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Final Thesis

Building envelope Design Integrated with Parametric shading system For a Residential Building in Damascus

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A C K N O W L E D G M E N T S

I would first like to thank my thesis advisor prof Giuliana Iannaccone of the School of architecture urban planning and construction engineering at Politecnico Di Milano University. The door to Prof. Iannacone office was always open whenever I ran into a trouble spot or had a question about my research or writing. She consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it.

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Finally, special thanks go to my parents, for the continuous support they have given me throughout my time in graduate school; I could not have done it without them.

ABSTRACT

After the eight-year war in Syria, the Syrians began a forced flight from their areas to safer and more stable areas within Syria, while others went outside Syrian territory to escape the scourge of war in their cities. Many human rights organizations and humanitarian organizations have tried to alleviate their suffering, address their situation and make positive recommendations for refugees in general and internally displaced persons in particular, whose situation is dire and lacking the most basic elements of life. Internally displaced persons must enjoy full rights alongside Humanitarian assistance and protection, which falls on the State, become international assistance and protection. The number of displaced persons exceeded the threshold of 2.2 million, most of them from the neighborhoods of the southern and eastern capitals, which had the highest rate of displacement due to the extensive and systematic destruction of these neighborhoods and the city of Darya and the eastern Ghouta in Duma, Qabun and Barzeh in particular, which are considered semi-empty areas as a result of their occupation by religiously extremist terrorist elements. Start to introduce many site to construct new residential buildings that can be used for the refugee population and for future use. Most of that population displaced to the capital city of Syria because it is the closest city to their areas. The problem is there is no enough residential buildings can accommodate this huge number of population, so the people started to live in the schools and another governments buildings which don't have the function of residential. From this point, the government authorities and human rights organizations start to introduce many site to construct new residential buildings that can be used for the refugee population and for future use.

In this report, the design of a modern residential project on a site containing a random one-storey building in the downtown of the city will be explained, with new ideas appropriate to the culture of Damascus and Syrian society.

The modern design will be a link between the past and the present, as well as the idea of closing the social and cultural gap created by the war between the inhabitants of the safe areas and the affected areas to be a modern reference for future reconstruction.

The research includes two main sections, the first part will explain the modern residential buildings design linked to Damascene culture, and the other section will be about the parametric design of the facade of the building taking into account the global energy performance of the envelop and had been innovated from the Syrian culture.

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INTRODUCTION

The house was the first human production, Since human existence. the people look to their private space to accommodate their daily needs . the development of dwelling to suit requests and the needs of the life, using the building materials in his nearest surroundings. Throughout history, the human residence improved, growing more and more sophisticated with the emergence of new needs. Architectural diversity is thus an answer to the wide array of daily needs and activities.

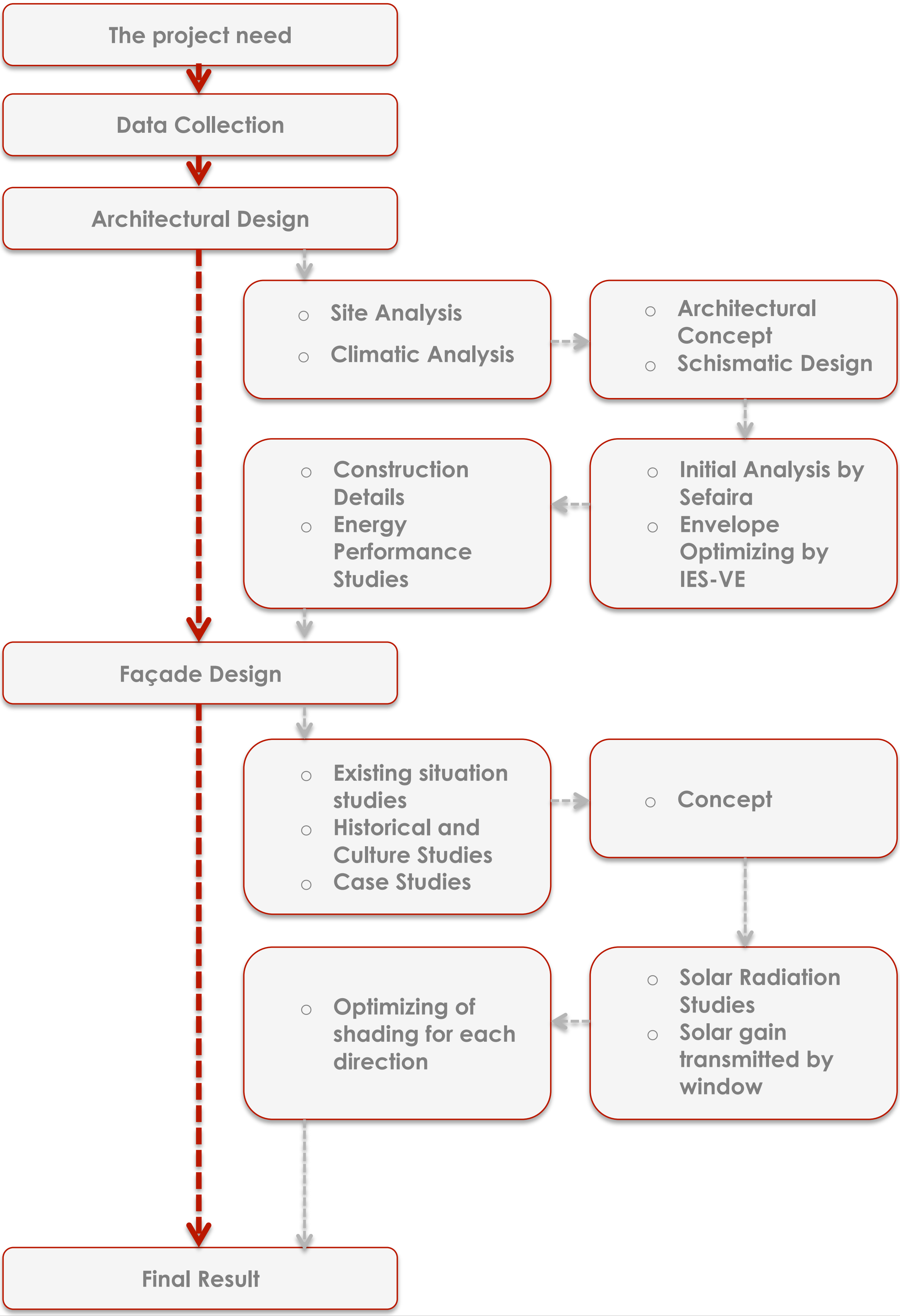
A house is a building that functions as a home. fixed structures of wood, brick, concrete or other materials containing plumbing, ventilation, and electrical systems. To ensure the daily lives of the residents and provide comfort and safety. Most conventional modern houses in cultures will contain one or more bedrooms and bathrooms, a kitchen or cooking area, and a living room. A house may have a separate dining room, or the eating area may be integrated into another room.

In Damascus, there are many architectural styles, approaches, and construction techniques for residential buildings. Yet, one paradigm has governed the production of architecture. It revolves around the issue of modernity and tradition as two antagonistic paradigms, to be reconciled at best. The best concept can be use is to integrate the traditional approaches of the old Damascus housing which it reflect these days' cultures of the city by innovations with the modern construction techniques.

The modern design will allow to have a sustainable energy-efficient for building in Damascus, Syria. The building must benefit from an integrated design approach so as to offer owners and users increased people living satisfaction and productivity, improved health, greater flexibility. which it will be related to the culture

The parametric Design will be used to create a static fixed facade allowing to manage light, air, energy, and even information. They can act to reduce solar gain as well as allowing the passage of fresh air into the building, helping to alter the interior environment. The fixed elements of the facade can be programmed to limit to climatic or other environmental factors, time, levels and type of occupancy and so on to improve energy performance and efficiency.

DESIGN PROCESS



PROJECT AIMS

Two main important points divide the aims of the project. As project, the function of the building where the increasing of housing is needed for the situation of population displaced, providing a commercial spaces to be a charitable investment and provide employment opportunities for residents with the aim of engaging in the new community, flexible Design to keep the building changeable from residential to another propose in the future, involve new technologies To promote innovations in the field of reconstruction of the city, recycling of the destroyed buildings wastes due to the war and finally the experience of using of the parametric facade with it lead for the building many function as daylight control, thermal control, glare control and view from inward and outward.

The second point as aim of the project is related to the researcher, the study of the context and achieve the relation of the new project with the stopped renaissance context, provide new technologies which it lead to increase the energy performance which can be used in the future construction market, the experience of using of the parametric design as new useful building technique and finally The study of new materials and systems.

PROJECT DESCRIPTION

The project is to design mixed residential and commercial building in Damascus, Syria. The building must benefit from an integrated design approach so as to offer owners and users increased people living satisfaction and productivity, improved health, greater flexibility.

The residential spaceswill be used for the displaced population and secondary as commercial in the lower floors to be a charitable investment and provide employment opportunities for residents. The main requirement is to develop a vision for a transcultural vibrant community development. The design will have to propose a viable combination of residential and public spaces while respecting the plot characteristic and its history. Special focus will be given on developing the sustainability dimensions as well as the comfort ones.

PROJECT ELEMENTS

The typical floor will contain different types of apartments which depends on the number of the member of the families. The first type will fit a famaly of six people, it will has two bedrooms and one master bedroom, in addition to three bathrooms, kitchen with living space, dining room with suitible reception hall. The second type will consist from two bedrooms with its services spaces, kitchen and open space for the daily activities as dining and living area. The third type will be an apartmant of one bedroom and the spaces of the other functions.

The typical floor will be repeated vertically where the number of the floor will be depends on the harmony of the context and neighborhood buidlings.While different functions for the ground and underground floor ranging between parkings and commercial spaces.

SITE

Syria, officially known as the Syrian Arab Republic is a country in Western Asia, bordering Lebanon and the Mediterranean Sea to the west, Turkey to the north, Iraq to the east, Jordan to the south. Syria's capital and largest city is Damascus. Damascus is the capital of the Syrian Arab Republic. It is colloquially known in Syria as ash-Sham and titled the City of Jasmine . In addition to being one of the oldest continuously inhabited cities in the world, Damascus is a major cultural centre of the Levant and the Arab world. It Located in south-western Syria, Damascus is the centre of a large metropolitan area. Geographically embedded on the eastern foothills of the Anti-Lebanon mountain range 80 kilometres inland from the eastern shore of the Mediterranean on a plateau 680 metres above sea level, Damascus experiences a semi-arid climate because of the rain shadow effect. The Barada River flows through Damascus.

Many sites proposed now for new projects in Damascus. The chosen one for this project is a site has area equal to 1900 square meter which it can fit for many repetitive residential buildings. The site is located in the eastern part of the city in Victoria Bridge area, Shoukry Al-Qouwatly street (old Beirut road) which it is one of the most important residential commercial area in the capital city.

In the lower figures shows that the site has very importance location, it can be an approach for the visitors of the city specially those they are going to Downtown of the city. The context of the city has strong respect to the old city, which it is the creation part of the modern areas. this must be considered in the design process of the project.

Figure: Map of Damascus city shows the location of the site

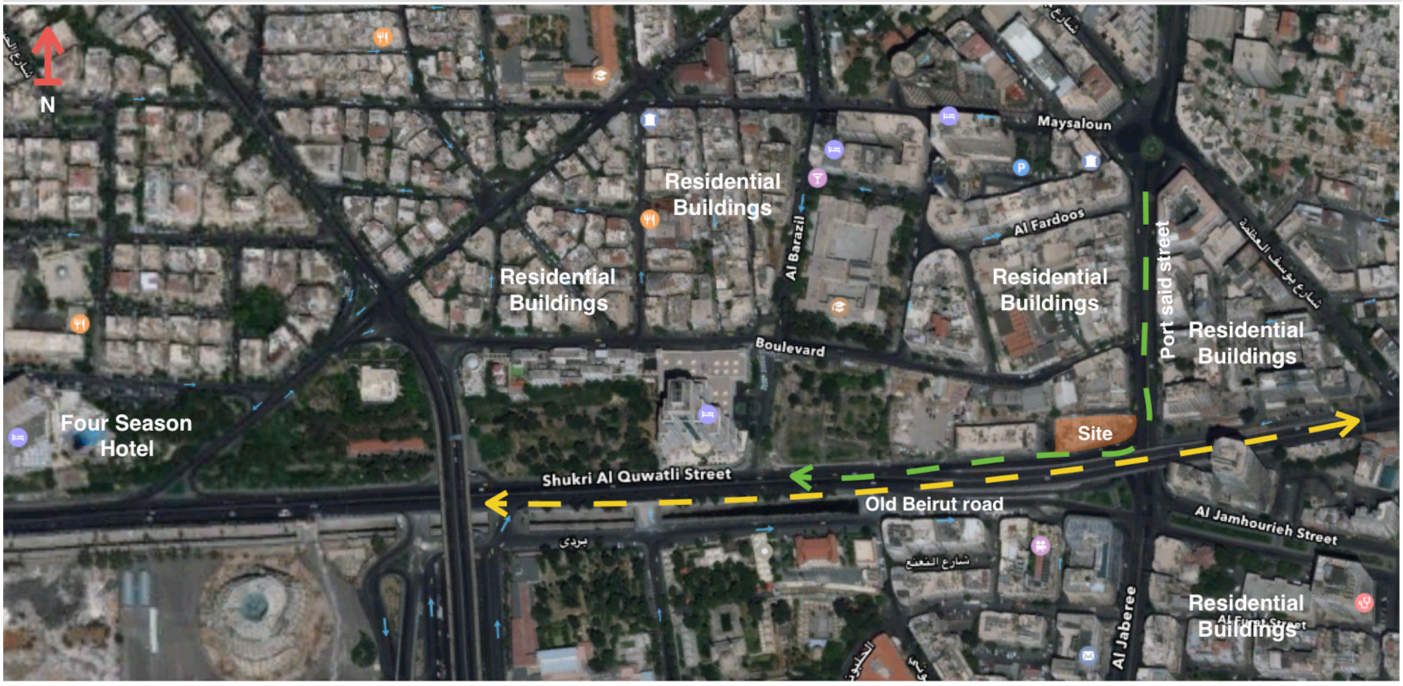


Figure: Map of Damascus city shows the location of the site

Figure: The location of the site

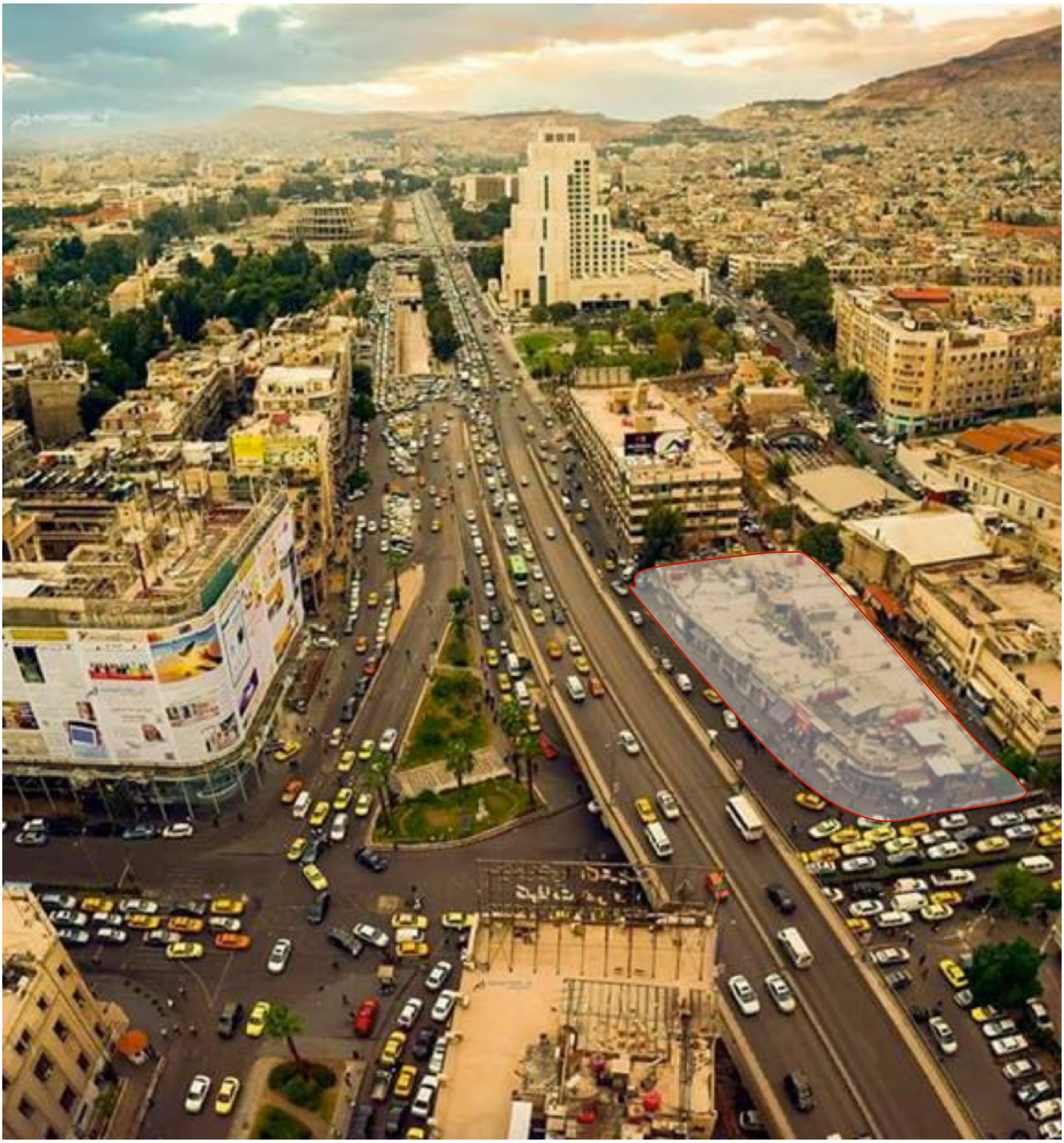


Figure: The existing building

The surrounding zones of the site has residential fiction while the some commercial spaces is included with some buildings in the area. The site is located in the corner of cross of two streets, old Beirut road and Port Said. It can be useful to have a good view.

The context of the area can be explained by the lower figure, most of the building used the concrete as structure system. The envelopes are simply designed by opaque walls mixed with aluminum windows.

CONDITION OF CONSTRUCTION AND SPECIFICATIONS FOR THE SPACES

The chosen site is located in Zone L as Damascus Governorate decided which means the residential building can has commercial spaces in its basement and ground floor. More constraints for the buildings noted here:

- 150-1: The minimum area of the building shall not be less than 200 m2.
- 150-2: The lowest distance from the public property 8 m and can be used as green areas or parking.
- 150-3/4: It is allowed to built 2 basement, one for commercial use and the second one as services zone for the owner of the properties. The heights shall be determined as follows:

- 0.2 m roof of the commercial basement
- 3.75 m commercial ground height
- 3.25 m for the others floors

- 150-5: The height of the building may be twenty-five meters for the gates directly on the roads which are 25 m / s or more or on the squares, provided that these buildings and adjacent buildings are in harmony.
- 150-6: In this area it is necessary to make the first basement and ground floor exclusively commercial and leave the option for the owner to use the rest of the floors for residential or commercial purposes, and can't combine commercial and residential on the same floor. All the conditions of the commercial zone shall apply to this area even when licensed locally (Elevator - parking)

Other constraint related to the number of parking (one for each apartment), and the lighting hole of the bathrooms minimum dimension.

BUILDING ENERGY PERFORMANCES CONSTRAINTS

Other type of constraint is related to the energy performance of the building where NERC provide a code for the insulation and energy performances.

The code aims to:

- Reduce energy consumption used for heating and air conditioning.
- Reducing heat loss. .
- Reduce the cost of establishment and maintenance of heating and air-conditioning systems.
- To ensure the conditions of the heat and health of the occupants of construction throughout the seasons.
- Avoid condensation or reduce the internal surfaces of the building in the cold areas. Use heating and avoid the damage caused by it.
- Reduce the cost of periodic maintenance resulting from thermal stresses of buildings.
- Extending investment life for construction.

Design requirements:

In the table below, it shows the maximum allowable thermal transmission for each part of the building as the code required.

Element	U-value (W/m2.K)
Roofs	0.5
External wall	0.8
Slab in contact to the soil	1
Slabs between the floors	1
Windows when Area of windows < 0.2 Area of facade	5.2
Windows when Area of windows > 0.2 Area of facade	3.5

The code is suggestion some type of stratigraphy to be used as the reference.

ARCHITECTURAL DESIGN

After the part of the project description and the data collection about the site which they are the starting point of the creating the architectural design of the building and planning the master plan of the site to be connected to its context. The procedure to get the correct powerful design is to follow the process of designing new architectural project

SITE ANALYSIS

The starting point of the design is from the existing site and the surrounding context. To have an integrated building with the context, it is useful to study the height of the surrounding building and its envelope in proper way. The circulation of the transportation is important too, as the site located in a corner of cross streets.

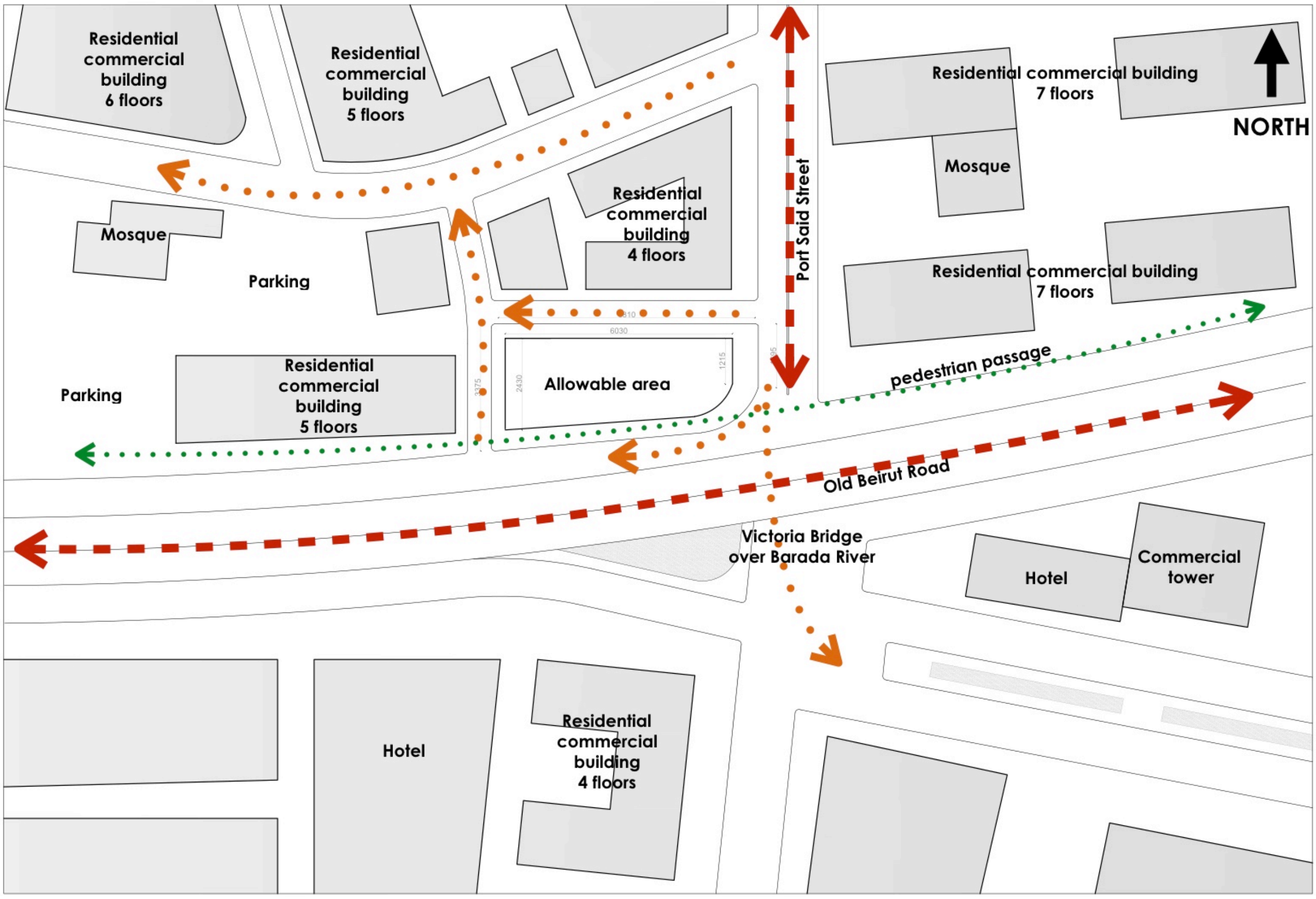


Figure: Site Analysis

The building area is shown considering the constraints of the area, taking into account the harmony of the surrounding buildings. two main streets and two secondary surrounding the site where they can give a clear idea about the entrance of the commercial spaces and the residential one. To achieve the constraints of the height, the site is divided into two part, the part on port said street can be 4 floors plus the basement and the ground floors while the other part will take the constant of old Beirut road where it can has height until 25 m.

The city of Damascus, is located in the moist-temperate area of the earth, according to the Koppen-Geiger classification it belongs to the subgroup BSk. This means that the weather is influenced by the local steppe climate with little rainfall during the year and cold winter with a yearly mean temperature of about 18°C.

As it is possible to see from the graph below the monthly average temperature is about 26°C during the summer period while during the coldest months it can reaches also value lower than 0°C.

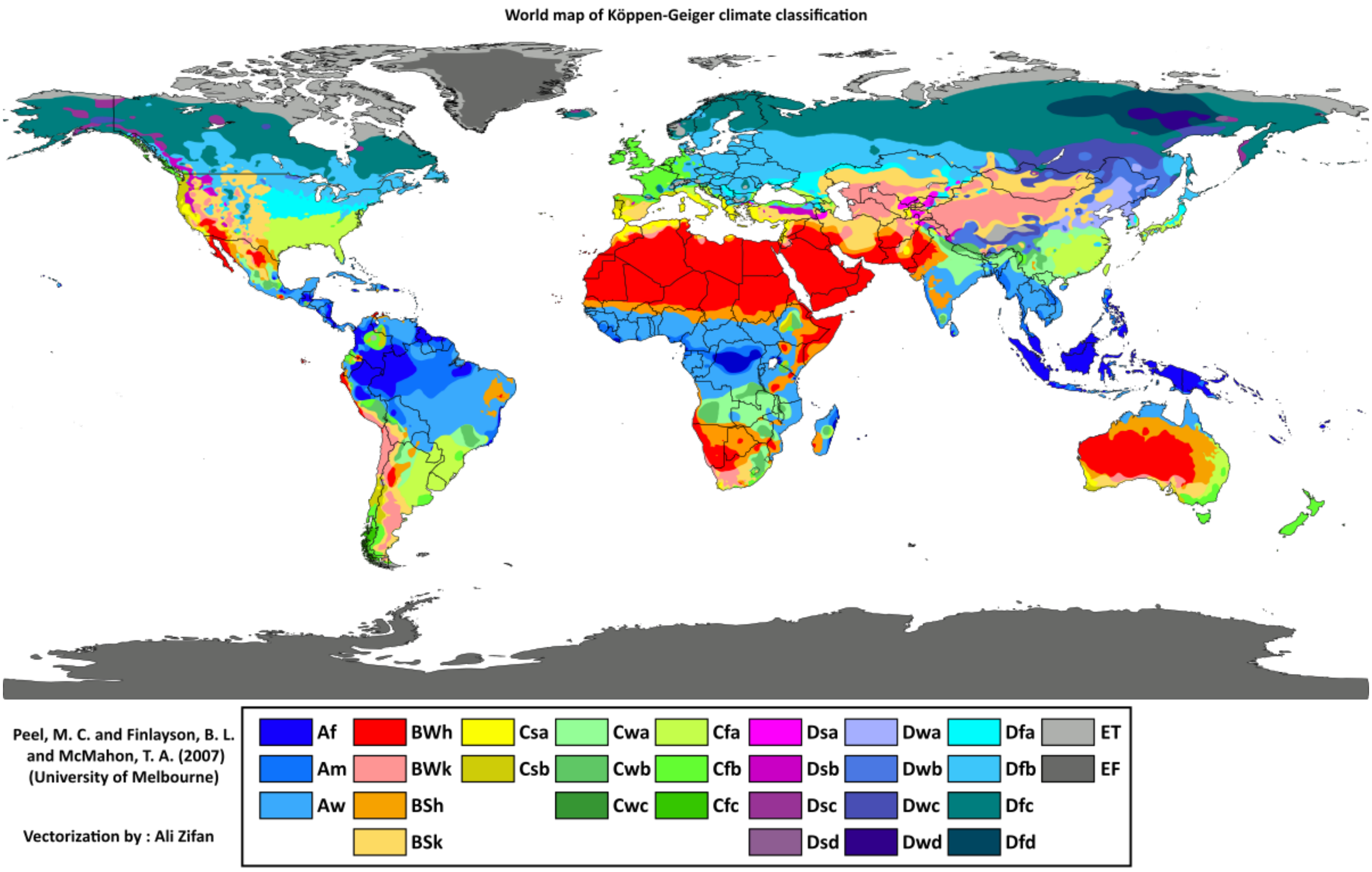


Figure: World map of koppen-Geiger climate classification

In the lowergraph it is clearly understandable that cooling and heating system is needed to keep the internal zone in comfort zone range, the out door temperature will influence the internal one where it has a strong difference specially in winter season. As it can be seen the hourly dry bulb temperature for all the year with the light blue colour, the minimum temperature in the winter months arrive until -7 C while the maximum in June as summer season until 43 C and has a daily fluctuating trend due to the change of temperature during day and night hours. As a monthly average (blue line), the temperature ranging between 7 C and 26 C.

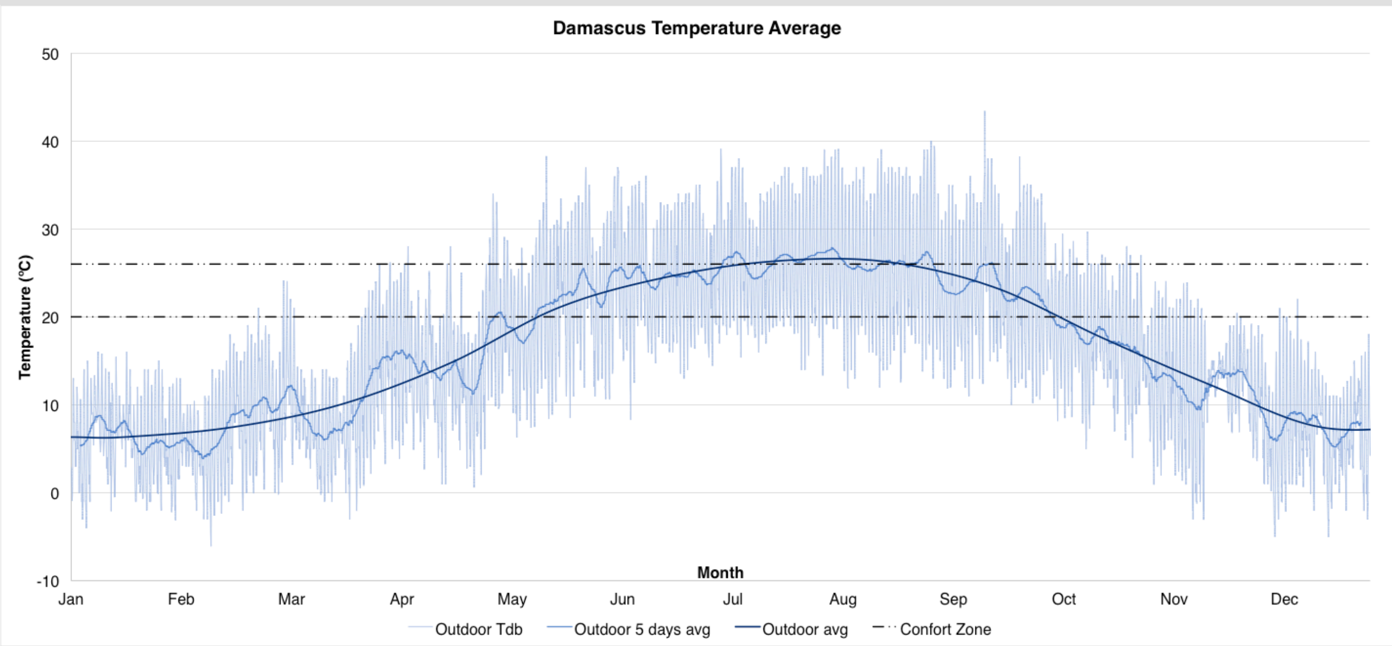
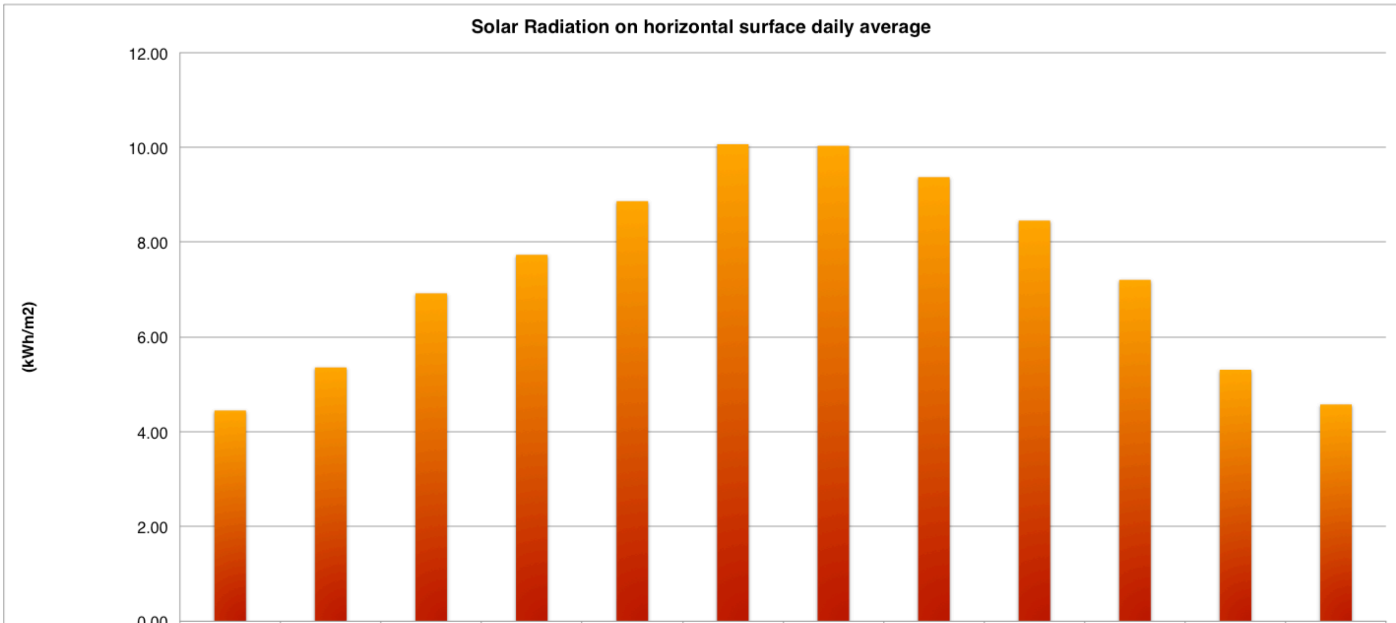


Chart: The monthly and hourly average temperature of Damascus



	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily avg (kWh/m2)	4.45	5.35	6.92	7.73	8.86	10.06	10.03	9.37	8.45	7.20	5.30	4.57

Month

Chart: The daily average solar radiation on horizontal surface

The total amount solar radiation on the horizontal surface is shown on the upper graph. It is clearly visible that the maximum values of irradiation are recorded in the summer months while the lower amounts in winter.

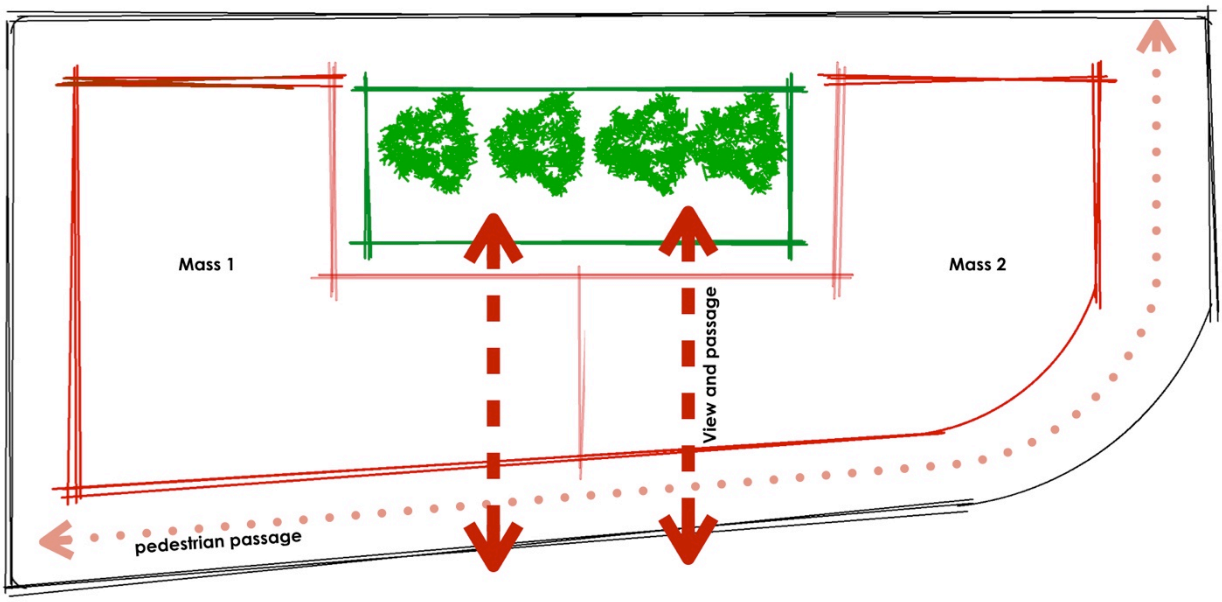
BUILDING DESIGN CONCEPT

To describe the houses in the culture of Damascus , the first thing that comes to mind is the traditional Damascus house. a harmony between human and nature. The building of old Damascus houses is a kind of specialized houses for the people of Damascus. The house consists of colored stone, in addition to the heavily decorated wood, the large courtyard and the fountain in the center of the house. This type of Damascus architecture began in in 1036 AD.

The summary of space elements of those houses consist an entrance to large courtyard and different functional zone distributed around it. A piece of paradise as described by the architects of the heritage, a heavenly space surrounded by a large sea of fountains, based on a stone column and the scattered with jasmine and lemon and citric fruits and greenery spread throughout the place. Here in this space the people can be connecting to the nature.

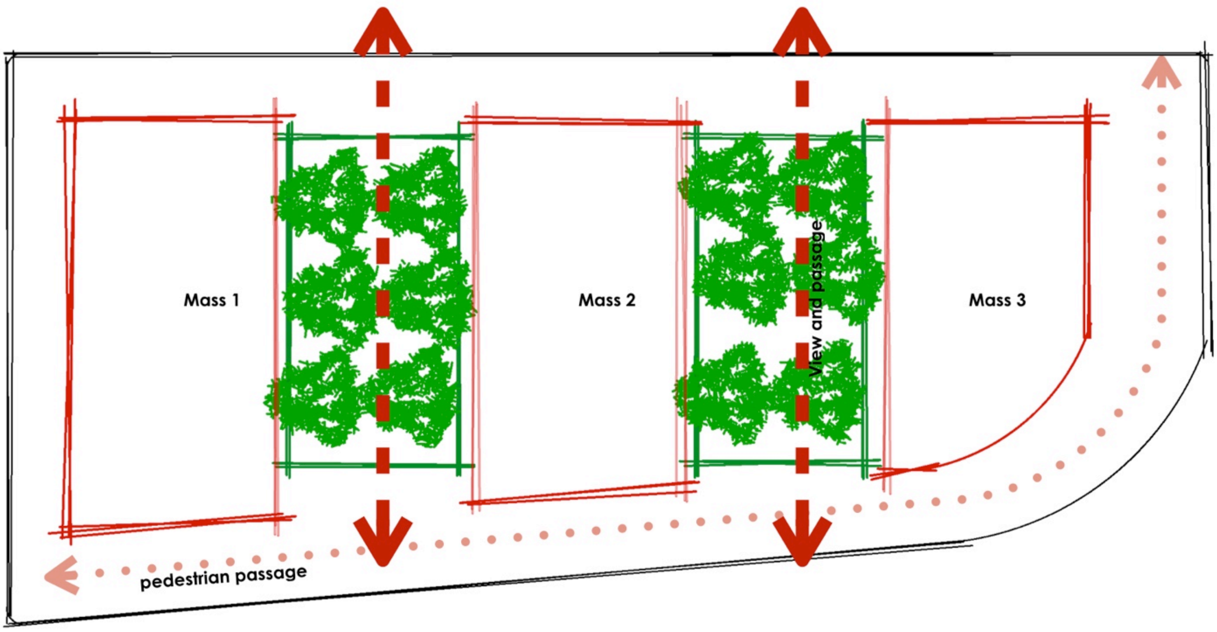
From this point of view; the courtyard that is the most important element in the Damascus housing culture, the concept of the building can be taken to integrate the culture of the city with the modern building.

Figures: Courtyard of Damascus house



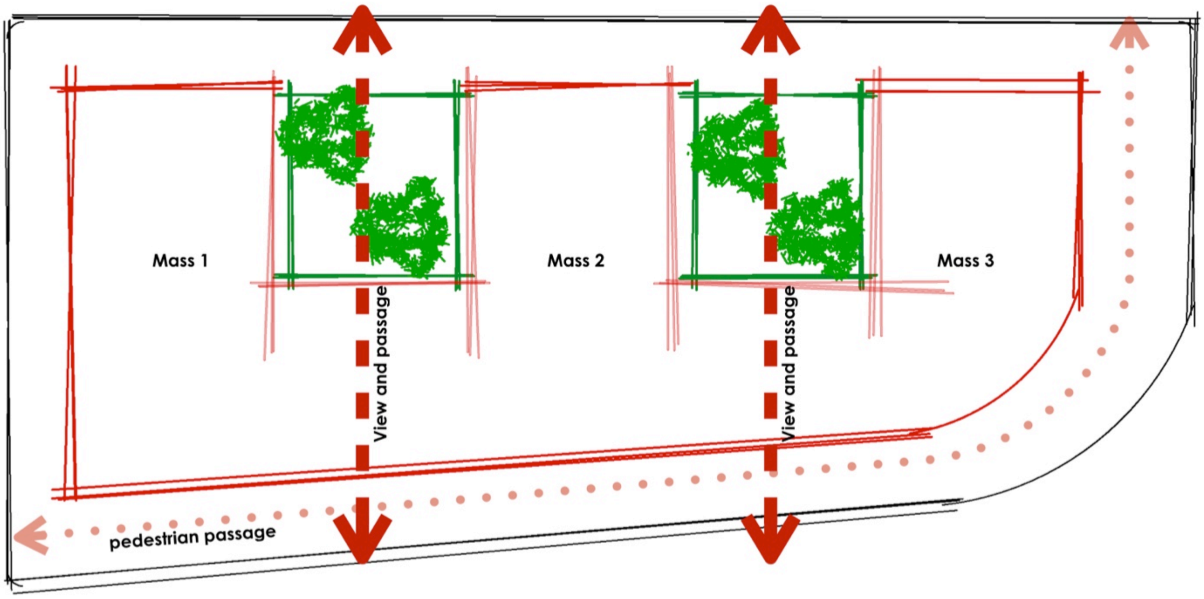
Figures: sketch explain the first stage of the concept

The first idea was to have a centralized courtyard divided the allowable built area to two parts with saving the same path of pedestrians that suitable with the other buildings of the context. Middle passage can make a view for the courtyard, which allow to have some commercial spaces in the other side of the building as the existing building has.



Figures: sketch explain the second stage of the concept

Same ideas of the first stage with having more spaces for the residential area by adding another mass of building in the middle and dividing the courtyard into two parts



Figures: sketch explain the third stage of the concept

To have continuous line with the street, it can be useful to complete the residential floors while the ground floor will have the same passage and view inward the building. In this way there is more space for fitting more apartments as its needed while the same criteria will be followed in the ground floor.

To achieve the needs of the project, another concept has been taken from the area of the site. the history of the area says that this area was a bridge linking the residential zone with the active commercial zone in the past by a steel bridge over Barada river. The conceptual zoning of the project is to have a commercial spaces in the ground and under ground levels, so by recalling the bridge to have sufficient external zones in the underground level, also providing a pedestrian ways for the ground level spaces.

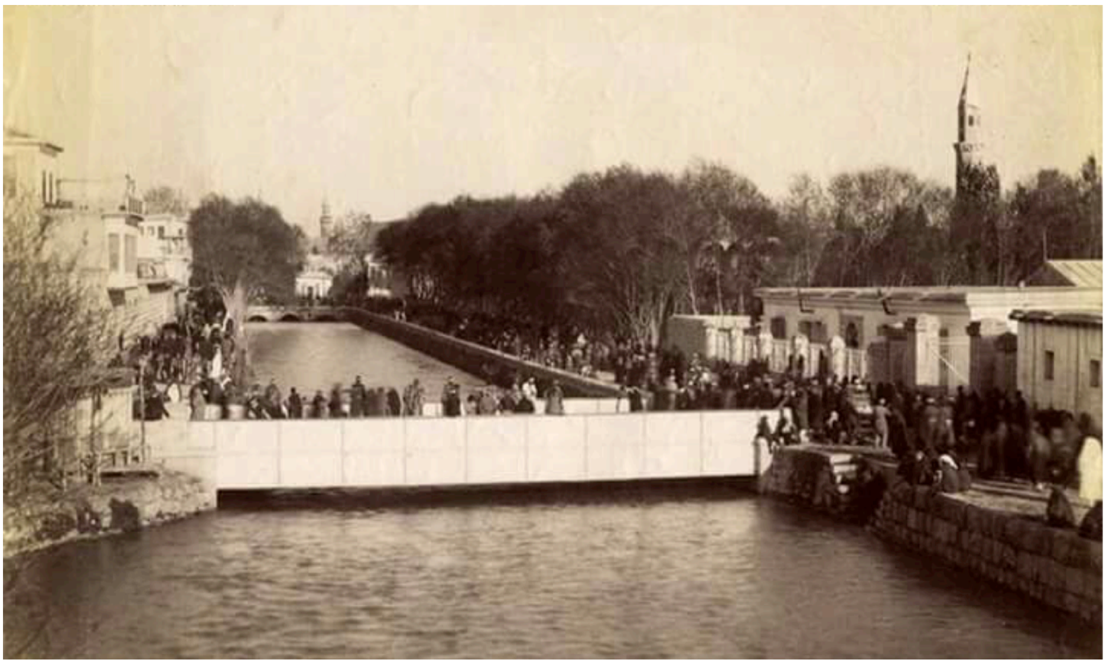
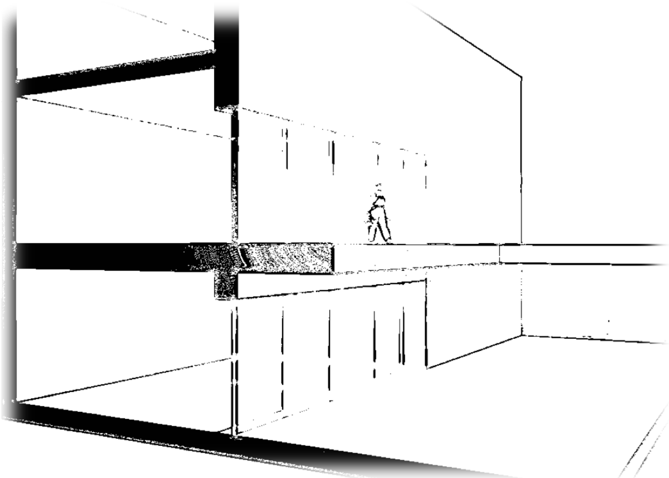


figure:Victoria Bridge - 1898

From this point, the concept gave the project an idea to divide the site into two parts by a bridge linking the 2 side of it. Then choosing the correct zone for each main element can do the zoning of the spaces.

The bridge definition is A bridge is a structure built to span physical obstacles without closing the way underneath such as a body of water, valley, or road, for the purpose of providing passage over the obstacle. In the case of this project the propose of the bridge is to let people, natural light and air to pass under it and also used as horizontal connection for the pedestrians over it. That's will allow for the underground to be useful spaces as commercials zones connection and green areas.

By thinking in a way to use the basement of the built area as livable spaces, the bridges can allow for the design to have some holes in the ground floor to allow for the daylight and natural air to pass to the underground levels. The using of the bridges used as horizontal connection for the people to pass through the site to the shopping stores.



CASE STUDIES

The next step after defining the concept is to have some case studies for the typical apartments in Damascus, which it can explain the way of how the people used to live in their houses in that place. The chosen cases provided by Tamleek company, A real estate and tourist investment company, innovation, implementation and management of real estate investment projects and tourist projects.

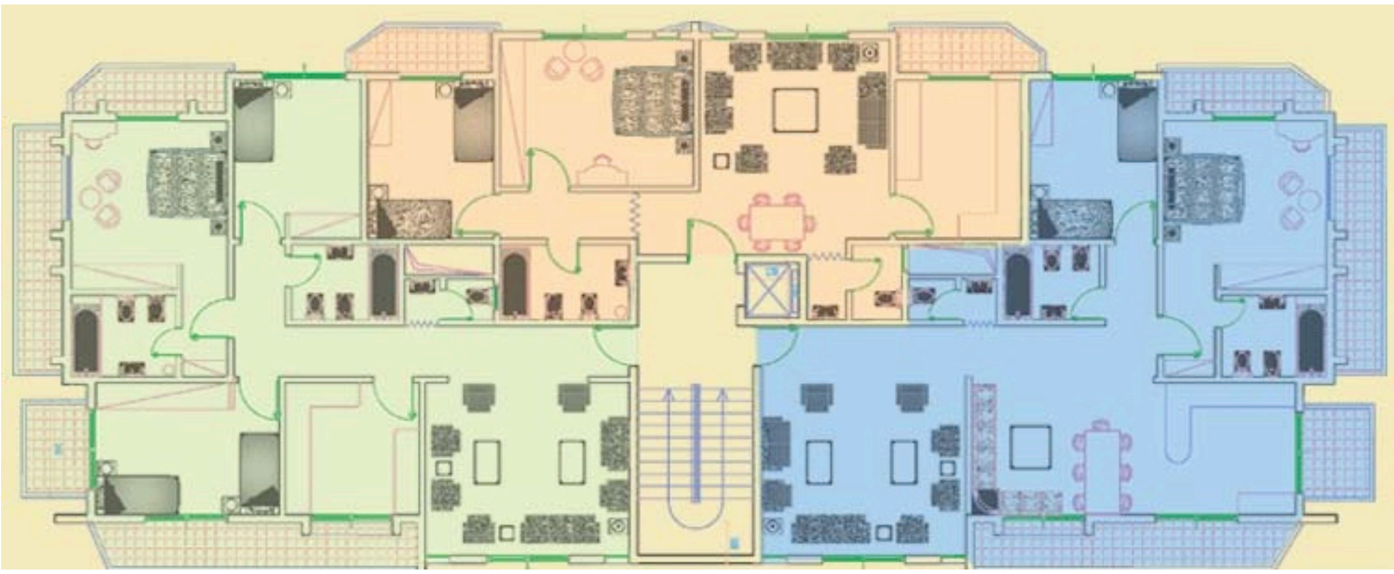


Figure: Residential Building in Damascus

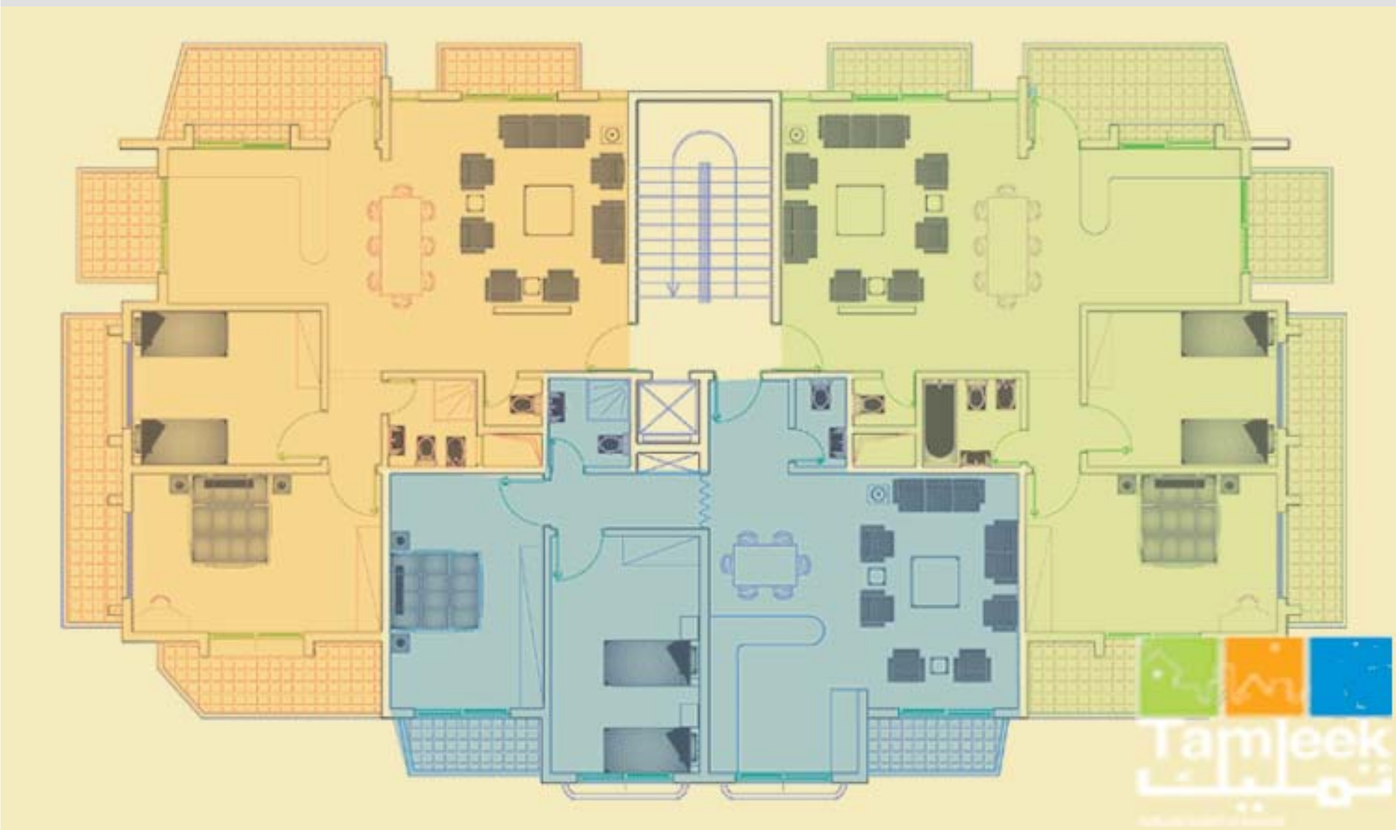


Figure: Residential Building in Damascus

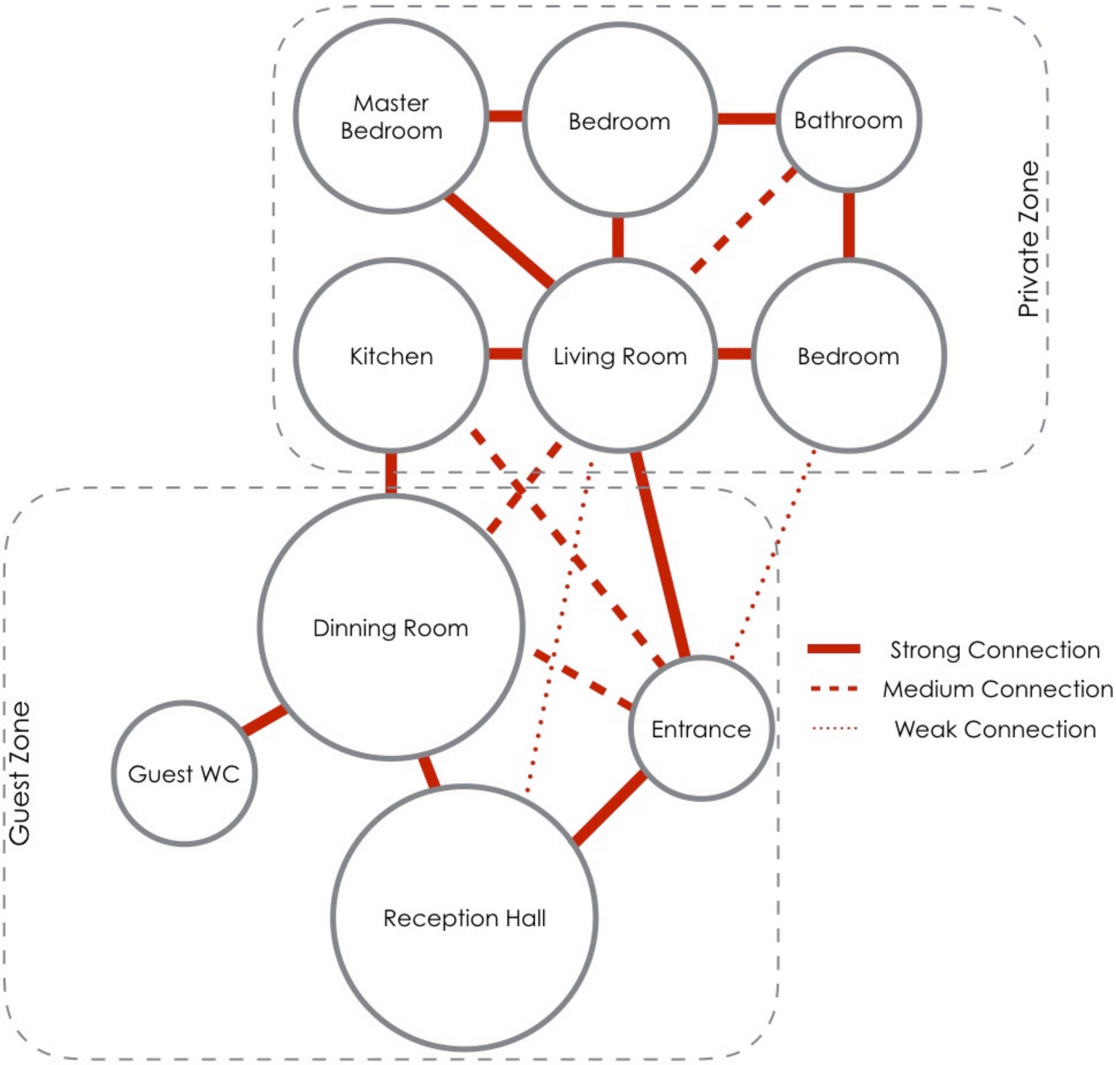
The upper plans are for two different repetitive buildings in western part of Damascus for a project under construction. Each floor consist 3 simple apartments of 2 or 3 bedrooms in addition to the daily activities spaces such as living rooms and kitchens.

Figures: perspective of the two examples plans

BUBBLE DIAGRAM

Bubble diagrams In architecture and interior design are used for arrangement and placement, too, with a focus on a list and relationships. By definition, the bubble diagram is a freehand diagrammatic drawing made by architects and interior designers to be used for space planning and organization at the preliminary phase of the design process. The bubble diagram is important because later phases of the design process are based on them.

Bubble Diagram for typical residential apartments



By dividing the aparment into two parts,one as private zone related to residents consists the bedrooms and living space, while the other is related to the guests.

SCHEMATIC DESIGN

The next three pages, they show the plans of the architectural design for the typical floor, ground and underground floors. The typical floor include three apartments type while the ground floor divided for many commercial spaces and the underground has two separated part, parcking for the building and commertial spaces.

Ground Floor Plan – Use Of Spaces

Scale: 1:200

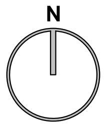
Bloc 1:
- Apartment with 3 bedrooms (154 m2).
- Apartment with 2 bedrooms (123 m2).
- Apartment with 1 bedroom (77 m2).
- Staircase (36.7 m2).

Bloc 2:
- Apartment with 3 bedrooms (154 m2).
- Apartment with 2 bedrooms (105 m2).
- Apartment with 1 bedroom (58 m2).
- Staircase (36.7 m2).

Bloc 3:
- Apartment with 2 bedrooms (104 m2).
- Apartment with 1 bedroom. (75.4 m2).
- Staircase (28 m2).

Typical Floor Plan – Use Of Spaces

Scale: 1:200



- Parking (732.7 m2).
- Building service spaces (148.4 m2).
- Retail Shop 1 (166.2 m2).
- Retail Shop 2 (21.3 m2).
- Retail Shop 3 (21.3 m2)
- Retail Shop 4 (32.6 m2)
- Staircases (44.8 m2).

Underground Floor Plan – Use Of Spaces

Scale: 1:200

INITIAL ANALYSIS BY SEFAIRA

In ordar to define the openings of the residential spaces in proper way. A technical process has been followd related to the percentage of the opening in the envelope and the u value of the opaque parts.This process can allow to have better percentage of opening and the correct dimenssions of the windows without over estimation.The process has been done by using Sefaira application.

Sefaira is a software specializing in cloud-based computing solutions for high-performance building design. This application is used to allow the designers to take the decisions as an immersive and seamless part of the design process to have sustainable energy efficient solutions.The built environment is civilization's most visible artefact. As the biggest consumer of the world's resources (including energy), it also has the most substantial impact on our interaction with Earth and its ecosystem. For this reason, creating a sustainable built environment is an important factor in creating a symbiotic interaction between human and Earth.

CONSTRUCTION STRATIGRAPHIES

different construction stratigraphies has been applied of the building with different U value in order to compare how the U value inflounce the result of the energy need in relation with the ratio between area of the window and the opaque.

The first type has high U value, this type is the common way of the building in Damascus spicially the constructions that built in 80s.

Type 1					
External Walls		**Material**	**Thickness**	**λ**	**R**
	External		[m]	[W/m K]	[m2.K/W]
	1	External plaster, Cement plaster, sand aggregate	0.02	0.42	0.048
	2	Dense aggregate block	0.15	0.85	0.176
	3	Air cavity	0.05		0.180
	4	Dense aggregate block	0.1	0.85	0.118
	5	Gypsum plaster, sand aggregate	0.02	0.42	0.048
	Internal		0.34		
		R tot	0.569	[m2.K/W]	
		U	1.756	[W/m2K]	
Roofing		**Material**	**Thickness**	**λ**	**R**
	External		[m]	[W/m K]	[m2.K/W]
	1	Stone cover	0.02	1.8	0.011
	2	Membrane	0.001	1	0.001
	3	Reinforced concrete	0.2	2.3	0.087
	4	Gypsum plaster, sand aggregate	0.02	0.42	0.048
	Internal		0.241		
		R tot	0.147	[m2.K/W]	
		U	6.817	[W/m2K]	
Flooring		**Material**	**Thickness**	**λ**	**R**
	External		[m]	[W/m K]	[m2.K/W]
	1	Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Membrane	0.001	1	0.001
	4	Reinforced concrete	0.2	2.3	0.087
	Internal		0.236		
		R tot	0.251	[m2.K/W]	
		U	3.985	[W/m2K]	

The second is recommended by NERC، National Energy Research Center, thermal insulation code for buildings in the Syrian Republic.

Type 2					
External Walls		**Material**	**Thickness**	**λ**	**R**
	External		[m]	[W/m K]	[m2.K/W]
	1	External plaster, Cement plaster, sand aggregate	0.02	0.42	0.048
	2	Dense aggregate block	0.15	0.85	0.176
	3	Mineral fiber wool	0.05	0.03	1.667
	4	Gypsum plaster, sand aggregate	0.02	0.42	0.048
	Internal		0.24		
		R tot	1.938	[m2.K/W]	
		U	0.516	[W/m2K]	
Roofing		**Material**	**Thickness**	**λ**	**R**
	External		[m]	[W/m K]	[m2.K/W]
	1	Roofing Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Membrane	0.001	1	0.001
	4	Thermal Insulation	0.05	0.03	1.667
	5	Membrane	0.001	1	0.001
	6	Light weight concrete for slope	0.05	1.4	0.036
	7	Reinforced concrete	0.2	2.3	0.087
	Internal		0.337		
		R tot	1.954	[m2.K/W]	
		U	0.512	[W/m2K]	
Flooring		**Material**	**Thickness**	**λ**	**R**
	Internal		[m]	[W/m K]	[m2.K/W]
	1	Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Membrane	0.001	1	0.001
	4	Thermal Insulation	0.05	0.03	1.667
	5	Light weight concrete for slope	0.05	1.4	0.036
	6	Reinforced concrete	0.2	2.3	0.087
	External		0.336		
		R tot	1.953	[m2.K/W]	
		U	0.512	[W/m2K]	

Type 3					
External Walls		**Material**	**Thickness**	**λ**	**R**
		External	[m]	[W/m K]	[m2.K/W]
	1	Laminate compact (HPL) stone surface	0.01	0.3	0.033
	2	Air cavity	0.05		0.180
	3	Sandwich corrugated steel panel filled with polyurethane	0.1	0.023	4.348
	4	Air cavity	0.05		0.180
	5	Rigid panel of medium-low density mineral wool	0.05	0.037	1.351
	6	Plaster board integrated with aluminum vapor barrier	0.0125	0.2	0.063
	7	Plaster board of gypsum washable with paint	0.0125	0.2	0.063
		Internal	0.2725		
		R tot	6.218	[m2.K/W]	
		U	0.161	[W/m2K]	
Roofing		**Material**	**Thickness**	**λ**	**R**
		External	[m]	[W/m K]	[m2.K/W]
	1	Roofing Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Sand	0.05	0.15	0.333
	4	Membrane	0.001	1	0.001
	5	Extruded polystyrene panel	0.1	0.037	2.703
	6	Light weight concrete for slope	0.05	1.4	0.036
	7	Reinforced concrete	0.3	2.3	0.130
	8	Air cavity	0.05		0.180
	9	Gypsum Board fall ceiling	0.022	0.16	0.138
		Internal	0.236		
		R tot	3.684	[m2.K/W]	
		U	0.271	[W/m2K]	
Flooring		**Material**	**Thickness**	**λ**	**R**
		Internal	[m]	[W/m K]	[m2.K/W]
	1	Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Membrane	0.001	1	0.001
	4	Extruded polystyrene panel	0.1	0.037	2.703
	5	Light weight concrete for slope	0.05	1.4	0.036
	6	Reinforced concrete	0.2	2.3	0.087
		External	0.386		
		R tot	2.989	[m2.K/W]	
		U	0.335	[W/m2K]	

This opaque stratigraphies have been designed in such way to limit the thermal transmittance, avoiding the water vapor transfer. Ventilated façade stratigy has been used.

WINDOWS-WALL RATIO

Four different cases have been used to define the ratio between the windows area and the wall area. Some fixed parameters such as the bathrooms windows (0.7m x 0.7m), stairs windows (0.7m x 1m) and the glazing for the commertial spaces. The variable dimenssion of the residential floors ranging between three width dimenssions, 1.2m ,2.4m and 3 for each space in the apartment where those dimenssion is the common to be use for the building there.

The fourth case is considered as combination between the three types of windows where they separeted in relation to the function of the space, Kitchen (1.2m x 1.75), dining and living rooms (3m x 1.75) and for the bedrooms (2.4m x 1.75m).

		Total façade area	Residential windows	WC windows	Stair window	Commercial glazing	Total windows	total wall	Awin/Aopa
Case		[m2]	[m2]	[m2]	[m2]	[m2]	[m2]	[m2]	[%]
1	Windows 1.2 x 1.75		175.0	78.0	15.0				
	Envelope	3651.6915	367.5	41.5	9.5	445.2	863.6	2788.05	**0.31**
2	Windows 2.4 x 1.75		175.0	78.0	15.0				
	Envelope	3651.6915	735.0	41.5	9.5	445.2	1231.1	2420.55	**0.51**
3	Windows 3 x 1.75		175.0	78.0	15.0				
	Envelope	3651.6915	918.8	41.5	9.5	445.2	1414.9	2236.80	**0.63**
4	Combination windows			78.0	15.0				
	Envelope	3651.6915	707.9	41.5	9.5	445.2	1204.0	2447.70	**0.49**

SEFAIRA PLUG-IN

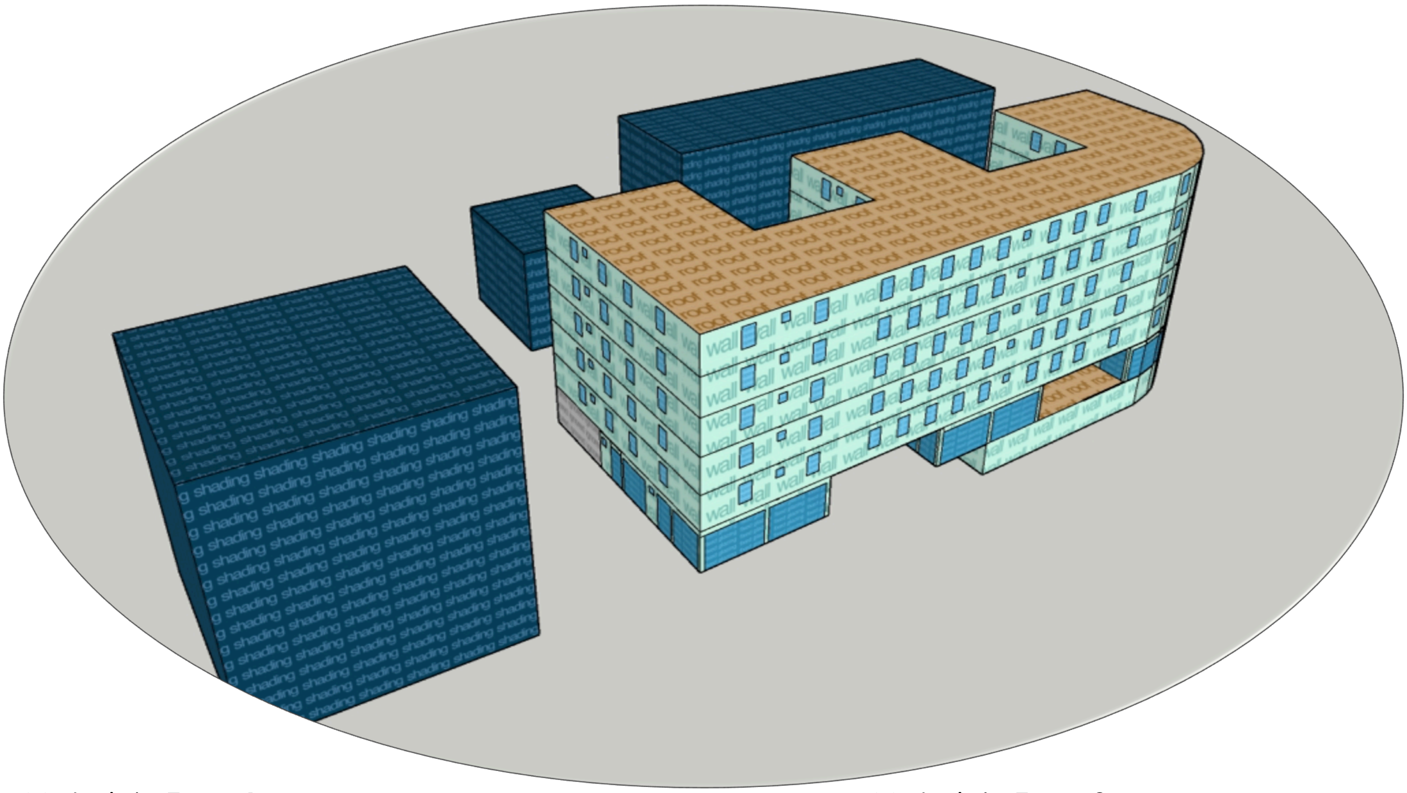
In order to start the energy analysis thanks to the plug-in Sefaira adaptable on Sketchup. Several test had been done dealing with the different wall stratigraphies and the windows/wall ratio which they have been explained in the upper part. The lower table shows the different types of analysis.

Cases			1st to 5th	all envelope
	Insulation Type	Window Dimension	Awin/Aopa [%]	Awin/Aopa
			[%]	[%]
1.1	Type 1	1.2 x 1.75	0.14	0.31
1.2	Type 2	1.2 x 1.75	0.14	0.31
1.3	Type 3	1.2 x 1.75	0.14	0.31
2.1	Type 1	2.4 x 1.75	0.30	0.51
2.2	Type 2	2.4 x 1.75	0.30	0.51
2.3	Type 3	2.4 x 1.75	0.30	0.51
3.1	Type 1	3 x 1.75	0.40	0.63
3.2	Type 2	3 x 1.75	0.40	0.63
3.3	Type 3	3 x 1.75	0.40	0.63
4.3	Type 3	Combination	0.28	0.49

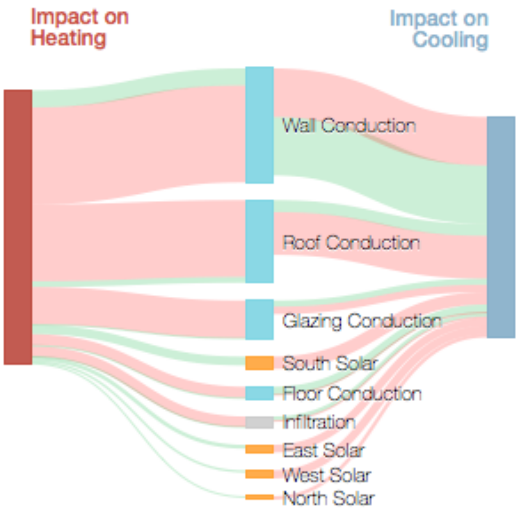
To make a comparison between all of those cases, a standard values considered as a baseline and it getted from different reference. Values refrences will be explained In the lower table.

Baseline			
	Value	Unit	Range
Wall insulation	1.75	W/m2K	Common (no insulation)
	0.51	W/m2K	Recommended by NERC
	0.16	W/m2K	Well Insulated
Floor Insulation	3.98	W/m2K	Common (no insulation)
	0.51	W/m2K	Recommended by NERC
	0.33	W/m2K	Well Insulated
Roof Insulation	6.81	W/m2K	Common (no insulation)
	0.51	W/m2K	Recommended by NERC
	0.27	W/m2K	Well Insulated
Glazing U-factor	3.03	W/m2K	2 Pane (economical choice)
Visible Light Transmittance	0.42	-	2 Pane
Solar Heat Gain Coefficient	0.25	SHGC	Reflective
Heating and cooling system	Fan Coils w/ Central Outdoor Air		
Infiltration Rate	2	m3/m2h	Best Practice
Equipment	10	W/m2K	Standard
Lighting	12	W/m2K	Standard

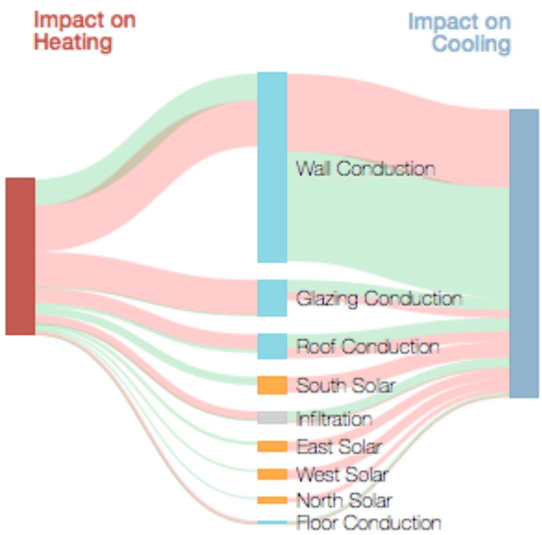
Case 1: Windows 1.2m x 1.75m



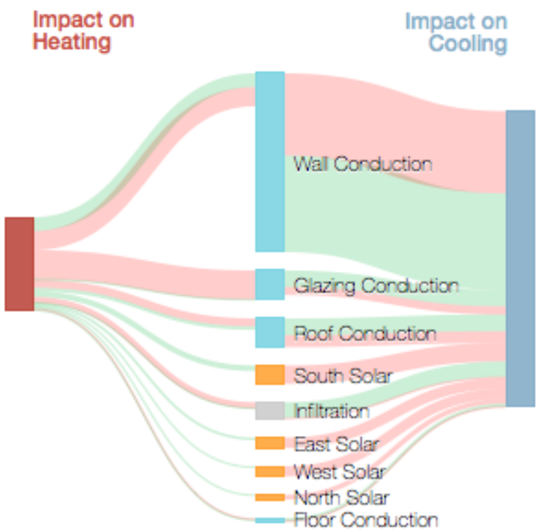
Materials: Type 1



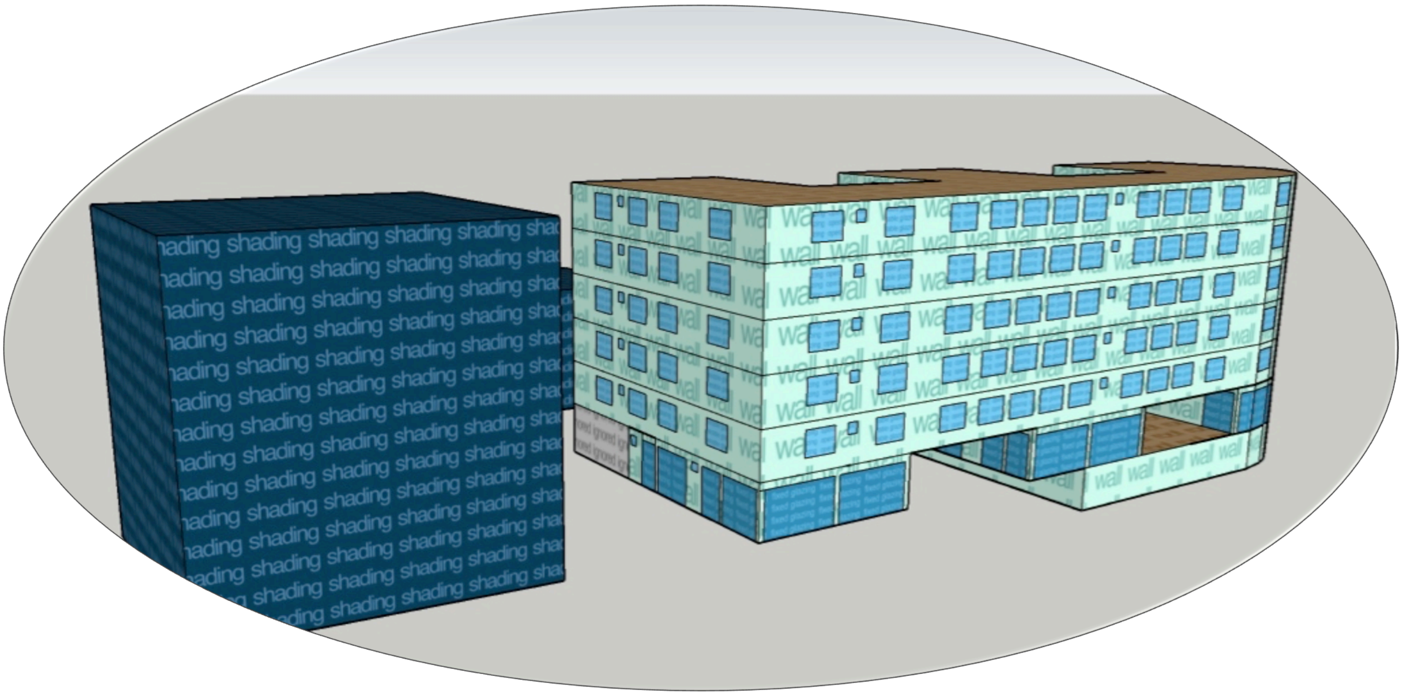
Materials: Type 2



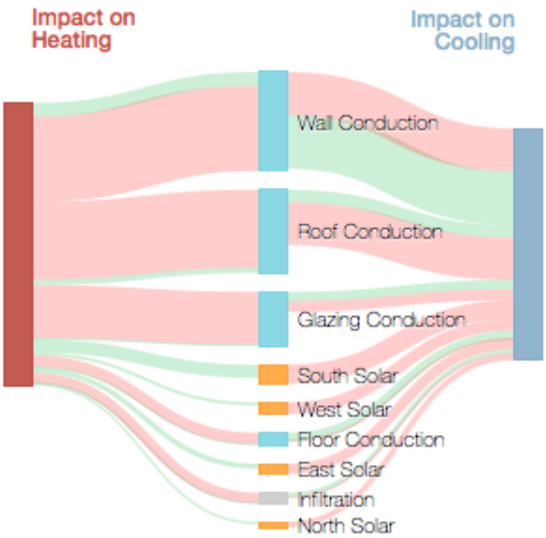
Materials: Type 3



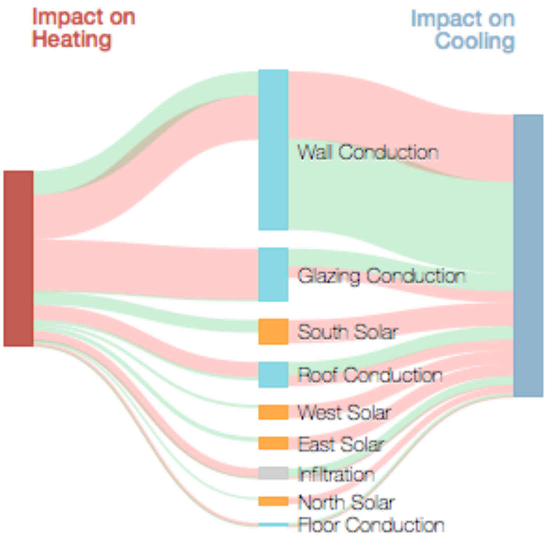
Case 2: Windows 2.4m x 1.75m



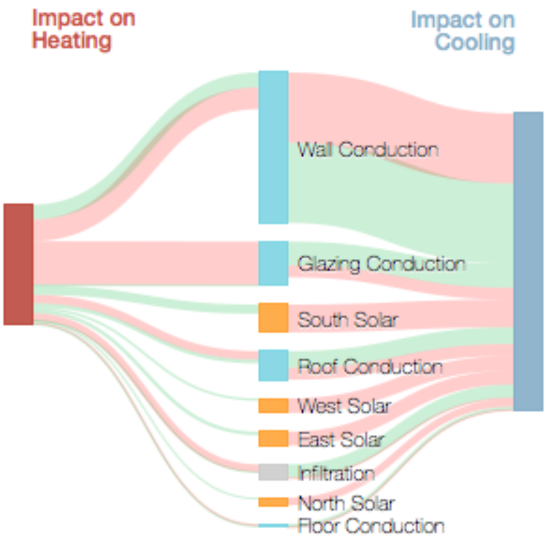
Materials: Type 1



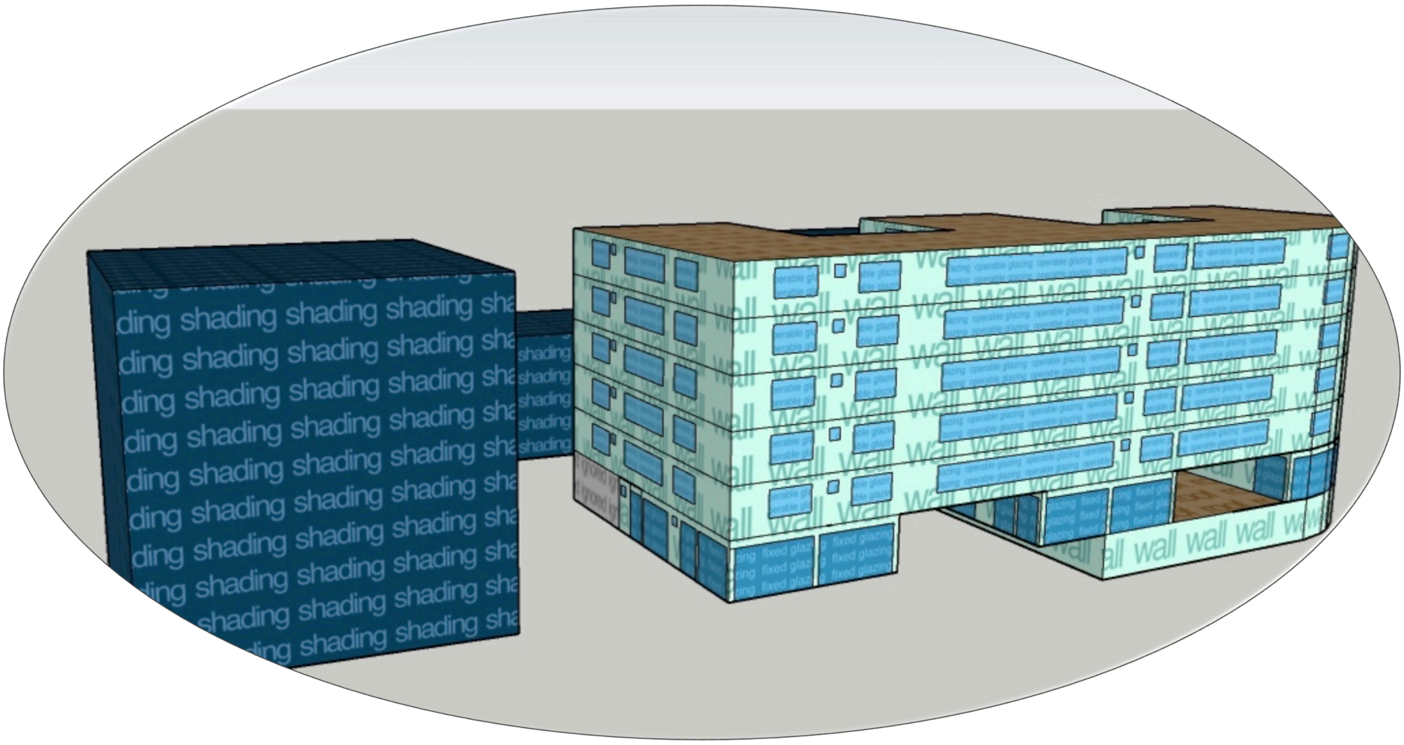
Materials: Type 2



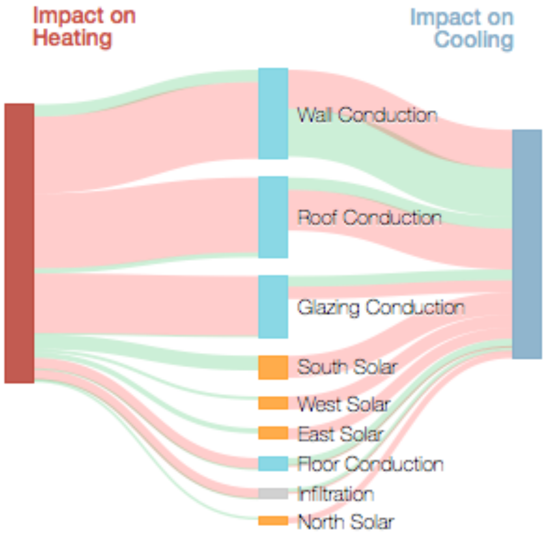
Materials: Type 3



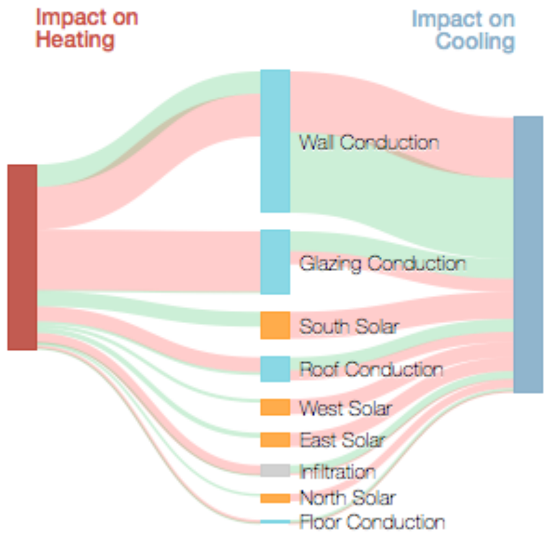
Case 3: Windows 3m x 1.75m



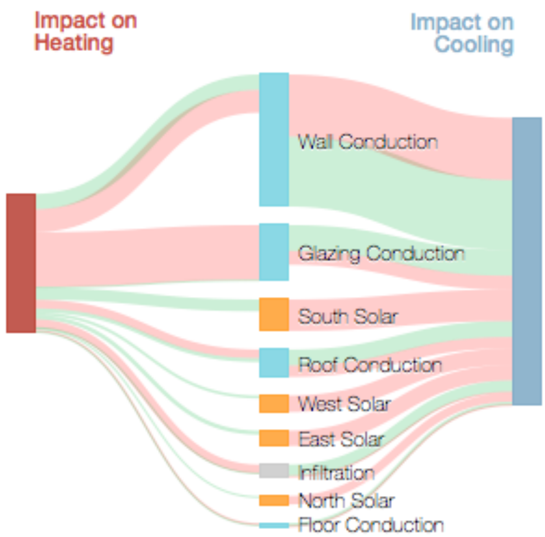
Materials: Type 1



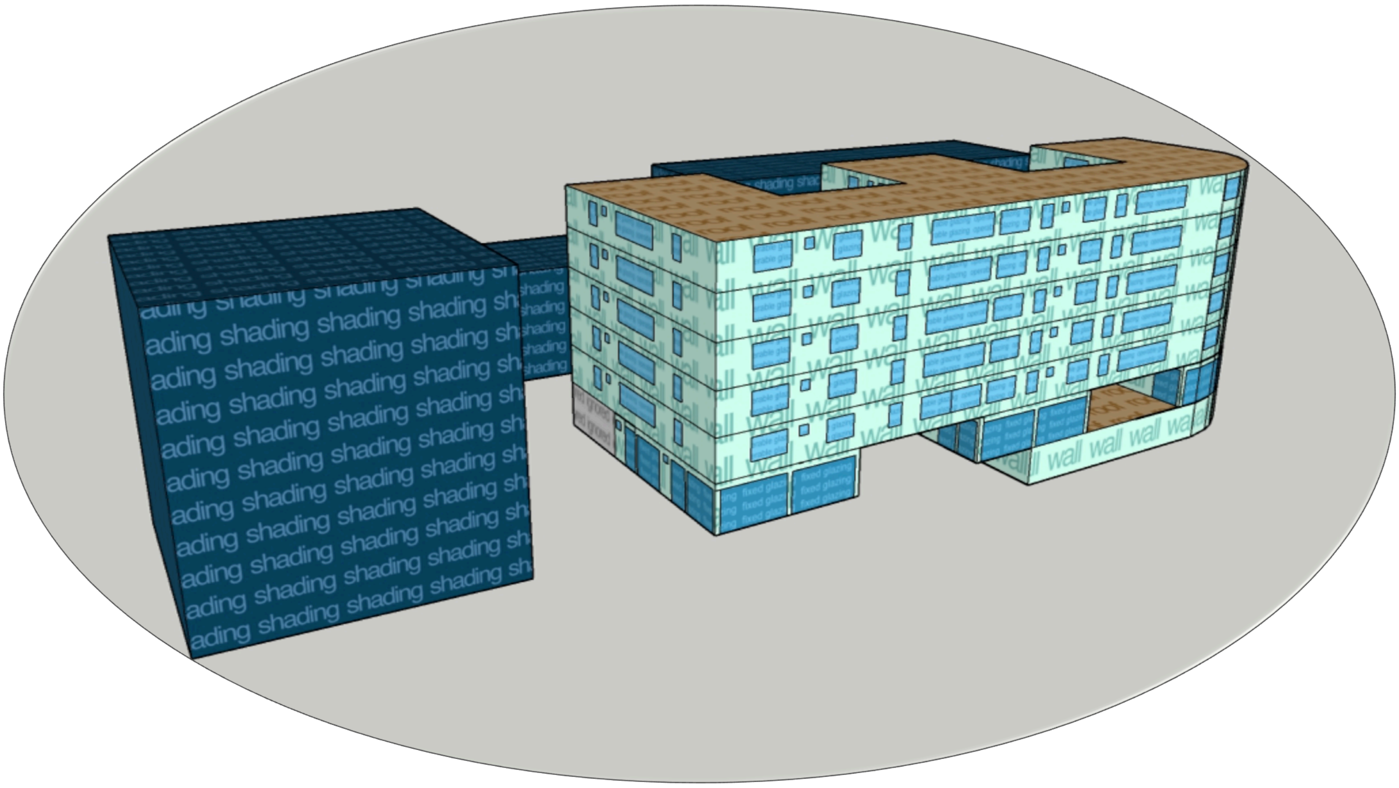
Materials: Type 2



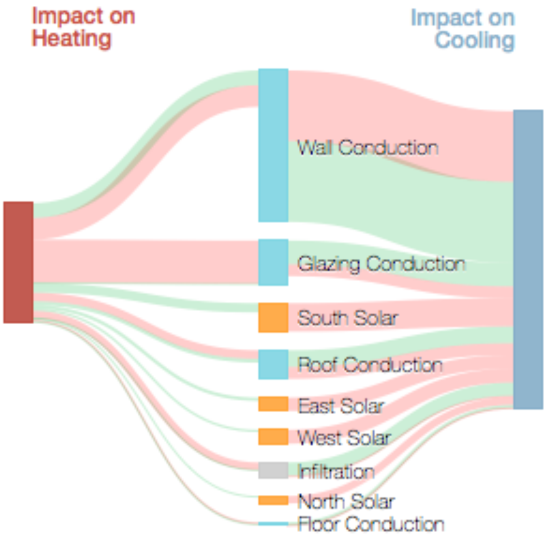
Materials: Type 3



Case 4: Windows depends on the space



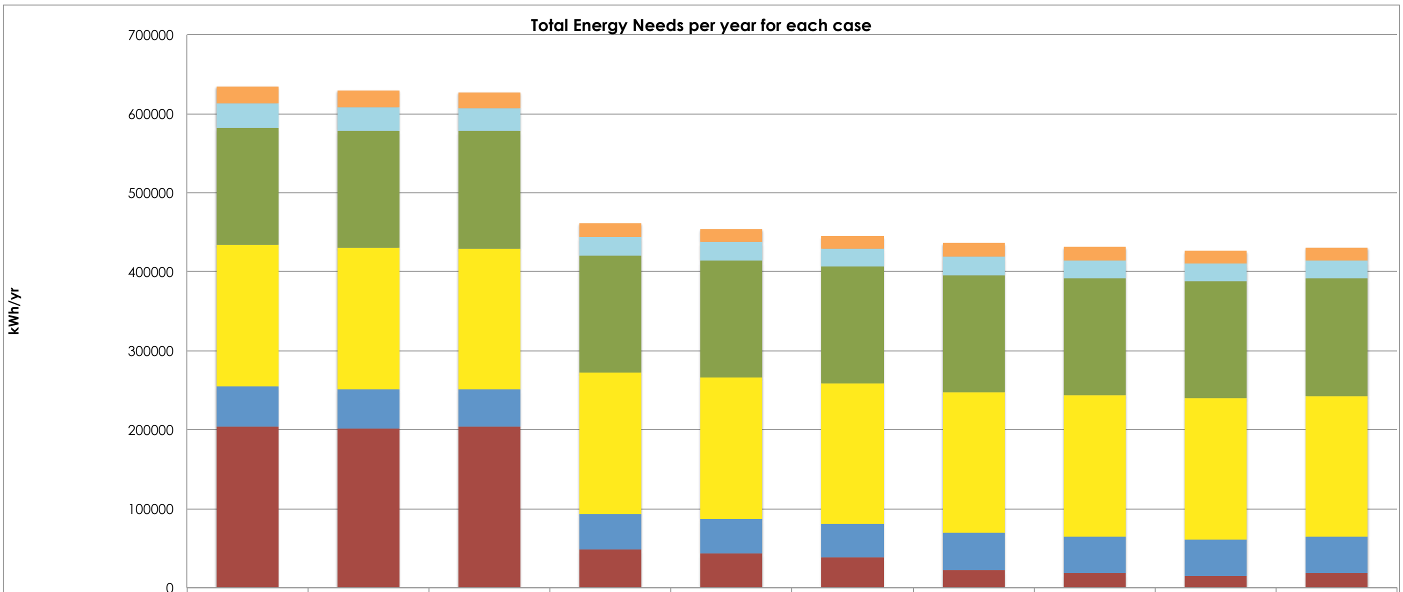
Materials: Type 3



As the analysis shows, The lower U value able to decrease the impact on heating while it assess to increase the impact on cooling in low percentage. By these result it will be useful to think how to decrease the amount of gain for cooling.

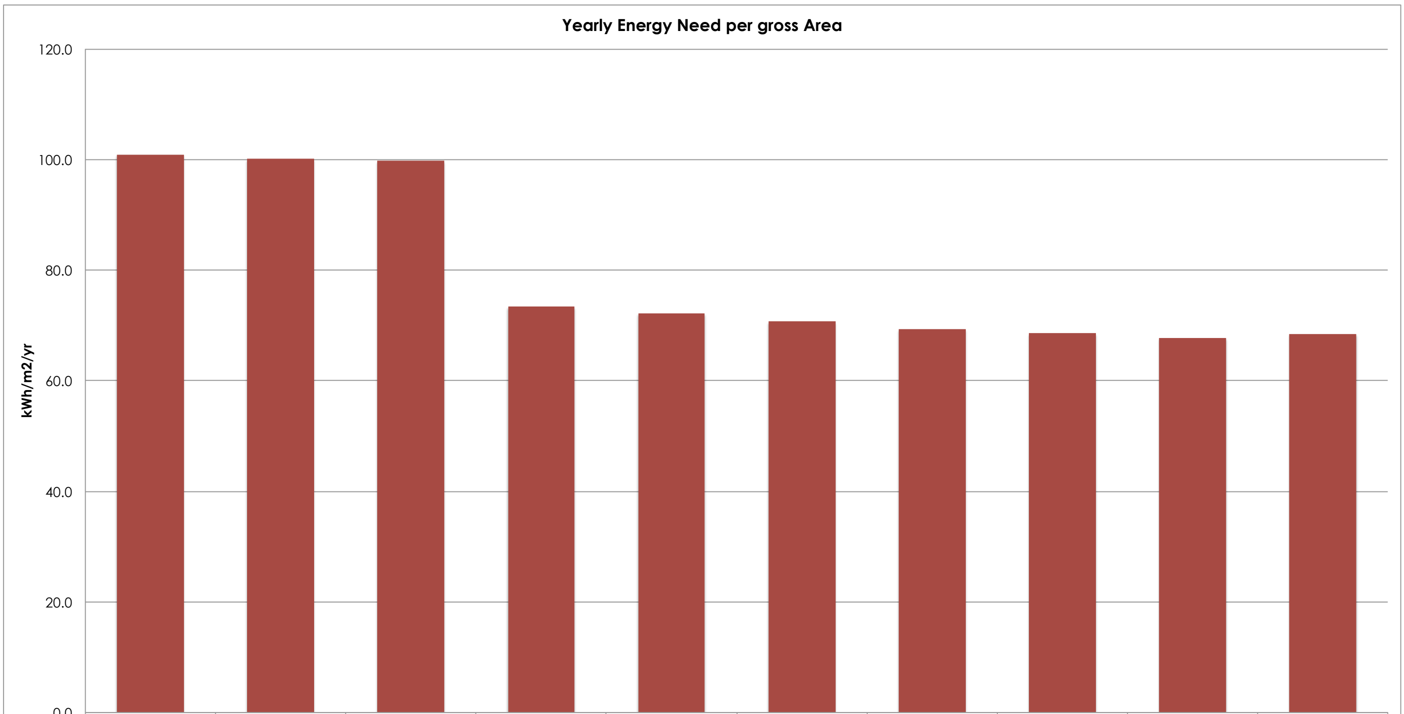
The next step is to show the final result of all the cases and compare between them.

For more understanding the result of all cases, it will be useful to compare all the cases from the point of view of total energy need and the amout of energy needs for cooling and heating.



	3.1	2.1	1.1	3.2	2.2	1.2	3.3	2.3	1.3	4.3
Pump	21386	20853	19965	17418	16750	15492	17205	16758	15920	16694
Fans	30863	30278	29493	23630	22974	21997	23063	22668	22215	22625
Equipments	148612	148612	148612	148612	148612	148612	148612	148612	148612	148612
Lighting Energy need	178335	178335	178335	178335	178335	178335	178335	178335	178335	178335
cooling Energy need	51145	49539	46735	45606	44229	41768	47252	46653	46058	46550
Heating energy needs	204339	201990	204208	48078	43243	38523	21729	18182	15037	18014

Chart: Total Energy Needs per year for each case (kWh/yr)



	3.1	2.1	1.1	3.2	2.2	1.2	3.3	2.3	1.3	4.3
Total	100.9	100.1	99.7	73.4	72.2	70.7	69.3	68.5	67.7	68.5

Chart: Yearly Energy Needs per gross area (6291 m2)

As the upper charts show, The lower U value of the construction element able to decrease the amount of energy consuption. Also lower Awindows/Awalls starting from 1.2 m width of the window (case 1.3) has better result then the other. In order to have clear idea about the result, an analysis have been done by Sefaira Webapp.

Sefaira Web App is an application allow the designers the ability to initiate any number of analysis runs in the Sefaira web application, and obtain the results of all analyses whenever and wherever you log in next. The browser window does not need to be open after the runs have been started. This means that you can analyze very large models as well.
By choosing the best four cases which they analyzed in previous part of this chapter, assign an additional parameters as schedules of occupancy for the floors and the correct values of ventilation, then compare between the result between all of them to get the best choice.

- Internal Gains:

  The first step is by define the internal gain for each floor depends on the use of it. Stating from the residential floors which they have there apartments of three bedrooms so the occupancy of each will be six peaple in addition to 10% for the others as guests and so on. For the shops spaces they have a fixed and variable occupancy, both considered depends on meter squer and the function of the zone.

  The consideretion of the lighing and equipment has been taken from references related to the gains of the residential buildings.

Zone		Area	Occupancy	Area for person	Total Gain	load/m2	Lighting	Equipment	Additional
		[m2]	[People]	[m2/person]	[W]	[W/m2]	[W/m2]	[W/m2]	[W/m2]
Typical floor		1032	165	6.25	16500	15.99	10	10	20
Ground floor	**Part 1**	143	20	7.15	2000	13.99	12	-	-
	Part 2	273	40	6.83	4000	14.65	12	10	20
	Part 3	228	30	7.60	3000	13.16	12	-	-
Heated basement		489	40	12.23	4000	8.18	12	-	-

- Ventilation:

  Regarding the ventilation, it has to be taken into account the Indoor Air Quality which refers to the minimum values for a correct ventilation to assure the health of the occupants. In the primary case, the minimum values will be used, and then it will be change in the part of optimizing taking into account the minimum values of the standard. The Indoor Air Quality minimum values has been taken from the standard ASHRAE 62.1-2013.

Ventilation		People outdoor air rate	Area outdoor air rate	Infiltration
		[L/s. person]	[L/s.m2]	[m3/m2h]
Typical floor		3	0.3	2
Ground floor	**Part 1**	5	0.3	2
	Part 2	5	0.3	2
	Part 3	5	0.3	2
Heated basement		5	0.3	2

- Schedules:

  Two types of schedules will be considered,one related to the residential and the other for the commercial for both occopancy and the heating cooling systems. The choosen percentage related to life of the residences in the building and the market crowding

Schedules	**00:00-07:00**	**07:00-08:00**	**08:00-09:00**	**09:00-10:00**	**10:00-11:00**	**11:00-12:00**	**12:00-13:00**	**13:00-14:00**	**14:00-15:00**	**15:00-16:00**	**16:00-17:00**	**17:00-18:00**	**18:00-19:00**	**19:00-20:00**	**20:00-21:00**	**21:00-22:00**	**22:00-23:00**	**24:00-00:00**
Residential	100%	50%							80%						100%			
Commercial	0%	70%					30%			70%		100%				30%		0%

The other parameters kept as the previous part.

Recalling the cases which they will be analysed in Sefaira Web-app:

Cases			**1st to 5th**	**all envelope**
	Insulation Type	Window Dimension	Awin/Aopa [%]	Awin/Aopa
			[%]	[%]
1.3	Type 3	1.2 x 1.75	0.14	**0.31**
2.3	Type 3	2.4 x 1.75	0.30	**0.51**
3.3	Type 3	3 x 1.75	0.40	**0.63**
4.3	Type 3	Combination	0.28	**0.49**

The result increased comparing it with Sefaira Plug-in, that's due to the occupancy internal load and the schedules of the occupancy and the system of heating and cooling. For mor understanding the situation, stating from the monthly energy needs can show accurate result.

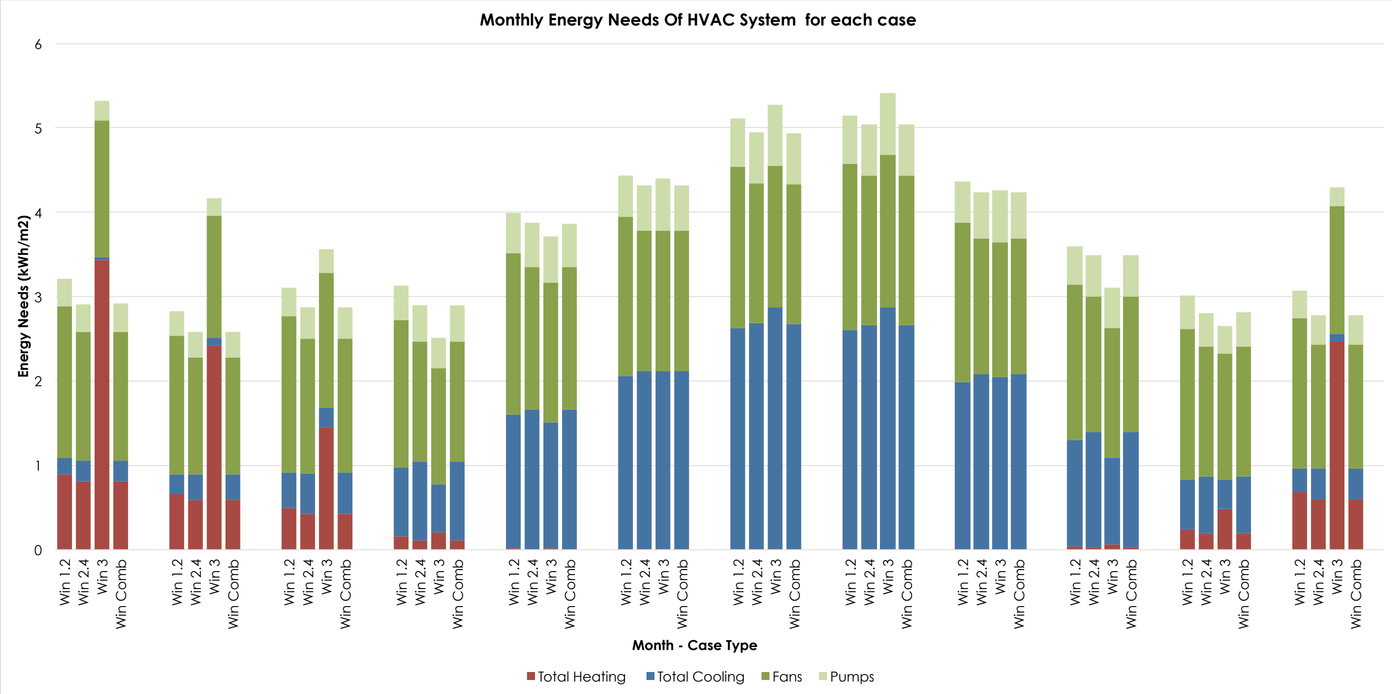


Chart: Monthly Energy Needs for the Heating and cooling (kWh/m2)

The upper graph shows the cooling and heating energy need for each case in each month. High increasing in the case of Awin/Awall equal 0.63, this result due to the glazing conduction loss. The best case is the one that has different combination windows with Awin/Awall equal 0.49.

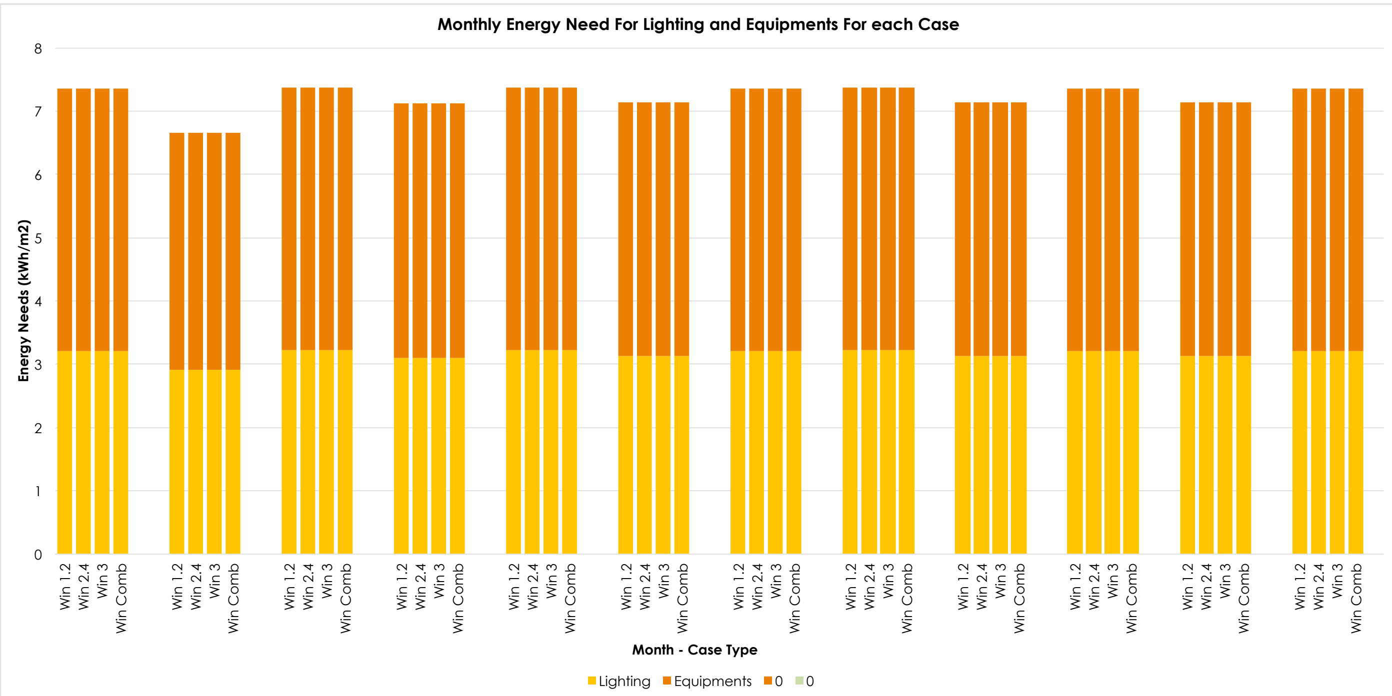
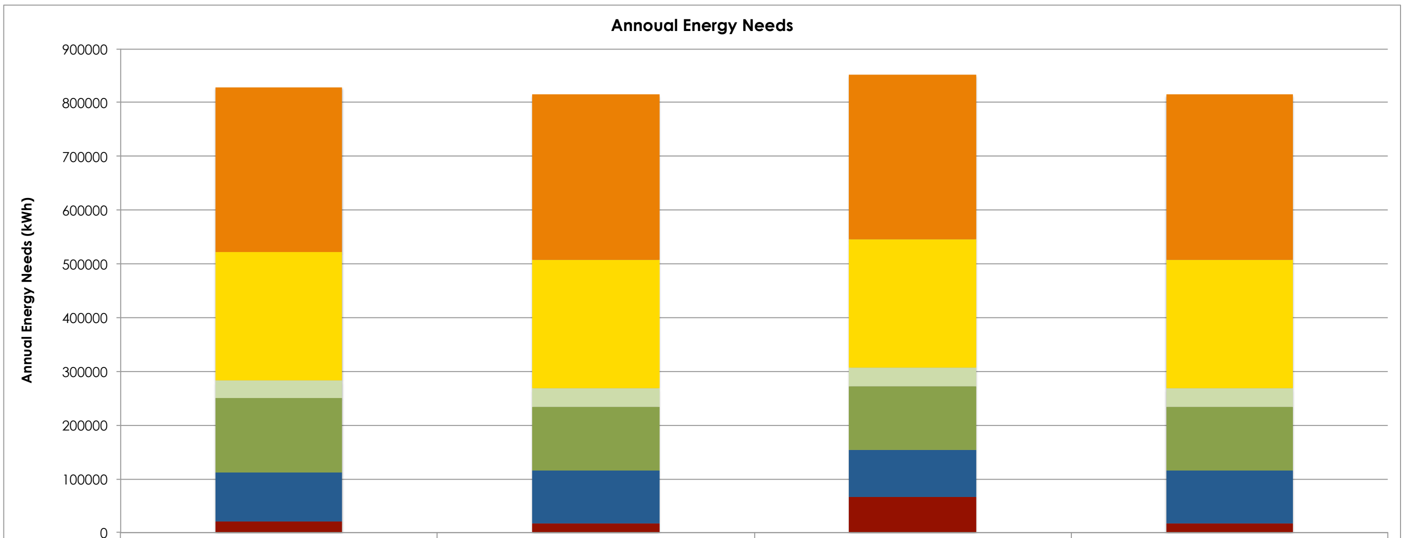


Chart: Monthly Energy Needs for Lighting and Equipment (kWh/m2)

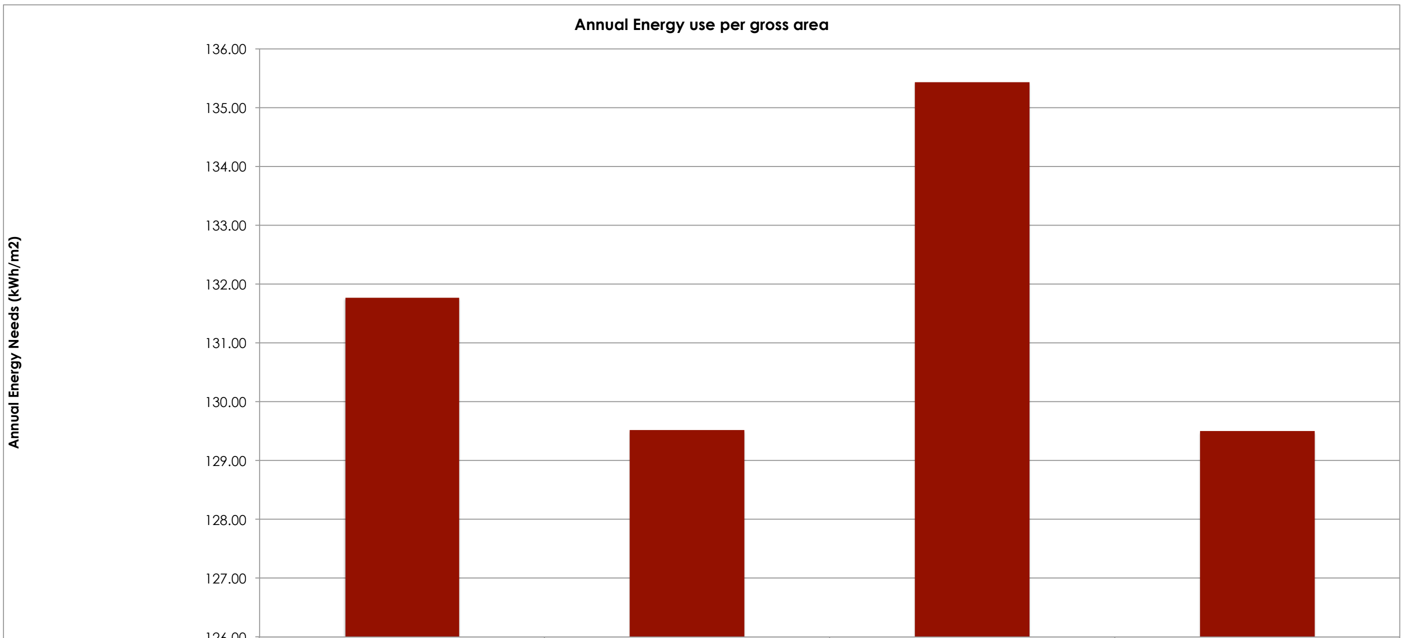
The upper graph shows the Energy needs for the lighting and equipment where they have equal result in all cases.



	1	2	3	4
Equipments	307205	307205	307205	307205
Lighting	238615	238615	238615	238615
Pumps	32459	34614	33720	34562
Fans	138517	119069	119472	119057
Cooling	92118	97848	86784	97794
Heating	20058	17409	66204	17409

Chart: Annual Energy Needs (kWh)

As the lighting and equipment energy needs are equal, so the changing between all the cases related to the heating and cooling. The best case the one that has Awin/Awall equal to 0.49.



	1	2	3	4
Annual Energy use per gross area	131.77	129.51	135.43	129.49

Chart: Annual Energy Needs (kWh/m2)

The energy needs per gross area is quite high for an residential building especially by comparing it by the reference that sefaira consider. AIA 2030 challage consider for this type of building 37 kWh/m2

OPTIMIZED CASE

After understanding all the cases, Some optimizing process will be applied on the best case which has Awin/Awall equal to 0.49. As the analysis shows that the cooling load is much higher then the heating load specially in the ground floor which it divided to three parts, due to the glazing loss and the solar gain. Also the glazing loss in case of winter is much high too.

- Processes:
  - Lower U-value for windows.
  - Decrease the area of ground floor glazing in 25%.
  - Apply natural ventilation.

After several simulation the choosen parameters area recorded in the lower table:

	Awin/Aopa	**Window U-value**	**HVAC Integration**	**Mechanical ventilation**	**Glazing Area open**	**Free area of opening**
Case	[%]	[W/m2K]	Natural ventilation + Cooling & Heating	Off if widows open	[%]	[%]
4.3.Optimized	0.43	1.00			50	50

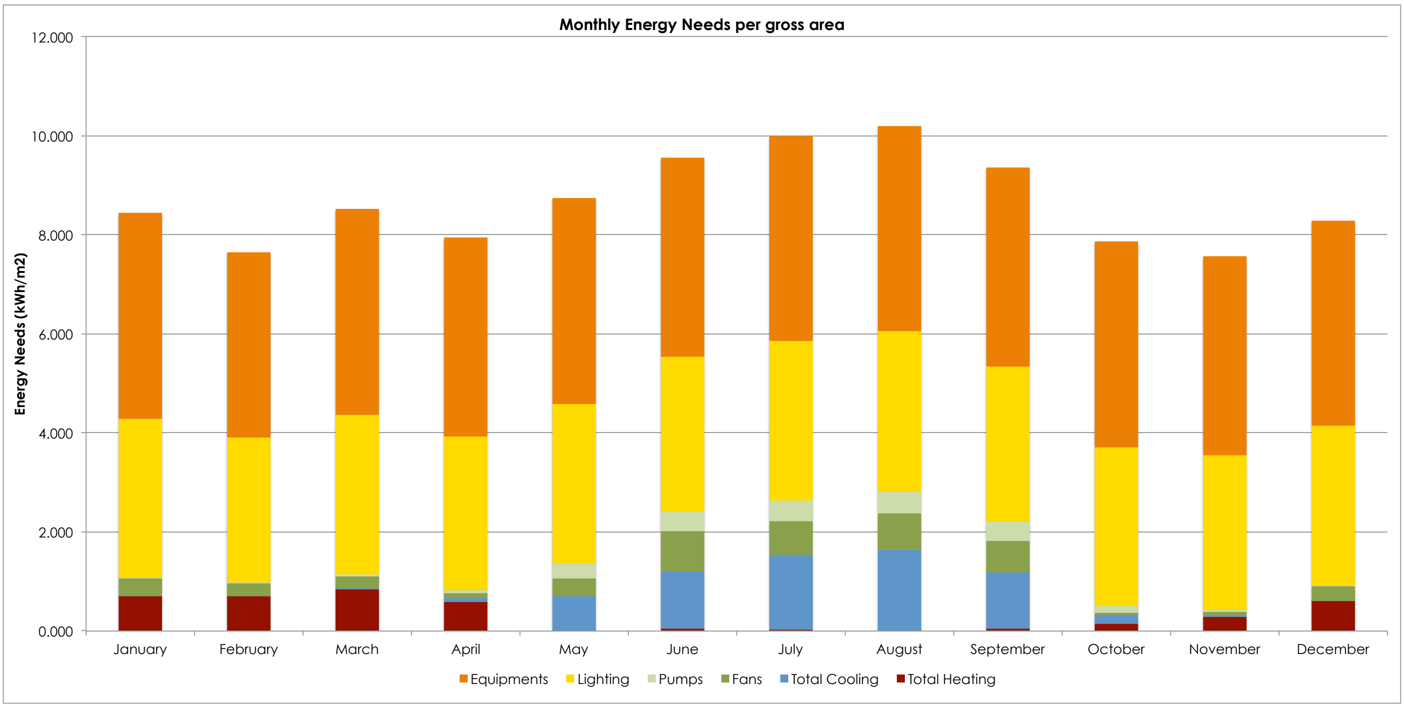


Chart: Monthly Energy Needs (kWh/m2)

By the assessment of the natural ventilation, it is clearly seen that the cooling energy need has been eleminated,.Thats happen because the zone can arrive to the comfort temperature by providing some ventilation.

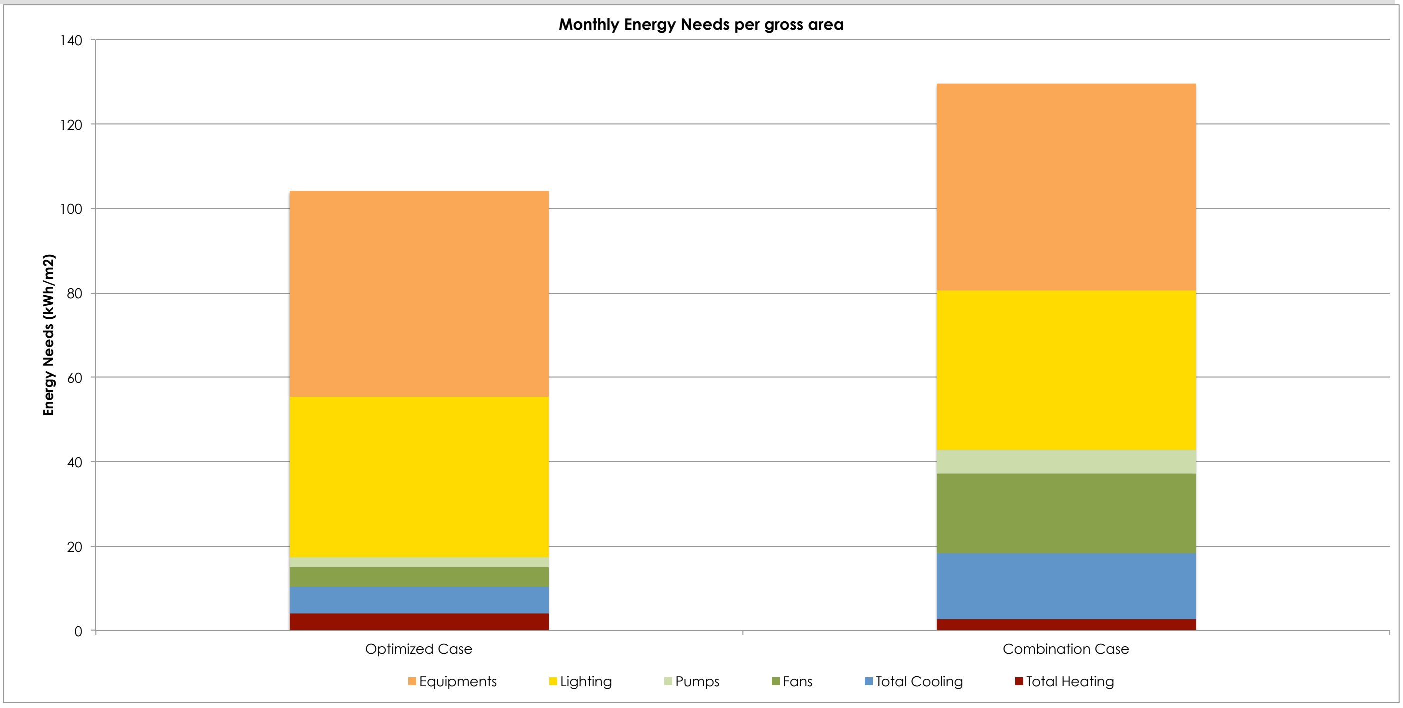


Chart: Annual Energy Needs (kWh/m2)

The upper chart is comparing the energy needs per gross area for case 4.3 and its developmet. The amount of energy decreased around 30kWh/m2 just by use lower U value for glazing to limit the loss, providing some ventilation and decreasing the glazing area of ground floor.

IES-VE ANALYSIS

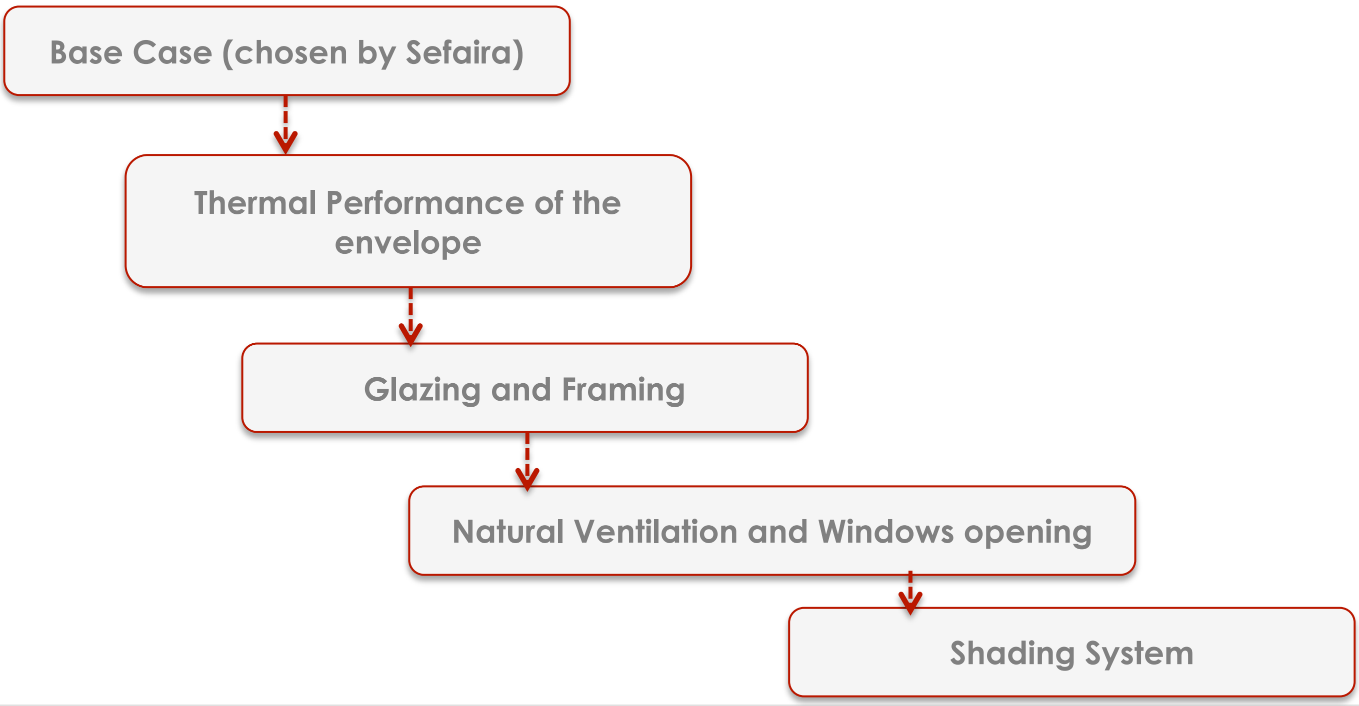
To complete the design of the envelope, full energy performance analysis is needed in order to decrease the amount of energy consumption. IES-VE application will be used for this step. The IES Virtual Environment (VE) is a suite of building performance analysis applications. The main goal of this software is to test different options, identify passive solutions, compare low-carbon & renewable technologies, and draw conclusions on energy use, occupant comfort. Integrated Environmental Solutions Ltd, a software and consultancy company that specializes in building performance analysis does it. IES create software tools for designing and operating energy efficient buildings.

The whole building that will be analyzed by divided the zone in general. Underground floor will be divided to four stores, unheated storage of and the unheated parking. The ground floor too has been separated each store as one zone plus the unheated staircases. The typical floor divided into three blocs, each one has separated apartments and the unheated staircase.

The aim of the process is to improve the building energy performance, model this real building case and check different strategies in order to implement the thermal behavior.

The climatic data of Damascus city will be used for the building to see how the climate influences the design process.

DEVELOPING STRATEGIES



BUILDING DESCRIPTION

The building has a 7140 m2 area in total divided between heated and unheated zones, the heated zone has 5480 m2 while the unheated has 1660 m2 area. The lower table shows all the spaces with its properties.

		Space	Floor Area	Wall area	Glazed Area	Note
			[m2]	[m2]	[m2]	
Basement		U-Parking1	694.98	424.8	0	Unheated
		U-Storage	119.53	179.05	0	Unheated
		U-Shop1	181.31	231.14	20.5	Heated
		U-stair1	25.19	64.29	0	Unheated
		U-shop2	30.41	70.71	11.39	Heated
		U-shop3	30.37	70.66	11.39	Heated
		U-stair2	33.25	74.2	0	Unheated
		U-shop4	69.74	90.85	20.5	Heated
Ground	Bloc 1	G1-shop1	104.99	125.08	67.76	Heated
		G1-shop2	89.34	161.84	67.52	Heated
		G1-stair1	33.92	88.83	4.42	Unheated
	Bloc2	G2-shop3	35.85	71.77	18.68	Heated
		G2-shop4	38.4	85.37	26.25	Heated
		G2-stair2	47.46	138.4	7.33	Unheated
		G2-meeting	38.7	94.83	5.78	Heated
		G2-café	112.62	113.15	63.61	Heated
	Bloc 3	G3-shop5	46.15	84.32	18.68	Heated
		G3-shop6	48.82	77.97	28.29	Heated
		G3-shop7	53.21	99.21	10.76	Heated
		G3-stair3	34.65	86.75	4.11	Unheated
		G3-ramps	110.59	148.95	21.44	Unheated
Typical Floors	Bloc 1	1-5-B1-apartment1	112.21	151.05	22.06	Heated
		1-5-B1-apartment2	84.87	146.42	15.69	Heated
		1-5-B1-stair1	31.17	72.76	2.48	Unheated
	Bloc 2	1-5-B2-apartment3	109.12	126.85	20.94	Heated
		1-5-B2-apartment4	66.46	120.18	12.08	Heated
		1-5-B2-apartment5	165.57	183.86	21.55	Heated
		1-5-B2-stair2	40.55	82.83	2.48	Unheated
	Bloc 3	1-5-B3-apartment6	128.94	137.52	21.29	Heated
		1-5-B3-apartment7	87.29	125.95	17.3	Heated
		1-5-B3-apartment8	165.57	183.86	26.8	Heated
		1-5-B3-stair3	40.55	82.83	2.48	Unheated

Space	Floor Area
	[m2]
Heated	5480.06
Unheated	1660.92
Total	7140.98

BUILDING DESCRIPTION

The schedules of this building will be divided into 2 main parts, weekly to consider the weekend's days, and hourly to each function during each day. In each spaces, the maximum values will be considered but the changing will be related to each schedule to control the occupancy, ventilation, infiltration and the heating cooling systems.

Schedules	**Sat**	**Sun**	**Mon**	**Tue**	**Wed**	**Thu**	**Fri**
Residential	100%						
Commercial	100%						0%

Schedules	**00:00-07:00**	**07:00-08:00**	**08:00-09:00**	**09:00-10:00**	**10:00-11:00**	**11:00-12:00**	**12:00-13:00**	**13:00-14:00**	**14:00-15:00**	**15:00-16:00**	**16:00-17:00**	**17:00-18:00**	**18:00-19:00**	**19:00-20:00**	**20:00-21:00**	**21:00-22:00**	**22:00-23:00**	**24:00-00:00**
Residential	100%	50%							80%						100%			
Commercial	0%	70%					30%			70%		100%				30%		0%
Lighting	0%											100%						0%
Equipment	0%	100%																0%
Additional	0%	100%																0%

INTERNAL GAINS

As it has been explained in previous chapter, by using the references to find the occupancies values for each zone where it depends of the square meter of each zone, all values recorded in the lower table including the lighting, equipment and the additional gains. The additional in each apartment will be calculated as 20 W/m2 while the values in the table is lower because it considers only the kitchens area not all the apartment space.

The occupancies and gains in the unheated zone will be not considered because there will be no cooling and heating system and they have a variable occupancy not fixed values.

		Space	Occupancy	People	Lighting	Equipment	Additional
			[m2/person]	[No]	[W/m2]	[W/m2]	[W/m2]
Basement		U-Parking1	-	-	-	-	-
		U-Storage	-	-	-	-	-
		U-Shop1	7	25.90	12	-	-
		U-stair1	-	-	10	-	-
		U-shop2	7	4.34	12	-	-
		U-shop3	7	4.34	12	-	-
		U-stair2	-	-	10	-	-
		U-shop4	7	9.96	12	-	-
Ground	Block1	G1-shop1	7	15.00	12	-	-
		G1-shop2	7	12.76	12	-	-
		G1-stair1	-	-	10	-	-
	Block2	G2-shop3	7	5.12	12	-	-
		G2-shop4	7	5.49	12	-	-
		G2-stair2	-	-	10	-	-
		G2-meeting	7	5.53	10	-	-
		G2-café	4.6	24.48	10	10	20
	Block3	G3-shop5	7	6.59	12	-	-
		G3-shop6	7	6.97	12	-	-
		G3-shop7	7	7.60	12	-	-
		G3-stair3	-	-	10	-	-
		G3-ramps	-	-	-	-	-
Typical Floors	Block1	1-5-B1-apartment1	18	6.23	10	5	2.85
		1-5-B1-apartment2	18	4.72	10	5	3.77
		1-5-B1-stair1		-	10	-	-
	Block2	1-5-B2-apartment3	18	6.06	10	5	2.93
		1-5-B2-apartment4	18	3.69	10	5	4.81
		1-5-B2-apartment5	18	9.20	10	5	1.93
		1-5-B2-stair2		-	10	-	-
	Block3	1-5-B3-apartment6	18	7.16	10	5	2.48
		1-5-B3-apartment7	18	4.85	10	5	3.67
		1-5-B3-apartment8	18	9.20	10	5	1.93
		1-5-B3-stair3		-	10	-	-

VENTILATION

Regarding the ventilation, it has to be taken into account the Indoor Air Quality that refers to the minimum values for a correct ventilation to assure the health of the occupants. In the primary case, the minimum values will be used, and then it will be change in the part of optimizing taking into account the minimum values of the standard. The Indoor Air Quality minimum values have been taken from the standard *ASHRAE 62.1-2013*.

ventilation	**people outdoor ari rate**	**Area outdoor air rate**	**Infiltration**
	[L/s.person]	[L/s.m2]	[ach]
Typical floor	3	0.3	0.2
Ground floor	5	0.3	0.2
Basement	5	0.3	0.2

In terms of infiltration it has been taken a low value (0.2 ach) considering a high air- tightness building, due to the extreme climates that the building is facing in locations.

CONSTRUCTION PERFORMANCE

The same construction that has been used in the previous analysis will be used (type 3). Additional parts added as the application allows to be more specific in the analysis.

Type 3					
External Walls		Material	Thickness	ʎ	R
	External		[m]	[W/m K]	[m2.K/W]
	1	Laminate compact (HPL) stone surface	0.01	0.29	0.034
	2	Air cavity	0.05		0.180
	3	Sandwich corrugated steel panel filled with polyurethane	0.1	0.023	4.348
	4	Air cavity	0.05		0.180
	5	Rigid panel of medium-low density mineral wool	0.05	0.036	1.389
	6	Plaster board integrated with aluminum vapor barrier	0.0125	0.16	0.078
	7	Plaster board of gypsum washable with paint	0.0125	0.16	0.078
	Internal		0.2725	[m]	
		R tot	6.287	[m2.K/W]	
		U	0.159	[W/m2K]	

Roofing		Material	Thickness	λ	R
		External	[m]	[W/m K]	[m2.K/W]
	1	Roofing Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Sand	0.05	0.35	0.143
	4	Membrane	0.001	1	0.001
	5	Extruded polystyrene panel	0.1	0.037	2.703
	6	light weight concrete for slope	0.05	1.4	0.036
	7	Reinforced concrete	0.15	1.4	0.107
	8	Air cavity	0.05		0.180
	9	Gypsum Board fall ceiling	0.022	0.16	0.138
		Internal	0.236	[m]	
		R tot	3.470	[m2.K/W]	
		U	0.288	[W/m2K]	
Flooring		Material	Thickness	λ	R
		Internal	[m]	[W/m K]	[m2.K/W]
	1	Tiles	0.015	0.13	0.115
	2	Mortar	0.02	0.42	0.048
	3	Membrane	0.001	1	0.001
	3	Rigid panel of medium-low density mineral wool	0.05	0.037	1.351
	6	Reinforced concrete	0.15	2.3	0.065
	7	Air cavity	0.05		0.180
	8	Gypsum Board fall ceiling	0.022	0.16	0.138
		External	0.308	[m]	
		R tot	1.898	[m2.K/W]	
		U	0.527	[W/m2K]	
External Walls (Underground)		Material	Thickness	λ	R
		External	[m]	[W/m K]	[m2.K/W]
	1	Membrane	0.001	1	0.001
	2	Reinforced concrete	0.3	1.4	0.214
	3	Rigid panel of medium-low density mineral wool	0.05	0.036	1.389
	4	Air cavity	0.05		0.180
	5	Rigid panel of medium-low density mineral wool	0.05	0.036	1.389
	6	Plaster board integrated with aluminum vapor barrier	0.0125	0.16	0.078
	7	Plaster board of gypsum washable with paint	0.0125	0.16	0.078
		Internal	0.4635	[m]	25
		R tot	3.329	[m2.K/W]	
		U	0.300	[W/m2K]	

Floor (Underground)		Material	Thickness	λ	R
		External	[m]	[W/m K]	[m2.K/W]
	1	Tiles	0.015	0.84	0.018
	2	Mortar	0.02	1.5	0.013
	3	Membrane	0.001	1	0.001
	4	Extruded polystyrene panel	0.1	0.036	2.778
	5	Reinforced concrete	0.15	1.4	0.107
		Internal	0.286	[m]	
		R tot	2.917	[m2.K/W]	
		U	0.343	[W/m2K]	
Internal Walls		Material	Thickness	λ	R
		Internal	[m]	[W/m K]	[m2.K/W]
	1	Plaster board of gypsum washable with paint	0.0125	0.16	0.078
	2	Rigid panel of medium-low density mineral wool	0.05	0.036	1.389
	3	Air cavity	0.05		0.180
	4	Rigid panel of medium-low density mineral wool	0.05	0.036	1.389
	5	Plaster board of gypsum washable with paint	0.0125	0.16	0.078
		Internal	0.175	[m]	
		R tot	3.114	[m2.K/W]	
		U	0.321	[W/m2K]	

Glazing			Thickness	Emissivity	Frame Area	Net U-value
			[mm]	[-]	[%]	[W/m2K]
	1	Outer Pane	6	0.2	10	1.3
	2	Cavity	12			
	3	Inner Pane	6			

In order to start the analysis of the building, it is analyzed with the base case characteristics previously explained. The first analysis run, it has been in free-floating conditions, considering heating and cooling plants off. With this analysis it is possible to see the indoor temperature which gives an initial idea of the plants that will be required and in which months. It is necessary to define a comfort zone and set the boundaries. For Syria, the comfort zone has been defined between 20C˚ and 26C˚.

In this section are shown the results represented in monthly percentage of hours. So, it is given a deeper vision on how these results vary month by month.

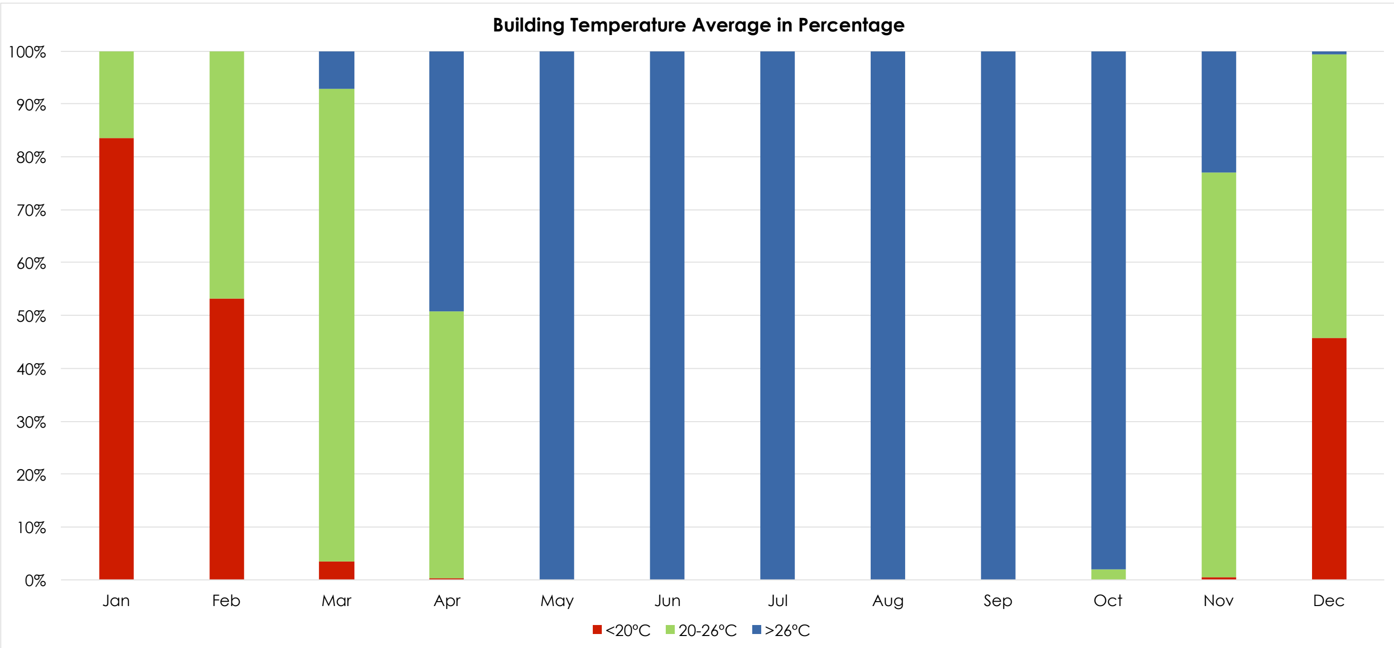
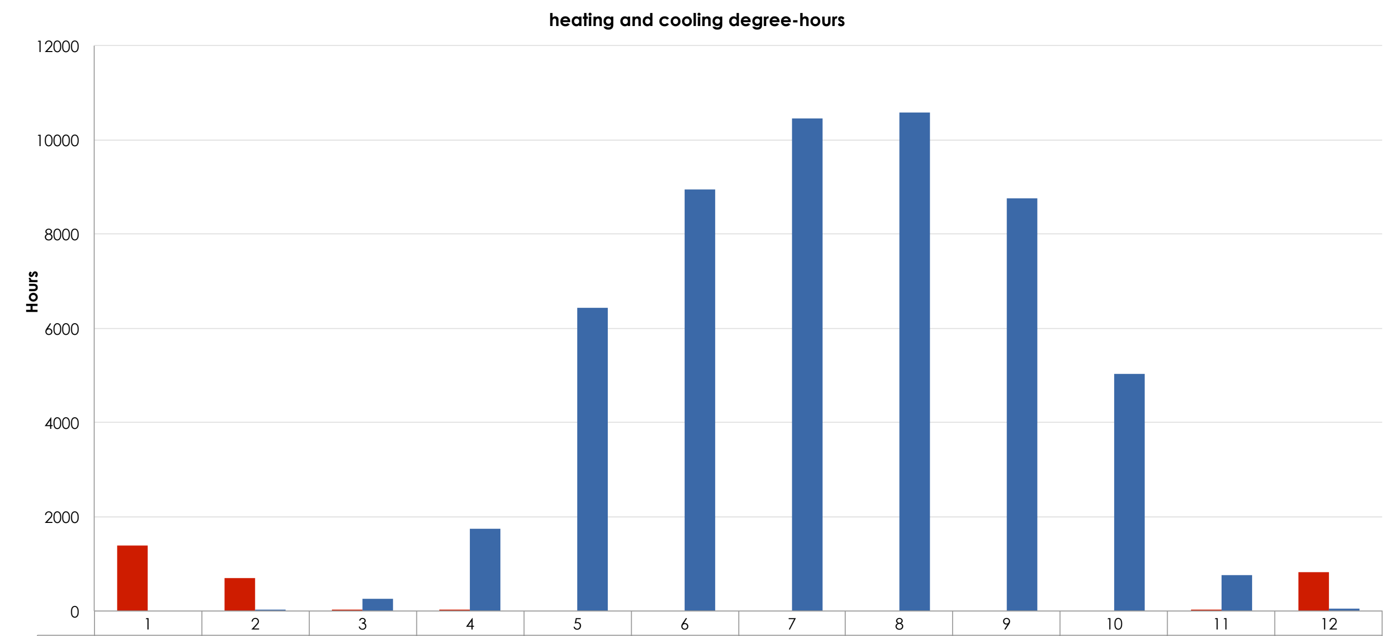


Chart: Building Temperature Average in Percentage

As the graph shows Damascus has a cool weather in winter and warm in summer, by using the low U-values of the construction which it had been chosen in previous chapter so the majority of the hours the temperature is higher then 26C˚, considered the higher limit of the comfort zone, so the main energy needs will be the cooling ones.

The percentage of hours higher then 26C˚ is 57% while the once under 20C˚ is 16%. The rest of hours those in the range of the comfort zone has percentage of 28% that's due to the previous optimizing process of Sefaira.

Other way to represent it is with the heating and cooling degree hours, having similar results as in the previous analysis.



	1	2	3	4	5	6	7	8	9	10	11	12
DHH	1380.898553	701.5667105	12.04723684	0.324210526	0	0	0	0	0	0	0.850789474	816.7672368
DHC	0	3.994473684	265.4181579	1741.264342	6430.740789	8937.636579	10446.70921	10582.52329	8755.247237	5026.756974	763.1567105	50.72013158

Chart: Heating and Cooling Degree-Hours

After the free-floating analysis, the plants are turned on to maintain the building in the comfort zone in the defined schedule in order to check the load of the zones for the whole heated and cooled area.

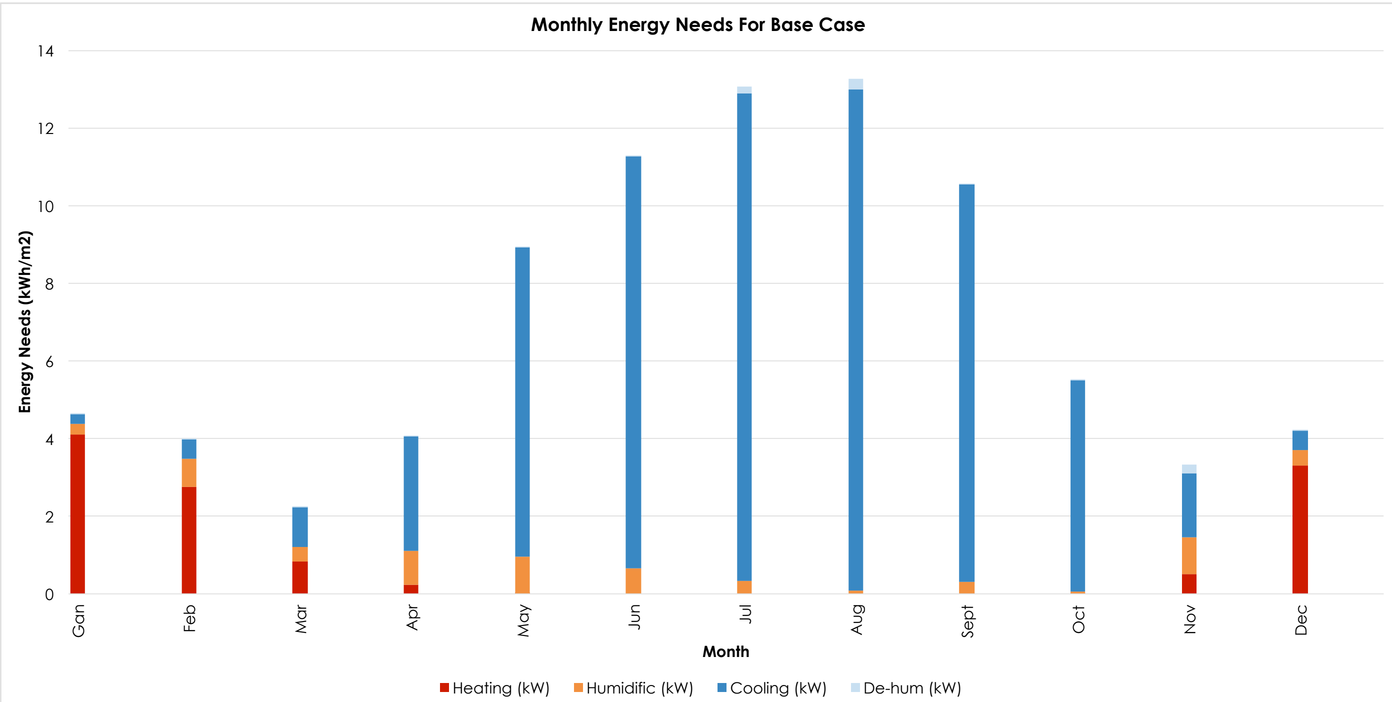


Chart: Monthly Energy Needs For Base Case

The results obtained above are related to the base case with the parameter used as it has been explained in the previous chapter. It can be seen the monthly heating, humidifying, cooling and dehumidifying loads. The total energy need is around 86 kWh/m2 where the area of the heated zone considered only.

The first optimized case is to change the internal surface of the external and internal walls. So instead of using the gypsum board, cement board of 5 cm will be used for all the zones.

In building design, thermal mass is a property of the mass of a building which enables it to store heat, providing "inertia" against temperature fluctuations. when outside temperatures are fluctuating throughout the day, a large thermal mass within the insulated portion of a house can serve to "flatten out" the daily temperature fluctuations, since the thermal mass will absorb thermal energy when the surroundings are higher in temperature than the mass, and give thermal energy back when the surroundings are cooler, without reaching thermal equilibrium. This is distinct from a material's insulative value, which reduces a building's thermal conductivity, allowing it to be heated or cooled relatively separate from the outside, or even just retain the occupants' thermal energy longer.

In order to see the influence of this stratigy on the building, the cooling and heating load will by sorted in the chart below in comparison with the base case.

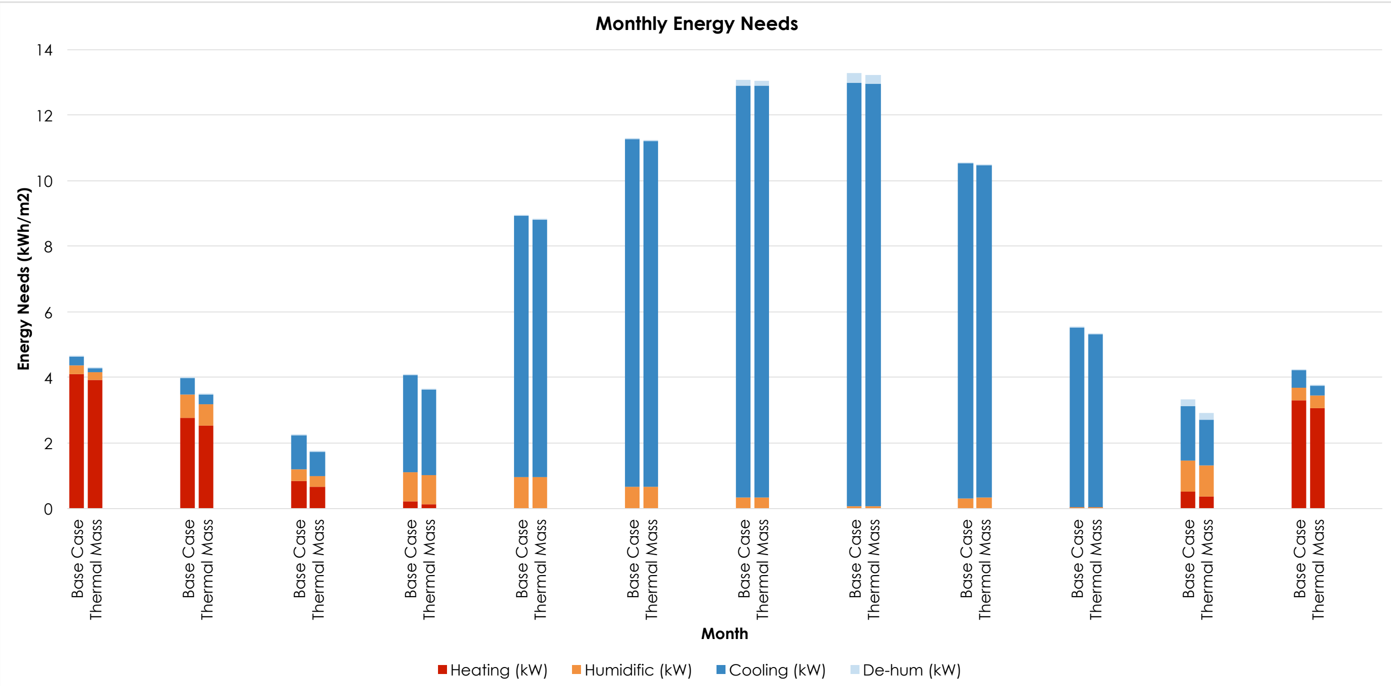


Chart: Monthly Energy Needs

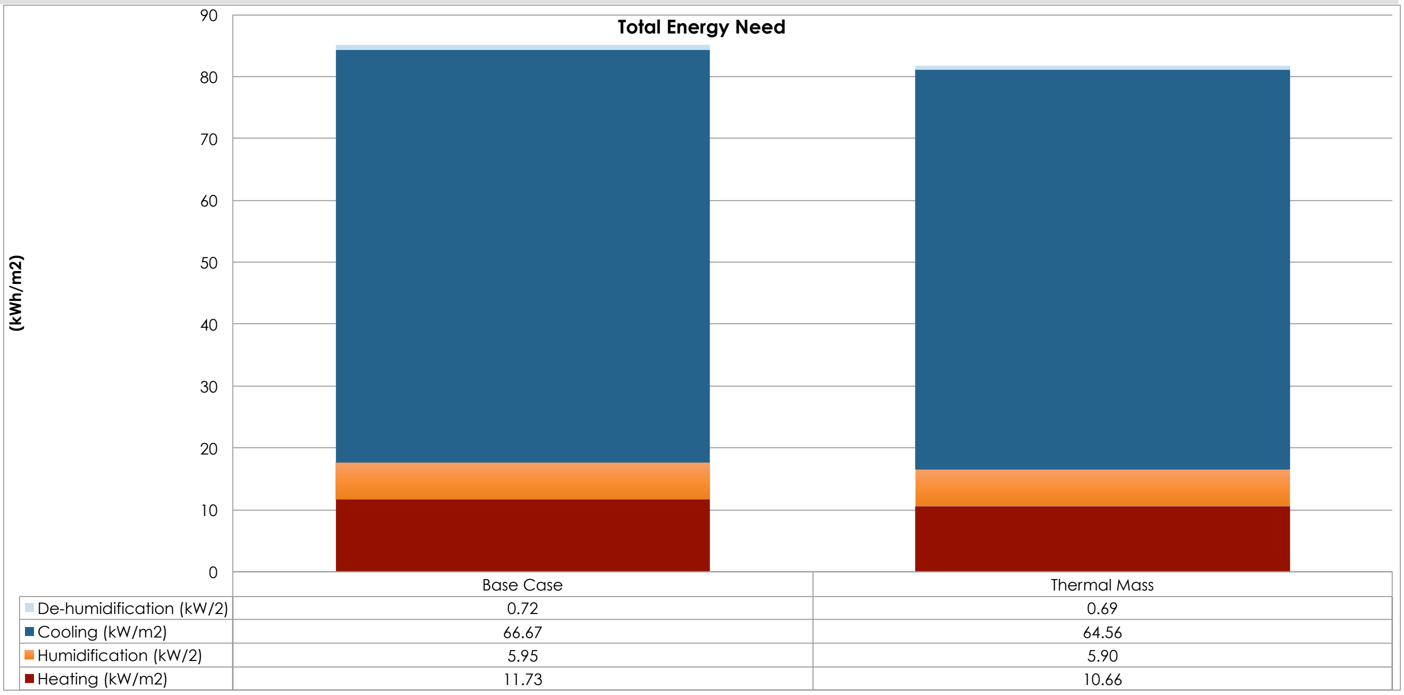


Chart: Total Energy Needs

As the result shows, decreasing of the total load from 86 kWh/m2 to 81 kWh/m2.

OPTIMIZING CASE: GLAZING

The following steps consists in applying different types of glass with different properties and compare the results obtained in terms of energy performance, costs and feasibility.

The different glazing types sorted in the lower table with different properties.

		Pane	Thickness	Cavity	Filled	Emissivity	Net U value
	Glazing		[mm]	[mm]			[W/m2K]
0	Thermal mass	Double pane	6	12	Argon	0.83	1.6
1	Analysis 1	Double pane	8	16	Argon	0.2	1.4
2	Analysis 2	Double pane	8	16	Krypton	0.2	1.36
3	Analysis 3	Triple pane	6	2 x 8	Argon	0.2	1.47
4	Analysis 4	Triple pane	6	2 x 8	Krypton	0.2	1.1

In order to see the influence of those types of glazing the building, the cooling and heating load will by sorted in the chart below in comparison with the previous case.

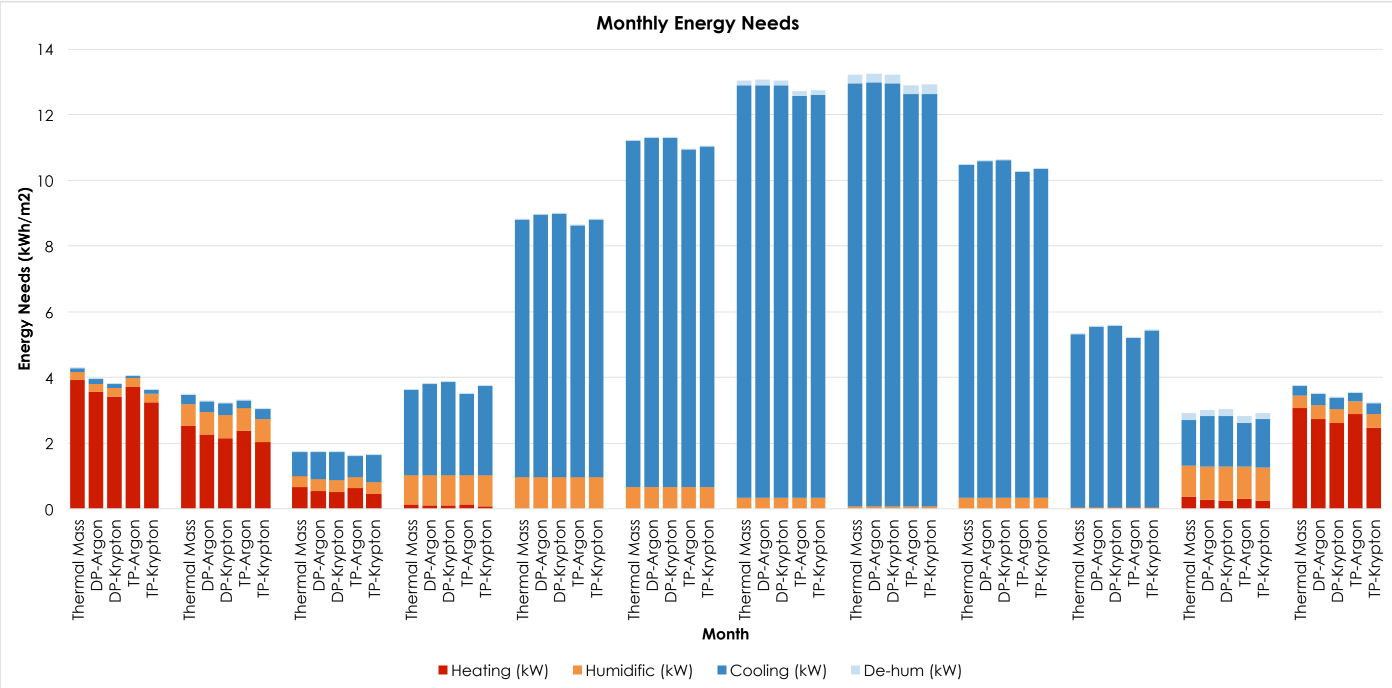
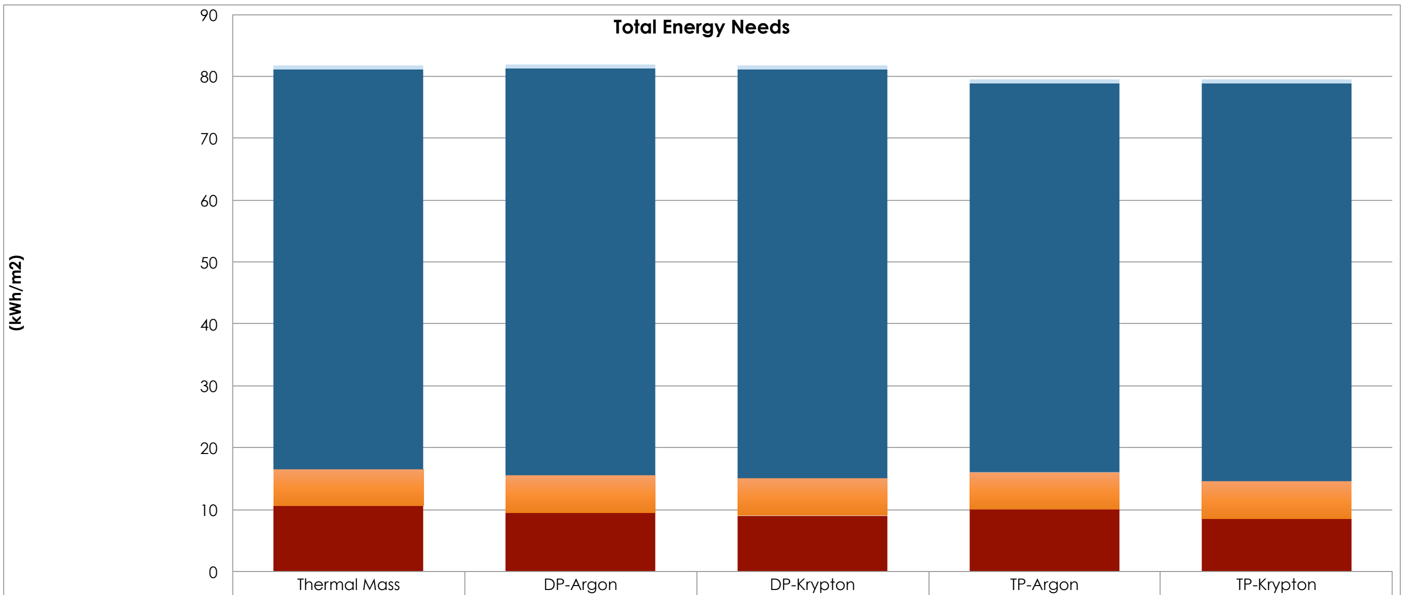


Chart: Monthly Energy Needs



	Thermal Mass	DP-Argon	DP-Krypton	TP-Argon	TP-Krypton
De-humidification (kW/2)	0.69	0.65	0.64	0.67	0.63
Cooling (kW/m2)	64.56	65.77	66.04	62.93	64.24
Humidification (kW/2)	5.90	6.04	6.10	5.91	6.12
Heating (kW/m2)	10.66	9.51	9.05	10.06	8.54

Chart: Total Energy Needs

Seeing the small difference in all solutions proposed, and considering that the triple glazing has higher price than the double so the best solution from the economical point of view is to chose the simple case. Double pane glazing filled with argon in with the common thickness will be choosen.

The third optimizing process also considering the properties of the windows, by changing the framing properties and area percentage. That can influence on the net U-value of the windows.

The new characterize of the windows will be seen in the lower table.

			Height	Width	Total area	Frame area	Glazing area	%	net U-value
Analysis			[m]	[m]	[m2]	[m2]	[m2]		
1	One side	Window 1	1.75	1.2	2.1	0.354	1.746	17%	1.28
	One side	Window 2	1.75	2.4	4.2	0.708	3.492	17%	
	Two side	Window 3	1.75	3	5.25	0.78	4.47	15%	
2	Two side	Window 1	1.75	1.2	2.1	0.426	1.674	20%	1.29
	Two side	Window 2	1.75	2.4	4.2	0.852	3.348	20%	
	Three side	Window 3	1.75	3	5.25	1.065	4.185	20%	

The frames above considered the uPVC as material. uPVC windows start to be common in middle east countries, and their popularity in the construction industry has increased tremendously over the last five years due to the consideration of their benefits, such as low-cost and easy maintenance and insulation.

The lower chart will shows the monthly energy needs compared between the two processes.

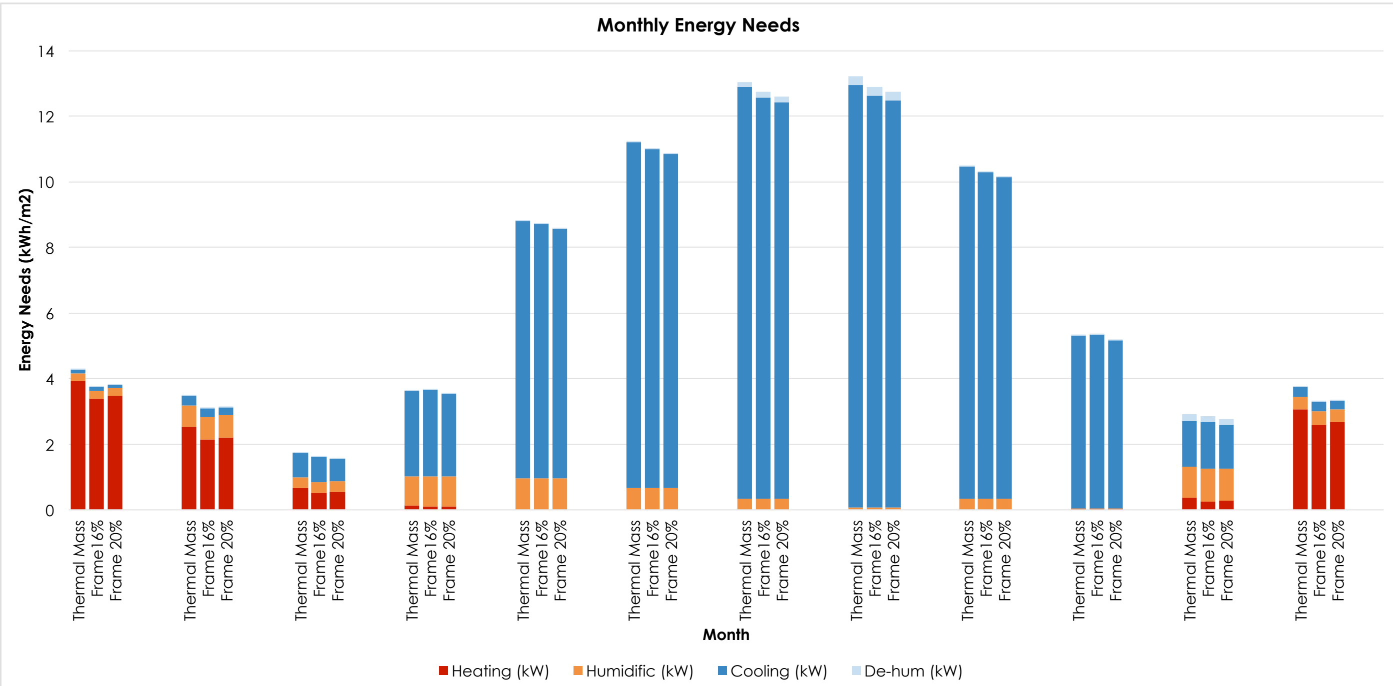


Chart: Monthly Energy Needs

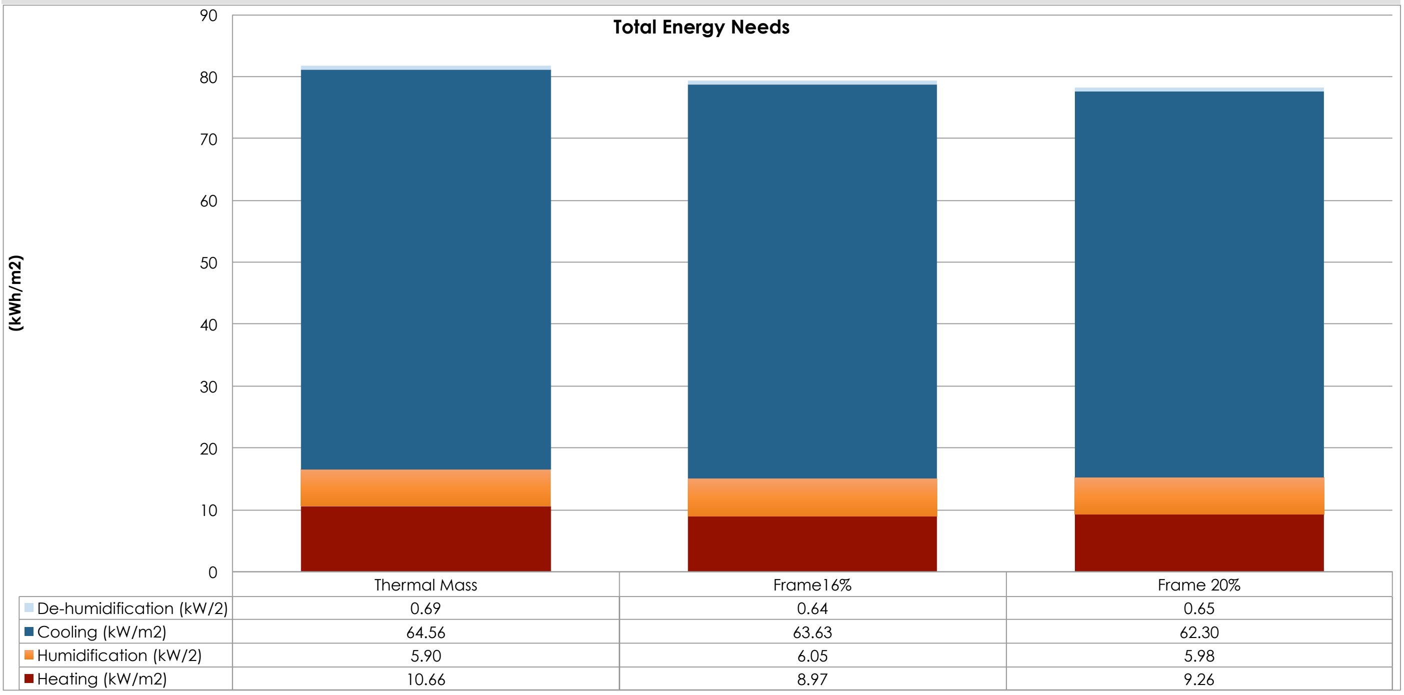


Chart: Total Energy Needs

The result shows that a decreasing of 3kWh/m2 when the frame area considered as 20% from the total area of window. The total energy needs becomes 78 kWh/m2.

OPTIMIZING CASE: NATURAL VENTILATION IN SUMMER

The next step is to apply different amount of natural ventilation in order to decrease the load of cooling. Four types of analysis with different amount of air change will be used where they will be linked to scheduals of summer.

Ventilation	Air change	Type	Schedules
	[ach]		
Type 1	4	Natural	On from 1/5-30/9
Type 2	2	Natural	On from 1/5-30/9
Type 3	1	Natural	On from 1/5-30/9
Type 4	1	Natural	On from 1/5-30/9 with external T = 20-26

In order to see the results of the additional ventilation on the cooling load, the lower charts will shows the monthly and the yearly heating and cooling energy needs

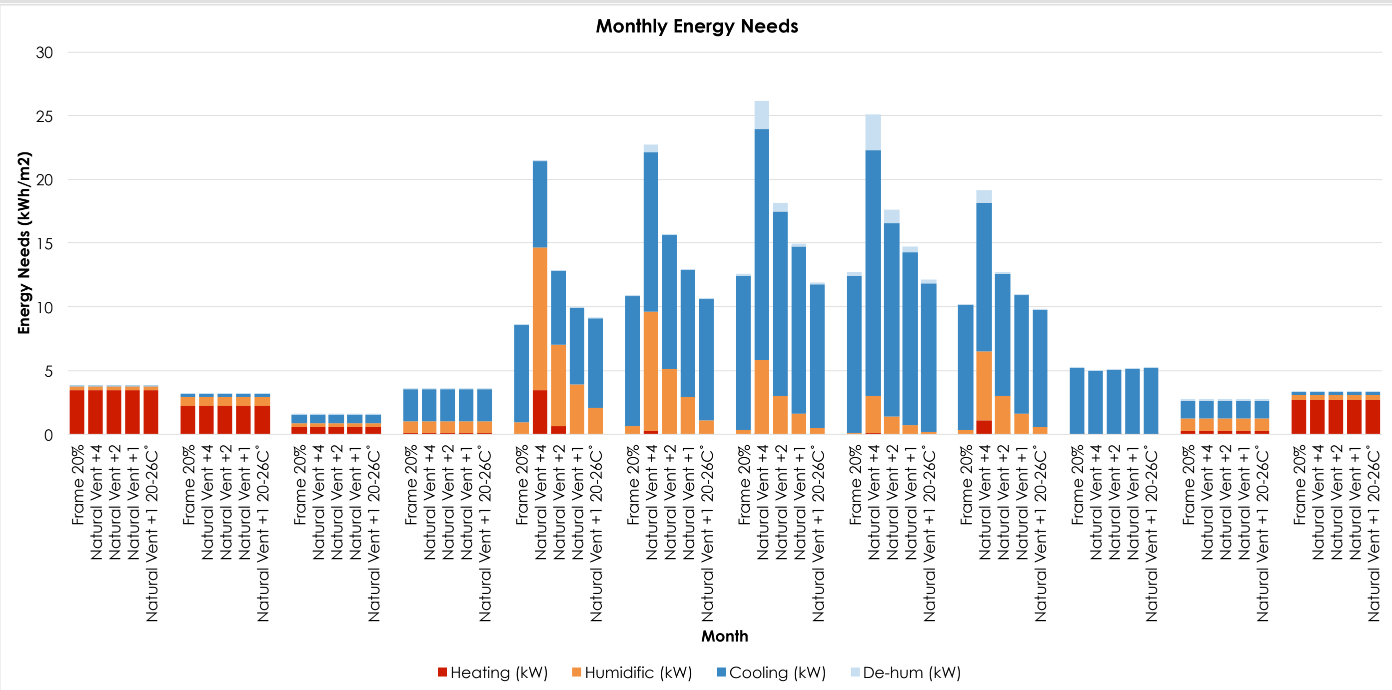
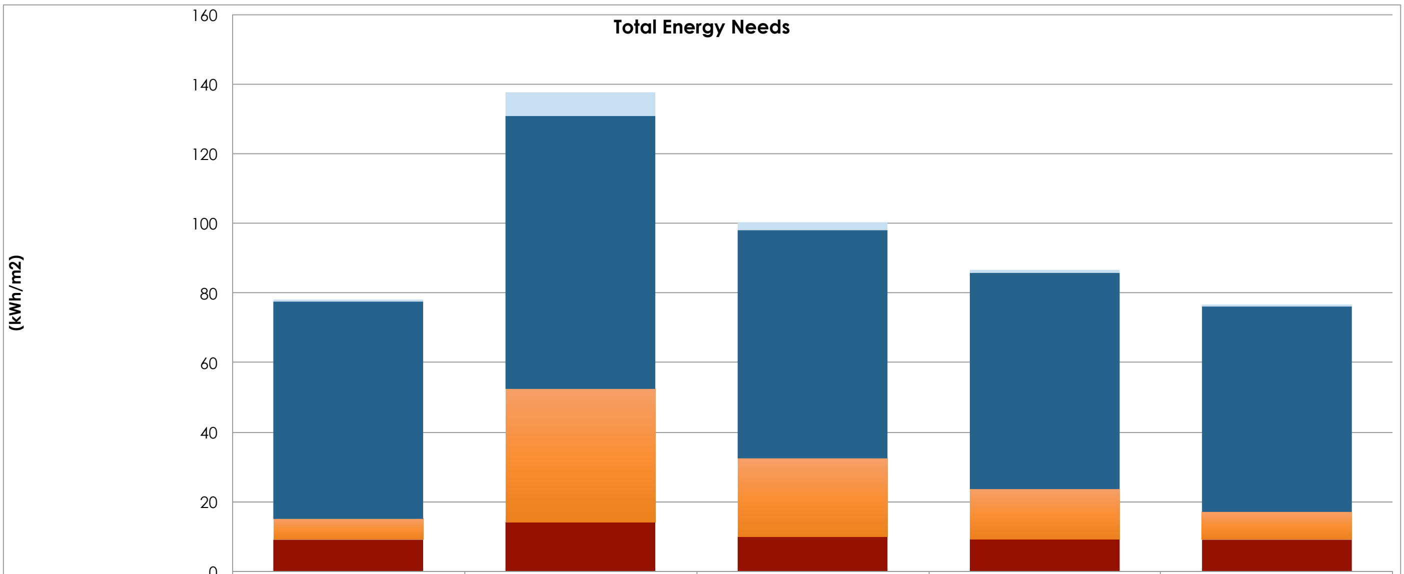


Chart: Monthly Energy Needs



	Frame 20%	Natural Vent +4	Natural Vent +2	Natural Vent +1	Natural Vent +1 20-26C°
De-humidification (kW/2)	0.65	6.89	2.22	0.99	0.68
Cooling (kW/m2)	62.30	78.39	65.59	62.06	58.92
Humidification (kW/2)	5.98	38.34	22.50	14.35	7.94
Heating (kW/m2)	9.26	14.14	9.99	9.29	9.26

Chart: Total Energy Needs

The additional ventilation of 4 ach asses to make a big lose which it influence to increase the cooling loads, while when the natural ventilation linked to the external temperature, this will decrease the cooling energy needs and this is the core of this step. The total load decreased from 78 kWh/m2 to 76 kWh/m2

OPTIMIZING CASE: WINDOWS OPENING

From the previous analysis and in order to determine the percantage the opening of the windows, the MACROFLOW application of IES-VE to see the needs of the opening. Different percentage of opening will be assigned as the lower table showes.

		C°	
Analysis 1	T outside	20-26	on
	T inside	22-26	off
	Open residential	80%	45deg
	Open commercial	40%	90deg
Analysis 2	T outside	20-26	on
	T inside	22-26	off
	Open residential	40%	45deg
	Open commercial	40%	90deg
Analysis 3	T outside	20-26	on
	T inside	22-26	off
	Open residential	20%	45deg
	Open commercial	40%	90deg

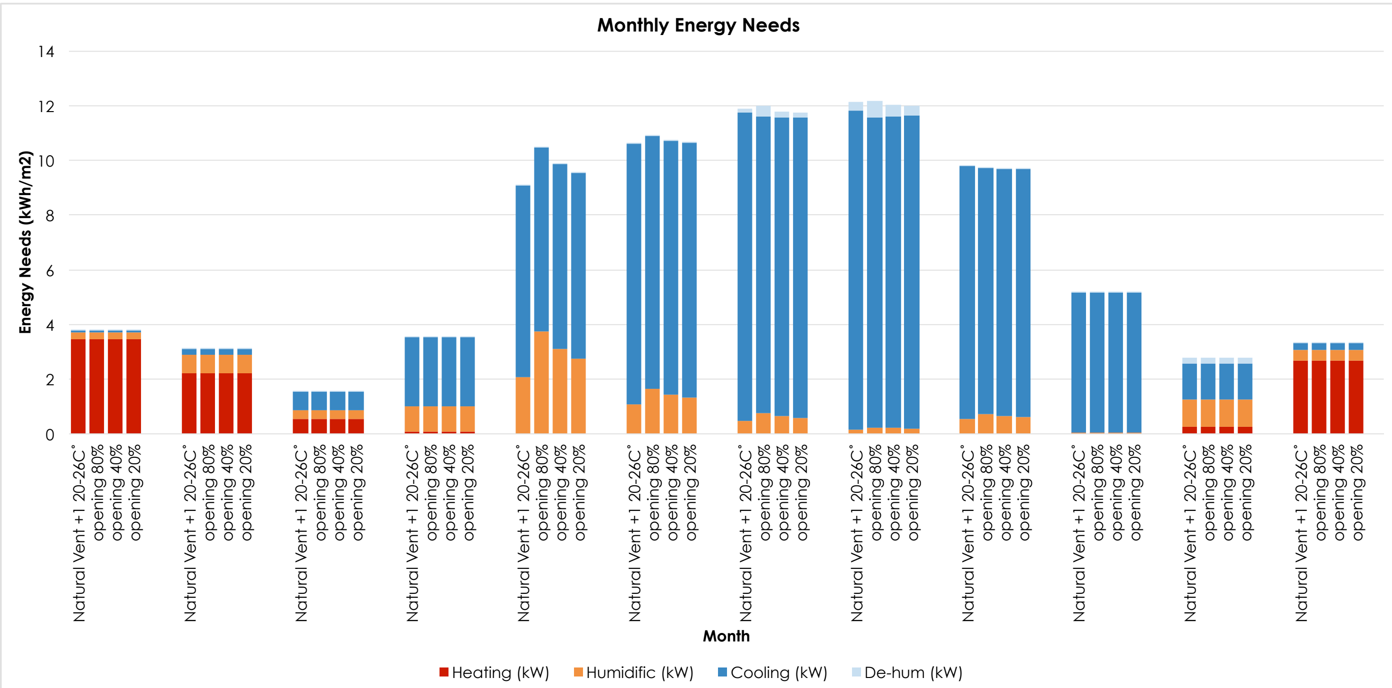
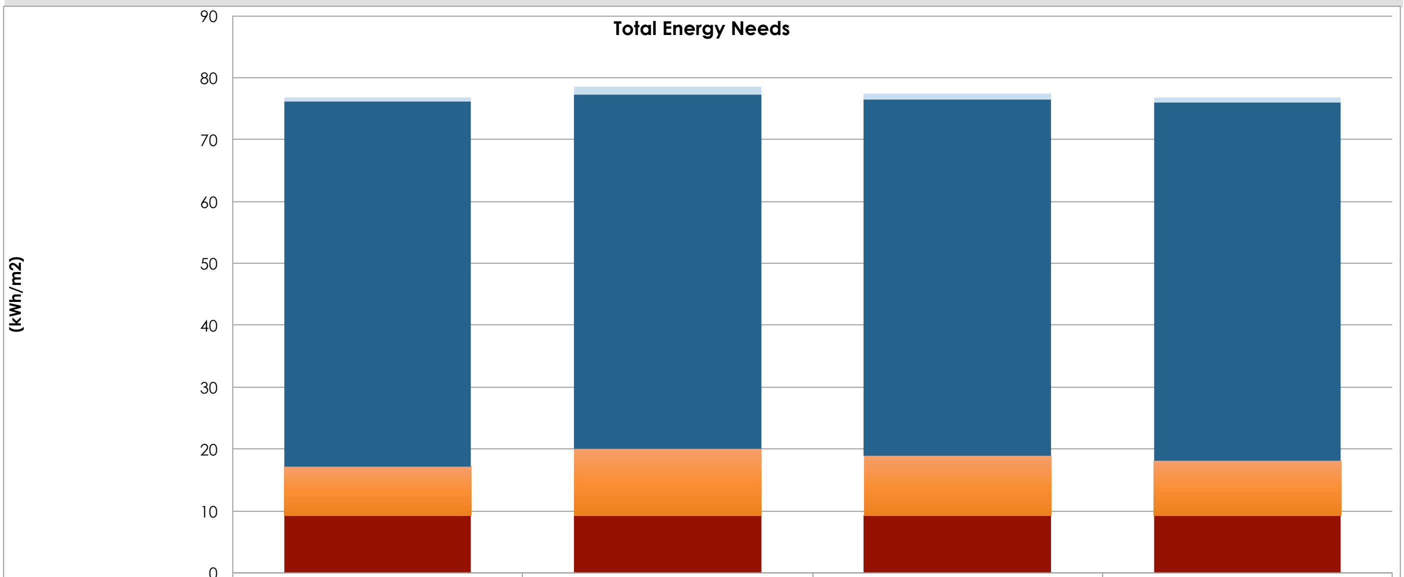


Chart: Monthly Energy Needs



	Natural Vent +1 20-26C˚	opening 80%	opening 40%	opening 20%
De-humidification (kW/2)	0.68	1.23	0.90	0.77
Cooling (kW/m2)	58.92	57.32	57.56	57.83
Humidification (kW/2)	7.94	10.73	9.66	8.87
Heating (kW/m2)	9.26	9.26	9.26	9.26

Chart: Total Energy Needs

As the chart shows the percantage of opening must be between 20% and 40% where in this percentage will not change the load when the external temperature range between 20-26 C˚. The windows opening with 20% able to decrease the energy amount of cooling 1 kWh/m2. The total energy need becomes 75 kWh/m2.

OPTIMIZING CASE: WHITE SURFACE AND SHADING SYSTEM

Finally the last optimizing process is to include a white surface on the roof and on the walls in order to decrease the amount of energy that absorbed from the solar radiation. The other process is by adding external shading system linked to the summer solar radiation in order to don't increase it in winter. The shading system that assigned as shullters on the top of the windows. Finally by having a thermal mass included with insulation system of the wall in order to see the behavior of larger mass in the external walls, this process will create for the project a flexible choices in the design process.

Type 3					
External Walls		Material	Thickness	λ	R
	External		[m]	[W/m K]	[m2.K/W]
	1	Laminate compact (HPL) stone surface	0.01	0.29	0.034
	2	Air cavity	0.05		0.180
	3	Rigid panel of medium-low density mineral wool	0.08	0.023	4.348
	4	Brickwork	0.12	0.84	
	5	Rigid panel of medium-low density mineral wool	0.06	0.036	
	6	brickwork	0.08	0.62	
	7	Plaster board of gypsum washable with paint	0.0125	0.16	0.078

Same U value will be used with different materials where the concrete block is used as economical choice.

The next chart will shows the result of load monthly and yearly.

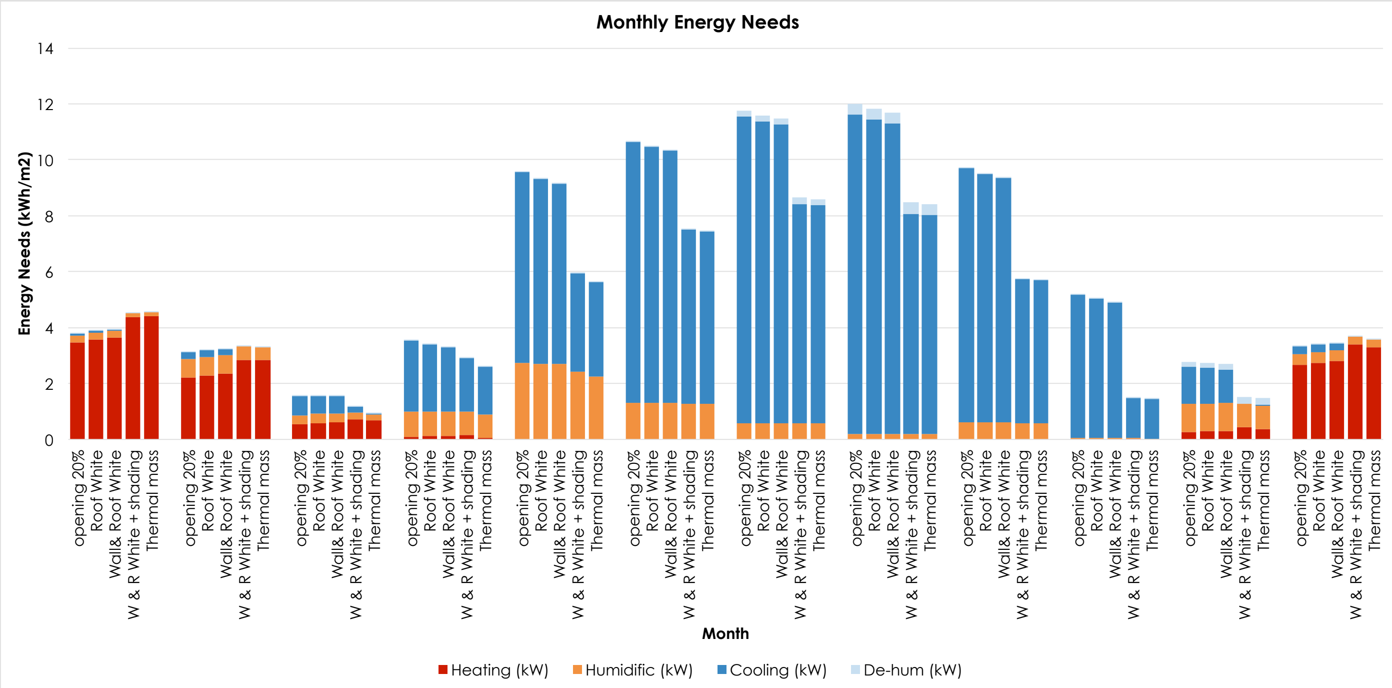
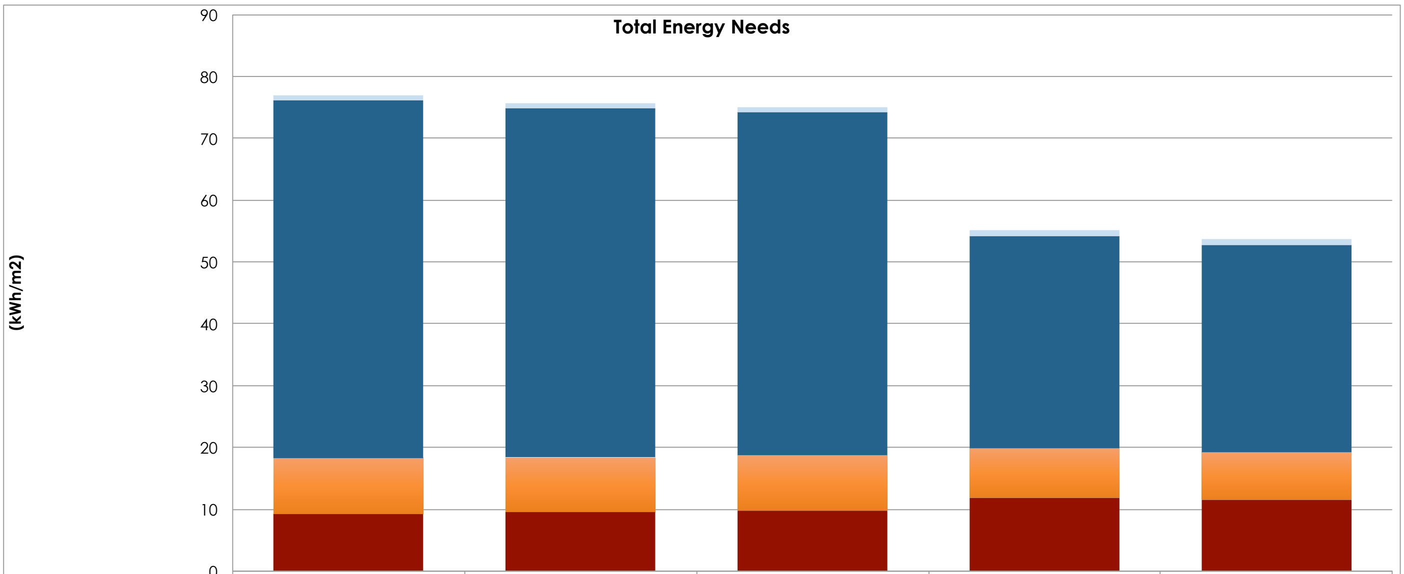


Chart: Monthly Energy Needs



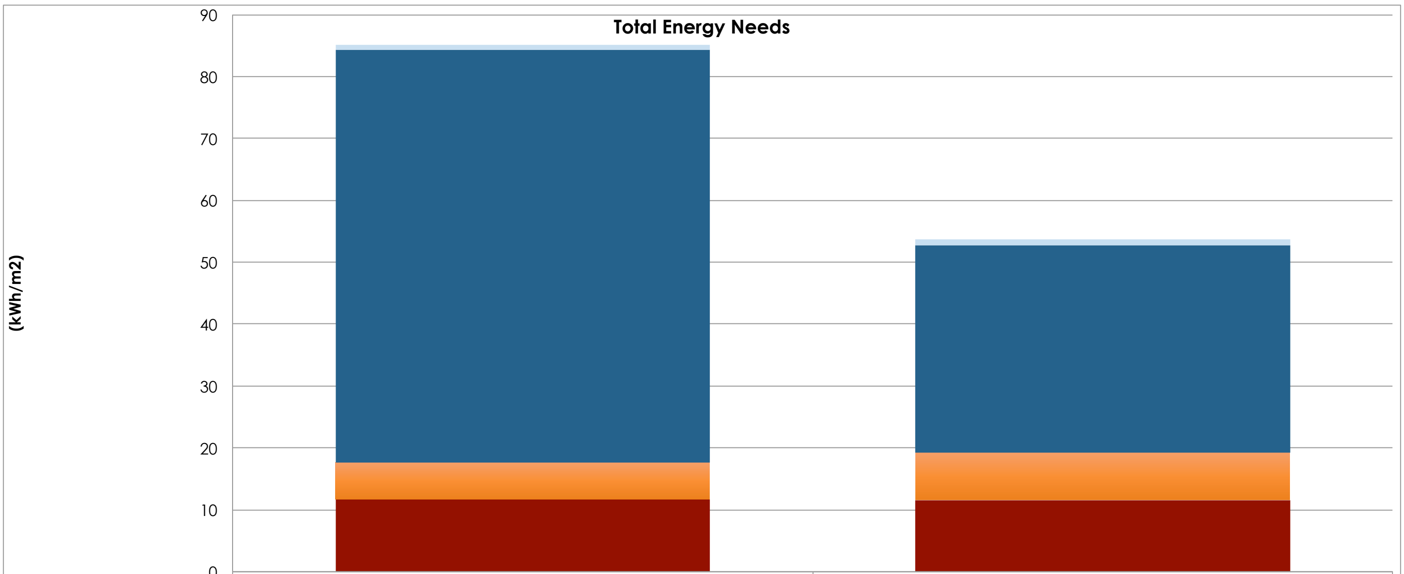
	opening 20%	Roof White	Wall& Roof White	W & R White + shading	Thermal mass
De-humidification (kW/2)	0.77	0.80	0.81	0.93	0.89
Cooling (kW/m2)	57.83	56.55	55.50	34.26	33.50
Humidification (kW/2)	9.05	8.78	8.89	7.97	7.70
Heating (kW/m2)	9.26	9.58	9.85	11.92	11.60

Chart: Total Energy Needs

As the result shows suficient decreasing by using white surface and summer shading system and larger thermal mass esspicially on the cooling load. The total energy needs decreased from 75 kWh/m2 to 53 kWh/m2 .

FINAL RESULT

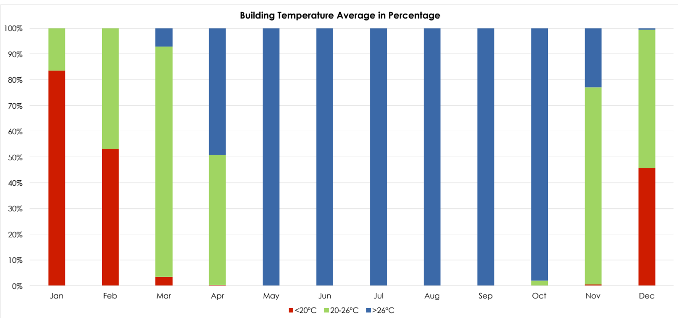
In this part are summarized the results from the starting point to the final solution. As it can be observed in the graphs the strategies are focused in decrease the cooling needs which are the main issue. The progressive reduction of the loads leads to a final value of nearly 54kW/m2 coming from an energy consumption of 85 kW/m2 which is a reduction of the 37%, all of that just by optimizing the envelope of the building.

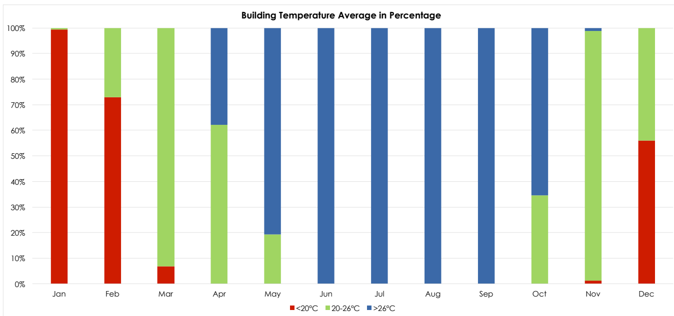


	Base Case	Thermal mass
De-humidification (kW/2)	0.72	0.89
Cooling (kW/m2)	66.67	33.50
Humidification (kW/2)	5.95	7.70
Heating (kW/m2)	11.73	11.60

Chart: Total Energy Needs

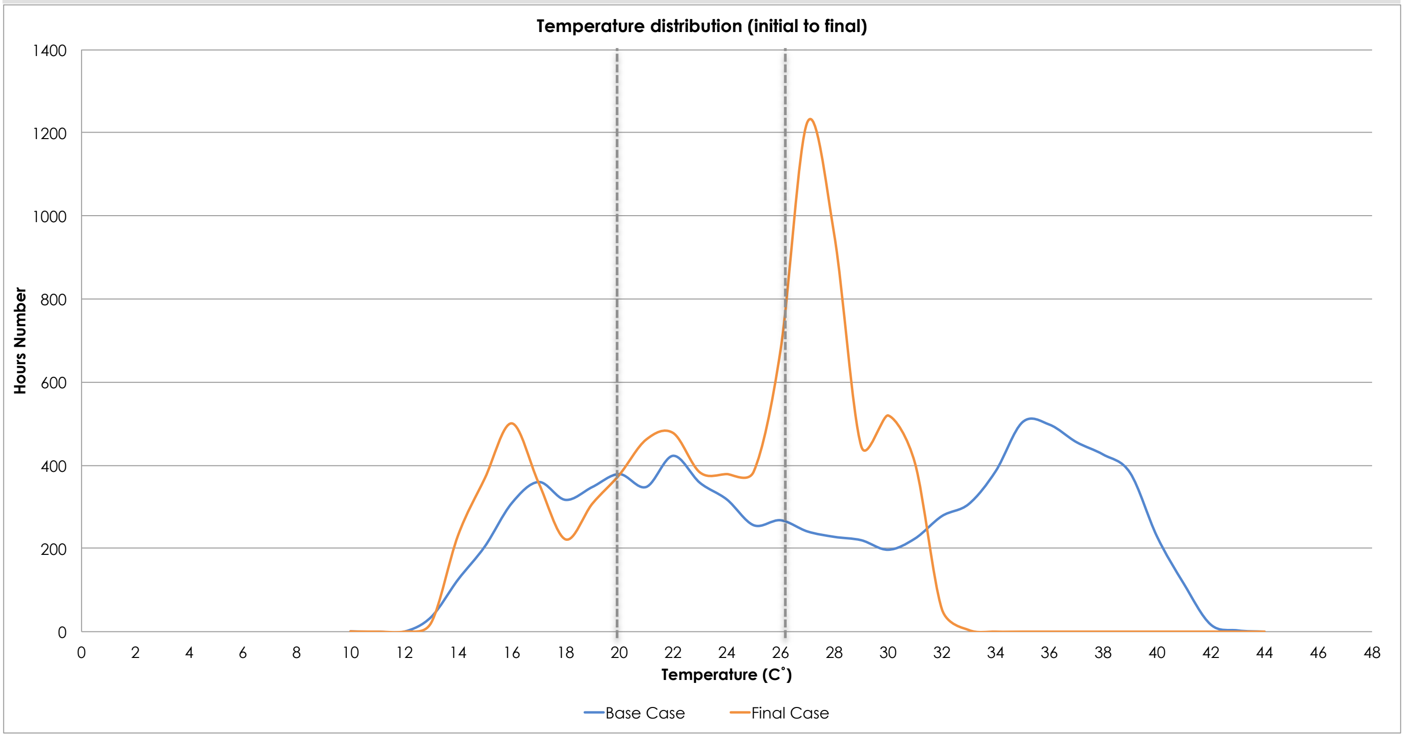
To end the analysis it has been analyzed again the free-floating conditions to see if the number of hours inside the comfort zone without plant has been increased.





As it is shown on the graphs the percentage of hours inside the comfort zone in the building have increased. In the initial case the 28% of the total hours were in the comfort zone while 35% in comfort zone after all optimizing processes.

Graph below shows the comparison of temperatures registered in free floating conditions, it can be observed that passively the building has a much higher frequency in the comfort boundaries, this allows for a lower energy consumptions and validates all the strategies and analyses done in this paper.



Graph: Frequency of Temperature

CONCLUSION OF ENERGY ANALYSIS OF FACADE PERFORMANCES

In this part the conclusion of the energy performances of the envelope will be sorted to have them as referance for the next steps of design:

- The external window area / wall area equal to 49%.
- The thermal transmittance of the envelope:
  - External wall U-value: 0.16 [w/m2.K]. (with cavity),(Thermal mass will be used)
  - Roof U-value : 0.288 [w/m2.K].
  - Floor U-value : 0.527 [w/m2.K].
  - Walls exposed to ground U-value : 0.3 [w/m2.K].
  - Floor exposed to ground U-value: 0.343 [w/m2.K]
  - Internal walls U-value: 0.321 [w/m2.K]
- The windows consist from double pane of 6 mm each with argon cavity, while the frames has 20% of the total area of the window and the opening part has rang between 20% to 40%.
- The external mateiral of the roof and the walls have to be between light gray to white with emmisivity equal to 0.8 and absorptance of 0.2.
- A fixed shading system related to the summer monthes (May-September) allow to limit the solar radiation esspicially the noon time (between 600 - 300 w/m2).

PARAMETRIC DESIGN OF ENVELOPE AND SHADING SYSTEM

The aim of this chapter is to design an adaptable facade for the building considering to control the solar gain, daylight and glare control in order to reach the building to the comfort zone. the facade will consist different types of opaque and open shaded elements. The main goal is to design a fixed facade, able to increase the internal comfort for residances, controlling the daylight and glare, controlling the internal air temperature and allowing the visibility to the out view.

Starting from the definition of the parametric design, it is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the relationship between design intent and design response. Parametric design is a paradigm in design where the relationship between elements is used to manipulate and inform the design of complex geometries and structures.

The term parametric originates from mathematics (parametric equation) and refers to the use of certain parameters or variables that can be edited to manipulate or alter the end result of an equation or system. The parametric modeling systems can be divided into two main types: Propagation-based systems where one computes from known to unknowns with a dataflow model.The second is the constraint systems which solve sets of continuous and discrete constraints.

The software that will be used in this point is Grasshopper, which is a visual programming language and environment developed by David Rutten at Robert McNeel & Associates,that runs within the Rhinoceros 3D computer-aided design (CAD) application. Programs are created by dragging components onto a canvas. The outputs to these components are then connected to the inputs of subsequent components.

Rhinoceros®
NURBS modeling for Windows

Grasshopper is primarily used to build generative algorithms, such as for generative art. Many of Grasshopper's components create 3D geometry. Advanced uses of Grasshopper include parametric modelling for structural engineering, parametric modelling for architecture and fabrication, lighting performance analysis for eco-friendly architecture and building energy consumption.

grasshopper

CASE STUDY1: BROADWAY HOUSING

- **Location:** Santa Monica, CA,USA
- **Architects:** Kevin Daly Architects

The objective of this housing project is to provide low income families that work on the Westside of Los Angeles with affordable housing that is both environmentally and economically sustainable. The design clusters economical, repeatable housing blocks around the canopy of an existing shade tree.




One facade of each building was given an expressive treatment featuring projecting green hoods that are angled to provide solar shading. According to Daly, these higher performance details are appropriately balanced with the rest of the more understated surfaces. "That seems like a good equation for affordable housing: 75 per cent economical," said the architect.

A number of sustainable techniques are incorporated into the design:

- a green roof that insulates and slows runoff
- custom window frames from aluminum that protect units from solar heat gain
- canted wall panels that breathe and release heat
- a vegetative screen wall that insulates and reflects noise
- a 15,000 gallon underground cistern that collects rain water for irrigation.
- formaldehyde-free insulation, and low VOC paint.
- As a result of smart planning and integrated sustainable design the thirty-three units do not have air conditioning, yet remain a comfortable temperature throughout the year.

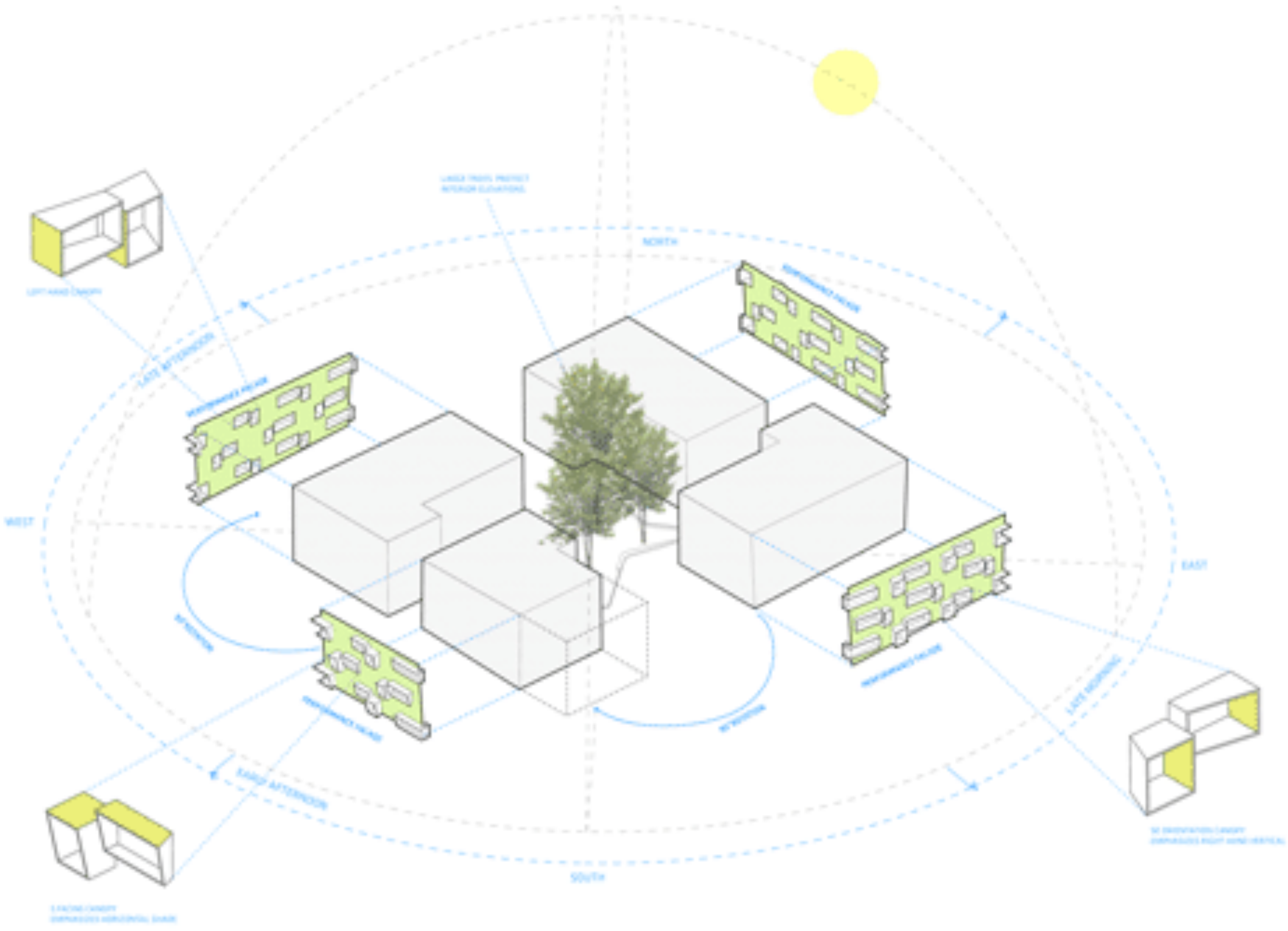


Figure: Sun Arc Diagram

As the diagram shows, each façade has difference type of shading divice where they respect the solar orientation in order to minimize the gain on radiation.

CASE STUDY2: URBAN RURAL

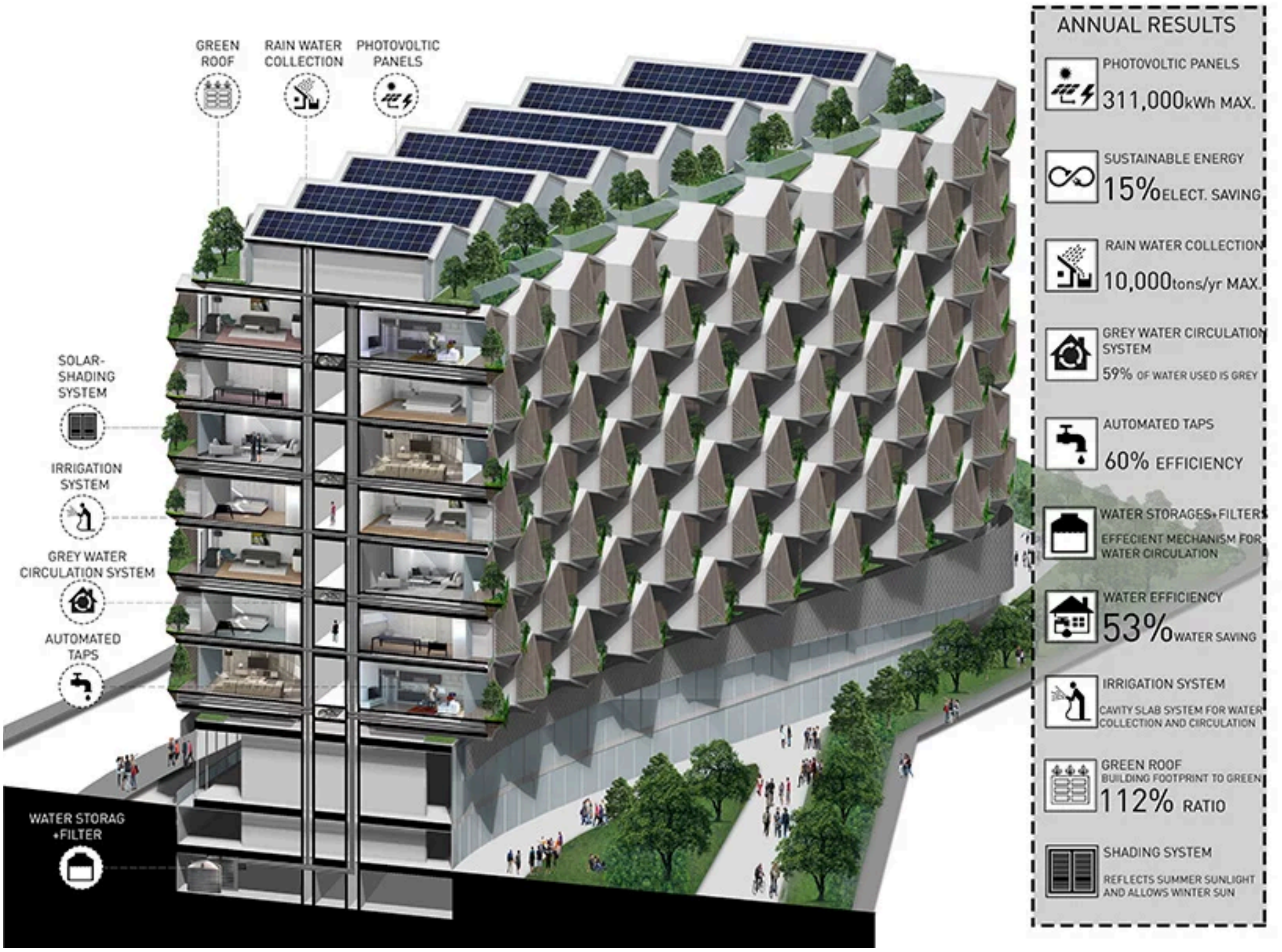
- **Location:** Istanbul, Turkey.
- **Architects:** Eray Carbajo

Urban Rural is a new typology of urban living set to become a benchmark for future development in Istanbul, Turkey. The vision behind Urban Rural is for a hybrid model of living, combining close proximity to urban centers with the lush landscape of rural life. Challenging the status quo of typical residential typologies, the scheme will consist of modular hexagonal units with triangular gardens, forming an active façade designed to become a future landmark for the city.

The architectural form of Urban Rural is dominated by its unique, hexagonal, modular residential units. Each hexagon unit consists of a polygonal area for living, and a triangular cavity to be used as an irrigable garden. When units are combined, the triangular cavities act as a truss structure, creating an interdependency between building systems, structure, landscape, and aesthetic. Sustainability is central to the scheme, with a combination of locally sourced materials and an efficient component-based modular design enhancing the scheme's environmental and economic viability.

The integration of various systems makes for an efficient and sustainable building:

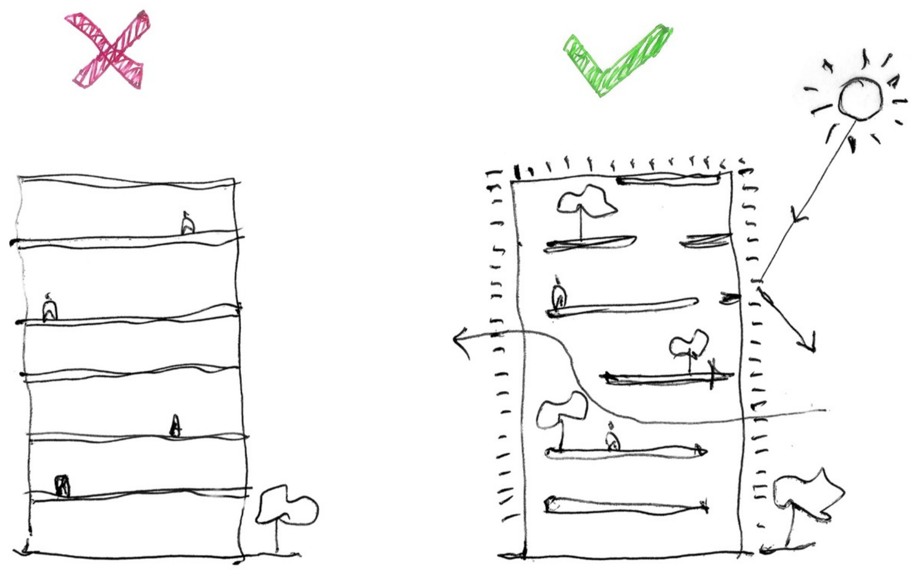
- Photovoltic Panels gives a part of the energy needs of the building (311 kWh/yes).
- Sustainable Energy saving of 15%.
- Shading system reflects summer sunlight and allows winter sun.
- Rain water collection.
- Green roof



- **Location:** Đông Anh, Hanoi, Vietnam.
- **Architects:** H & P Architects

The concept of the project is A "properly breathing" where it is a solution of suffocatingof buildings in the city, buildings as often found in newly planned, stuffy urban areas characterized with land plot subdivision for building row houses. Featured in both living and working space, a "properly breathing" house serves as a solution to the quality improvement of used space by creating a natural sense of breathing rhythm in monsoon tropical conditions, which is attributed to the two built-in functions: The Inside and outside. The inside offers many voids while the outside has double-skin facade including the inner layer as all-glass panels; the between as corridor for movement; the outer layer as recycled ceramic bricks (40cmx40cm). Pot plants are also randomly arranged to absorb the humidity and mitigate calorific radiation.

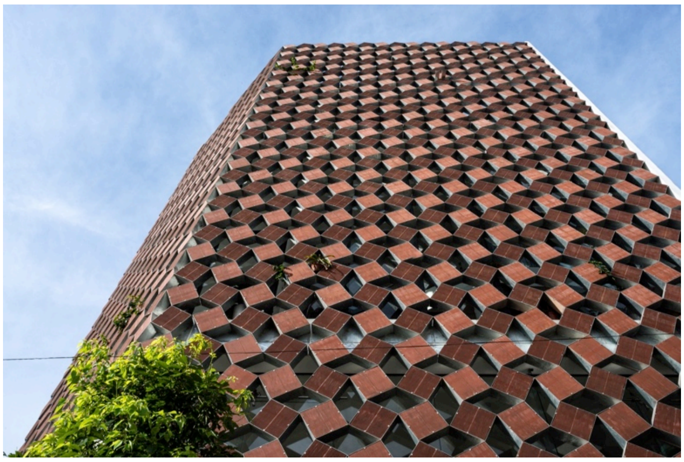
Together with the inner duplex, the layer of ceramic bricks is to purify dust and smoke, suck in fresh air and take heat away through open panels alternated with pot plants on the facade. This filter helps revitalize the architectural space by balancing the breathing of human and nature, and promoting the connection and interaction between the inner and outer scenery, roofs with creepers above and pot plants and vegetables below, sunlight and shade.
As a breathing space is only considered an existence; therefore, a properly breathing space is required so that it can breathe properly towards a healthy life in both natural and socio-cultural habitat particular to each region. In this sense, the properly breathing house is expected to contribute to highlighting the local architecture in a current global context.

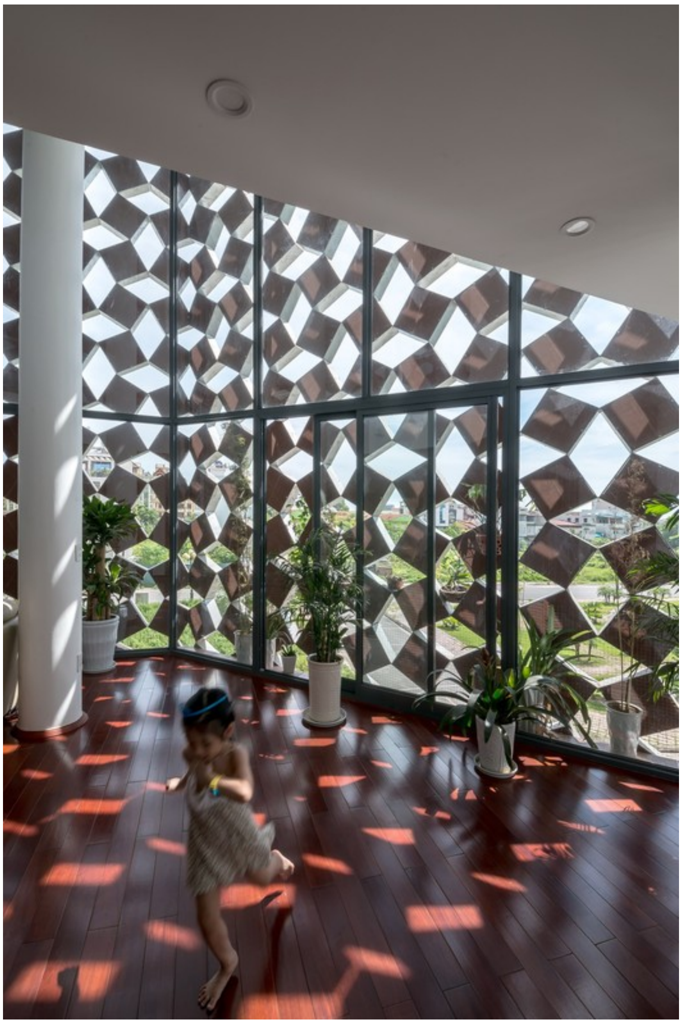


"suffocating" buildings — a properly breathing house

The shading system consist of framing included a ceramic bricks allows many benefits on the glazing:

- Allow to decrease the humidity of the air passing to the internal zones
- Decrease the solar radiation gain
- Allow to have high ventilation ratio with lower air temperature
- Purify the air from the dust and smoke which allow to the fresh ari pass to the internal zone.



In order to find an expressive concept to the façade shading can be link to the solar radiation and the daylight passing to the zone, the starting is to find the most used shapes in the city culture and the buildings. The building of the historic city of Damascus is influenced to a great extent by the Islamic architecture, which is poisoned by the Ottoman heritage as it was one of the ottomanic cities before 1900, and after that some building effected by the french architecture.

Figure: Al Hijaz Train Station

To extract the concept, architectural elements of facades in Damascene houses can be retrieved. One of those elements is the windows where it was only in the first floor not in the ground, they were using (Mashrabia) for the women living rooms and (Khoss) for the normal windows of the bedrooms.

Mashrabiya is an architectural element is the emergence of the rooms on the first floor or higher, extends above the street or inside the courtyard of the building (in houses with courtyards moderation). Mashrabiya built of carved wood and ornate and lined with colored glass. Mashrabiya is considered one of the elements of traditional desert architecture in the Arab country's warm, their appearance in the sixth century began (third century AD) during the Abbasid period, and continued to be used until the early twentieth century. Mashrabiyya frequently used in traditional palaces and houses (residential buildings).

While the Khoss consist from wooden strips crossing each other creating angular shapes voids.

Figures: Mashrabya In Damascus

Figures: Khoss In Damascus

Uses of Mashrabiya

- Temperature
  - Summer

The biggest cause of rising temperatures in the interior architectural spaces is the direct heat gain from the sun, and therefore it is advisable to avoid radiation falling on the windows at an angle a big fall and directly, and only surface reflected less dense which does not cause heat gain inside. Since mashrabiya allowed large holes in the walls, it has become possible steady stream of air that passes through small openings into the rooms, which helps users place on the heat loss from the body through sweating.

  - Winter

The design of the tracks and slots mashrabiya to sunlight allows winter access to the interior architecture vacuum, where the design of these openings and taking into account the corners of the fall of the sun in winter (where they are closer to the ground), and thus increases the degree of the interior heat .an points and residents feel mashrabiya shift from tool to soften the hot air into an instrument to keep winter temperatures are a critical point, so be on the literal and architectural be understood completely mashrabiya work and responsiveness to the sun in both seasons.

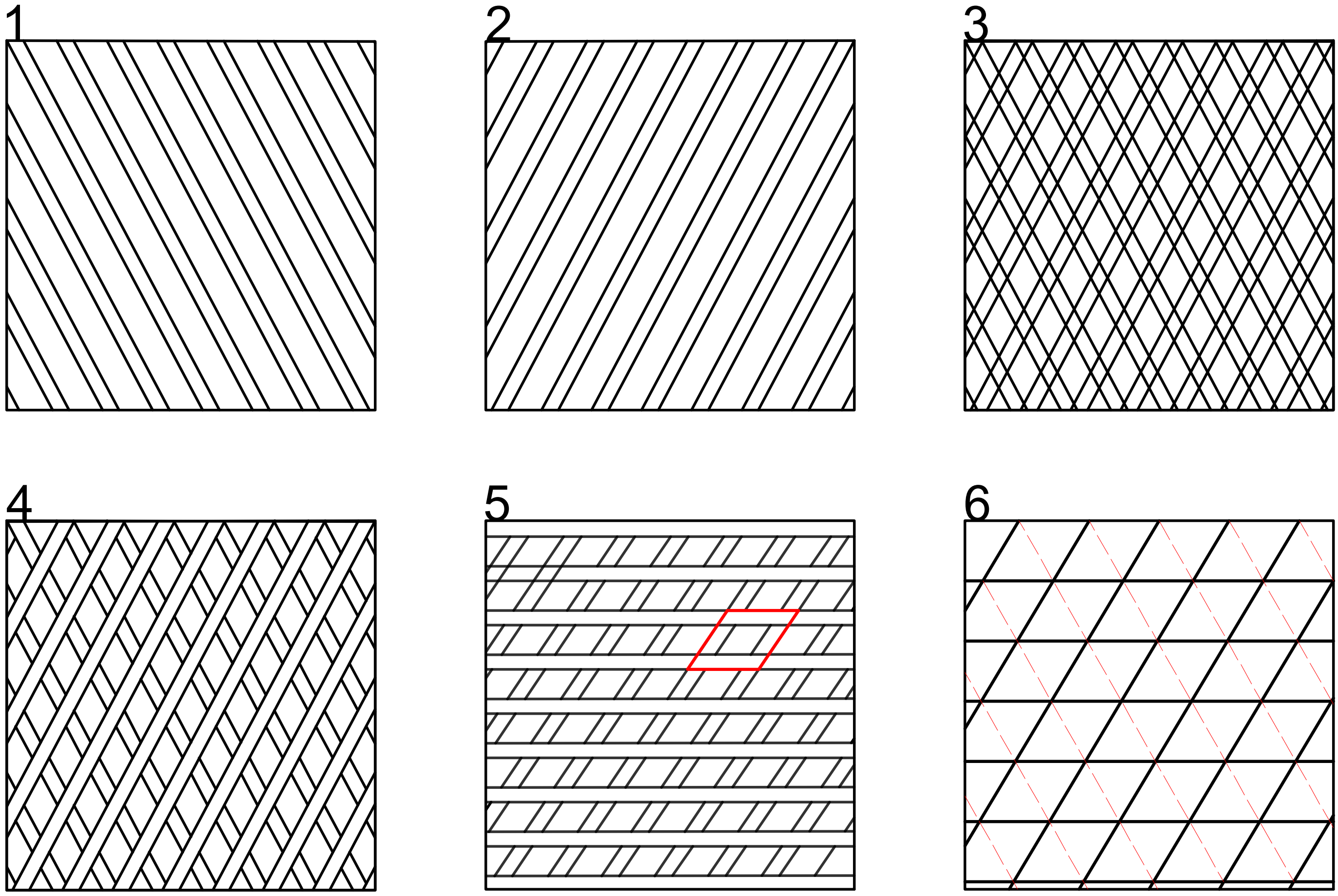
- The passage of light.

The designer can choose the size and spacing of the rods suitable bay, which covers a hole in the facade so that the object of direct solar radiation, in the southern interfaces used clip a small distances part. it reduces the gradient in the light intensity (gradient resulting from a fall on circular rails section) of the unit contrast between dark bars (impermeable to light) and the intensity of the glare between them, so the eye of the beholder does not dazzle of this contrast between black and white, as opposed to what happens when you use breakers sun .
Preferably mashrabiya which lies on the human level close to bars to each other, to increase the fractures in the light passing through them, decrease the dazzling output of the sun's rays and components mashrabiya, and to compensate for the lack of lighting on the lower level, it is preferable to increase the distance between the rails as we head to the top.

- Providing privacy for residents.

In addition to the physical effects, mashrabiya provides privacy for residents, while allowing them at the same time given to the outside through them. This supports the use of mashrabiya parts, where the bottom ensures privacy, while the air flow over the top of them. This gives mashrabiya psychological dimension where dwells a great feel it is separated from the outdoor spaces, without loss of solitude factor, which gives the resident a feeling reassured.

Now, from the the shape of the upper pictures of the wooden strips (Al Khoss), it is possible to create the concept of the shading system where the same properties of its funtion is needed as they sorted in the upper part.



Figures: Elicitation of the concept

By starting from the details of the wooden cover (Al khoss) of the windows in the historical building in Damascus, it is possible to derive the concept. In the upper figures (1) and (2) they shows the two angles strips in both direction. By applying them over each other as figure (3), the result is the final shape of the wooden cover. In order to have flexible shape, by rotating the pattern with angle of one strip to have it in the horizontal direction as figure (5) and get the final shape of the chosen pattern as parallelogram. The final result of the pattern as figure (6) shows how many parallelograms mix together to have them in uniform pattern.

The pattern of this shape can be flexible to provide the facade its need, so shading related to the summer solar radiation to limit the solar gain, visible view for the residence, architectural point of view derived from the Damascus history.

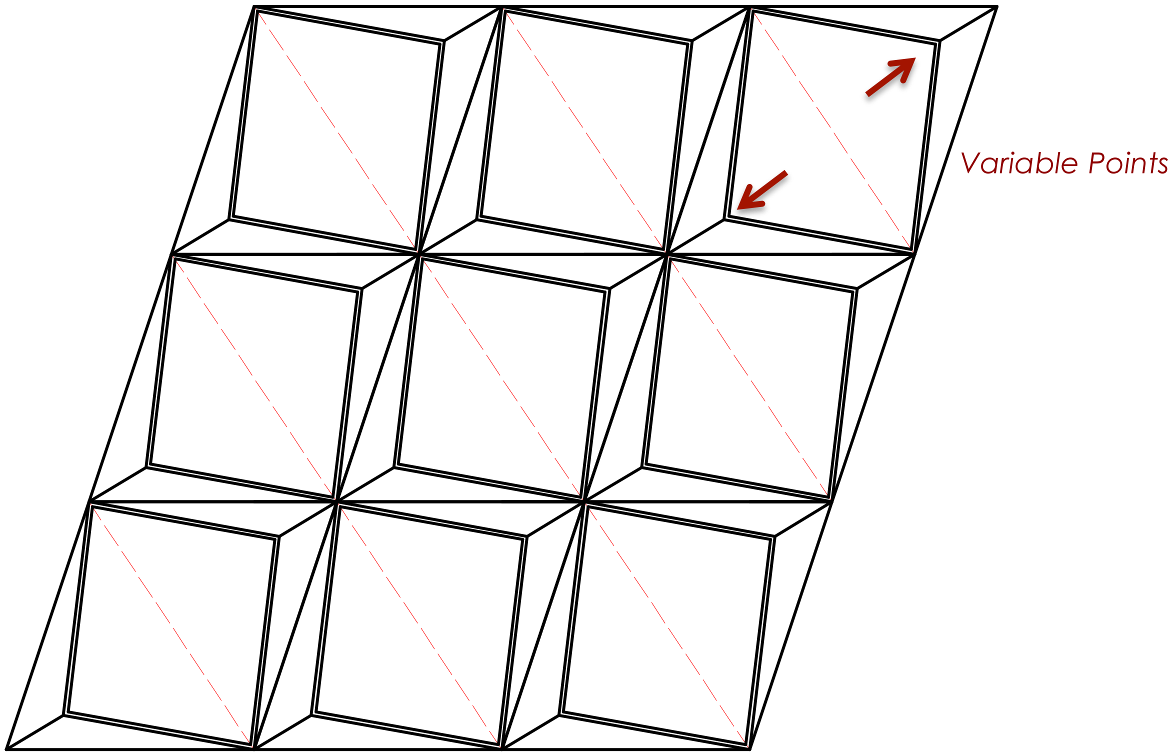


Figure: The chosen pattern in final shape

In the upper figure, it is shown up how the parallelograms made a mesh of structure while 2 variable points can create the surfaces which they block the direct solar radiation the diffuse. The variable points can move in the X,Y,Z direction with different distances as each façade needs creating surfaces with or without slope to block as much as it can from the solar gain.

SOLAR RADIATION ANALYSIS

The aim of this point is to control from the external environment and the internal one, It is very important to check the sun path on the site and the effect of the solar radiation on the facades. So this analysis have been done in order to understand how direct and diffuse solar radiation change in the different direction facades.

As the previous part of IES-VE analysis for the shading system, the months of the year are separated into two part, April to September as a cooling period and October to march as heating period.So the main goal now is to define a shading system able to block as much as it can from the solar gain between the months 4-9 and allow for it between 10-3.

The analysis in this part have been done by Ladybug plug-in which it allows to import a standard EnergyPlus Weather files (*epw) into Grasshopper and provides a variety of 3D interactive graphics/metrics, including: Sun-path, wind-rose, radiation-roses, radiation analysis, shadow studies, and view analysis.

- The first analysis is to check graphically the hourly global, direct and diffuse solar radiation in the city of damascus in each month.

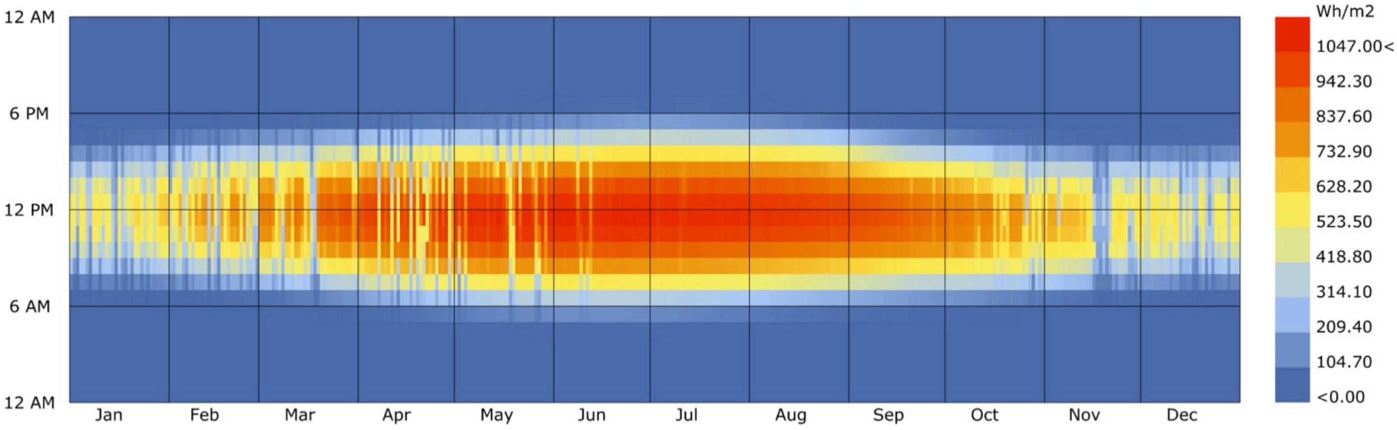


Chart: Global Solar Radiation on horizontal surface (Wh/m2)

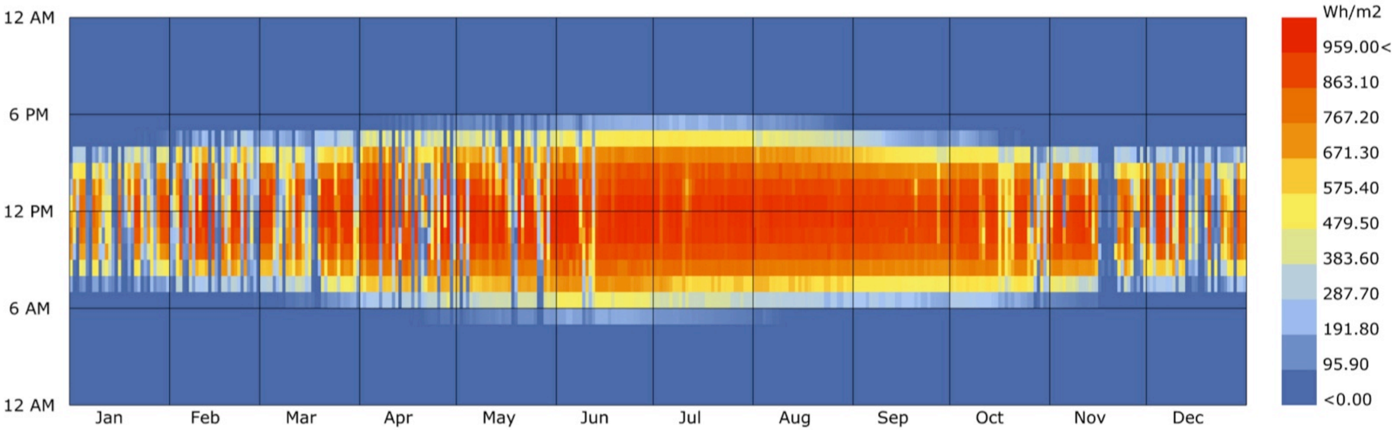


Chart: Direct Solar Radiation horizontal surface (Wh/m2)

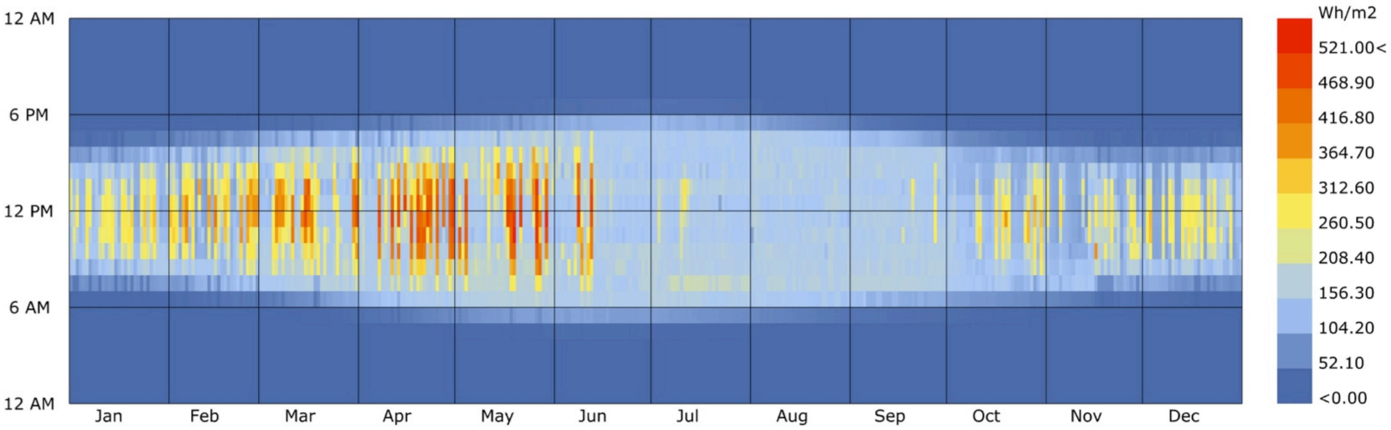


Chart: Diffuse Radiation horizontal surface (Wh/m2)

The upper graphs show that high amount of solar radiation in the summer months between April and September in hours of all the days between 8:00 and 17:00. From this point, it is possible to determine the next analysis between this range. Also by going back to IES-VE the highest load of cooling was in this range where the free floating analysis has high temperature.

- The second point in the analysis is to check the sun path and the position of the sun in the year. The position of the Sun is a major factor in the heat gain of buildings and in the performance of solar energy systems. This point lead essential for decisions in the summer shading design. especially in this case because the need of solar gain in winter is very important.

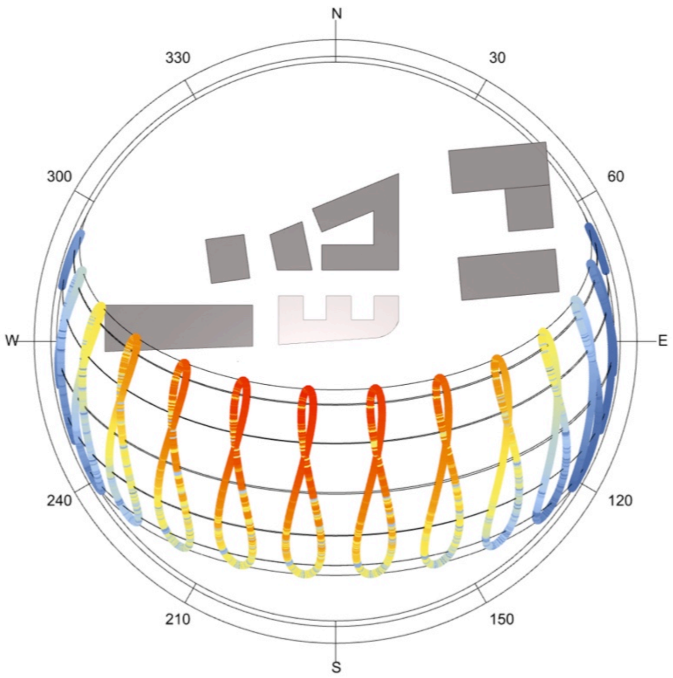


Figure: Sun Path – All year hours

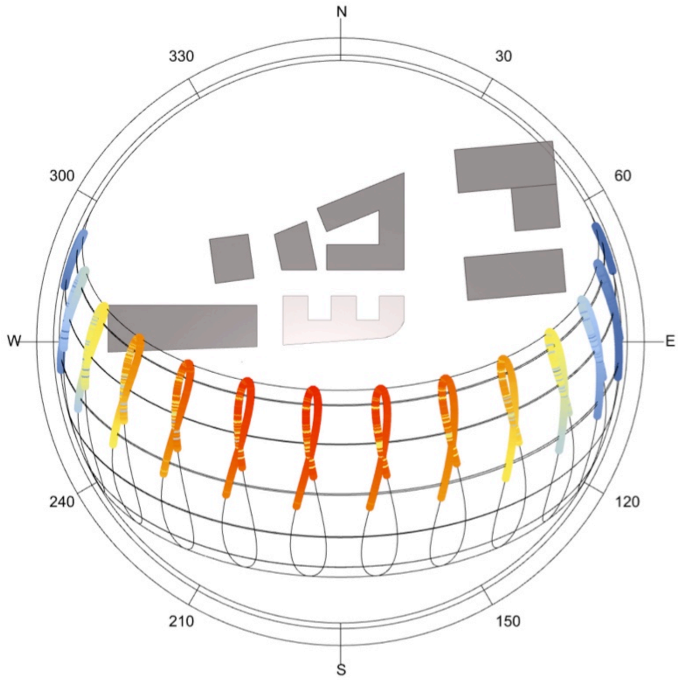


Figure: Sun Path – Apr to Sep

By linking each hourly sun position with the global solar radiation, certainly, what was mentioned earlier that the shading system must be effective during this time of the year while blocking the minimum in the rest of the year.

The next step of the analysis will be more accurate, to check the solar radiation in each surface of the building.

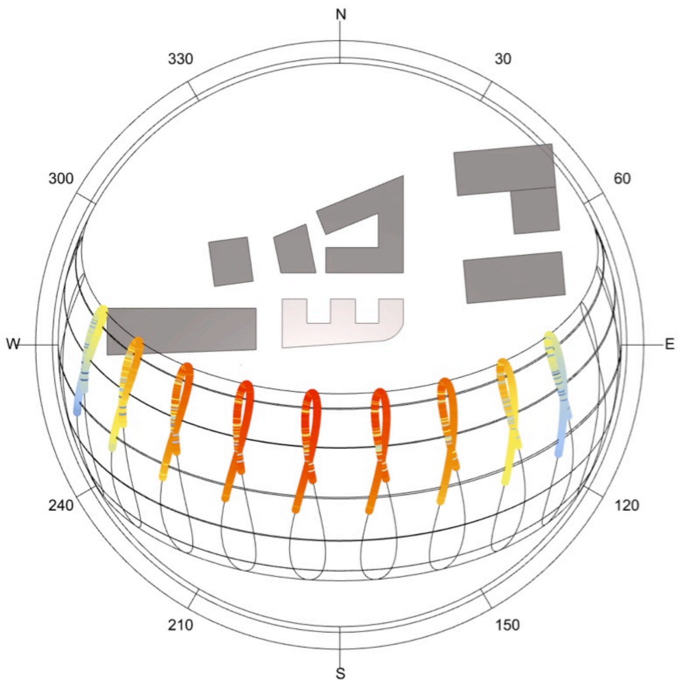


Figure: Sun Path – Apr to Sep – 8:00 to 17:00

- The third point of the analysis part, it will be useful to check the total energy per year that hitting the surfaces of the building from all direction in each square meter. this allow the design of the shading system to be more acurate on the glazing part. Also to know the behavior of the context shadows on each surface of the building. the starting will be from the global solar radiation in the year then the global radiation in the cooling period months.

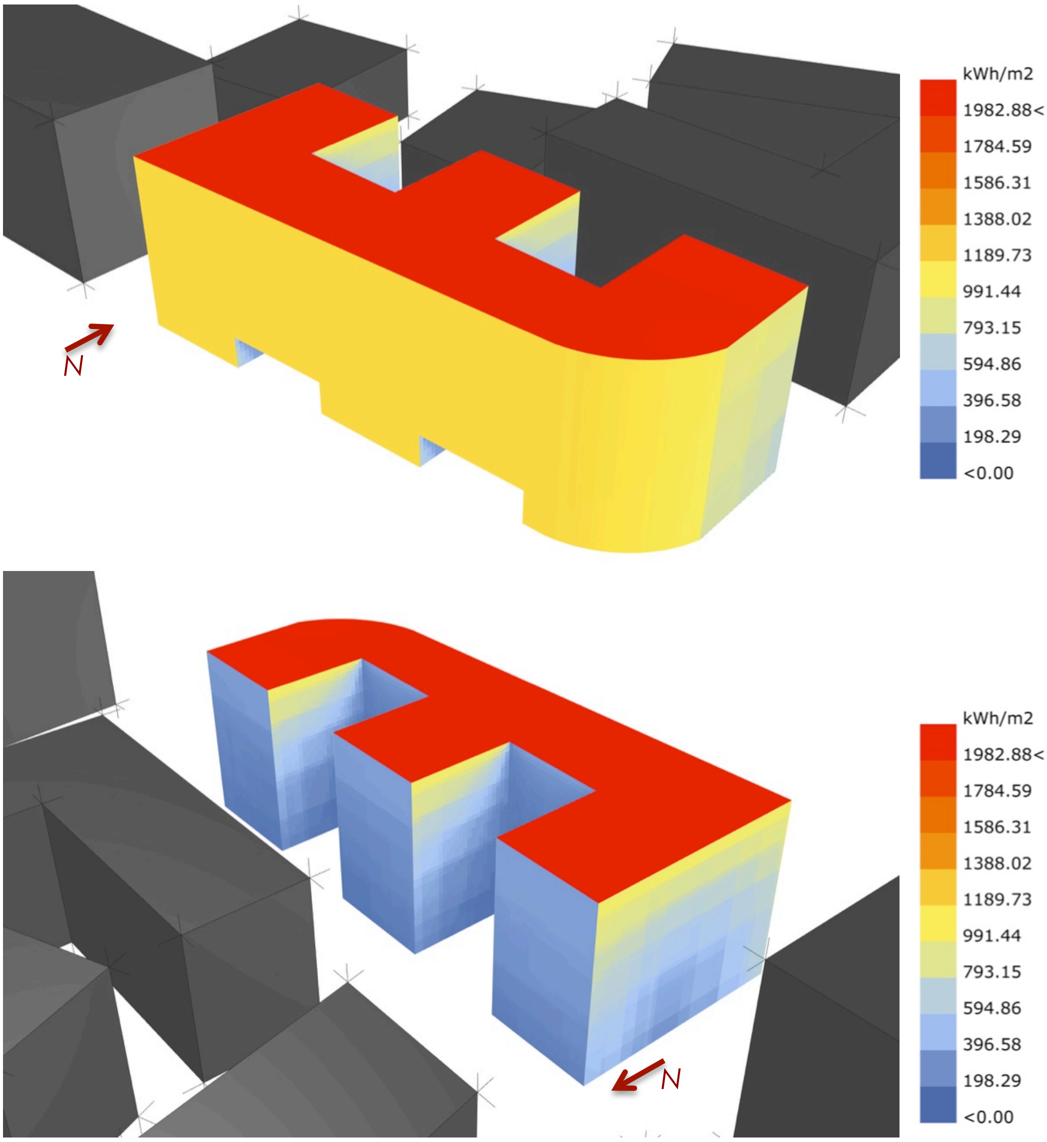
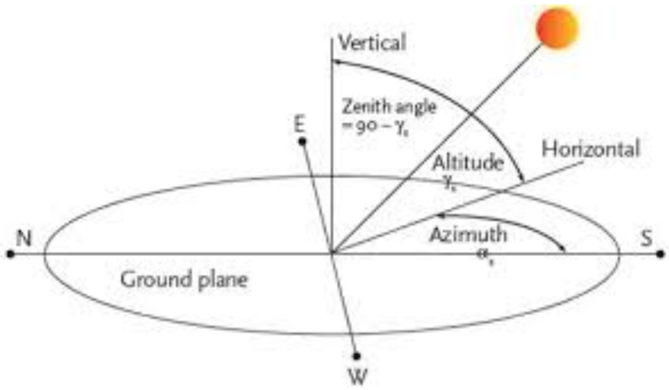


Figure: Global Radiation on each surface (kWh/m2)

As the upper figure shown, high amount of energy on the roof that it decreased by cover it by white surface as it has been explained in the part of IES-VE analysis. The southern façade hitted also by high amount of energy due to the altitude angle with the surface in winter



As the previous parts o the analysis, it is useful to check the solar radiation on the building surface in the cooling period that needs the shading system for more understanding the situation. In the lower figure the total radiation hit the sufaces from 1st of April to 30th of September.

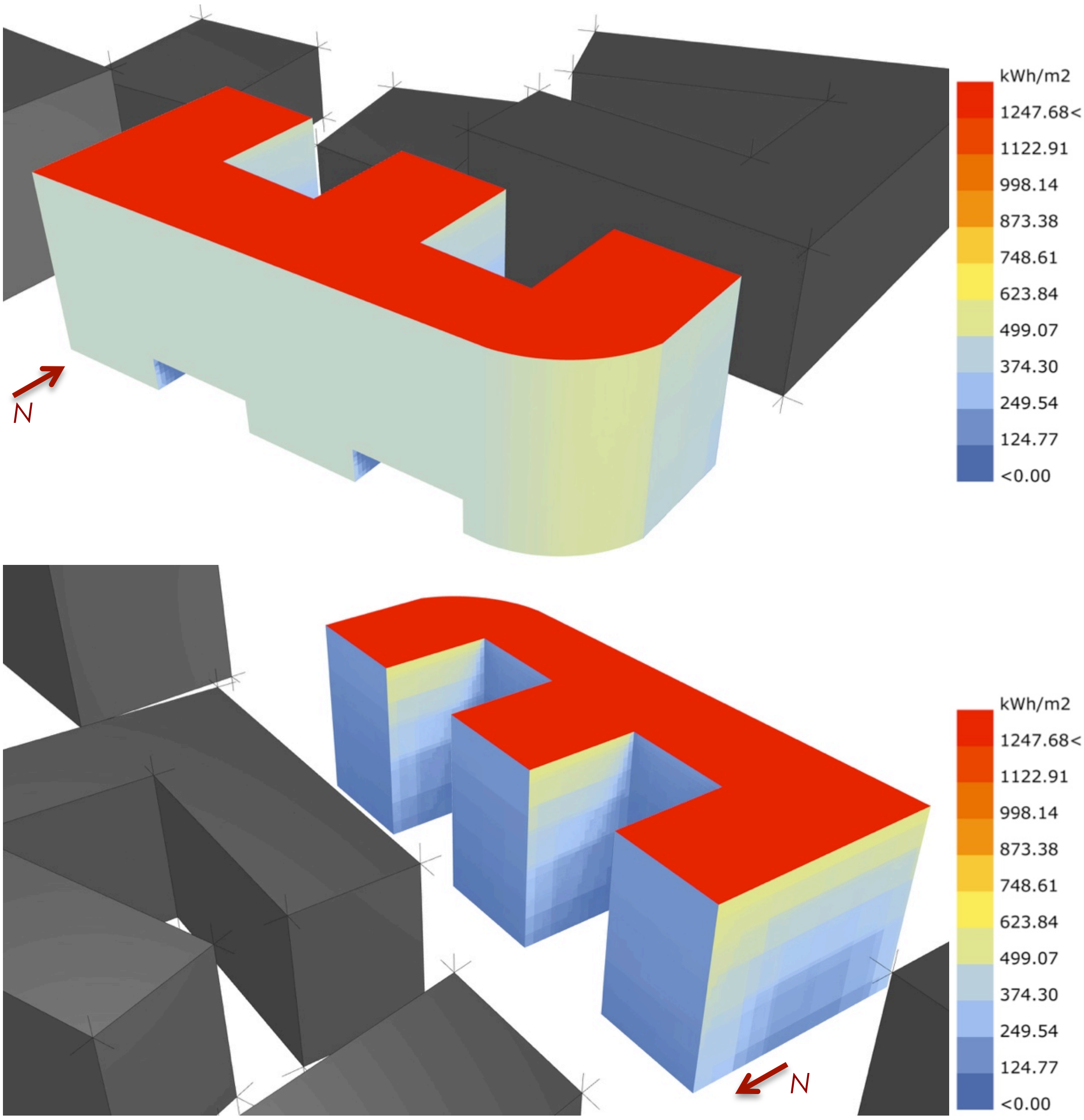


Figure: Global Radiation on each surface between Apr to Sep (kWh/m2)

As the upper figure shown, the eastern and southern façades hitted almost by the same amount of radiation energy due to the free space from their side while the back side of the building shaded by the context. This can give the design some strategies where the lowest floors of the building and the northern façade don't need for any shading system. But the decision will be taken after separate this global analysis to direct and diffuse to understand if this step could be good or bad.

As it has been explained in previous part, in order to decide the application of the shading system places on the envelope. the lower figures will showes the the direct and diffuse radiation effects on the envelope.

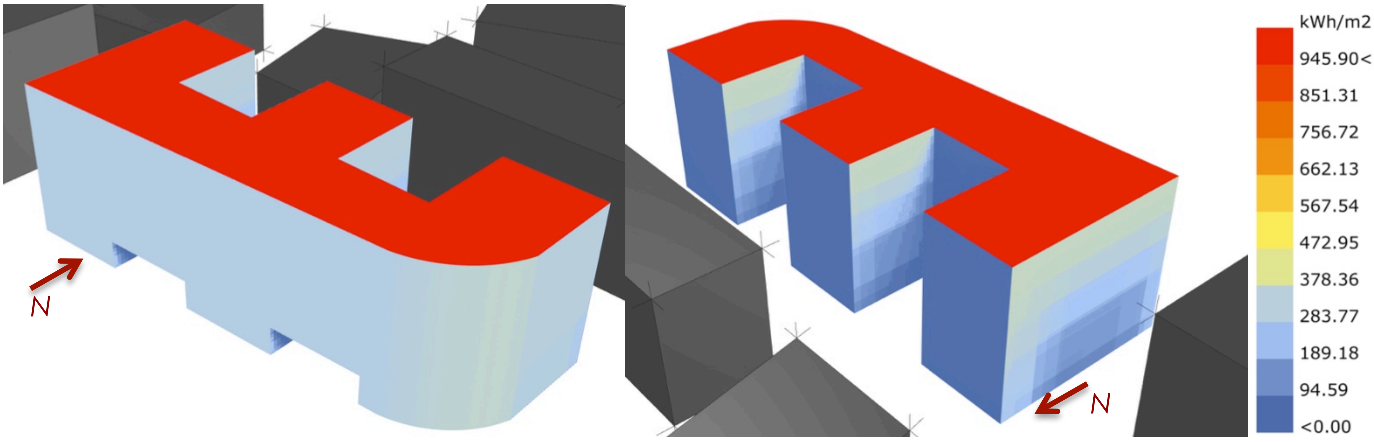


Figure: Direct Radiation on each surface between Apr to Sep (kWh/m2)

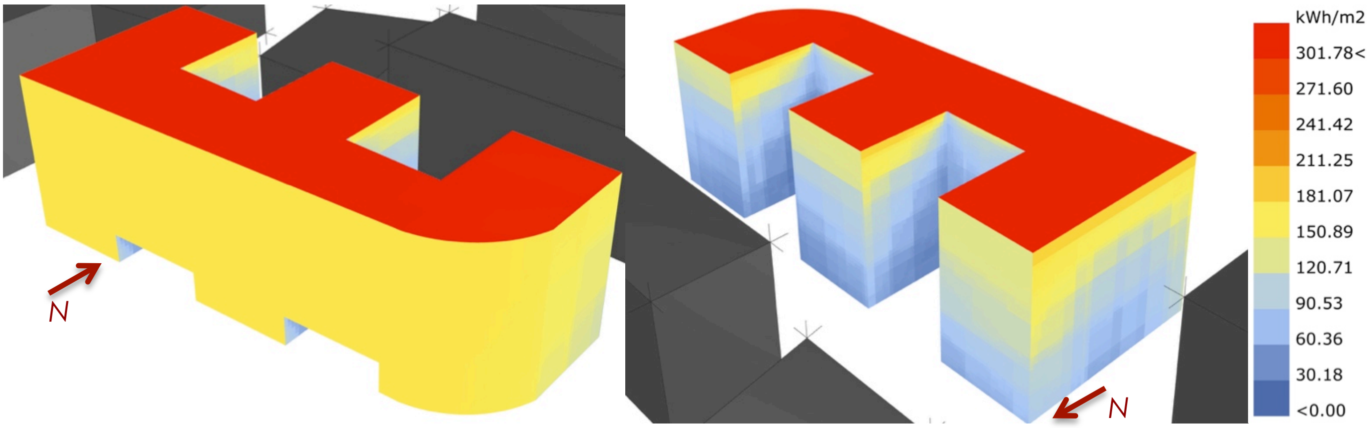


Figure: Diffuse Radiation on each surface between Apr to Sep (kWh/m2)

The conclusin of the Analysis:

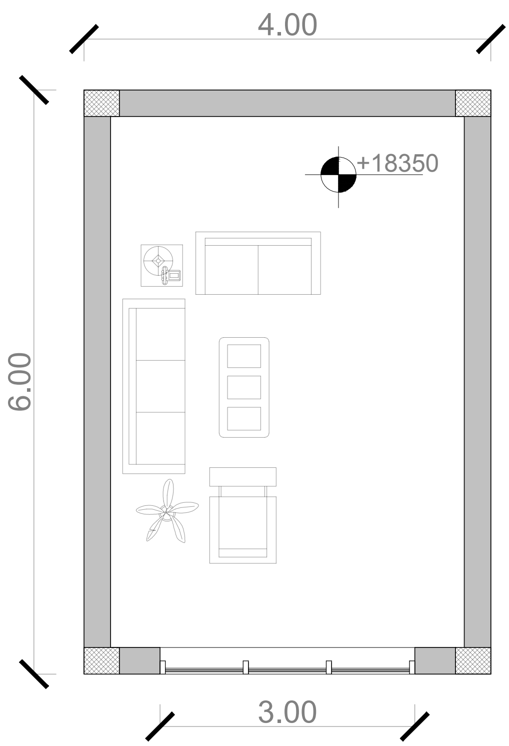
- the period that the shading system must be effective is between 1st of April to 30th of September taking into account to minimum blocking the solar radiation in the other months.
- the application on the facades:
  - South: totally shaded.
  - North: not shaded.
  - East: totally shaded.
  - Internal East facade: from 3^{rd} floor to 5^{th} floor.
  - West: from 2^{nd} floor to 5^{th} floor.
  - Internal West:from 3^{rd} floor to 5^{th} floor .

SHADING SYSTEM DESIGN

External shading device is much more effective than internal one because it blocks the solar radiation before it reaches the indoor environment. Nevertheless, there are only several primitive models for external shading devices which can only be applied in some traditional projects. The shading system is not just some beautiful panels applied on the facade It is a combination between science and architecture. When the shading system designed in a proper way it will work to decrease the energy consumption of the cooling loads esspicially in the projects in the middle east.

After all the analysis about the sun and the solar radiations on the surfaces of the building thanks to open source software (Ladybug), now the design process of the static shading system will use another open source software, a plug-in with grasshopper which is (Honeybee). Honeybee supports detailed daylighting and thermodynamic modeling that tends to be most relevant during mid and later stages of design. Specifically, it creates, runs and visualizes the results of daylight simulations using Radiance, energy models using EnergyPlus/OpenStudio, and heat flow through construction details using Berkeley Lab Therm/Window. It accomplishes this by linking these simulation engines to CAD and visual scripting interfaces such as Grasshopper/Rhino and Dynamo/Revit plugins. It also serves as an object-oriented Application Programming Interface (API) for these engines. For this reason, Honeybee is one of the most comprehensive plugins presently available for environmental design.

- **Inputs and parameters:**



In order to define the configuration of the shading system for each facade, starting by modelling a room in the last floor has area withen the average of the living rooms in the project in grasshopper with dimension of (6m x 4m) which it the dimension of the structure module building. From the conclusion of the Sefaira chapter says the living zones has a window of 3m width and 1.7 hight with frame area of 16%. all of those parameters have been took into account in the modelled room.
the room walls, ceiling and roof tooked as adiabatic properties.

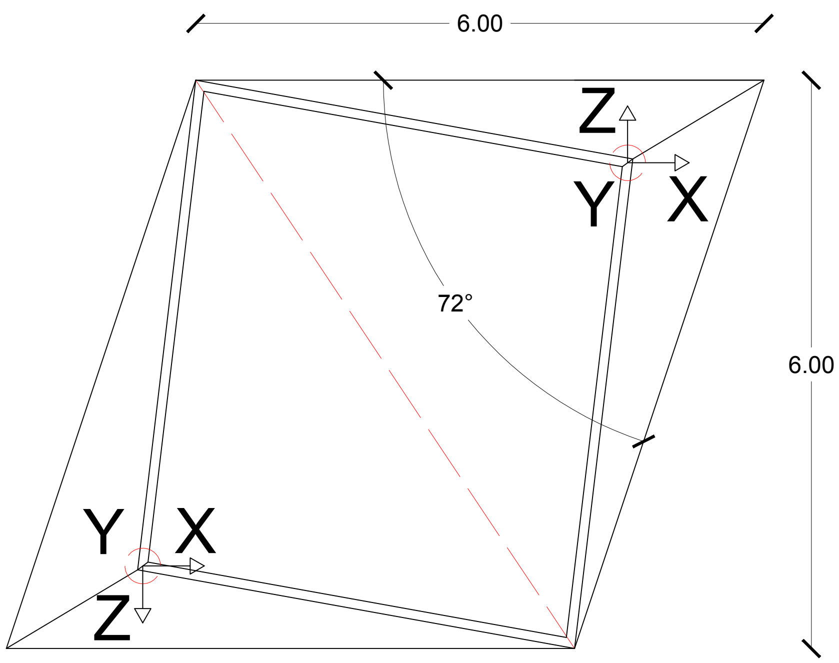
In the tables below are reported all the values used as inputs and parameters to run the simulations.

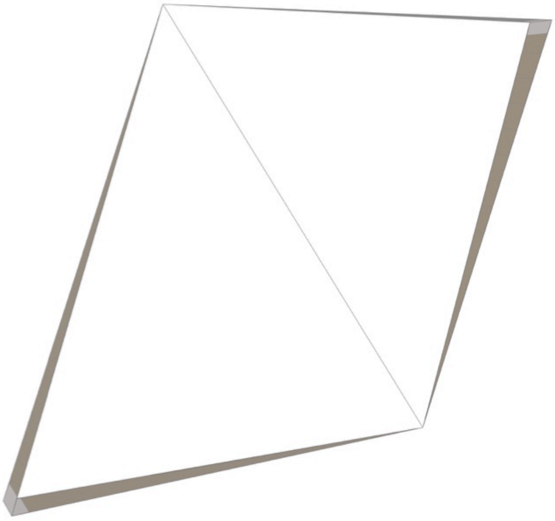
For the window has been chosen a real product, optimized according to previous thermal analyses done with IESve software: the insulated glass unit is com- posed by an external clear glass of 6 mm and an in- ternal low emissivity glass of 6 mm. The frame is in PVC. The data which are not present in data sheets have been obtained from the software Optics and Window.

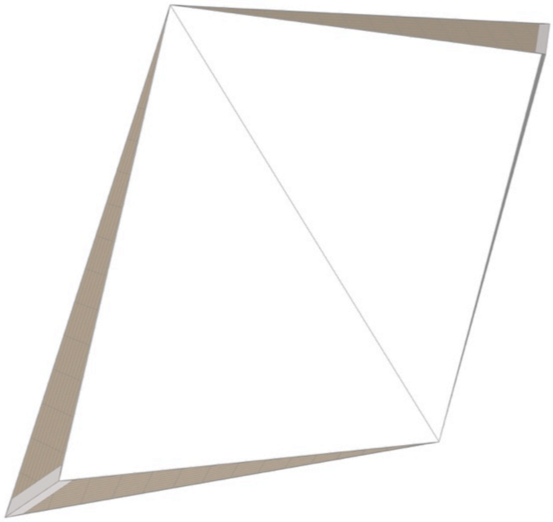
Glazing Surface	
Dimension	3m x 1.75
Total U-value	1.6
SHGC	0.693
Refractive Index	1.520
Frame area	20% PVC frame

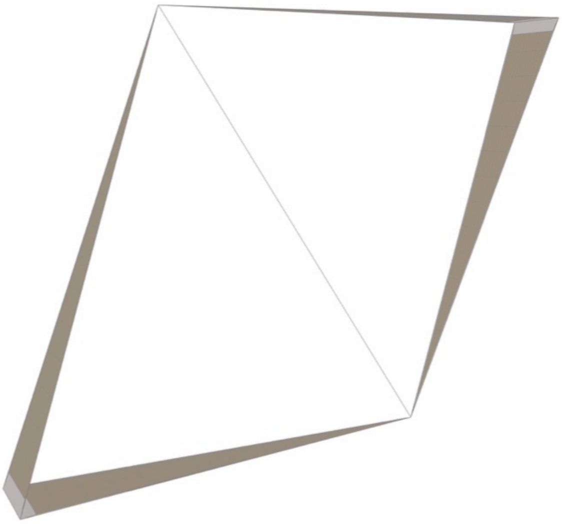
- **Possible configuration:**

The pattern concept lead the design to have various configuration by two the variable points. The dimension of the base is 6cm by 6cm is a constant dimension while the free point can change the area of the shading panels. This pattern will cover the modeled window with a distance of 15 cm .

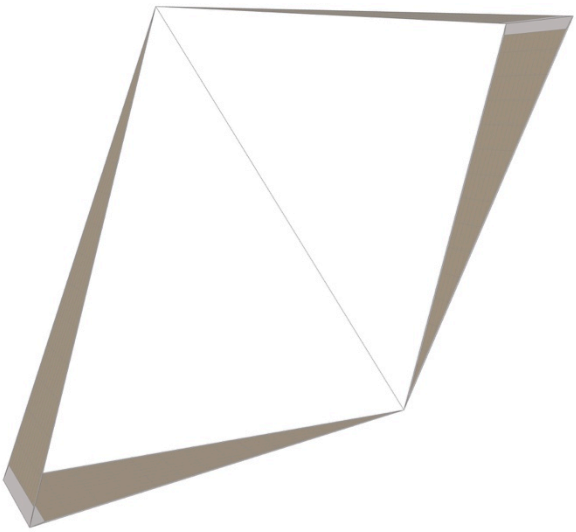


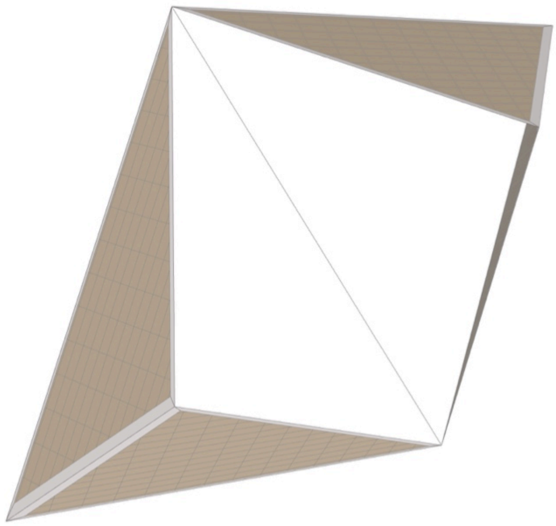

1.A: 5cm with out slope


1.B: 5cm with slope of 45˚


2.A: 10cm with out slope


2.B: 10cm with slope of 45˚


3.A: 15cm with out slope


3.B: 15cm with slope of 45˚

- **Solar gain transmitted through the window in each configuration of shading system analysis:**

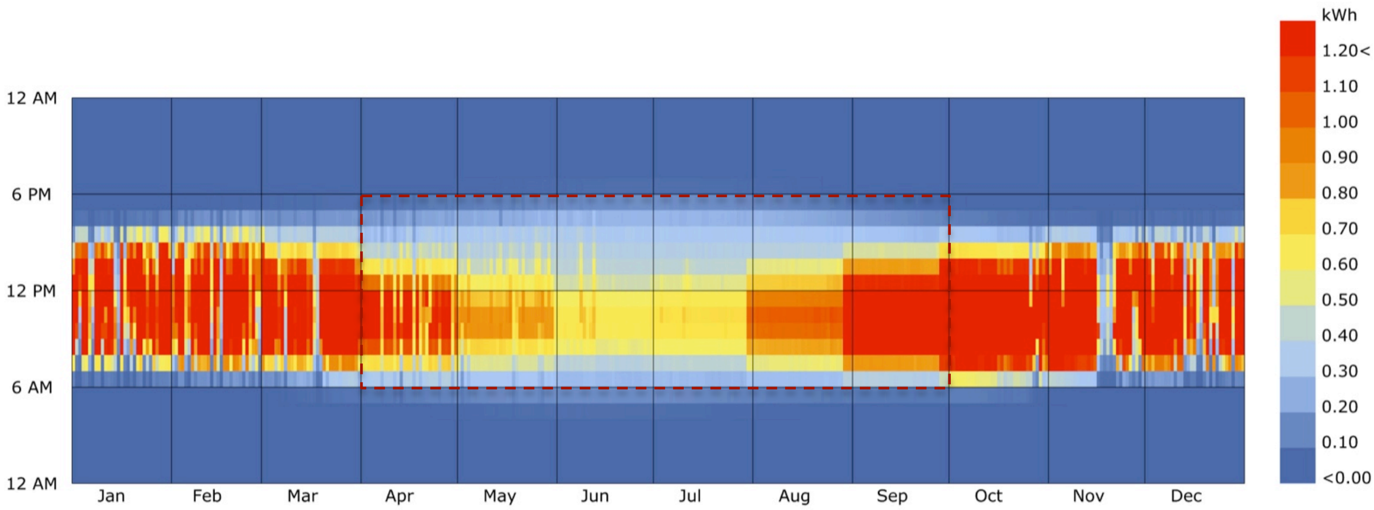
In order to provide the best configuration of shading system, the shading system applied on the window in all direction. The balance between the heating period and the cooling period is the base in this analysis where the base line is to arrive to the same analysis in the IES-VE which it was a decreasing of the total load in 27%, separated between decreasing of the cooling load of 38% while increasing of the heating load of 17%. so the need of the shading system is to decrease the amount of solar gain in 38% considering that the maximum increasing in the heating period of 17% in order to have the same total energy load for the builing (53 kW/m2).

- **Southern Façade:**

By starting from the southern façade with all possible configuration until to arrive to the maximum decreasing in the cooling period and minimum increasing in the heating period of the solar gain transmittance considering the balance between them.

- **0.0: without shading system**

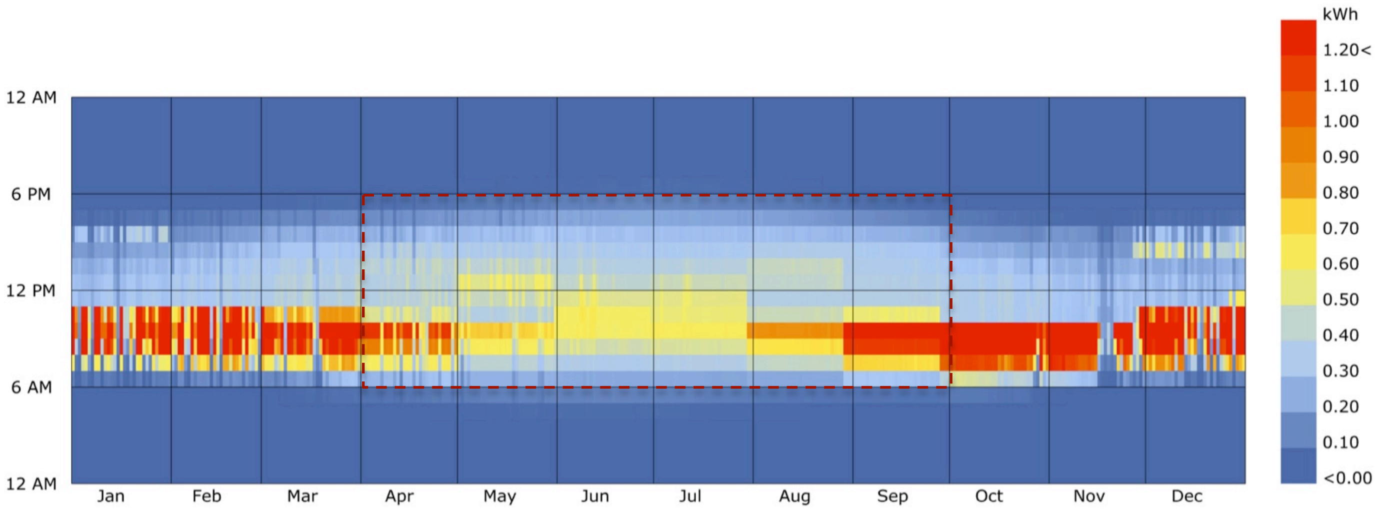
In order to make the comparison the first step is to check the window without shading system.



Graph: Solar Gain transmitted through the window without shading (kWh)

As the upper graph shown that the higher amount of energy will be gained in the heating period (1979.48 kWh) while the lower in the cooling one (1234.02 kWh), but the need of the shading is to decrease the amount in the summer and keep the maximum in the winter. This analysis considering bothe the direct and the diffuse radiation.

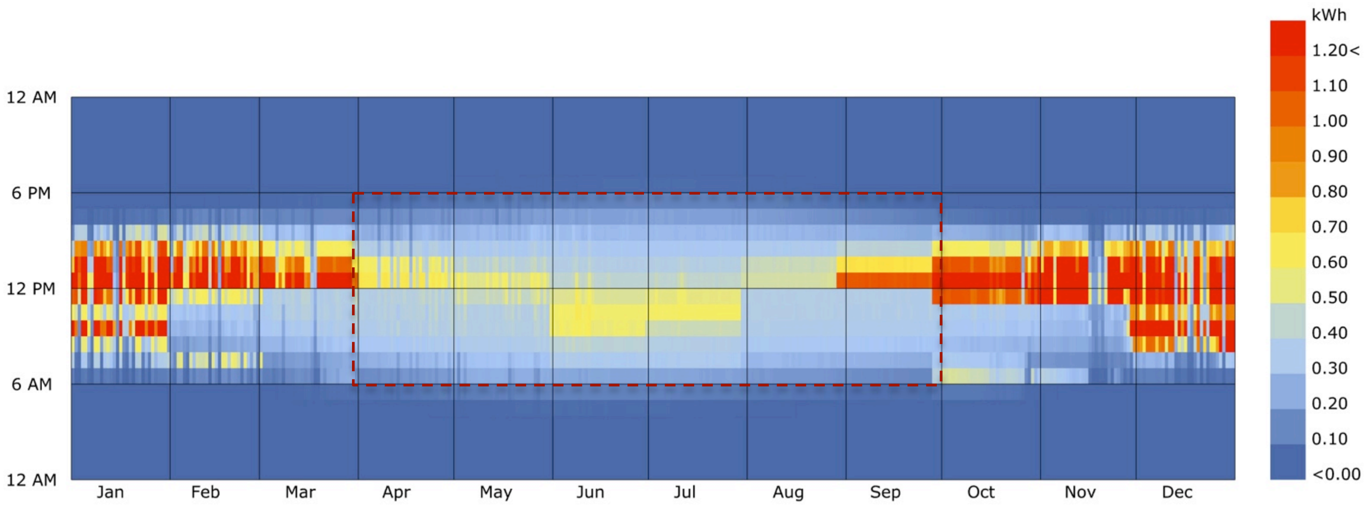
❖ 1.A: 5cm without slope, upper surface oriented to east.



Graph: Solar Gain transmitted through the window, shading 1.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (977.26 kWh) while between April and September is (850.7 kWh).

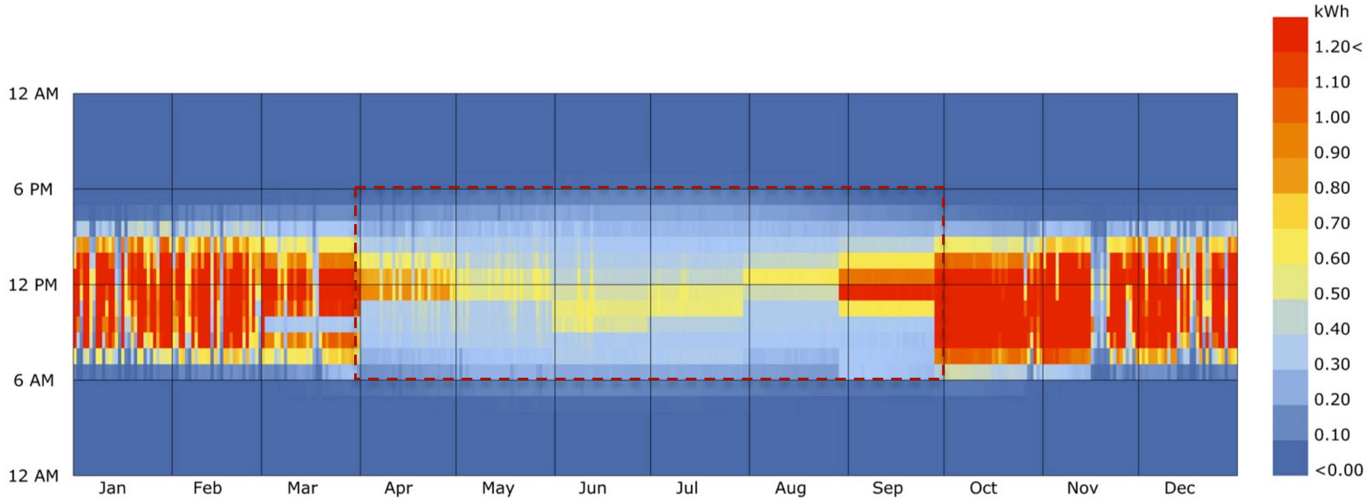
❖ 1.A.1: 5cm without slope, upper surface oriented to west.



Graph: Solar Gain transmitted through the window, shading 1.A.1 (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (1059.47 kWh) while between April and September is (678.43 kWh). As values showes Increasing in the heating period and decreasing in the cooling period, so the by keeping the upper part oriented to west is more effective. The next analysis, the upper surface oriented to the west always.

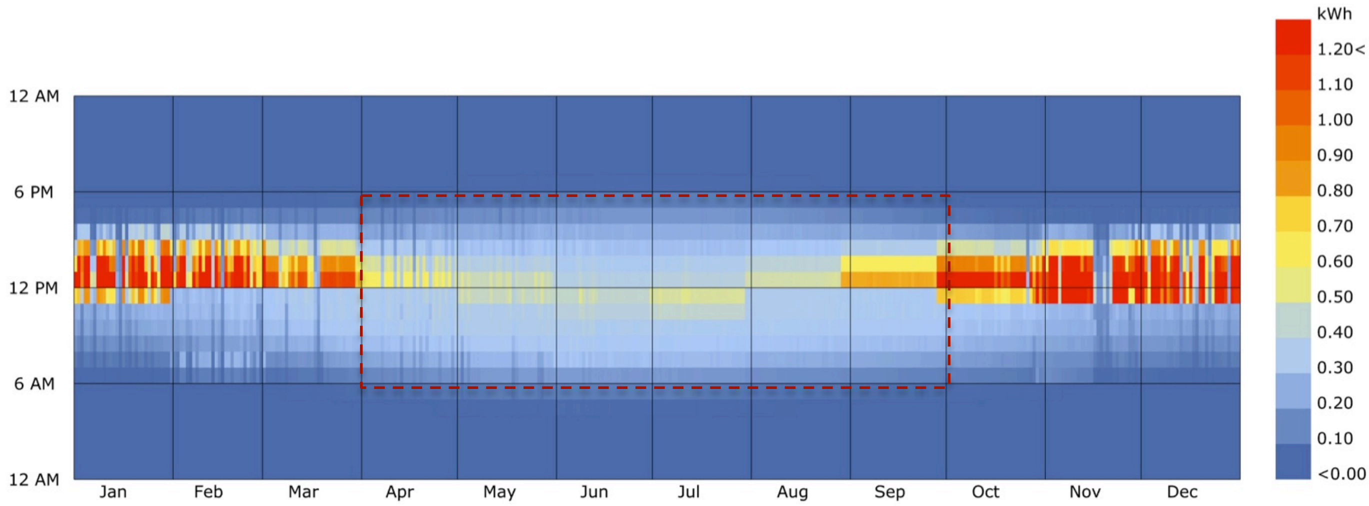
- **1.B: 5cm with 45˚ slope, upper surface oriented to west.**



Graph: Solar Gain transmitted through the window, shading 1.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (1627.32 kWh) while between April and September is (748.98 kWh). The slope effect on the analysis and give better result

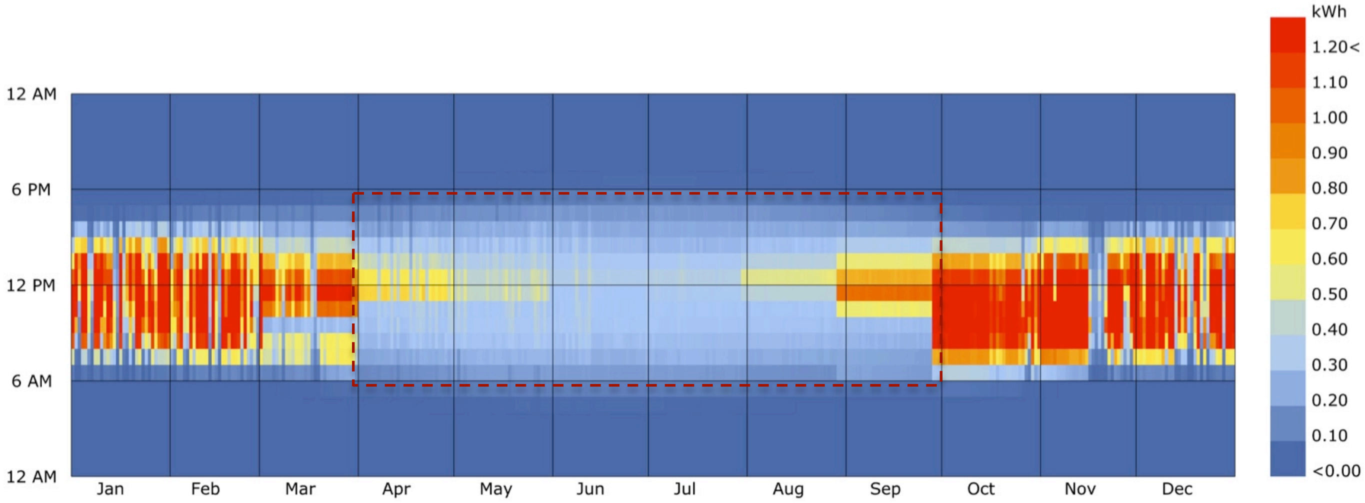
- **2.A: 10cm without slope, upper surface oriented to west.**



Graph: Solar Gain transmitted through the window, shading 2.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (572.2 kWh) while between April and September is (781.88 kWh). The values deacreased too much .

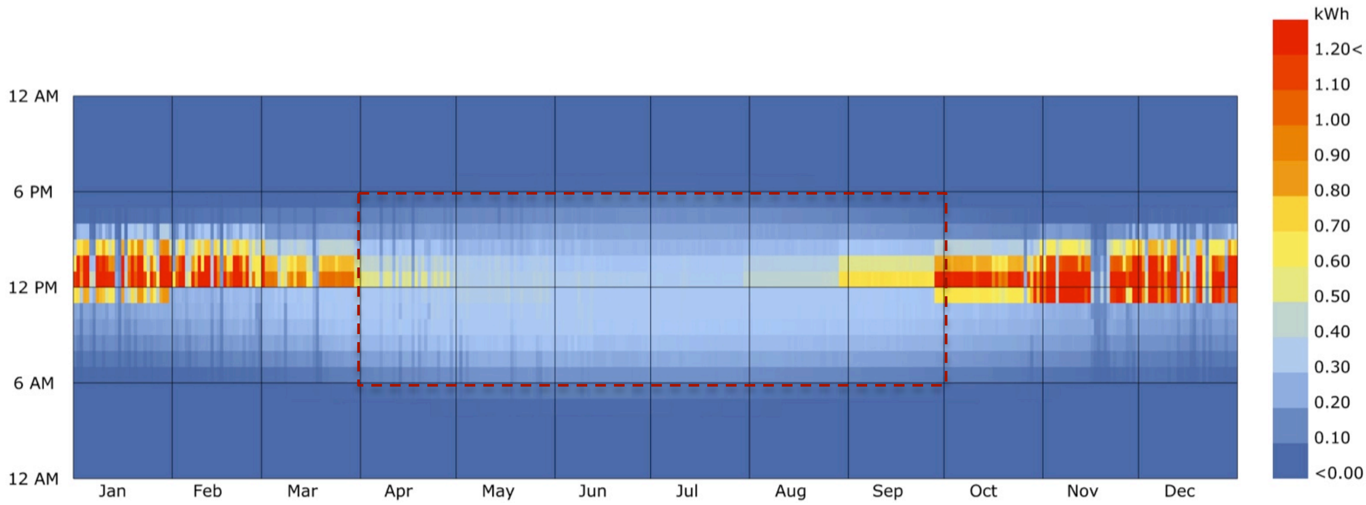
❖ 2.B: 10cm with 45˚ slope, upper surface oriented to west.



Graph: Solar Gain transmitted through the window, shading 2.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (1335.91kWh) while between April and September is (595.66 kWh). The slope effect on the analysis and give the best result until now.

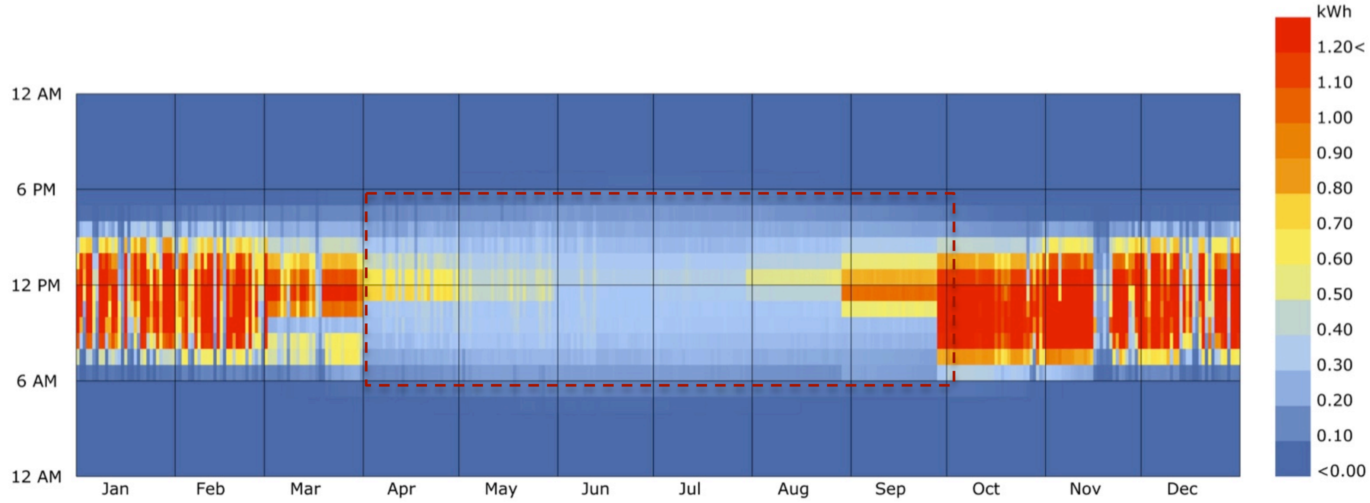
❖ 3.A: 15cm without slope, upper surface oriented to west.



Graph: Solar Gain transmitted through the window, shading 3.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (689.46 kWh) while between April and September is (492.2 kWh).

❖ **3.B: 10cm with 45˚ slope, upper surface oriented to west.**

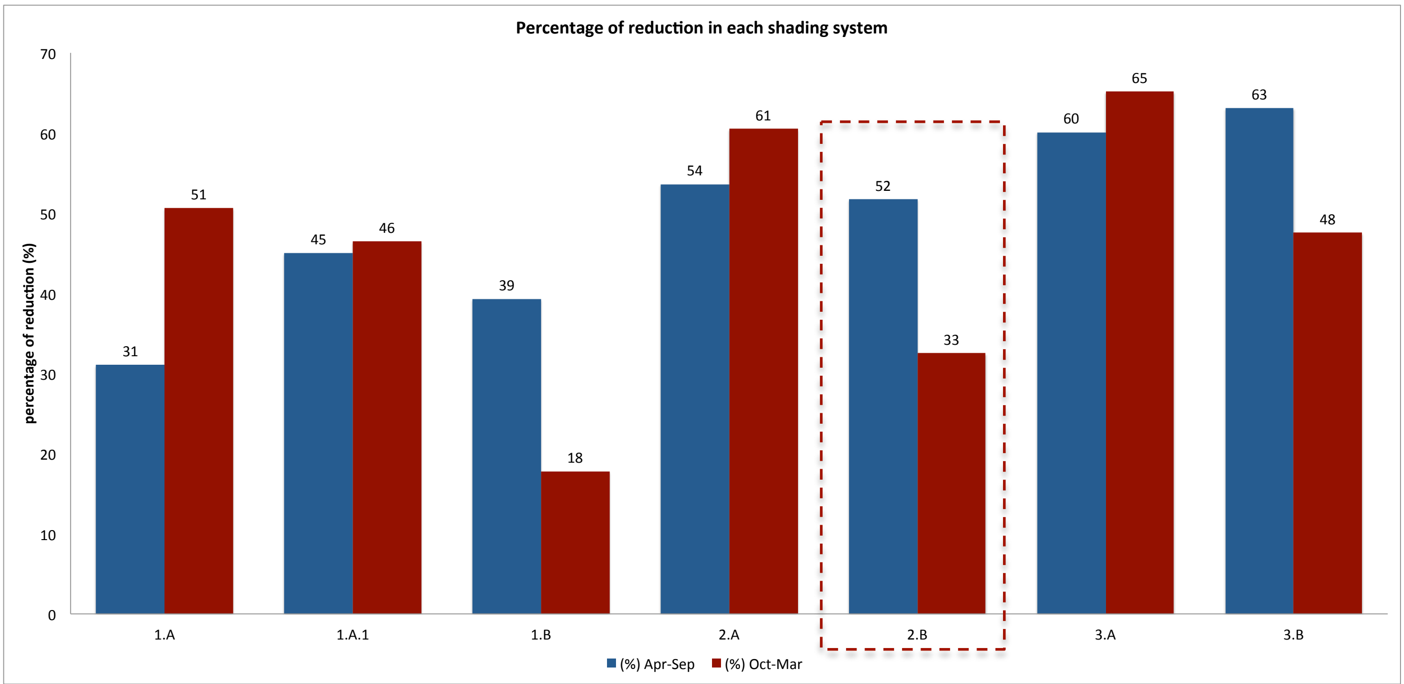


Graph: Solar Gain transmitted through the window, shading 3.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (1038.32kWh) while between April and September is (455.2 kWh). From here, the analysis will be stopped because of the result of the heating period start to be un effective.

❖ **Conclusion**

In order to check the best configuration between all the shading panels sorted up for the southern façade, the lower graph showes the reduction of solar gain in each period.



Graph: Percentage of energy gained reduction in all cases

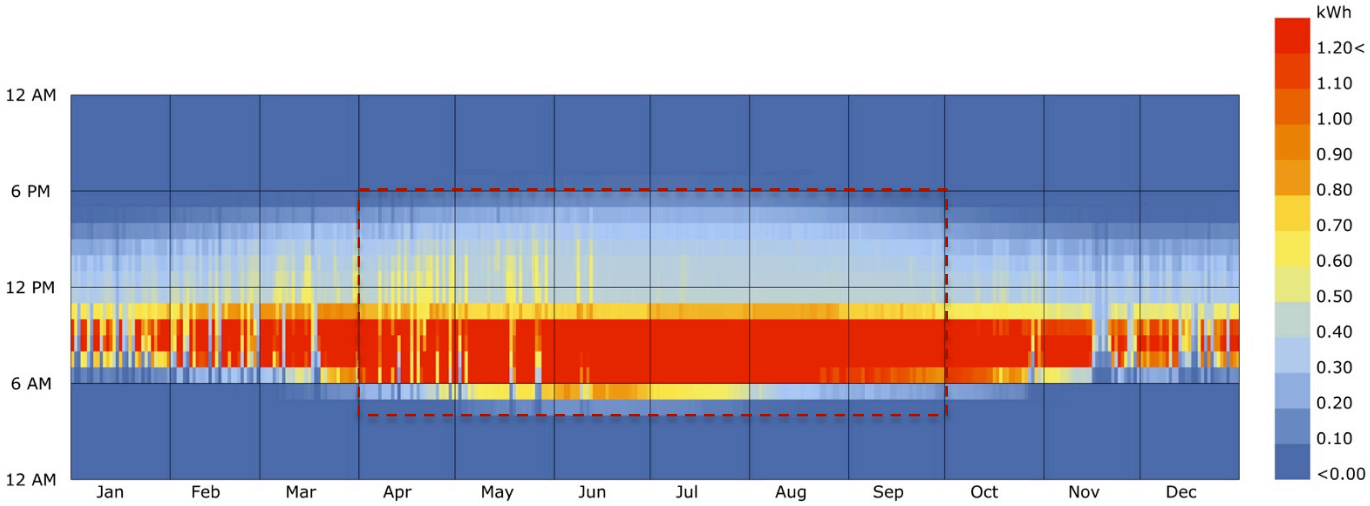
The case 1.B and 2.B has the minimum reduction in winter while balancing them with the cooling period, the best case can be 2.B which means 10cm with slope of surface of 45˚.

- **Eastern Façade:**

The second analysis will be for the eastern façade with all possible configuration until to arrive to the maximum decreasing in the cooling period and minimum increasing in the heating period of the solar gain transmittance considering the balance between them.

❖ **0.0: without shading system**

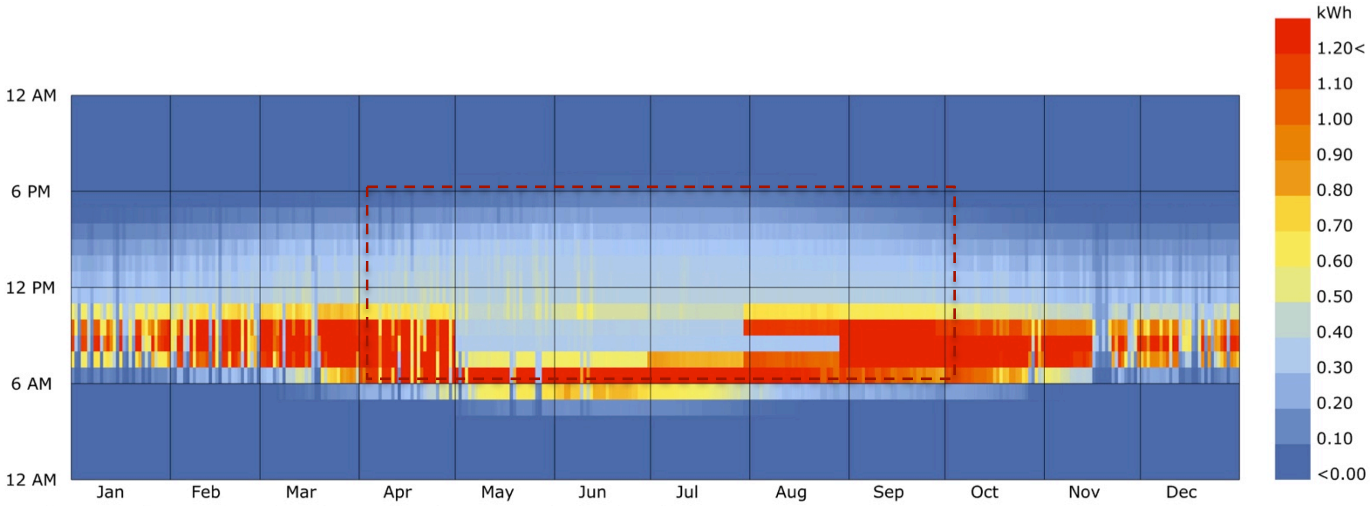
In order to make the comparison the first step is to check the window without shading system.



Graph: Solar Gain transmitted through the window without shading (kWh)

As the upper graph shown that the higher amount of energy will be gained in the heating period (998.41 kWh) while the lower in the cooling one (1761.49 kWh), but the need of the shading is to decrease the amount in the summer and keep the maximum in the winter. This analysis considering bothe the direct and the diffuse radiation.

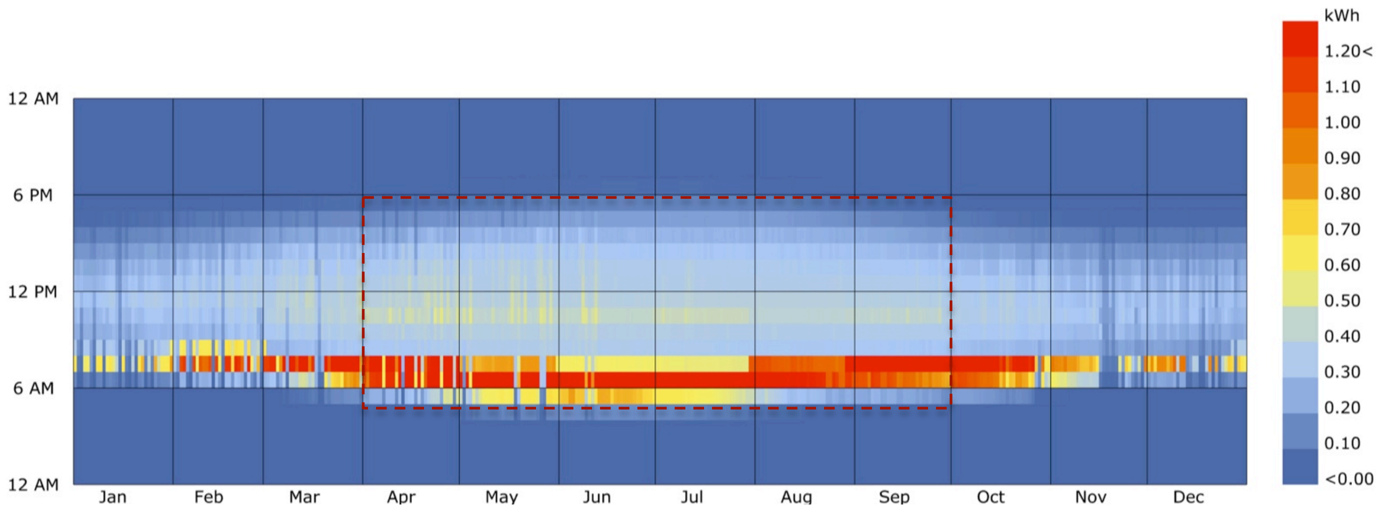
❖ **1.A: 5cm without slope, upper surface oriented to south.**



Graph: Solar Gain transmitted through the window, shading 1.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (861.17kWh) while between April and September is (1171.63 kWh).

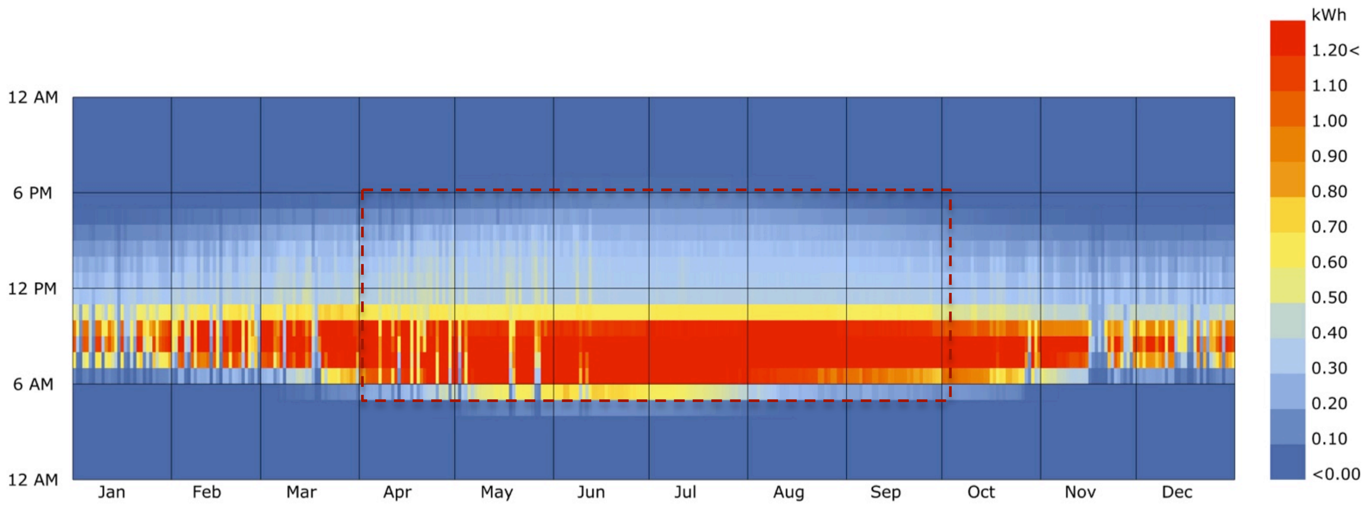
❖ 1.A.1: 5cm without slope, upper surface oriented to north.



Graph: Solar Gain transmitted through the window, shading 1.A.1 (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (536.44kWh) while between April and September is (961.86 kWh). The previous analysis gives better result so the next once the upper part will be oriented to south

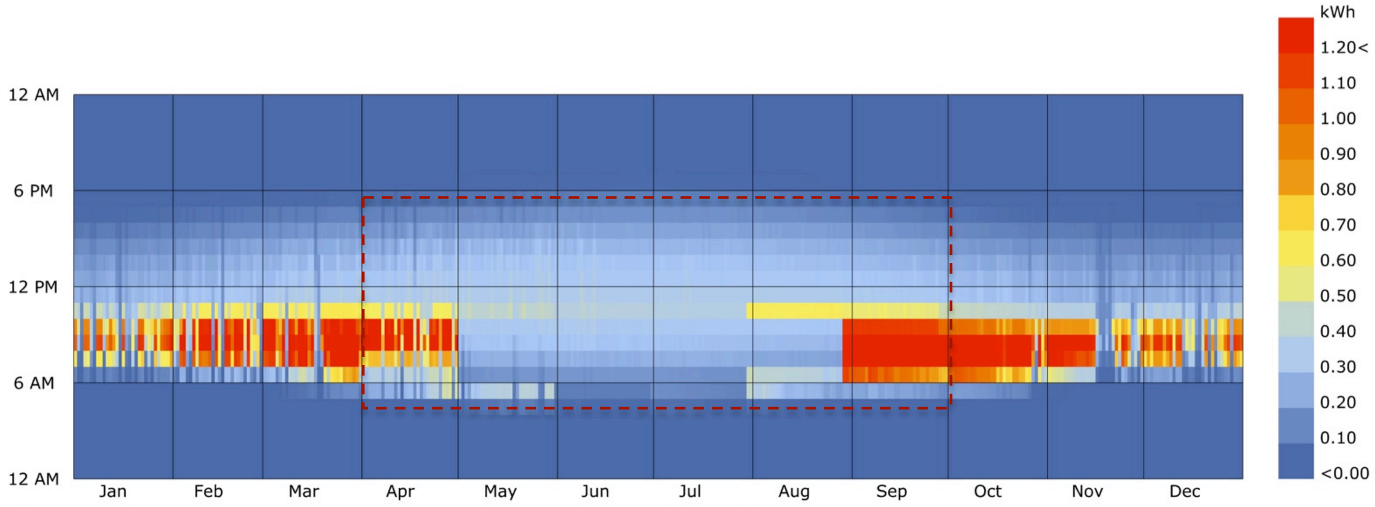
❖ 1.B: 5cm with 45° slope, upper surface oriented to south.



Graph: Solar Gain transmitted through the window, shading 1.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (826.53kWh) while between April and September is (1475.37 kWh). The slope is not effective in ths case.

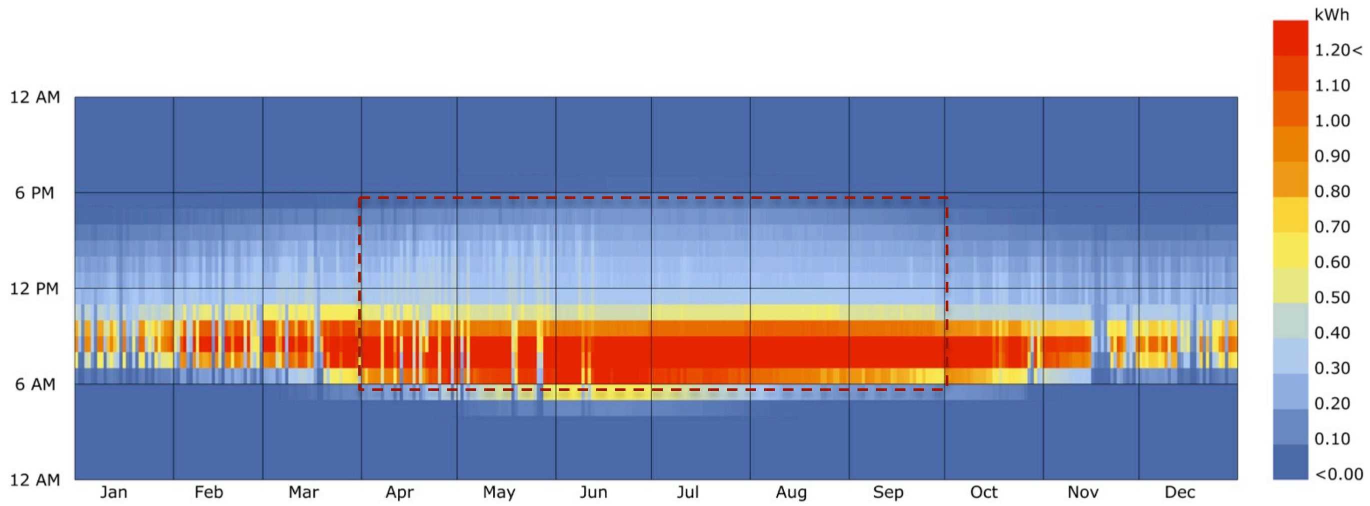
❖ 2.A: 10cm without slope, upper surface oriented to south.



Graph: Solar Gain transmitted through the window, shading 2.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (749.79kWh) while between April and September is (756.82 kWh).

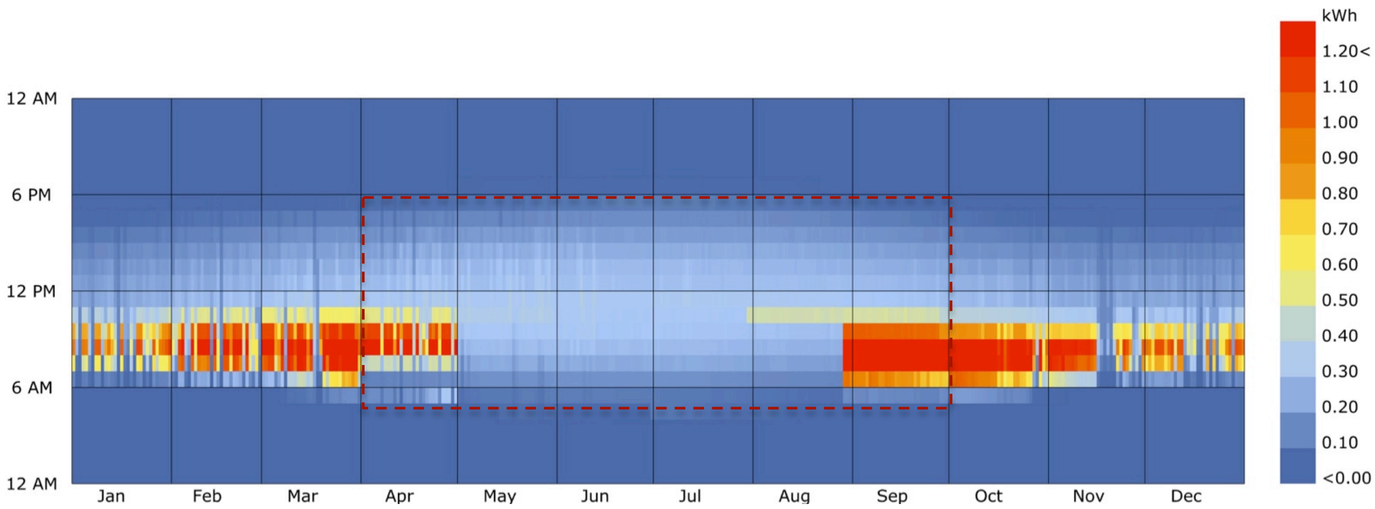
❖ 2.B: 10cm with 45° slope, upper surface oriented to south.



Graph: Solar Gain transmitted through the window, shading 2.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (689.08 kWh) while between April and September is (1232.4 kWh). The slope is not effective in ths case.

❖ 3.A: 15cm without slope, upper surface oriented to south.

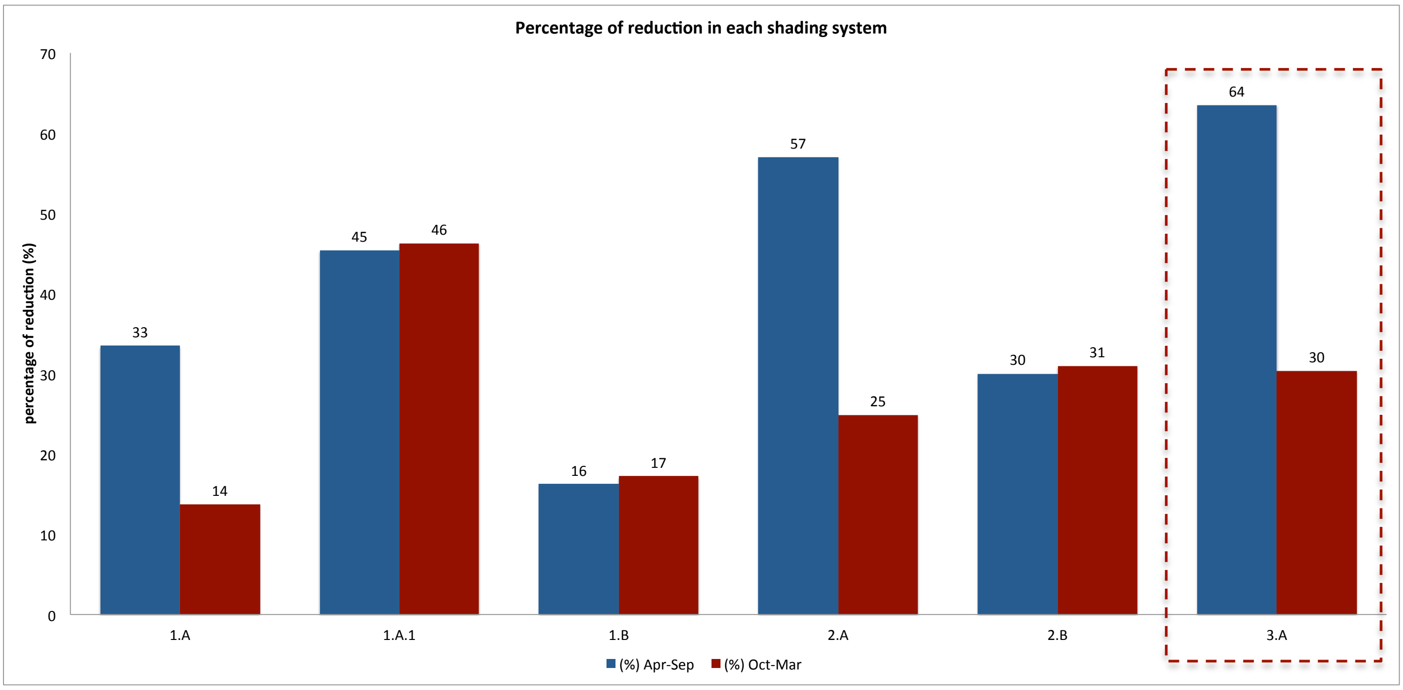


Graph: Solar Gain transmitted through the window, shading 3.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (694.8 kWh) while between April and September is (642.48 kWh).

❖ Conclusion

In order to check the best configuration between all the shading panels sorted up for the southern façade, the lower graph showes the reduction of solar gain in each period.



Graph: Percentage of energy gained reduction in all cases

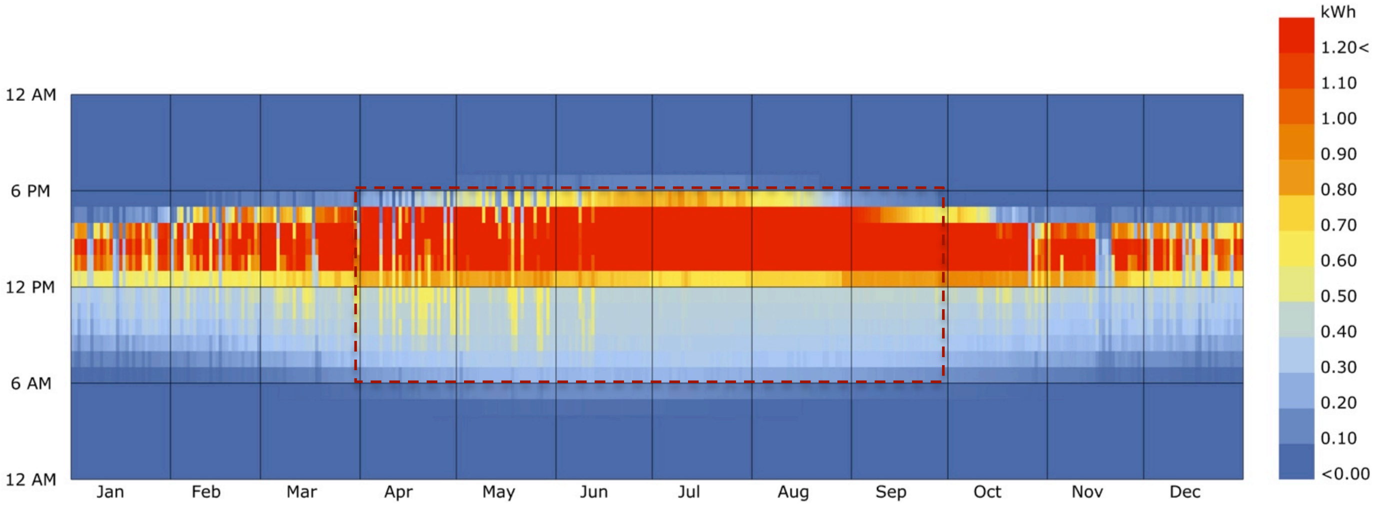
The case 2.A and 3.A has the maximum reduction in summer while balancing them with the heating period, the best case can be 3.A which means 15cm without slope.

- **Eastern Façade:**

The third analysis will be for the western façade with all possible configuration until to arrive to the maximum decreasing in the cooling period and minimum increasing in the heating period of the solar gain transmittance considering the balance between them.

❖ **0.0: without shading system**

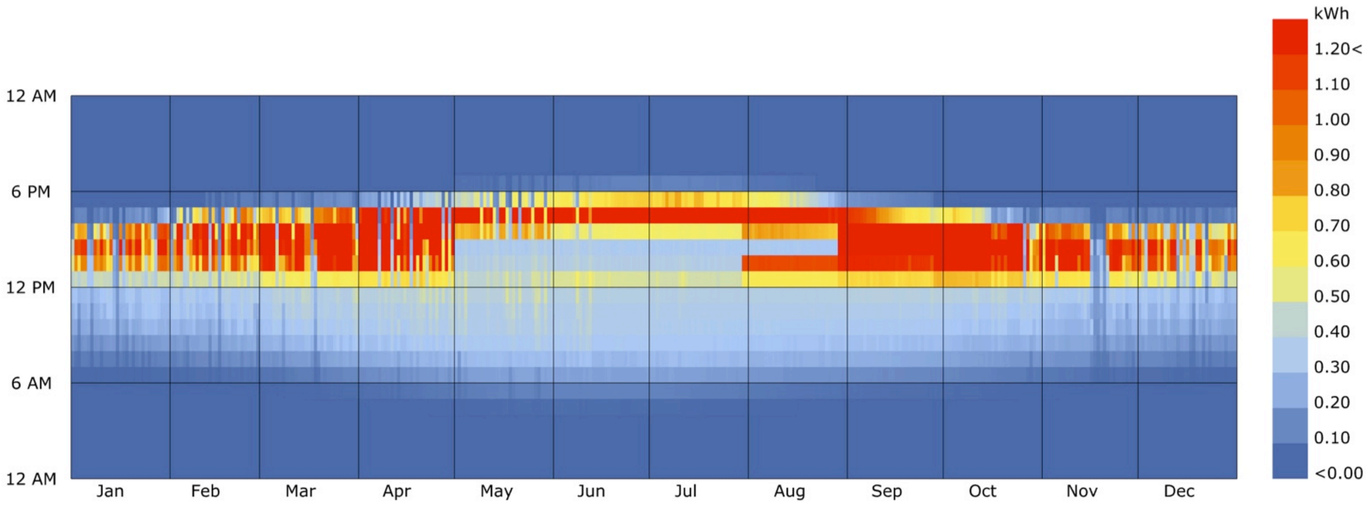
In order to make the comparison the first step is to check the window without shading system.



Graph: Solar Gain transmitted through the window without shading (kWh)

As the upper graph shown that the higher amount of energy will be gained in the heating period (1022.72 kWh) while the lower in the cooling one (1768.56 kWh), but the need of the shading is to decrease the amount in the summer and keep the maximum in the winter. This analysis considering bothe the direct and the diffuse radiation.

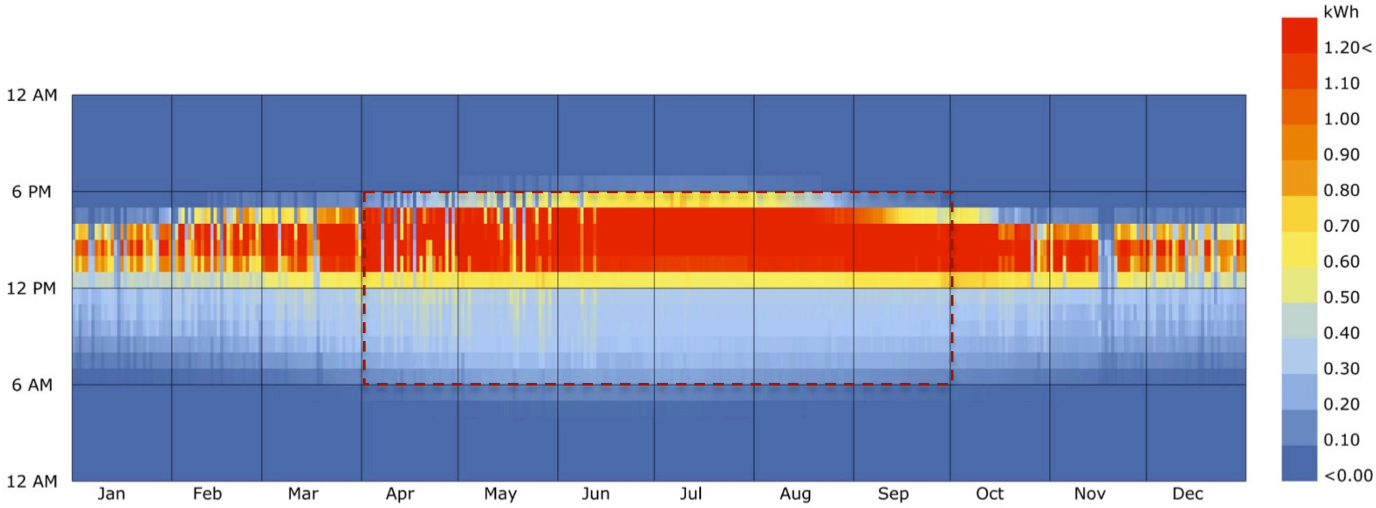
❖ **1.A: 5cm without slope, upper surface oriented to south.**



Graph: Solar Gain transmitted through the window, shading 1.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (883.62 kWh) while between April and September is (1158.45 kWh).

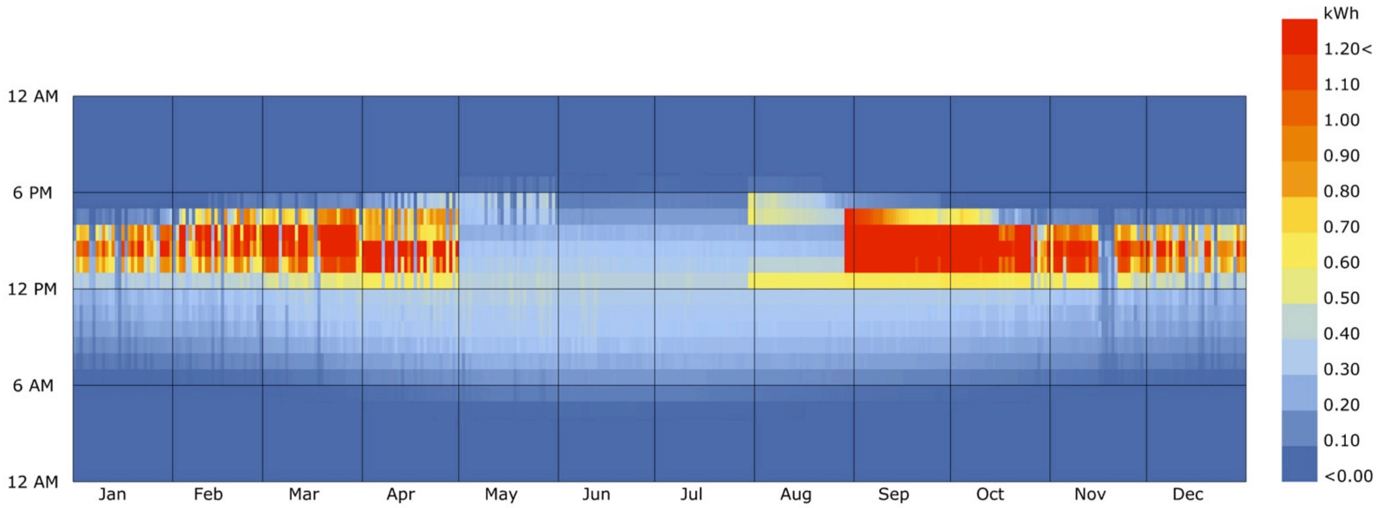
❖ 1.B: 5cm with 45˚ slope, upper surface oriented to south.



Graph: Solar Gain transmitted through the window, shading 1.B (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (846.82 kWh) while between April and September is (1478.96 kWh). The slope is not effective in ths case.

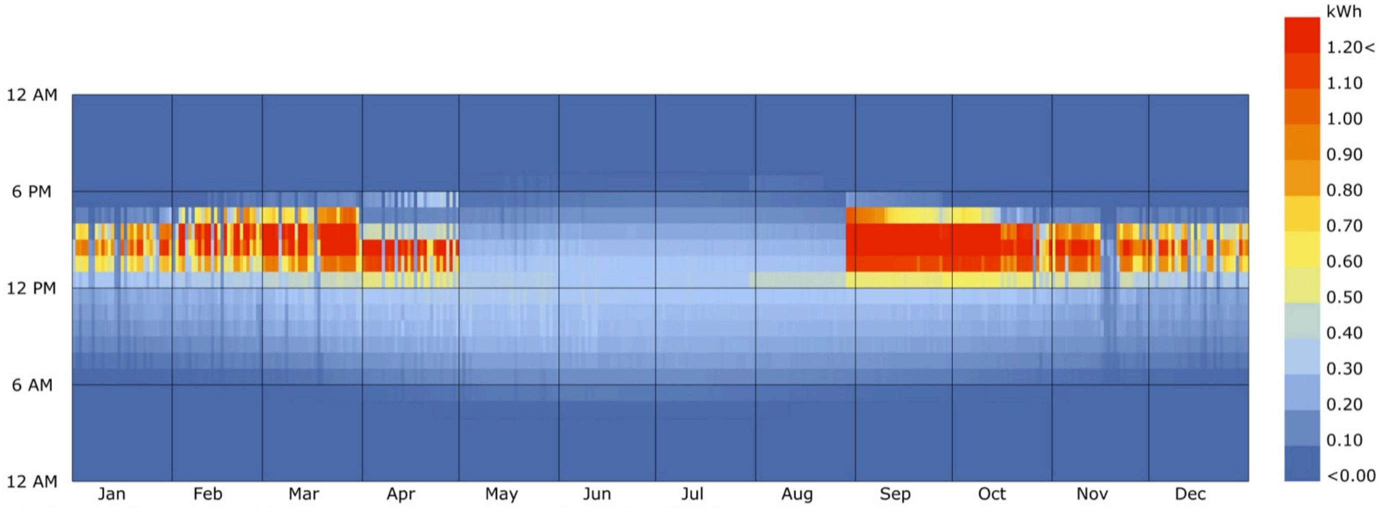
❖ 2.A: 10cm without slope, upper surface oriented to south.



Graph: Solar Gain transmitted through the window, shading 2.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (789.45 kWh) while between April and September is (798.86 kWh).

❖ 3.A: 15cm without slope, upper surface oriented to south.

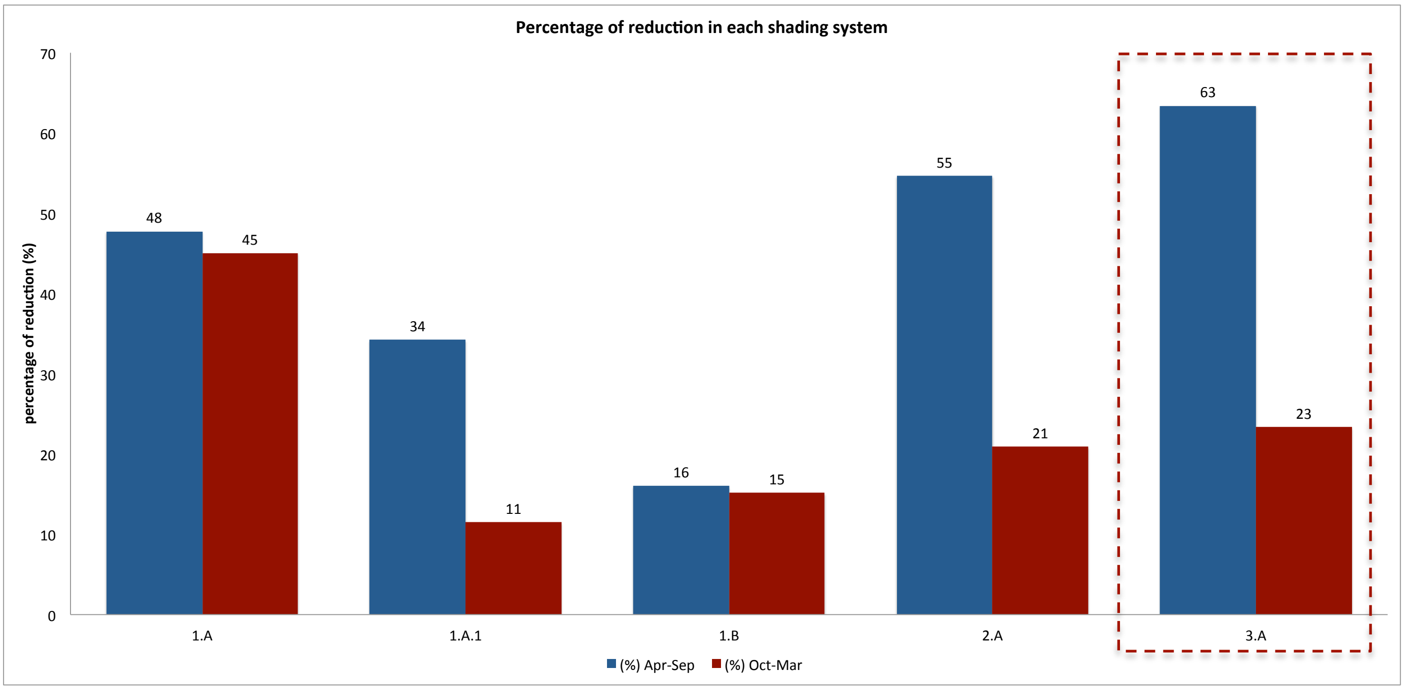


Graph: Solar Gain transmitted through the window, shading 3.A (kWh)

As the upper graph shown that the higher amount of energy will be gained between October and March is (765.2 kWh) while between April and September is (644.46 kWh).

❖ Conclusion

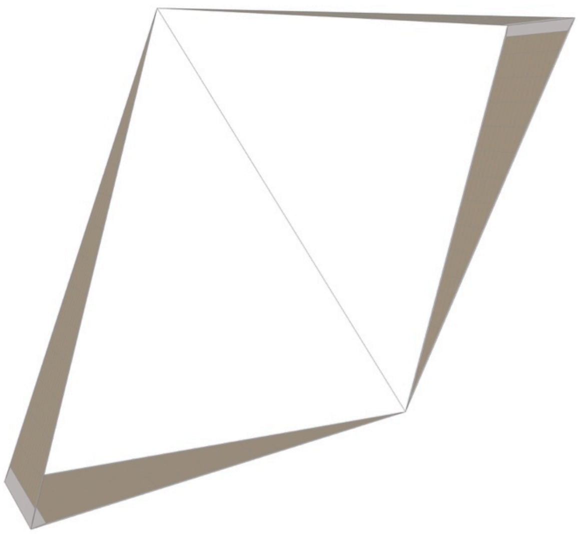
In order to check the best configuration between all the shading panels sorted up for the southern façade, the lower graph showes the reduction of solar gain in each period.



Graph: Percentage of energy gained reduction in all cases

The case 1.B and 2.B has the minimum reduction in winter while balancing them with the cooling period, the best case can be 2.B which means 10cm with slope of surface of 45˚.

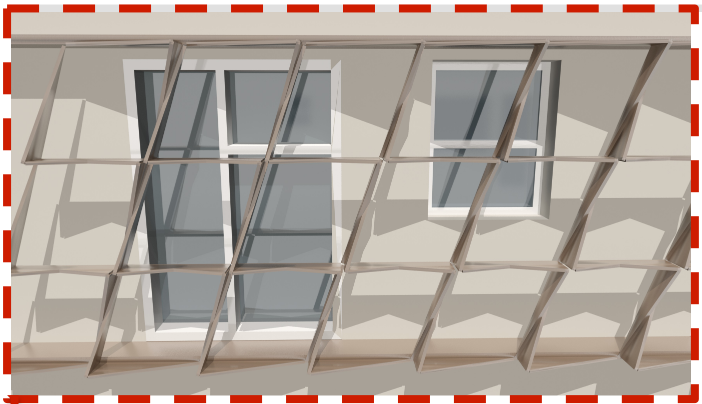
- **Conclusion**
  - the application on the facades:
    - South: totally shaded.
    - North: not shaded.
    - East: totally shaded.
    - Internal East facade: from 3rd floor to 5th floor.
    - West: from 2nd floor to 5th floor.
    - Internal West:from 3rd floor to 5th floor .
  - Type of shading on the facades:
    - South: 2.B
    - North: Only the 15cm panel.
    - East: 3.A
    - Internal East facade: 3.A
    - West: 3.A
    - Internal West:3.A



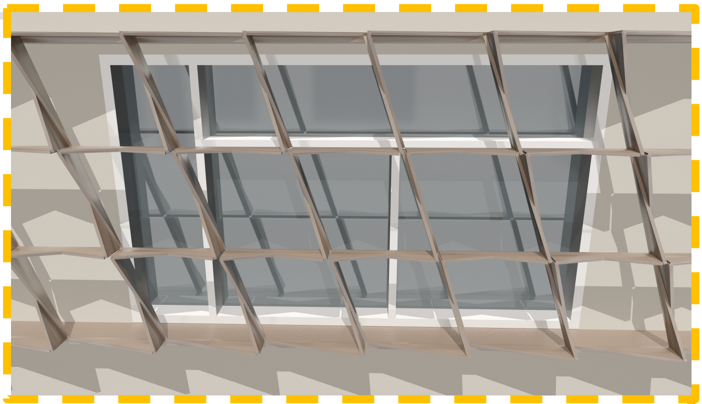
3.A: 15cm with out slope

2.B: 10cm with slope of 45˚

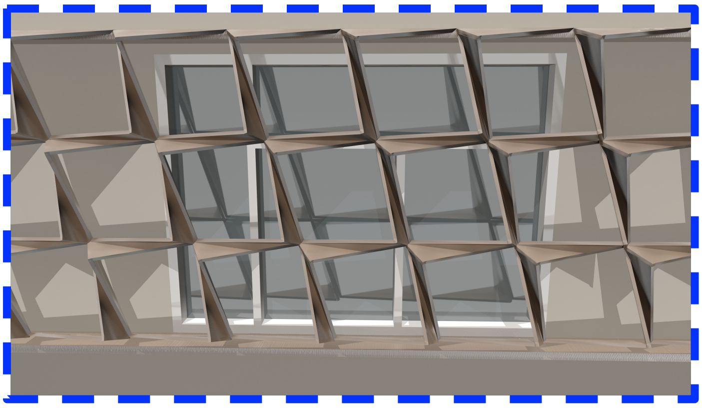
  - Materials:
    - For the structure frame, steel.
    - For the panels , wooden panels or strips



Living Area with Eastern shading System



Kitchen and WC with Western shading System



Bedroom with Southtern shading System

A R C H I T E C T U R E   D R A W I N G S

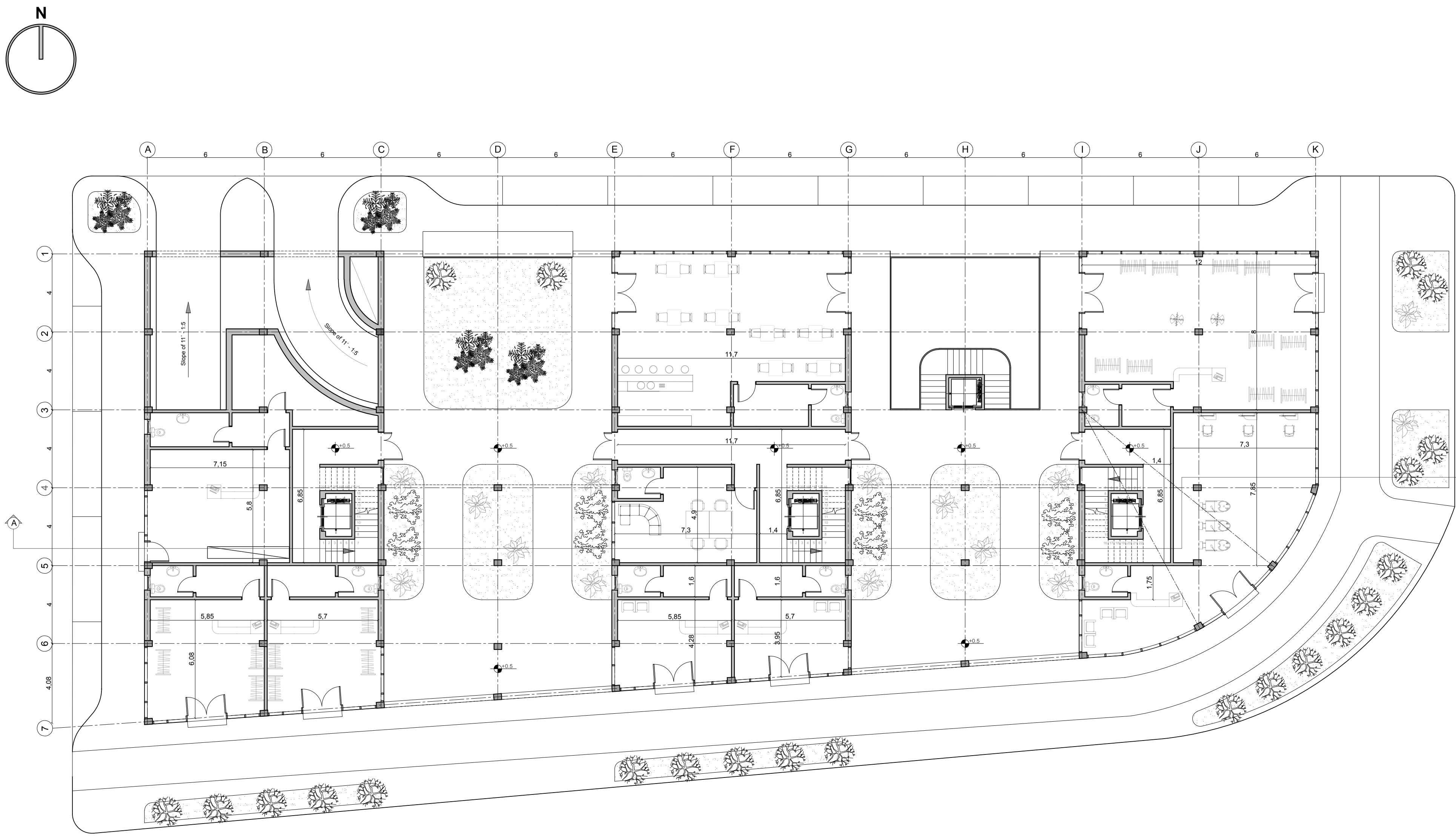
As a final result of all of those analysis, starting from the site analysis, climatic analysis, getting the architectural concept and the schematic separation of the zones. Then starting to analyze the best wall/window ratio for better energy performance of the building. After that going through the envelope of the builing in each specific part by several trial in IES-VE for the walls, roof and flooring as a part of the opaque envelope. And the windows unit, glazing and framing. Also other passive strategies in order to improve the energy performance of the building. Then by going through the shading system which it got an effective result in IES-VE and improve it in another software where the parametric design can be used where the shading system design follow the parameter of the glazing transmittance of the solar gain through the glazing.

From all of those points, the result will affect on the architectural design of the project as the next pages of drawing will show.

- A.00 : Layout
- A.01 : Ground Floor Plan
- A.02: Typical Floor Plan
- A.03: Underground Plan
- B.01: Vertical Section A-A
- D.01: Southern Elevation
- D.02: Northern Elevation
- D.03: Eastern and Western Elevations
- E.01: Perspective.

A.00 - Layout

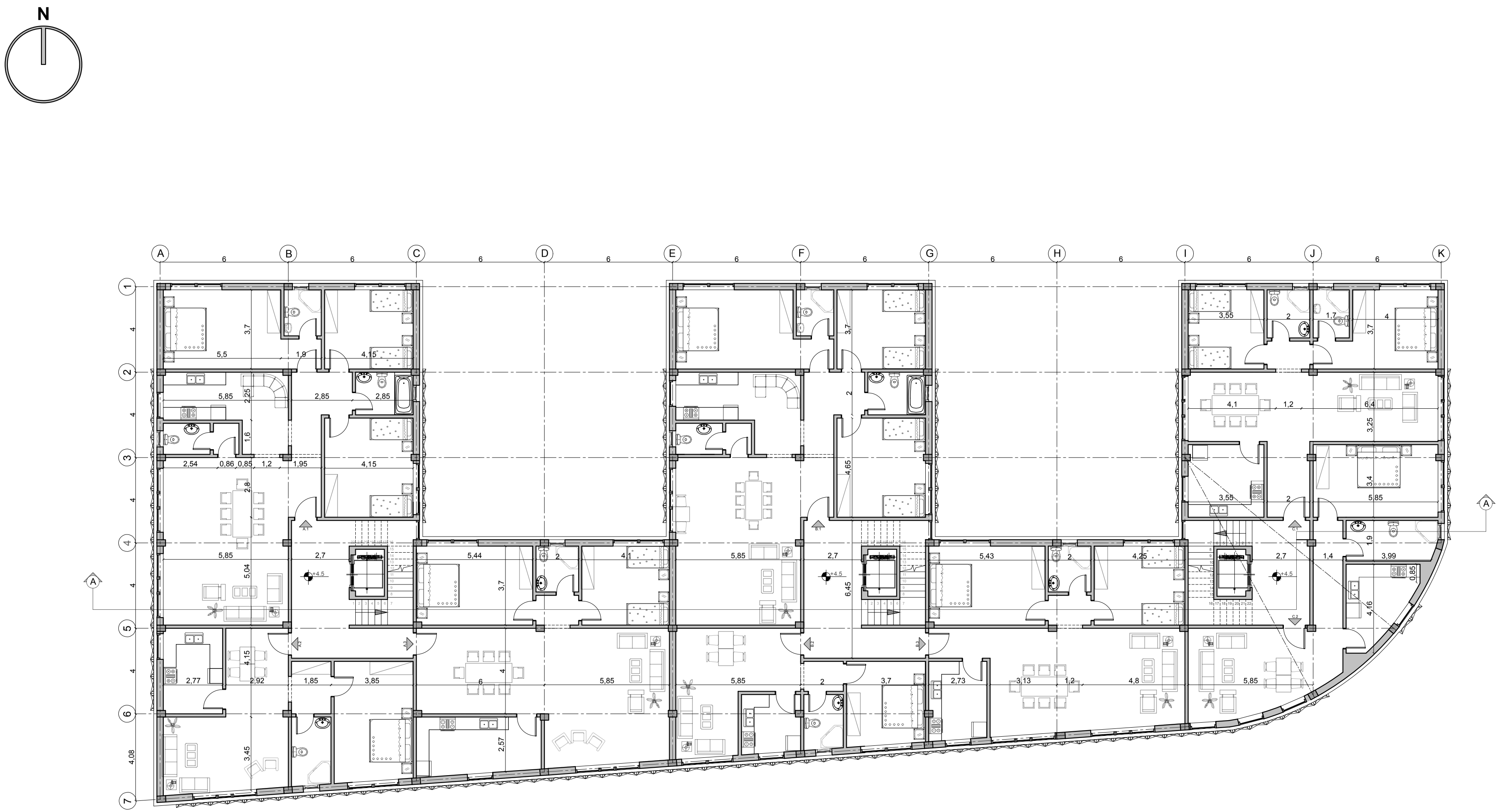
Scale: 1:500



A.01 - Ground Floor Plan.

Scale : 1:200

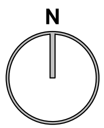
Dim in m

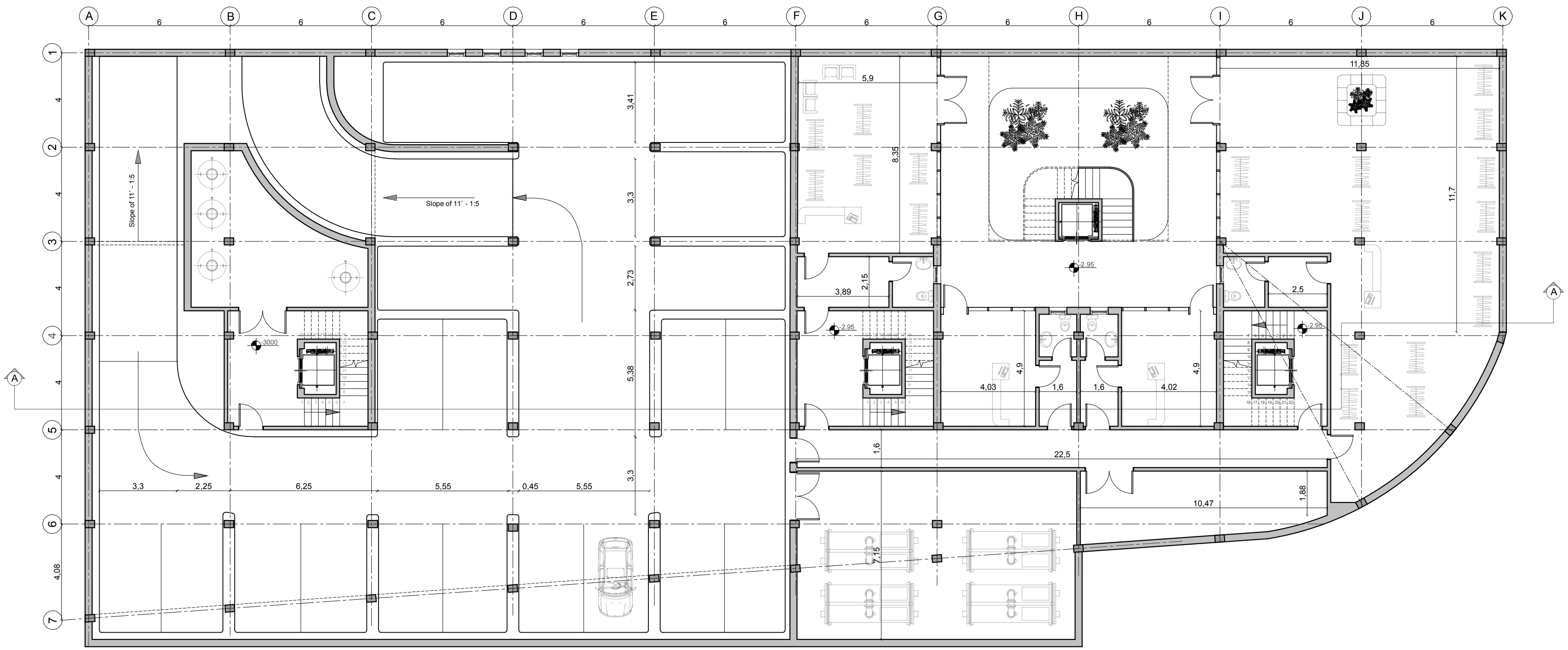


A.02- Typical Floor Plan - 1st to 5th floors

Scale : 1:200

Dim in m

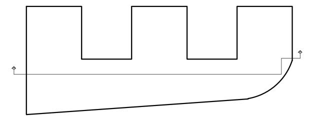


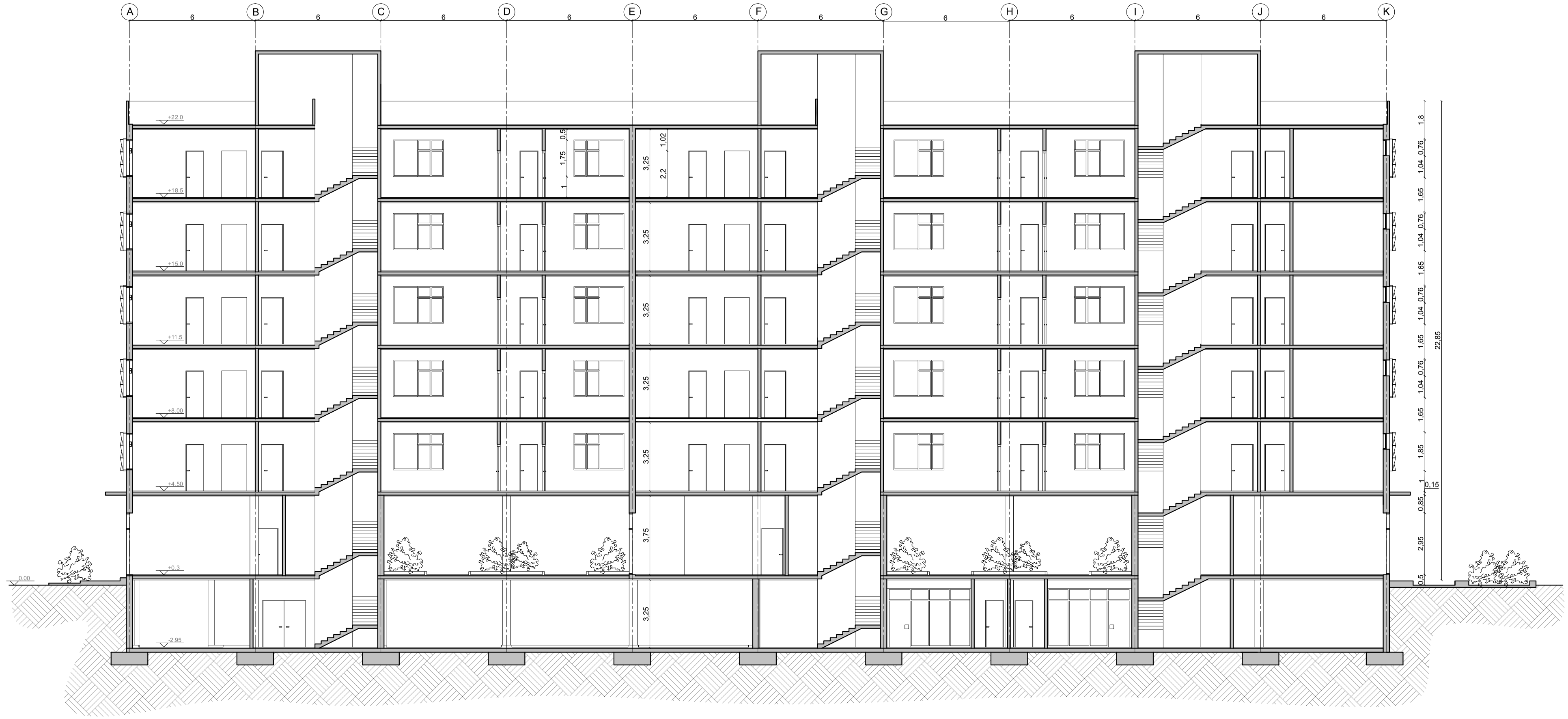


A.03 - Underground Plan

Scale : 1:200

Dim in m

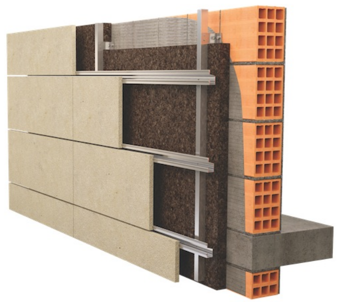




B.01 - Vertical Section A - A

Scale : 1:200

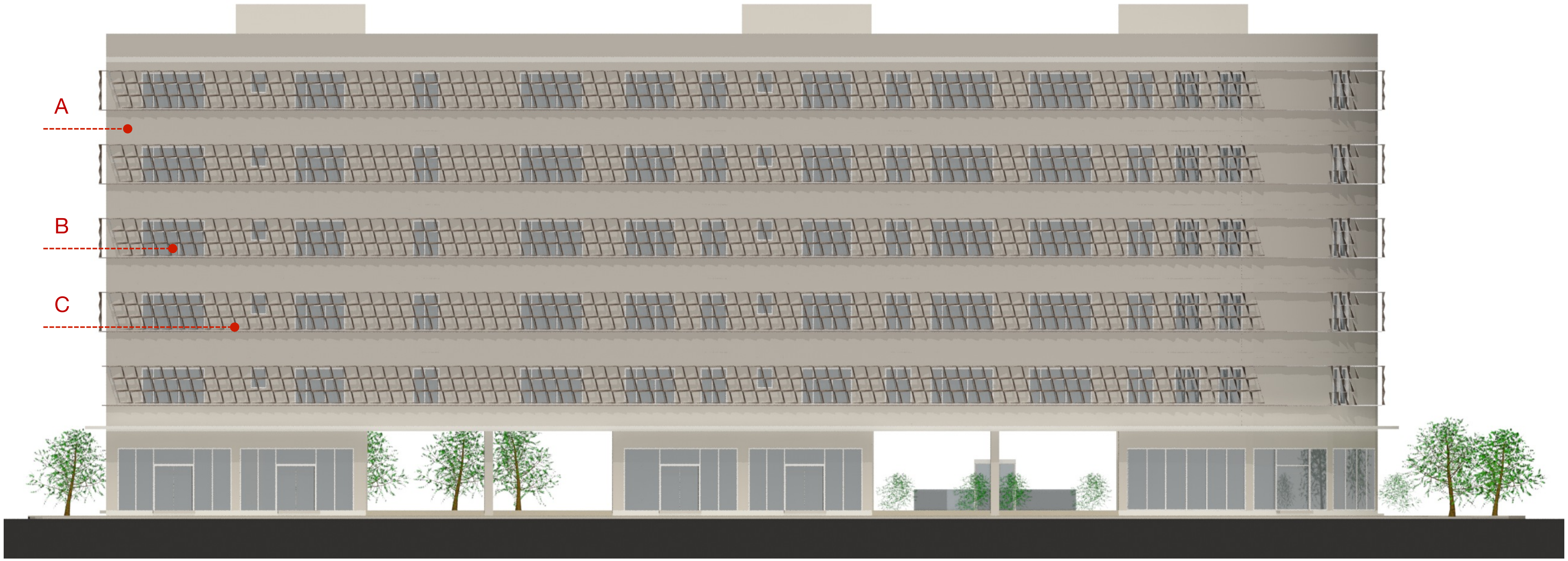
Dim in m



A. Ventilated Façade with double brickwork.

B. PVC Casement Window Unit in different sizes.

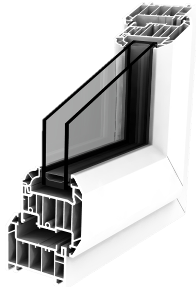
C. Wooden shading System



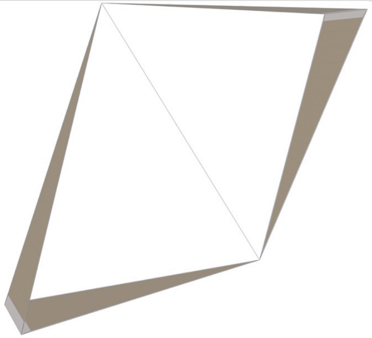
D.01 – Southern Elevation
Scale: 1:200

A. Stone Cover.


B. PVC Casement Window Unit in different sizes.

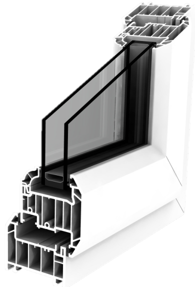

B. PVC Frames

D.02 – Northern Elevation
Scale: 1:200

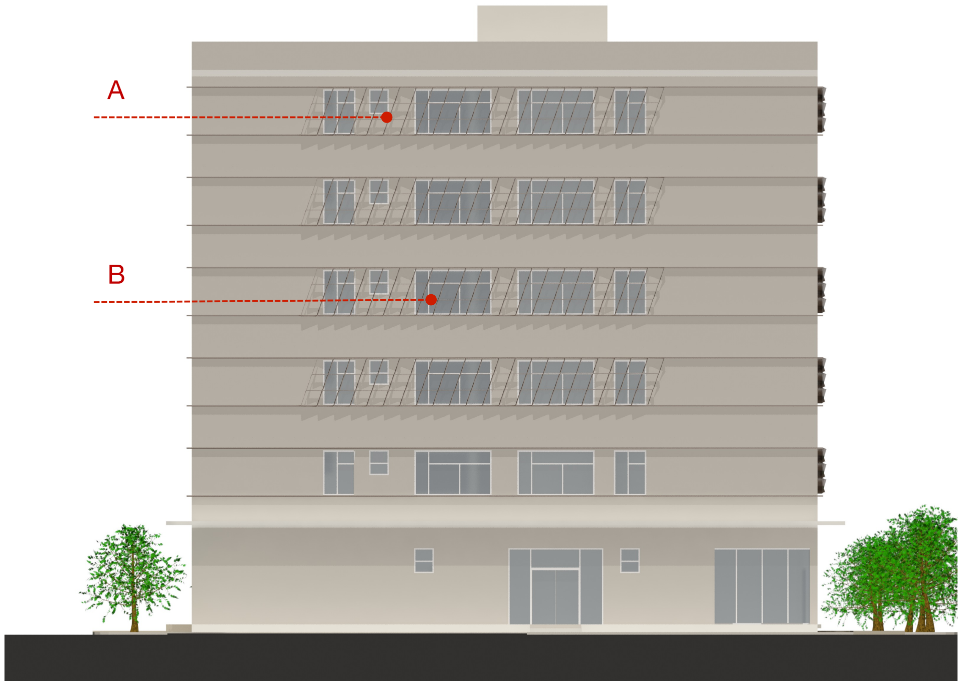


A. Wooden shading System

B. PVC Casement Window Unit in different sizes.

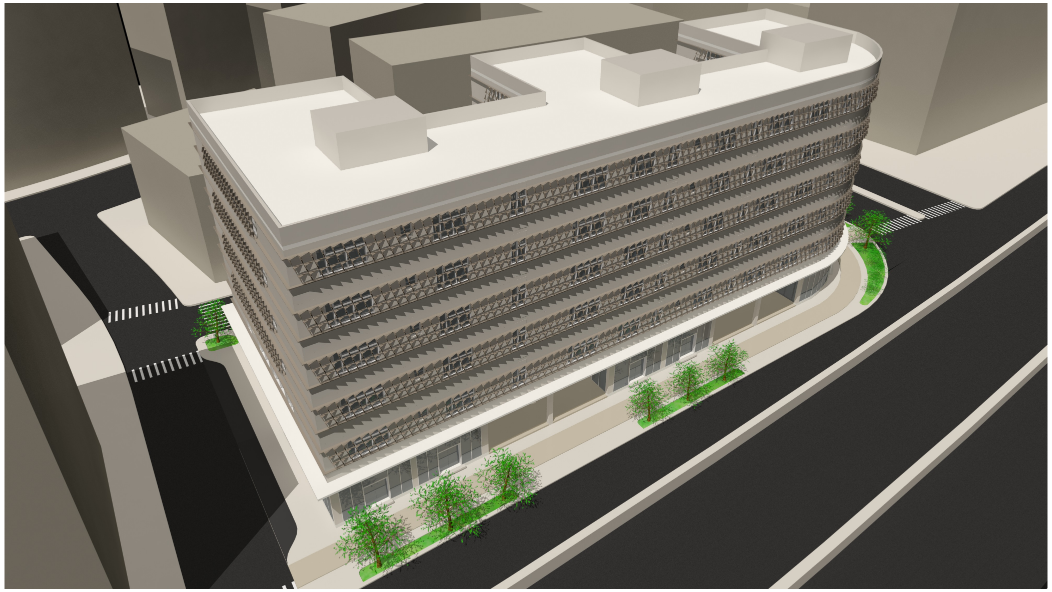


B. PVC Frames



D.03 – Western Elevation
Scale: 1:200

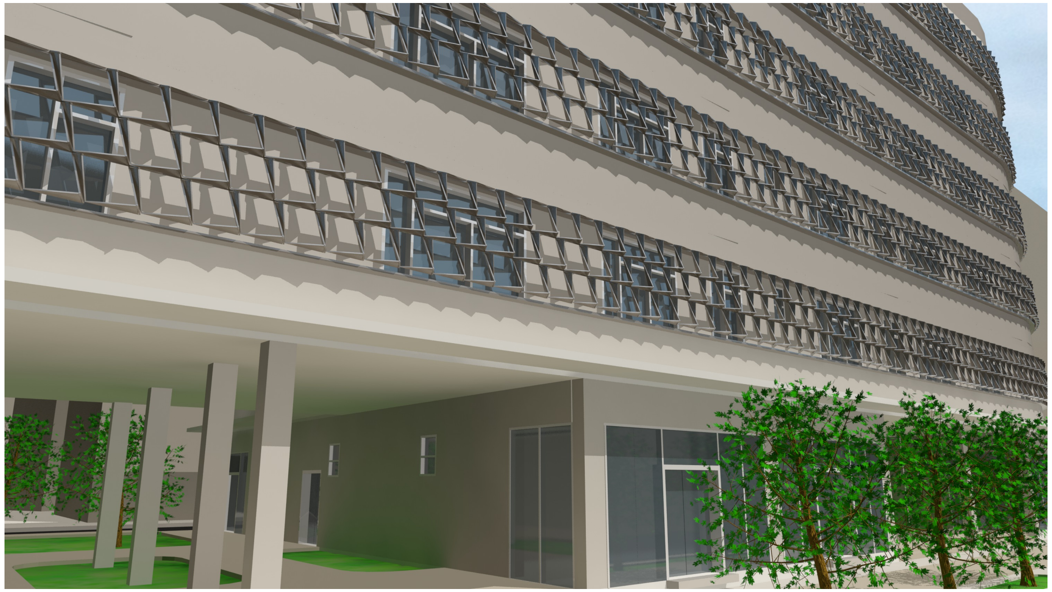
D.03 – Eastern Elevation
Scale: 1:200



Perspective from south

Perspective from north

Eastern Façade.



Southern Façade.

C O N C L U S I O N

In the end of this report, The result of each chapter will be sorted out in order to have a clear explanation of the design. Starting from the needs of a residential buildings in Damascus where its demand Increased these days to cover the needs of citizens after returning from displacement in different countries And the large number of damaged residential buildings in various Syrian regions, So the idea of the project created.

In order to achieve the idea of the project on the ground, it was started to search the sites of residential projects in the city by the government and human rights organizations in order to start architectural design on them professionally. By the given site and its context, it has been decided that the project will be designed as a mixed residential and commercial building following to the regulations of Damascus Governorate.

The next step was to start the architectural design of the building starting from the site and climatic analysis where it gives some limitation to the initial schematic design.
For the concept of the building design, The best one can be use is to integrate the traditional approaches of the old Damascus housing which it reflect these days' cultures of the city by innovations with the modern construction techniques. By making some studies on the old houses in Damascus, a lot of idea can be considered. Court yards located to north direction, are able to separate the building in 3 blocs in order to increase the wall surface for the opening and this allow to increase the internal spaces. Gardens are The aesthetic aspects of the inhabitants and has some climatic advantages. underground daylights able to increase the functional spaces.

After defending the architectural design of the building and the building shape was created, it will be useful to find an effective ways to improve energy efficiency without reducing the indoor environment quality is to design the building so that the expectations of the users are, as much as possible, satisfied with passive measures, that is without other energy sources than the environment and the sun. This case can be provided by many example, some of them sorted in this report but still there is many processes the designer can follow to arrive to a high energy performance building. The passive strategies in the building design is a processes that the architect or the engineer must be considered them in the initial stage of the design processes for energy efficiency in a building, producing low energy buildings that require little energy for space heating or cooling. Passive design is not an attachment or supplement to architectural design, but a design process that integrates with architectural design. Although it is principally applied to new buildings.

In order to achieve that, Starting from the initial stage will be grateful. Thanks to Sefaira software, it gives the ability to find the best window/wall ratio, by using different window dimension and different opaque U-value. many trials of simulation arrive the building to the best window/wall percentage by comparing the energy needs result of the building which is 49% or by subtracting the commercial floor it will be 28%.

To complete the design of the envelope, full energy performance analysis is needed in order to decrease the amount of energy consumption. Thanks to The IES Virtual Environment (VE) which it is a suite of building performance analysis applications. It gives the ability to test different options, identify passive solutions, compare low-carbon & renewable technologies, and draw conclusions on energy use, occupant comfort. Starting by the base case, which it has been chosen in Sefaira.

- The first optimizing case is to have a thermal mass in the walls where it considered as 5 cm thickness cement board, it decreases the total load in 5 kWh/m2.
- The second optimizing case is about the glazing; different type of glazing has been simulated.
- The third optimizing case is about the framings of the window where the chosen one is 20% of the window area with UPVC material, that decreased the load 3 kWh/m2..
- The fourth optimizing case is about the natural ventilation in summer in certain schedule and that decreased the load 2 kWh/m2.
- The fifth optimizing case is about the window opening by using macro flow, by this case to know the best opening percentage of the window in order to limit the residence behaviours.
- Finally, using of the shading system in summer and white surface on the roof with new thermal mass in the external walls able to decrease the total amount of the load in 22 kWh/m2.

The total reduction from the base case to the last case is around 38% only by the passive strategies. The total load needed is 53 kWh/m2 considered as a good amount for the new generation building.

As a result of IES-VE simulation the shading system is needed in summer to limit the solar radiation gain. From this point, another chapter has been created in order to design a parametric shading system able to achieve this need. Some case studies have been done in order to see how the residential building can use the shading system. The next step is to find the pattern concept of the shading system, the concept is considered from the old building in Damascus, from the shape of (Al-Khoss) as it was a shading system element in the historical building.

The next step was The solar radiation studies was useful on the building and how the context shaded on the building surfaces. This can gives information about the floors and period that need the shading system in order to design an accurate system. The period that the shading system must be effective is between 1st of April to 30th of September taking into account to minimum blocking the solar radiation in the other months. While the application on the facades:

- South: totally shaded.
- North: not shaded.
- East: totally shaded.
- Internal East facade: from 3rd floor to 5th floor.
- West: from 2nd floor to 5th floor.
- Internal West: from 3rd floor to 5th floor .

Finally, the design of the shading system was for each facade. Many simulations in order to find the best configuration have been done to arrive to the best solution for each facade.

The reduction of the energy consumption becomes a very important sector these days. Significant savings in energy use in new buildings of all types and in all climate zones, compared to current practice, are possible using existing technologies. For the residential building in Damascus more then 50% of reduction of the energy consumption can be achievable by using the passive strategies as this report starts from a building has same performances of the existing building there.