with door block 3 W-E (engine system room 2)	20 mins	Tue 17.6.14	Tue 17.6.14
75	Partition wall block with door block W-E (bathroom)	25 mins	Tue 17.6.14	Tue 17.6.14
76	Doors placement	15 mins	Tue 17.6.14	Tue 17.6.14
77	**Placing of engine system rooms**	**200 mins**	**Tue 17.6.14**	**Tue 17.6.14**
78	**Engine system room 1**	**100 mins**	**Tue 17.6.14**	**Tue 17.6.14**
79	Heat pump	20 mins	Tue 17.6.14	Tue 17.6.14
80	Heat exchanger	20 mins	Tue 17.6.14	Tue 17.6.14
81	Engine system room 1 setup	60 mins	Tue 17.6.14	Tue 17.6.14
82	**Engine system room 2**	**100 mins**	**Tue 17.6.14**	**Tue 17.6.14**
83	Washing Machine	10 mins	Tue 17.6.14	Tue 17.6.14
84	DHW Tank	15 mins	Tue 17.6.14	Tue 17.6.14
85	Energy Storage Tank	15 mins	Tue 17.6.14	Tue 17.6.14
86	Engine system room 2 Setup	60 mins	Tue 17.6.14	Tue 17.6.14
87	**Roof panels assembly**	**295 mins**	**Tue 17.6.14**	**Tue 17.6.14**
88	Temporary construction suport assembly	60 mins	Tue 17.6.14	Tue 17.6.14
89	Roof panel 3	25 mins	Tue 17.6.14	Tue 17.6.14
90	Roof panel 1	25 mins	Tue 17.6.14	Tue 17.6.14
91	Roof panel 5	25 mins	Tue 17.6.14	Tue 17.6.14
92	Roof panel 2	35 mins	Tue 17.6.14	Tue 17.6.14
93	Roof panel 4	35 mins	Tue 17.6.14	Tue 17.6.14
94	Synthetic waterproofing	30 mins	Tue 17.6.14	Tue 17.6.14
95	Temporary construction suport removal	20 mins	Tue 17.6.14	Tue 17.6.14
96	Steel braces placement	60 mins	Tue 17.6.14	Tue 17.6.14
97	**Northern wall insolation panels assembly**	**100 mins**	**Tue 17.6.14**	**Tue 17.6.14**
98	**West**	**20 mins**	**Tue 17.6.14**	**Tue 17.6.14**
99	W - Insolation panel 1	20 mins	Tue 17.6.14	Tue 17.6.14
100	**North**	**80 mins**	**Tue 17.6.14**	**Tue 17.6.14**
101	N - Insolation panel 1	20 mins	Tue 17.6.14	Tue 17.6.14
102	N - Insolation panel 2	20 mins	Tue 17.6.14	Tue 17.6.14
103	N - Insolation panel 3	20 mins	Tue 17.6.14	Tue 17.6.14
104	N - Insolation panel 4	20 mins	Tue 17.6.14	Tue 17.6.14
105	N - Insolation panel 5	20 mins	Tue 17.6.14	Tue 17.6.14
106	N - Insolation panel 6	20 mins	Tue 17.6.14	Tue 17.6.14
107	N - Insolation panel 7	20 mins	Tue 17.6.14	Tue 17.6.14
108	**East**	**20 mins**	**Tue 17.6.14**	**Tue 17.6.14**
109	E - Insolation panel 1	20 mins	Tue 17.6.14	Tue 17.6.14
110	**Glass partition walls assembly**	**400 mins**	**Tue 17.6.14**	**Wed 18.6.14**
111	**West**	**120 mins**	**Tue 17.6.14**	**Tue 17.6.14**
112	W - Glass partition wall 1	30 mins	Tue 17.6.14	Tue 17.6.14
113	W - Glass partition wall 2	30 mins	Tue 17.6.14	Tue 17.6.14
114	W - Glass partition wall 3	30 mins	Tue 17.6.14	Tue 17.6.14
115	W - Glass partition wall 4	30 mins	Tue 17.6.14	Tue 17.6.14
116	**East**	**120 mins**	**Tue 17.6.14**	**Tue 17.6.14**
117	E - Glass partition wall 1	30 mins	Tue 17.6.14	Tue 17.6.14
118	E - Glass partition wall 2	30 mins	Tue 17.6.14	Tue 17.6.14
119	E - Glass partition wall 3	30 mins	Tue 17.6.14	Tue 17.6.14
120	E - Glass partition wall 4	30 mins	Tue 17.6.14	Tue 17.6.14
121	**South**	**240 mins**	**Tue 17.6.14**	**Wed 18.6.14**
122	S - Glass partition wall 1	30 mins	Tue 17.6.14	Tue 17.6.14
123	S - Element wih door block 1	30 mins	Tue 17.6.14	Tue 17.6.14
124	S - Glass partition wall 2	30 mins	Tue 17.6.14	Tue 17.6.14
125	S - Glass partition wall 3	30 mins	Tue 17.6.14	Tue 17.6.14
126	S - Glass partition wall 4	30 mins	Tue 17.6.14	Tue 17.6.14
127	S - Glass partition wall 5	30 mins	Tue 17.6.14	Wed 18.6.14
128	S - Element wih door block 2	30 mins	Wed 18.6.14	Wed 18.6.14
129	S - Glass partition wall 6	30 mins	Wed 18.6.14	Wed 18.6.14
130	**Slicone sealant applying**	**40 mins**	**Wed 18.6.14**	**Wed 18.6.14**
131	**Outer glass facade assembly**	**630 mins**	**Wed 18.6.14**	**Wed 18.6.14**
132	**West**	**125 mins**	**Wed 18.6.14**	**Wed 18.6.14**
133	W - Glass façade block 1	25 mins	Wed 18.6.14	Wed 18.6.14
134	W - Glass façade block 2	25 mins	Wed 18.6.14	Wed 18.6.14



Project: Site Operation Schedule
Date: Sun 9.3.14

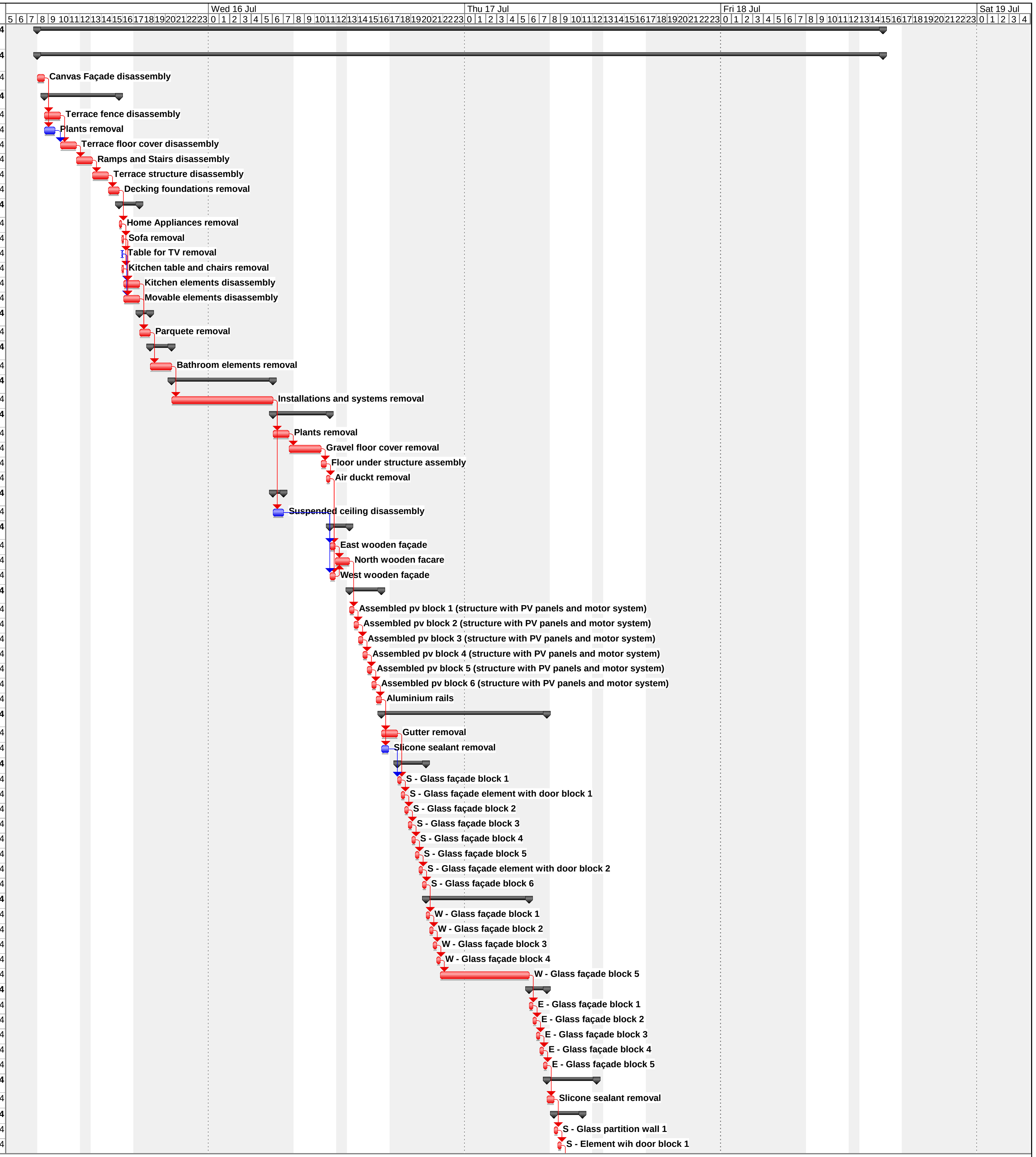
Task	Progress	Summary	Rolled Up Critical Task	Rolled Up Progress	External Tasks	Group By Summary	
Critical Task	Milestone	Rolled Up Task	Rolled Up Milestone	Split	Project Summary	Deadline	

ID		Task Name	Duration	Start	Finish
135		W - Glass façade block 3	25 mins	Wed 18.6.14	Wed 18.6.14
136		W - Glass façade block 4	25 mins	Wed 18.6.14	Wed 18.6.14
137		W - Glass façade block 5	25 mins	Wed 18.6.14	Wed 18.6.14
138		**East**	**125 mins**	**Wed 18.6.14**	**Wed 18.6.14**
139		E - Glass façade block 1	25 mins	Wed 18.6.14	Wed 18.6.14
140		E - Glass façade block 2	25 mins	Wed 18.6.14	Wed 18.6.14
141		E - Glass façade block 3	25 mins	Wed 18.6.14	Wed 18.6.14
142		E - Glass façade block 4	25 mins	Wed 18.6.14	Wed 18.6.14
143		E - Glass façade block 5	25 mins	Wed 18.6.14	Wed 18.6.14
144		**South**	**200 mins**	**Wed 18.6.14**	**Wed 18.6.14**
145		S - Glass façade block 1	25 mins	Wed 18.6.14	Wed 18.6.14
146		S - Glass façade element with door block 1	25 mins	Wed 18.6.14	Wed 18.6.14
147		S - Glass façade block 2	25 mins	Wed 18.6.14	Wed 18.6.14
148		S - Glass façade block 3	25 mins	Wed 18.6.14	Wed 18.6.14
149		S - Glass façade block 4	25 mins	Wed 18.6.14	Wed 18.6.14
150		S - Glass façade block 5	25 mins	Wed 18.6.14	Wed 18.6.14
151		S - Glass façade element with door block 2	25 mins	Wed 18.6.14	Wed 18.6.14
152		S - Glass façade block 6	25 mins	Wed 18.6.14	Wed 18.6.14
153		**Gutter assembly**	120 mins	Wed 18.6.14	Wed 18.6.14
154		**Silicone sealant applying**	60 mins	Wed 18.6.14	Wed 18.6.14
155		**Active roof (PV harmonic) assembly**	**340 mins**	**Wed 18.6.14**	**Thu 19.6.14**
156		Aluminium rails	40 mins	Wed 18.6.14	Wed 18.6.14
157		Assembled pv block 1 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
158		Assembled pv block 2 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
159		Assembled pv block 3 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
160		Assembled pv block 4 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
161		Assembled pv block 5 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
162		Assembled pv block 6 (structure with PV panels and motor system)	40 mins	Wed 18.6.14	Wed 18.6.14
163		PV System Setup	60 mins	Wed 18.6.14	Thu 19.6.14
164		**Wooden façade assembly**	**120 mins**	**Thu 19.6.14**	**Thu 19.6.14**
165		West wooden façade	40 mins	Thu 19.6.14	Thu 19.6.14
166		East wooden façade	40 mins	Thu 19.6.14	Thu 19.6.14
167		North wooden facade	80 mins	Thu 19.6.14	Thu 19.6.14
168		**Suspended ceiling assembly**	**180 mins**	**Thu 19.6.14**	**Thu 19.6.14**
169		Suspended ceiling	180 mins	Thu 19.6.14	Thu 19.6.14
170		**Winter Garden Works**	**270 mins**	**Thu 19.6.14**	**Thu 19.6.14**
171		Air duckt placement	30 mins	Thu 19.6.14	Thu 19.6.14
172		Floor under structure assembly	30 mins	Thu 19.6.14	Thu 19.6.14
173		Gravel floor covering	120 mins	Thu 19.6.14	Thu 19.6.14
174		Plants	90 mins	Thu 19.6.14	Thu 19.6.14
175		**Installations and systems setup**	**360 mins**	**Thu 19.6.14**	**Thu 19.6.14**
176		Installations and systems setup	360 mins	Thu 19.6.14	Thu 19.6.14
177		**Bathroom elements setup**	**180 mins**	**Thu 19.6.14**	**Thu 19.6.14**
178		Bathroom elements setup	180 mins	Thu 19.6.14	Thu 19.6.14
179		**Floor covering**	**120 mins**	**Thu 19.6.14**	**Thu 19.6.14**
180		Parquete	120 mins	Thu 19.6.14	Thu 19.6.14
181		**Interior furnishing assembly and setup**	**120 mins**	**Thu 19.6.14**	**Fri 20.6.14**
182		Kitchen elements (with movable element)	90 mins	Thu 19.6.14	Fri 20.6.14
183		Movable elements (workstation, bed and closet)	90 mins	Thu 19.6.14	Fri 20.6.14
184		Sofa	10 mins	Fri 20.6.14	Fri 20.6.14
185		Kitchen table and chairs	10 mins	Fri 20.6.14	Fri 20.6.14
186		Table for TV	5 mins	Fri 20.6.14	Fri 20.6.14
187		Home Appliances	20 mins	Fri 20.6.14	Fri 20.6.14
188		**Decking assembly**	**780 mins**	**Fri 20.6.14**	**Fri 20.6.14**
189		Placing decking foundations	180 mins	Fri 20.6.14	Fri 20.6.14
190		Terrace structure	180 mins	Fri 20.6.14	Fri 20.6.14
191		Ramps and Stairs	120 mins	Fri 20.6.14	Fri 20.6.14
192		Terrace floor covering	120 mins	Fri 20.6.14	Fri 20.6.14
193		Terrace fence	60 mins	Fri 20.6.14	Fri 20.6.14
194		Plants	120 mins	Fri 20.6.14	Fri 20.6.14
195		**Canvas Façade assembly**	80 mins	Fri 20.6.14	Fri 20.6.14
196		**Assembly Revision and Site Cleaning**	480 mins	Fri 20.6.14	Sat 21.6.14

Project: Site Operation Schedule
Date: Sun 9.3.14

Task	Progress	Summary	Rolled Up Critical Task	Rolled Up Progress	External Tasks	Group By Summary	
Critical Task	Milestone	Rolled Up Task	Rolled Up Milestone	Split	Project Summary	Deadline	

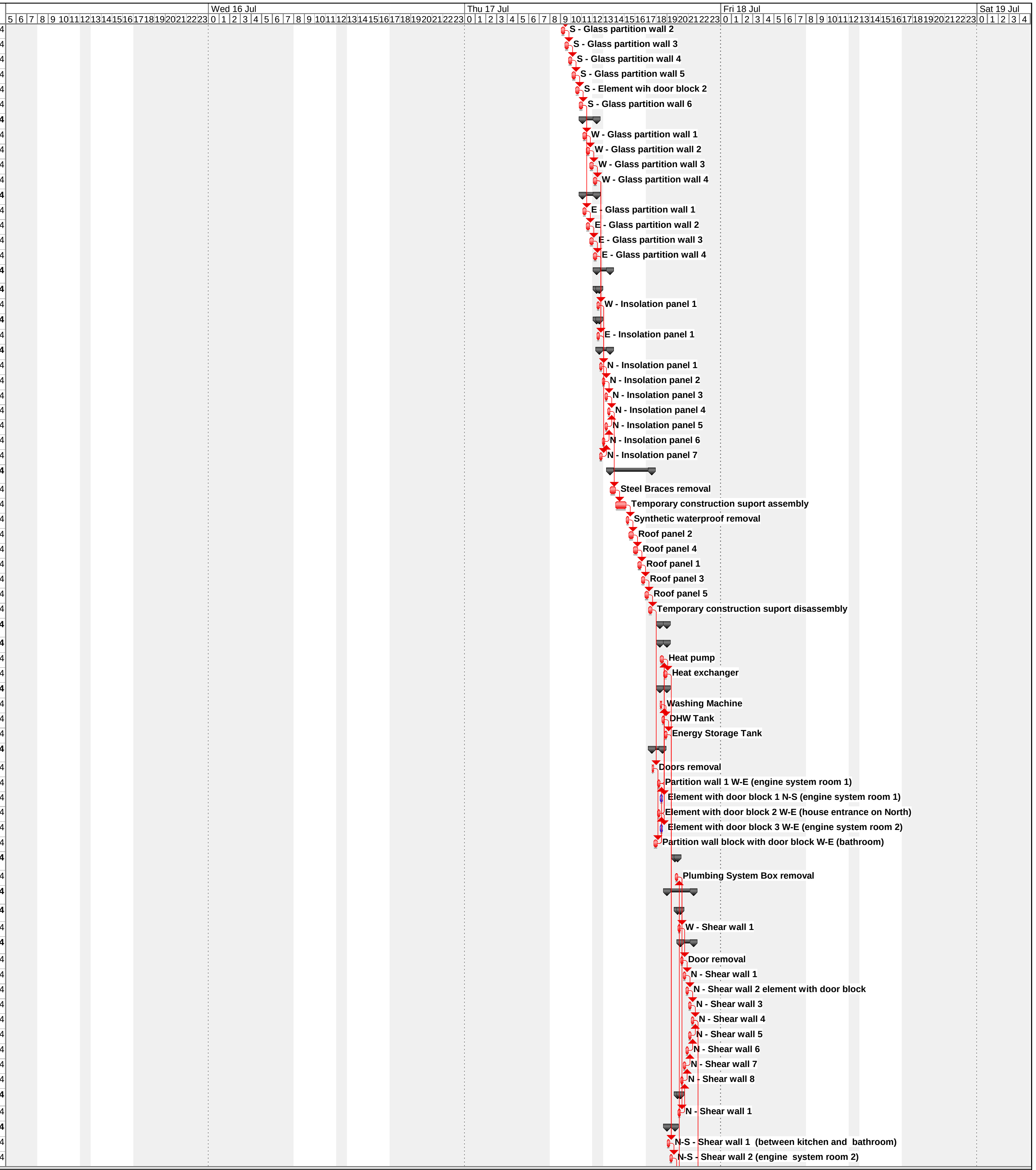
ID		Task Name	Duration	Start	Finish
1		**Concept Membrain**	**3315 mins**	**Tue 15.7.14**	**Fri 18.7.14**
2		***Disassembly Phase***	**3315 mins**	**Tue 15.7.14**	**Fri 18.7.14**
3		**Canvas Façade disassembly**	40 mins	Tue 15.7.14	Tue 15.7.14
4		**Decking disassembly**	**420 mins**	**Tue 15.7.14**	**Tue 15.7.14**
5		Terrace fence disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
6		Plants removal	60 mins	Tue 15.7.14	Tue 15.7.14
7		Terrace floor cover disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
8		Ramps and Stairs disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
9		Terrace structure disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
10		Decking foundations removal	60 mins	Tue 15.7.14	Tue 15.7.14
11		**Interior furnishing removal**	**115 mins**	**Tue 15.7.14**	**Tue 15.7.14**
12		Home Appliances removal	15 mins	Tue 15.7.14	Tue 15.7.14
13		Sofa removal	10 mins	Tue 15.7.14	Tue 15.7.14
14		Table for TV removal	5 mins	Tue 15.7.14	Tue 15.7.14
15		Kitchen table and chairs removal	10 mins	Tue 15.7.14	Tue 15.7.14
16		Kitchen elements disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
17		Movable elements disassembly	90 mins	Tue 15.7.14	Tue 15.7.14
18		**Floor cover removal**	**60 mins**	**Tue 15.7.14**	**Tue 15.7.14**
19		Parquete removal	60 mins	Tue 15.7.14	Tue 15.7.14
20		**Bathroom elements removal**	**120 mins**	**Tue 15.7.14**	**Tue 15.7.14**
21		Bathroom elements removal	120 mins	Tue 15.7.14	Tue 15.7.14
22		**Installations and system removal**	**90 mins**	**Tue 15.7.14**	**Wed 16.7.14**
23		Installations and systems removal	90 mins	Tue 15.7.14	Wed 16.7.14
24		**Winter Garden removal**	**320 mins**	**Wed 16.7.14**	**Wed 16.7.14**
25		Plants removal	90 mins	Wed 16.7.14	Wed 16.7.14
26		Gravel floor cover removal	180 mins	Wed 16.7.14	Wed 16.7.14
27		Floor under structure assembly	30 mins	Wed 16.7.14	Wed 16.7.14
28		Air duckt removal	20 mins	Wed 16.7.14	Wed 16.7.14
29		**Suspended ceiling disassembly**	**60 mins**	**Wed 16.7.14**	**Wed 16.7.14**
30		Suspended ceiling disassembly	60 mins	Wed 16.7.14	Wed 16.7.14
31		**Wooden façade disassembly**	**110 mins**	**Wed 16.7.14**	**Wed 16.7.14**
32		East wooden façade	30 mins	Wed 16.7.14	Wed 16.7.14
33		North wooden facare	80 mins	Wed 16.7.14	Wed 16.7.14
34		West wooden façade	30 mins	Wed 16.7.14	Wed 16.7.14
35		**Active roof (PV harmonic) disassembly**	**180 mins**	**Wed 16.7.14**	**Wed 16.7.14**
36		Assembled pv block 1 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
37		Assembled pv block 2 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
38		Assembled pv block 3 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
39		Assembled pv block 4 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
40		Assembled pv block 5 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
41		Assembled pv block 6 (structure with PV panels and motor system)	25 mins	Wed 16.7.14	Wed 16.7.14
42		Aluminium rails	30 mins	Wed 16.7.14	Wed 16.7.14
43		**Outer glass façade disassembly**	**450 mins**	**Wed 16.7.14**	**Thu 17.7.14**
44		**Gutter removal**	90 mins	Wed 16.7.14	Wed 16.7.14
45		**Slicone sealant removal**	40 mins	Wed 16.7.14	Wed 16.7.14
46		**South**	**160 mins**	**Wed 16.7.14**	**Wed 16.7.14**
47		S - Glass façade block 1	20 mins	Wed 16.7.14	Wed 16.7.14
48		S - Glass façade element with door block 1	20 mins	Wed 16.7.14	Wed 16.7.14
49		S - Glass façade block 2	20 mins	Wed 16.7.14	Wed 16.7.14
50		S - Glass façade block 3	20 mins	Wed 16.7.14	Wed 16.7.14
51		S - Glass façade block 4	20 mins	Wed 16.7.14	Wed 16.7.14
52		S - Glass façade block 5	20 mins	Wed 16.7.14	Wed 16.7.14
53		S - Glass façade element with door block 2	20 mins	Wed 16.7.14	Wed 16.7.14
54		S - Glass façade block 6	20 mins	Wed 16.7.14	Wed 16.7.14
55		**West**	**100 mins**	**Wed 16.7.14**	**Thu 17.7.14**
56		W - Glass façade block 1	20 mins	Wed 16.7.14	Wed 16.7.14
57		W - Glass façade block 2	20 mins	Wed 16.7.14	Wed 16.7.14
58		W - Glass façade block 3	20 mins	Wed 16.7.14	Wed 16.7.14
59		W - Glass façade block 4	20 mins	Wed 16.7.14	Wed 16.7.14
60		W - Glass façade block 5	20 mins	Wed 16.7.14	Thu 17.7.14
61		**East**	**100 mins**	**Thu 17.7.14**	**Thu 17.7.14**
62		E - Glass façade block 1	20 mins	Thu 17.7.14	Thu 17.7.14
63		E - Glass façade block 2	20 mins	Thu 17.7.14	Thu 17.7.14
64		E - Glass façade block 3	20 mins	Thu 17.7.14	Thu 17.7.14
65		E - Glass façade block 4	20 mins	Thu 17.7.14	Thu 17.7.14
66		E - Glass façade block 5	20 mins	Thu 17.7.14	Thu 17.7.14
67		**Glass partition walls disassembly**	**280 mins**	**Thu 17.7.14**	**Thu 17.7.14**
68		**Slicone sealant removal**	40 mins	Thu 17.7.14	Thu 17.7.14
69		**South**	**160 mins**	**Thu 17.7.14**	**Thu 17.7.14**
70		S - Glass partition wall 1	20 mins	Thu 17.7.14	Thu 17.7.14
71		S - Element wih door block 1	20 mins	Thu 17.7.14	Thu 17.7.14



Project: Site Operation Schedule
Date: Sun 9.3.14

Task		Progress		Summary		Rolled Up Critical Task		Rolled Up Progress		External Tasks		Group By Summary	
Critical Task		Milestone	◆	Rolled Up Task		Rolled Up Milestone	◇	Split		Project Summary		Deadline	⇩

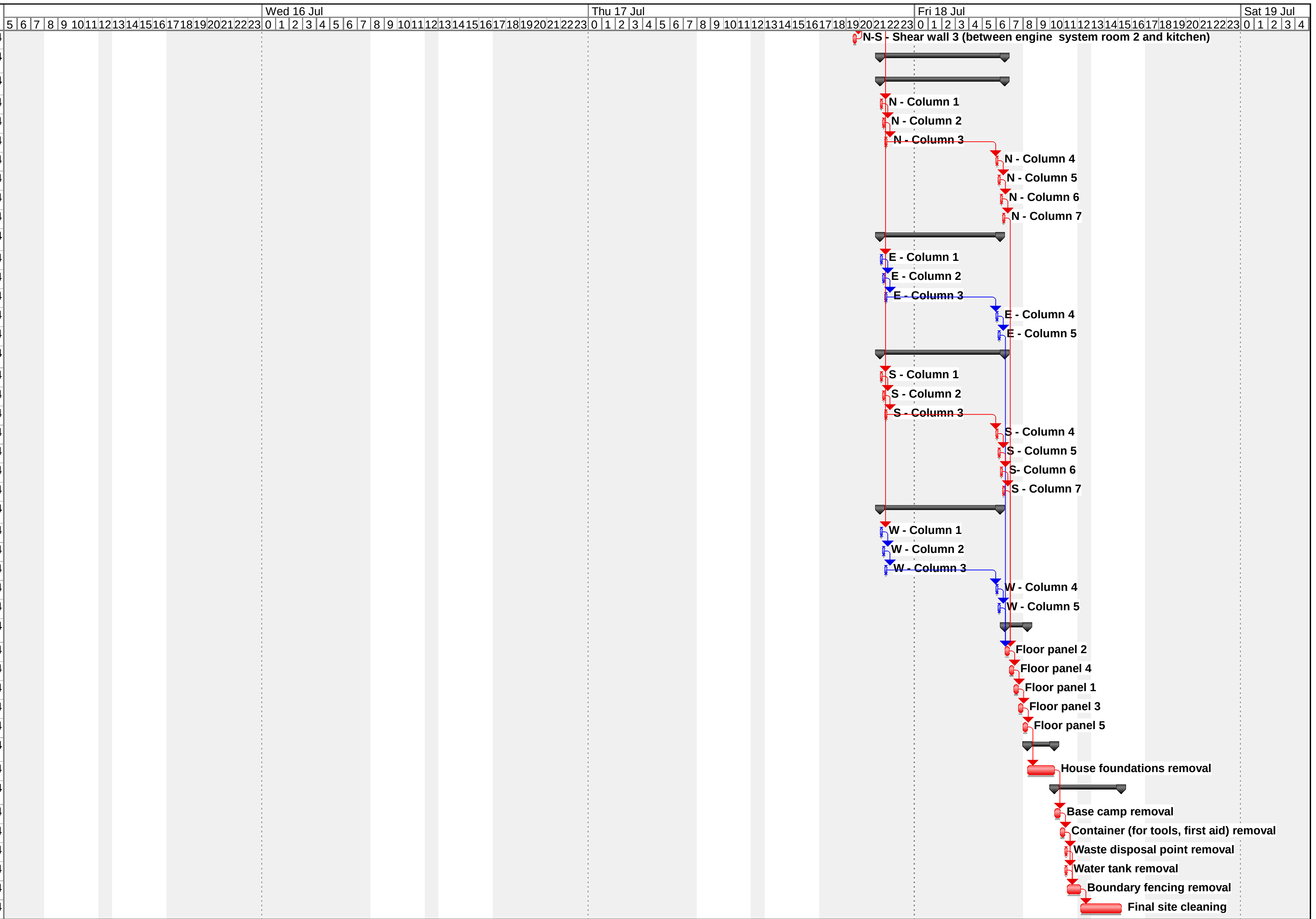
ID		Task Name	Duration	Start	Finish
72		S - Glass partition wall 2	20 mins	Thu 17.7.14	Thu 17.7.14
73		S - Glass partition wall 3	20 mins	Thu 17.7.14	Thu 17.7.14
74		S - Glass partition wall 4	20 mins	Thu 17.7.14	Thu 17.7.14
75		S - Glass partition wall 5	20 mins	Thu 17.7.14	Thu 17.7.14
76		S - Element wih door block 2	20 mins	Thu 17.7.14	Thu 17.7.14
77		S - Glass partition wall 6	20 mins	Thu 17.7.14	Thu 17.7.14
78		**West**	**80 mins**	**Thu 17.7.14**	**Thu 17.7.14**
79		W - Glass partition wall 1	20 mins	Thu 17.7.14	Thu 17.7.14
80		W - Glass partition wall 2	20 mins	Thu 17.7.14	Thu 17.7.14
81		W - Glass partition wall 3	20 mins	Thu 17.7.14	Thu 17.7.14
82		W - Glass partition wall 4	20 mins	Thu 17.7.14	Thu 17.7.14
83		**East**	**80 mins**	**Thu 17.7.14**	**Thu 17.7.14**
84		E - Glass partition wall 1	20 mins	Thu 17.7.14	Thu 17.7.14
85		E - Glass partition wall 2	20 mins	Thu 17.7.14	Thu 17.7.14
86		E - Glass partition wall 3	20 mins	Thu 17.7.14	Thu 17.7.14
87		E - Glass partition wall 4	20 mins	Thu 17.7.14	Thu 17.7.14
88		**Norten wall insulation panels disassembly**	**75 mins**	**Thu 17.7.14**	**Thu 17.7.14**
89		**West**	**15 mins**	**Thu 17.7.14**	**Thu 17.7.14**
90		W - Insolation panel 1	15 mins	Thu 17.7.14	Thu 17.7.14
91		**East**	**15 mins**	**Thu 17.7.14**	**Thu 17.7.14**
92		E - Insolation panel 1	15 mins	Thu 17.7.14	Thu 17.7.14
93		**North**	**60 mins**	**Thu 17.7.14**	**Thu 17.7.14**
94		N - Insolation panel 1	15 mins	Thu 17.7.14	Thu 17.7.14
95		N - Insolation panel 2	15 mins	Thu 17.7.14	Thu 17.7.14
96		N - Insolation panel 3	15 mins	Thu 17.7.14	Thu 17.7.14
97		N - Insolation panel 4	15 mins	Thu 17.7.14	Thu 17.7.14
98		N - Insolation panel 5	15 mins	Thu 17.7.14	Thu 17.7.14
99		N - Insolation panel 6	15 mins	Thu 17.7.14	Thu 17.7.14
100		N - Insolation panel 7	15 mins	Thu 17.7.14	Thu 17.7.14
101		**Roof panels disassembly**	**235 mins**	**Thu 17.7.14**	**Thu 17.7.14**
102		Steel Braces removal	30 mins	Thu 17.7.14	Thu 17.7.14
103		Temporary construction suport assembly	60 mins	Thu 17.7.14	Thu 17.7.14
104		Synthetic waterproof removal	15 mins	Thu 17.7.14	Thu 17.7.14
105		Roof panel 2	25 mins	Thu 17.7.14	Thu 17.7.14
106		Roof panel 4	25 mins	Thu 17.7.14	Thu 17.7.14
107		Roof panel 1	20 mins	Thu 17.7.14	Thu 17.7.14
108		Roof panel 3	20 mins	Thu 17.7.14	Thu 17.7.14
109		Roof panel 5	20 mins	Thu 17.7.14	Thu 17.7.14
110		Temporary construction suport disassembly	20 mins	Thu 17.7.14	Thu 17.7.14
111		**Engine system rooms disassembly and truck loading**	**40 mins**	**Thu 17.7.14**	**Thu 17.7.14**
112		**Engine system room 1**	**40 mins**	**Thu 17.7.14**	**Thu 17.7.14**
113		Heat pump	20 mins	Thu 17.7.14	Thu 17.7.14
114		Heat exchanger	20 mins	Thu 17.7.14	Thu 17.7.14
115		**Engine system room 2**	**40 mins**	**Thu 17.7.14**	**Thu 17.7.14**
116		Washing Machine	10 mins	Thu 17.7.14	Thu 17.7.14
117		DHW Tank	15 mins	Thu 17.7.14	Thu 17.7.14
118		Energy Storage Tank	15 mins	Thu 17.7.14	Thu 17.7.14
119		**Wooden partition walls disassembly**	**60 mins**	**Thu 17.7.14**	**Thu 17.7.14**
120		Doors removal	10 mins	Thu 17.7.14	Thu 17.7.14
121		Partition wall 1 W-E (engine system room 1)	15 mins	Thu 17.7.14	Thu 17.7.14
122		Element with door block 1 N-S (engine system room 1)	15 mins	Thu 17.7.14	Thu 17.7.14
123		Element with door block 2 W-E (house entrance on North)	15 mins	Thu 17.7.14	Thu 17.7.14
124		Element with door block 3 W-E (engine system room 2)	15 mins	Thu 17.7.14	Thu 17.7.14
125		Partition wall block with door block W-E (bathroom)	20 mins	Thu 17.7.14	Thu 17.7.14
126		**Plumbing System removal**	**15 mins**	**Thu 17.7.14**	**Thu 17.7.14**
127		Plumbing System Box removal	15 mins	Thu 17.7.14	Thu 17.7.14
128		**Vertical structure - Shear Walls disassembly**	**150 mins**	**Thu 17.7.14**	**Thu 17.7.14**
129		**West**	**15 mins**	**Thu 17.7.14**	**Thu 17.7.14**
130		W - Shear wall 1	15 mins	Thu 17.7.14	Thu 17.7.14
131		**North**	**75 mins**	**Thu 17.7.14**	**Thu 17.7.14**
132		Door removal	15 mins	Thu 17.7.14	Thu 17.7.14
133		N - Shear wall 1	15 mins	Thu 17.7.14	Thu 17.7.14
134		N - Shear wall 2 element with door block	15 mins	Thu 17.7.14	Thu 17.7.14
135		N - Shear wall 3	15 mins	Thu 17.7.14	Thu 17.7.14
136		N - Shear wall 4	15 mins	Thu 17.7.14	Thu 17.7.14
137		N - Shear wall 5	15 mins	Thu 17.7.14	Thu 17.7.14
138		N - Shear wall 6	15 mins	Thu 17.7.14	Thu 17.7.14
139		N - Shear wall 7	15 mins	Thu 17.7.14	Thu 17.7.14
140		N - Shear wall 8	15 mins	Thu 17.7.14	Thu 17.7.14
141		**East**	**15 mins**	**Thu 17.7.14**	**Thu 17.7.14**
142		N - Shear wall 1	15 mins	Thu 17.7.14	Thu 17.7.14
143		**North - South**	**45 mins**	**Thu 17.7.14**	**Thu 17.7.14**
144		N-S - Shear wall 1 (between kitchen and bathroom)	15 mins	Thu 17.7.14	Thu 17.7.14
145		N-S - Shear wall 2 (engine system room 2)	15 mins	Thu 17.7.14	Thu 17.7.14



Project: Site Operation Schedule
Date: Sun 9.3.14

Task	Progress	Summary	Rolled Up Critical Task	Rolled Up Progress	External Tasks	Group By Summary	
Critical Task	Milestone	Rolled Up Task	Rolled Up Milestone	Split	Project Summary	Deadline	

ID	Task Name	Duration	Start	Finish
146	N-S - Shear wall 3 (between engine system room 2 and kitchen)	15 mins	Thu 17.7.14	Thu 17.7.14
147	**Vertical structure - Columns disassembly**	**70 mins**	**Thu 17.7.14**	**Fri 18.7.14**
148	**North**	**70 mins**	**Thu 17.7.14**	**Fri 18.7.14**
149	N - Column 1	10 mins	Thu 17.7.14	Thu 17.7.14
150	N - Column 2	10 mins	Thu 17.7.14	Thu 17.7.14
151	N - Column 3	10 mins	Thu 17.7.14	Thu 17.7.14
152	N - Column 4	10 mins	Fri 18.7.14	Fri 18.7.14
153	N - Column 5	10 mins	Fri 18.7.14	Fri 18.7.14
154	N - Column 6	10 mins	Fri 18.7.14	Fri 18.7.14
155	N - Column 7	10 mins	Fri 18.7.14	Fri 18.7.14
156	**East**	**50 mins**	**Thu 17.7.14**	**Fri 18.7.14**
157	E - Column 1	10 mins	Thu 17.7.14	Thu 17.7.14
158	E - Column 2	10 mins	Thu 17.7.14	Thu 17.7.14
159	E - Column 3	10 mins	Thu 17.7.14	Thu 17.7.14
160	E - Column 4	10 mins	Fri 18.7.14	Fri 18.7.14
161	E - Column 5	10 mins	Fri 18.7.14	Fri 18.7.14
162	**South**	**70 mins**	**Thu 17.7.14**	**Fri 18.7.14**
163	S - Column 1	10 mins	Thu 17.7.14	Thu 17.7.14
164	S - Column 2	10 mins	Thu 17.7.14	Thu 17.7.14
165	S - Column 3	10 mins	Thu 17.7.14	Thu 17.7.14
166	S - Column 4	10 mins	Fri 18.7.14	Fri 18.7.14
167	S - Column 5	10 mins	Fri 18.7.14	Fri 18.7.14
168	S- Column 6	10 mins	Fri 18.7.14	Fri 18.7.14
169	S - Column 7	10 mins	Fri 18.7.14	Fri 18.7.14
170	**West**	**50 mins**	**Thu 17.7.14**	**Fri 18.7.14**
171	W - Column 1	10 mins	Thu 17.7.14	Thu 17.7.14
172	W - Column 2	10 mins	Thu 17.7.14	Thu 17.7.14
173	W - Column 3	10 mins	Thu 17.7.14	Thu 17.7.14
174	W - Column 4	10 mins	Fri 18.7.14	Fri 18.7.14
175	W - Column 5	10 mins	Fri 18.7.14	Fri 18.7.14
176	**Floor panels disassembly**	**100 mins**	**Fri 18.7.14**	**Fri 18.7.14**
177	Floor panel 2	20 mins	Fri 18.7.14	Fri 18.7.14
178	Floor panel 4	20 mins	Fri 18.7.14	Fri 18.7.14
179	Floor panel 1	20 mins	Fri 18.7.14	Fri 18.7.14
180	Floor panel 3	20 mins	Fri 18.7.14	Fri 18.7.14
181	Floor panel 5	20 mins	Fri 18.7.14	Fri 18.7.14
182	**House foundation removal**	**120 mins**	**Fri 18.7.14**	**Fri 18.7.14**
183	House foundations removal	120 mins	Fri 18.7.14	Fri 18.7.14
184	**Site cleaning**	**295 mins**	**Fri 18.7.14**	**Fri 18.7.14**
185	Base camp removal	25 mins	Fri 18.7.14	Fri 18.7.14
186	Container (for tools, first aid) removal	20 mins	Fri 18.7.14	Fri 18.7.14
187	Waste disposal point removal	10 mins	Fri 18.7.14	Fri 18.7.14
188	Water tank removal	10 mins	Fri 18.7.14	Fri 18.7.14
189	Boundary fencing removal	60 mins	Fri 18.7.14	Fri 18.7.14
190	Final site cleaning	180 mins	Fri 18.7.14	Fri 18.7.14



Project: Site Operation Schedule Date: Sun 9.3.14	Task		Progress		Summary		Rolled Up Critical Task		Rolled Up Progress		External Tasks		Group By Summary
	Critical Task		Milestone		Rolled Up Task		Rolled Up Milestone		Split		Project Summary		Deadline

9.6 Equipment requirement Chart

CATEGORIE 1 : MOBILE CRANE

PLEASE COMPLETE THE ASSEMBLY & DISASSEMBLY CHARTS

CATEGORIE 2 : CONSTRUCTION EQUIPMENT

HANDLING			
DESIGNATION	REFERENCE	U	QUANTITY NEEDED
Forklift	H.FL.01	u	1

CATEGORIE 3 : OTHER EQUIPMENT

EQUIPMENT			
DESIGNATION	REFERENCE	U	QUANTITY NEEDED
Scaffolding 5 m	O.OE.03	u	2
Fences HERAS (including plots)	O.OE.04	m	90

9.7 Assembly and Disassembly Chart

This is the first draft of Assembly and Disassembly Chart! It will it will be probably change when Assembly and Disassembly schedule will be developed!

9.7.1 Assembly chart

DAY 1 - 16.06.2014	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks	T1	T1					T2	T2	T2	T2	T3	T3	T3			
Crane																

DAY 2 - 17.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks											T4	T4	T4	T5	T5	T5	T5							
Crane																								
DAY 3 - 18.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks							T6	T6	T6	T6	T6	T6	T6	T6	T6			T7	T7	T7	T7	T7		
Crane																								
DAY 4 - 19.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks							T8	T8	T8	T8										T9	T9	T9		
Crane																								
DAY 5 - 20.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks							T10	T10	T10	T10	T10													
Crane																								
DAY 6 - 21.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks																								
Crane																								
DAY 7 - 22.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks																								
Crane																								
DAY 8 - 23.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks																								
Crane																								
DAY 9 - 24.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks																								
Crane																								
DAY 10 - 25.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks																								
Crane																								

DAY 11 - 26.06.2014	0	1	2	3	4	5	6	7	8	9	10	11	1 2	13	14	15	16	17	18	19	20	21	22	23
INSPECTIONS DAY																								
USAGE OF THE CRANE																								
Crane capacity: 35 Tn																	*Usage time: 56 h*							

9.7.2 Disassembly chart

DAY 1 - 15.07.2014	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Trucks				T1	T1	T1	T1	T2	T2							
Crane																

DAY 2 - 16.07.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1 5	16	17	18	19	20	21	22	23
Trucks											T3	T3	T4	T4	T4	T4		T5	T5	T5	T5	T5	T5	
Crane																								
DAY 3 - 17.07.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1 5	16	17	18	19	20	21	22	23
Trucks										T6	T6	T6	T6	T7	T7	T7	T7	T8	T8	T8	T8			
Crane																								
DAY 4 - 18.07.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1 5	16	17	18	19	20	21	22	23
Trucks							T9	T9	T9	T10	T10	T10	T10	T10	T10									
Crane																								
DAY 5 - 19.07.2014	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1 5	16	17	18	19	20	21	22	23
Trucks																								
Crane																								
USAGE OF THE CRANE																								
Crane capacity: 35 Tn																	***Usage time: 40 h***							

9.8 Site Operation Chart

Table 78 - Site Operation Chart

0. GENERAL INFORMATION		FUNCTION	CONSTRUCTION WORKING TEAM	NAME	TELEPHONE NUMBER
	1	Site Operation Coordinator	Team A	Velimir Šilec	+385 98 951 7051
	2		Team B	Viktor Pernjek	+958855454

1. MODULES AND MAIN COMPONENTS		NAME	DIMENSIONS [m]	WEIGHT [kg]	MACHINERY USE FOR UNLOADING/LOADING
	1	Foundations	42 x (0,65 x 0,65 x 0,35)	42 x 25 = 1050	Forklift
	2	Tool Container	2 x 2 x 3	1000	Crane
	3	Waste containers	5 x 0,6 x 0,6 x 0,8	5 x 10 = 50	Forklift
	4	Water containers	2 x (1,2 x 1,2 x 1)	2 x 1500 = 3000	Crane
	5	Tent	2 x 4 x 3	80	Forklift
	6	Floor panels	2 x (7,20x1,27,5x0,36) + 3 x (7,20 x 2,55 x 0,36)	2 * 1000 + 3 * 2000 = 8000	Crane
	7	Roof panels	2 x (7,20x1,27,5x0,30) + 3 x (7,20 x 2,55 x 0,40)	2 * 1000 + 3 * 2000 = 8000	Crane
	8	Columns	24 x (3 x 0,12 x 0,20)	24 x 36 = 864	Forklift
	9	Shear wall	2 x (0,94 x 0,2 x 3) + 4 x (1 x 0,2 x 3) + 5 x (1,07 x 0,2 x 3)	9 x 220= 1980	Crane
	10	Partition wall	5 x (1,2 x 3 x 0,12)	5 x 170 = 750	Forklift
	11	Heat pump	0,6 x 0,5 x 0,8	50	Forklift
	12	Heat exchanger	0,2 x 0,4 x 0,4	20	Forklift
	13	Washing machine	0,85 x 0,6 x 0,6	75	Forklift
	14	DHW tank	0,7 x 1,5	350	Forklift
	15	Energy storage tank	0,4 x 1,2		Forklift
	16	Aluminium rails	4 x(7,40 x 0,1 x 0,1)	230	Crane
	17	Assembled PV block		130	Crane
	18	Glass partition wall	16 x (1,20 x 3)	16 x 108 = 1728	Crane
	19	Glass façade block	18 x (1,20 x 3,33)	18 x 220 = 3960	Crane
	20	Bathroom elements	245 x 0,65 x 2,25	300	Forklift
	21	Kitchen elements	2,50 x 0,65 x 0,80	350	Forklift
	22	Movable elements	2,45 x 0,65 x 2,25	250	Forklift
	23	Sofa	2,10 x 0,85 x 0,80	75	Forklift
	24	Kitchen table and chairs	1,10 x 0,50 x 0,95	120	Forklift
	25	Home TV block	2,45 x 0,65 x 2,30	160	Forklift

2. VEHICULES		TYPE	DIMENSIONS [m] (Tractor unit + Trailer)	WEIGHT [kg] (Truck + Loading)
	1	Truck 1	16x2,45x4,20	40 000
	2	Truck 2	16x2,45x4,20	40 000
	3	Truck 3	16x2,45x4,20	40 000
	4	Truck 4	16x2,45x4,20	40 000
	5	Truck 5	16x2,45x4,20	40 000
	6	Truck 6	16x2,45x4,20	40 000

	7	Truck 7	16x2,45x4,20	40 000
	8	Truck 8	16x2,45x4,20	40 000
	9	Truck 9	16x2,45x4,20	40 000
	10	Truck 10	16x2,45x4,20	40 000
3. CRANES			CAPACITY	USAGE TIME
	1	Crane provided by SDE 2014 Organization	35 Tn	

			PHASE	MATERIAL AND EQUIPMENT RESOURCES	HUMAN RESOURCES	DURATION
4. GENERAL DESCRIPTION OF THE PHASE	ASSEMBLY	1	Site preparation	Steel, Wood, PVC, Forklift, Mobile Crane, Pallet Truck, Hand Tools	N/A	3 h
		2	House foundation	Steel, Wood, Pallet Truck, Hand Tools	N/A	4 h
		3	Floor panels assembly	Wood, Insulation, PCM, Steel, Mobile Crane, Hand Tools	N/A	2,5 h
		4	Vertical structure assembly-columns	Wood, Steel, Froklift, Alluminium telesopic ladder	N/A	2 h
		5	Vertical structure assembly- shear walls	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	3 h
		6	Plumbing system	Hand Tools	N/A	10 min
		7	Wooden partition walls assembly	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	1,5 h
		8	Placing of engine system room	Pallet Truck, Froklift, Hand Tools	N/A	3,5 h
		9	Roof panels assembly	Wood, Steel, Scaffolding, Mobile Crane, Hand Tools	N/A	5 h
		10	Northern wall insulation panels assembly	Wood, Steel, Insulation Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	2 h
		11	Glass partition walls assembly	Glass, Forklift, Alluminium telesopic ladder, Hand Tools	N/A	7 h
		12	Outer glass façade assembly	Glass,Mobile Crane, Alluminium telesopic ladder, Hand Tools	N/A	10,5 h
		13	Active roof assembly	PV Panels, Aluminium Structure, Steel, Scaffolding, Mobile Crane, Hand Tools	N/A	7 h
		14	Wooden façade assembly	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	2 h
		15	Suspended ceiling assembly	Canvas, Alluminium telesopic ladder, Hand Tools	N/A	3 h
		16	Winter garden works	PVC, Wood, Gravel, Plants, Pallet Truck, Froklift, Hand Tools	N/A	4,5 h
		17	Installation and system setup	Electrical Equipment, Hand Tools	N/A	6 h
		18	Bathroom elements setup	Inox, Ceramic, Froklift, Pallet Truck, Hand Tools	N/A	3 h
		19	Floor covering	Wood, Froklift, Pallet Truck, Hand Tools	N/A	2 h
		20	Interior furniture assembly and setup	Wood, , Froklift, Hand Tools	N/A	2 h
		21	Decking assembly	PVC, Wood, Steel, Froklift, Pallet Truck, Hand Tools	N/A	13 h
		22	Canvas façade assembly	Canvas, Steel, Alluminium telesopic ladder, Hand Tools	N/A	1,5 h
		23	Assembly Revision and Site Cleaning	Pallet Truck, Forklift	N/A	8 h

DISASSEMBLY	1	Canvas façade disassembly	Canvas, Steel, Alluminium telesopic ladder, Hand Tools	N/A	1 h
	2	Decking disassembly	PVC, Wood, Steel, Froklift, Pallet Truck, Hand Tools	N/A	7 h
	3	Interior furniture removal	Wood, , Froklift, Hand Tools	N/A	2 h
	4	Floor covering removal	Wood, Froklift, Pallet Truck, Hand Tools	N/A	1 h
	5	Bathroom elements removal	Inox, Ceramic, Froklift, Pallet Truck, Hand Tools	N/A	2 h
	6	Installations and systems removal	Electrical Equipment, Hand Tools	N/A	1,5 h
	7	Winter garden works	PVC, Wood, Gravel, Plants, Pallet Truck, Froklift, Hand Tools	N/A	5,5 h
	8	Suspended ceiling disassembly	Canvas, Alluminium telesopic ladder, Hand Tools	N/A	1 h
	9	Wooden facade disassembly	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	2 h
	10	Active roof disassembly	PV Panels, Aluminium Structure, Steel, Scaffolding, Mobile Crane, Hand Tools	N/A	3 h
	11	Outer glass facade disassembly	Glass,Mobile Crane, Alluminium telesopic ladder, Hand Tools	N/A	7,5 h
	12	Glass partition walls disassembly	Glass, Forklift, Alluminium telesopic ladder, Hand Tools	N/A	5 h
	13	Northern wall insulation panels assembly	Wood, Steel, Insulation Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	1,5 h
	14	Roof Panels assembly	Wood, Steel, Scaffolding, Mobile Crane, Hand Tools	N/A	4 h
	15	Engine system room removal	Pallet Truck, Froklift, Hand Tools	N/A	1 h
	16	Wooden partition walls disassembly	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	1 h
	17	Plumbing system removal	Hand Tools	N/A	10 min
	18	Vertical structure disassembly – shear walls	Wood, Steel, Froklift, Alluminium telesopic ladder, Mobile Crane, Hand Tools	N/A	2,5 h
	19	Vertical structure disassembly –columns	Wood, Steel, Froklift, Alluminium telesopic ladder	N/A	1,5 h
	20	Floor panels disassembly	Wood, Insulation, PCM, Steel, Mobile Crane, Hand Tools	N/A	2 h
	21	House foundation disassembly	Steel, Wood, Pallet Truck, Hand Tools	N/A	2 h
	22	Site cleaning	Steel, Wood, PVC, Forklift, Mobile Crane, Pallet Truck, Hand Tools	N/A	5 h

10 HEALTH & SAFETY PLAN

10.1 Health and Safety Checklist

LEGAL CONTENTS	LEGAL CONTENTS LOCATION IN THE REPORT OR IN DRAWINGS
Name and address of SDE 2014, HS Coordinator, Prevention authorities, Team	HS Report 10.2 General Data of the Project
Number of workers	HS Report 10.5.1 Construction Plan: Determination of work effective timing 10.5.3 Number of Team members taking part in construction
Contact information of the Site Operations Coordinator	HS Report 10.2 General Data of the Project
Description of works	HS Report 10.4.8 Planned activities
First aid procedure	HS Report 10.12.4 Accident victims evacuation
Name and number of first aid certificated worker	To be determined!
Description of the Team's first aid kit.	HS Report 10.12.2 First aid bag
Description of hygiene conditions (toilet, changing room, restroom...)	HS Report 10.4.3 Site Description
Detailed description of operating modes	HS Report 10.4.8 Planned activities HS Drawings: HS-403 – HS-447 HEALTH AND SAFETY DURING ASSEMBLY / MAINTENANCE / DISASSEMBLY
Risk assessment – risks generated by other	HS Report 10.6 Risk identification and efficacy evaluation of the adopted protections HS Report 10.7 Critical work phases for risk prevention HS Report 10.13 Risk identification for possible later works HS Report Annex 1 HS Report Annex 2
Risk assessment – risks generated by environment	HS Report 10.6 Risk identification and efficacy evaluation of the adopted protections HS Report 10.7 Critical work phases for risk prevention HS Report 10.13 Risk identification for possible later works HS Report Annex 1 HS Report Annex 2
Risk assessment – risks generated on other	HS Report 10.6 Risk identification and efficacy evaluation of the adopted protections HS Report 10.7 Critical work phases for risk prevention HS Report 10.13 Risk identification for possible later works HS Report Annex 1 HS Report Annex 2
Risk assessment – self generated risks	HS Report 10.6 Risk identification and efficacy evaluation of the adopted protections

	HS Report 10.7 Critical work phases for risk prevention HS Report 10.13 Risk identification for possible later works HS Report Annex 1 HS Report Annex 2
Procedures to adapt collective protection	HS Report Annex 1 HS Report Annex 2 HS Drawings: HS-403 – HS-447 HEALTH AND SAFETY DURING ASSEMBLY / MAINTENANCE / DISASSEMBLY

10.2 General Data of the Project

Table 79 - General data of the Project

Project Name		Membrain
Project Developer		Team UNIZG
Faculty advisor		MladenJošić, prof.
Project Manager		Ivan Ivić, mag.ing.aedif.
Student Team Leader		Hrvoje Nikola Vučemilo
HS Plan Developer		Construction Management Team
Construction Management Team Members		KristijanJurić, mag.ing.aedif. (Team Leader)
		Viktor Pernjek, univ.bacc.ing.aedif.
		Velimir Šilec, univ.bacc.ing.aedif.
		Ivan Ivanov, univ.bacc.ing.aedif.
		Nino Kovačić, univ.bacc.ing.aedif.
		Sonja Kolarić, univ.bacc.ing.aedif.
Period of execution of the construction work	**Assembly**	Max. 10 days
	Disassembly	Max. 5 days
Type of the construction work		Prefabricated housing
Place of the construction work		La Cité du Soleil®, Versailles, France

The Team UNIZG Health and Safety Coordinator are:

Ivan Ivanov, univ. bacc. ing. aedif.

Tel: +385 98 976 3109

e-mail: ivan.ivanov@membrain.com.hr

Matej Mihić, mag. ing. aedif.

Tel: +385 98 1605 415

e-mail: matej.mihic@grad.hr

Constuction site in Croatia:

Zagreb Fair

Avenija Dubrovnik 15

10000 Zagreb, Hrvatska

Tel: +385 (0)1 6503 111

Emergency call in Croatia:

For police, ambulance or

fire department call 112

Address of the nearest hospital:

KBC Sestre milosrdnice

Vinogradska cesta 29

10000 Zagreb, Croatia

Construction site in France:

Le Cité du Soleil®

Domaine du château de Versailles

Allée des Matelots

78000 Versailles, France

Emergency call in France:

Emergency: 112

Police: 17

SAMU: 15

Fire department: 18

Address of the nearest hospital:

Centre Hospitalier de Versailles

177 Rue de Versailles

78150 Le Chesnay, France

10.3 Health and Safety Plan Objectives

This Health and Safety Plan is established in compliance with rule 52 of the Solar Decathlon Europe 2014, with respecting regulation based on the International Labour Organization (ILO) and the corresponding European directives.

The main goal of the Health and Safety Plan is to prevent and avoid any possible risks, professional accidents, etc. that might arise during the material testing and production, transport from Zagreb to Versailles, the house assembly, exhibition, disassembly or any subsequent maintenance tasks.

Health and Safety Plan will help to carry out every task under the health and safety adequate conditions and this document tries to:

- Clearly show all phases and processes of the project execution.
- Identify the avoidable risks and define safety measures to avoid them.
- Identify the unavoidable risks and present how to reduce their impact on the Project.
- Define the necessary protective equipment.
- Define adequate safe working conditions at any time.
- Define evacuation plan.
- Define planned measures in case of accident.
- Provide each participant in material testing and production phase and each participant on site with the training and information needed to carry out their work in the safest way possible, following regulations in a coordinated manner.
- Provide each participant in material testing and production phase and each participant on site with the training and information needed to know how to behave in case of risk or accident.

10.4 Conditions of the site where construction will take place, and interesting data related to the prevention of risks during the construction process

10.4.1 Constructive process

Construction process of Mem**brain** prototype consists of several phases that are summed up in 23 phases as following:

Table 80 - Assembly Phases

Constructive phase	Explanation	Corresponding HS Drawing
1. Site preparation	Site´s boundary fencing, Previous security means introduction, tool and waste containers, toilets and first aid tent	HS - 403
2. House foundation	Unloading and placement of foundations and geotextile	HS - 404
3. Floor panels assembly	Unloading and placement of house floor panels and their insulation	HS – 405
4. Vertical structure assembly - columns	Unloading and placement of load bearing columns	HS – 406
5. Vertical structure assembly – shear walls	Unloading and placement of shear walls	HS – 407
6. Plumbing system	Unloading and installation of plumbing system box	HS – 408
7. Wooden partition walls assembly	Unloading and placement of wooden partition walls	HS – 409
8. Placing of engine system room	Unloading and placement of the systems of engine room	HS – 410
9. Roof panels assembly	Unloading and placement of the 5 roof panels with insulation and PCM	HS – 411
10. Northern wall insulation panels assembly	Unloading and placement of the insulation panels	HS – 412
11. Glass partition walls assembly	Unloading and placement of glass partition walls	HS – 413
12. Outer glass facade assembly	Unloading and placement of outer glass partition	HS – 414
13. Active roof assembly	Unloading and assembling of all components of the active roof	HS – 415
14. Wooden facade assembly	Unloading and placement of outer wood panels	HS – 416
15. Suspended ceiling assembly	Unloading and placement of suspended ceiling	HS – 417
16. Winter garden works	Unloading and placement of winter garden floor, elements and flowerpots	HS - 418
17. Installations and systems setup	Unloading and setup of prototype installations and systems and their testing	HS – 419
18. Bathroom elements setup	Unloading and placement of bathroom elements	HS – 420

19. Floor covering	Unloading and placement of bathroom tiles and parquet	HS – 421
20. Interior furnishing assembly and setup	Unloading, assembly and placement of furniture	HS – 422
21. Decking assembly	Unloading and placement of terrace construction carriers, terrace floor panels, stairways and ramps	HS – 423
22. Canvas facade assembly	Unloading and placement of the canvas facade elements	HS - 424
23. Site cleaning	Cleaning of the site	HS - 425

10.4.2 Type and characteristic of the materials and elements

Table 81 - Type and characteristic of the materials and elements

	NAME	MATERIAL	DIMENSIONS [m]	WEIGHT [kg]
1	Foundations	Steel and wood	42 x (0,65 x 0,65 x 0,35)	42 x 25 = 1050
2	Tool Container	Steel	2 x 2 x 3	1000
3	Waste containers	PVC	5 x 0,6 x 0,6 x 0,8	5 x 10 = 50
4	Water containers	PVC	2 x (1,2 x 1,2 x 1)	2 x 1500 = 3000
5	Tent	PCV	2 x 4 x 3	80
6	Floor panels	Wood, insulation	2 x (7,20x1,27,5x0,36) + 3 x (7,20 x 2,55 x 0,36)	2 * 1000 + 3 * 2000 = 8000
7	Roof panels	Wood, insulation	2 x (7,20x1,27,5x0,30) + 3 x (7,20 x 2,55 x 0,40)	2 * 1000 + 3 * 2000 = 8000
8	Columns	Wood	24 x (3 x 0,12 x 0,20)	24 x 36 = 864
9	Shear wall	Wood	2 x (0,94 x 0,2 x 3) + 4 x (1 x 0,2 x 3) + 5 x (1,07 x 0,2 x 3)	9 x 220= 1980
10	Partition wall	Wood	5 x (1,2 x 3 x 0,12)	5 x 170 = 750
11	Heat pump	/	0,6 x 0,5 x 0,8	50
12	Heat exchanger	/	0,2 x 0,4 x 0,4	20
13	Washing machine	/	0,85 x 0,6 x 0,6	75
14	DHW tank	/	0,7 x 1,5	350
15	Energy storage tank	/	0,4 x 1,2	
16	Aluminium rails	Aluminium	4 x(7,40 x 0,1 x 0,1)	230
17	Assembled PV block	Aluminium		130
18	Glass partition wall	Glass	16 x (1,20 x 3)	16 x 108 = 1728
19	Glass façade block	Glass	18 x (1,20 x 3,33)	18 x 220 = 3960

20	Bathroom elements	Inox, Ceramics	245 x 0,65 x 2,25	300
21	Kitchen elements	Wood	2,50 x 0,65 x 0,80	350
22	Movable elements	Wood	2,45 x 0,65 x 2,25	250
23	Sofa	Wood	2,10 x 0,85 x 0,80	75
24	Kitchen table and chairs	Wood, Inox	1,10 x 0,50 x 0,95	120
25	Home TV block	Wood	2,45 x 0,65 x 2,30	160

10.4.3 Site description

The following description refers to the different Phases of the section 10.4.1. of this document.The pre-stages of manufacturing the Mem**brain** prototype.

The stages mentioned in section 10.5.1 will be performed in the La Cité du Soleil. Inside the La Cité du Soleil®, Mem**brain** prototype will be assembled and disassembled at the lot designed by the organization. Its dimensions are 20x20m. Near to lot is the stock area which dimensions are 10x20 m.

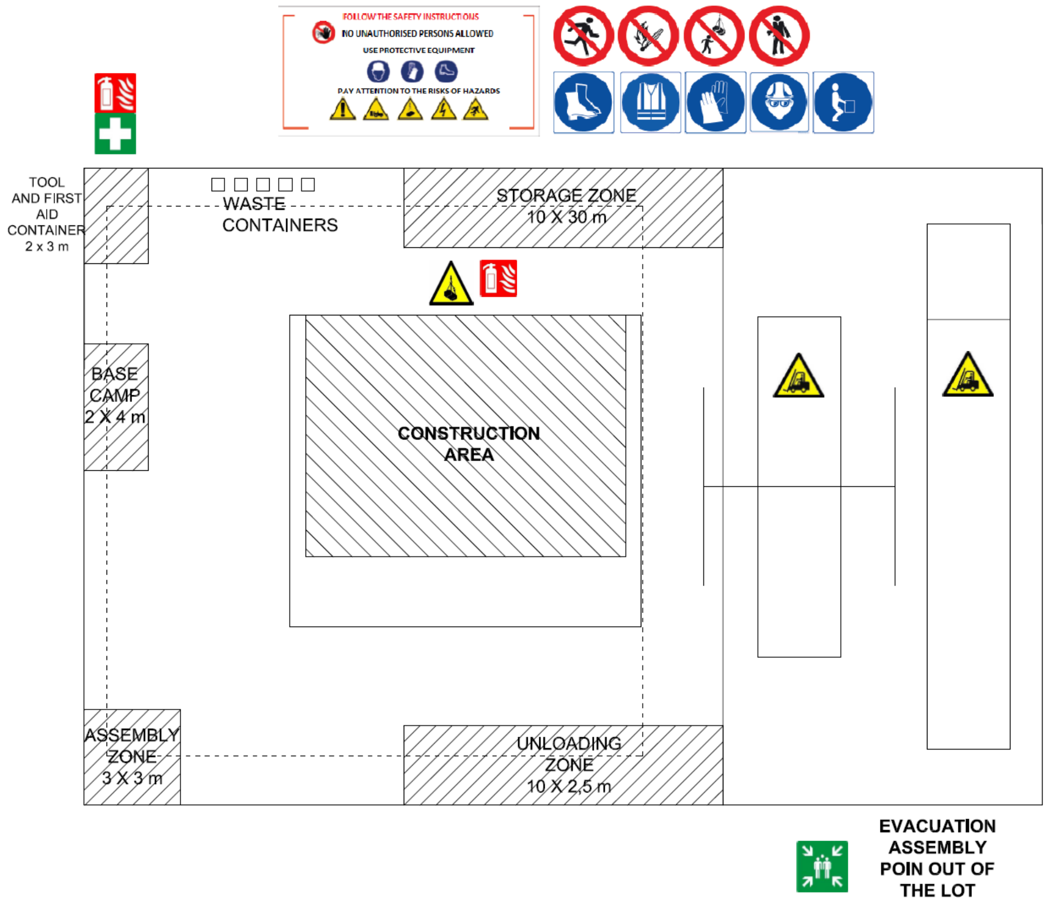


Figure 270. – Site description and site arrangement on lot S3 (assumed lot)

Lot´s boundaries (we assume that our lot is Lot S3; The SDE 2014 Organization has not specified Team UNIZG lot yet):

- Northern boundary: open area
- Southern boundary: open area and access to the lot
- Eastern boundary: open area
- Western boundary: a lot of other team.

According to General coordination plan MOE and MOA will be responsible for providing facilities for cooperants on building site.

Facilities will be installed, held and maintained during the work on site.

They consist of:

- Building site platform
- Parking for staff vechiles . It will be illuminated and clearly defined. Also, it will be on safe distance from construction vechiles, operating machines and with direct access from public road
- Construction site offices
- Sanitation facilities (WC, showers, washbasins and common changing rooms)
- Common cantines for construction site staff (team+cooperants)

Installations d'accueil dans les chantiers		*Durée du chantier* > 4 mois	< 4 mois	*Observations*
Tous les locaux		X	X	Aéré, éclairé et chauffé ; tenu dans un état de propreté constant.
			X	Si les locaux fixes ne sont pas adaptés, possibilité d'utiliser des véhicules de chantier spécialement aménagés à cet effet qui doivent pouvoir répondre aux mêmes besoins. Pour un chantier de travaux souterrains le local vestiaire doit se trouver au jour. Le local en sous sol n'est toléré qu'exceptionnellement à défaut d'autres solutions. Il n'est accepté que s'il est possible de l'aérer et de l'éclairer convenablement et de le tenir propre.
Local vestiaires	Armoires vestiaires	X	X	Ininflammables, à 2 compartiments
			X	Si le chantier est trop exigu pour des armoires, possibilité de les remplacer par des patères en nombre suffisant.
	Sièges	X	X	En nombre suffisant, nettoyage après chaque repas.
Local réfectoires	Tables et chaises	X	X	En nombre suffisant, nettoyage après chaque repas
	Appareil de réchauffage ou de cuisson	X	X	Chauffe gamelle, cuisinière, micro ondes…avec consignes d'utilisation
	Eau potable fraîche et chaude	X	X	Un robinet pour 10 usagers conseillé (OPPBTP) (obligatoire dès que 25 salariés prennent leur repas)
	Garde manger ou réfrigérateur	X	X	Réfrigérateur conseillé (OPPBTP)
Eau potable	Pour la boisson	X	X	Eau potable fraîche, 3 litres au moins par jour et par travailleur
Sanitaires	Lavabos	X	X	Lavabos , 1 au moins pour 10 travailleurs ou système de rampes équivalent.
	Eau pour se laver	X	X	Eau courante à température réglable
			X	Si l'eau courante est impossible, possibilité de se raccorder sur un réservoir avec quantité suffisante. Si possible, l'eau doit être à température réglable.
	Moyens de nettoyage, séchage, essuyage	X	X	Savon liquide adapté, rouleaux tissu ou séchoirs électriques adaptés.
Cabinets d'aisance WC, urinoirs.		X	X	Un cabinet et un urinoir pour 20 (ou 2 cabinets) Papier hygiénique Un cabinet au mois avec poste d'eau
Douches		X	X	Installations conseillées 1 douche pour 3 personnes est obligatoire pour les travaux salissants, insalubres….

Figure 271 - Facilities and appliances on site

10.4.4 Climatology description

The following description refers to the Phases of the section 10.4.1. of this document.

Assembly Phases from 1st to 23rd and Disassembly Phases 1st to 22nd will be performed between June 15 and July 20, 2014 (approximated period).

The figures below show climatological data important for the mentioned stages.

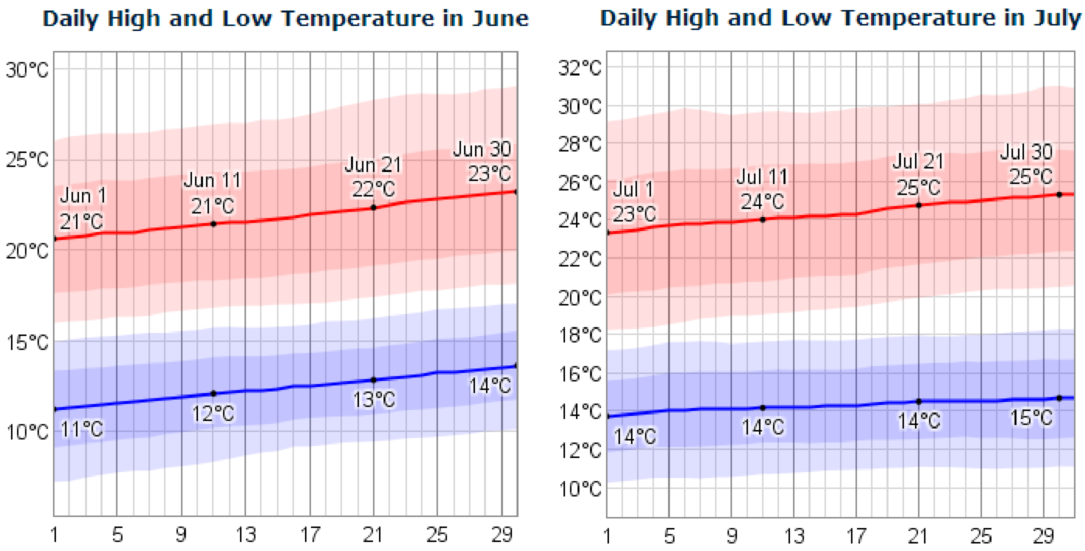


Figure 272 - Average low (blue) and high (red) temperature in June and July for Paris, France (data collected from weatherspark.com)

The month of June is characterized by rising daily high temperatures, with daily highs increasing from 21°C to 23°C and over the course of the month, exceeding 29°C or dropping below 16°C only one day in ten. Daily low temperatures range from 11°C to 14°C, falling below 7°C or exceeding 17°C only one day in ten.

The month of July is characterized by gradually rising daily high temperatures, with daily highs around 24°C throughout the month, exceeding 31°C or dropping below 18°C only one day in ten. Daily low temperatures are around 14°C, falling below 10°C or exceeding 18°C only one day in ten.

Probability of Precipitation at Some Point in the Day in June

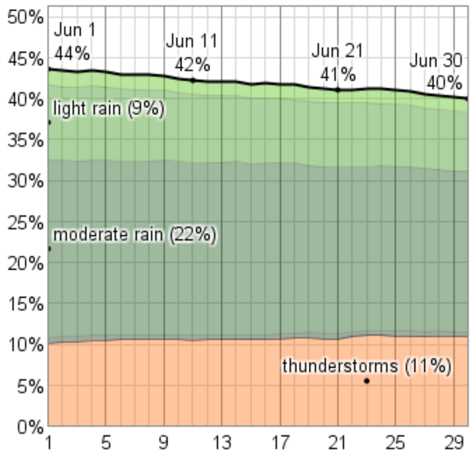


Figure 273 - Probability of Precipitation at Same Point in the Day in June for Paris, France (data collected from weatherspark.com)

In June the average probability that some form of precipitation will be observed in a given day is 42%, with little variation over the course of the month. Throughout June, the most common forms of precipitation are moderate rain, thunderstorms, and light rain.

Moderate rain is the most severe precipitation observed during 49% of those days with precipitation. It is most likely around June 1, when it is observed during 22% of all days. Thunderstorms are the most severe precipitation observed during 25% of those days with precipitation. They are most likely around June 23, when it is observed during 11% of all days. Light rain is the most severe precipitation observed during 19% of those days with precipitation. It is most likely around June 1, when it is observed during 9% of all days.

Probability of Precipitation at Some Point in the Day in July

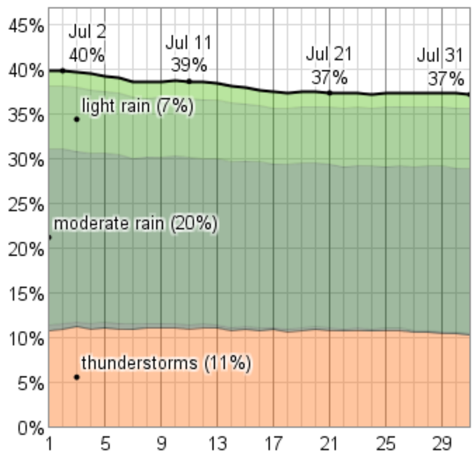


Figure 274 - Probability of Precipitation at Same Point in the Day in July for Paris, France (data collected from weatherspark.com)

In July the average probability that some form of precipitation will be observed in a given day is 38%, with little variation over the course of the month.Through out July, the most common forms of precipitation are the same as in June.

Moderate rain is the most severe precipitation observed during 49% of those days with precipitation. It is most likely around July 1, when it is observed during 20% of all days. Thunderstorms are the most severe precipitation observed during 28% of those days with precipitation. They are most likely around July 3, when it is observed during 11% of all days. Light rain is the most severe precipitation observed during 17% of those days with precipitation. It is most likely around July 3, when it is observed during 7% of all days.

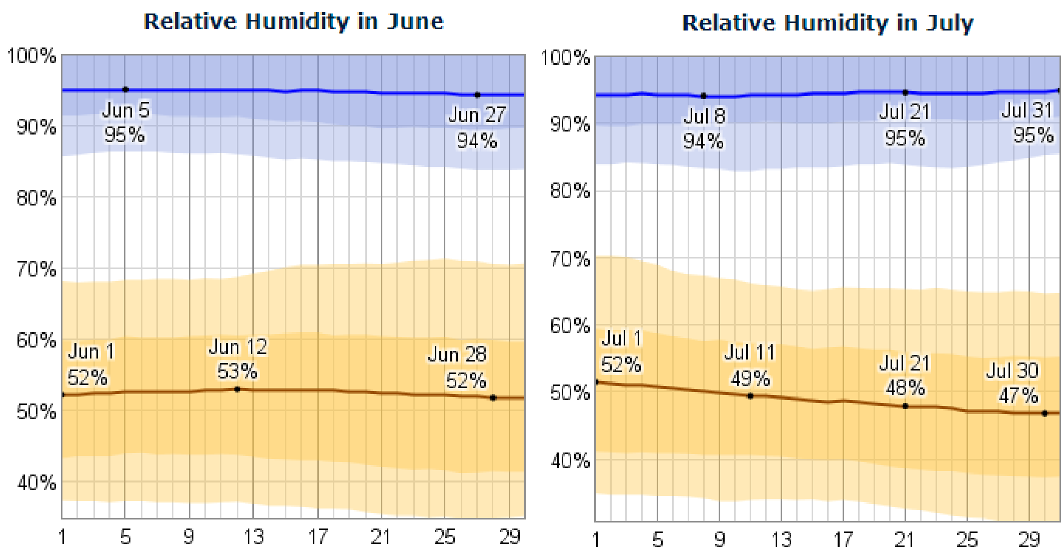


Figure 275 - Average high (blue) and low (brown) relative humidity in June and July for Paris, France (data collected from weatherspark.com)

The relative humidity typically ranges from 52% (mildly humid) to 95% (very humid) over the course of a typical June, rarely dropping below 35% (comfortable) and reaching as high as 100% (very humid). The air is driest around June 28, at which time the relative humidity drops below 60% (mildly humid) three days out of four; it is most humid around June 5, rising above 92% (very humid) three days out of four.

The relative humidity typically ranges from 47% (comfortable) to 95% (very humid) over the course of a typical July, rarely dropping below 31% (comfortable) and reaching as high as 100% (very humid). The air is driest around July 30, at which time the relative humidity drops below 55% (mildly humid) three days out of four; it is most humid around July 31, rising above 91% (very humid) three days out of four.

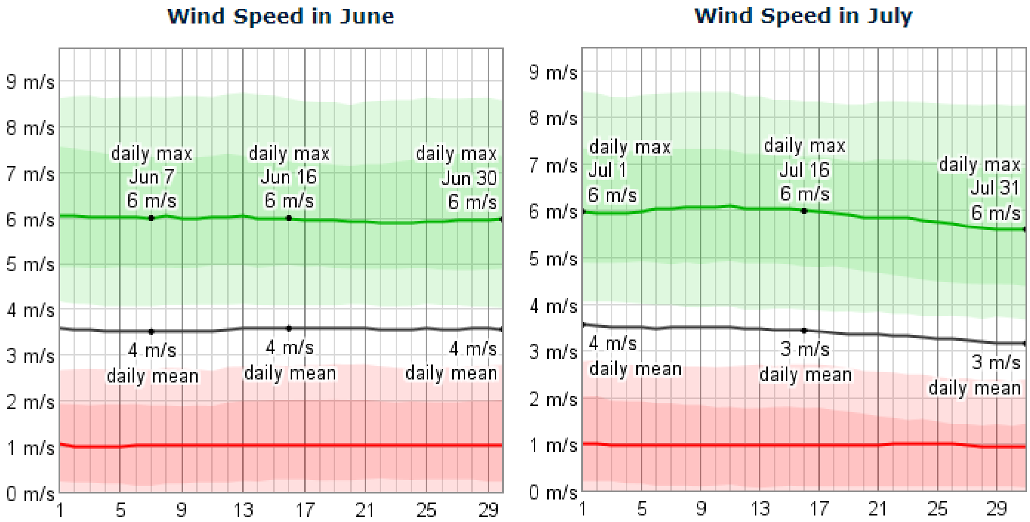


Figure 276 - Average minimum (red), maximum (green) and average (black) Wind Speed in June for Paris, France (data collected from weatherspark.com)

Over the course of June typical wind speeds vary from 1 m/s to 6 m/s (light air to moderate breeze), rarely exceeding 9 m/s (fresh breeze).The highest average wind speed of 4 m/s (gentle breeze) occurs around June 1, at which time the average daily maximum wind speed is 6 m/s (moderate breeze).The lowest average wind speed of 4 m/s (gentle breeze) occurs around June 7, at which time the average daily maximum wind speed is 6 m/s (moderate breeze).

Over the course of July typical wind speeds vary from 1 m/s to 6 m/s (light air to moderate breeze), rarely exceeding 9 m/s (fresh breeze).The highest average wind speed of 4 m/s (gentle breeze) occurs around July 1, at which time the average daily maximum wind speed is 6 m/s (moderate breeze).The lowest average wind speed of 3 m/s (light breeze) occurs around July 31, at which time the average daily maximum wind speed is 6 m/s (moderate breeze).

According to the given climatology description for Paris in the months of June and July below are preventive measures depending on the weather during the work processes:

PREVENTIVE MEASURES FOR THE HEAT AND SUNNY DAYS

- Drink water frequently
- Wear 100% cotton clothes, long-sleeve shirts and long trousers
- For parts of the body directly exposed to the sun, use sun protection, and apply it frequently (several times per day)
- Try work in shade places if it is possible

PREVENTIVE MEASURES FOR WINDY, RAINY AND STORMY DAYS

- If it´s less rainy day wear work raincoat and avoid works or tasks with electric tools or machinery outside the house

- If it´s very rainy day work only under cover and inside the house
- In case of storm no works will be allowed

10.4.5 Accesses and paths for vehicles

To be developed in next deliverable (The SDE 2014 Organization has not specified Team UNIZG lot yet).

10.4.6 Determining factors for the house placing

The factors to emphasize in this section are referred about characteristics and environment of the lot:

1. Lot's soil characteristics:

- House footings will be set up on the top soil without ground excavation nor penetration. Height differences of the top soil are between 40 and 60 cm. SD organization will provide a leveled platform on the construction site where the prototype will be assembled.
- Possible influence on the Health and Safety.

Health and Safety measures: After assembly of the foundation, other work processes can be continued after detailed verification and inspection by the SDE 2014 Organization. As assembly of the house progresses it is necessary to monitor possible height deformations adjust the height of the foundations.

2. Lot's location – our lot is still not defined!

10.4.7 Overlaps with the affected services and other circumstances or activities o the environment, able to cause risks during the construction

To be developed in next deliverable.

10.4.8 Planned activities

Assembly phase:

<u>Phase 1: Site preparation (Corresponding drawing: HS - 403)</u>

First, we will install the security fence around the construction site. The next step is unloading and placement of tool, safety accessory and storage containers and construction of the base camp. While the work is in progress, the site will be safeguarded by the team members and the electricians will install the electrical distribution cables and spotlights for works performed during night hours. Afterwards, the prototype boundaries will be specified.

Phase 2: House foundation (Corresponding drawing: HS - 404)

After measuring the boundaries of the prototype, the foundation system will be installed using theodolithe and laser meter. The 45 high adjustable foundation steel elements of portable weight will be placed by hand at predetermined positions.

Phase 3: Floor panels assembly (Corresponding drawing: HS - 405)

The 5 prefabricated floor panels,consisting of load bearing wooden plate, thermal insulation and hydro isolation, will be unloaded from the truck and placed during this phase. It's a critical phase because these panels are large and heavy (as specified in chapter 10.6.2.). First, we will implement the central panel and then we will start implementing west and east panels. We will seal these panels with each other mechanically using a steel connection system. Once the floor panels are placed and connected they will be leveled with the adjustable foundations.

Phase 4: Vertical structure assembly - columns (Corresponding drawing: HS - 406)

In this phase the vertical load bearing columns walls will be unloaded from the trucks one by one and placed in predetermined positions. The order in which the columns will be installed is described in the site operation plan in details. It is critical that the columns are placed with no vertical inclination.

Phase 5: Vertical structure assembly – shear walls (Corresponding drawing: HS - 407)

After the placement of columns the shear walls will be inserted and connected between the columns on the northern side of the prototype making a compact wall unit that will provide horizontal stability.

Phase 6: Plumbing system placement (Corresponding drawing: HS - 408)

Unloading and placement of the plumbing system box in position on the northern wall of the prototype. The plumbing system box will assure more precisely placement of the northern wooden partition walls.

Phase 7: Wooden partition walls assembly (Corresponding drawing: HS - 409)

After load bearing columns and shear wall are assembled, the wooden partition walls, which separate the system room and bathroom from residual part of the prototype, will be unloaded from trucks by the crane and placed in numbered order at determined position at the northern side of the prototype.

Phase 8: Placing of engine system room (Corresponding drawing: HS - 410)

The next phase is placement of the system engine room which is transported as a prebuilt unit to the construction site. Unloading of the system engine room and its placement will be done by the crane at the determined place taking care of safety measures during the process.

Phase 9: Roof panels assembly (Corresponding drawing: HS - 411)

First, temporary construction support will be installed on some wooden columns to provide safety and stability during this phase. In this phase 5 prefabricated roof panels, consisting of load bearing wooden plate, thermal insulation and active roof carriers, will be unloaded from the truck by the crane, taking care of necessary safety measures, and placed in predetermined order. It's also a critical phase because these panels are large and heavy (as specified in chapter 10.4.2.). First, we will implement the central panel and then we will start implementing west and east panels in a similar process described as in Phase 3. We will seal these panels with each other mechanically using a steel connection system. Once the panels are placed and connected hydro isolation will be rolled and sealed on top of the constructed roof. During the assembly of the panels no other work on the prototype should be carried out as a critical safety measure.

After roof is assembled, steel braces will be mounted between the wooden columns to provide safety and stability of the house.

Phase 10: Northern wall insulation panels assembly (Corresponding drawing: HS - 412)

In this phase the insulation boxes/panels will be unloaded form the truck and placed in determined position accordingly to the site operation plan. It will be performed using the crane and taking care of necessary safety measures.

Phase 11: Glass partition walls assembly (Corresponding drawing: HS - 413)

In this phase the glass partition walls, which make the mem**brain** of the prototype, will be unloaded from trucks by the forklift, carried by pallet trucks to predetermined place and installed one by one in order specified as in the site operation plan. It is imperative to handle with the glass walls with caution using necessary equipment described in the Health and Safety plan. Individual glass partition walls have to be installed without vertical inclination to allow connection with other glass elements.

Phase 12: Outer glass facade assembly (Corresponding drawing: HS - 414)

In the next phase the outer glass facade will be mounted in place. The singular elements will be unloaded by crane from the truck and placed one by one in determined positions as in the site operation plan. As the elements are hard to manipulate with, necessary safety equipment for handling, as defined in the health and safety plan, will be mandatory to use. The glass elements will be connected with each other by water resistant silicone providing impermeability

Phase 13: Active roof assembly (Corresponding drawing: HS - 415)

This phase consists of connecting prefabricated active roof components with preinstalled photovoltaic plates to the carriers on the roof panels. The 6 prefabricated modules will be unloaded from the truck by crane and placed at the determined position. As this phase is carried out at the roof of the prototype, necessary use of high safety equipment will be imperative for the workers.

Phase 14: Wooden facade assembly (Corresponding drawing: HS - 416)

Outer wooden panels will be unloaded from truck and placed by the crane in predefined positions on the outer side of the northern wall. Prefabrication of the panels is planned to shorten the assembly time and assure safety for the workers.

Phase 15: Suspended ceiling assembly (Corresponding drawing: HS - 417)

In this phase the fireproof suspended ceiling, which covers the view of the installations and systems set up on the roof of the residual area of the prototype, will be placed and connected to the carriers on the roof panels. The carriers of the suspended ceiling are included in the roof panels assembled in phase 8 and therefor placing and connecting the suspended ceiling will be simpler and safer for workers. For this job safety ladders will be used as a measure of caution.

Phase 16: Winter garden works (Corresponding drawing: HS - 418)

The Air duct will be unloaded manually from the truck and placed on the floor of the winter garden. Then floor under structure will be placed. Gravel will be transported in bags and manually carried and dissipated in place. After the flooring is finished flowerpots with plants will be mounted.

Phase 17: Installations and systems setup (Corresponding drawing: HS - 419)

The next phase consists of installing and connecting different systems/installations which are required for operability of the prototype. The underfloor heating elements will be installed in the residual area and connected with the engine system room. Electrical systems will be manually connected by certified electricians. Every work phase will be performed by certified workers and necessary safety measures will be assured.

Phase 18: Bathroom elements setup (Corresponding drawing: HS - 420)

The bathroom elements will be manually unloaded from the truck and carried inside the prototype bathroom where they will be installed as predetermined positions.

Phase 19: Floor covering (Corresponding drawing: HS - 421)

After the installations are placed and connected, the floor covering will be unloaded from trucks and manually placed on predetermined positions using pallet trucks for help.

Phase 20: Interior furnishing assembly and setup (Corresponding drawing: HS - 422)

The elements will be manually unloaded from the truck and partially assembled on the assembly zone of the lot. After this step the individual elements will be carried inside the prototype using pallet trucks for help and assembled into finished furniture.

Phase 21: Decking assembly (Corresponding drawing: HS - 423)

The last constructive phase will be assembly of the terrace construction carriers and placement of the terrace floor panels. The construction carriers will be unloaded from truck manually by hand, as they are made of hard plastic, and placed in determined positions. After this step the terrace floor panels will be unloaded on pallet trucks and driven to assigned position. Placing of the panels will be also done by hand taking care of maximal allowed weight of one panel.

Phase 22: Canvas facade assembly (Corresponding drawing: HS - 424)

The last phase of assembly of the prototype is mounting of the canvas façade on declared positions using moveable safety ladders. The canvas façade is easy and assembly will therefore be carried out manually.

Phase 23: Assembly Revision and Site cleaning (Corresponding drawing: HS - 425)

Assembly revision and manual cleaning of the site and removal of base camp and equipment container.

Disassembly phase:

The disassembly will take place in the same phase but in opposite order. We must take a special attention during these phases because the disassembly will be done in a shorter period. Other risks are equal to risks mentioned in assembly phases of this section.

Phase 1: Canvas facade disassembly (Corresponding drawing: HS - 426)

The canvas facade will be manually disassembled using safety ladders as a safety measure. It will be transported and loaded into trucks by hand as the canvas facade is light.

Phase 2: Decking disassembly (Corresponding drawing: HS - 427)

The first step of the disassembly of terrace, stairways and access ramp is removing of the terrace fences and floor coverings. The transportation of the elements will be done by forklift or manually if the weight of the elements doesn't exceed the maximal allowed carrying weight. After this step the construction carriers will be manually removed and loaded into the truck.

Phase 3: Interior furnishing removal (Corresponding drawing: HS - 428)

Interior furnishing will be manually disassembled and carried from the prototype using pallet trucks as a help and safety measure. The elements will be packed correspondingly and loaded into the trucks using the crane, forklift or manually. Loading of the elements into the trucks will be performed with caution because of the possibility of falling objects.

Phase 4: Floor covering removal (Corresponding drawing: HS - 429)

This phase consists of removing and loading of the floor covering elements from the residual area. The individual panels will be transported to the truck using pallet trucks and the loading into the truck will be done by the forklift. It is necessary to take care of falling objects.

Phase 5: Bathroom elements removal (Corresponding drawing: HS - 430)

Bathroom will be manually disassembled and carried from the prototype using pallet trucks as a help and safety measure. The elements will be packed correspondingly and loaded into the trucks using the crane, forklift or manually. Loading of the elements into the trucks will be performed with caution because of the possibility of falling objects.

Phase 6: Installations and systems removal (Corresponding drawing: HS - 431)

The systems of the prototype will be disconnected by qualified workers assuring safety.

Phase 7: Winter garden works (Corresponding drawing: HS - 432)

Gravel will be manually removed and loaded into bags which will be transported to the truck using pallet trucks and loaded into the truck. After this step, the floor under structure will be removed manually from the winter garden and transported to the truck. It will be loaded into the truck by forklift taking care of necessary safety measures. The flowerpots with plants will be also removed by hand and transported to the loading/unloading zone from where they will be loaded into the truck.

Phase 8: Suspended ceiling disassembly (Corresponding drawing: HS - 433)

Disassembly will be carried out in the same way as in the assembly phase taking care of necessary safety measures using safety ladders.

Phase 9: Wooden facade disassembly (Corresponding drawing: HS - 434)

Outer wooden panels will be disassembled from the prototype in blocks and loaded to truck by the crane.

Phase 10: Active roof disassembly (Corresponding drawing: HS - 435)

The phase of disassembly of the active roof will be carried out in several steps. First the individual components will be disassembled from the roof and it will be imperative to use necessary safety equipment as a precaution to work on high ground. After this the single panels will be carried by crane to the trucks and loaded in position. It will be mandatory not to stand below the working crane as a safety measure from falling objects or elements.

Phase 11: Outer glass facade disassembly (Corresponding drawing: HS - 436)

Outer glass facade will be disassembled from the prototype individually one by one and loaded to truck by crane taking care of necessary safety measures as described in the Health and Safety plan.

Phase 12: Glass partition walls disassembly (Corresponding drawing: HS - 437)

Glass partition walls will be disassembled from the prototype individually and transported to the trucks using pallet trucks for help. Loading of the individual elements will be carried out by the forklift or crane taking care of the possibility of falling objects/elements.

Phase 13: Northern wall insulation panels assembly (Corresponding drawing: HS - 438)

The insulation panels will be lifted with the crane and loaded into the truck taking care of safety measures as described in the section 10.6. and 10.7.

Phase 14: Roof panel disassembly (Corresponding drawing: HS - 439)

As in the section of assembly, the roof panels will have to be transported into the trucks with great caution as the single elements are very heavy. The roof panel connection between panels will be removed one at the time and the single panel will be transported to the truck and loaded taking care of all necessary safety measures described in the section of risk assessment.

Phase 15: Engine system room removal (Corresponding drawing: HS - 440)

The engine system room of the prototype will be disconnected by qualified workers assuring safety. The individual elements will be transported and loaded into the truck by crane or forklift.

Phase 16: Wooden partition walls disassembly (Corresponding drawing: HS - 441)

The partition walls will be lifted with the crane and loaded directly into the trucks where workers will reach and position single elements into trucks.

Phase 17: Plumbing system removal (Corresponding drawing: HS - 442)

The plumbing system box will be carried and loaded manually from the prototype into the truck.The box will be lifted and positioned into the truck with the forklift.

Phase 18: Vertical structure disassembly – shear walls (Corresponding drawing: HS - 443)

The shear walls will be lifted with the crane and loaded directly into the trucks where workers will reach and position single elements into trucks.

Phase 19: Vertical structure disassembly – columns (Corresponding drawing: HS - 444)

Columns will be detached from the floor panels by 2 workers and manually carried and loaded into the truck.

Phase 20: Floor panels disassembly (Corresponding drawing: HS - 445)

Exactly as the disassembly phase of the roof panels, the floor panels will have to be transported into the trucks with great caution as the single elements are very heavy. The floor panel connection between panels will be removed and the single one by one panel will be transported to the truck and loaded taking care of all necessary safety measures described in the section of risk assessment.

Phase 21: House foundation disassembly (Corresponding drawing: HS - 446)

The foundation system will be manually loaded into the truck by workers because the single element doesn't exceed maximal carrying weight of a worker.

Phase 22: Site cleaning (Corresponding drawing: HS - 447)

The site will be cleaned and everything will be left as it was at the start of the assembly works. Boundary fencing will be removed, containers will be loaded into trucks by the crane and the base camp will be disassembled and loaded into the truck.

10.4.9 Trades whose intervention is affected by the risk prevention

Safety measures must be made or agreed with:

- Team UNIZG,
- With the other teams who are our nearest neighbors and visiting workers,
- With the transport company,
- With supporting companies their will work on-site (crane operator),

- With organizers (general security agreements, jury and the officers),
- Visitors and guests,
- Guides,

Security problems, by which the above-mentioned groups are affected, and possibilities for solving them are shown in charts.

During the assembly, maintenance and disassembly, we may have visitors from some other teams, not related with the work processes. The HS Team Coordinator will be responsible for solving any kind of risks associated to these circumstances. So, the minimum mandatory individual protection to be used by these visitors will be:

- Hard hat,
- Safety boots with ankle support,
- Reflective jacket.

Also, HS Coordinator will ensure that whenever important activities are being developed, visitors shouldn't be inside the lot and shouldn't disturb the activities developed by the rest of people.

10.4.10 Auxiliary resources, tools and machinery planned for the construction

Table 82 - Auxiliary resources, tools and machinery planned for the construction

Auxiliary resources	Where	When	How it will be used	Activites related
Trucks	Will be developed when we will know our lot position	When a truck arrives and waits for being load or unload	The speed of trucks will be adapted to the step of a man, one person shall walk in front of the truck, and another person must walk behind.	Truck arrival/Truck departure
Mobile crane	Will be developed when we will know our lot position	During all the construction	It will be parked on area predicted for crane and it will stay there until the construction will be finished.	Loading and unloading the truck, inner site transport
Forklift	Will be developed when we will know our lot position	When it is not possible to unload/load some of house elements with crane	It will be used to unload/load some house elements from truck and transport them to their assembly place.	Loading and unloading the truck, inner site transport

Mobile scaffolding	Will be developed when we will know our lot position	When planned activities that use scaffolding are in line	It will be placed on the location where work on higher altitudes is required.	All activities that require the scaffolding(See Annex 1)
Base tent	Will be developed when we will know our lot position	During all the constructions	It will be used as site off ice, for reading plans, eating, refreshing, etc.	All activities
Tool and first aid container	Will be developed when we will know our lot position	During all the constructions	It will be used for storage tools and first aid kit.	All activities that require the use of hand tools
Lights	Will be developed when we will know our lot position	During night	It will be used to illuminate the construction site during night	All activities
Waste containers	Will be developed when we will know our lot position	During all construction	It will be used for separate and dispose garbage on construction site	All activities
Hand tools	Hand tools will be stocked in the tool container and it will be used on the entire lot	When a task required it.	Directions for use according to manufacturer's	Most activities

10.4.11 Construction site installations

Electrical power will be available during the assembly and disassembly phases on our lot in a specific Construction Site Box. Electrical installations and lines on construction site need to be designed according to the standards and regulations.

Generators will not be permitted to power auxiliary equipment and construction lights necessary during assembly and disassembly.

Important for construction site installations:

- After using all electric tools should be cleaned and not be left it in humid areas
- Cables that lie on the ground should be protected at the locations where the vehicles cross them
- All electrical devices must be isolated in order to avoid physical contact with parts that are under voltage
- While working with a crane and other construction machinery it is necessary to pay attention to existing installations

10.4.12 Characteristic table for the stocks

To be developed in next deliverable!

Table 83 - Characteristic table for the stocks

Stock characteristic	Dimensions(m)			Weight(kg)	How the stock will be moved	Where the stocks will be placed
	L	W	H			

10.5 Activities for risk prevention

Activities that the team will develop when preparing works:

- Periodic team meetings
- Presentation of all necessary Health and Safety measures
- Work training
- Specific Health and Safety courses
- Previous assembly and disassembly of the house in Zagreb

Activities that the team will develop during the work:

- Previously daily internal meeting with the team members of every shift
- Daily meetings with SDE 2014 Organization
- Monitoring and control of all work processes
- In case of non-resolved situation, analysis of the adequate solution in coordination with SDE 2014 Organization

10.5.1 Construction Plan: determination of work effective timing

Names of workers will be defined in deliverable #5.

Working Team A:

Table 84 - Working Team A

Surname	Name	Charge/Position	ID number	Date of birth
Šilec	Velimir	SO Coordinator		
Mihić	Matej	HS Coordinator		
		Worker (HS Officer)		
		Worker (Electrician)		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		

		Worker		
		Worker		
		Worker		
		Worker		

Working TeamB:

Table 85 - Working Team B

Surname	Name	Charge/Position	ID number	Date of birth
Pernjek	Viktor	SO Coordinator		
Ivanov	Ivan	HS Coordinator		
		Worker (HS Officer)		
		Worker (Electrician)		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		
		Worker		

10.5.2 Overlaps and incompatibilities in the construction

To be developed in next deliverable!

Table 86 - Overlaps and incompatibilities in the construction

Overlaps between activities	Description	Additional risk	Activities developed at the same time	Indications for the activities that cannot be developed at the same time

10.5.3 Number of Team members taking part in construction

See 10.5.1. Construction Plan: determination of work effective timing.

10.5.4 Contracting planned

Planned contracting is with a company that will provide us with crane and other machinery on site through SDE organization, and with the transportation company which will provide us trucks and professional drivers for outside logistics.

Only students from our team will work in assembly, maintenance and disassembly phases of our prototype. No other contractors are planned.

10.6 Risk identification and efficacy evaluation of the adopted protections

10.6.1 Identified risks in processing and related preventive and protective measures

Identified risks in processing and related preventive and protective measures are listed below:

1. Fall of persons at different level
2. Fall of person at the same level
3. Fall of objects because of collapse
4. Fall of objects because they come loose
5. Fall of objects because of manipulation
6. Stepping on objects
7. Colliding with still objects
8. Colliding whit objects in motion
9. Knocked by object or tools
10. Flying fragments or particles
11. Accidents caused by living beings
12. Trapped by or between objects
13. Trapped by turned over machines, tractors or vehicles
14. Overexertion
15. Exposure to extreme environmental temperatures
16. Thermal contact
17. Exposure to electric connection
18. Exposure to radiation
19. Exposure to harmful substance

20. Contact with caustic or corrosive substances
21. Explosion
22. Fire
23. Run over or hit by vehicles
24. Non traumatic pathologies
25. ''In itinere''

Fall of persons at different level

Preventive and protective measures: Injuries due to falls from height for loss of balance stability in the absence of appropriate preventive measures check that the ladders do not show defects. Do not use metal ladders to perform machining operations on elements under tension. Do not work on the ladder astride. No lateral movement of the ladder if it is a worker above. Do not climb on the top step of the ladder. Use the ladder ever turning towards it both in the descent and the ascent. Is not allowed to have more than one worker on the same ladder. The ladder must be provided with a suitable device that will prevent the opening beyond the limit set. If the ground is unstable the scale is placed on a single breakdown table. The rungs of the ladder should be slip resistant. Shall be provided helmets, safety shoes, gloves. The ladders must be stable and bound it was not possible to to constrain it must be retained to the foot by a person who performs the operation during the entire time of use. Ensure the good condition of all elements scaffolding. Ensure that the scaffolding is assembled in all its parts and with all the components provided by the manufacturer. Ensure a perfect flatness and verticality of the structure. Ensure the effectiveness of the locking system of the wheels. Not install any machinery on the scaffold. Before moving the scaffolding make sure that no one is above it, the width should be large enough to resist to the load and providing security to the tip result from all types of oscillation (wind, movement of the structure ...). The sliding plane of the wheels will have to be leveled and compacted. The wheels of the scaffolding must be made of metal and a diameter not less than 20 cm and a thickness of not less than 5 cm, the wheels must be blocked with wedges or stabilizers, must be present on the scaffolding a plate showing the data structure and the characteristics of safety and use. To prevent the extension of the rods they must be equipped with locking with vertical elements, diagonal and horizontal. The security parapet running around the work plan must be accompanied by toe board at least 20 cm high. Access to the floors of the scaffolding must be made by ladders presenting an angle not exceeding 75 °. Should be provided appropriate personnel protective equipment such as helmets and safety shoes (non – slip) and harnesses attached to the elements of the scaffolding. Specify the correct location and shape of the parapets. Indicate access to coverage, indicate the paths to reach the work area indicating overload permitted on the coverage. Provide and indicate devices to constrain the safety harness. Define procedures for implementing of the anchoring system of the PPE fall arrest. Have sub cover networks where possible. The base must be large enough to resist to the load. If you are loading materials on scaffolding use sticks equipped with hooks avoiding leaning out over the protections.

Fall of person at the same level

Injuries due to slips and falls on the work surface, caused by bad conditions of workplace or bad lighting of workplaces.

Preventive and protective measures: must be well defined pedestrian walkways, maintained in good repair and free of materials and obstructions that may present a risk of tripping or slipping. Provide nonslip footwear to the workers. Provide lighting on all 4 sides of construction site to avoid low visibility caused by shadows. The storage area of all materials and positioning of fixed machinery must be performed outside of transit routes so not to create obstacles to working.

<u>Fall of objects because of collapse</u>

Injuries caused from investment of masses due to structural failure.

Preventive and protective measures: the areas that will placed machinery, temporary structures and stored materials shall be maintained in good condition and free from materials and obstructions that may present a risk of loss of balance. Control the routes and areas of operation machinery. Stabilize elements using special devices for machine stability and if necessary extend the support base provided by adequate strength. After use of the crane don't leave suspended loads. Sling correctly the loads on the means of lifting and transport. Verify, after the installation, the efficacy of the attachment of each element on the roof as to avoid the fall. Control the routes and areas for maneuvering, check that all the light and audible warning devices are functioning normally, so you have the driving position is excellent, check all devices and braking controls. On construction site proceed slowly. Ask for intervention of personnel to the ground if you will have to maneuver in confined spaces. Verify that the load is stable on the forklift, otherwise secure it with anchoring systems, belts or plastic film so as to avoid the loss of components during transportation. The load should not be placed on the end of the forks, you should never exceed the maximum load allowed. Announcing the start of the lifting and transportation by appropriate acoustic signal. Keep down the forks during the movements with or without the load. Position the load on the forks according to the conditions of the route, without ever exceeding the maximum load allowed . Check all audible warning devices. Make sure that the visibility from the driving position is excellent. Make sure they are properly disposed all the protection from moving parts. Check the paths and maneuvering areas. Proceed at reduced speed. For maneuvering is required intervention of ground personnel. Operate the Rotating light during the maneuvers of positioning of the vehicle and lifting, delimit the radius of action of the medium. Stabilize the vehicle using the proper equipment and if necessary to provide supporting to extend the base. Announces lifting maneuvers using the appropriate acoustical signal. During night work, use the special lighting devices, follow the rules of the personnel on the ground during lifting and moving cargo.

Fall of objects because they come loose

Lesions caused by the investment of masses falls from height due to loss of the same during the lifting with machinery

Preventive and protective measures: before lifting maneuvers make sure that the cargo has been properly restrained. When lifting the load workers must accompany him outside the areas of interference with the work only as absolutely necessary. During the step of lifting the load, workers must move away quickly. Is forbidden to stand in the path of the load. Is permitted to approach to the load only to guide it towards the area of destination, and only when it is almost reached the target plane. Before lifting the load must be sure in advance of its stability. After commanding the operation of retrieving the hook it must be escorted from the involved area for equipment or materials to avoid accidental hooks.

Fall of objects because of manipulation

Injuries caused by the investment of the masses falls from height due to an improper use of equipment.

Preventive and protective measures: tools or equipment must be kept in bags or attached to a belt to avoid dropping, after using all the tools place neatly in the appropriate containers. Avoid lifting too heavy loads (> 25 kg.), avoid lifting themselves bulky loads or difficult to grasp, avoid lifting loads in unstable equilibrium, (stabilize and then unload), be careful to loads which contain something that may to shift. If the lifting of the load requires twisting or tilting avoid turning your torso trunk and prefer a rotation of the entire body during the activity. Don't cover too far away distance with the weight. During lifting, bend your legs and not your back, do not lift the load above the head, preferring steps or platforms during the removal of the load from the vehicle if the plan is higher than shoulder height.

Stepping on objects

Injury from stepping on objects, caused by poor workplace or pedestrian traffic

Preventive and protective measures: must be well defined pedestrian walkways maintained in good repair and free of materials and obstructions, provide imperforable footwear, level, where necessary, the ground provide lighting on all 4 sides the construction site to avoid low visibility due to shadows. The storage area of all the materials needed for the realization of the work and positioning of the fixed installations must be performed outside of transit routes in so as not to create obstacles to working.

Colliding with still objects

Injuries from bumps and collisions with protruding parts of the yard, steps to the height of a man, abandoned objects in the passages.

Preventive and protective measures: provide for a correct illumination of the working environment. Reporting steps at eye level with appropriate signage. Must be well defined pedestrian walkways, maintained in good repair and free of materials and obstructions that may present a risk impact. Provide anti slip and imperforable footwear. Avoid leaving tools in passages. Providing to place them in containers. The protruding rods are marked with colored tape and/ or tables related to the same provisionally. Provide lighting on all 4 sides of the construction site to avoid low visibility caused by shadows. The area affected by the works shall be completely enclosed, or enclosed with the progress of the work to ensure the prohibition of access by unauthorized persons. On accesses shall be exposed the signs of prohibition, danger and requirements and the identification of yard. The storage area of all materials for the realization of the work and positioning of the fixed installations must be performed outside of transit routes in so as not to create obstacles to working, to have an agent suitable for the handling of loads, Use caution when driving speed according to a crawl. Must be well defined traffic routes. Means, kept in good condition and free of obstacles view to reduce the risk of bumping into objects in the yard and cause damage to parts the site or to any person. Keep a safe distance from vehicles in lifting and moving. Do not leave suspended loads.

<u>Colliding whit objects in motion</u>

Lesions caused by investment due to improper handling of loads

Preventive and protective measures: check all acoustic devices. Ensure that the visibility from the driving position is excellent. Check that are properly disposed all protection from moving parts. Check the paths and maneuvering areas. Proceed at reduced speeds. For maneuvering is necessary the intervention of staff on the ground. Driving the rotating light during the maneuvers for positioning and lifting. Delimit the radius of action of the medium. Dispose a zone of pedestrian crossing and arrange for its relative safety measures. Stabilize the vehicle using the proper equipment and if necessary arrange to extend the support base with an adequate resistance, announces lifting maneuvers using the special beeper, during night work use the proper lighting devices. Observe the rules of the ground staff during the lifting and shifting of cargo. Avoid, when possible, to move the load above workstations and / or passage. Cure instrumentation and controls keeping them clean and free of grease. Forbidden to carry out maintenance on moving parts. After use, don't leave suspended loads, remove the boom and make sure you have applied the parking brake. It is necessary that the slingers receive the necessary instructions and also know requirements for hand signals. If the slingers are more than one, only one of them can give signals to the manipulator. The departure, the subsequent movements and arrests must be gradual and not abrupt. The suspended load should not be guided by hand but with ropes and hooks. The slinger must perform the coupling and uncoupling only hook latch. For the truck: test all audible warning devices, ensure that the visibility from the driving position is excellent, proceeding at a crawl, for maneuvers require the intervention of personnel on the ground, activate the Rotating light.

<u>Knocked by object or tools</u>

Contusions shocks, knocks, impacts during the use of tools.

Preventive and protective measures: ensure the good condition of the working tool. Ensure the good condition of the handle and its attachment. Use appropriate buffers while using drills or chisels. When using impact tools remove third persons nearby. Take a stable and correct position. Use gloves, wear shoes with iron tip. The protruding shackles must be marked with colored stripes and / or using temporary tables related to them. Ensuring the lighting on all 4 sides the construction site to avoid low visibility caused by shadows.

<u>Flying fragments or particles</u>

Projection of fragments and splinters in the eyes or inside of the skin after using hand tools or machine tools.

Preventive and protective measures: during process pay attention to the activity that is taking place respecting the procedures, use protective gloves, use protective masks for the eyes, wear clothes suitable to the work on site, make sure the condition of the working part of each tool. Check the status of tool wear at the end of the processing

<u>Accidents caused by living beings</u>

Preventive and protective measures: ensure the good condition of the working tool. Ensure the good condition of the handle and its attachment. Use appropriate buffers while using drills or chisels. When using impact tools remove third persons nearby. Take a stable and correct position. Use gloves, wear shoes with iron tip. The protruding shackles must be marked with colored stripes and / or using temporary tables related to them. Ensuring the lighting on all 4 sides the construction site to avoid low visibility caused by shadows.

<u>Trapped by or between objects</u>

Injury caused against entrapping and entanglement of parts of clothing after contact with motorized machines or protruding parts of the opera

Preventive and protective measures: the protruding rods are marked with colored tape and / or tables related to the same provisionally. Only use suitable work clothing and if it equipped with belts or laces make sure they fit snugly and does not oscillate freely around it. Never to open or remove the doors and / or protection screens with shelter function and all devices for collective protection with shelter function. Do the maintenance of the machines only with the engine is off and when they are not bootable by third parties and when the machine has finished its operation. After having commanded the maneuver of booster of the hook is not to be simply released but accompanied out of the area engaged by equipment or materials, to avoid accidental hooks.

<u>Trapped by turned over machines, tractors or vehicles</u>

Accidents happen because drivers misjudge slopes, ignore changing ground conditions and forget the effect of loads on stability – do not drive on slopes until you are properly trained.

Preventive and protective measures: overturning can happen on flat ground as well as on slopes. Although a tractor can be driven up a slope with a hard surface, it cannot necessarily come down the same slope safely. Always couple and use trailer and trailed equipment brakes. Use seat belts if they are fitted. If they are not, get them fitted. You are at risk even if you have a cab. Make sure a safety cab is fitted – or a roll frame on older tractors (in which case a seat belt must be fitted and used). In the event of an overturn stay in the cab – do not attempt to jump out. If in doubt, walk the ground before driving over it to check for hollows, hidden logs, tree stumps, rock outcrops, rabbit holes etc. Get yourself trained in slope safety. Always plan work in advance so that the work methods are safe at all stages. Drive slowly where the ground surface is not easily seen, eg in long grass, bracken etc. Ensure you use a large enough tractor for the machine or trailer you are using, taking account of the weight of the machine, trailer and any load.

Overexertion

Lesions of the lumbar back area caused, for the characteristic or the unfavorable ergonomic conditions, as a result of operations of transport or supporting of a load.

Preventive and protective measures: tools or equipment must be kept in bags or attached to a belt to avoid dropping. After using all tools place them in the appropriate containers. Avoid lifting too heavy loads (> 25 kg.), avoid lifting alone bulky loads or load that are difficult to grasp. Avoid lifting loads in unstable equilibrium, (stabilize and then unload). Be careful to loads which contain something that may shift. If the lifting of the load requires twisting or tilting avoid turning your torso trunk and prefer a rotation of the entire body during the activity. Do not cover too far away distance with the weight. During lifting, bend your legs and not your back, Do not lift the load above the head, preferring steps or platforms during the removal of the load from the vehicle if the plan is higher than shoulder height.

Exposure to extreme environmental temperatures

Exposure to solar radiation that could present a risk of burns, sunburn and skin diseases or exposure to high temperatures with consequent risk of fatigue.

Preventive and protective measures: wear protective helmet (preferably white), frequently wetting his head to avoid a heat stroke, make available sufficient quantities of drinking water there is a need use sunscreen to avoid skin burns, use work clothes appropriate to the conditions environment.

Thermal contact

Burns resulting from contact with materials with high temperature in the operations involving heating or for contact with bodies of machines or by contact with hot metal particles or motors, or harsh chemicals.

Preventive and protective measures: avoid coming in contact with engine parts as they may be hot and cause burns and scalds. In case of failure of the vehicle rely on specialized companies which will provide to remove it and transport to mechanical specialized workshops. Use protective gloves when machining heat, or harsh chemicals.

Exposure to electric connection

Electrocution by direct or indirect contact with parts of the electrical voltage or electrical parts of machinery and tools.

Preventive and protective measures: construction site wiring system, including facility grounding and lightning protection system, will be made with a cable protected by a special conduit, deriving it from the existing one, its declaration of conformity will be issued by the installer.

Protection against direct contact shall be provided with one of the following ways: protection by insulation of live parts, protection using wrappers or barriers (removable only with the use of a key or a tool), protection by obstacles that prevent the unintentional approach with live parts.

Every panel, regardless of the function performed, must have: in entry a disconnecting device with the ability to lock in the open position in addition to a device for protection against overcurrents, not strictly necessary if the protection is ensured by an upstream device, in exit, one or more circuits, individually protected against overcurrent and indirect contact, not strictly necessary if the protection is ensured by an upstream device. In addition to these reels are also used cables Extenders (extensions) that will have them with industrial type plug outlets with minimum degree of protection IP67. Make sure beforehand that the equipment is fit for manual work, working and in good condition. To avoid direct contact verify that the active parts have adequate insulation at rated voltage of the system, in case of failure rely on skilled workers, notify your manager of any dangers or malfunctions that may occur while using the tool, training and information on first aid measures: in case of electrocution of the operator avoid touching it directly in an attempt to secure it, but, to use sticks or rods of insulating material (e. g wood) with which try to remove it from power source , the practice of first aid (unblocking airway, artificial respiration and heart massage) should be implemented exclusively by experienced staff or those who received appropriate training, operations must be repeated (though apparently they may seem unnecessary) until the arrival of a doctor, run the installation and maintenance with power off (switch open). Verify that the tool is double insulated (220 V), or fed at very low voltage (50 V), but not electrically connected to earth. Verify that the tool is double insulated (220 V), or fed at very low voltage (50 V), but not electrically connected to the ground. Check the integrity and insulation of cables and power plug. Check the functionality of the tool. Verify that the tool is of suitable conformation. Shut off the power supply during work breaks. Do not obstruct the passages with the power cord. Report any malfunctions to the site manager. Disconnect the electrical connection of the tool. Thoroughly clean the tool.

Exposure to radiation

In our house we won't use any devices which contain of radioactive materials.

Exposure to harmful substance

Injuries caused by contact with substances harmful to the respiratory tract, skin and eyes

Preventive and protective measures: avoid direct contact with all chemicals used in processing, do not breathe the product directly but use a protective mask for respiratory purposes dust cover with filter, use a protective mask for the eyes, wear gloves, wear overalls, use said devices also before and after processing: pay attention to whether the substance used is reactive with water, keep all cleaning products and chemicals used in processing away from heat sources, open flames, no smoking during refueling of machinery.

Contact with caustic or corrosive substances

Lesions on any part of the body during work performed with substances that could give rise to corrosion during the contact

Preventive and protective measures: avoid direct contact with all chemicals used in processing, do not breathe the product directly but use a protective mask for respiratory purposes dust cover with filter, use a protective mask for the eyes, wear gloves, wear overalls, use said devices also before and after processing: pay attention to whether the substance used is reactive with water, keep all cleaning products and chemicals used in processing away from heat sources, open flames, no smoking during refueling of machinery.

Explosion

Injury from explosion as a result of processes in the presence or in the vicinity of materials, substances or products highly reactive

Preventive and protective measures: turn off the engine when refueling, avoid smoking and ensure that there is the presence of open flames. In form the manager for any malfunctions, perform all maintenance of the machine as is shown in the owner's manual of the vehicle and always after making sure that the engines are turned off and not bootable by third parties accidentally the work must be carried out of tension. Portable electric tools must be double insulated and not connected to the ground. Mobile and portable power tools used in restricted conductive locations need to be powered by low voltage (50V maximum provided by safety transformer). The temporary lighting to perform the work may be obtained by using portable electric lamps powered by low voltage (50V maximum provided by safety transformer). Check the wear of tools and their use that will satisfy and verify that the attachment between the handle of wood and metal elements. Power electric tools must be used with an insulated handle. Make sure beforehand that the equipment is fit for manual labor, working and in good condition.

Fire

Injury from fire as a result of processes in the presence or in the vicinity of materials, substances or products highly reactive

Preventive and protective measures: turn off the engine when refueling, avoid smoking and ensure that there is the presence of open flames. Inform the manager for any malfunctions. Perform all maintenance of the machine as is shown in the owner's manual and always after making sure that the engines are turned off and not bootable by third parties accidentally the work must be carried out tension. You must check that it operates outside providing voltage to a suitable instrument to measure voltage. Portable electric tools must be double insulated and not connected to the ground. Mobile and portable power tools used in restricted conductive locations need to be powered by low voltage (50V maximum provided by safety transformer). The temporary lighting to perform the work may be obtained by using portable electric lamps powered by low voltage (50V maximum provided by safety transformer). Check the wear of tools and their use that will satisfy and verify that the attachment between the handle of wood and metal elements. With power electric tools must be used with an insulated handle. Make sure beforehand that the equipment is fit for manual labor, working and in good condition. Do not smoke or use open flames adjacent to processes that include the use of reactive and flammable substances. .

Run over or hit by vehicles

Lesions caused by from investment of machinery or consequential overturning of the same

Preventive and protective measures: control all the lights and acoustic devices. Make sure that the visibility from the driving position is excellent. Make sure they are properly disposed all the protection from moving parts. Check the paths and maneuvering areas, proceeding at a crawl. For maneuvers it is necessary the intervention of staff on the ground, driving the rotating light during the maneuvers of positioning and lifting of the means. Delimit the radius of action of the medium and have a zone of pedestrian crossing. Arrange for its relative safety measures. Stabilize the vehicle using the proper equipment and if necessary provide to extend the support base equipped with adequate resistance. Announces lifting maneuvers using the appropriate acoustical signal device. During night work use the proper lighting. Observe the rules of staff on the ground during the lifting and displacement of the medium.

Non traumatic pathologies

Inhaling dust

Inhalation of fine dust coming from the work that may cause asthma, allergies following the abrupt movement of machinery and adverse weather conditions

Preventive and protective measures: wear, in case of extremely bad conditions (wind, repeated movements of vehicles in the construction site ...) mask for respiratory and eyes, wear respiratory masks also in processes that include the use of substances that can release dust into the air during use.

Rumor

Diseases such as hearing loss and deafness due to noise in work activities

Preventive and protective measures: if the step of work involves a noise level greater than 85 dB (A) must not be carried out other work in the immediate vicinity, to delimit the working area exposed to an increased noise levels, perform periodic maintenance to machinery in order to reduce the risk of noise, if you exceed the exposure limits must wear hearing protection, do not attempt to open or remove doors and / or screens soundproofing.

Vibrations

Risk of osteoarticular diseases caused by vibrations

Preventive and protective measures: the vehicle must be equipped with seat cushioning, protective gloves should be provided attenuation of vibrations transmitted to the hand-arm. must be defined limit values of exposure to vibration in order to reduce exposure of workers.

Inhaling gasses, vapors, fumes

Inhalation gas, fumes, vapors coming from the exhaust pipe of machinery or due to chemical reactions of components that release gaseous products in the air

Preventive and protective measures: avoid working nearby machinery turned on so as not to get in touch with the exhaust gas, wear protective masks for the respiratory tract, perform all the operations of maintenance of the machine according to what reported in the booklet of use and maintenance of the vehicle. Pay attention the substance used is reactive with water, keep cleaning products and chemicals used in manufacturing away from sources of heat, naked flames, do not inhale the product directly but use a protective mask for respiratory filter Dust Cover for use protective masks for the eyes.

''In itinere''

Injury to the worker during the normal route to and from the place of the work, or during the normal path that connects two places of employment if the worker has more working relationship and if there is no service the canteen, during the usual journey to and back from work to that of regular consumption of meals.

Preventive and protective measures:

- run the journey safer and more immediate.
- avoid taking alternative routes.
- in the case in which one moves by a means must be complied with traffic rules and speed limits.

10.6.2 Risk analysis of phases and related group activities

Risk analysis of phases and related group activities for assembly phases is shown below:

Table 87 - Risk analysis of phases and related group activities for assembly phases

	Phase, Group Activity and Activity description		*Specific Needs*	*Reference to the corresponding item where solutions are explained*	*Serious Risk*
			Assembly Phase		
1.	Site Preparation				
1.1		Boundary fencing	-	Risk assessment RA1, RA2	-
1.2		Placing container (for	-	Risk assessment RA1, RA9, RA18, RA24	-

		tools, first aid)			
1.3		Setting up waste disposal point	-	Risk assessment RA1, RA4	-
1.4		Setting up assembly zone	-	Risk assessment RA1, RA3	-
1.5		Setting up storage area	-	Risk assessment RA1, RA3	-
1.6		Setting the base camp	-	Risk assessment RA1, RA4, RA24	-
1.7		Water tank placement	-	Risk assessment RA1, RA9, RA18, RA24	
2.	**House Foundation**				
2.1		Placing foundations	-	Risk assessment RA1, RA5, RA14, RA23	-
2.2		Foundations leveling	-	Risk assessment RA1, RA23	-
3.	**Floor panels assembly**				
3.1		Floor panels assembly	-	Risk assessment RA1, RA11, RA20, RA25, RA33	Unloading On site transport Assembly
4.	**Vertical structure assembly - Columns**				
4.1		Columns assembly	-	Risk assessment RA1, RA4, RA14, RA26	-
5.	**Vertical Structure assembly - Shear Walls**				
5.1		Shear Walls assembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
5.2		Door placement	-	Risk assessment RA1, RA10, RA19, RA29, RA33	-
6.	**Plumbing System Placement**				
6.1		Placing Plumbing System Box	One specific person	Risk assessment RA1, RA22, RA35, RA36	-
7.	**Wooden Partition Walls assembly**				
7.1		Wooden Partition Walls assembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
7.2		Doors placement	-	Risk assessment RA1, RA10, RA19, RA29, RA33	-
8.	**Placing of Engine**				

	System rooms				
8.1		Heat pump placing	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
8.2		Heat exchanger placing	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
8.3		Engine system room 1 setup	One specific person	Risk assessment RA1, RA35, RA36	-
8.4		Washing Machine placing	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
8.5		DHW Tank placing	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
8.6		Energy Storage Tank placing	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
8.7		Engine system room 2 Setup	One specific person	Risk assessment RA1, RA35, RA36	-
9.	**Roof Panels assembly**				
9.1		Temporary construction support assembly	Alluminium telesopic ladder	Risk assessment RA1, RA34	
9.2		Roof Panels assembly	Scaffolding, Safety harness, Alluminium telesopic ladder	Risk assessment RA1, RA11, RA20, RA42, RA33	Unloading On site transport Assembly
9.3		Synthetic Waterproofin g	Safety harness	Risk assessment RA1, RA34	-
9.4		Temporary construction support removal	Alluminium telesopic ladder	Risk assessment RA1, RA34	
9.5		Steel Braces placement	Alluminium telesopic ladder	Risk assessment RA1, RA34	
10.	**Norten Wall Insolation Panels assembly**				
10. 1		Insolation Panels assembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
11.	**Glass Partition Walls assembly**				
11. 1		Glass Partition Walls assembly	Alluminium telesopic ladder	Risk assessment RA1, RA12, RA21, RA30	Unloading On site transport Assembly
11. 2		Silicone sealant applying	-	-	

12.	**Outer Glass Facade assembly**				
12. 1		Outer Glass Facade assembly	Alluminium telesopic ladder	Risk assessment RA1, RA12, RA21, RA30	Unloading On site transport Assembly
12. 2		Gutter assembly	Alluminium telesopic ladder	Risk assessment RA1, RA4, RA14, RA34	
12. 3		Silicone Sealant applying	-	-	-
13.	**Active roof (PV harmonic) assembly**				
13. 1		Aluminium Rails assembly	Safety harness	Risk assessment RA1, RA11, RA20, RA27	-
13. 2		Assembled PV Blocks assembly (structure with PV panels and motor system)	Scaffolding, Safety harness	Risk assessment RA1, RA11, RA20, RA28	Unloading On site transport Assembly
13. 3		PV System Setup	Safety harness	Risk assessment RA1, RA36	-
14.	**Wooden Façade assembly**				
14. 1		Wooden Façade assembly	Alluminium telesopic ladder	Risk assessment RA1, RA34	-
15.	**Suspended Ceiling assembly**				
15. 1		Suspended Ceiling assembly	Alluminium telesopic ladder	Risk assessment RA1, RA34	-
16.	**Winter Garden works**				
16. 1		Air duct placement	-	Risk assessment RA1, RA38	-
16. 2		Floor under structure assembly	-	Risk assessment RA1, RA38	-
16. 3		Gravel floor covering	-	Risk assessment RA1, RA38	
16. 4		Plants	-	Risk assessment RA1, RA41	-
17.	**Installation s and Systems setup**				
17. 1		Installations and Systems setup	One specific person	Risk assessment RA36	-
18.	**Bathroom Elements setup**				

18.1		Bathroom Elements setup	One specific person	Risk assessment RA1, RA8, RA16	-
19.	**Floor covering**				
19.1		Laying of parquet	-	Risk assessment RA1, RA7, RA16, RA39	-
20.	**Interior furnishing assembly and setup**				
20.1		Kitchen elements (with movable element) assembly and setup	-	Risk assessment RA1, RA8, RA1, RA40	-
20.2		Movable elements (workstation, bed and closet) assembly and setup	-	Risk assessment RA1, RA8, RA1, RA40	-
20.3		Sofa setup	-	Risk assessment RA1, RA8, RA1, RA40	-
20.4		Kitchen table and chairs setup	-	Risk assessment RA1, RA8, RA1, RA40	-
20.5		Table for TV setup	-	Risk assessment RA1, RA8, RA1, RA40	-
20.6		Home Appliances setup	-	Risk assessment RA1, RA8, RA1, RA40	-
21.	**Decking assembly**				
21.1		Placing decking foundations	-	Risk assessment RA1, RA5, RA14, RA23	-
21.2		Terrace structure assembly	-	Risk assessment RA1, RA13, RA22, RA25	-
21.3		Ramps and Stairs assembly	-	Risk assessment RA1, RA13, RA22, RA31	-
21.4		Terrace floor covering	-	Risk assessment RA1, RA7, RA16, RA39	-
21.5		Terrace fence assembly	-	Risk assessment RA1, RA4, RA14, RA32	-
21.6		Plants	-	Risk assessment RA1, RA41	-
22.	**Canvas Façade assembly**				
22.1		Canvas Façade assembly	Alluminium telesopic ladder	Risk assessment RA1, RA34, RA36	-
23.	**Site Cleaning**				
23.1		Assembly revision and Site Cleaning	-	-	-

Risk analysis of phases and related group activities for disassembly phases is shown below:

Table 88 - Risk analysis of phases and related group activities for disassembly phases

	Phase, Group Activity and Activity description			*Reference to the corresponding item where solutions are explained*	*Activities with Serious Risk*
Disassembly Phase					
1.	**Canvas Façade disassembly**				
1.1		Canvas Façade disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA34, RA36	-
2.	**Decking disassembly**				
2.1		Terrace fence disassembly	-	Risk assessment RA1, RA4, RA14, RA32	-
2.2		Plants removal	-	Risk assessment RA1, RA41	-
2.3		Terrace Floor Cover disassembly	-	Risk assessment RA1, RA13, RA22, RA25	-
2.4		Ramps and Stairs disassembly	-	Risk assessment RA1, RA13, RA22, RA31	-
2.5		Terrace Structure disassembly	-	Risk assessment RA1, RA7, RA16, RA39	-
2.6		Decking Foundations removal	-	Risk assessment RA1, RA5, RA14, RA23	-
3.	**Interior Furnishing removal**				
3.1		Home Appliances removal	-	Risk assessment RA1, RA8, RA17, RA40	-
3.2		Sofa removal	-	Risk assessment RA1, RA8, RA17, RA40	-
3.3		Table for TV removal	-	Risk assessment RA1, RA8, RA17, RA40	-
3.4		Kitchen Table and Chairs removal	-	Risk assessment RA1, RA8, RA17, RA40	-
3.5		Kitchen Elements disassembly	-	Risk assessment RA1, RA8, RA17, RA40	-
3.6		Movable Elements	-	Risk assessment RA1, RA8, RA17, RA40	-

		disassembl y			
4.	**Floor Cover removal**				
4.1		Parquet removal	-	Risk assessment RA1, RA7, RA16, RA39	-
5	**Bathroom Elements removal**				
5.1		Bathroom Elements removal	One specific person	Risk assessment RA1, RA8, RA16	-
6	**Installations and System removal**				
6.1		Installations and Systems removal	One specific person	Risk assessment RA36	-
7	**Winter Garden removal**				
7.1		Plants removal	-	Risk assessment RA1, RA41	-
7.2		Gravel Floor cover removal	-	Risk assessment RA1, RA38	-
7.3		Floor under structure assembly	-	Risk assessment RA1, RA38	-
7.4		Air duct placement	-	Risk assessment RA1, RA38	-
8	**Suspended Ceiling disassembly**				
8.1		Suspended Ceiling disassembl y	Alluminium telesopic ladder	Risk assessment RA1, RA34	-
9	**Wooden Façade disassembly**				
9.1		Wooden Façade disassembl y	Alluminium telesopic ladder	Risk assessment RA1, RA34	-
10	**Active Roof (PV Harmonic) disassembly**				
10. 1		Assembled PV Blocks (structure with PV panels and motor system) disassembl y	Safety harness	Risk assessment RA1, RA11, RA20, RA28	Disassembly , On site transport, Truck Loading
10. 2		Aluminium Rails disassembl y	Safety harness	Risk assessment RA1, RA11, RA20, RA27	-

11	**Outer Glass Façade disassembly**				
11.1		Gutter removal			
11.2		Silicone Sealant removal	-	-	-
11.3		Outer Glass Façade disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA12, RA21, RA30	Disassembly, On site transport, Truck Loading
12	**Glass Partition Walls disassembly**				
12.1		Silicone Sealant removal	-	-	-
12.2		Glass Partition Walls disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA12, RA21, RA30	Disassembly, On site transport, Truck Loading
13	**Norten Wall Insolation Panels assembly**				
13.1		Insolation Panels assembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
14	**Roof Panels disassembly**				
		Steel Braces removal	Alluminium telesopic ladder	Risk assessment RA1, RA34	
		Temporary construction support assembly	Alluminium telesopic ladder	Risk assessment RA1, RA34	
14.1		Synthetic Waterproof removal	Safety harness	Risk assessment RA1, RA34	-
14.2		Roof Panels disassembly	Scaffolding, Safety harness, Alluminium telesopic ladder	Risk assessment RA1, RA11, RA20, RA27, RA33	Disassembly, On site transport, Truck Loading
14.3		Temporary construction support disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA34	
15	**Engine system Room disassembly**				
15.1		Heat Pump	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
15.2		Heat Exchanger	One specific person	Risk assessment RA1, RA6, RA15, RA37	-

15.3		Washing Machine	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
15.4		DHW Tank	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
15.5		Energy Storage Tank	One specific person	Risk assessment RA1, RA6, RA15, RA37	-
16	**Wooden Partition Walls disassembly**				
16.1		Doors removal	-	Risk assessment RA1, RA10, RA19, RA29, RA33	-
16.2		Wooden Partition Walls disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
17	**Plumbing System removal**				
17.1		Plumbing System Box removal	-	Risk assessment RA1, RA22, RA35, RA36	-
18	**Vertical Structure - Shear Walls disassembly**				
18.1		Door removal	-	Risk assessment RA1, RA10, RA19, RA29, RA33	-
18.2		Shear Walls disassembly	Alluminium telesopic ladder	Risk assessment RA1, RA10, RA19, RA29	-
19	**Vertical structure - Columns disassembly**				
19.1		Columns disassembly	-	Risk assessment RA1, RA4, RA14, RA26	-
20	**Floor Panels disassembly**				
20.1		Floor Panels disassembly	-	Risk assessment RA1, RA11, RA20, RA25, RA33	Disassembly, On site transport, Truck Loading
21	**House Foundations removal**				
21.1		House Foundations removal	-	Risk assessment RA1, RA5, RA14, RA23	-
22	**Site cleaning**				
22.1		Base Camp removal	-	Risk assessment RA1, RA4, RA24	-
22.2		Water tank removal	-	Risk assessment RA1, RA9, RA18, RA24	
22.3		Container (for tools, first aid) removal	-	Risk assessment RA1, RA9, RA18, RA24	-

22. 4		Waste Disposal Point removal	-	Risk assessment RA1, RA4	-
22. 5		Boundary Fencing removal	-	Risk assessment RA1, RA2	-

10.7 Critical work phases for risk prevention

Corresponding to risk assessment analysis in Annex 1, we came to conclusion that these tasks are critical in our project:

Loading/Unloading of the floor, roof panels and assembled pv block

Risk identification:

Fall of objects because they come loose, Colliding with still objects, Knocked by objects or tools, Accidents caused by living beings, Trapped by or between objects, Overexertion, Exposure to extreme environmental temperatures, Thermal contract, Exposure to electric connections, Exposure to harmful substances, Contact with caustic or corrosive substances, Explosion, Fire, Non traumatic pathologies: inhaling gasses, fumes, vibrations, rumor, In itinere.

To avoid this risks:

- Collective protection: Auxiliary ropes for safety load orientation
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing pretection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Loading/Unloading of glass elements

Risk identification:

Fall of persons at the same level, Fall of objects because they come loose, Fall of objects because of manipulation, Stepping on objects, Colliding with still objects, Colliding with objects in motion, Knocked by objects or tools, Accidents caused by living beings, Trapped by or between objects, Trapped by turned over machines, tractors or vehicles, Overexertion, Exposure to extreme environmental temperatures, Thermal contact, Exposure to electric connections, Exposure to harmful substances, Explosion, Fire, Run over or hit by vehicles, Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor, In itinere

To avoid this risks:

- Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation

- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing pretection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

<u>On site transport and load manipulation of the floor, roof panels and assembled pv block</u>

Risk identification:

Fall of objects because they come loose, Fall of objects because of manipulation, Colliding with still objects, Thermal contact, Exposure to electric connections, Exposure to harmful substances, Explosion, Fire, Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor.

To avoid this risks:

- Collective protection: Auxiliary ropes for safety load orientation
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

<u>On site transport and load manipulation of glass elements</u>

Risk identification:

Fall of objects because they come loose, Fall of objects because of manipulation, Colliding with still objects, Trapped by turned over machines, tractors or vehicles, Thermal contact, Exposure to electric connections, Exposure to harmful substances, Explosion, Fire, Run over or hit by vehicles, Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor.

To avoid this risks:

- Collective protection: Auxiliary ropes for safety load orientation
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Protective gloves, Reflective jacket
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Assembly/Disassembly of the floor, roof panels and assembled pv block

Risk identification:

Fall of persons at a different level, Fall of persons at the same level, Fall of objects because they come loose, Fall of objects because of manipulation, Stepping on objects, Colliding with still objects, Colliding with objects in motion, Knocked by objects or tools, Flying fragments or particles, Accidents caused by living beings, Trapped by or between objects, Exposure to extreme environmental temperatures, Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor.

To avoid this risks:

- Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchoring points at heights, Scaffolding
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Hearing protectors, Safety harness
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Assembly/Disassembly of glass elements

Risk identification:

Fall of persons at the same level, Fall of objects because they come loose, Fall of objects because of manipulation, Stepping on objects, Colliding with still objects, Colliding with objects in motion, Knocked by objects or tools, Flying fragments or particles, Accidents caused by living beings, Trapped by or between objects, Exposure to extreme environmental temperatures, Non traumatic pathologies: vibrations, rumor.

To avoid this risks:

- Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchorage points at heights, Scaffolding
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Alluminium telesopic ladder
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

10.8 Collective protections to use

All team members and crew that will use the collective protections will be trained on their proper use, inspection, and limitations. Concerning complete technical specifications of the collective protections, in accordance with the current French Legislation, all the protection equipment, auxiliary means, machinery, etc. shall have the CE branding, guaranteeing their adaptation to the regulation in force.

Collective protection that will be used during the assembly, maintenance and disassembly phases:

- **Perimeter and protection fences**: will be metallic and with supports in order to maintain their stability. Fences will be used to mark the boundaries of plot.
- **Anchorage points at heights**: In order to avoid fall from heights on the roof of the Mem**brain** prototype will be anchorage points to which workers must mounted their height safety belt when performing work at height.
- **Scaffolding:** For works at heights.
- **Individual Platform:** For works at heights.
- **Fire extinguishers:** Must be on lot all time during the assembly, maintenance and disassembly phases.
- **General grounding installation of the site**
- **Auxiliary ropes for the safety load orientation:** must be used when unloading, assembling and disassembling larger house elements (e.g. roof panels, floor panels, columns, etc.)
- **Portable spotlights:** For safely perform work in night shifts.
- **Signposting** (cones, panels, etc.) – See 10.9.1 Singposting of the risk

10.9 Individual protection resources to use

All team members, crew and volunteers will be briefed on the proper use, inspection, and limitations of the individual protection resources. Aspects to be taken care of from individual protection resources are:

- Demand the CE branding
- Demand the instructions manual
- Train and inform the worker following those instructions
- Follow those instructions
- Keep up with the maintenance, cleaning and repairing it without losing or changing its initial safety characteristics

During the assembly, maintenance and disassembly phases, a minimum level of individual protection resource is mandatory and required at all times:

- Hard hat
- Safety glasses
- A shirt with sleeves and long trousers
- Safety boots with ankle supports
- Reflective jacket
- Protective gloves

Individual protection resource depending on the tasks:

- Safety harness(works at height)
- Tool belt
- Protective girdle in cases of excess load
- Safety screen for the face, secure to the helmet
- Paper dust mask
- Work cloth made of cotton
- Hearing protectors
- Insolating gloves for low voltage
- Raincoat

10.9.1 Signposting of the risk

A copy of approved HS plan will be placed in the container next to the first aid box.

Signposting (cones, panels, etc.) - signposting will include:

- PROHIBITIONS:
  - No access for unauthorized persons
- WARNINGS:
  - General/overall danger
  - Electric shock risk
  - Falling objects
- OBLIGATIONS:
  - Obligatory head protection
  - Obligatory foot protection
  - Obligatory eyesight protection
  - Obligatory hearing protection
  - Obligatory hands protection
  - Obligatory face protection
- FIRE-FIGHTING:
  - Fire extinguisher
- FIRST AIDS:
  - Rescue and relief operations
  - First aids
  - Evacuation plan
- Other:
  - STOP (In the vehicles access/exit to La Cité du Soleil®, in La Cité du Soleil® - provided by SDE2014 Organization)
  - Maximum speed (In the vehicles access/exit to La Cité du Soleil®, in La Cité du Soleil® - provided by SDE2014 Organization)
  - Signaling cones
  - Light marker

Permanent signpost on the at the lot's entrance is shown below. The other signposts are included in the HS drawing 401 and 402.

Figure 277 - Permanent signpost on the lot´s entrance

10.10 Safe working procedures of every Team member

Safe working procedures of every worker and team member according to the work they are performing are stated below:

Truck drivers:

- Truck drivers need to be certified
- Daily driving period shall not exceed 9 hours
- Every truck will carry the following equipment: first-aid kit, fire extinguisher with carbonic snow or halogenated components with a minimum capacity of 5kg, essential tools to repair while on the road, spare lamps, blinkers, reflectors, etc.
- Trucks can drive inside La Cité du Soleil® only after permission of SDE2014 Organization
- Before starting loading and unloading of trucks the hand break must be activated, as well as wedges on the wheels to immobilize trucks.
- The movements through La Cité du Soleil® will be guided by a person signaling dedicated specifically to it (Especially when reversing, entries or exits).
- Signaling worker and crane operator must know the signs by which they will be understood each other when performing any task
- If truck drivers lose sight of the signaling worker – STOP immediately!

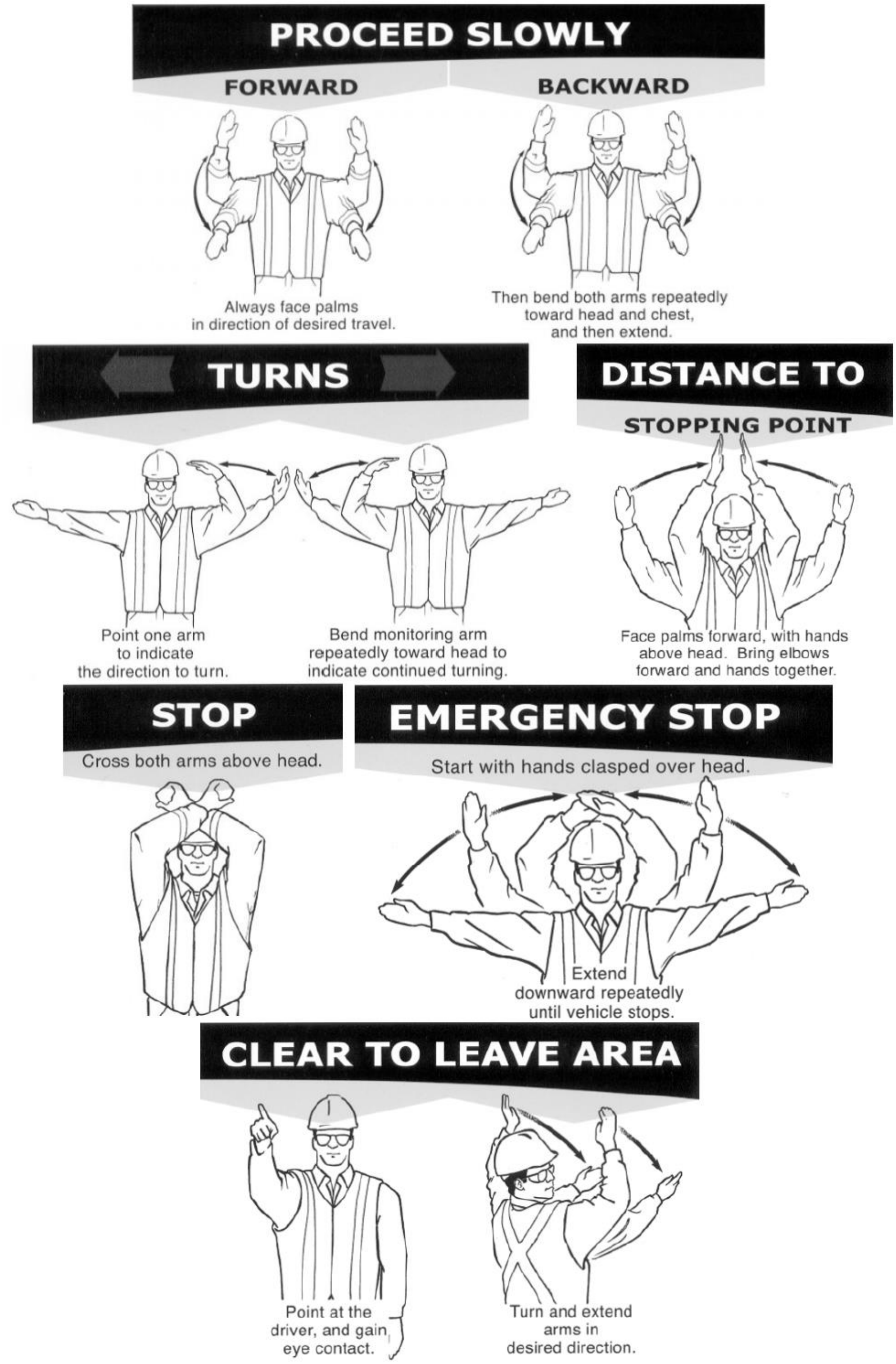


Figure 278 - Hand signals for signaling to truck drivers

- Signaling worker and truck drivers must know the signs by which they will be understood each other when trucks driving inside La Cité du Soleil®
- If trucks drive inside La Cité du Soleil® at night it is necessary to use lighting warning devices for signaling
- Signaling worker need to:
    - Wear high visibility clothing
    - Be visible to the truck driver
    - Maintain eye contact with truck driver
    - Protect himself, not to approach too close to the truck

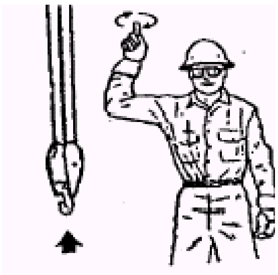
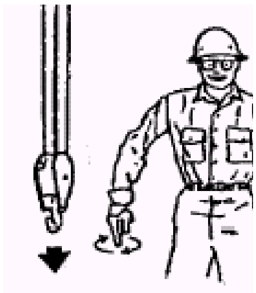
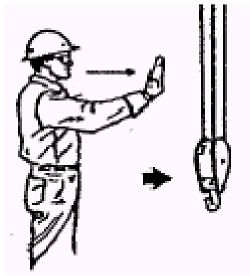
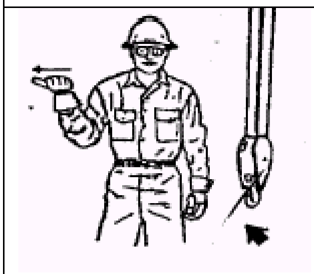
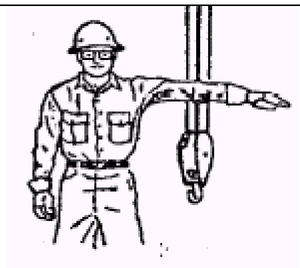
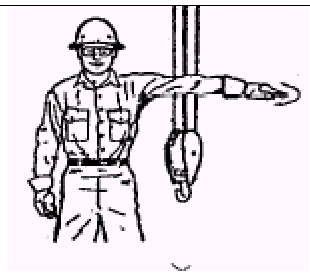
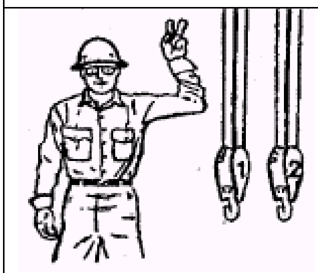
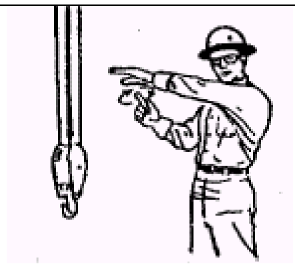
Crane operator (valid for crane and truck mounted crane operators):

- Crane operator need to be certified
- Before any task need to previously know the task and the working process to be carried on, and will need permission to begin.
- When performing any task needs good visual communication with the person signaling at any time and follow its instructions.
- Do not handle loads above other workers
- In case of any breakdown or anomalies do not work with a crane
- Do not leave suspended loads on the crane when works are finished
- Do not raise loads that weigh more or equal to the limit stated by crane specifications
- When transporting and assembling larger elements of the house with a crane, elements need to be secure with additional rope by workers.
- When attaching or moving a load, the operator and worker who hooks load must make sure of all of the following:
    - The hoisting rope or chain is free of kinks or twist and not wrapped around the load
    - The load is attached to the load block hook by means of a sling or other approved device
    - The sling and load will clear all obstacles or obstructions
    - The load is balanced and secured before lifting the load
    - Multiple lines are not twisted around each other
    - The hook is brought over the load in a manner to prevent swinging
    - There is no sudden acceleration or deceleration of the moving load

Signaling worker for crane

Table bellow shows hand signals for signaling to crane operator:

Figure 279 - Hand signals for signaling to crane operator

 HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle	 LOWER. With arm extended downward, forefinger pointing down, move hand in small horizontal circle.	 BRIDGE TRAVEL. Arm extended forward, hand open and slightly raised, make pushing motion in direction of travel.
 TROLLEY TRAVEL. Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.	 STOP. Arm extended, palm down, hold position rigidly.	 EMERGENCY STOP. Arm extended, palm down, move hand rapidly right and left.
 MULTIPLE TROLLEYS. Hold up one finger for block marked “1” and two fingers for block marked “2”. Regular signals follow.	 MOVE SLOWLY. Use one hand to give any motion signal and place other hand motionless in front of hand giving the motion signal. (Hoist Slowly shown as an example.)	

- Signaling worker and crane operator must know the signs by which they will be understood each other when performing any task
- Signaling worker must pay attention to workspace and if there is person inside working space must immediately give a hand signal for emergency stop
- Signaling worker need to:
    - Wear high visibility clothing
    - Be visible to the crane operator
    - Maintain eye contact with truck driver

<u>Forklift operator</u>

- Forklift operator need to be certified, need to know the technical specifications of the forklift
- Every day before work need to check correctness of forklift: tires, oil level, oil leaks, water, breaks, clutch, lights, lighting, fire extinguisher, pitchfork operation, slope and elevation systems.
- Before performing any task check working space. If there is person or obstacles around do not performing task.
- When performing any task keep safety distance from person and obstacles around.
- When performing any task seatbelts must be worn and speed limits and stop signs must be respected
- When doing load carrying: pick load up and raise it 15cm above ground, circulate with the pitchfork sloped at its maximum. First try to move forward if there is enough visibility, if the load does not allow it, the circulation must be carried out in reverse.
- When unloading: place the forklift in front of the area and in the correct position, raise the load up to the height needed keeping the breaks on, move the forklift until the load is located above the designated area for unloading, situate the pitchfork in a horizontal position, unload the load, and back away slowly.
- Do not circulate over unprotected cables, do not manipulate or repair any of the forklift systems while in motion or when not having the knowledge or authorization to do that.
- When leaving the forklift: leave it in a correct area, with the hand break on, take away the contact keys, and always leave with the pitchfork in the lowest position possible.
- Operations that Forklift operator **must not perform** when performing tasks:
    - Moving with pitchfork raised and no load
    - Turning sharply
    - Travelling across an incline or uneven ground
    - Moving with a raised load
    - Carrying load forwards down a slope
    - Carrying an unevenly balanced load
    - Braking hard when loaded
    - Transport people on the pitchfork

Assembly worker, adjustable house foundations made of steel

- Every worker needs to use mandatory protective equipment
- Do not work underneath the crane´s field of action.
- Check the correct placement of the foundations
- When placing the foundation elements take care of workers around
- Do not swing loads to reach them for unloading in inaccessible areas
- Do not stand on the near the position of the foundation element when the element are being placed

Assembly worker, timber

- Every worker needs to use mandatory protective equipment
- Do not work underneath the crane´s field of action
- Work on stable and dry areas
- Do not swing loads to reach them for unloading in inaccessible areas
- Be aware of falling loads and equipment
- Wear protective girdle in cases of excess load
- Ensure that tools and equipment are in good working order
- Use fall protection and other precautions when working at heights
- Apply safe lifting techniques to avoid injuries

Assembly worker, glazing

- Every worker needs to use mandatory protective equipment
- Do not work underneath the crane´s field of action
- -Use protective gloves when handling glass panels
- Ensure that tools and equipment are in good working order
- Use fall protection and other precautions when working at heights
- Apply safe lifting techniques to avoid injures
- Assembly glazing by holding them through the complete process with suction pads

Assembly worker, Active Roof

- Every worker needs to use mandatory protective equipment
- Do not work underneath the crane´s field of action
- Handle careful with the PV panels
- Use fall protection and other precautions when working at heights
- Load and unload of the material in a safe and stable way in the designated areas

Electrician

- Every worker needs to use mandatory protective equipment
- Workers need to wear gloves for low voltage
- Inform the workers affected by the systems on which work will be carried on
- Do not work in the open if adverse weather
- Protect the system or electric elements avoiding the circulation of machinery above hoses and tripping over them
- Always work in dry conditions
- Carry out the electric system with the protective devices that will guarantee safety
- All electrical energy sources must be locked out when any employee is exposed to direct or indirect contact with parts of fixed electrical equipment or circuits
- Use Insulated tools or handling equipment

Plumber

- Every worker needs to use mandatory protective equipment
- If working on hot pipes, use heat-insulating gloves and eye/face shields and make sure to drain pipes before you open them
- Install and maintain good ventilation
- To avoid electric shock, only use power tools that are safe for a wet environment and that have a ground fault circuit interrupter

Gardener

- Every worker needs to use mandatory protective equipment
- Do not swing loads to reach them for unloading in inaccessible areas
- Know all the possible systems located underneath the ground, or in the site surface that might affect its work
- Pay special attention in case of excavation or watering
- Work on stable and dry areas

Coordinators and decathletes

- Coordinators and decathletes who participate in any work during assembly and disassembly phases need to use mandatory protective equipment
- Coordinators and decathletes has to be recognizable
- Be aware of changes on the site since the last visit
- Follow the Health and Safety plan, as well as the safety measures, safe working proceedings, etc.
- Be available at any moment for any consultation
- Do not hassle the rest of the workers
- Make sure that Health and Safety measures are followed

10.11 Machinery and auxiliary resources

It is responsibility of the contractor of machinery and auxiliary means (SD organization) to make sure all the equipment, auxiliary means and machinery employed in site comply with the current regulations. Moreover, team members know and will obey the safe user's manual from the manufacturers of every machine, tool and/or auxiliary resource, provided by the contractors.

10.12 Planned Measures in case of accident

10.12.1 First aid

People at work can suffer injuries or be taken ill. First aid is the provision of initial care for an illness or injury. The key aims of first aid can be summarized in three key points: preserving life, prevent future harm and promote recovery. Therefore it is essential to train the personnel for first aid. The Health and Safety Regulations require providing adequate and appropriate first-aid equipment, facilities and people, so that workers can be given immediate help if they are injured or taken ill at work. The minimum first-aid provision on any work site is:

- a suitably stocked first-aid box
- an appointed person to take charge of first-aid arrangements
- information for employees about first-aid arrangements

Our team will have a Health and Safety Team Coordinator, a person with specific training for the action in emergency situations. Health and Safety Team Coordinator will be selected on a voluntary basis and his main duties will be:

- To take charge when someone is injured or becomes ill
- look after the first-aid equipment
- ensures that an ambulance or other professional medical help is summoned when appropriate

GUIDELINES FOR FIRST AID:

10.12.1.1 Cardiopulmonary resuscitation

Cardiopulmonary resuscitation (CPR) is performed when a person’s heart stops beating to prevent brain damage and death. The heart may stop because of heart disease, a motor vehicle accident, drowning, or choking. Anyone who has lost consciousness may need CPR. Also, confusion, weakness, and chest pain may signal that cardiac arrest is about to occur and CPR may be needed. After the heart stops, even a few minutes’ delay in starting CPR can mean the difference between life and death. Performing CPR supports the heart and brain with oxygen until medical help arrives.

CPR involves three steps:

Step 1: Compressing the person’s chest to keep the blood circulating.

Figure 280 - Compressing the person's chest

- Place the heel of one hand over the center of the person’s chest between the nipples (lower half of breastbone); place the heel of your other hand over the first. Keep your arms straight and locked at the elbows
- Firmly compress the person’s chest
- Push hard and fast, at a rate of at least 100 compressions/minute

Step 2: Opening the person’s airway

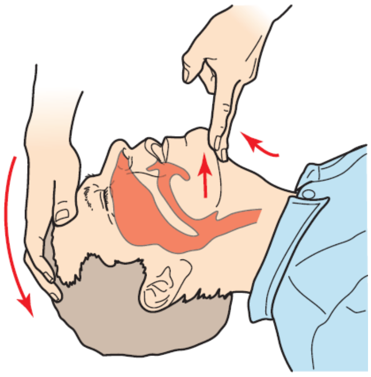


Figure 281 - Opening the person's airway

- Place the person face up on a hard, flat surface
- Lift the person’s chin with one hand while pushing down on the forehead with the other hand. This aligns the airway structures

Step 3: Giving rescue breaths that fill the lungs with air

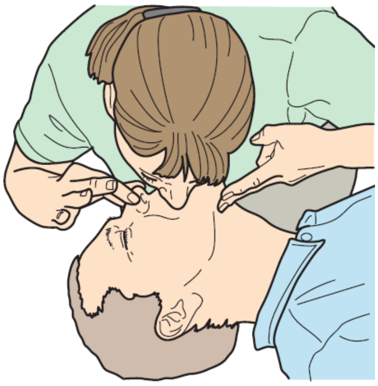


Figure 282 - Mouth-to-mouth method

- Open the person's airway by tilting the head and lifting the chin as shown
- Pinch the person's nose shut with your fingers
- Inhale normally and cover the person's mouth with your mouth to create an airtight seal
- Exhale
- Watch for the person's chest to rise as you give each breath

10.12.1.2 Choking

Choking is a common breathing emergency. It occurs when the person´s airway is partially or completely blocked. If a conscious person is choking, his or her airway has been blocked by a foreign object, such as a piece of food by swelling in the mouth or throat.

Causes of choking:

- Trying to swallow large pieces of poorly chewed food.
- Drinking alcohol before or during meals. (Alcohol dulls the nerves that aid swallowing.)Wearing dentures. (Dentures make it difficult to sense whether food is fully chewed before it is swallowed.)
- Eating while talking excitedly or laughing, or eating too fast.
- Walking, playing or running with food or objects in the mouth.

<u>EMERGENCY ACTIONS:</u>

Step 1: Determine whether the airway is blocked

Step2: If you determine the airway is blocked, stand behind the person and wrap your arms around the person's waist. Locate the navel (bellybutton).

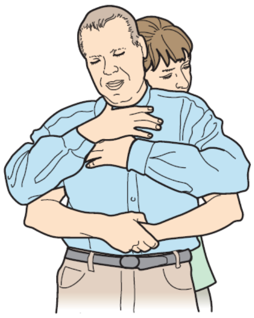


Figure 283 - Giving abdominal thrusts

Step 3: Make a fist and place thumb side just above the person's navel.

Step 4: Grasp your fist with your other hand. Press your fist abruptly into the person's abdomen and use an upward, inward thrust. Continue thrusts until the object is coughed out and the person can breathe or talk.

10.12.1.3 Bleeding

External bleeding can be minimal or severe, depending on the seriousness of the wound. Any external bleeding must be controlled immediately.

Three types of bleeding:

- Arterial bleeding: Arteries carry blood away from the heart. Blood from a cut artery is bright red and spurts out under high pressure, reflecting the pumping action of the heart. A large volume of blood can be lost in a short time. Arterial bleeding must be controlled immediately or the person may die.
- Venous bleeding: Veins carry blood back to the heart under low-pressure. Blood from a cut vein is dark red. Venous bleeding is more easily controlled than arterial bleeding but is still considered serious.
- Capillary bleeding: Capillaries are small vessels that connect arteries and veins. Capillary bleeding is easily controlled and usually results from small cuts and abrasions.

Bleeding Management:

- Direct pressure: Press directly on the wound through a clean dressing to stop the blood flow. The pressure must be firm and should be maintained long enough to close the damaged surface.
- Elevation: Whenever possible, the bleeding area should be elevated above the level of the heart (by raising an arm or leg) to slow the blood flow.

Figure 284 - Direct pressure and elevation

- Pressure dressing: If bleeding continues after direct pressure and elevation, consider a pressure dressing. Apply a thick pad of gauze or other material and hold it in place with a bandage that's tightly wrapped but not overly constricting. Keep it loose enough to permit circulation.

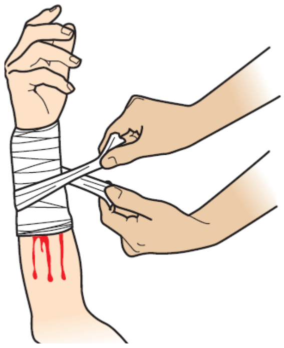


Figure 285 - Pressure dressing

In most situations, it's best to cleanse the wound with soap and water but not close it. Leaving the wound open will allow drainage from any infection that may occur. Once bleeding is controlled, cover the wound with a clean dressing and bandage, and seek immediate medical care. The dressing should be changed daily if possible.

10.12.1.4 Burns

The severity of a burn injury is related to the cause of the burn (heat, chemical, electrical), its depth and size, and the part of the body injured. Recovery from a burn can be more difficult in people who are older, are in poor general health, or have associated injuries. Inhalation injuries, which are common, are caused by carbon monoxide, smoke, and toxic products.

First-Degree Burn (Superficial Burn)

A first-degree burn involves only the outer layer of skin (the epidermis).A common example is sunburn, which occurs after exposure to the ultraviolet rays of the sun.

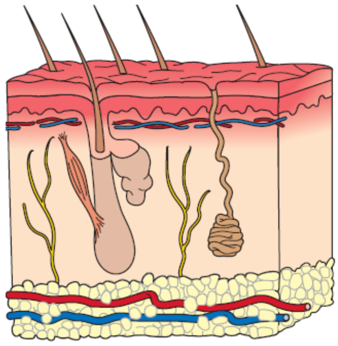


Figure 286 - First degree burn

Treat smaller burns by applying cold cloths or flushing with cool water. Give acetaminophen or ibuprofen for pain. After cooling apply an aloe Vera gel or skin moisturizer lotion to keep the skin moist and reduce itching and peeling. If a large area is burned and the person has a fever and chills, a trip to the doctor would be in order.

Second-Degree Burn (Partial-Thickness Burn)

A second-degree burn involves the outer layer of skin (the epidermis) and the second layer (the dermis). The burn does not pass through to the underlying tissues.

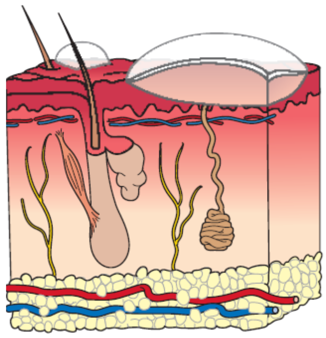


Figure 287 - Second degree burn

Treat burns by applying cold cloths or flushing with cool water. If blisters form, don't break them. Give acetaminophen or ibuprofen for pain. Give fluids by mouth if the person's airway is not impaired. Use an antibiotic ointment. Cover the burn with sterile, dry bandages. Seek immediate medical care.

Third-Degree Burn (Full-Thickness Burn)

A third-degree burn involves all three layers of the skin: the epidermis, dermis, and fatty layer (subcutaneous tissue). If the burn is severe, even the muscle and bone may be involved.

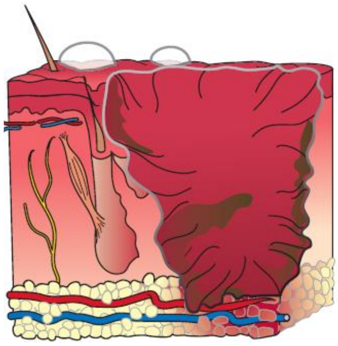


Figure 288 - Third degree burn

Check the airway and administer oxygen if smoke inhalation is suspected. Remove all burned clothing and jewelry (especially rings) if not stuck to the skin. Swelling may make these items hard to remove later. Cover the burn with a dry, nonstick, sterile dressing or a clean cloth. Treat for shock, and seek immediate medical care. Critical burn areas involve the face, hands, feet, and genital region.

Electrical Burn

An electrical burn from even a mild electric shock can cause external and internal damage. A current of 1000 volts or more is considered high voltage, but even the ordinary household current of 110 volts can be deadly.

Figure 289 - For electrical burn, look for entry and exit wounds and give the appropriate care

Treatment: Unplug or turn off the power source. Then remove the person from the electrical source. If the person is not breathing, begin CPR. If the power source cannot be turned off, you should not touch the person or you will become a victim yourself. Wait until the fire department or power company service arrives to shut off the live current of electricity.

10.12.1.5 Shock

Shock is caused by inadequate delivery of blood to the vital organs, especially the brain, heart, and kidneys. It may develop after sudden illness, infection, injury, burns, heart failure, bleeding, anaphylaxis, or fluid loss (vomiting or diarrhea). Sometimes even mild injury will lead to shock. Prompt treatment can save a person's life.

Signs and symptoms: Cool, pale, moist skin; fast breathing; and rapid, weak pulse, weakness, dizziness, excessive thirst; confusion or anxiety; and nausea or vomiting.

Treatment: Check for breathing problems and any bleeding. Lay the person face-up with feet raised unless you suspect head, neck, or back injuries. Try to control bleeding with direct pressure. Keep the person warm; use a blanket or sheet, depending on the weather. Don't give anything to eat or drink. Seek immediate medical attention. Continue to monitor airway, breathing, and circulation until help arrives.

10.12.1.6 Electric shock

An electric shock can occur when someone is using an electric appliance with wet hands or standing on a wet bathroom floor or otherwise around water. Someone can also receive an electric shock from exposed or faulty wiring, or, in rare circumstances, from being struck by lightning.

Treatment: Unplug or turn off the power source. Then remove the person from the electrical source. If the person is not breathing, begin. Treat for shock and burns if necessary. If the power source cannot be turned off, you should not touch the person or you will become a victim. Wait until the fire department or power company service arrives to shut off the live current of electricity.

10.12.1.7 Fractures

A broken bone is called a fracture. A fracture may occur from direct trauma or from any motion that bends or twists the bone suddenly. If the force shatters the bone, its fragments can cause extensive damage to adjacent blood vessels, peripheral nerves, muscles, and ligaments. Fractures may be closed or open. In a closed fracture, the skin is not broken. Open fractures involve broken or torn skin and possible protruding bone fragments. An open injury increases the likelihood of infection.

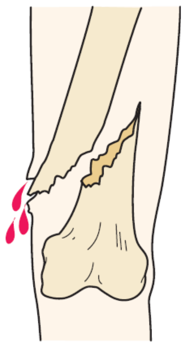


Figure 290 - Closed fracture and open fracture

Treatment: Don't move the person if neck or back injuries are suspected. Treat breathing, bleeding, and shock first. For an open fracture (bone protruding from the skin), control the bleeding and cover the open wound with a clean dressing or cloth. Immobilize the injury before moving the person. Seek immediate medical care.

10.12.1.8 Immobilization Techniques

Fractures should be immobilized to prevent injury to blood vessels and nerves. Splinting is the primary immobilization technique. It helps prevent further damage and protects the injury until you can seek medical help. An improvised splint will immobilize an injured limb, reduce pain, and prevent further injury. A simple splint can be used on an arm, finger, leg, or toe.

- Remove all rings, watches, and bracelets. Swelling may make these items hard to remove later.
- Tie or tape the injured limb to a stiff object, such as rolled-up newspapers or magazines or a large stick. Ties can be made out of items such as a torn sheet, rope, or belt. Don't tie too tightly. Try to splint the joint above and below a suspected fracture to keep the injury from bending. For example, splint a fractured leg from above the knee to below the ankle.
- Tape a fractured finger or toe to the next uninjured finger or toe with padding between them.
- For joint injuries, immobilize the bone above and below the joint.
- Use a triangular arm sling to secure arm and shoulder injuries.

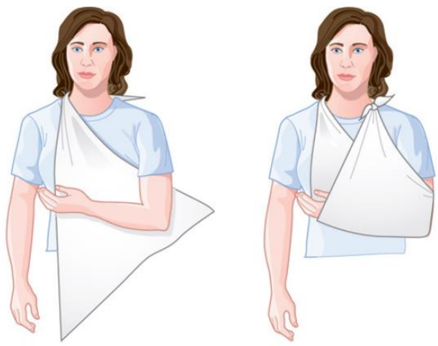


Figure 291 - Applying a triangular arm sling

10.12.1.9 Sprain and Strain

Ligaments connect one bone to another; tendons connect muscle and bone. A sprain is the stretching or tearing of ligaments when a joint is twisted beyond its normal range of motion. A strain is caused by overstretching or tearing a muscle or tendon.

Signs and symptoms: Swelling, severe pain, and inability to move the limb normally because of both weakness and pain.

Treatment: During the first 48 to 72 hours, apply an icepack or cold pack for 10 to 15 minutes at a time each hour. This treatment reduces swelling. Keep a damp cloth between the skin and the pack so the cold doesn't damage the skin. Heat should not be used because it encourages internal capillary bleeding and increases swelling. Use a compression wrap such as an elastic bandage to prevent swelling and support the joint. Don't wrap it too tightly. If possible, elevate the injury above the level of the heart to reduce swelling.

10.12.1.10 Splinter

A splinter is a small, sharp object, usually a thorn or a tiny piece of wood or metal, embedded in the skin.

Treatment: Put a piece of tape over the splinter and pull it up. If that doesn't work, grip the end of the splinter with tweezers and gently try to pull it out. If the splinter isn't sticking out where you can reach it, clean a needle with alcohol and make a small hole in the skin over the end of the splinter. Then lift the splinter with the tip of the needle until you can grab it with the tweezers. After the splinter is removed, wash the area with soap and water. Watch for signs of infection. If the splinter is large, deep in the skin, or in the eye, do not try to remove it and seek immediate medical attention.

10.12.1.11 Sunburn

Signs and symptoms: Minor skin redness and irritation in mild and uncomplicated cases, possibly severe pain after sufficient exposure. Initially skin turns red about 2 to 6 hours after exposure and feels irritated. The peak effects appear at 12 to 24 hours.

Treatment: Medications such as aspirin (if more than 18 years old) and ibuprofen are useful to relieve discomfort, especially when started early. For mild sunburn, cool compresses may suffice. Aloe-based lotions help soothe and moisturize the skin. Obviously, stay out of the sun while you're sunburned. Seek medical care if you experience a fever, chills, dehydration, or blistering.

10.12.1.12 Dehydration

Dehydration is a loss of too much fluid from the body. The person loses not only water, but also important minerals called electrolytes. Dehydration can also be caused by intense exercise and excessive sweating without adequate fluid replacement. Severe dehydration can be life threatening, especially for infants, children, and the elderly.

Signs and symptoms:

- Mild: Vomiting and diarrhea, dry mouth and tongue, and dark or not much urine
- Severe: Sunken eyes, no tears, fast breathing and heartbeat, little or no urine for 8 hours, confusion, and skin that sags when you pinch it.

Treatment:

- Mild: To stop vomiting or diarrhea, the person should avoid eating solid foods. During the first 24 hours, the person should sip water or a rehydration or sports drink. The person should keep the sips small until the stomach can handle larger amounts. Drinking too much fluid can make the person vomit again
- Severe: Seek immediate medical care if vomiting and diarrhea last more than 24 hours, or the person is very young or elderly with severe symptoms. Intravenous fluids may be required.

10.12.1.13 Blisters

A blister is a fluid-filled area that forms under the skin. Blisters commonly arise when constant friction or rubbing of footwear over the skin's surface causes microscopic tears under the skin. Most blisters can be avoided with proper footwear and some preventive measures.

Figure 292 - Doughnut-shaped cover

It’s best to never drain a blister. Instead, make a doughnut shaped cover to keep pressure off the blister by cutting a hole in a piece of moleskin. If you do find it necessary to drain a blister, be sure you have adequate first aid supplies. First, clean the area around the blister. Then, using a clean needle, make a small hole in the top of the skin and press out the fluid. Next, apply an antibiotic ointment.

10.12.1.14 First aid bag

First aid bag contains the items necessary to provide urgent care. According to Croatian law, regardless of the number of workers on the construction site, a first aid bag or locker must be present. First aid bag must be located in a visible and easy accessible place and be marked with the Red Cross sign. Near the bag should also be a card with the address and phone number of the nearest doctor or help facility.

Figure 293 - First aid bag

10.12.2 First aid material:

- a leaflet giving general guidance on first aid
- 20 individually wrapped sterile plasters (assorted sizes)
- two sterile eye pads
- four individually wrapped triangular bandages, preferably sterile
- six safety pins
- scissors
- two large, individually wrapped, sterile, unmedicated wound dressings
- six medium-sized, individually wrapped, sterile, unmedicated wound dressings

- a pair of disposable gloves
- tweezers
- insulation blanket

Medications:

- Acetaminophen (Tylenol): Relieves pain and reduces fever
- Antacid tablets (Rolaids, Tums): Relieve stomach indigestion
- Antihistamine (diphenhydramine [Benadryl]): Relieves sneezing, itchy and watery eyes from an allergy relieves itchiness from insect bites and stings and from poison ivy, oak, and sumac
- Antifungal cream or ointment
- Aspirin: Relieves pain and reduces fever and inflammation
- Cough suppressant
- Decongestant tablets
- EpiPen: Prescription medication (epinephrine) in an injectable form counteracts life-threatening allergic reactions
- Hydrocortisone (1%) cream or packet: Relieves minor skin irritations, itches, and rashes
- Ibuprofen (Motrin, Advil): Relieves pain and reduces fever and inflammation
- Laxative: Relieves constipation
- Loperamide (Imodium): Relieves diarrhea
- Nasal spray: Relieves symptoms of colds, stuffy nose, or blocked sinuses
- Prescription medications: Especially for asthma, heart disease, diabetes, or high blood pressure

10.12.3 Preventive medicine

Team UNIZG will have an own prevention system during all the stages. . In the case of Team UNIZG, there will be a medical insurance which covers them since the beginning of the transport, assembly and disassembly operations of the prototype Mem**brain** for the competition SDE 2014.

Every team member who will participate in assembly and disassembly phases will have to undergo a medical check to prove they are capable of carrying out their tasks in a safe and adequate condition.

To be developed in more detail in next deliverable!

10.12.4 Accident victims evacuation

SLIGHT ACCIDENT OR DISCOMFORT:

It is not necessary to warn the emergency services. The victim will be moved by vehicle to the assigned medical center. The victim must be accompanied by another person. The medical center assigned will depend on the medical insurance.

ACCIDENT:

- Follow the protocol in section 10.12.1 of this document
- Warn the SDE Organization
- If the victim needs to be evacuated, examine the victim to discard possible spine injuries (by observing its ability to move arms and legs, if the victim feels them or has any head injury)
- If any of the mentioned symptoms are present: Do not bend the spine, lean the victim heads up on a hard surface(head, torso and legs must be on the same plane), move and hold the victim at any time as a block (including the head), do not evacuate until having correctly immobilized the victim, hold by the victim´s clothes at the shoulder level, lean the victim´s head over your wrists and forearms, drag the victim from its clothes
- The transportation to the medical center must be carried out by the emergency services in an ambulance. This medical center is Centre Hospitalier de Versailles. Way to the hospital is shown in the Table below.

Table 89 - Way to the hospital un Versailles France

0.	**Allée des Mortemets, 78000 Versailles, France**
1.	Take the northwest of the Allée des Mortemets by Allée des Matelots
2.	Turn right at Allée des Matelots and continue to D10
3.	Turn right at D10(Route de Saint Cyr)
4.	Continue along D10(Route de Saint Cyr)
5.	Turn left into Rue de l ' Indépendance Américaine
6.	Continue on Rue Saint-Julien
7.	Turn left into Rue des Récollets
8.	Turn right at Av Nepveu Court
9.	Turn slightly left at Av Rockefeller
10.	Continue along Rue Hoche/D186
11.	Continue along Rue Carnot
12.	Keep up the right side to the other on Rue Carnot
13.	Turn slightly to the right in the Rue des Reservoirs
14.	At the roundabout take the exit second to Bd du Roi/D186
15.	At the roundabout take the exit fifth of Bd Saint-Antoine/D186
16.	Connect with the D307 through the exit for La Celle-Saint-Cloud/Rocquencourt-Étang
17.	Continue straight to the Route de Mantes/D307
18.	Turn right into Rue de Versailles
19.	**Centre Hospitalier de Versailles, 177 Rue de Versailles, 78150 Le Chesnay, France**

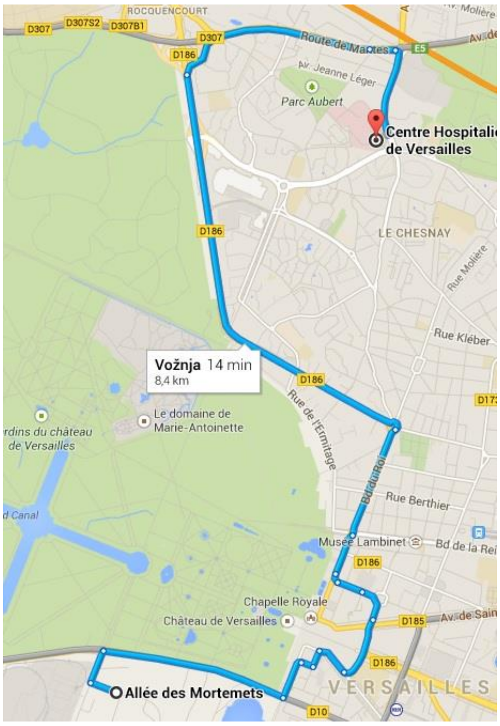


Figure 294 - Way to the hospital in Versaille, France

10.12.5 Incident/accident report form

This form shall be used to report incidents and accidents that occur while transporting, assembling, maintaining, operating, or disassembling the Mem**brain** prototype in Versailles. Incidents and accidents include any physical injury and any worksite incident or accident that did or could have resulted in injury or property damage (e.g., falling objects, allergic reactions, headaches from fumes, back injury). An incident report form shall be completed and submitted to SDE Organization even if no injury or property damage occurred.

Table 90 - Incident / accident report form

1. Date:
2. Time:
3. Location:
4. Incident/accident description:

5. Casual factors: (List the basic causes. A basic cause is any cause that, if eliminated, would have prevented the incident/accident. Contributing causes may also be listed, but should not be confused with basic causes.)
6. Corrective actions to prevent recurrence: (Indicate whether actions have been taken or are planned, as well as the person responsible for each action and the date by witch planned actions shall be completed.)
7. Lessons learned: (What wold you communicate to other Solar Decathlon Teams as a result of this incident/accident?)

10.13 Risk identification for possible later works

Corresponding to risk assessment analysis in Annex 2, risk identification for possible later works is shown for each task:

Site cleaning

Risk identification:

Fall of persons at a different level, Stepping on objects, Accidents caused by living beings, Exposure to extreme environmental temperatures, Exposure to harmful substances, Contact with caustic or corrosive substances

To avoid this risks:

- Collective protection: Perimeter and protection fences, General grounding installation of the site
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves
- Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Cleaning PV-panels

Risk identification:

Fall of persons at a different level, Stepping on objects, Knocked by objects or tools, Accidents caused by living beings, Trapped by or between objects, Exposure to extreme environmental temperatures, Thermal contact

To avoid this risks:

- Collective protection: Perimeter and protection fences, General grounding installation of the site, Anchorage points at heights
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Allumunium telesopic ladder, Safety harness
- Signposting: No access for unauthorized person, First aids, Evacuation plan, Fire extinguisher

Repairing the electrical installation

Risk identification:

Stepping on objects, Knocked by objects or tools, Accidents caused by living beings, Exposure to extreme environmental temperatures, Exposure to electric connections:

To avoid this risks:

- Collective protection: Fire extingushers, General grounding installation of the site
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves
- Signposting: No access for unauthorized person, First aids, Evacuation plan, Fire extinguisher, Electric shock risk

Outer glass façade and glass partition walls cleaning

Risk identification:

Fall of persons at a different level, Stepping on objects, Knocked by objects or tools, Accidents caused by living beings, Trapped by or between objects, Exposure to extreme environmental temperatures, Thermal contact

To avoid this risks:

- Collective protection: Perimeter and protection fences
- Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Allumunium telesopic ladder
- Signposting: No access for unauthorized person, First aids, Evacuation plan, Falling objects

10.14 Useful plans and information about health and safety

To be developed in next deliverable

10.15 Adopted system for the level of Health and Safety control during works

At any time during the assembly and disassembly of the house HS Coordinator or Safety Officer will be on the site. They will be responsible about health and safety on construction site, checking the proper use of the PPE, the collective protection, signposting, the monitoring of the preventive procedures and safety work process.

In the beginning of every shift the HS Coordinator or Safety Officer must talk with HS Coordinator or Safety Officer of previous shift about anything important or interesting in health and safety terms. Also, they first enter the site in the beginning of each shift and check to see if everything is in order.

To control for the required action effectively on the construction site there will be copy of Health and Safety Plan and risk charts for every shift.

According to these documents, the leaders overlook quickly whether all required action is taken and where the hazards may occur.

By means of my signature, I declare: UNIZG Team has provided me with the individual protections required (PPE), in accordance with the work I'm going to develop, and the possible risks associated. Those risks are indicated in this document. I have received enough information concerning the safe use if the PPE, its maintenance and storage procedure. I have received training concerning the Collective Protections to use, its correct usage and its maintenance procedure.

Table 91 - Template for the Adopted system for the level of Health and Safety control during works

Name	Surname	ID	Date of birth	Signature

10.16 Formation and information about health and safety

To be developed in next deliverable

10.17 Emergency evacuation plan during assembly and disassembly periods

In case of emergency during the assembly or disassembly it will be easy to evacuate from the prototype because it is open from three sides until the phase of outer glass facade assembly. After this point, emergency escape can be carried out through the two escape ways in the north (main door - Exit 1) and the other one in the south (main door - Exit 2) of the house.

During the competition, it must be possible to open the main entrance and the maintenance door on the northern side of the prototype at any given time.

- escape through exit 1: You have to leave the house on the north side by the main door, turn to the west side and leave the construction site over the terrace or approach ramp.
- escape through exit 2: You have to leave the house on the south side through the terrace and go over the approach ramp and terrace and leave the construction site.

During the evacuation, a team member will be in charge of directing people to the exits. The people will be asked to stay calm and leave the house area without pushing. Inside the house, we will ask people to leave the house calmly to avoid any risk of falling and after verifying that the house is empty we will start necessary emergency actions.

In the event of an incident, people shall:

- Remove any individuals from situations involving additional danger
- Call appropriate response teams: - 112 in case of Emergency
- Perform first aid, by properly trained team members
- Maintain control of the environment and prevent further injuries until professional help arrives
- Notify the SD Organizers including available public safety organizers

Planned protocol of action in case of fire:

In case of a small-scale fire, fire extinguishers from the interior or exterior areas will be use to extinguish the fire. In case of a large-scale fire, we will call the fire department immediately and will notify the organization to avoid any risk.

Planned protocol of action in case of accident:

In case of accident, all the team members are able to provide first aid. First aid bag will be stored in the house and ready to be used. Team members will leave other people of the site and create a security perimeter around the person before help arrives.

As soon as help has received the patient, team members will assist them and turn their attention to the appropriate evacuation procedure.

Telephone numbers of emergency:

Emergency: 112

Police: 17

SAMU: 15

Fire department: 18

10.18 Annex 1– Identification of risk and evaluation of the efficiency of the adopted protections

ASSEMBLY / DISASSEMBLY

RISK ASSESMENT ANALYSIS

Table 92 - Symbol Explanation

Probability of the event	Determined precaution	Consequence of the risk	Risk qualification with precaution applied
R=Remote	**Cl**=Collective Protection	**L**=Slight Injury	**T**=Trivial Risk
P=Possible	**Pi**=Individual Protection	**G**=Serious injury	**To**=Tolerable Risk
C=Certain	**PP**=Preventive Procedures	**Mo**=Fatal Injury	**M**=Moderate Risk
	S=Signs		**I**=Important Risk
			In=Intolerable risk

RISK ASSESSTMENT RA1

Task Name: Truck arrival/Truck departure	Evaluation place: drawings														
Activity name: All activity															
AGENTS (human resources, machinery, materials, etc.):	Truck driver, Signaling worker for truck + (SD Coordinator and SO Coordinator), Truck														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:		X					X		X		X				
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~															
Colliding with still objects:		X				X	X		X		X				
Colliding with objects in motion:		X		X		X			X			X			
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X		X					X			X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:		X		X		X			X			X			
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X				X			X			X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X		X		X	X			X		X			
Non traumatic pathologies: rumor, vibrations	X						X	X							
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA2															
Task Name: Boundary facing setup/removal	Evaluation place: drawings														
Activity name: Boundary fencing setup / removal															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator)														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X			X		X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X		X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:		X					X	X				X			
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling dust	X						X		X		X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection:

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA3

Task Name: Setting up/Removal assembly zone and storage area | Evaluation place: drawings

Activity name: Setting up assembly zone, Setting up storage area/Assembly zone removal, Storage area removal

AGENTS (human resources, machinery, materials, etc.): Workers + (SD Coordinator and SO Coordinator)

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X			X		X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X		X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:		X					X	X				X			
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling dust	X						X		X		X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSMENT RA4															
Task Name: Unloading/loading by hand from the trucks	Evaluation place: drawings														
Activity name: Setting up disposal point, Setting the Base Camp, Terrace fence/Disposal point removal, Base Camp removal, Terrace fence removal, Gutter assembly / disassembly															
AGENTS (human resources, machinery, materials, etc.):	**Workers + (SD Coordinator and SO Coordinator), trash can, tent, terrace fence**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X		X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X					X	X			X				
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X				X	X		X			X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, dust	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSSTMENT RA5															
Task Name: Unloading/loading by hand from the trucks	Evaluation place: drawings														
Activity name: Column assembly, Placing foundations, Placing plumbing system box/Column disassembly, Foundations removal, Plumbing system box removal															
AGENTS (human resources, machinery, materials, etc.):	Workers+ (SD Coordinator and SO Coordinator), column, foundations, plumbing system box														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X		X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X					X		X			X			
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X					X	X				X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, dust	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA6															
Task Name: Unloading/loading by forklift from the trucks	Evaluation place: drawings														
Activity name: Engine system room 1 (Heat pump, Heat exchanger), Engine system room 2 (Washing machine, DHW tank, Energy store tank)															
AGENTS (human resources, machinery, materials, etc.):	**Forklift operator + (SD Coordinator and SO Coordinator), forklift, heat pump, heat exchanger, washing machine, DHW tank, energy store tank**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X		X			X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:		X					X		X			X			
Stepping on objects:		X				X	X	X			X				
Colliding with still objects:		X					X		X			X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:		X			X	X	X				X				
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X		X				
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X				X				
Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA7															
Task Name: Unloading/loading by forklift from the trucks	Evaluation place: drawings														
Activity name: Parquet, Terrace floor covering, Parquet removal, Terrace floor covering removal															
AGENTS (human resources, machinery, materials, etc.):	**Forklift operator + (SD Coordinator and SO Coordinator), forklift, bathroom tiles, parquet, terrace floor covering**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X		X			X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:		X					X		X			X			
Stepping on objects:		X				X	X	X			X				
Colliding with still objects:		X					X		X			X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:		X			X	X	X				X				
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X		X				
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X				X				
Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA8															
Task Name: Unloading/loading by forklift from the trucks					Evaluation place: drawings										
Activity name: Kitchen elements, Movable elements, Sofa, Kitchen table and chairs, Table for TV, Home appliances, Bathroom elements setup/removal															
AGENTS (human resources, machinery, materials, etc.):	Forklift operator + (SD Coordinator and SO Coordinator), forklift, kitchen elements, movable element (bed and closet), sofa, kitchen table and chairs, table for TV, home appliances, bathroom elements														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X		X			X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:		X					X		X			X			
Stepping on objects:		X				X	X	X			X				
Colliding with still objects:		X					X		X			X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:		X			X	X	X				X				
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X		X				
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X				X				
Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															

Collective protection: Perimeter and protection fences, General grounding installation of the site
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA9															
Task Name: Unloading/loading by crane from the trucks				Evaluation place: drawings											
Activity name: Placing container, Placing water tank /Container removal, Water tank removal															
AGENTS (human resources, machinery, materials, etc.):	Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, container														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~	X				X			X			X				
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X				X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, vibrations, rumor	X				X	X	X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															

Collective protection: Auxiliary ropes for safety load orientation
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protection
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA10															
Task Name: Unloading/loading by crane from the trucks and stocking						Evaluation place: drawings									
Activity name: Shear wall assembly (structure and insulation part), Wooden partition wall assembly, Element with door block assembly, Northern wall insolation panels assembly / Shear wall disassembly (structure and insulation part), Wooden partition wall disassembly, Element with door block disassembly, Northern wall insolation panels disassembly															
AGENTS (human resources, machinery, materials, etc.):	Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, shear wall (structure and insulation part), wooden partition wall, element with door block, northern wall insolation panels														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
~~Fall of objects because of manipulation:~~															
Stepping on objects:	X				X			X			X				
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X				X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, vibrations, rumor	X				X	X	X	X			X				
In itinere:	X						X	X			X				

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table raplaces the nominal lists as unnecessary
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED
Collective protection: Auxiliary ropes for safety load orientation
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Hearing protectors
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA11															
Task Name: Unloading/loading by crane from the trucks							Evaluation place: drawings								
Activity name: Floor panel assembly, Roof panel assembly, Aluminium rails, Assembled pv block assembly / Floor panel disassembly, Roof panel disassembly, Aluminium rails, Assembled pv block disassembly															
AGENTS (human resources, machinery, materials, etc.):	**Crane operator, Signaling worker for cran + (SD Coordinator and SO Coordinator), crane, floor panel, roof panel, aluminium rails, assembled pv block**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~	X				X			X			X				
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X				X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, vibrations, rumor	X				X	X	X	X			X				

	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
In itinere:	X						X	X			X				

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA12

Task Name: Unloading/loading from the trucks

Evaluation place: drawings

Activity name: Glass partition wall assembly, Glass element with door block assembly, Glass facade block assembly, Glass facade element assembly / Glass partition wall disassembly, Glass element with door block disassembly, Glass facade block disassembly, Glass facade element disassembly

AGENTS (human resources, machinery, materials, etc.): Operator, Signaling worker for cran + (SD Coordinator and SO Coordinator), Glass lifting, glass partition wall, glass element with door block, glass facade block, glass facade element

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X		X			X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:		X					X		X			X			
Stepping on objects:		X				X	X	X			X				
Colliding with still objects:		X					X		X			X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
Trapped by turned over machines, tractors or vehicles:		X			X	X	X								
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X		X				
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X				X				

Non traumatic pathologies: inhaling gasses, fumes, dust, vibrations, rumor	X						X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA13															
Task Name: Unloading/Loading by crane from the trucks				Evaluation place: drawings											
Activity name: Terrace structure, Ramps and stairs setup/removal															
AGENTS (human resources, machinery, materials, etc.):	**Crane operator, Signaling worker for cran + (SD Coordinator and SO Coordinator), crane, terrace structure, ramps and stairs**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~	X				X			X			X				
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X				X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				

~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, fumes, vibrations, rumor	X				X	X	X	X			X				
In itinere:	X						X	X			X				
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Auxiliary ropes for safety load orientation															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSSTMENT RA14															
Task Name: On site transport by hand				Evaluation place: drawings											
Activity name: Placing foundations, Column assembly, Terrace fence / Foundations removal, Column disassembly, Gutter assembly / disassembly															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), column, foundations, terrace fence														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X		X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X					X		X			X			
~~Stepping on objects:~~															
Colliding with still objects:		X					X	X				X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X		X		X			X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
~~Exposure to extreme environmental temperatures:~~															
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															

~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: inhaling gasses, fumes, dust~~															
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA15															
Task Name: On site transport by forklift							Evaluation place: drawings								
Activity name: Engine system room 1 (Heat pump, Heat exchanger), Engine system room 2 (Washing machine, DHW tank, Energy store tank)															
AGENTS (human resources, machinery, materials, etc.):	Forklift operator + (SD Coordinator and SO Coordinator), forklift, heat pump, heat exchanger, washing machine, DHW tank, energy store tank														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X	X				X	X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
Trapped by turned over machines, tractors or vehicles:		X			X	X	X		X		X				
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															

Exposure to harmful substances:	X				X		X		X						
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X			X	X				
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X		X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA16															
Task Name: On site transport by forklift					Evaluation place: drawings										
Activity name:Parquete, Terrace floor covering setup/removal, Bathroom elements setup/removal															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), forklift, bathroom tiles, parquete, terrace floor covering														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X	X				X	X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
Trapped by turned over machines, tractors or vehicles:		X			X	X	X		X		X				
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				

~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X						
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X			X	X				
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X		X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA17															
Task Name: On site transport by forklift	Evaluation place: drawings														
Activity name: Kitchen elements, Movable elements, Sofa, Kitchen table and chairs, Table for TV, Home appliances, Bathroom elements setup/removal															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), forklift, kitchen elements, movable element (bed and closet), sofa, kitchen table and chairs, table for TV, home appliances, bathroom elements														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X	X				X	X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
Trapped by turned over machines, tractors or vehicles:		X			X	X	X		X		X				
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															

	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X						
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X			X	X				
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X		X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA18

Task Name: On site transport by crane — Evaluation place: drawings

Activity name: Placing container, Placing water tank / Container removal, Water tank removal

AGENTS (human resources, machinery, materials, etc.): Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, container

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															

Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA19

Task Name: On site transport by crane — Evaluation place: drawings

Activity name: Shear wall assembly (structure and insulation part), Wooden partition wall assembly, Element with door block assembly, Northern wall insolation panels assembly / Shear wall disassembly (structure and insulation part), Wooden partition wall disassembly, Element with door block disassembly, Northern wall insolation panels disassembly

AGENTS (human resources, machinery, materials, etc.): Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, shear wall (structure and insulation part), wooden partition wall, element with door block, northern wall insolation panels

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															

~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Hearing protectors

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA20

Task Name: On site transport by crane | Evaluation place: drawings

Activity name: Floor panel assembly, Roof panel assembly, Aluminium rails, Assembled pv block assembly / Floor panel disassembly, Roof panel disassembly, Aluminium rails, Assembled pv block disassembly

AGENTS (human resources, machinery, materials, etc.): **Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, floor panel, roof panel, aluminium rails, assembled pv block**

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															

~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Auxiliary ropes for safety load orientation															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Hearing protectors															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA21															
Task Name: On site transport				Evaluation place: drawings											
Activity name: Glass partition wall assembly, Glass element with door block assembly, Glass facade block assembly, Glass facade element assembly / Glass partition wall disassembly, Glass element with door block disassembly, Glass facade block disassembly, Glass facade element disassembly															
AGENTS (human resources, machinery, materials, etc.):	Operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), glass lifting, glass partition wall, glass element with door block, glass facade block, glass facade element														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X						X		X		X				
Fall of objects because of manipulation:	X						X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X	X				X	X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															

~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
Trapped by turned over machines, tractors or vehicles:		X			X	X	X		X		X				
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X				X	X	X		X		X				
Exposure to electric connections:	X				X		X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X		X		X						
~~Contact with caustic or corrosive substances:~~															
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
Run over or hit by vehicles:		X			X	X	X			X	X				
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X		X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED
Collective protection: Auxiliary ropes for safety load orientation
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Protective gloves, Reflective jacket
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA22	
Task Name: On site transport by crane	Evaluation place: drawings
Activity name: Terrace structure, Ramps and stairs setup/removal	
AGENTS (human resources, machinery, materials, etc.):	Crane operator, Signaling worker for crane + (SD Coordinator and SO Coordinator), crane, terrace structure, ramps and stairs

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X	X	X			X	X				
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~															
Colliding with still objects:		X				X	X		X		X				
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															

~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X					X	X		X		X				
Exposure to electric connections:	X					X	X			X	X				
~~Exposure to radiation:~~															
Exposure to harmful substances:	X						X		X		X				
Contact with caustic or corrosive substances:	X						X		X		X				
Explosion:	X					X	X			X	X				
Fire:	X					X	X			X	X				
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Auxiliary ropes for safety load orientation															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA23															
Task Name: Foundation system setup/removal	Evaluation place: drawings														
Activity name: Placing foundations, Foundation leveling, Placing decking foundations / Foundations removal, Decking foundations removal															
AGENTS (human resources, machinery, materials, etc.):	**Workers + (SD Coordinator and SO Coordinator), foundations**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X				X	X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X	X	X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				

Flying fragments or particles:	X						X	X				X			
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
Contact with caustic or corrosive substances:	X						X		X		X				
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA24															
Task Name: Exterior setup/removal								Evaluation place: drawings							
Activity name: Placing the container, Setting the Base Camp / Container removal, Base Camp removal															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), container, tent														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X				X	X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X	X	X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				

Flying fragments or particles:	X						X	X				X			
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
Contact with caustic or corrosive substances:	X						X		X		X				
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations, rumor	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA25

Task Name: Assembly/Disassembly of structural elements and crane operations | Evaluation place: drawings

Activity name: Floor panel assembly, Terrace structure assembly/Floor panel disassembly, Terrace structure disassembly

AGENTS (human resources, machinery, materials, etc.): **Workers + (SD Coordinator and SO Coordinator), crane, floor panel, terrace structure**

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X	X	X	X			X				
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X					X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
Colliding with objects in motion:		X				X	X			X		X			

Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: rumor, vibrations	X				X	X	X		X		X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA26															
Task Name: Assembly/Disassembly of structural elements	Evaluation place: drawings														
Activity name: Column assembly/Column disassembly															
AGENTS (human resources, machinery, materials, etc.):	**Workers + (SD Coordinator and SO Coordinator), column**														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X				X			X			
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X				X				
Fall of objects because of manipulation:	X				X	X			X		X				
~~Stepping on objects:~~															
~~Colliding with still objects:~~															

Colliding with objects in motion:		X			X	X	X		X			X			
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X				X	X		X			X			
Trapped by or between objects:		X				X	X		X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies:~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchoring points at heights
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Alluminium telescopic ladder
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA27															
Task Name: Assembly/Disassembly of structural elements and crane operations				Evaluation place: drawings											
Activity name: Aluminium rails assembly / Aluminium rails disassembly															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, roof panel, aluminium rails														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X	X	X	X							
Fall of persons at the same level:		X			X	X	X	X				X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X		X	X			X				

~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
Accidents caused by living beings:		X					X	X			X				
Trapped by or between objects:		X			X	X	X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: rumor, vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Anchorage points at heights

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Safety harness

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA28															
Task Name: Assembly/Disassembly of structural elements and crane operations	Evaluation place: drawings														
Activity name: Assembled pv block assembly/Assembled pv block disassembly															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, assembled pv block														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X	X	X			X		X			
Fall of persons at the same level:		X		X	X		X		X			X			
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															

Fall of objects because of manipulation:	X				X			X			X				
Stepping on objects:		X			X			X			X				
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X			X				X			X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X		X	X	X			X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: rumor, vibrations~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Scaffolding, Anchorage points at heights

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Hearing protectors, Safety harness

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA29

Task Name: Assembly/Disassembly of structural elements and crane operations

Evaluation place: drawings

Activity name: Shear wall block assembly (structure and insulation part), Wooden partition wall assembly, Element with door block assembly, Northern wall insolation panels / Shear wall block disassembly (structure and insulation part), Wooden partition wall disassembly, Element with door block disassembly, Northern wall insolation panels disassembly

AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, shear wall (structure and insulation part), wooden partition wall, element with door block														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															

Fall of persons at the same level:		X			X	X	X	X				X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
Fall of objects because of manipulation:		X					X	X			X				
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
Colliding with objects in motion:		X				X	X			X		X			
Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
Accidents caused by living beings:															
Trapped by or between objects:		X			X	X	X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: rumor, vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchorage points at heights
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Hearing protectors, Alluminuim telescopic ladder
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

<table>
<tr><td colspan="5">RISK ASSESSTMENT RA30</td></tr>
<tr><td colspan="2">Task Name: Assembly/Disassembly of structural elements</td><td colspan="3">Evaluation place: drawings</td></tr>
<tr><td colspan="5">Activity name: Glass partition wall assembly, Glass element with door block assembly, Glass facade block assembly, Glass facade element assembly / Glass partition wall disassembly, Glass element with door block disassembly, Glass facade block disassembly, Glass facade element disassembly</td></tr>
<tr><td>AGENTS (human resources, machinery, materials, etc.):</td><td colspan="4">Workers + (SD Coordinator and SO Coordinator), glass lifting, glass partition wall, glass element with door block, glass facade block, glass facade element with door block</td></tr>
<tr><td>Risk identification and its causes</td><td>Probability of the event</td><td>Determined precaution</td><td>Consequence of the risk</td><td>Risk qualification with precaution applied</td></tr>
</table>

Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X	X	X	X				X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
Fall of objects because of manipulation:		X					X	X			X				
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
Colliding with objects in motion:		X				X	X			X		X			
Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
Accidents caused by living beings:															
Trapped by or between objects:		X			X	X	X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: rumor, vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchorage points at heights, Scaffolding
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Alluminium telescopic ladder
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA31	
Task Name: Assembly / Disassembly of structural elements and crane operations	Evaluation place: drawings
Activity name: Ramps and stairs assembly/disassembly	
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, ramps, stairs

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In

~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X				X	X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X	X	X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:	X				X		X	X			X				
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
Trapped by turned over machines, tractors or vehicles:															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling dust, rumor, vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA32				
Task Name: Assembly/Disassembly by hand		Evaluation place: drawings		
Activity name: Terrace fence assembly/disassembly				
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, terrace fence			
Risk identification and its causes	Probability of the event	Determined precaution	Consequence of the risk	Risk qualification with precaution applied

Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X				X	X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
~~Stepping on objects:~~															
~~Colliding with still objects:~~															
Colliding with objects in motion:		X			X		X			X		X			
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: inhaling dust, rumor, vibrations~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA33				
Task Name: Interconnection of panels		Evaluation place: drawings		
Activity name: Floor panel assembly, Roof panel assembly, Element with door block assembly				
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), floor panels, roof panels, alemat with door block			
Risk identification and its causes	Probability of the event	Determined precaution	Consequence of the risk	Risk qualification with precaution applied

knocked by objects or tools:	R	P	C	C l	P i	S	P P	L	G	Mo	T	T o	M	I	I n
Fall of persons at a different level:		X		X	X	X	X	X							
Fall of persons at the same level:		X			X	X	X	X				X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
Fall of objects because of manipulation:		X					X	X			X				
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
Colliding with objects in motion:		X				X	X			X		X			
Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
Accidents caused by living beings:															
Trapped by or between objects:		X			X	X	X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchoring points at heights

Personal Protection Equipment: Hard hat, safety glasses, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Safety harness

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA34	
Task Name: Working at heights	Evaluation place: drawings
Activity name: Wooden facade assembly, Suspending celling setup, Synthetic waterproofing setup, Canvas facade assembly, Temporary construction support assembly, Suspending celling removal, Synthetic waterproofing removal, Canvas facade disassembly, Wooden facade disassembly, Temporary construction support removal, Gutter assembly / disassembly, Steel Braces assembly / removal	

AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), ladder, wooden facade, suspending ceilings, synthetic waterproofing														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X			X	X			X			X			
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X				X			X			X				
Fall of objects because of manipulation:	X				X	X		X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X			X				X			
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X			X			X				
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
Thermal contact:	X				X			X			X				
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies:~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, Anchorage points at heights, General grounding installation of the site, Auxiliary ropes for safety load orientation

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Allumunium telescopic ladder, Safety harness

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENTRA35	
Task Name: Plumbing works	Evaluation place: drawings

Activity name: Engine system room 1 setup, Engine system room 2 setup, Placing plumbing system box / Engine system room 1 removal, Engine system room 2 removal, Plumbing system box removal

AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator)														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~		X		X	X	X	X			X	X				
Fall of persons at the same level:		X			X	X	X	X			X				
Fall of objects because of collapse:		X				X	X			X	X				
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X			X		X	X			X				
~~Stepping on objects:~~															
Colliding with still objects:		X			X		X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:		X					X	X				X			
Accidents caused by living beings:															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:															
Exposure to electric connections:	X				X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies:	X						X		X		X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA36	
Task Name: Electrical works	Evaluation place: drawings

Activity name: Engine system room 1 setup, Engine system room 2 setup, Installations and system setup, Canvas facade assembly, PV system setup / Engine system room 1 removal, Engine system room 2 removal, Plumbing system box removal, Canvas facade disassembly, PV system removal															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator)														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~		X		X	X	X	X			X	X				
Fall of persons at the same level:		X			X	X	X	X			X				
Fall of objects because of collapse:		X				X	X			X	X				
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X			X		X	X			X				
Stepping on objects:		X			X						X				
Colliding with still objects:		X			X		X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:		X					X	X				X			
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:															
Exposure to electric connections:	X				X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies:	X						X		X		X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Fire extinguishers, General grounding installation of the site, Anchorage points at heights															
Personal Protection Equipment: Hard hat, Safety glasses, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Safety harness															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects, Fire extinguisher, Electric shock risk															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSTMENT RA37	
Task Name: Electrical works	Evaluation place: drawings

Activity name: Engine system room 1 (Heat pump, Heat exchanger), Engine system room 2 (Washing machine, DHW tank, Energy store tank)

AGENTS (human resources, machinery, materials, etc.): Workers + (SD Coordinator and SO Coordinator), heat pump, heat exchanger, washing machine, DHW tank, energy store tank

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~		X		X	X	X	X			X	X				
Fall of persons at the same level:		X			X	X	X	X			X				
Fall of objects because of collapse:		X				X	X			X	X				
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X			X		X	X			X				
Stepping on objects:		X			X						X				
Colliding with still objects:		X			X		X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:		X					X	X				X			
~~Accidents caused by living beings:~~															
Trapped by or between objects:		X					X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
Thermal contact:															
Exposure to electric connections:	X				X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies:	X						X		X		X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Fire extinguishers, General grounding installation of the site

Personal Protection Equipment: Hard hat, Safety glasses, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects, Fire extinguisher, Electric shock risk

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSSTMENT RA38															
Task Name: Loading/unloading the gravel, air duct, floor under structure by hand	Evaluation place: drawings														
Activity name: Gravel floor covering, Floor under structure assembly, Air duct placement															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), gravel														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X			X		X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:		X					X		X			X			
~~Stepping on objects:~~															
Colliding with still objects:		X					X	X				X			
Colliding with objects in motion:		X					X	X				X			
Knocked by objects or tools:			X		X		X					X			
~~Flying fragments or particles:~~															
Accidents caused by living beings:		X					X	X				X			
Trapped by or between objects:		X				X			X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
~~Exposure to extreme environmental temperatures:~~															
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: inhaling gasses, fumes, dust~~															
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection:															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

RISK ASSESSSTMENT RA39

Task Name: Installing the floor / Floor covering removal | Evaluation place: drawings

Activity name:Parquete, Terrace floor covering, Parquete removal, Terrace floor covering

AGENTS (human resources, machinery, materials, etc.): Workers + (SD Coordinator and SO Coordinator), bathroom tiles, parquete, terrace floor covering

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X					X	X				X			
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:	X				X		X	X			X				
Stepping on objects:		X			X		X	X			X				
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
~~Flying fragments or particles:~~															
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies:~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection:

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA40

Task Name: Interior furnishing setup/removal	Evaluation place: drawings
Activity name: Kitchen elements, Movable elements, Sofa, Kitchen table and chairs, Table for TV, Home appliances, Bathroom elements setup/removal	
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), kitchen elements, movable elements, sofa, kitchen table and chairs, table for TV, home appliances, bathroom elements

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
Fall of persons at the same level:		X				X	X	X			X				
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X	X	X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X			X				
Flying fragments or particles:	X						X	X				X			
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
Overexertion:			X				X	X				X			
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X			X	X				
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
Contact with caustic or corrosive substances:	X						X		X		X				
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: inhaling gasses, vapors, fumes, dust, vibrations	X				X	X	X	X			X				
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection:

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA41														
Task Name: Garden works								Evaluation place: drawings						
Activity name: Plants														
AGENTS (human resources, machinery, materials, etc.):	Worker + (SD Coordinator and SO Coordinator), plants													
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied			
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X	X			X			X			
Fall of persons at the same level:		X			X		X	X				X			
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
Fall of objects because of manipulation:	X				X				X		X				
Stepping on objects:		X			X			X			X				
Colliding with still objects:		X					X	X				X			
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X		X		X	X				X			
Flying fragments or particles:		X			X		X	X				X			
~~Accidents caused by living beings:~~															
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
~~Exposure to extreme environmental temperatures:~~															
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies:~~															
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RA42															
Task Name: Assembly/Disassembly of structural elements and crane operations	Evaluation place: drawings														
Activity name: Roof panel assembly / Roof panel disassembly															
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator), crane, roof panel, aluminium rails														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X	X	X	X							
Fall of persons at the same level:		X			X	X	X	X				X			
~~Fall of objects because of collapse:~~															
Fall of objects because they come loose:	X					X	X			X	X				
Fall of objects because of manipulation:		X					X	X			X				
Stepping on objects:		X			X		X	X			X				
Colliding with still objects:		X			X	X	X	X			X				
Colliding with objects in motion:		X				X	X			X		X			
Knocked by objects or tools:			X		X	X	X		X		X				
Flying fragments or particles:		X					X	X			X				
Accidents caused by living beings:		X					X	X			X				
Trapped by or between objects:		X			X	X	X	X			X				
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X						X		X		X				
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
Non traumatic pathologies: rumor, vibrations	X				X	X	X	X			X				
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences, General grounding installation of the site, Auxiliary ropes for safety load orientation, Anchoring points at heights, Scaffolding															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, safety boots, Reflective jacket, Protective gloves, Hearing protectors, Safety harness															
Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Obligatory hearing protection, Rescue and relief operations, First aids, Evacuation plan, STOP, Maximus speed, Signaling cones, Fire extinguisher, Falling objects															

10.19 Annex 2– Identification of risk for possible later works

POSSIBLE LATER WORKS

RISK ASSESMENT ANALYSIS

Table 93 - Symbol Explanation

Probability of the event	Determined precaution	Consequence of the risk	Risk qualification with precaution applied
R=Remote	**Cl**=Collective Protection	**L**=Slight injury	**T**=Trivial Risk
P=Possible	**Pi**=Individual Protection	**G**=Serious injury	**To**=Tolerable Risk
C=Certain	**PP**=Preventive Procedures	**Mo**=Fatal injury	**M**=Moderate Risk
	S=Signs		**I**=Important Risk
			In=Intolerable risk

RISK ASSESSTMENT RALW1

Task Name: Site cleaning — Evaluation place: drawings

AGENTS (human resources, machinery, materials, etc.): Workers + (SD Coordinator and SO Coordinator)

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	CI	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X		X	X		X		X			X			
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X		X		X			X			
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
~~Knocked by objects or tools:~~															
~~Flying fragments or particles:~~															
Accidents caused by living beings:	X				X				X			X			
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:		X			X	X			X			X			
~~Thermal contact:~~															
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
Exposure to harmful substances:	X				X				X			X			
Contact with caustic or corrosive substances:	X				X			X				X			
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: rumor, vibrations~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, Obligatory head protection, Obligatory foot protection, Obligatory hands protection, Rescue and relief operations, First aids, Evacuation plan

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RALW2

Task Name: Cleaning PV-panels | Evaluation place: drawings

AGENTS (human resources, machinery, materials, etc.): Workers + (SD Coordinator and SO Coordinator)

Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X			X		X		X			X			
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X		X	X			X				
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X	X	X		X		X		X				
~~Flying fragments or particles:~~															
Accidents caused by living beings:	X				X		X		X			X			
Trapped by or between objects:		X			X		X		X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X			X	X				X			X			
Thermal contact:	X				X		X		X			X			
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: rumor, vibrations~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Perimeter and protection fences, General grounding installation of the site, Anchorage points at heights

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Allumunium telescopic ladder, Safety harness

Signposting: No access for unauthorized person, First aids, Evacuation plan, Fire extinguisher

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RALW3

Task Name: Repairing the electrical installation

Evaluation place: drawings

AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator)														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
~~Fall of persons at a different level:~~															
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X		X	X			X				
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X	X	X		X				X				
~~Flying fragments or particles:~~															
Accidents caused by living beings:	X				X		X		X			X			
~~Trapped by or between objects:~~															
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X			X	X				X			X			
~~Thermal contact:~~															
Exposure to electric connections:	X			X	X	X	X		X			X			
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: rumor, vibrations~~															
~~In itinere:~~															

In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary

DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED

Collective protection: Fire extinguishers, General grounding installation of the site

Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves

Signposting: No access for unauthorized person, First aids, Evacuation plan, Fire extinguisher, Electric shock risk

Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.

For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.

RISK ASSESSTMENT RALW4															
Task Name: Outer glass facade and glass partition walls cleaning	Evaluation place: drawings														
AGENTS (human resources, machinery, materials, etc.):	Workers + (SD Coordinator and SO Coordinator)														
Risk identification and its causes	Probability of the event			Determined precaution				Consequence of the risk			Risk qualification with precaution applied				
Date: 01.03.2014.	R	P	C	Cl	Pi	S	PP	L	G	Mo	T	To	M	I	In
Fall of persons at a different level:		X			X		X		X			X			
~~Fall of persons at the same level:~~															
~~Fall of objects because of collapse:~~															
~~Fall of objects because they come loose:~~															
~~Fall of objects because of manipulation:~~															
Stepping on objects:		X			X		X	X			X				
~~Colliding with still objects:~~															
~~Colliding with objects in motion:~~															
Knocked by objects or tools:			X	X	X		X		X		X				
~~Flying fragments or particles:~~															
Accidents caused by living beings:	X				X		X		X			X			
Trapped by or between objects:		X			X		X		X			X			
~~Trapped by turned over machines, tractors or vehicles:~~															
~~Overexertion:~~															
Exposure to extreme environmental temperatures:	X			X	X				X			X			
Thermal contact:	X				X		X		X			X			
~~Exposure to electric connections:~~															
~~Exposure to radiation:~~															
~~Exposure to harmful substances:~~															
~~Contact with caustic or corrosive substances:~~															
~~Explosion:~~															
~~Fire:~~															
~~Run over or hit by vehicles:~~															
~~Non traumatic pathologies: rumor, vibrations~~															
~~In itinere:~~															
In complying with the current legislation, in this evaluation we consider "avoided risks" all qualified as "trivial" or "tolerable"; the rest of the qualifications are considered "not avoided risks"; for operative criteria unification, this table replaces the nominal lists as unnecessary															
DESIGNED RISK PREVENTION, WHICH JOINT EFFECTIVENESS IS EVALUATED															
Collective protection: Perimeter and protection fences															
Personal Protection Equipment: Hard hat, Shirt with sleeves and long trousers, Safety boots, Reflective jacket, Protective gloves, Allumunium telescopic ladder															
Signposting: No access for unauthorized person, First aids, Evacuation plan, Falling objects															
Preventive procedure: Please refer to Health and Safety report, on chapter 10.8.b, where protective measures are defined for each risk cited in table.															
For more detailed instructions or in order to clarify specific items, please also refer to the information given in the text of the Health and Safety Report.															

11 DETAILED WATER BUDGET

Detailed water budget will be updated from Deliverable 5 on.

12 CONSTRUCTION SPECIFICATION

Construction specification will be updated from Deliverable 5 on.

13 STRUCTURAL CALCULATIONS

13.1 SECTION A: Technical description

The following text describes a structural solution for our concept Mem**brain**.

The list of criteria that presided the elaboration of this project guarantees safety, durability, functionality, as well as being reasonably within budgets as the sustainability of this solution.

13.1.1 The justification of the adopted structural solutions

The main idea for concept Mem**brain** is a timber house. Fully customizable and modular, self-sustainable passive house, by using modern technology and design. Our principle is to realize the construction without the concrete, only by mounting different bearing elements which are produce by very simple industrialization. Thus reduces manufacturing costs while ensuring reliability since they are produce at the factory.

Our main aims from the beginning this SDE projects are:

- To work with locals and to restart Croatian manufacture and industry
- To build a sustainable house and to consume less energy as possible
- To have easy industrialize house with smart technical solutions

The house is composed by several parts, made of floors, walls and columns. The loads are applied on the roof plate first. Vertical loads are transmitted by the columns and the horizontal loads are transmitted by walls and bracing system on the floor plate. From floor all loads are transmitted from the foundations to the ground.

The most parts of construction are made up of timber. The choice of using material is primary made with regards to its environmental impacts and in accordance with their natural properties. So the timber was a logically decision because of its nearby availability, too. Timber is a renewable material and acts as a carbon storage which makes it carbon neutral. Floors, columns and walls are made of glued laminated timber. GLT fits perfectly in our concept because it is a new and innovative building material that permits fast and efficient construction of single or multi-residential type buildings. By gluing thin layers of timber imperfections in the original timber, such as knots, can be removed in the factory to reduce variability and enhance structural performance. The wood waste derivate from the bearing elements fabrication can also be used to make a wood wool insulation panels or to produce energy in wood-fired boilers, so the whole wood is used and there is no waste during wood processing.

13.1.2 Description of the house bearing system

Load bearing structure of our house is a combination of several systems that are usually used in design of timber structures. System consists of glued laminated element for floor, ceiling, walls and vertical columns. Glued laminated wall structures on northern side of house have different properties, like a good insulation and good location of any closed storage, same as the bearing system. The wooden columns on the periphery of house are the main vertical bearing structure. Fully glassed south façade has two aims, first is the assumption of Sun lighting in indoor of house, and the second is the connection with the open space. Foundations are positioned under every column (24) and alternately under floor slab (17).

Ceiling structure is glued laminated slab whose dimensions along two main axes are much greater than thickness. Thickness of the ceiling slab is 18 cm, as provided by the design calculations. It has a function of load bearing slab and a diaphragm. Total dimensions of this panel are 9,6 x 7,2 meters. However, due to issues with transport, it will be made in smaller segments. Three 2,4 x 7,2 and two 1,2 x 7,2 meter segments that will be joined together on the construction yard according to the manufacturer instructions. We will use wood screws to ensure their connections.

Bearing system of the floor structure is identical as the ceiling. Ground plan dimensions are 9,6 x 7,2 m, but it will be also made of three 2,4 x 7,2 and two 1,2 x 7,2 meter segments, and it will be joined in the same way as the ceiling panel. Roof and floor glued laminated timber slabs are designed with same thickness. – 18 cm. That's because of our pursuit of modularity and easily design of a double (or more) floor house.

Vertical loads are carried from the ceiling to the glued laminated wooden columns built along the perimeter of the house. This columns are 3,0 meters high, and the cross section area is a rectangle, b x h = 12 x 20 cm. Axial spacing of columns is 1,2 meters, with the note that there are no columns in the four corners of the house. Total number of columns in the house is 24.

Carrying horizontal loads (wind, earthquake etc.) and stiffening of the house is achieved with the assistance of stiffening shear walls and steel structure bracing system. Combined with floor and ceiling slabs it creates a rigid three dimensional structure. Shear walls are located on the north facade of the house, and in the interior part like a partition walls on north side of house. Their width dimensions are 0,95, 1,0 and 1,1 m and all 3,0 meters high. Shear walls are also made of glued laminated timber, and their thickness is d = 6 cm. They will be assembled on the columns and the floor and ceiling slab. Whole northern facade will be walled, with openings for doors and windows, as per architectural designs.

The structure is equipped with two diagonal bracing to prevent the building torsion. Steel structure bracing system is placed on south side of house between the glass elements. Steel bracing elements are made from steel class S275 with diameter of 8 mm. We use steel braces in combination with glued laminated timber wall to increase a building's capability to withstand seismic activity and wind actions on our house. Braces are made from steel with yield strength of 1770 MPa, which is guaranteed from manufacturer and cross section of each brace is shown in Figure 295.

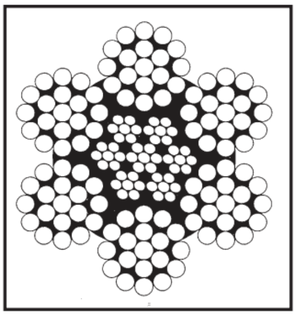


Figure 295 - Cross section of steel braces

Braces are placed diagonally between columns in shape of letter M, as it's shown in figure below. Each brace can only take tensional stress, but because of their horizontal stability is guaranteed.

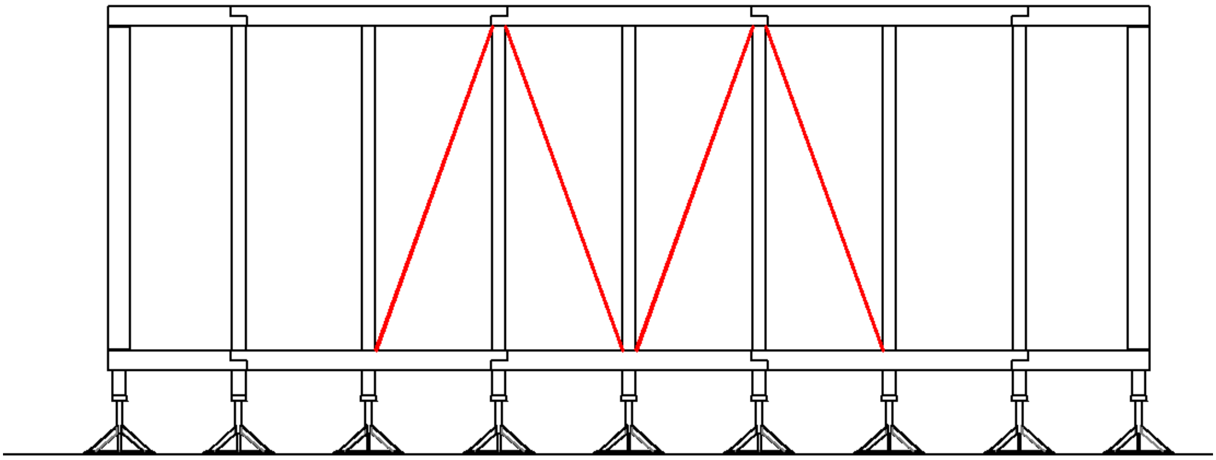


Figure 296 - Positions of steel braces

For all load bearing elements, adequate system of joining is designed, so that all elements and connections are able to carry design loads. Such connectors will have their resistance specified and guaranteed by the manufacturer. As we need to rebuild out house multiple times all connectors will be easily disassembled and reassembled.

Connection of wall panels with floor slabs, other walls and columns will be achieved using patented L profile steel angle brackets by Rothoblaas®, and bolts. Ceiling slabs will not be supported directly by wall panels, so that wall panels take only lateral loads.

Connection of columns with floor slabs will be achieved using T profile steel plates. Connections between roof and columns will be achieved using IdeFix® patented IF 406 connectors, made by Sigha® company.

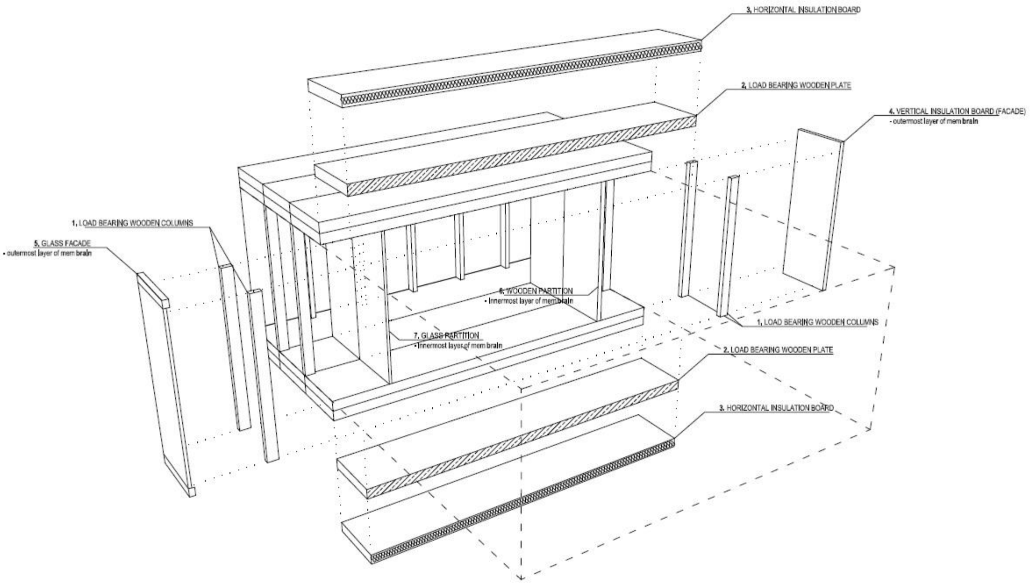


Figure 297 - Load bearing structure of Mem**brain** house

Some of the advantages of this bearing system are:

- Wooden skeleton bears all vertical loads, while walls do not, and they are therefore independent of the skeletal structure
- Walls are designed so that they can be moved and transferred easily
- Freedom in organization of the living space
- Stability of the house is achieved with ceiling and wall diaphragms, and shear walls made of cross laminated wood
- Possibility of both single floor and multi floor structures
- Prefabrication of elements in factories
- Quick construction time
- Simple assembly and erection on the construction spot

13.1.3 The list of codes used for the design and construction

In the making of our project we will comply with every Croatian laws and regulations, primarily with Building Act - entered into force on 1 January 2014 Official Gazette 153/13 and its corresponding regulations, ordinances and technical regulations.

All previously quoted regulations are complemented, by the adoption of dimensioning rules that are more up to date:

- Eurocode 0: Basis of structural design
- Eurocode 1: Actions on structures
- Eurocode 3: Design of steel structures
- Eurocode 5: Design of timber structures
- Eurocode 7: Geotechnical design
- Eurocode 9: Design of aluminium structures

13.2 SECTION B: Material description

13.2.1 Glued Laminated Timber

Glued laminated timer, or commonly called glulam, is a timber product manufactured of individual timber laminations, specifically selected and positioned based on their performance characteristics, and then bonded together with durable, moisture-resistant adhesives. The grain of all laminations runs parallel with the length of the element, so it can be used in horizontal applications as a beam, or vertically as a column. Because of its composition, glulam provides the strength and versatility of large wood members without relying on the old growth-dependent solid-sawn timbers. Glulam is one of the strongest structural materials per unit weight, depending on specific loading conditions, a structural steel beam may be 20% heavier, and a reinforced concrete beam 600% heavier than an equivalent glulam beam of the same load-carrying capacity.

Figure 298 - Glued Laminated Timber Elements

Mechanical properties of glued laminated timber:

GL24h timber

- Bending strength: $f_{m,k}$ = 24,00 N/mm^2
- Tensile strength parallel to grain: $f_{t,0,k}$ = 14,00 N/mm^2
- Tensile strength perpendicular to grain: $f_{t,90,k}$ = 0,35 N/mm^2
- Compression strength parallel to grain: $f_{c,0,k}$ = 21,00 N/mm^2
- Compression strength perpendicular to grain: $f_{c,90,k}$ = 2,40 N/mm^2
- Shear strength: $f_{v,k}$ = 2,20 N/mm^2
- Mean modulus of elasticity parallel to grain: $E_{0,mean}$ = 11 600 N/mm^2
- 5% modulus of elasticity parallel to grain: $E_{0,05}$ = 9 400 N/mm^2
- Mean modulus of elasticity perpendicular to grain: $E_{90,mean}$ = 320 N/mm^2
- Mean shear modulus: G_{mean} = 590 N/mm^2
- Density: ρ = 350 kg/m^3

GL28c timber

- Bending strength: $f_{m,k}$ = 28,00 N/mm^2

- Tensile strength parallel to grain: $f_{t,0,k}$ = 16,50 N/mm^2
- Tensile strength perpendicular to grain: $f_{t,90,k}$ = 0,40 N/mm^2
- Compression strength parallel to grain: $f_{c,0,k}$ = 24,00 N/mm^2
- Compression strength perpendicular to grain: $f_{c,90,k}$ = 2,70 N/mm^2
- Shear strength: $f_{v,k}$ = 2,70 N/mm^2
- Mean modulus of elasticity parallel to grain: $E_{0,mean}$ = 12 600 N/mm^2
- 5% modulus of elasticity parallel to grain: $E_{0,05}$ = 10 200 N/mm^2
- Mean modulus of elasticity perpendicular to grain: $E_{90,mean}$ = 390 N/mm^2
- Mean shear modulus: G_{mean} = 720 N/mm^2
- Density: ρ = 380 kg/m^3

13.2.2 Aluminium

A building is rarely constructed today without aluminium, as the physical properties of aluminium make it a perfect material for construction. Its light weight means that the load on the bearing structure is less, and its strength makes it suitable for a great variety of solutions. Its resistance to corrosion gives it special advantages: aluminium is perfect for regions with severe weather conditions. Finally, its fluidity gives freedom to architects and designers.

- Tensile yield strength: $f_{ty,k}$ = 240,00 N/mm^2
- Tensile ultimate strength: $f_{tu,k}$ = 260,00 N/mm^2
- Modulus of elasticity: E = 70 000 N/mm^2
- Shear modulus: G = 27 000 N/mm^2
- Density: ρ = 2 700 kg/m^3

13.2.3 Steel

Steel is the most recycled material on the planet, more than all other materials combined. Steel retains an extremely high overall recycling rate, which in 2012, stood at 88 percent. The amazing metallurgical properties of steel allow it to be recycled continually with no degradation in performance, and from one product to another. Steel products one of the most widely used building materials in construction today, mainly because they are versatile, durable, and affordable. Steel has the highest strength-to-weight ratio of any other building material, making it ideal for buildings both large and small. It is also very consistent, since steel industry must follow national standards in steel production for various grades, there is no variation from one steel to another and you can get consistently straight. In addition to being one of the most durable materials available, steel products are also good for the environment. It is one of the few metals that is continuously recyclable, and any steel product that you use likely contains at least 25% recycled steel. The recycling process does not break down or weaken steel, making it an ideal candidate for continuous reuse.

- Tensile yield strength: f_{yb} = 235,00 N/mm^2
- Tensile ultimate strength: f_{ub} = 400,00 N/mm^2
- Modulus of elasticity: E = 210 000 N/mm^2
- Shear modulus: G = 81 000 N/mm^2
- Density: ρ = 7 850 kg/m^3

13.3 SECTION C: Load analysis

All actions on construction are determinate from Eurocode1 (EN 1991)

13.3.1 Dead loads

Photovoltaic modules

Mass: 800 kg

Weight of contracted construction: 0,085 kN/m^2

Weight of stretched construction: 0,076 kN/m^2

13.3.2 Roof

Table 94 - Roof dead loads

	Density [kg/m^3]	Thickness [mm]	Width by m'	Weight [kN/m^2]
OSB plate	720	20	1,00	0,14
Sheep wool	30	160	1,00	0,05
Constructive timber beams	550	160	0,10	0,09
Laminated timber slab	380	180	1,00	0,68
PCM				0,07
				g = 1,03

13.3.3 Columns

a/b = 20 cm/12 cm

h= 3,00 m

$$g = 0,20 \cdot 0,12 \cdot 3,00 \cdot 350 = 252N = 0,252kN$$

13.3.4 Glass

Mass: 250 kg

Line load: 2,08 kN/m’

13.3.5 Walls

Table 95 - Exterior wall dead loads

	Density [kg/m³]	Thickness [mm]	Width by m'	Weight [kN/m²]
Wood wool	550	35	1,00	0,19
Plaster	900	15	1,00	0,14
Laminated timber slab	380	60	1,00	0,23
Sheep wool	30	200	1,00	0,06
Constructive timber beams	550	60	0,16	0,05
Timber facade	700	20	1,00	0,14
				g = 0,81

Line load: 2,46kN/m'

Table 96 - Interior wall dead loads

	Density [kg/m³]	Thickness [mm]	Width by m'	Weight [kN/m²]
Wood wool	550	35	1,00	0,19
Plaster	900	15	1,00	0,14
Laminated timber slab	380	60	1,00	0,23
				g = 0,56

Line load: 1,71kN/m'

13.3.6 Floor

Table 97 - Greenhouse floor dead loads

	Density [kg/m³]	Thickness [mm]	Width by m'	Weight [kN/m²]
Gravel	1700	50	1,00	0,85
EPS	25	100	1,00	0,03
Laminated timber slab	380	180	1,00	0,68
Sheep wool	30	160	1,00	0,05
Constructive timber beams	550	160	0,10	0,09
OSB plate	720	20	1,00	0,14
				g = 1,84

Table 98 - Heated space floor dead loads

	Density [kg/m³]	Thickness [mm]	Width by m'	Weight [kN/m²]
Parquet	550	15	1,00	0,09
Aluminum plate	2700	17	1,00	0,46
OSB plate	720	40	1,00	0,28
Sheep wool	30	80	1,00	0,02
Constructive timber beams	550	80	0,10	0,04
Laminated timber slab	380	180	1,00	0,68
Sheep wool	30	160	1,00	0,05
Constructive timber beams	550	160	0,10	0,09
OSB plate	720	20	1,00	0,14
				g = 1,85

Additional floor area loads takes in consideration weight of water tanks in house.

Table 99 - Additional floor load

Mass [kg]	Area [m²]	Weight [kN/m²]
500	1,44	3,47

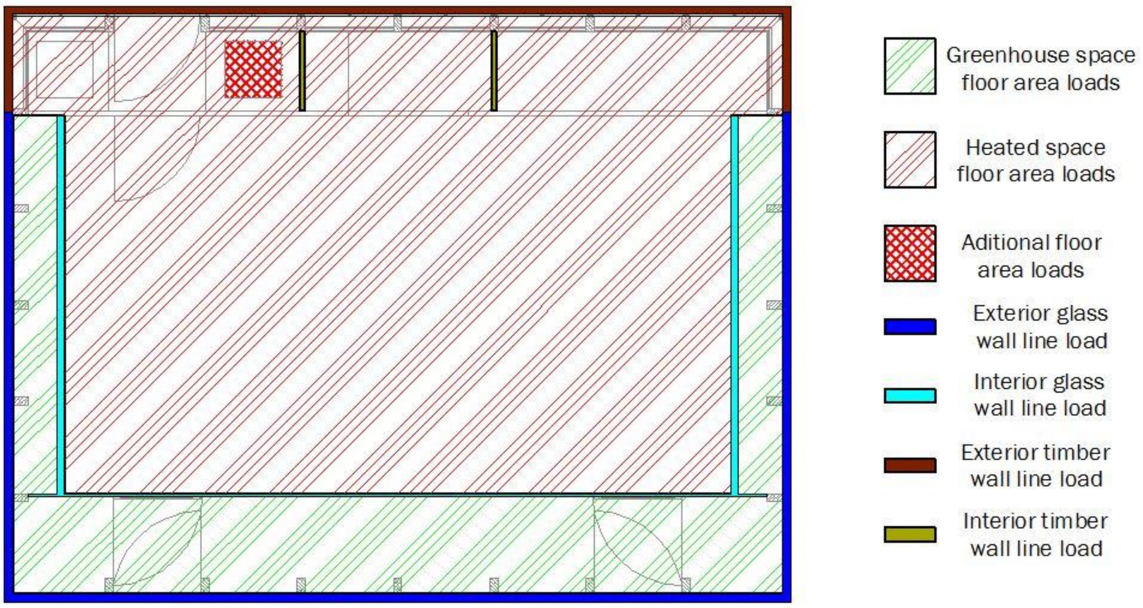


Figure 299 - Floor loads distribution

13.3.7 Live

Live load is 2,0 kN/m²

13.3.8 Snow

Elevation: 100 m

Zone: A

$$s = \mu_i \cdot C_e \cdot C_t \cdot s_k = 0{,}80 \cdot 1{,}00 \cdot 1{,}00 \cdot 1{,}13 = 0{,}904 \;\; kN/m^2$$

s - snow load on the roof

μ_i - snow load shape coefficient

C_e - exposure coefficient

C_t - thermal coefficient

s_k - characteristic value of snow on the ground at the relevant site

13.3.9 Wind

13.3.9.1 General

$$v_b = c_{dir} \cdot c_{season} \cdot v_{b,0} = 1{,}00 \cdot 1{,}00 \cdot 1{,}10 \cdot 24{,}00 = 26{,}4 \;\; m/s$$

v_b - basic wind velocity

c_{dir} - directional factor

c_{season}- seasonal factor

$$q_b = \frac{\rho}{2} \cdot v_b^2 = \frac{1{,}25}{2} \cdot 26{,}4^2 = 435{,}6 \;\; N/m^2 = 0{,}44 \;\; kN/m^2$$

q_b - reference mean velocity pressure

ρ - air density

$$w_e = q_b \cdot c_e(z) \cdot c_{pe}$$

$$w_i = q_b \cdot c_e(z) \cdot c_{pi}$$

w_e - external wind pressure

w_i - internal wind pressure

$c_e(z)$ - exposure factor

c_{pe} - external pressure coefficient

c_{pi} - internal pressure coefficient

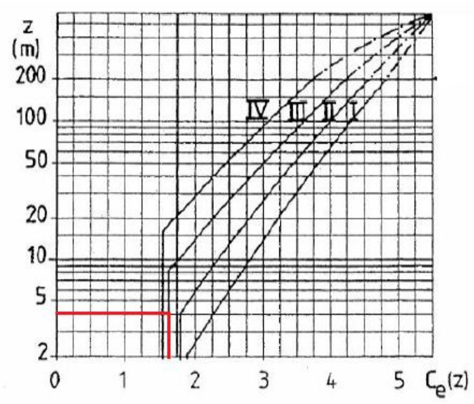


Figure 300 - Ce(z)

$C_e(z) = 1,7$

13.3.9.2 Contracted, θ=0°

$$e = \min \begin{cases} b = 10{,}80m \\ 2h = 8{,}16m \end{cases} \rightarrow e = 8{,}16m$$

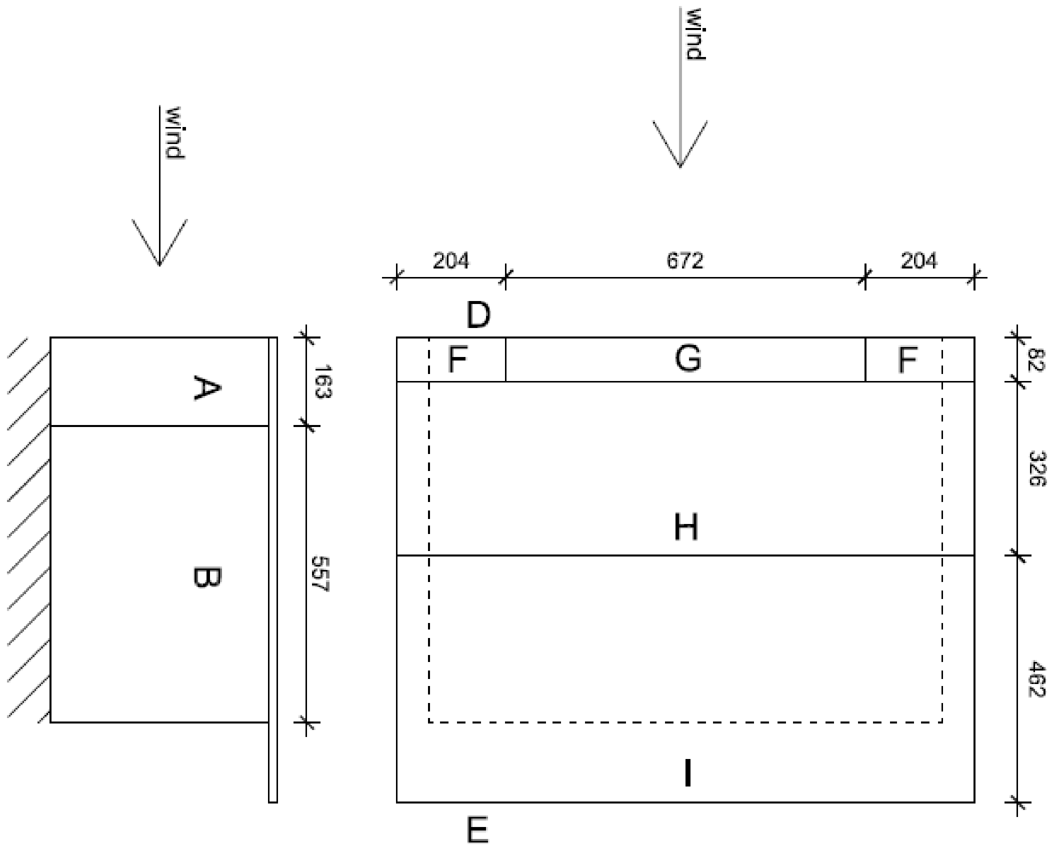


Figure 301 - Load areas for contracted roof, direction θ=0°

Table 100 - Loads by areas for contracted roof, direction θ=0°

	A $[m^2]$	c_{pe}	w_e
A	6,65	-1,24	-0,92
B	22,73	-0,80	-0,60
D	39,17	0,80	0,60
E	39,17	-0,40	-0,30
F	1,67	-2,34	-1,75
G	5,51	-1,41	-1,05
H	35,21	-0,70	-0,52
I	49,9	-0,20	-0,15
I	49,9	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot 0{,}80 = 0{,}60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot (-0{,}50) = -0{,}37 kN/m^2$$

13.3.9.3 Contracted, θ=180º

$$e = \min\begin{cases} b = 10,80m \\ 2h = 8,16m \end{cases} \rightarrow e = 8,16m$$

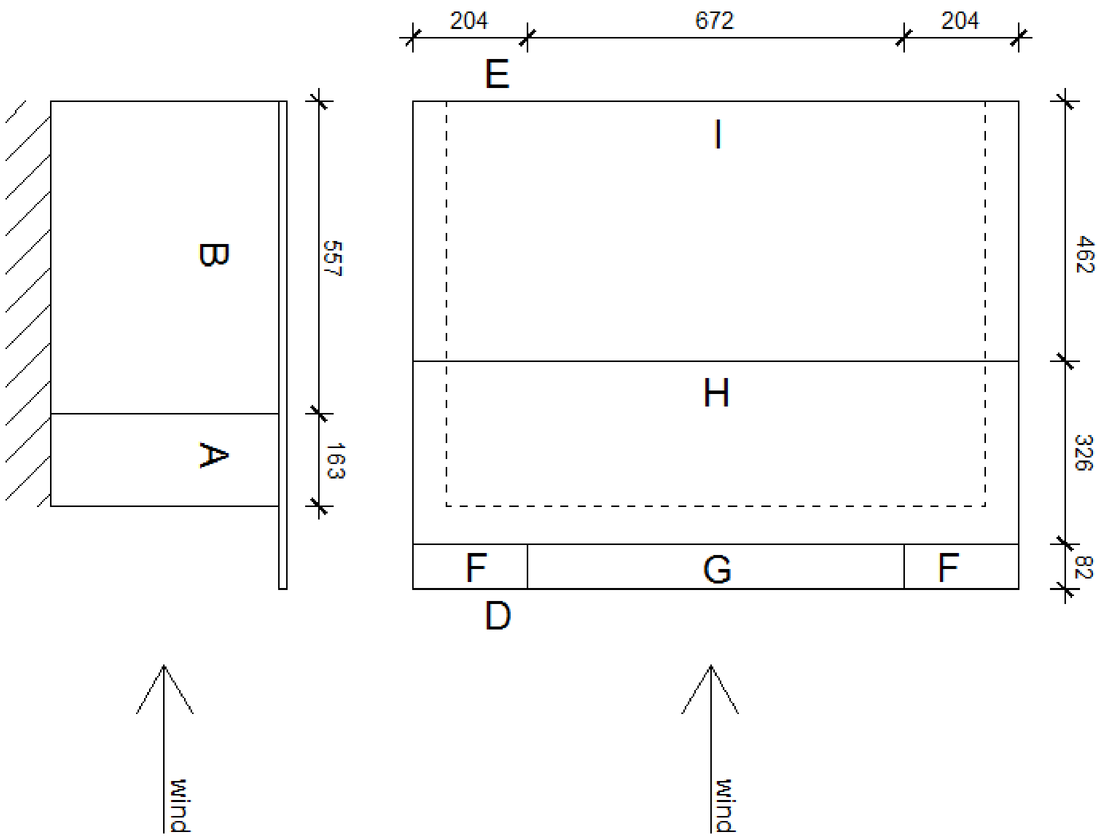


Figure 302 - Load areas for contracted roof, direction θ=180º

Table 101 - Loads by areas for contracted roof, direction θ=180º

	A $[m^2]$	C_{pe}	w_e
A	6,65	-1,24	-0,92
B	22,73	-0,80	-0,60
D	39,17	0,80	0,60
E	39,17	-0,40	-0,30
F	1,67	-2,34	-1,75
G	5,51	-1,41	-1,05
H	35,21	-0,70	-0,52
I	49,9	-0,20	-0,15
I	49,9	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot 0,80 = 0,60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot (-0,50) = -0,37 kN/m^2$$

13.3.9.4 Contracted, θ=90º=270º

$$e = \min \begin{cases} b = 8,70m \\ 2h = 8,16m \end{cases} \rightarrow e = 8,16m$$

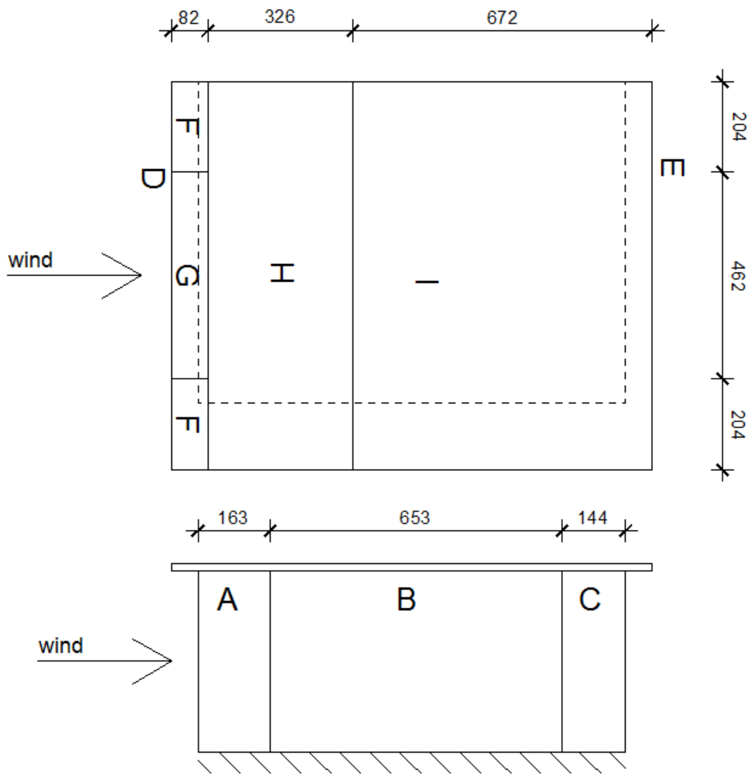


Figure 303 - Load areas for contracted roof, direction θ=90º

Table 102 - Loads by areas for contracted roof, direction θ=90º

	A $[m^2]$	c_{pe}	w_e
A	6,65	-1,24	-0,92
B	26,64	-0,80	-0,60
C	5,88	-0,50	-0,37
D	29,38	0,80	0,60
E	29,38	-0,40	-0,30
F	1,67	-2,34	-1,75
G	3,79	-1,54	-1,15
H	28,36	-0,70	-0,52
I	58,46	-0,20	-0,15
I	58,46	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot 0,80 = 0,60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot (-0,50) = -0,37 kN/m^2$$

13.3.9.5 Stretched, θ=0º

$$e = \min \begin{cases} b = 10{,}80m \\ 2h = 8{,}16m \end{cases} \rightarrow e = 8{,}16m$$

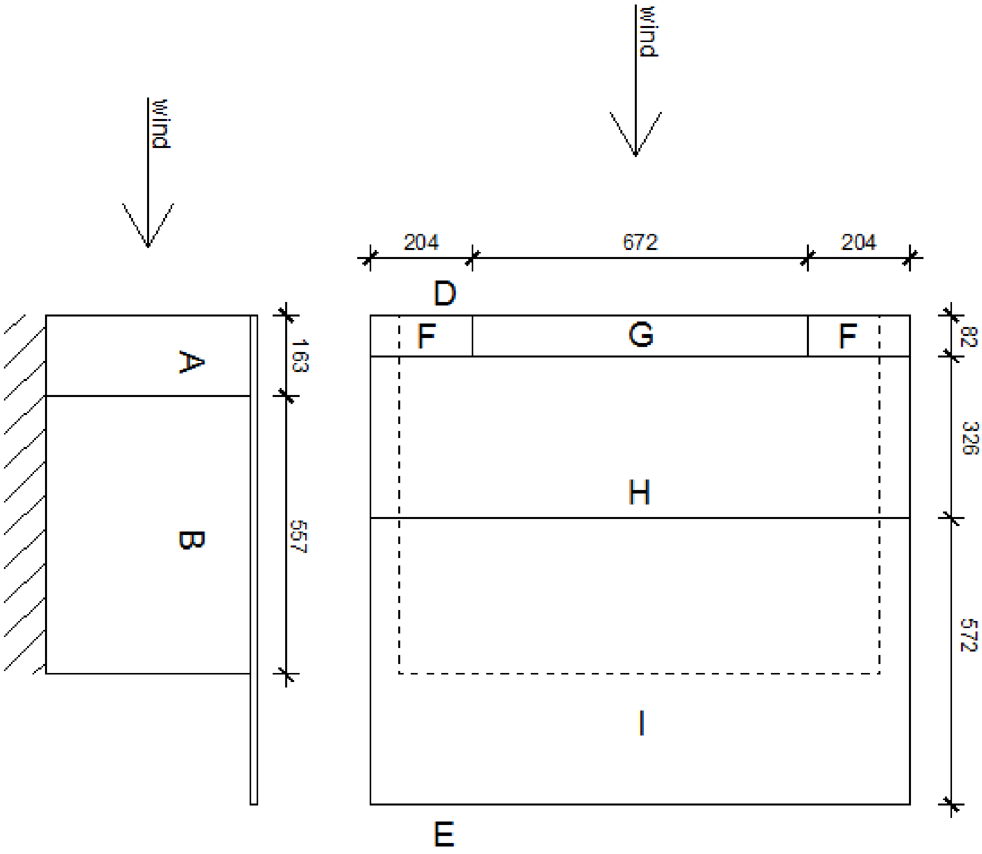


Figure 304 - Load areas for stretched roof, direction θ=0º

Table 103 - Loads by areas for stretched roof, direction θ=0º

	A $[m^2]$	c_{pe}	w_e
A	6,65	-1,24	-0,92
B	22,73	-0,80	-0,60
D	39,17	0,80	0,60
E	39,17	-0,40	-0,30
F	1,67	-2,34	-1,75
G	5,51	-1,41	-1,05
H	35,21	-0,70	-0,52
I	61,78	-0,20	-0,15
I	61,78	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot 0{,}80 = 0{,}60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot (-0{,}50) = -0{,}37 kN/m^2$$

13.3.9.6 Stretched, θ=180º

$$e = \min\begin{cases} b = 10,80m \\ 2h = 8,16m \end{cases} \rightarrow e = 8,16m$$

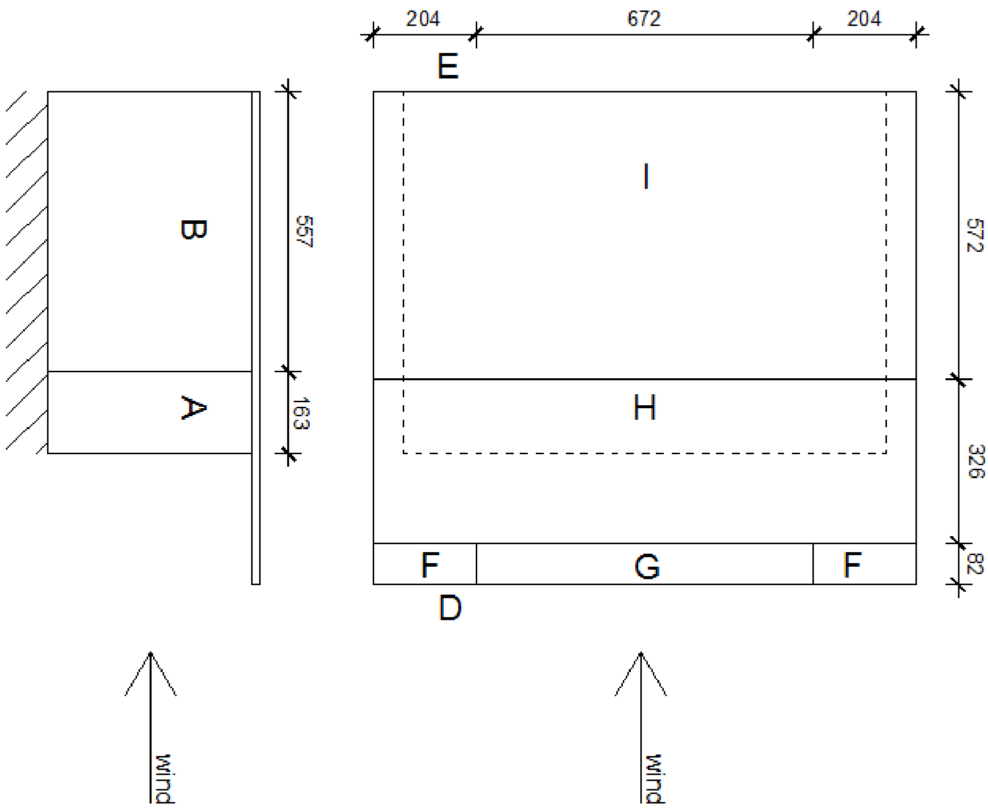


Figure 305 - Load areas for stretched roof, direction θ=180º

Table 104 - Loads by areas for stretched roof, direction θ=180º

	A $[m^2]$	c_{pe}	w_e
A	6,65	-1,24	-0,92
B	22,73	-0,80	-0,60
D	39,17	0,80	0,60
E	39,17	-0,40	-0,30
F	1,67	-2,34	-1,75
G	5,51	-1,41	-1,05
H	35,21	-0,70	-0,52
I	61,78	-0,20	-0,15
I	61,78	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot 0,80 = 0,60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0,44 \cdot 1,7 \cdot (-0,50) = -0,37 kN/m^2$$

13.3.9.7 Stretched, θ=90°=270°

$$e = \min \begin{cases} b = 9{,}80m \\ 2h = 8{,}16m \end{cases} \rightarrow e = 8{,}16m$$

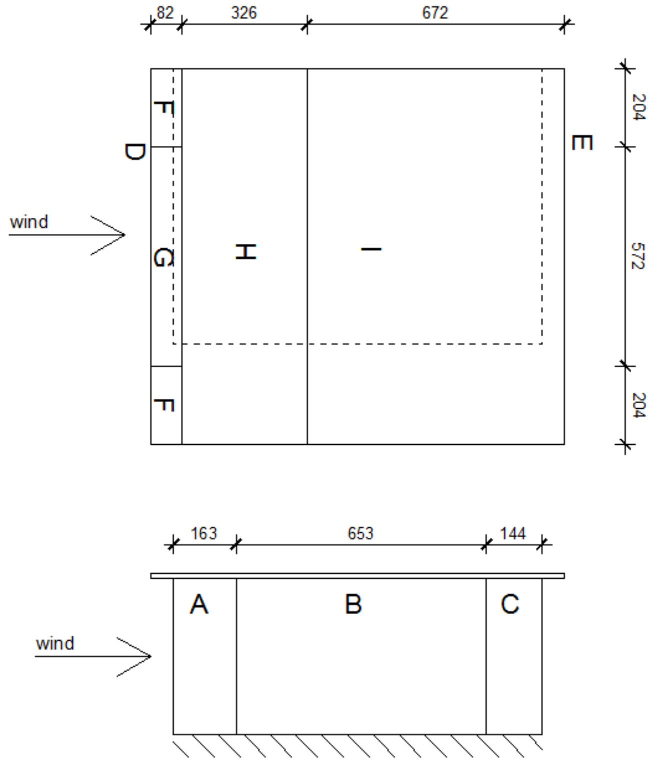


Figure 306 - Load areas for stretched roof, direction θ=90°

Table 105 - Loads by areas for stretched roof, direction θ=90°

	A $[m^2]$	C_{pe}	w_e
A	6,65	-1,24	-0,92
B	26,64	-0,80	-0,60
C	5,88	-0,50	-0,37
D	29,38	0,80	0,60
E	29,38	-0,40	-0,30
F	1,67	-2,34	-1,75
G	4,69	-1,46	-1,09
H	31,95	-0,70	-0,52
I	65,86	-0,20	-0,15
I	65,86	0,20	0,15

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot 0{,}80 = 0{,}60 kN/m^2$$

$$w_i = q_{ref} \cdot c_e(z) \cdot c_{pi} = 0{,}44 \cdot 1{,}7 \cdot (-0{,}50) = -0{,}37 kN/m^2$$

13.3.10 Load combinations

$$E_d = \sum \gamma_{G,j} \cdot G_{k,j} + \gamma_{Q,1} \cdot Q_{k,1} + \sum_{i>1} \gamma_{Q,i} \cdot \psi_{Q,i} \cdot Q_{k,i}$$

- Combination 1

$$E_d = 1{,}35 \cdot g + 1{,}50 \cdot q + 1{,}50 \cdot s_k$$

- Combination 2

$$E_d = 1{,}35 \cdot g + 1{,}50 \cdot q + 1{,}50 \cdot w_k$$

- Combination 3

$$E_d = 1{,}00 \cdot g + 1{,}50 \cdot w_k$$

- Combination 4

$$E_d = 1{,}35 \cdot g + 1{,}50 \cdot q + 1{,}50 \cdot (s_k + 0{,}60 \cdot w_k)$$

- Combination 5

$$E_d = 1{,}35 \cdot g + 1{,}50 \cdot q + 1{,}50 \cdot (w_k + 0{,}70 \cdot s_k)$$

Safety factors:

Timber

- Partial safety factor for timber materials: γ_m = 1,30
- Modification factor for service type 2 and short term load: k_{mod} = 0,90

Aluminium

- Partial safety factor for aluminum materials: γ_m = 1,00

Steel

- Partial safety factor for aluminum materials: γ_{m1} = 1,00

13.4 SECTION D: Calculations model description

Our calculations model is made in software called ETABS 2013. ETABS 2013 is the integrated software package based on finite element method used for structural analysis and design of buildings developed by Computers and Structures, Inc. (CSI), Berkley, USA.

Bearing system of roof and floor consists of 18 cm thick glued lamented slabs, glued laminated timber columns, with cross section 20 cm / 12 cm which are connected with roof and floor slabs with pin steel joints. Horizontal shear resistance is assured with 6 cm thick glued laminated timber shear walls and steel braces with diameter of 8 mm. Foundations are positioned under every column (24) and alternately under floor slab (17).

Simplifications are used to check software results for stress on the roof slab and for calculating wind forces in walls and braces.

Control of stress values will be done on finished structure with test loads. Values of test load will be same as snow load in calculations model.

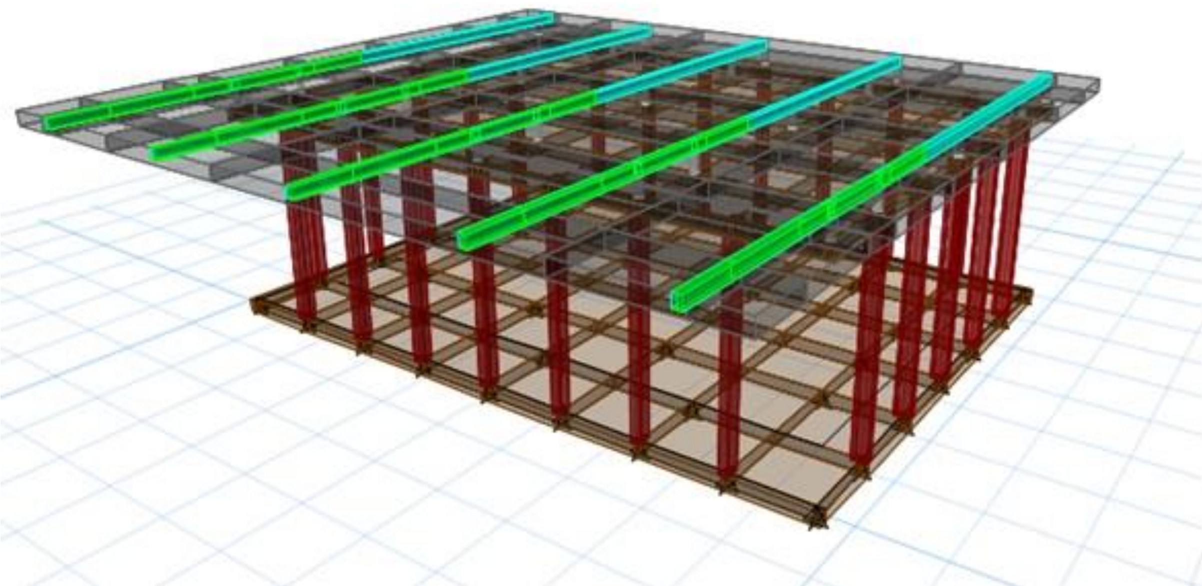


Figure 307 - Calculations model

13.5 SECTION E: Calculation results

13.5.1 Roof and floor

Figure 308 - Slab cross section

Stress on slabs are calculated with computer ETABS 2013. Results from numerical analysis are compared with simplified beam. Results from software analysis are used to determine safety of the slabs.

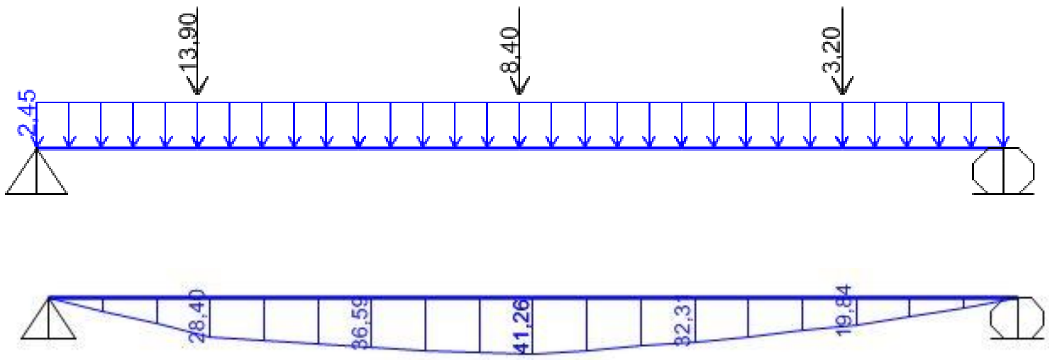


Figure 309 - Bending moment for beam model

$$\sigma_m = \frac{M_z}{W_y} = \frac{41,26 \cdot 10^6}{\frac{1000 \cdot 180^2}{6}} = 7,64 \ MPa$$

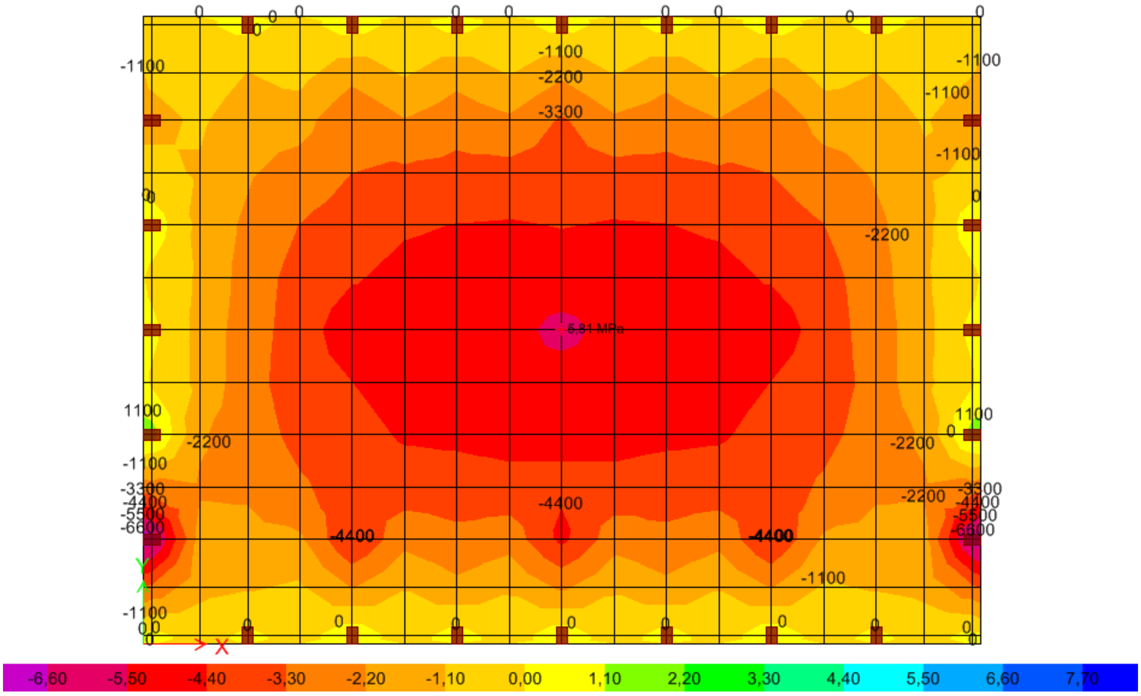


Figure 310 - Bending moment for roof slab model

$$f_{m,d} = k_{\text{mod}} \cdot \frac{f_{m,k}}{\gamma_m} = 0,90 \cdot \frac{24,00}{1,3} = 16,61 N / mm^2$$

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{7,64}{16,61} = 0,46 \leq 1,00$$

Stress in numerical model is smaller because structure is calculated as a timber slab, in simplified model, bearing structure is calculated as a beam.

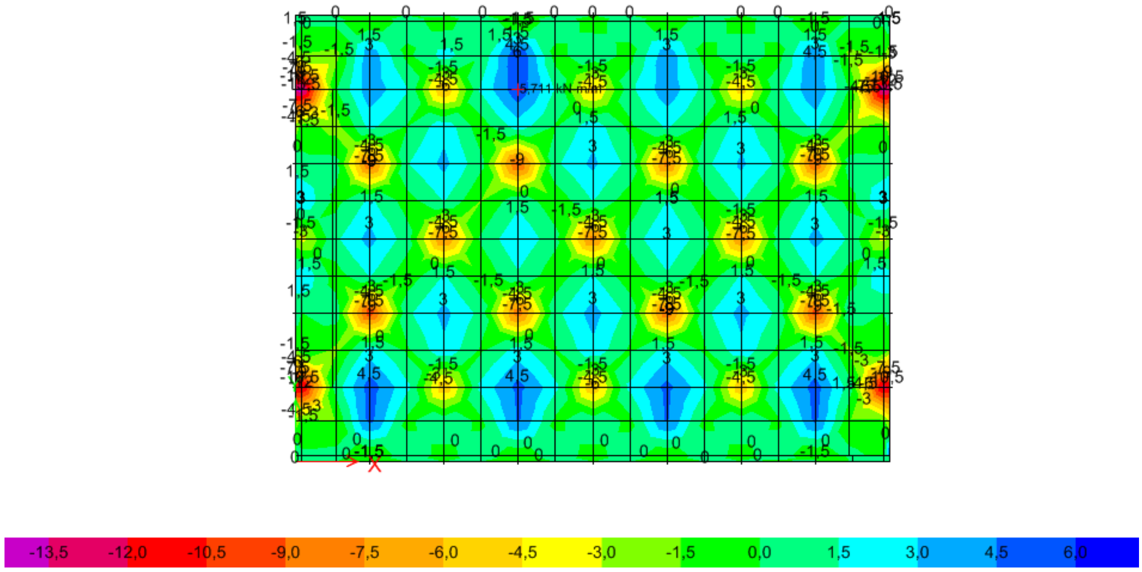


Figure 311 - Bending moment for floor slab model

$$f_{m,d} = k_{\text{mod}} \cdot \frac{f_{m,k}}{\gamma_m} = 0,90 \cdot \frac{24,00}{1,3} = 16,61 N / mm^2$$

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{5,17}{16,61} = 0,31 \leq 1,00$$

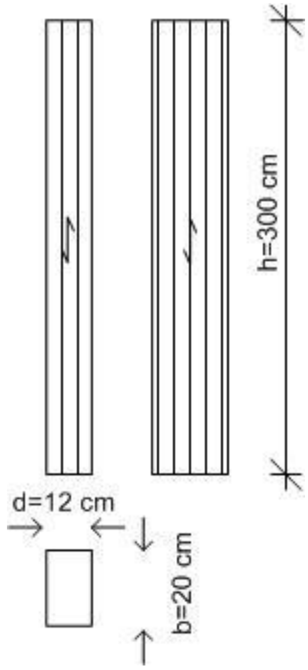


Figure 312 - Column sketch

Wooden columns bear vertical loads from the roof slab to floor slab and then the load is transferred to foundations.

Table 106 - Anvelope forces (kN) in columns

	Compression	Tensile
C 01	13,7	0,0
C 02	23,3	0,3
C 03	18,6	0,0
C 04	22,0	0,8
C 05	18,6	0,0
C 06	22,5	0,9
C 07	13,4	0,0
C 08	4,5	7,9
C 09	10,7	0,0
C 10	13,3	2,9

C 11	26,6	8,4
C 12	23,8	26,5
C 13	15,0	0,2
C 14	37,7	15,0
C 15	19,1	0,0
C 16	38,1	15,3
C 17	19,1	0,0
C 18	37,7	14,9
C 19	14,9	0,5
C 20	23,9	26,5
C 21	26,7	8,5
C 22	12,5	4,8
C 23	10,0	0,0
C 24	5,3	9,0
Max	38,1 kN	26,5 kN

Tensile strength

$$A_{neto} = 0,8 \cdot A = 19200 \ mm^2$$

$$f_{t,0,d} = k_{\mathrm{mod}} \cdot \frac{f_{t,0,k}}{\gamma_m} = 0,90 \cdot \frac{14,00}{1,3} = 9,70 N/mm^2$$

$$\sigma_{t,0,d} = \frac{F_{t,d}}{A_{neto}} = \frac{26,50 \cdot 10^3}{19200} = 1,38 N/mm^2$$

$$\frac{\sigma_{t,0,d}}{f_{t,0,d}} = \frac{1,38}{9,70} = 0,14$$

Buckling strength:

$$\lambda_y = \frac{l_y}{\sqrt{\frac{I_y}{A}}} = \frac{3000}{\sqrt{\frac{80000000}{24000}}} = 51,96$$

$$\lambda_z = \frac{l_z}{\sqrt{\frac{I_z}{A}}} = \frac{3000}{\sqrt{\frac{28800000}{24000}}} = 86,60$$

$$\lambda_{rel,y} = \lambda_y \cdot \sqrt{\frac{f_{c,0,k}}{\pi^2 \cdot E_{0,05}}} = 51,96 \cdot \sqrt{\frac{24,00}{\pi^2 \cdot 9400}} = 0,836$$

$$\lambda_{rel,z} = \lambda_z \cdot \sqrt{\frac{f_{c,0,k}}{\pi^2 \cdot E_{0,05}}} = 86,60 \cdot \sqrt{\frac{24,00}{\pi^2 \cdot 9400}} = 1,393$$

$$k_y = 0,50 \cdot \left(1 + \beta_c \cdot \left(\lambda_{rel,y} - 0,3\right) + \lambda_{rel,y}{}^2\right) = 0,50 \cdot \left(1 + 0,1 \cdot \left(0,836 - 0,3\right) + 0,836^2\right) = 0,876$$

$$k_z = 0,50 \cdot \left(1 + \beta_c \cdot \left(\lambda_{rel,z} - 0,3\right) + \lambda_{rel,z}{}^2\right) = 0,50 \cdot \left(1 + 0,1 \cdot \left(1,393 - 0,3\right) + 1,393^2\right) = 1,525$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}{}^2}} = \frac{1}{0,876 + \sqrt{0,876^2 - 0,836^2}} = 0,879$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}{}^2}} = \frac{1}{1,525 + \sqrt{1,525^2 - 1,393^2}} = 0,466$$

$k_{c,z}$ – decisive

$$\sigma_{c,0,d} = \frac{F_{c,d}}{A} = \frac{38,10 \cdot 10^3}{24000} = 1,59 N / mm^2$$

$$f_{c,0,d} = k_{\mathrm{mod}} \cdot \frac{f_{c,0,k}}{\gamma_m} = 0,90 \cdot \frac{21,00}{1,3} = 14,54 N / mm^2$$

$$\sigma_{m,crit} = \frac{0,78 \cdot b^2}{h \cdot l_{ef}} \cdot E_{0,05} = \frac{0,78 \cdot 120^2}{200 \cdot 0,9 \cdot 3000} \cdot 9400 = 195,52$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} = \sqrt{\frac{24,00}{195,52}} = 0,35$$

$$k_{crit} = \begin{cases} 1 \quad for \ \lambda_{rel,m} \le 0,75 \\ 1,56 - 0,75 \cdot \lambda_{rel,m} \quad for \ 0,75 < \lambda_{rel,m} \le 1,4 \\ \dfrac{1}{(\lambda_{rel,m})^2} \quad for \ \lambda_{rel,m} > 1,4 \end{cases}$$

$$k_{crit} = 1$$

$$M_{y,d} = \frac{1,2 \cdot (w_e + w_i) \cdot l^2}{8} = \frac{1,2 \cdot (0,50 + 0,60) \cdot 3,00^2}{8} = 1,49 kNm$$

$$\sigma_{m,y,d} = \frac{M_{y,d}}{I_y} \cdot \frac{h}{2} = \frac{1,49 \cdot 10^6}{80000000} \cdot \frac{200}{2} = 1,86 N / mm^2$$

$$f_{m,d} = k_{\mathrm{mod}} \cdot \frac{f_{m,k}}{\gamma_m} = 0,90 \cdot \frac{24,00}{1,3} = 16,62 N / mm^2$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} + \frac{\sigma_{m,y,d}}{k_{crit} \cdot f_{m,d}} = \frac{1,59}{0,466 \cdot 14,54} + \frac{1,86}{1,0 \cdot 16,62} = 0,35 \le 1,00$$

13.5.3 Shear wall

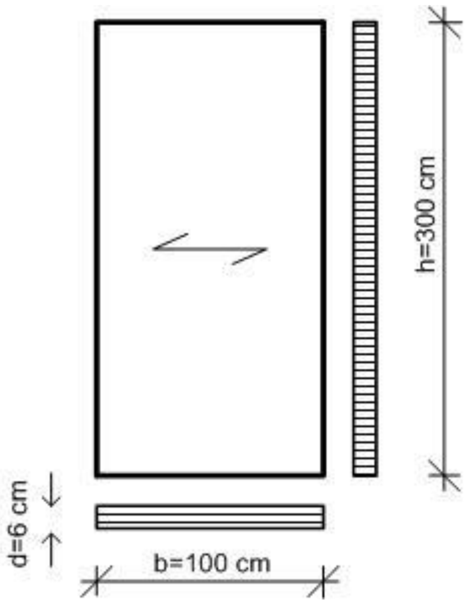


Figure 313 - Wall sketch

Wind resistance in direction north – south is ensure with two laminated timber shear walls. Each wall takes half of total wind load in N-S direction.

$$V_d = \frac{A \cdot (w_e + w_i)}{2} = \frac{(3,0 \cdot 9,6)(0,6+0,3+0,6)}{2} = 21,6kN$$

$$\tau_{v,d} = \frac{V_d}{b \cdot d} = \frac{21,6 \cdot 10^3}{1000 \cdot 60} = 0,36N/mm^2$$

$$f_{v,d} = k_{\text{mod}} \cdot \frac{f_{v,k}}{\gamma_m} = 0,90 \cdot \frac{2,20}{1,3} = 1,52N/mm^2$$

$$\frac{\tau_{v,d}}{f_{v,d}} = \frac{0,36}{1,52} = 0,24 \leq 1,00$$

13.5.4 Braces

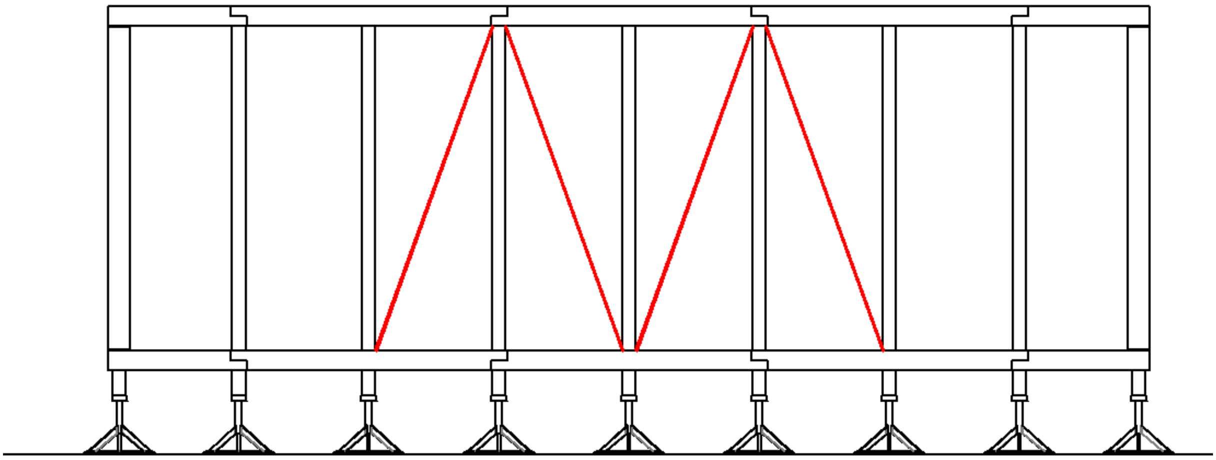


Figure 314 - Braces position on south wall

Wind resistance in direction east - west is ensure with laminated timber shear wall and two pairs of steel braces.

$$F_{t,d} = \frac{A \cdot (w_e + w_i)}{4} \cdot \frac{1}{\cos 71,5^\circ} = \frac{(3,0 \cdot 7,2)(0,6 + 0,3 + 0,6)}{4} \cdot \frac{1}{\cos 71,5^\circ} = 25,52kN$$

$$\sigma_{t,d} = \frac{N_{t,d}}{A_{neto}} = \frac{25,52 \cdot 10^3}{0,8\left(\frac{8^2}{4} \cdot \pi\right)} = 634,63N / mm^2$$

$$f_{y,d} = \frac{f_{y,k}}{\gamma_m} = \frac{1770,00}{1,10} = 1609,09N / mm^2$$

$$\frac{\sigma_{t,d}}{f_{ty,d}} = \frac{634,63}{1609,09} = 0,39 \leq 1,00$$

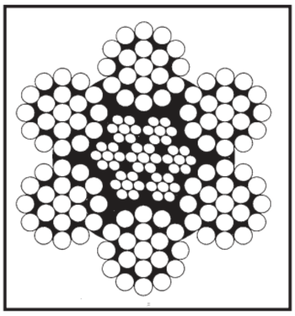


Figure 315 - Braces cross section

13.5.5 Roof spike

Roof spike is located on top of our roof slab and it bears load from aluminium beams that hold photovoltaic panels.

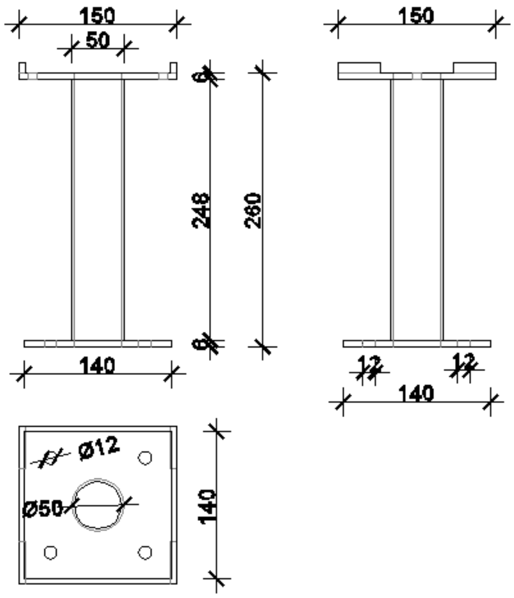


Figure 316 - Dimensions for roof spike

$$I_y = \frac{\left[d^4 - (d-2t)^4\right]\pi}{64} = \frac{\left[5,0^4 - (5,0-1,0)^4\right]\pi}{64} = 18,11\ cm^4$$

$$A = \frac{\left[d^2 - (d-2t)^2\right]\pi}{4} = \frac{\left[5,0^2 - (5,0-1,0)^2\right]\pi}{4} = 7,07\ cm^2$$

$$N_{cr} = \frac{\pi^2 \cdot E \cdot I_y}{l_y^2} = \frac{\pi^2 \cdot 7000 \cdot 18,11}{26,0^2} = 1850,84\ kN$$

$$\bar{\lambda} = \sqrt{\frac{A \cdot f_y}{N_{cr}}} = \sqrt{\frac{7,07 \cdot 23,5}{1850,84}} = 0,30$$

$$\phi = 0,5\left(1 + 0,21\left(\bar{\lambda} - 0,2\right) + \bar{\lambda}^2\right) = 0,5\left(1 + 0,21\left(0,3 - 0,2\right) + 0,3^2\right) = 0,55$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1}{0,55 + \sqrt{0,55^2 - 0,30^2}} = 0,99$$

$$N_{b,Rd} = \chi \cdot A \cdot \frac{f_y}{\gamma_{M1}} = 0,99 \cdot 7,07 \cdot \frac{23,5}{1,0} = 164,48kN$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{30}{164,48} = 0,18 \leq 1,00$$

13.5.6 Foundation pier

Square profile steel piers transfer house load on our foundation systems.

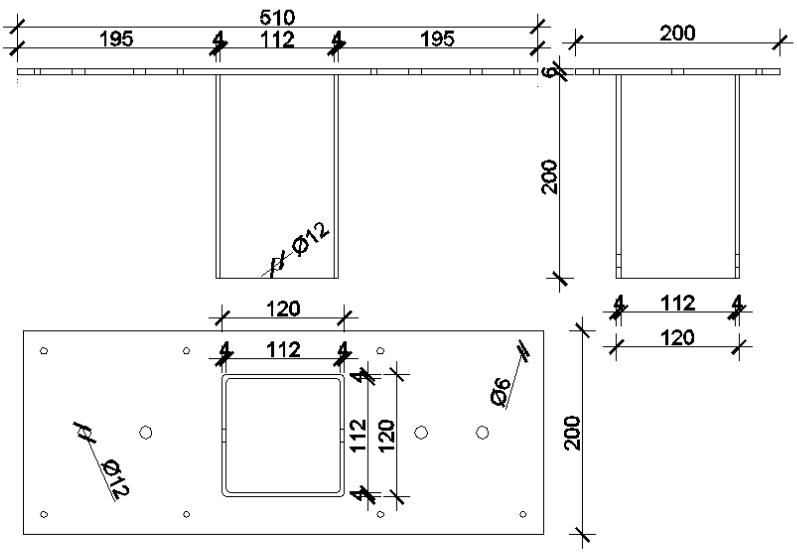


Figure 317 - Dimensions for foundation pier

$$I_y = 408 \ cm^4$$

$$A = 18,3 \ cm^2$$

$$N_{cr} = \frac{\pi^2 \cdot E \cdot I_y}{l_y^2} = \frac{\pi^2 \cdot 21000 \cdot 408}{20,0^2} = 211406 \ kN$$

$$\bar{\lambda} = \sqrt{\frac{A \cdot f_y}{N_{cr}}} = \sqrt{\frac{18,3 \cdot 23,5}{211406}} = 0,05$$

$$\phi = 0,5\left(1 + 0,21\left(\bar{\lambda} - 0,2\right) + \bar{\lambda}^2\right) = 0,5\left(1 + 0,21\left(0,05 - 0,2\right) + 0,05^2\right) = 0,48$$

$$\chi = \frac{1}{\phi + \sqrt{\phi^2 - \bar{\lambda}^2}} = \frac{1}{0,48 + \sqrt{0,48^2 - 0,05^2}} = 1,04$$

$$N_{b,Rd} = \chi \cdot A \cdot \frac{f_y}{\gamma_{M1}} = 1,0 \cdot 18,3 \cdot \frac{23,5}{1,0} = 430,05 kN$$

$$\frac{N_{Ed}}{N_{b,Rd}} = \frac{44}{430,05} = 0,10 \leq 1,00$$

13.5.7 Connections and joints

13.5.7.1 Connecting wall panels with floor slabs

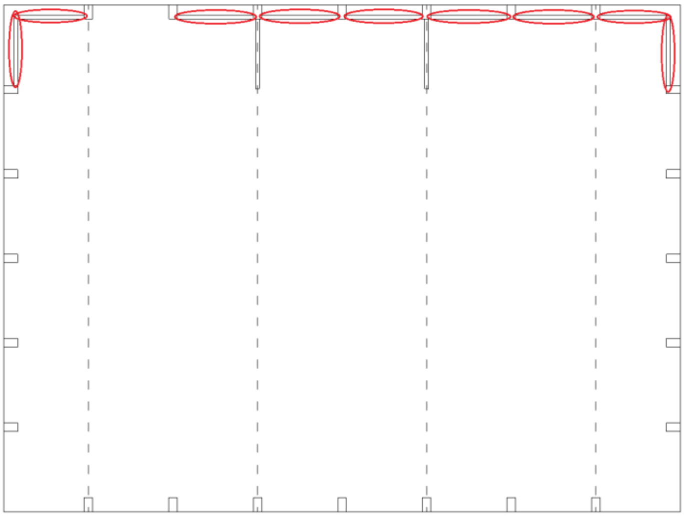


Figure 318 - Location of wall panels that will be connected to floor slabs

Connection of wall panels with floor slabs will be achieved using patented L profile steel angle brackets by Rothoblaas®, and bolts. Angle bracket type is WBR170110. Safety in case of fire is guaranteed by manufacturer. Connectors will also be easily disassembled and reassembled, which is mandatory as we need to rebuild our house multiple times. Ceiling slabs will not be supported directly to wall panels, so that wall panels take only lateral loads.

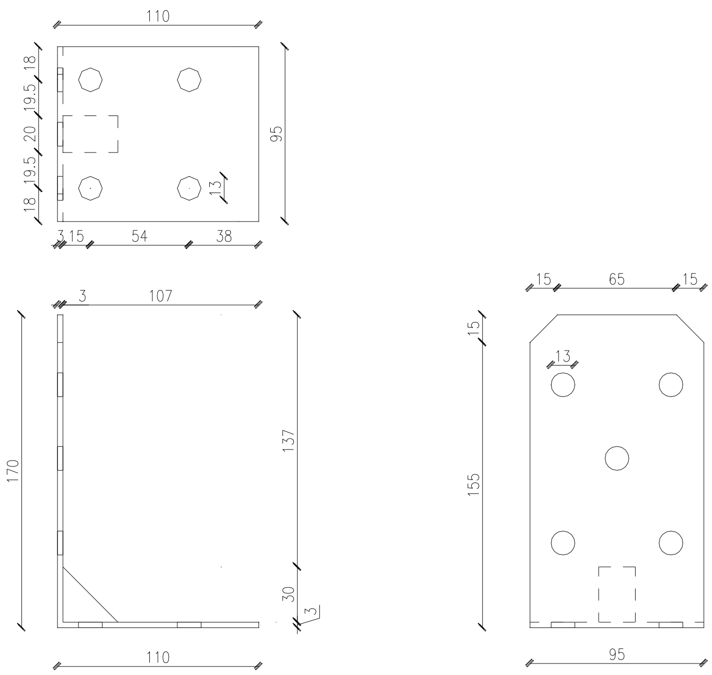


Figure 319 - Steel plate used for wall – floor connection

$t = 3\ mm$
$H = 170\ mm$
$L = 110\ mm$
$B = 155\ nmm$

number of bolts = 5+4

Bolt type: Ø 12,0 x 60 mm, KČ3.6 for wall

Ø 12,0 x 180 mm, KČ3.6 for floor

Number of connectors $n_{sel} = 2$

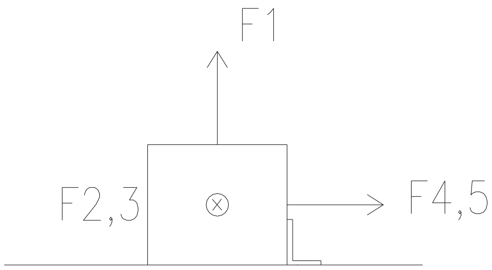


Figure 320 - Directions of forces for calculations

$$F_1 = 2{,}20\ kN < 2 \cdot R_{1,d} = 2 \cdot 12{,}86\ kN = 25{,}72\ kN$$

$$F_2 = F_3 = 21{,}60\ kN < 2 \cdot R_{3,4,d} = 2 \cdot 14{,}72\ kN = 29{,}44\ kN$$

$$F_4 = F_5 = 5{,}37\ kN < 2 \cdot R_{4,5,d} = 2 \cdot 11{,}52 = 23{,}04\ kN$$

$$n_{req} = n_{sel} = 2$$

$$f_{u,k} = 300\ N/mm^2$$

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{d^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 300 \cdot \frac{12^3}{6}}{1{,}1} = 62836{,}36\ Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\ N/mm^2$$

$$\mathrm{t}_2 = 60\ mm$$

$$R_{4,5,d} = 4 \cdot min \begin{cases} (\sqrt{2} - 1) \cdot 9{,}69 \cdot 60 \cdot 12 \\ 1{,}1 \cdot \sqrt{2 \cdot 62836{,}36 \cdot 9{,}69 \cdot 12} \end{cases} = min \begin{cases} 2889{,}88 \\ 4204{,}99 \end{cases} = 2{,}88\ kN$$

$$R_{4,5,d} = 4 \cdot 2{,}88 = 11{,}52\ kN$$

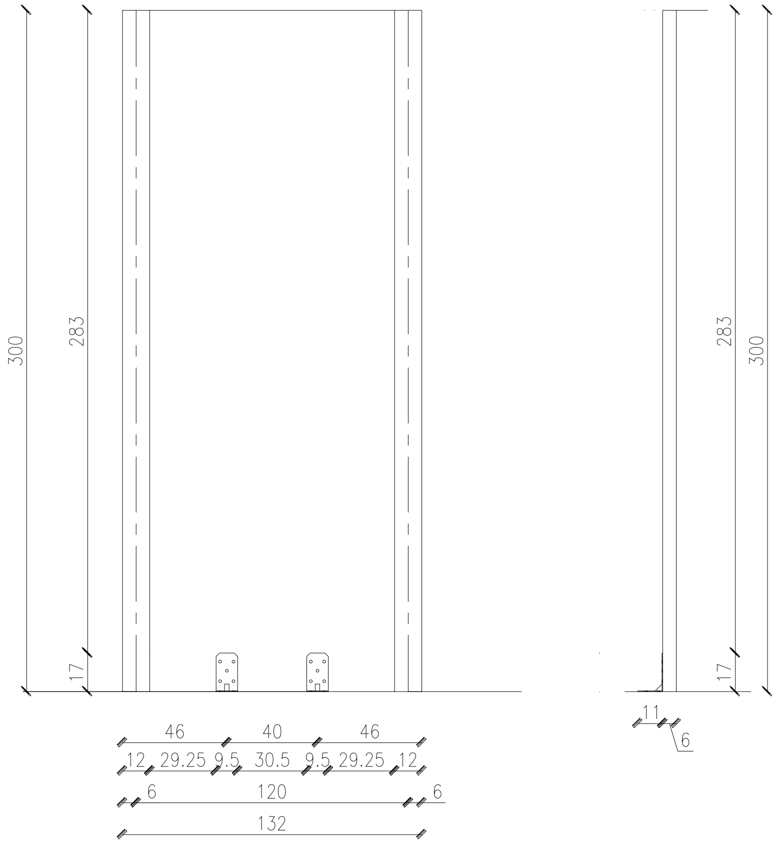


Figure 321 - Positions of wall – floor connections

13.5.7.2 Connecting columns with floor slabs

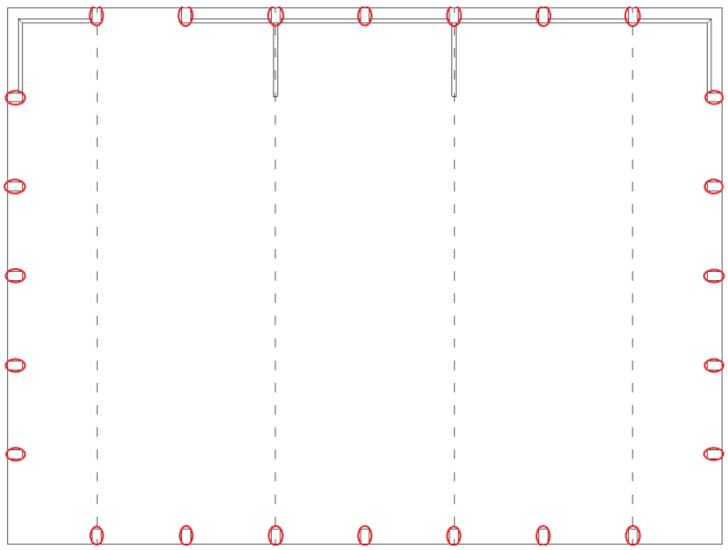


Figure 322 - Location of columns that will be connected to floor and ceiling slabs

Connection of columns with floor slabs will also be achieved using T profile steel plates. These plates will be connected to columns with 4 Ø 12,0 mandrels, and to floor with 4 Ø 12,0 bolts.

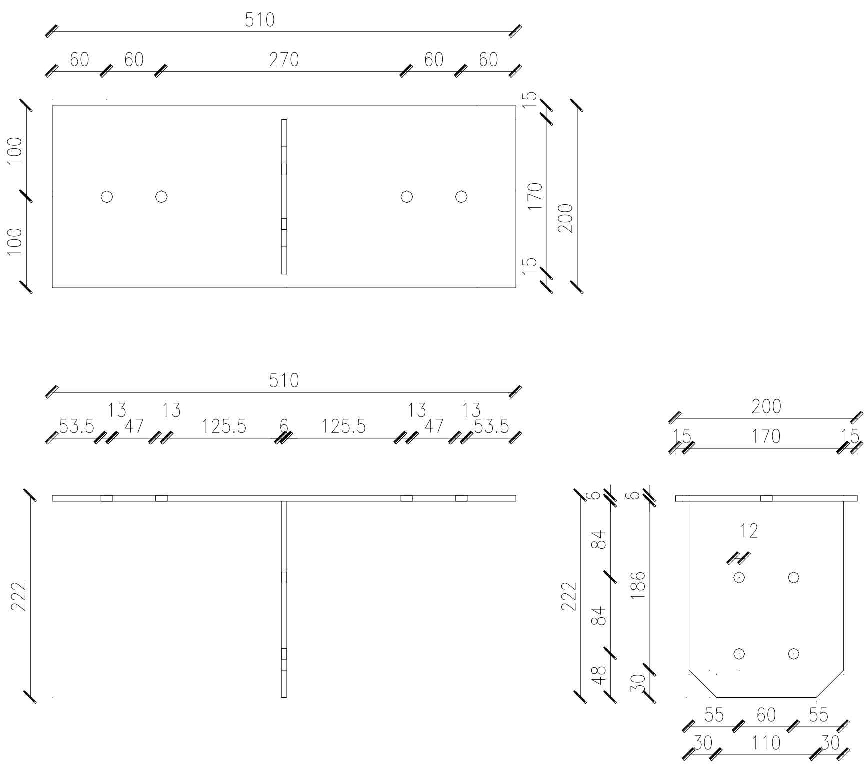


Figure 323 - Steel plate used for column – floor connection

$t = 6\,mm$

$H = 86\,mm$
$L = 510mm$
$B = 200\,nmm$

Bolt type: Ø 12,0 x 180 mm, KČ3.6 for floor

Mandrel type: Ø 12,0 x 110 mm, KČ3.6 for columns

Resistance to tension force in column:

$f_{u,k} = 360\,N/mm^2$ for S235

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{d^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 360 \cdot \frac{12^3}{6}}{1{,}1} = 75403{,}63\,Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\,N/mm^2$$

$$\mathrm{t}_1 = \frac{110-6}{2} = 52\,mm$$

$$R_d = 2 \cdot min \begin{cases} 52 \cdot 12 \cdot 9{,}69 \\ 1{,}1 \cdot 9{,}69 \cdot 52 \cdot 12 \cdot \left[\sqrt{2 + \frac{4 \cdot 75403{,}63}{9{,}69 \cdot 12 \cdot 52^2}} - 1 \right] \\ 1{,}5 \cdot \sqrt{2 \cdot 62836{,}36 \cdot 9{,}69 \cdot 12} \end{cases} = 2 \cdot min \begin{cases} 6046{,}56 \\ 4790{,}55 \\ 5734{,}08 \end{cases} = 4{,}79\ kN$$

$$R_d = 2 \cdot 4{,}79 = 9{,}58\ kN$$

number of mandrels: n=4

$$R_d = 4 \cdot 9{,}58 = 38{,}32\ kN$$

$$N_{t,Ed} = 29{,}16\ kN$$

$$R_d = 38{,}32\ kN > N_{t,Ed} = 26{,}50\ kN$$

minimum distance of mandrels= 7d = 84 mm

minimum distance to edge of column = 7d = 84 mm

Tension resistance of bolts:

$$R_{t,Ed} = 4 \cdot \frac{12^2 \pi}{4} \cdot 300 = 135712{,}8\ N = 135{,}7 kN > N_{t,Ed} = 26{,}50\ kN$$

Compression resistance of timber in floor slab under bolt plates:

$$f_{c,90,d} = k_{mod} \cdot \frac{f_{c,90,k}}{\gamma_M} = 0{,}9 \cdot \frac{2{,}4}{1{,}3} = 1{,}66\ N/mm^2$$

$$N_{t,Ed} = 26{,}50\ kN$$

$$d_s = 36\ mm$$

$$\frac{\sigma_{c,90,d}}{1{,}8 \cdot f_{c,90,d}} = \frac{\frac{2650}{4 \cdot 0{,}7 \cdot 36^2}}{1{,}8 \cdot 1{,}66} = 0{,}24 < 1{,}00$$

Resistance of steel plate:

Resistance of net cross section

$$R_d = \frac{0{,}9 \cdot d \cdot t \cdot f_{u,k}}{1{,}25} = \frac{0{,}9 \cdot 6 \cdot (170-13) \cdot 360}{1{,}25} = 223948{,}80\ kN = 223{,}94\ kN > 29{,}16\ kN$$

Resistance of full cross section:

$$R_d = \frac{d \cdot t \cdot f_{u,k}}{1{,}00} = \frac{6 \cdot 170 \cdot 235}{1{,}00} = 239700\ kN = 239{,}70\ kN > 29{,}16\ kN$$

Yield resistance of hole cladding:

$$R_d = 55{,}4\ kN\ for\ t = 10\ mm, S235, Ø12$$

$$R_d = 55{,}4 \cdot \frac{6}{10} = 33{,}24\ kN > 29{,}16\ kN$$

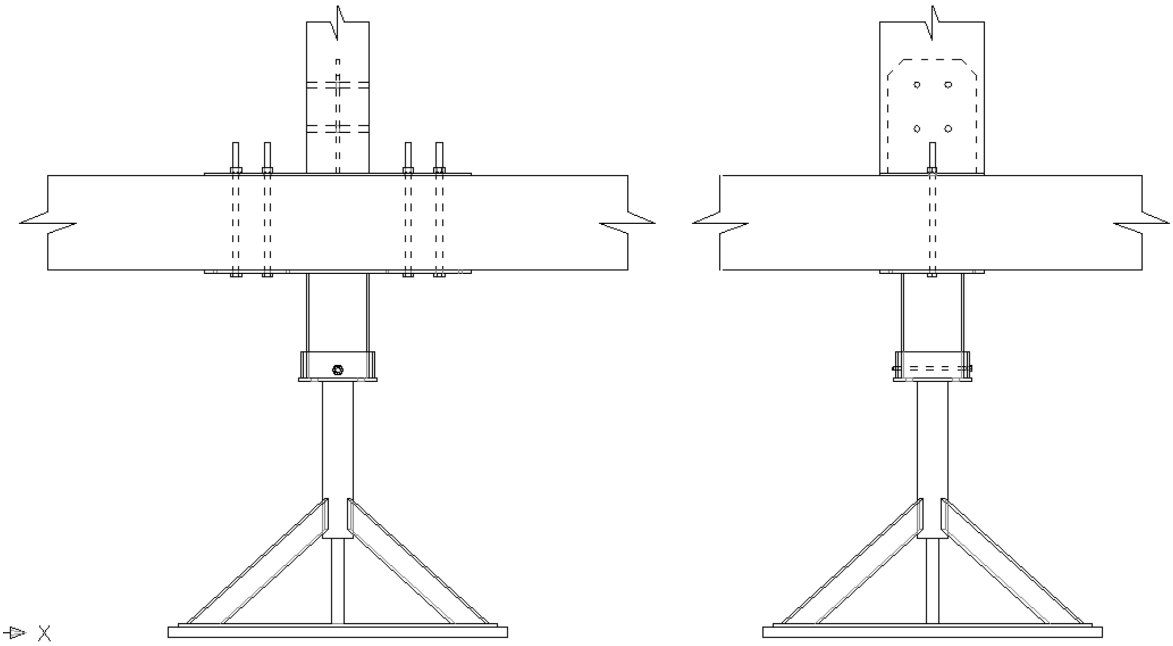


Figure 324 - Display of connections between wooden column, wooden slab, steel foundation pier and foundations

13.5.7.3 Connecting wall panels with wall panels

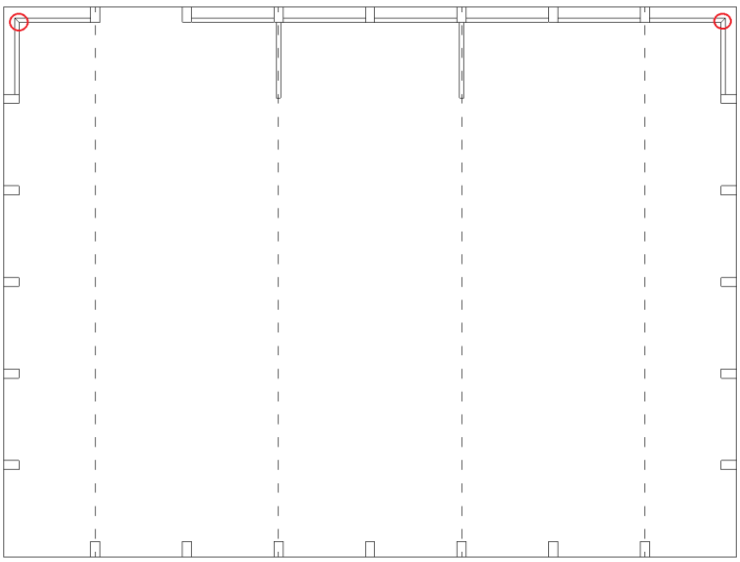


Figure 325 - Location of walls that will be connected directly to other walls

Wall panels that have to be connected under 90^0 angle will also be connected using patented L profile steel angle brackets by Rothoblaas® and bolts. Angle bracket type is WBR170110. Safety in case of fire is guaranteed by manufacturer. Connectors will also be easily disassembled and reassembled, which is mandatory as we need to rebuild our house multiple times. Ceiling slabs will not be fastened directly to wall panels, so that wall panels take only lateral loads.

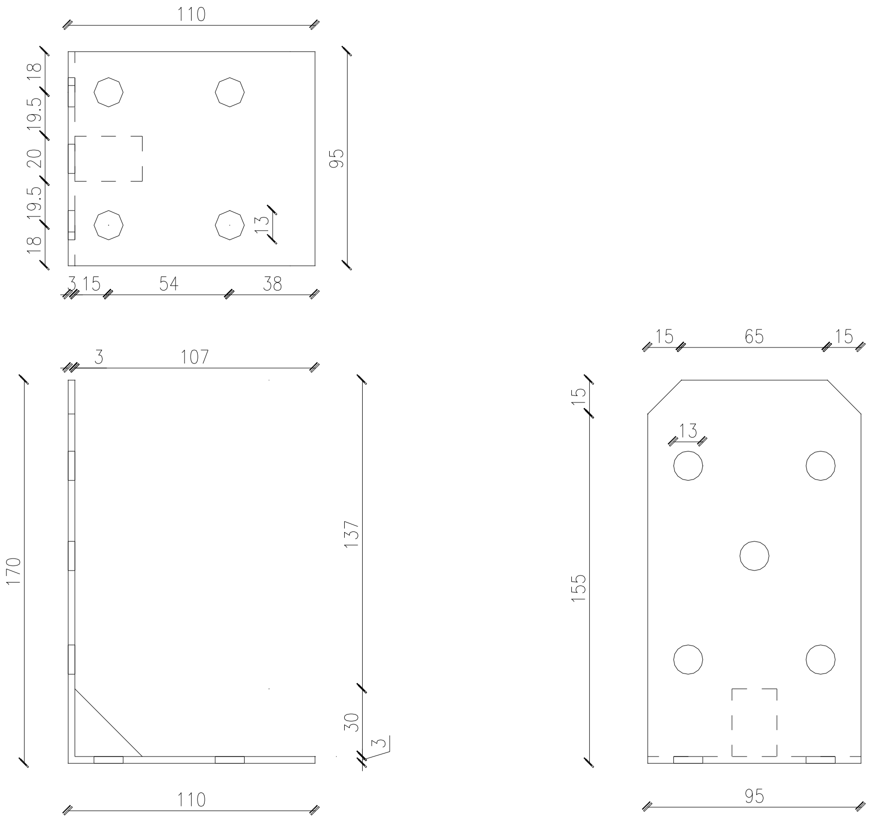


Figure 326 - Steel plate used for wall - floor connection

$t = 3\ mm$
$H = 170\ mm$
$L = 110\ mm$
$B = 155\ nmm$

number of bolts = 2+2

Bolt type: Ø 12,0 x 60 mm, KČ3.6

Number of connectors $n_{sel} = 4$

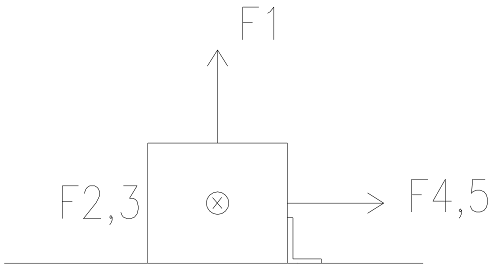


Figure 327 - Directions of forces for calculations

$$F_1 = 16{,}02\ kN < 4 \cdot R_{1,d} = 4 \cdot \frac{12{,}86}{2}\ kN = 25{,}72\ kN$$

$$F_2 = F_3 = 0{,}00\ kN < 4 \cdot R_{3,4,d} = 4 \cdot \frac{14{,}72}{2}\ kN = 29{,}44\ kN$$

$$F_4 = F_5 = 21{,}26\ kN < 2 \cdot R_{4,5,d} = 4 \cdot 5{,}76 = 23{,}04\ kN$$

$$n_{req} = n_{sel} = 2$$

$$f_{u,k} = 300\ N/mm^2$$

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{d^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 300 \cdot \frac{12^3}{6}}{1{,}1} = 62836{,}36\ Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\ N/mm^2$$

$$\mathrm{t}_2 = 60\ mm$$

$$R_{4,5,d} = 2 \cdot min \begin{cases} (\sqrt{2} - 1) \cdot 9{,}69 \cdot 60 \cdot 12 \\ 1{,}1 \cdot \sqrt{2 \cdot 62836{,}36 \cdot 9{,}69 \cdot 12} \end{cases} = 2 \cdot min \begin{cases} 2889{,}88 \\ 4204{,}99 \end{cases} = 2 \cdot 2{,}88\ kN$$

$$R_{4,5,d} = 2 \cdot 2{,}88 = 5{,}76\ kN$$

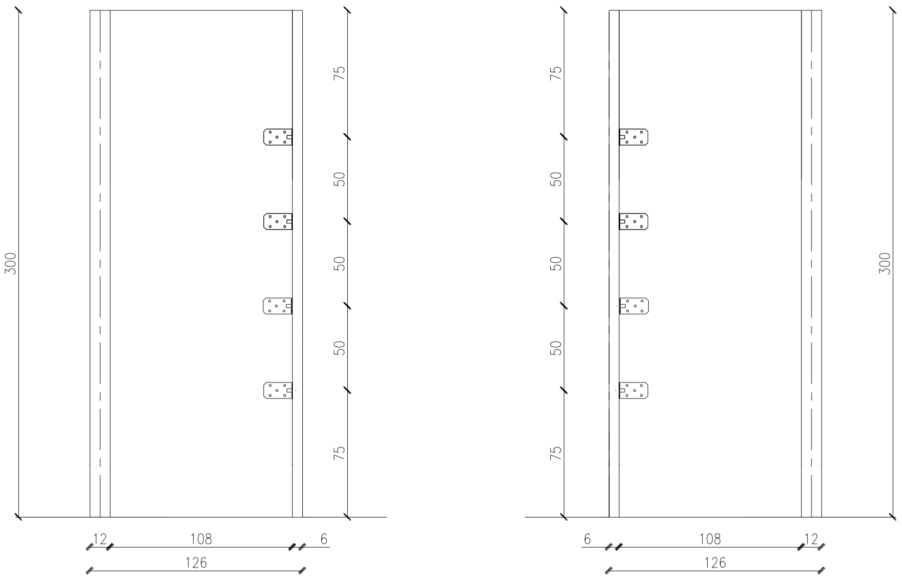


Figure 328 - Positions of wall-wall connections

13.5.7.4 Connecting parts of floor and ceiling slabs

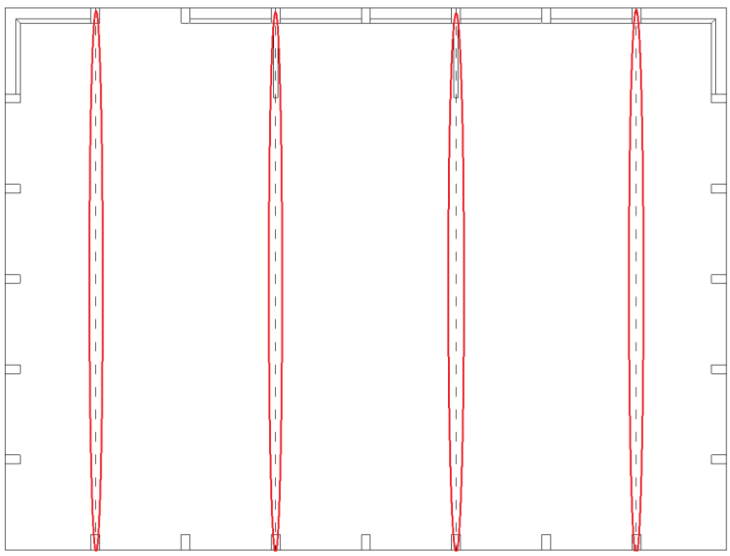


Figure 329 - Location of slab-slab connections

As our floor and ceiling slabs will have to be sawed into smaller parts due to transportation requirements, they will have to be reassembled at the building spot. This connection will have to be moment-bearing, to ensure full continuity of our slabs.

We will use wood screws, which will be evenly spaced along connection line, every 60 cm.

13.5.7.5 Connecting columns with wall panels

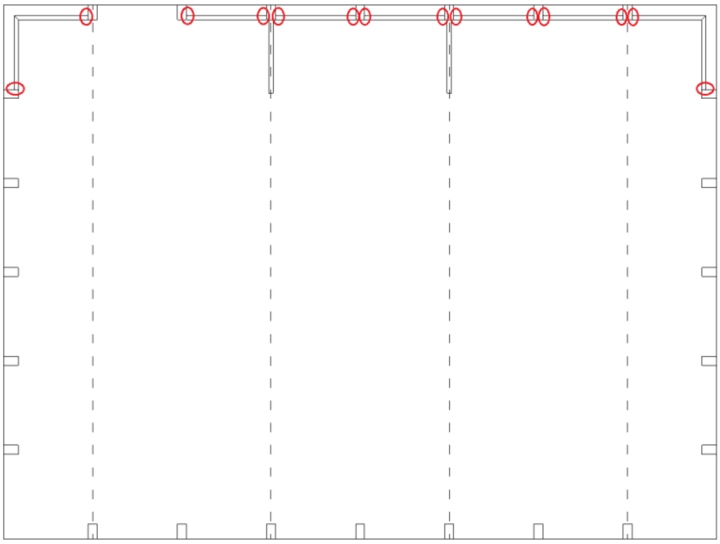


Figure 330 - Location of walls that will be connected to columns

Connection of wall panels with columns will be achieved using patented L profile steel angle brackets by Rothoblaas®, and bolts. Angle bracket type is WBR170110. Safety in case of fire is guaranteed by manufacturer. Connectors will also be easily disassembled and reassembled, which is mandatory as we need to rebuild our house multiple times. Ceiling slabs will not be fastened directly to wall panels, so that wall panels take only lateral loads.

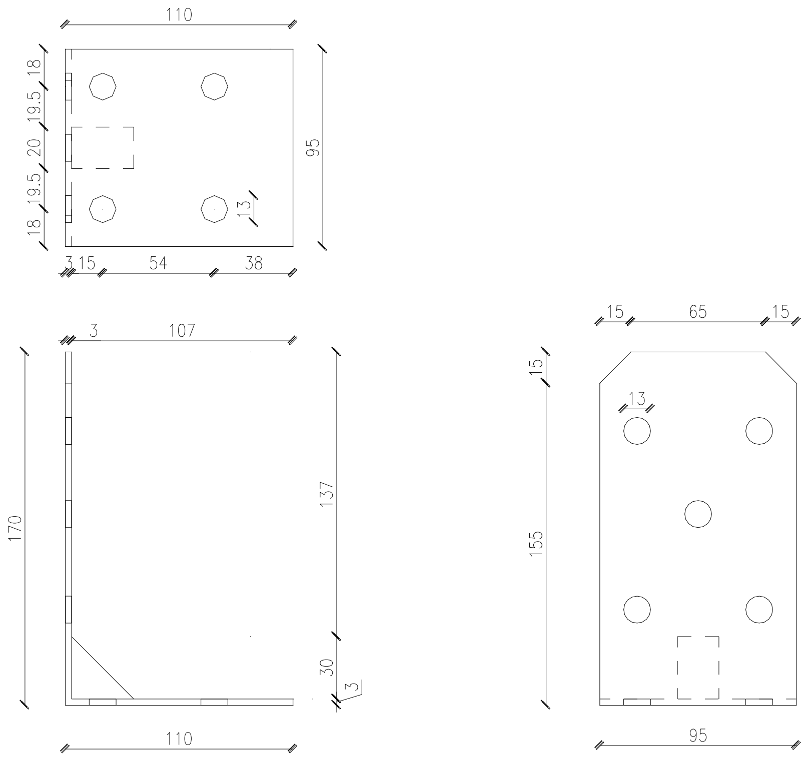


Figure 331 - Steel plate used for wall - floor connection

$t = 3\ mm$
$H = 170\ mm$
$L = 110\ mm$
$B = 155\ nmm$

number of bolts = 5+4

Bolt type: Ø 12,0 x 60 mm, KČ3.6 for wall

Ø 12,0 x 120 mm, KČ3.6 for column

Number of connectors $n_{sel} = 2$

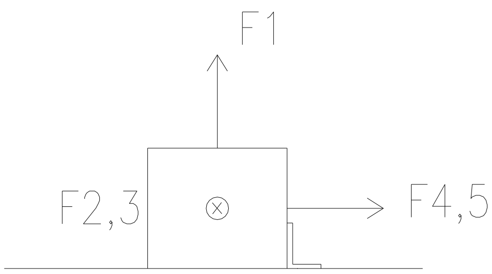


Figure 332 - Directions of forces for calculations

$$F_1 = 0{,}00\ kN < 2 \cdot R_{1,d} = 2 \cdot 12{,}86\ kN = 25{,}72\ kN$$

$$F_2 = F_3 = 21{,}60\ kN < 2 \cdot R_{2,3,d} = 2 \cdot 14{,}72\ kN = 29{,}44\ kN$$

$$F_4 = F_5 = 9{,}46\ kN < 2 \cdot R_{4,5,d} = 2 \cdot 11{,}52 = 23{,}04\ kN$$

$$n_{req} = n_{sel} = 2$$

$$f_{u,k} = 300\ N/mm^2$$

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{d^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 300 \cdot \frac{12^3}{6}}{1{,}1} = 62836{,}36\ Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\ N/mm^2$$

$$\mathrm{t}_2 = 60\ mm$$

$$R_{4,5,d} = 4 \cdot min \begin{cases} (\sqrt{2} - 1) \cdot 9{,}69 \cdot 60 \cdot 12 \\ 1{,}1 \cdot \sqrt{2 \cdot 62836{,}36 \cdot 9{,}69 \cdot 12} \end{cases} = min \begin{cases} 2889{,}88 \\ 4204{,}99 \end{cases} = 2{,}88\ kN$$

$$R_{4,5,d} = 4 \cdot 2{,}88 = 11{,}52\ kN$$

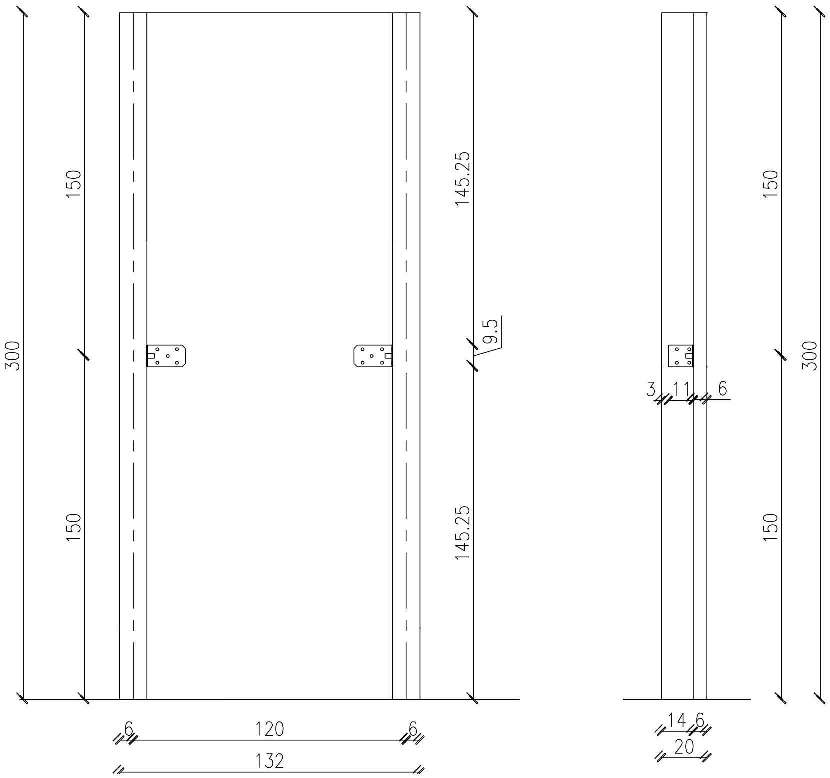


Figure 333 - Positions of wall-column connections

13.5.7.6 Connecting roof slab with photovoltaic panels

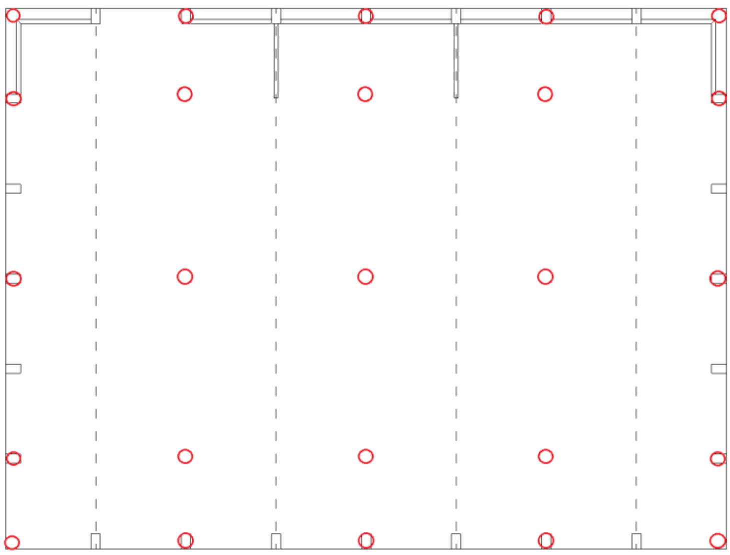


Figure 334 - Location of roof spikes on the roof slab

Photovoltaic panels will be supported on aluminum beams, which are connected with roof wooden slab by “roof spikes” shown in the Figure below.

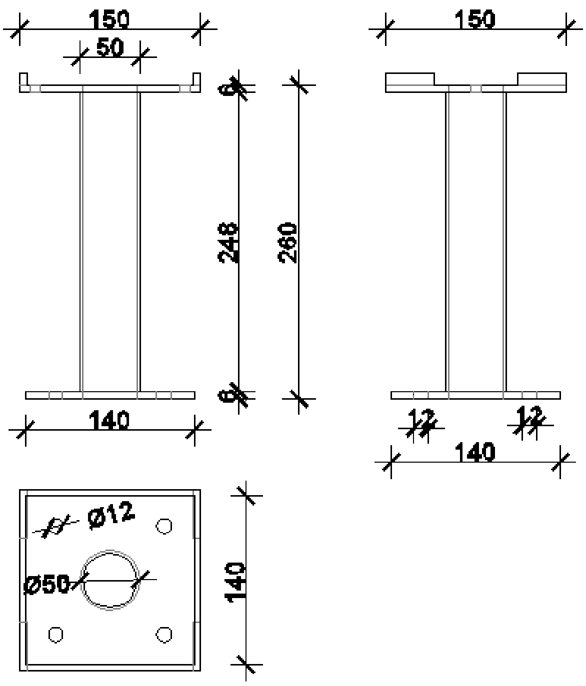


Figure 335 - Roof spike dimensions

Tensile force $N_{t,Ed} = 32{,}00\ \mathrm{kN}$

Resistance of cross section:

$$A = \frac{50^2\pi}{4} - \frac{45^2\pi}{4} = 373{,}05\ mm^2$$

$$R_{t,Ed} = \frac{337{,}05 \cdot 235}{1{,}00} = 87667{,}48\ N = 87{,}66\ kN > N_{t,Ed} = 32{,}00\ kN$$

Compression resistance in timber under plate:

$$f_{c,90,d} = k_{mod} \cdot \frac{f_{c,90,k}}{\gamma_M} = 0{,}9 \cdot \frac{2{,}4}{1{,}3} = 1{,}66\ N/mm^2$$

$$N_{t,Ed} = 32{,}00\ kN$$

$$\sigma_{c,90,d} = \frac{32000}{150 \cdot 150} = 1{,}422\ N/mm^2$$

$$\frac{\sigma_{c,90,d}}{f_{c,90,d}} = \frac{1{,}42}{1{,}66} = 0{,}85 < 1{,}00$$

Tension resistance of screws

$$f_{3,k} = (1{,}5 + 0{,}6d)\sqrt{\rho_k} = (1{,}5 + 0{,}6 \cdot 12)\sqrt{350} = 162{,}76\ N/mm'$$

$$f_{3,d} = k_{mod} \cdot \frac{f_{3,k}}{\gamma_M} = 0{,}9 \cdot \frac{162{,}76}{1{,}3} = 112{,}68\ N/mm'$$

$$R_d = f_{3,d} \cdot (l_e - d) = 112{,}68 \cdot (100 - 12) = 9915{,}96\ N = 9{,}91\ kN$$

$$R_{d,tot} = 4 \cdot 9{,}91 = 39{,}64\ kN > N_{t,Ed} = 32{,}00\ kN$$

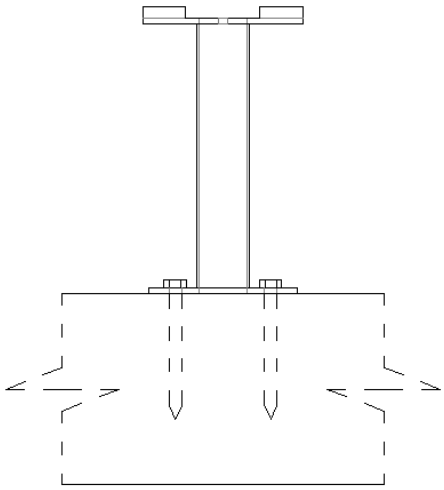


Figure 336 - Display of connections of roof spike with wooden roof slab

13.5.7.7 Connecting columns with roof slabs

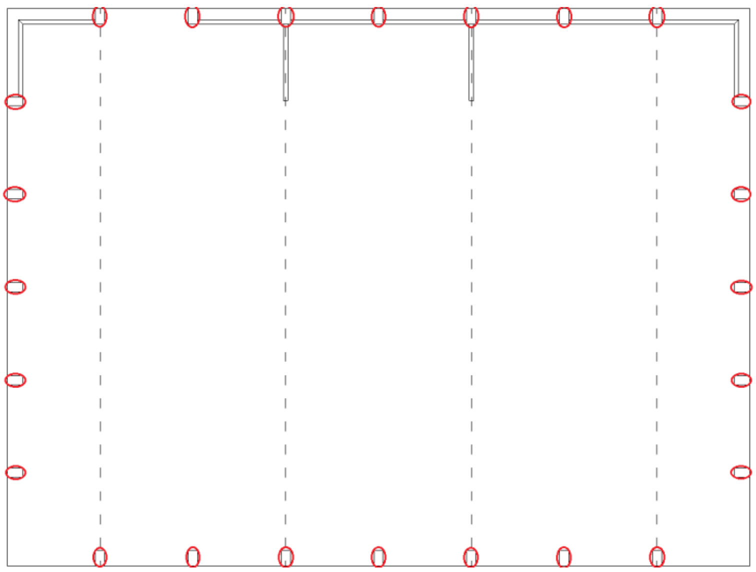


Figure 337 - Location of columns that will be connected to floor and ceiling slabs

Connections between roof and columns will be achieved using IdeFix® patented IF 406 connectors, made by Sigha company.

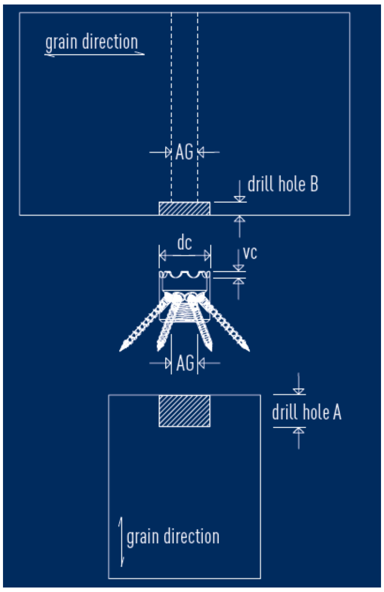


Figure 338 - Mounting scheme of IdeFix® connectors

First, hole will be drilled on top of a column. The second step is to insert IdeFix® connector in this hole, and screw a needed number of wood screws. The final step is to drill a hole in roof slab, insert a bolt, and mount a slab so that bolt fits in IdeFix® connector.

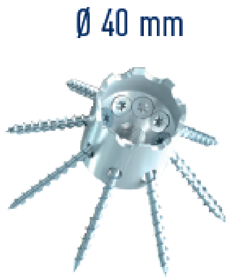


Figure 339 - IdeFix® connector

Resistances of the connectors are given in following tables:

Table 107 - Dimensions and resistance of connectors

Size	Dimensions	Joint	Joint /tensile force		Joint/ lateral force		System screw	Anti-twist protection
IdeFix® IF	dc	Thread	Drill hole [mm]		Drill hole [mm]		GoFix® HK	vc
Type	[mm]	AG	A	B	A	B	[mm]	[mm]
406	40	M16	35	35	25	10	6,0 x 60	5

SIHGA®		Dimensions	Secondary comp./ pillar		Characteristic values	
Montagepack		IdeFix® IF	Height	Width	Tensile force F1	Lateral force F2
Art. No.	PU	Type	[mm]	[mm]	[kN]	[kN]
28826	12	406	120	120	26,73	13,5

13.5.7.8 Connecting foundations

Connection of foundations with secondary columns will also be achieved using square steel profiles, dimensions 120 x 120 x 4 mm. These foundation piers connect to floor with 4 Ø 12,0 bolts.

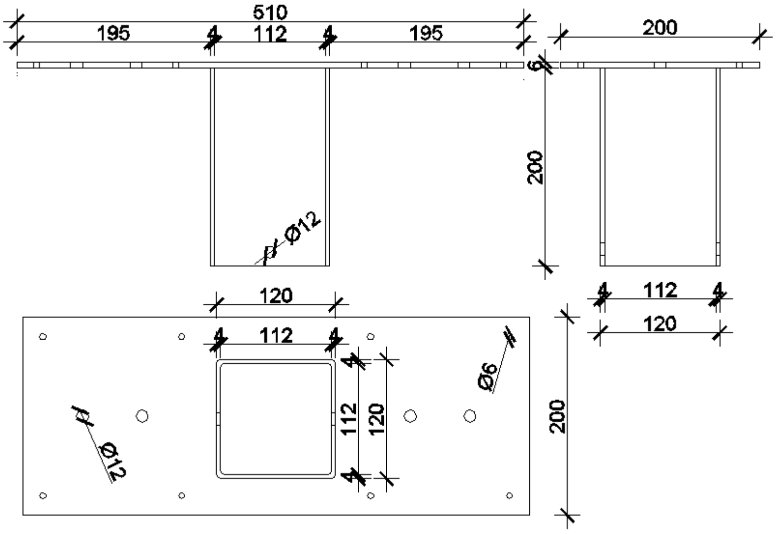


Figure 340 - Foundation piers (type 1) – underneath the columns

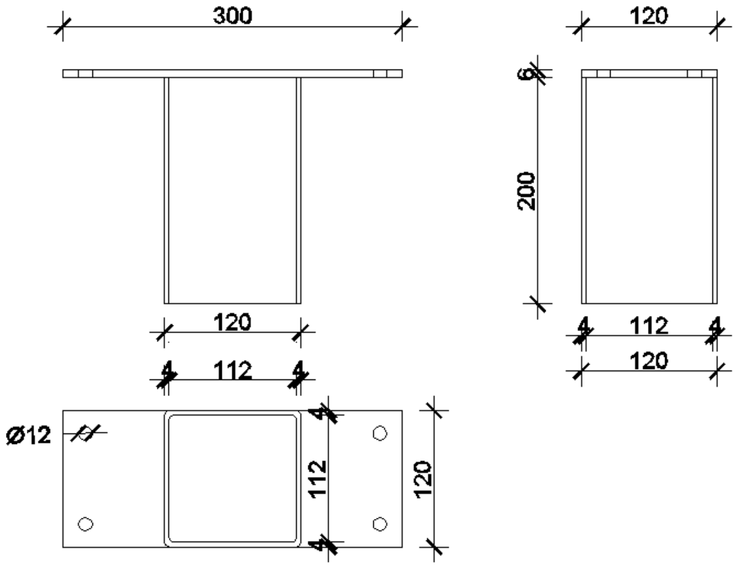


Figure 341 - Foundation piers (type 2)

$t = 6\ mm$

$H = 86\ mm$
$L = 510 mm$
$B = 200\ nmm$

Bolt type: Ø 12,0 x 60 mm, KČ3.6 for floor

Resistance to tension force in column:

$f_{u,k} = 360\ N/mm^2$ For S235

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{d^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 360 \cdot \frac{12^3}{6}}{1{,}1} = 75403{,}63\ Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\ N/mm^2$$

$$\mathrm{t}_1 = \frac{110-6}{2} = 52\ mm$$

$$R_d = 2 \cdot min \begin{cases} 52 \cdot 12 \cdot 9{,}69 \\ 1{,}1 \cdot 9{,}69 \cdot 52 \cdot 12 \cdot \left[\sqrt{2 + \dfrac{4 \cdot 75403{,}63}{9{,}69 \cdot 12 \cdot 52^2}} - 1\right] \\ 1{,}5 \cdot \sqrt{2 \cdot 62836{,}36 \cdot 9{,}69 \cdot 12} \end{cases} = 2 \cdot min \begin{cases} 6046{,}56 \\ 4790{,}55 \\ 5734{,}08 \end{cases} = 4{,}79\ kN$$

$$R_d = 2 \cdot 4{,}79 = 9{,}58\ kN$$

minimum distance of bolts= 7d = 84 mm

Compression resistance of timber in floor slab under bolt plates:

$$f_{c,90,d} = k_{mod} \cdot \frac{f_{c,90,k}}{\gamma_M} = 0{,}9 \cdot \frac{2{,}4}{1{,}3} = 1{,}66\ N/mm^2$$

$$d_s = 36\ mm$$

$$\frac{\sigma_{c,90,d}}{1{,}8 \cdot f_{c,90,d}} = \frac{\frac{2916}{4 \cdot 0{,}7 \cdot 36^2}}{1{,}8 \cdot 1{,}66} = 0{,}27 < 1{,}00$$

Yield resistance of hole cladding:

$$R_d = 55{,}4\ kN\ for\ t = 10\ mm, S235, Ø12$$

$$R_d = 55{,}4 \cdot \frac{6}{10} = 33{,}24\ kN > 29{,}16\ kN$$

13.5.7.9 Fastening of bracings

Bracing systems will be fastened to bolts in ceiling and floor slabs using nuts. Those bolts are part of floor-column connection for bottom part of bracing. For upper part of bracing, we will insert special bolt in ceiling slab.

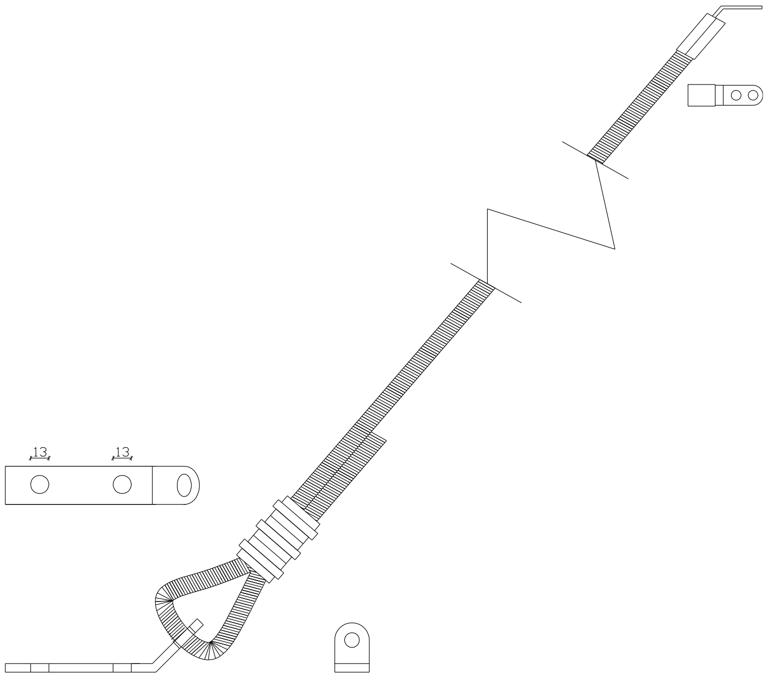


Figure 342 - Scheme of bracing fastening

$$F_{H1} = 8{,}10\ kN$$

$$F_{V1} = 24{,}20\ kN$$

$$F_{V2} = \frac{N_{t,Ed}}{4} = \frac{29{,}16}{4} = 7{,}29\ kN$$

$$F_V = F_{V1} + F_{V2} = 24{,}20 + 7{,}29 = 31{,}49\ kN$$

Resistance of bolts:

Bolt type: Ø 12,0x180 mm, KČ3.6

$$f_{u,k} = 300\ N/mm^2$$

$$M_{y,d} = \frac{0{,}8 \cdot f_{u,k} \cdot \frac{12^3}{6}}{\gamma_M} = \frac{0{,}8 \cdot 300 \cdot \frac{12^3}{6}}{1{,}1} = 62836{,}36\ Nmm$$

$$f_{h,t,d} = k_{mod} \cdot \frac{f_{h,t,k}}{\gamma_M} = 0{,}90 \cdot \frac{14{,}00}{1{,}3} = 9{,}69\ N/mm^2$$

$$t_2 = 180\ mm$$

$$R_d = min\begin{cases}(\sqrt{2}-1)\cdot 9{,}69\cdot 180\cdot 12 \\ 1{,}1\cdot\sqrt{2\cdot 62836{,}36\cdot 9{,}69\cdot 12}\end{cases} = min\begin{cases}8669{,}65 \\ 4204{,}99\end{cases} = 4{,}20\ kN$$

$$R_{d,tot} = 2\cdot 4{,}20 = 8{,}40\ kN$$

$$F_1 = 8{,}10\ kN < R_{d,tot} = 8{,}40\ kN$$

Tension resistance of bolts:

$$R_{t,Ed} = 4\cdot\frac{12^2\pi}{4}\cdot 300 = 135712{,}8\ N = 135{,}7kN > N_{t,Ed} = \frac{31{,}49\ kN}{2} = 15{,}75\ kN$$

Compression resistance of timber in floor slab under bolt plates:

$$f_{c,90,d} = k_{mod}\cdot\frac{f_{c,90,k}}{\gamma_M} = 0{,}9\cdot\frac{2{,}4}{1{,}3} = 1{,}66\ N/mm^2$$

$$N_{t,Ed} = 31{,}49\ kN$$

$$d_s = 36\ mm$$

$$\frac{\sigma_{c,90,d}}{1{,}8\cdot f_{c,90,d}} = \frac{\frac{31490}{120\cdot 100}}{1{,}8\cdot 1{,}66} = 0{,}87 < 1{,}00$$

To withstand uplift force from bracings, special 120x100 mm steel plates will be placed under bolts that hold bracings

13.6 SECTION F: Limit serviceability state

Serviceability refers to conditions on under which a building is still considered useful. If these limit states should be exceeded, even on a structure that can still bear loads, would nevertheless be considered unfit. It refers to conditions in which structure is considered unusable, rather than building strength.

Serviceability implies excessive deflections, vibrations and local deformations.

13.6.1 Deflections

The deflection of the roof and floor slabs for specific loads

Table 108 - Span deflection for characteristic loads

	Middle of the span deflection (mm)	
	Floor	Roof
Dead load	-0,60	-9,99
Live load	-0,50	0,00
Snow	0,00	-3,10
Wind 180˚ pressuring	0,00	-3,30
Wind 180˚ lifting	0,00	-1,80
Wind 0˚ pressuring	0,00	2,30
Wind 0˚ lifting	0,00	1,80
Wind 90˚ pressuring	0,00	-0,40
Wind 90˚ lifting	0,00	0,50
Internal pressure +	-0,10	3,10
Internal pressure -	0,10	-1,90

According to do Eurocode (expression EC5, 4.1.a) load combinations for limit serviceability state are:

$$\sum G_{k,j} + Q_{k,1} + \sum_{i>1} \Psi_{1,j} \cdot Q_{k,i}$$

Chosen partial factor of snow load for sites located at altitude H ≤ m a.s.l.

$$\Psi_1 = 0{,}2$$

Chosen partial factor of wind load on buildings

$$\Psi_1 = 0,2$$

Deflection from characteristic load combinations

Table 109 - Instant span deflection ($u_{inst,i}$) for characteristic load combinations

Combination	Middle of the span deflection (mm)	
	Floor	Roof
1	-1,10	-13,09
2 (maximum value)	-1,00	-4,59
2 (minimum value)	-1,20	-15,19
3 (maximum value)	-1,08	-12,01
3 (minimum value)	-1,08	-13,13
4 (maximum value)	-1,00	-5,21
4 (minimum value)	-1,20	-15,81
Maximum value	**-1,00**	**-4,59**
Minimum value	**-1,20**	**-15,81**

For final value of deflection for each individually load are calculated according to the following formula (expression EC5, 4.1.b)

$$u_{fin,i} = u_{inst,i} \cdot (1 + k_{def,i})$$

In which are:

$u_{fin,i}$ – final deflection of characteristic combination

$u_{inst,i}$ – instant deflection of characteristic combination

$k_{def,i}$ – coefficient of deformation which takes into consideration growth of deformation during time

Table 110 - Values of k_{def} for serviceability class 2

GLT	Serviceability class
Loads duration	2
Permanent	0,80
Long-term	0,50
Medium-term	0,25
Short-term	0,00

Final deflection values from characteristic load combinations

Table 111 - Final span deflection ($u_{fin,i}$) for characteristic load combinations

Combination	Middle of the span deflection (mm)	
	Floor	Roof
1	-1,71	-19,86
2 (maximum value)	-1,61	-10,58
2 (minimum value)	-1,81	-21,18
3 (maximum value)	-1,69	-18,78
3 (minimum value)	-1,69	-19,90
4 (maximum value)	-1,61	-11,36
4 (minimum value)	-1,81	-21,96
Maximum value	**-1,61**	**-10,584**
Minimum value	**-1,81**	**-21,959**

In project situations where it's considered to limit instant deflection caused characteristic load combinations allowed value of $u_{inst,perm}$ is:

$$u_{inst,perm} = \frac{L}{300} = \frac{700}{300} = 2{,}33\ cm$$

Absolute maximum value of instant deflection of floor slab $u_{inst,roof} = 0{,}12\ cm$

$$u_{inst,perm} = 2{,}33\ cm > u_{inst,roof} = 0{,}12\ cm$$

Absolute maximum value of instant deflection of roof slab $u_{inst,floor} = 1{,}58\ cm$

$$u_{inst,perm} = 2{,}33\ cm > u_{inst,floor} = 1{,}58\ cm$$

In project situations where it's considered to limit final deflection caused characteristic load combinations allowed value of $u_{fin,perm}$ is:

$$u_{fin,perm} = \frac{L}{200} = \frac{700}{200} = 3{,}50\ cm$$

Absolute maximum value of instant deflection of floor slab $u_{fin,roof} = 0{,}18\ cm$

$$u_{fin,perm} = 3{,}50\ cm > u_{fin,roof} = 0{,}18\ cm$$

Absolute maximum value of instant deflection of roof slab $u_{fin,floor} = 2{,}20\ cm$

$$u_{fin,perm} = 3{,}50\ cm > u_{fin,floor} = 2{,}20\ cm$$

13.7 SECTION G: Foundation system

For our foundation system we are going to use height adjustable CP Anchor Piers produced by American company Central Piers Ind. The CP Anchor Pier is a powder coated steel pier on a pressure treated plywood pad with ground spikes that penetrate 35 centimeters. We are going to use '10 inch piers' which have height adjustment from ground 30,5 cm to 43,0 cm

Figure 343 - CP Anchor Pier

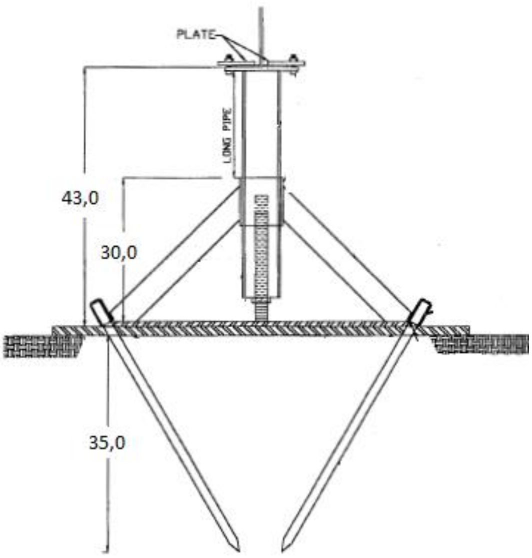


Figure 344 - CP AnchorPier – dawning

13.7.1 Positions plan

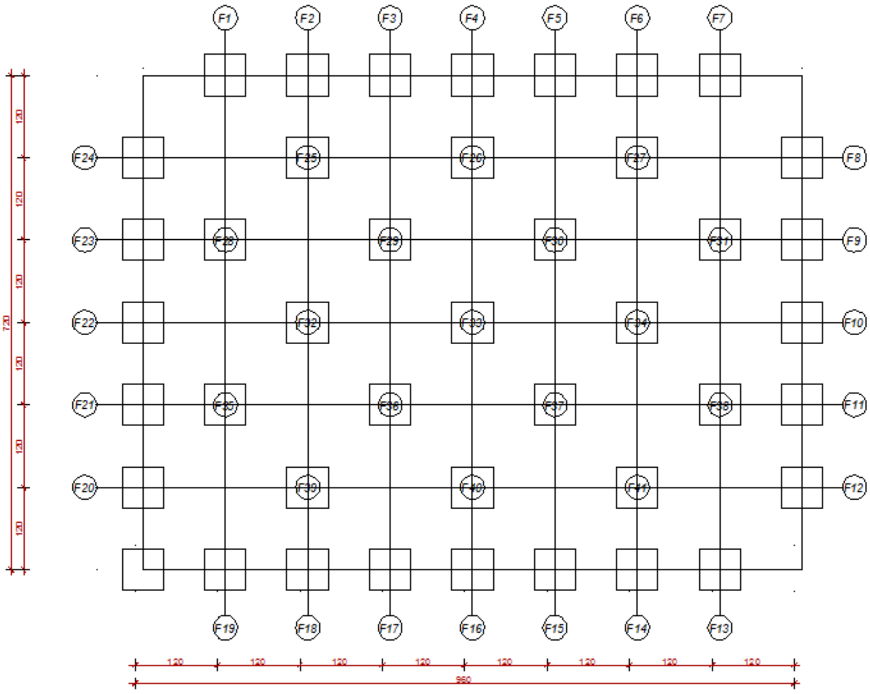


Figure 345 - Positions plan

13.7.2 Numerical model

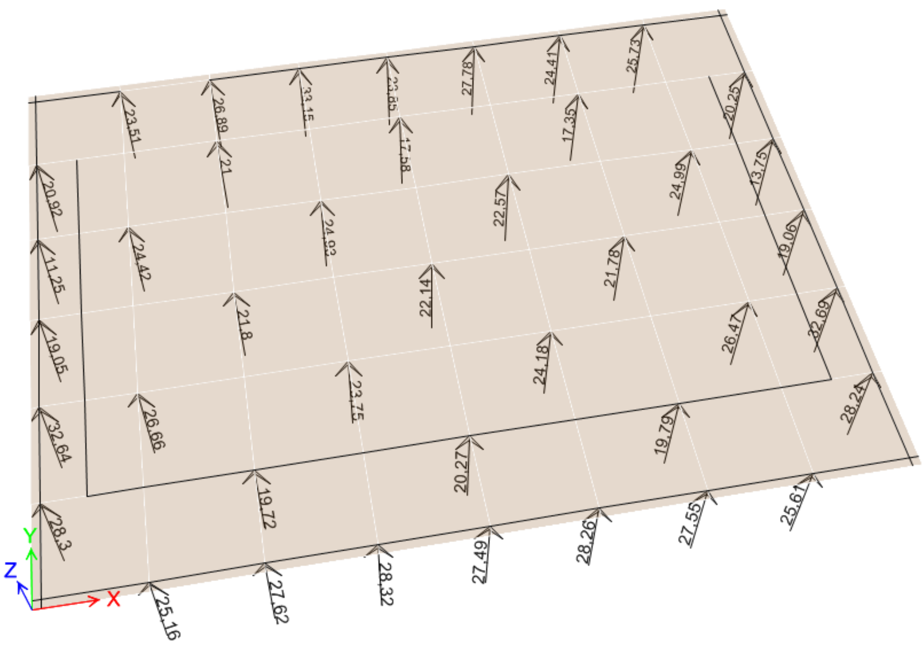


Figure 346 - Load values

According to test data given from producers, piers can take load up to 35 kN.

Pressure treated plywood pads have dimensions 65x65 cm and 80x80cm, depending on loads shown to Figure 346.

Soil bearing resistance is Rb = 50kN/m².

Used marks and explanation:

L – length (m)

B – width (m)

A – area (m²)

R (construction) – loads from construction (kN)

G (foundation) – piers weight (kN)

R_b- soil bearing resistance

R_{bd} – soil bearing resistance under pads depending on area (kN)

$R_{bd} = R_b \times A$ (kN)

R (total) <R_{bd}

Table 112 - Values of loads and bearing resistance for every pier under construction

FOUNDATION	B	L	A	R (construction)	G (foundation)	R (total)	R_{bd}
F1	0.8	0.8	0.64	23.86	0.25	24.11	32
F2	0.8	0.8	0.64	26.95	0.25	27.2	32
F3	0.8	0.8	0.64	33.11	0.25	33.36	32
F4	0.8	0.8	0.64	23.85	0.25	24.1	32
F5	0.8	0.8	0.64	27.76	0.25	28.01	32
F6	0.8	0.8	0.64	24.46	0.25	24.71	32
F7	0.8	0.8	0.64	25.73	0.25	25.98	32
F8	0.8	0.8	0.64	20.26	0.25	20.51	32
F9	0.8	0.8	0.64	13.75	0.25	14	32
F10	0.8	0.8	0.64	19.06	0.25	19.31	32
F11	0.8	0.8	0.64	32.69	0.25	32.94	32
F12	0.8	0.8	0.64	28.24	0.25	28.49	32
F13	0.8	0.8	0.64	25.61	0.25	25.86	32
F14	0.8	0.8	0.64	27.55	0.25	27.8	32
F15	0.8	0.8	0.64	28.26	0.25	28.51	32
F16	0.8	0.8	0.64	27.49	0.25	27.74	32
F17	0.8	0.8	0.64	28.32	0.25	28.57	32
F18	0.8	0.8	0.64	27.62	0.25	27.87	32
F19	0.8	0.8	0.64	25.16	0.25	25.41	32
F20	0.8	0.8	0.64	28.3	0.25	28.55	32

F21	0.8	0.8	0.64	32.64	0.25	32.89	32
F22	0.8	0.8	0.64	19.05	0.25	19.3	32
F23	0.8	0.8	0.64	11.25	0.25	11.5	32
F24	0.8	0.8	0.64	20.95	0.25	21.2	32
F25	0.8	0.8	0.64	21	0.25	21.25	32
F26	0.8	0.8	0.64	17.58	0.25	17.83	32
F27	0.8	0.8	0.64	17.35	0.25	17.6	32
F28	0.8	0.8	0.64	24.42	0.25	24.67	32
F29	0.8	0.8	0.64	24.93	0.25	25.18	32
F30	0.8	0.8	0.64	22.57	0.25	22.82	32
F31	0.8	0.8	0.64	24.99	0.25	25.24	32
F32	0.8	0.8	0.64	21.8	0.25	22.05	32
F33	0.8	0.8	0.64	22.14	0.25	22.39	32
F34	0.8	0.8	0.64	21.78	0.25	22.03	32
F35	0.8	0.8	0.64	26.66	0.25	26.91	32
F36	0.8	0.8	0.64	23.75	0.25	24	32
F37	0.8	0.8	0.64	24.18	0.25	24.43	32
F38	0.8	0.8	0.64	26.47	0.25	26.72	32
F39	0.8	0.8	0.64	19.72	0.25	19.97	32
F40	0.8	0.8	0.64	20.27	0.25	20.52	32
F41	0.8	0.8	0.64	19.79	0.25	20.04	32

For decking we will use Buzons made by Buzon Pedestal Internation. Buzons crew-jack pedestal offer uninterrupted adjustability, are made from 78% recycled and 100% recyclable polypropylene and support loads of more than 1000 kg per pedestal. They can be adjusted to compensate for up to 5% slope. Once pedestals are at the required height, their position is fixed with unique lockable keys. Buzons will be placed in raster 80 x 80 cm like it is shown on Figure 348. The way of setting is shown in the Figure 349.

Figure 347 - Height adjustable Buzons

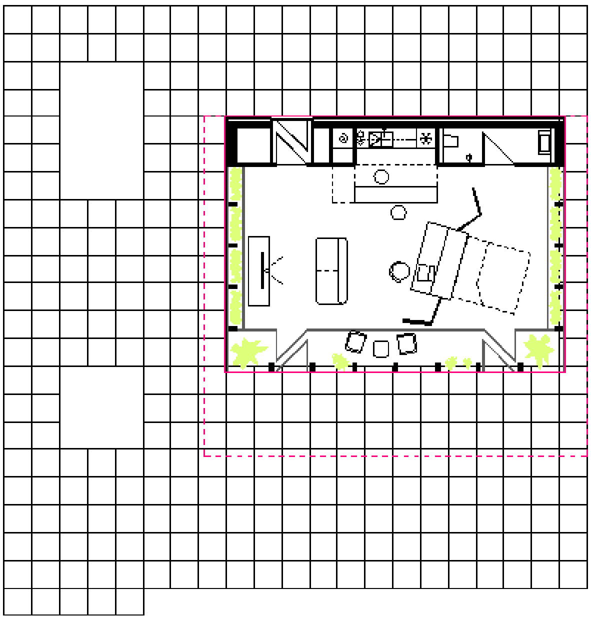


Figure 348 - Buzons in raster 80 x 80 cm

Figure 349 - The way of setting the Buzons

13.8 SECTION H: Structural Fire Safety

The Building Code requires that fire resistance of the structure is R30. Because the fire must be considered as an event of instantaneous duration that doesn't occurs simultaneously with other accidental actions, such as wind or snow. Therefore, the load combination for fire takes into account only vertical loads with different partial factors than those previously used.

One of the methods that is used to perform these verification, is to take into account a geometric reduction of the element cross section for consumption effects. First objective is to understand which the most vulnerable elements to fire and to assess the strength of their reduced sections.

The idea behind this method is to assess will the reduced area cross sections of columns, caused by burning for 30 min, withstand the loads. This ensures residents of the house to get of the house during that time.

13.8.1 Columns resistance

The most vulnerable wood elements in our house are the columns, because they are more exposed, and can be rapidly caught by fire from all four sides.

13.8.1.1 Charring depth

$$d_{char,n} = \beta_n \cdot t$$

Table 113 - Design charring rates of timber, LVL, wood paneling and wood-based panels

	β_0 mm/min	β_n mm/min
a) Softwood and beech Glued laminated timber with a characteristic density of ≥ 290 kg/m³ Solid timber with a characteristic density of ≥ 290 kg/m³	0,65 0,65	0,7 0,8
b) Hardwood Solid or glued laminated hardwood with a characteristic density of 290 kg/m³ Solid or glued laminated hardwood with a characteristic density of ≥ 450 kg/m³	0,65 0,50	0,7 0,55
c) LVL with a characteristic density of ≥ 480 kg/m³	0,65	0,7
d) Panels Wood panelling Plywood Wood-based panels other than plywood	 0,9[a] 1,0[a] 0,9[a]	 – – –
[a] The values apply to a characteristic density of 450 kg/m³ and a panel thickness of 20 mm; see 3.4.2(9) for other thicknesses and densities.		

Glued laminated hardwood with density >350 kg/m³:

Interpolated β_n value:

$$\beta_n = 0,64$$

$$\mathrm{t} = 30 \min$$

$$d_{char,n} = 0,64 \cdot 30 = 19,2 \quad mm$$

13.8.1.2 Cross Section Reduction

$$d_{ef} = d_{char,n} + k_0 \cdot d_0$$

$k_0 = 1,0$ for t =30 min > 20 min:

$$d_0 = 7mm$$

$$d_{ef} = 19,2 + 1,0 \cdot 7 = 26,2mm$$

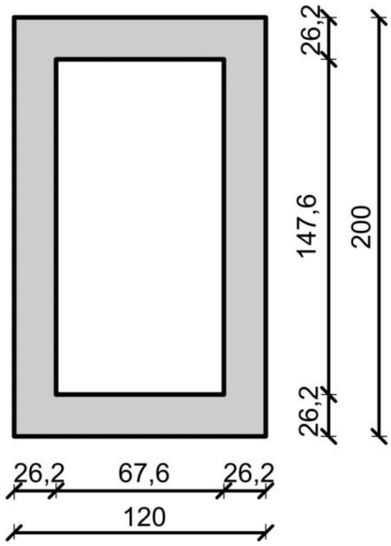


Figure 350 - Effective Beam Cross-Section

13.8.1.3 Cross-Section Resistance

$$A_{eff} = 67,6 \cdot 147,6 = 9977,76\,mm^2$$

$$F_{c,d} = \sum G_{k,j} + \sum \Psi_{2,i} Q_{2,i} = 16,34\,kN$$

$\Psi_{2,i} = 0,2$ for quasi-permanent combination

$$\sigma_{c,0,d} = \frac{F_{c,d}}{A} = \frac{12,25 \cdot 10^3}{9977,76} = 1,23N/mm^2$$

$$f_{c,0,d} = k_{\text{mod}} \cdot \frac{f_{c,0,k}}{\gamma_m} = 0,90 \cdot \frac{21,00}{1,3} = 14,538N/mm^2$$

$$\frac{\sigma_{c,0,d}}{f_{c,0,d}} = \frac{1,23}{14,538} = 0,085 \le 1,00$$

13.8.1.4 Element Resistance

$$A_{eff} = 67,6 \cdot 147,6 = 9977,76 mm^2$$

$$I_{eff,y} = \frac{67,6 \cdot 147,6^3}{12} = 18114423 \ mm^2$$

$$I_{eff,z} = \frac{67,6^3 \cdot 147,6}{12} = 3799664 \ mm^2$$

$$\lambda_y = \frac{l_y}{\sqrt{\frac{I_y}{A}}} = \frac{3000}{\sqrt{\frac{18114423}{9977,76}}} = 70,41$$

$$\lambda_z = \frac{l_z}{\sqrt{\frac{I_z}{A}}} = \frac{3000}{\sqrt{\frac{3799664}{9977,76}}} = 153,73$$

$$\lambda_{rel,y} = \lambda_y \cdot \sqrt{\frac{f_{c,0,k}}{\pi^2 \cdot E_{0,05}}} = 70,41\sqrt{\frac{21,00}{\pi^2 \cdot 9400}} = 1,059$$

$$\lambda_{rel,z} = \lambda_z \cdot \sqrt{\frac{f_{c,0,k}}{\pi^2 \cdot E_{0,05}}} = 153,73 \cdot \sqrt{\frac{21,00}{\pi^2 \cdot 9400}} = 2,31$$

$$k_y = 0,50 \cdot \left(1 + \beta_c \cdot \left(\lambda_{rel,y} - 0,3\right) + \lambda_{rel,y}{}^2\right) = 0,50 \cdot \left(1 + 0,1 \cdot \left(1,059 - 0,3\right) + 1,059^2\right) = 1,099$$

$$k_z = 0,50 \cdot \left(1 + \beta_c \cdot \left(\lambda_{rel,z} - 0,3\right) + \lambda_{rel,z}{}^2\right) = 0,50 \cdot \left(1 + 0,1 \cdot \left(2,31 - 0,3\right) + 2,31^2\right) = 3,27$$

$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}{}^2}} = \frac{1}{1,099 + \sqrt{1,099^2 - 1,059^2}} = 0,718$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}{}^2}} = \frac{1}{3,27 + \sqrt{3,27^2 - 2,31^2}} = 0,179$$

kc,z– decisive

$$\sigma_{c,0,d} = \frac{F_{c,d}}{A} = \frac{16,34 \cdot 10^3}{9977,76} = 1,64 N / mm^2$$

$$f_{c,0,d} = k_{\text{mod}} \cdot \frac{f_{c,0,k}}{\gamma_m} = 0,90 \cdot \frac{21,00}{1,3} = 14,538 N / mm^2$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} \cdot f_{c,0,d}} = \frac{1,64}{0,179 \cdot 14,538} = 0,63 \leq 1,00$$

13.8.2 Slab

The wooden slab isn't as exposed to fire as wooden columns, because they can be caught by fire only on one side. They are calculated to withstand 60 minutes of burning.

13.8.2.1 Charring depth

$$d_{char,n} = \beta_n \cdot t$$

Table 114 - Design charring rates of timber, LVL, wood paneling and wood-based panels

	β_0 mm/min	β_n mm/min
a) Softwood and beech Glued laminated timber with a characteristic density of ≥ 290 kg/m^3 Solid timber with a characteristic density of ≥ 290 kg/m^3	 0,65 0,65	 0,7 0,8
b) Hardwood Solid or glued laminated hardwood with a characteristic density of 290 kg/m^3 Solid or glued laminated hardwood with a characteristic density of ≥ 450 kg/m^3	 0,65 0,50	 0,7 0,55
c) LVL with a characteristic density of ≥ 480 kg/m^3	 0,65	 0,7
d) Panels Wood panelling Plywood Wood-based panels other than plywood	 0,9[a] 1,0[a] 0,9[a]	 – – –
[a] The values apply to a characteristic density of 450 kg/m^3 and a panel thickness of 20 mm; see 3.4.2(9) for other thicknesses and densities.		

Glued laminated hardwood with density >380 kg/m^3:

Interpolated β_n value:

$$\beta_n = 0{,}62$$

$$t = 60 \text{ min}$$

$$d_{char,n} = 0{,}62 \cdot 60 = 37{,}2 \;\; mm$$

13.8.2.2 Cross Section Reduction

$$d_{ef} = d_{char,n} + k_0 \cdot d_0$$

$k_0 = 1{,}0$ for t =60 min > 20 min:

$$d_0 = 7mm$$

$$d_{ef} = 37{,}2 + 1{,}0 \cdot 7{,}0 = 44{,}2mm$$

13.8.2.3 Cross-Section Resistance

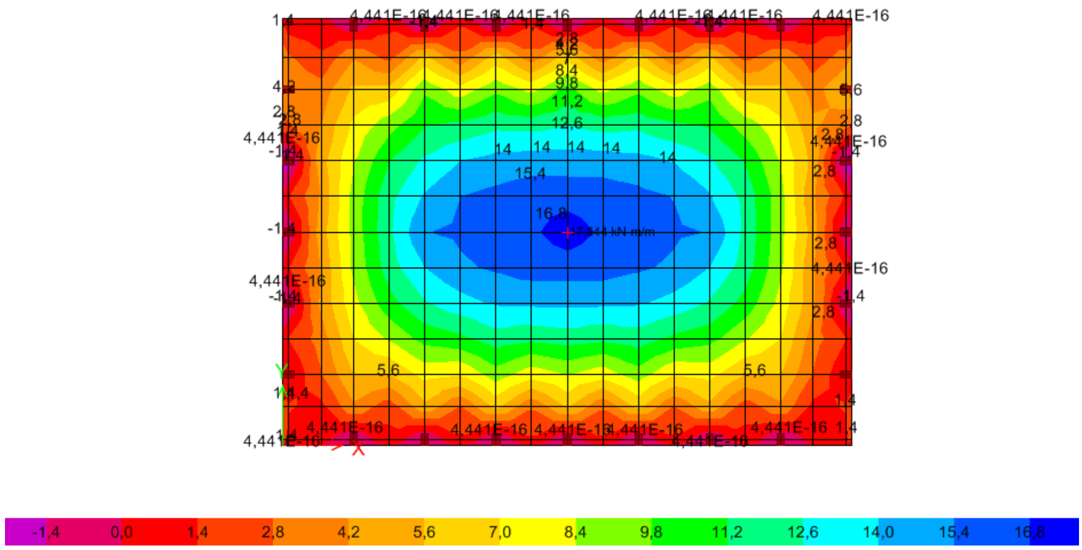


Figure 351 - Envelope moments with fire load combinations

$$\sigma_m = \frac{M_z}{W_y} = \frac{17,54 \cdot 10^6}{\frac{1000 \cdot 135,8^2}{6}} = 5,71 \ MPa$$

$$f_{m,d} = k_{\text{mod}} \cdot \frac{f_{m,k}}{\gamma_m} = 0,90 \cdot \frac{24,00}{1,3} = 16,61 N / mm^2$$

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{5,71}{16,61} = 0,34 \le 1,00$$