Cost Efficient Options and Financing Mechanisms for nearly Zero Energy Renovation of existing Buildings Stock

DELIVERABLE 2.1

REPORT PRESENTING THE 3 NZEB RENOVATION SCHEMES IN MESSINA, ITALY, FULLY DOCUMENTED WITH TECHNICAL AND ECONOMIC EVALUATION

Authors:

Alessandra Gugliandolo, Maria-Anna Segreto - ENEA

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Author(s):	Alessandra Gugliandolo, Maria Anna Segreto	
Contributors:	Pasquale Tripodo, Vito Leotta, Giacomo Villari, Chiara Santonocito, Gianfranco Scipilliti, Stella Styliani Fanou	
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Participating Partners:	1. ENEA - Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile - Italy 2. COMUNE MESSINA - Comune di Messina - Italy 3. ERRENTERIA - Errenteriako udala - Spain 4. CMC - camara municipal de coimbra - Portugal 5. ALIMOS - Dimos Alimou - Municipality of Alimos - Greece 6. ISR - Instituto de sistemas e robotica - Associacao - Portugal 7. SINLOC – Sistema Inizative Locali S.p.A.- Italy 8. ETVA VI PE - ETVA VI.PE. S.A. - Greece 9. TECNALIA - Fundacion Tecnalia Research & Innovation - Spain 10. EUDITI LTD - EuDiti - Energy and Environmental Design - Greece 11. INNOVA BIC - INNOVA BIC - Business Innovation Centre - Italy 12. AAU SBi - Aalborg University - Denmark 13. ASSISTAL - Associazione Nazionale Costruttori di impianti e dei servizi di efficienza energetica ESCo e Facility Management- Italy
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Deliverable D2.1: Short Description

The document presents three renovation schemes for Messina, Italy, with calculated energy performances and costs carried out through simulation software. The optimal renovation designed has been selected according overall energy efficiency, regulatory framework, comfort and visual impact of the solutions proposed

Keywords: Renovation plan, historic buildings, nZEB, energy efficiency, renewable energy, economic assessment, energy audit.

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Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

Acronym	Definition
CFL	Compact Fluorescent Lamp
CHP	Combined Heat and Power
COP	Coefficient Of Performance
EER	Energy Efficiency Ratio
ESCO	Energy Service Company
HVAC	Heating Ventilation Air Conditioning
LED	Light-Emitting Diode
nZEB	nearly Zero-Energy Building
PV	Photovoltaic
BACS	Building Automation Control System

CERTUS PROJECT IN BRIEF

Southern European countries undergo a severe economic crisis. This hinders the compliance to the latest Energy Efficiency Directive, demanding strict energy efficiency measures for the public sector. Investments required to renovate public buildings and achieve nearly zero energy consumption have long payback times. So the interest of financing entities and ESCOs is small, especially when banks have limited resources. Many of the municipal buildings in Southern Europe require deep renovations to become nZEB and this should not be regarded as a threat but rather as an opportunity for the energy service and the financing sector.

The objective of the proposed action is to help stakeholders gain confidence in such investments and initiate the growth of this energy service sector.

Municipalities, energy service companies and financing entities in Italy, Greece, Spain and Portugal are involved in this project. The plan is to produce representative deep renovation projects that will act as models for replication. Twelve buildings in four municipalities in each country have been selected. The partners will adapt existing energy service models and procedures and will work out financing schemes suitable for the 12 projects. Consequently, the partners will create materials, such as guides and maxi brochures, suitable to support an intensive communication plan.

The plan includes four workshops with B2B sessions targeted to municipalities, ESCOs and financing entities. These actions shall be complemented by four training activities targeting municipal employees and the participation in international events targeting all 3 stakeholders. We expect that our action will have a significant impact by triggering investments in renovations to achieve nZEB and the uptake of the ESCO market in Southern European member states.

SUMMARY

Messina municipality is participating with three buildings, namely, the City Hall (Zanca Palace) and two municipal offices (Satellite Palace and Antonello da Messina Cultural Palace).

The aim of the renovation design is to achieve the nearly zero energy building standard, ensuring the comfort of the occupants, workers and visitors.

The design, detailed in the subsequent chapters, was developed along the requirements and constraints imposed by the Technical Department, the Physical Planning Department and the Superintendence of Cultural Heritage of the City of Messina.

The principal constraints to be observed are:

(i) To maintain the historical memory and architectural building
(ii) Do not change in full the working functions
(iii) Do not interrupt the activities of workers and interfere as little as possible with the normal development of municipal activities.

Also in Italy has not yet entered into force legislation governing building design nZEB, should come into force in the year 2015.

Proposals for renewal concern the reduction of all energy consumption: lighting, heating / cooling, computer equipment and electronics. The analysis of the buildings has been carried out with: energy audits.

The software used is the Design Builder version v. 3.4.0.033, based on Energy Plus. The data for envelope materials, electronics and computing equipment, lighting, heating/cooling plants and management profiles of individual environments have been included using special schedules. Wherever experimental data were not available they have been referred to the values required by the regulations. Examined the conditions of the state of the simulation was then made of the state of the project, entering hypothesized renovation scheme. These interventions were extremely expensive, just because of the huge size of the building (13,500 sqm/ 90000 mc) but, at a later time, will be necessary to evaluate the investment payback.

MESSINA GENERAL INFORMATION

Messina is an Italian municipality with a population of 240,725, has an area of 211.23 km²; also called the "door of Sicily" and once Zancle and Messana, located in the North-Eastern part of Sicily (Capo Peloro), exactly on the Strait of Messina.

From sea level, within the same municipality, it is possible to climb up to 1,130 meters, through the hills above the city, to Mount Dinnammare (from the Latin "bimaris" two seas). From here the view extends on the two seas of the city, Sea Ionio (on the Strait of Messina) and the Tyrrhenian Sea.

Its marina is the first in Italy for number of passengers and the sixth for cruise traffic.

In 1908 an earthquake destroyed the city almost completely, causing the death of about half the city's population. Rebuilding started in 1912, and the modern city presents itself orderly and regular with wide and straight streets in direction north-south. In recent years, projects are underway aimed at the redevelopment of the city through works such as the waterfront or a new location for the train station.

With an Important and historic university, founded in 1548 by St. Ignatius of Loyola, Messina is a city with an economy based on services, trade, tourism and a significant industrial activity in naval shipbuilding.

FIGURE 1 - LOCALIZATION OF MESSINA IN ITALY

FIGURE 2 - LOCALIZATION OF MESSINA IN SICILY

FIGURE 3 - MESSINA VIEW FROM ABOVE

A. PALACE OF CULTURE – PALACULTURA ANTONELLO DA MESSINA

1. BUILDING GENERAL DESCRIPTION

1.1. LOCATION

Palacultura is a important building of Messina. The building is located near the marina of the city. The Palace of Culture (or more simply Palacultura) is a multifunctional center in the city of Messina, composed of three buildings, in which there are an auditorium, an outdoor theater, a library and an exhibition center located on the terrace.

FIGURE 4 - PALACULTURA

Made and designed in 1975 by engineer Aldo D'Amore and architect Fabio Baisle, after various events (such as the finding of some archaeological remains), it was completed only at the end of 2000. More precisely, April 16, 2009 were concluded the work started in 2005, after 30 years from the project. Located in the central part of the avenue Boccetta, which is for the city of Messina the first access road for motorists coming from the highways, it is therefore necessarily a visiting card on architecture that the city offers to visitors.

FIGURE 5 - PALACULTURE FROM AVENUE BOCCETTA

FIGURE 6 - A PARTICULAR VIEW OF PALACULTURE

Table 1 presents the main location data of the building.

TABLE 1 - LOCATION DATA OF THE BUILDING

Address	European Union Square, 41 98122 Messina (ME), Italy
Coordinates	LAT. 38°11'51.91"N- LONG. 15°33'14.05"E
Google Maps	https://www.google.it/maps/place/38%C2%B011%2751.9%22N+15%C2%B033%2714.1%22E/@38.1977494,15.5539167,2880m/data=!3m2!1e3!4b1!4m2!3m1!1s0x0:0x0!6m1!1e1

The building is located near the marina of the city. These figures show the location in the city map and aerial view.

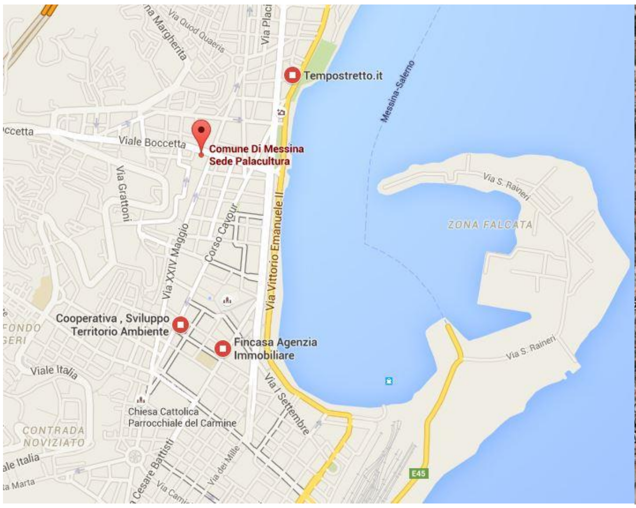


FIGURE 7 - LOCATION IN THE CITY (MAP)

FIGURE 8 - LOCATION IN THE CITY (AERIAL VIEW)

TABLE 2 - DATA OF THE SYSTEM CONSIDERED

Degree days	707											
Minimum temperature of project	5.0 °C											
Altitude	3 m s.l.m.											
Climatic Zone	B											
Heating days	121											
Wind speed	2.8 m/s											
Wind zone	2											
Province of reference	Messina - Reggio di Calabria											
Average monthly temperatures(°C)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	11.7	12.0	13.2	15.7	19.2	23.5	26.4	26.5	24.2	20.3	16.6	13.3
Averages monthly raditions (MJ/m²)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	7.2	10.8	15.2	20.3	24.4	27.3	27.2	24.6	19.0	12.9	8.9	6.6
	10.8	12.9	12.9	11.5	9.9	9.2	9.7	11.8	14.0	14.2	13.2	10.3
	8.6	11.1	12.7	13.6	13.6	13.8	14.3	15.3	14.9	12.6	10.7	8.2
	5.4	7.9	10.5	13.4	15.6	17.1	17.2	16.2	13.1	9.3	6.7	5.0
	2.7	4.2	6.6	9.7	12.5	14.5	14.1	11.8	8.2	5.1	3.2	2.4
	2.4	3.2	4.3	5.9	8.4	10.2	9.5	6.8	4.6	3.6	2.6	2.2

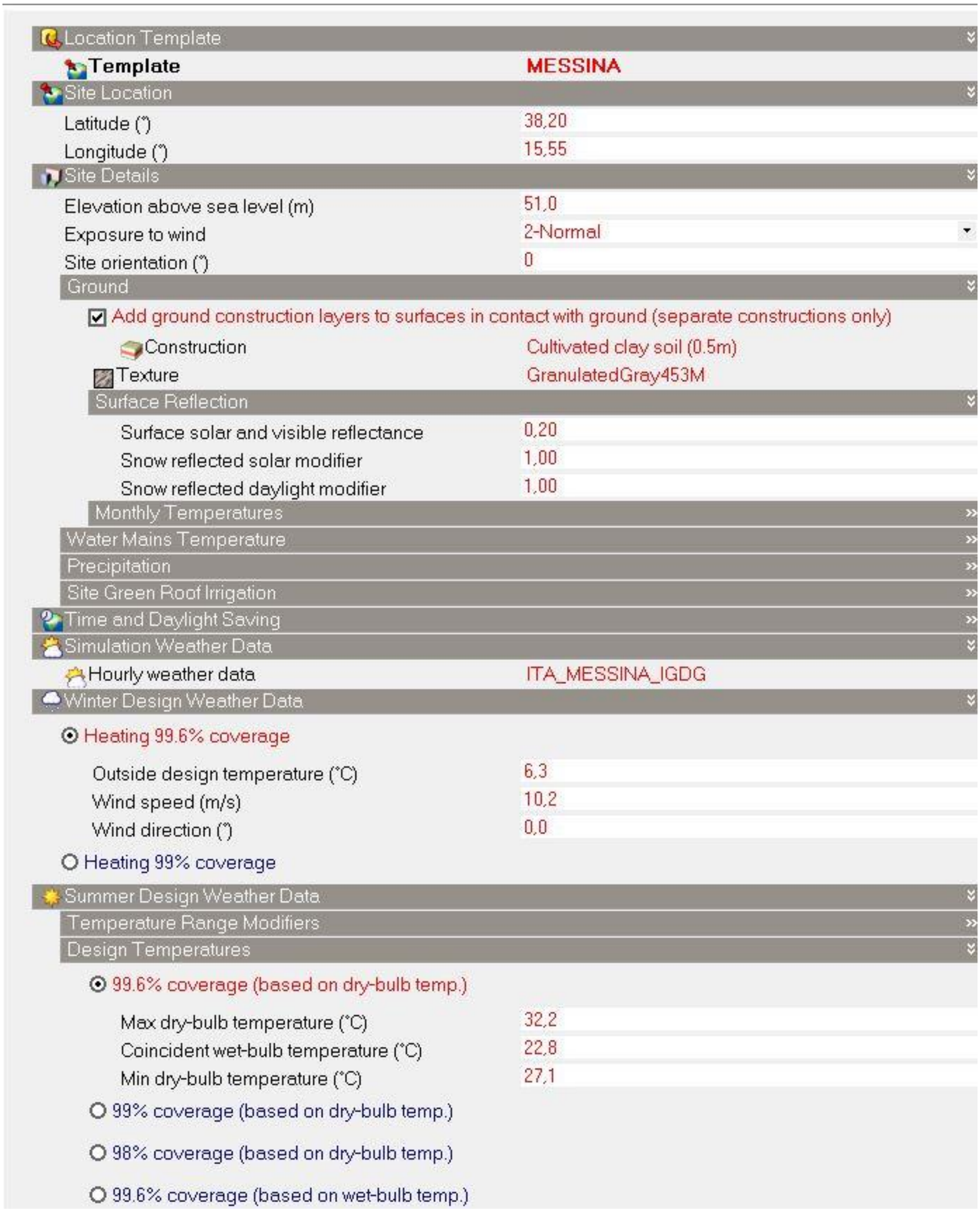


FIGURE 9 - DATA FOR THE SIMULATION WITH DESIGN BUILDER SOFTWARE

1.2. Shape And Orientation

This Palace is constituted from a building of 6 floors above ground. The dimensions are very different for each floor.
The next figure shows the road network near the studied area.

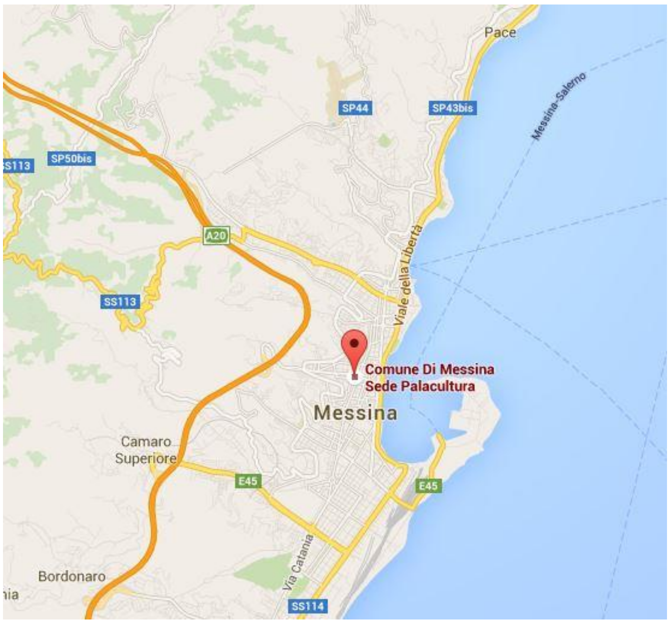


FIGURE 10 - ROAD NETWORK SCHEME

1.3. Area And Volume

The building has a total area of about 10,300 m^2 , this area is divided in different levels, which are however different in height and shape.

1.4. Current Use

It consists of three buildings used to house offices for culture, the largest town public library, a museum, a theater with 850 seats with 4 audiences, orchestra pit and booths for television direction of events, an auditorium for music outdoors among the largest and most modern of Italy, and even an exhibition hall located on the terrace of the second body of the building.
The inverted pyramid structure was obtained by exploiting the considerable flexibility offered by materials such as concrete and steel, of course taking into account that Messina is a seismic zone of 1st category.
On the ground floor there is the access to the building with hall, reception of the theater. All rooms are now used as offices for culture, with the exception of the bathrooms, deposits and some offices of municipal councillors.

FIGURE 11 - HALL AND RECEPTION

FIGURE 12 - THEATER

On the first floors there are numerous municipal offices, meeting rooms, a museum, a public library bathrooms and archives.

FIGURE 13 - MUSEUM

FIGURE 14 - AN ARTWORK OF THE MUSEUM

In the basement there are technical rooms and a garage for employees of the Palace of Culture.
The building is usually busy for the public activities and on the occasion of the museum exhibitions or theater performances. The public activities of employees carried out only between 7h30 and 19h30. Public access depends on the type of service provided and is between 08h30 and 13h30 from Monday to Friday, also between 14h30 and 16h30 on Tuesday and Thursdays.
The building hosts about 200 employees and visitor numbers change according to the activities taking place at the palace.
For the simulation of Palace of Culture of Messina with Design Builder, the building was divided into 11 blocks (named 11,12,13,14,16,2,3,4,5,6,7). Windows are modelled individually and has been dimensioned according to data of the original design.

The following image shows the Home screen of the software.

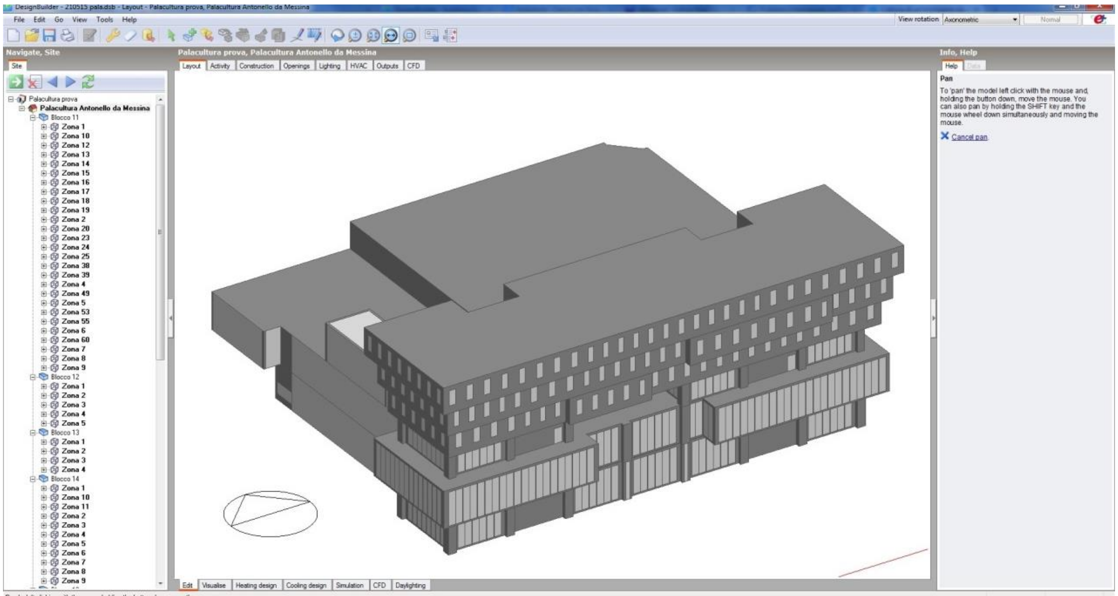


FIGURE 15 - HOME SCREEN OF THE SOFTWARE

The following figures show the floor plans of the blocks, as shown in the simulation software. Each floor is split into different areas, depending on the intended use. Therefore different usage profiles were created.

Block 11 consists of:

- Office Circulation
- Area for speculative office
- Theatre and Lecture space
- Area without any cooling or heating plant
- Office Toilet
- Office Meeting room
- Office Equipment

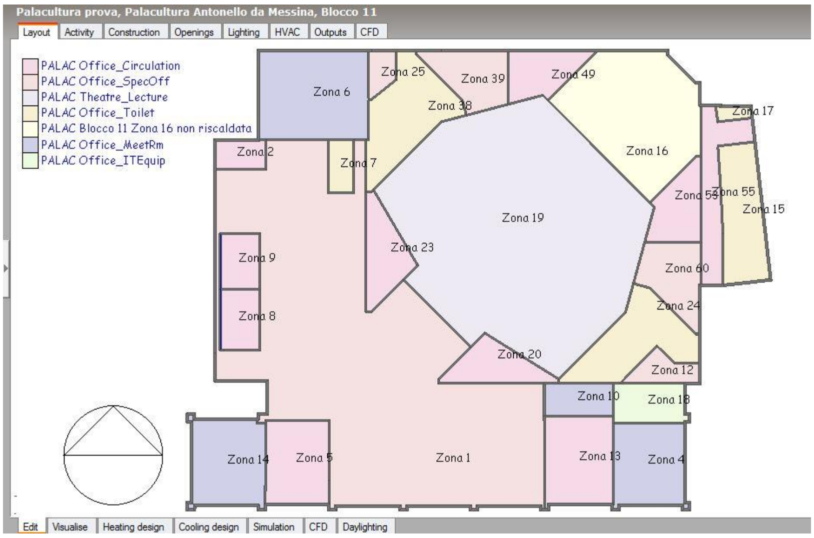


FIGURE 16 - PLAN OF BLOCK 11

Block 16 is the area intended for mobile stairs that connect the ground floor to the second floors the area of the:

- Office Circulation

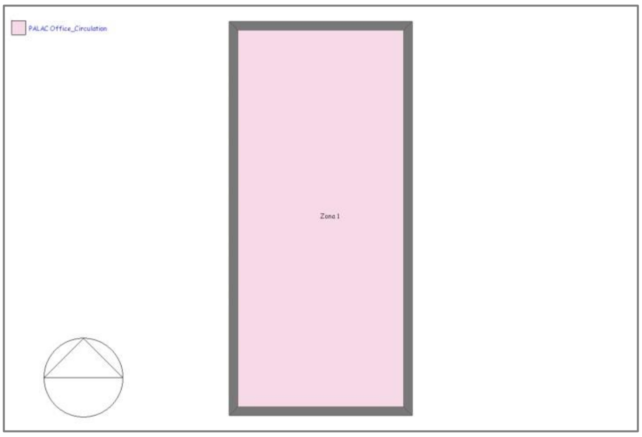


FIGURE 17 - PLAN OF BLOCK 16

Second floor is constituted by three blocks (12,13,14). Block 12 consists of:

- Office Circulation
- Office Toilet

- Office Meeting room

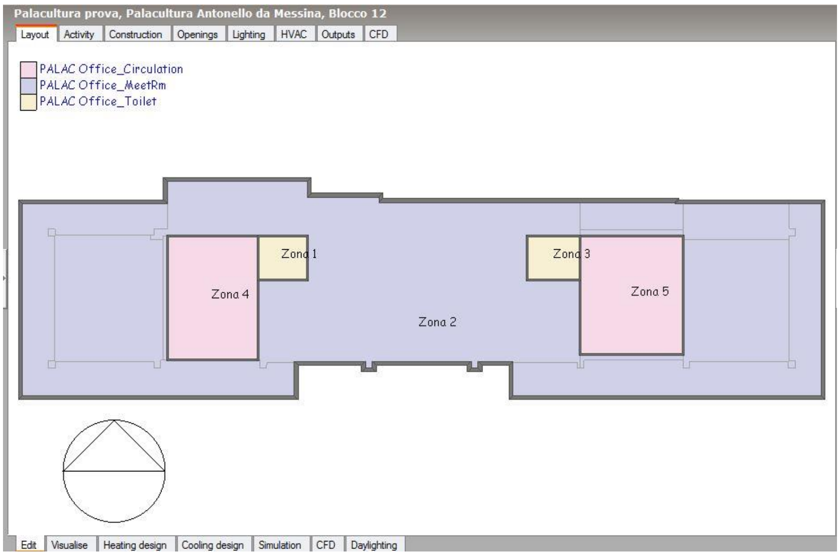


FIGURE 18 - PLAN OF BLOCK 12

Block 13 consists of:

- Office Circulation
- Office Toilet
- Office Meeting room

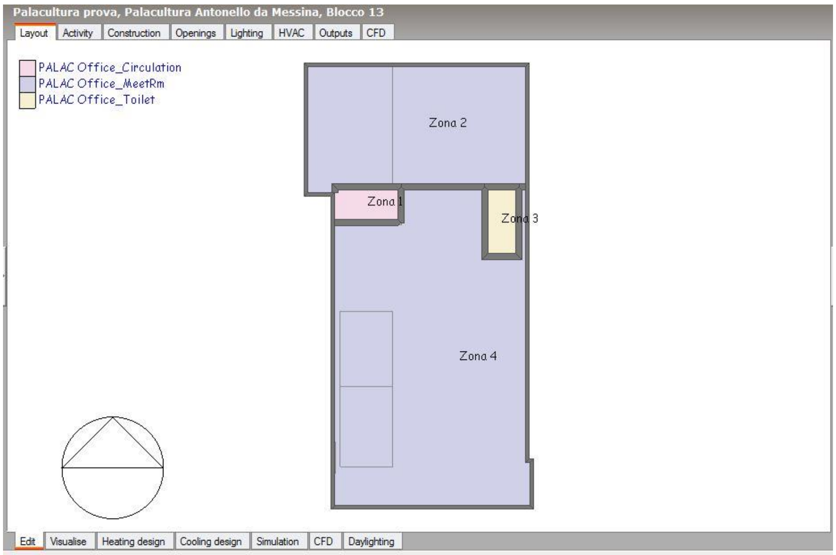


FIGURE 19 - PLAN OF BLOCK 13

Block 14 consists of:

- Office Circulation
- Area for speculative office
- Theatre and Lecture space

Area without any cooling or heating plant

- Office Toilet
- Office Equipment

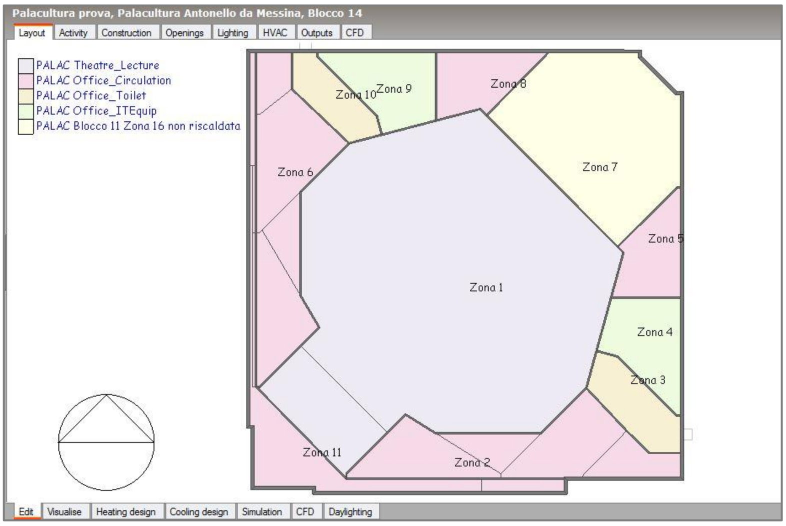


FIGURE 20 - PLAN OF BLOCK 14

Blocks 4 and 5 are in the same floor and have the same functional rooms:

- Office Typical
- Circulation

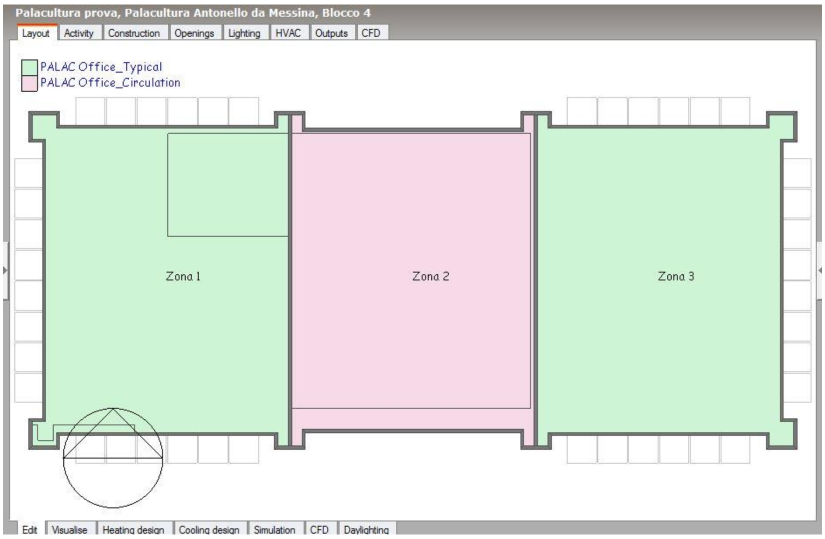


FIGURE 21 - PLAN OF BLOCK 4

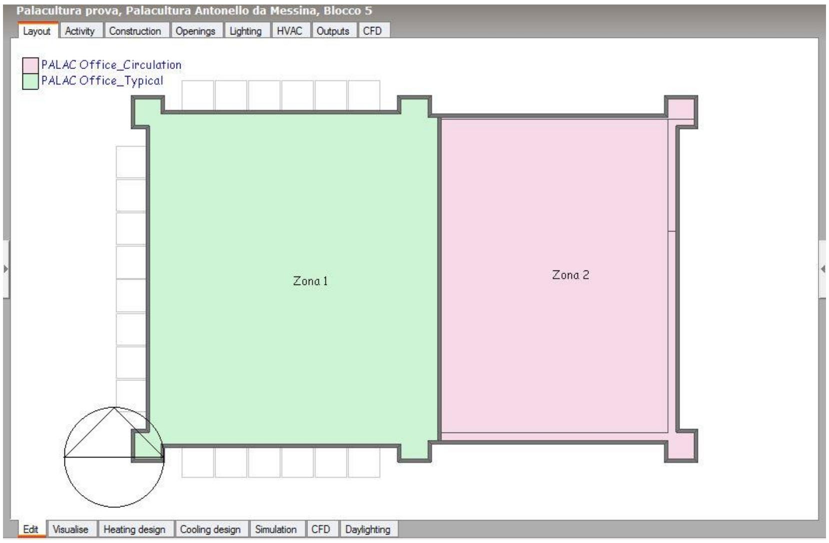


FIGURE 22 - PLAN OF BLOCK 5

Block 3 is the highest part of the area destined to the Theatre:

- Office Circulation
- Area for speculative office
- Theatre and Lecture space
- Area without any cooling or heating plant
- Office Toilet
- Office Equipment

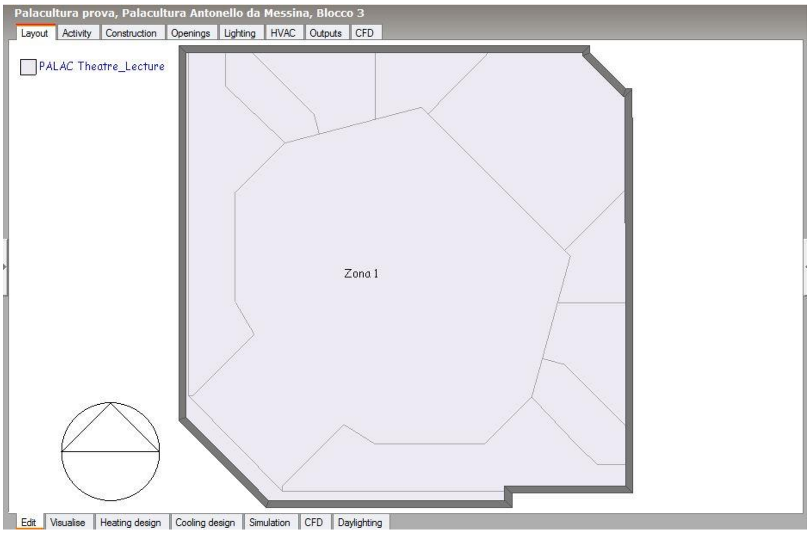


FIGURE 23 - PLAN OF BLOCK 3

Blocks 6, 7 and 2 are the top three floors of Culture Palace. Each floor has the geometry of a parallelepiped with a rectangular base, the dimensions of which increase from the floor below up to the highest one.

Blocks 6, 7 and 2 have the same functions:

- Office Circulation
- Office Toilet
- Office Meeting room

- Office Typical

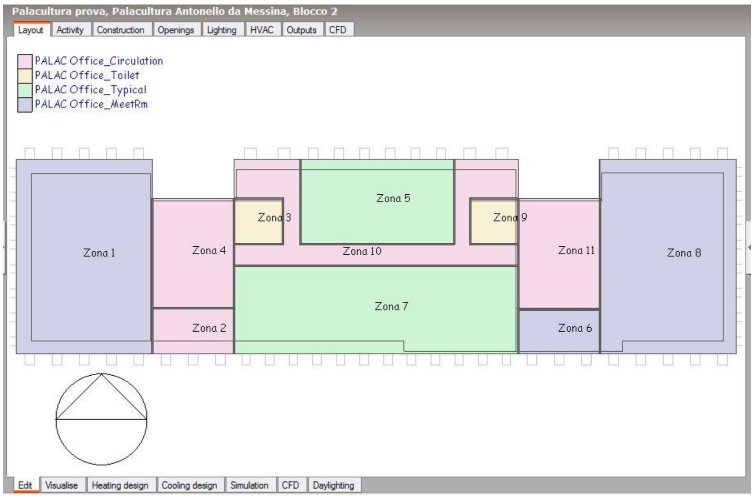


FIGURE 24 - PLAN OF BLOCK 2

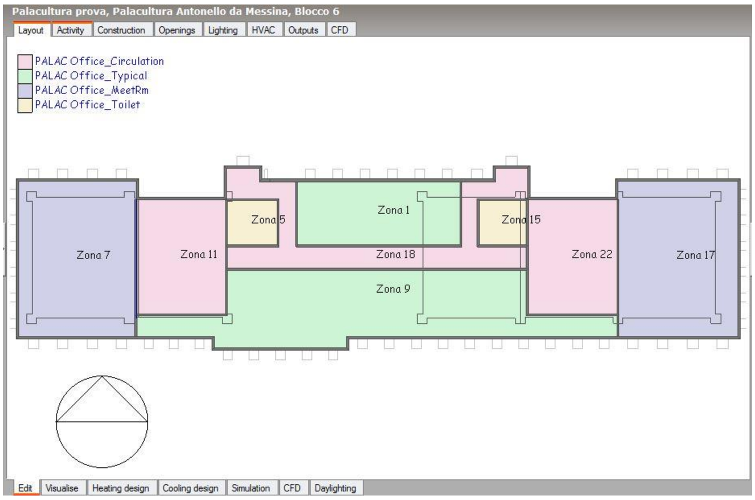


FIGURE 25 - PLAN OF BLOCK 6

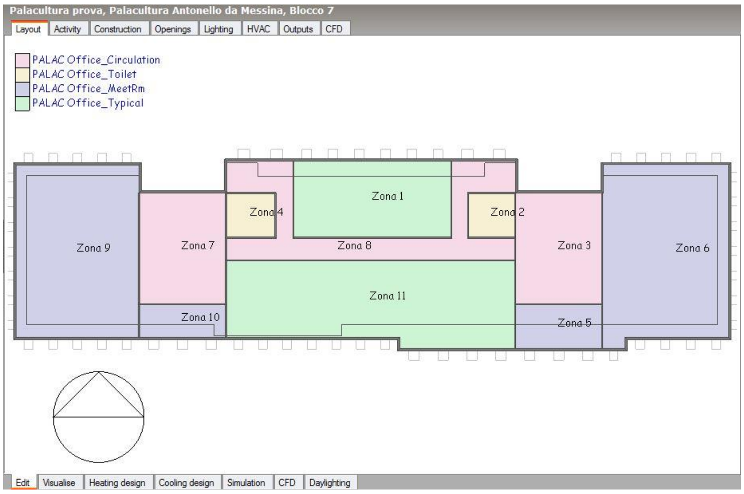


FIGURE 26 - PLAN OF BLOCK 7

2. CURRENT BUILDING CONDITIONS

2.1. CONSTRUCTIVE BUILDING CHARACTERISTICS

Palace of Culture respects the seismic regulations. It is a structure realized in steel and reinforced concrete, according to earthquake regulations in 2000 and does not meet any energy regulations still in force. The following figure presents the aerial view of the building.

FIGURE 27 - AERIAL VIEW OF THE BUILDING

On the ground floor there are the offices open to the public, the access to museum and the access to the theater. The first floor holds some administrative functions of the city of Messina and the library and all rooms of the museum. The other floors hold only administrative functions.

FIGURE 28 - ACCESS OF THE BUILDING

FIGURE 29 - ROOF OF THE BUILDING

The next figure shows the main facade orientation of the building, exposed to the North.

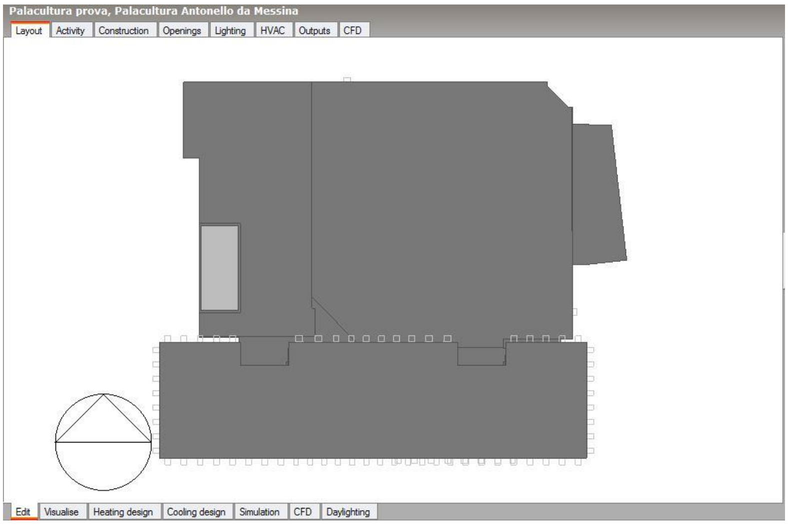


FIGURE 30 - ORIENTATION OF THE MAIN FAÇADE

2.1.1. Envelope Elements

The building is made of wide range of materials, mainly steel and concrete for the envelope. The walls are on the envelope, with the finishing plaster. The plaster has a low capacity, based on lime.

FIGURE 31 - FRONT OF PALACE OF CULTURE

FIGURE 32 - STAIR

2.1.2. Windows

All the windows have single glazing with pvc frames. The doors have the same characteristics of the windows with the exception of 8 doors on the ground floor, which are in glass and metal.

All the windows have simple shutters. A few rooms have opaque cloth curtains the rest have no curtains.

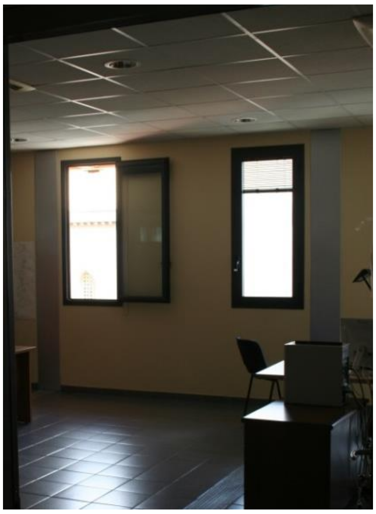


FIGURE 33 - WINDOWS WITH SHUTTERS

FIGURE 34 - EUROPEAN UNION SQUARE

All facades, specially on Boccetta Street, are not subject to any shading, as can be seen from the following figure.

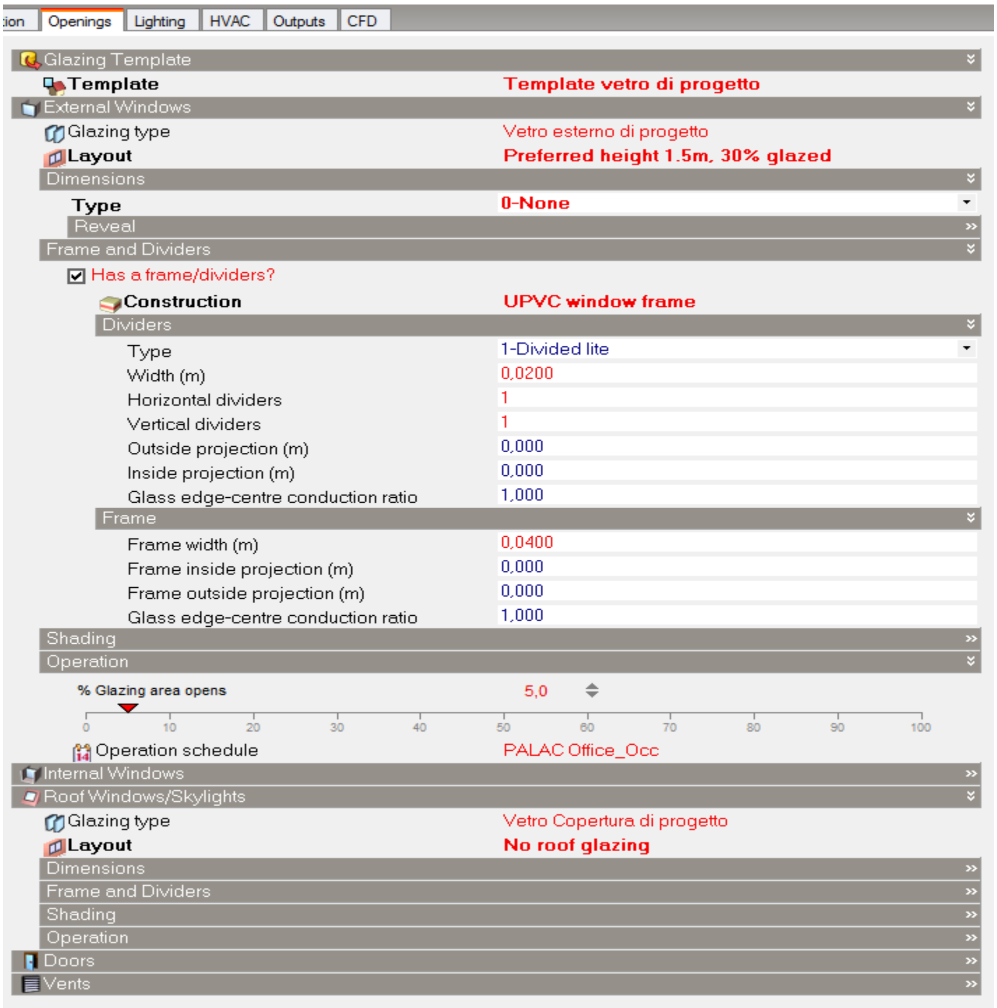


FIGURE 35 - SCHEDULE OF WINDOWS

2.1.3. Airflows And Pathologies

A previous study analysed the envelope with thermal imaging with an external air temperature of about 17°C.

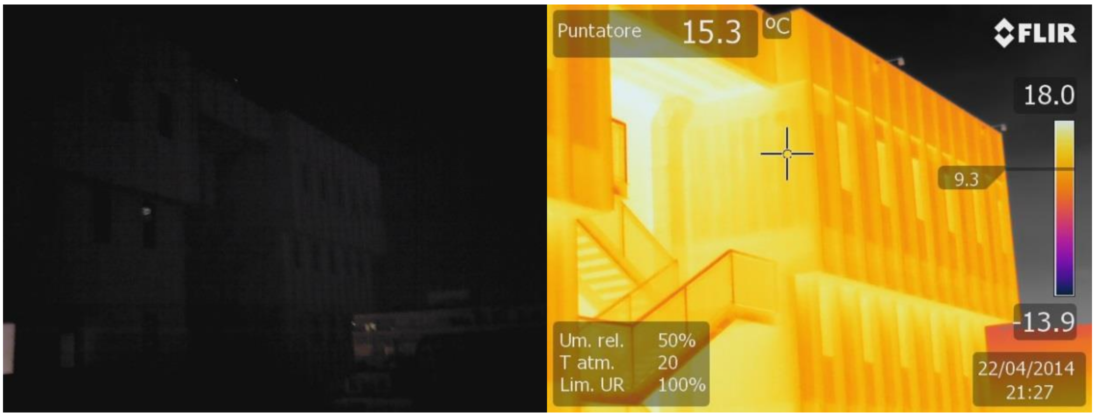


FIGURE 36 - THERMAL VIEW

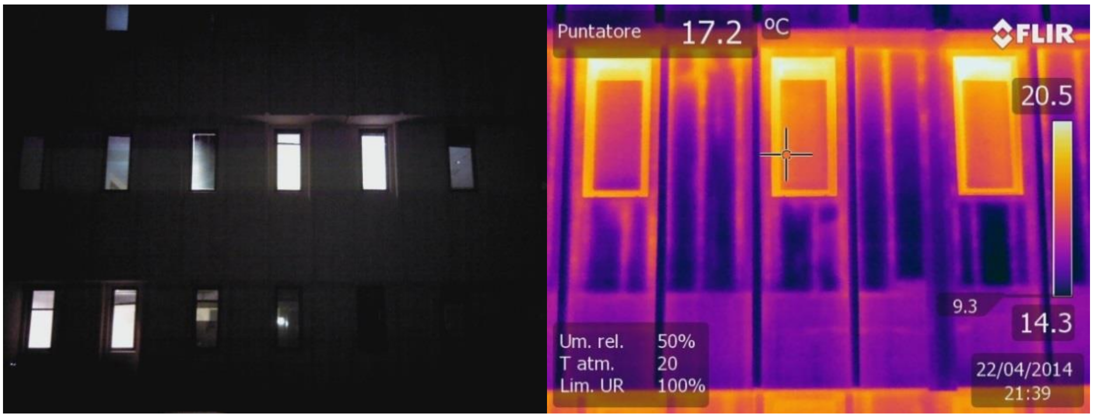


FIGURE 37 - THERMAL VIEW

The following figure shows the general image of the thermal performance of the envelope: the walls present a bad thermal performance.

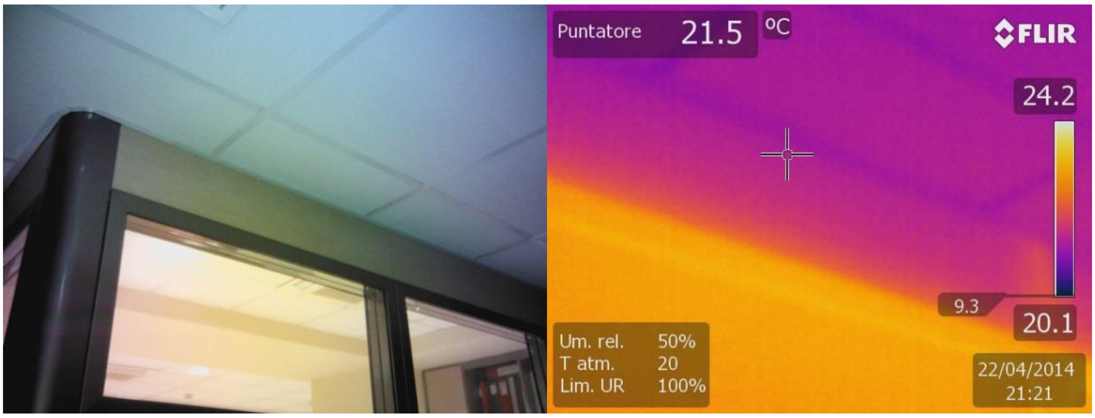


FIGURE 38 - THERMAL VIEW

The next figures show the thermal losses of the windows. The windows, with single glazing and PVC frames, present insulation problems.

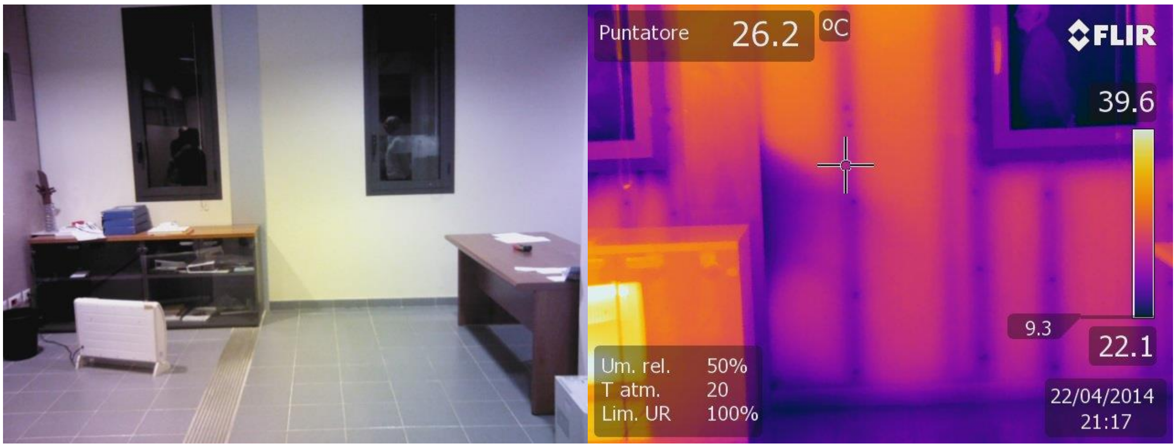


FIGURE 39 - THERMAL LOSSES IN THE WINDOWS AND WINDOW INVISIBLE TO THE NAKED EYE

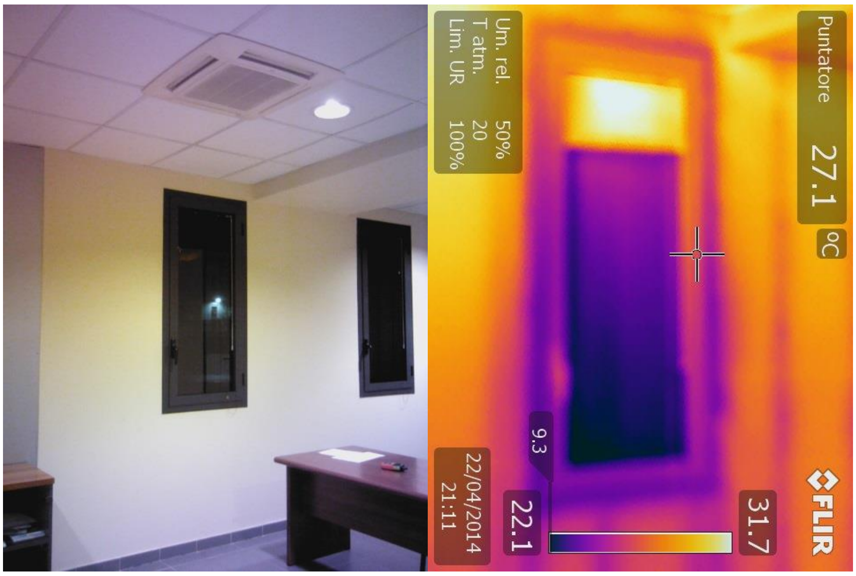


FIGURE 40 - THERMAL LOSSES IN THE WINDOWS AND WINDOW INVISIBLE TO THE NAKED EYE

The thermal losses due to thermal bridges in the corner of the room are also shown.

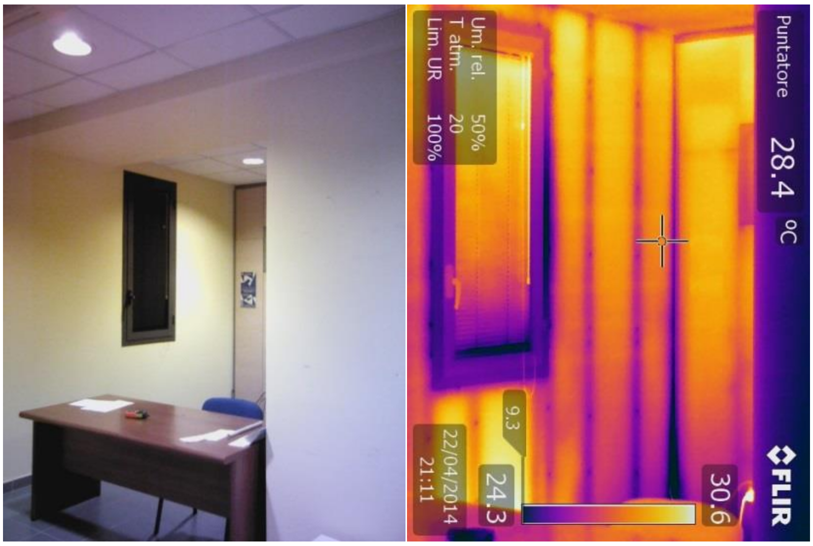


FIGURE 41 - THERMAL BRIDGES

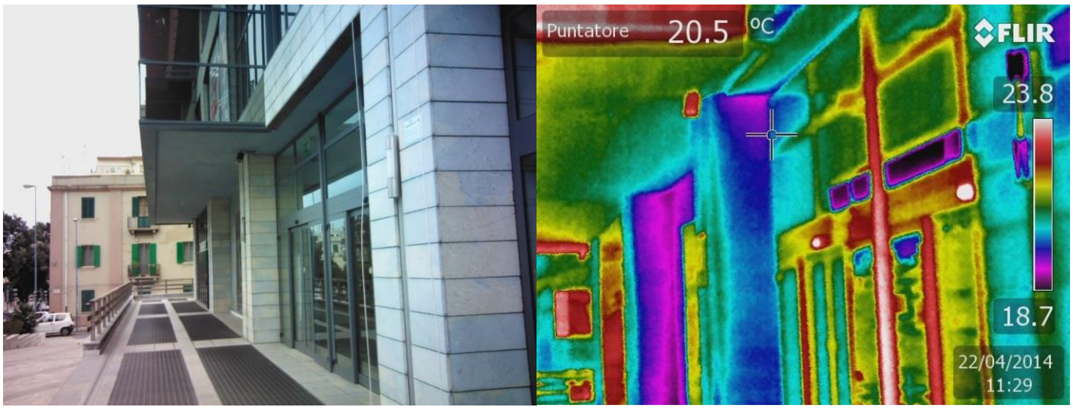


FIGURE 42 - THERMAL BRIDGES

Some characteristics of the building contribute to a bad thermal performance:

- The orientation is not good, due to this condition it is required an additional energy use for heating during the winter (mainly in the North areas). Also it is required more energy use during summer for cooling (mainly in the West areas where there is no protection from the direct solar radiation).
- The walls with high thermal inertia and large ceiling height provide advantages during the summer, but disadvantages during winter, since the building does not have users in the night period and weekends which leads to a high temperature decrease.
- The windows have low air-tightness, enabling a high level of air infiltration, which is not controllable, mainly during winter.
- The doors presents significant heat losses
- The building as a whole has a low energy performance

2.2. Energy Systems

2.2.1. HVAC

The HVAC is ensured with several ceiling mounted split, for the forced ventilation and air conditioning. Therefore, all split units are connected to a single hydronic heat pump.

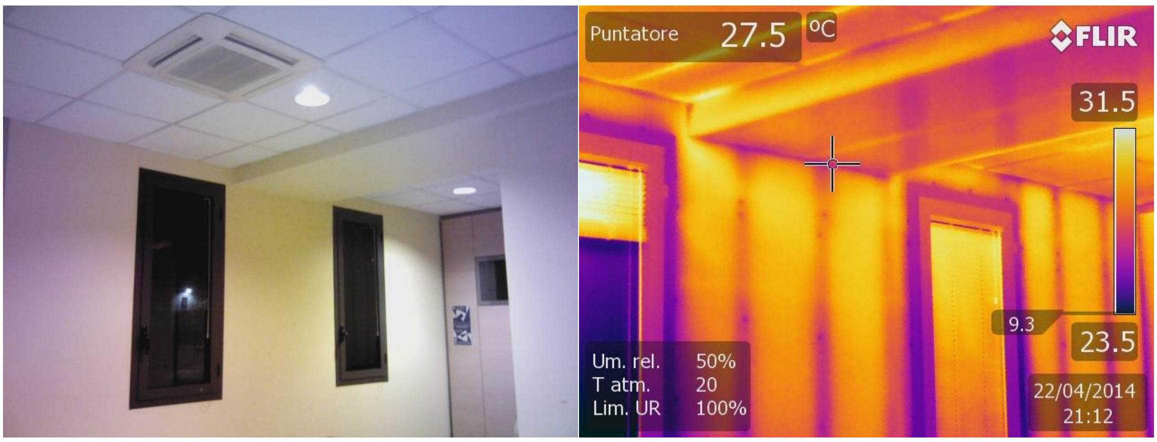


FIGURE 43 - THERMOGRAPHY OF AN AIR CONDITIONER ON

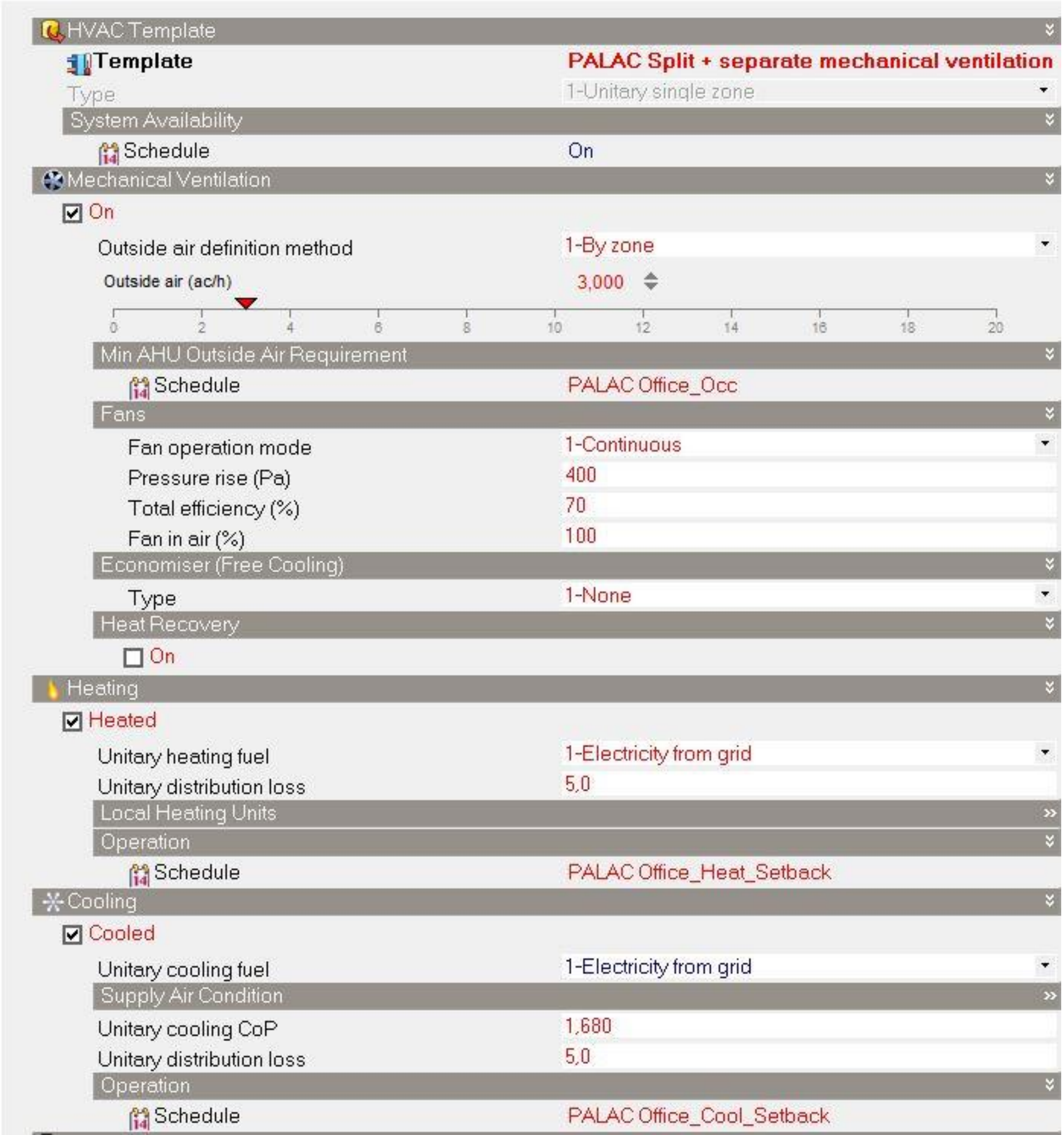


FIGURE 44 - HVAC TEMPLATE

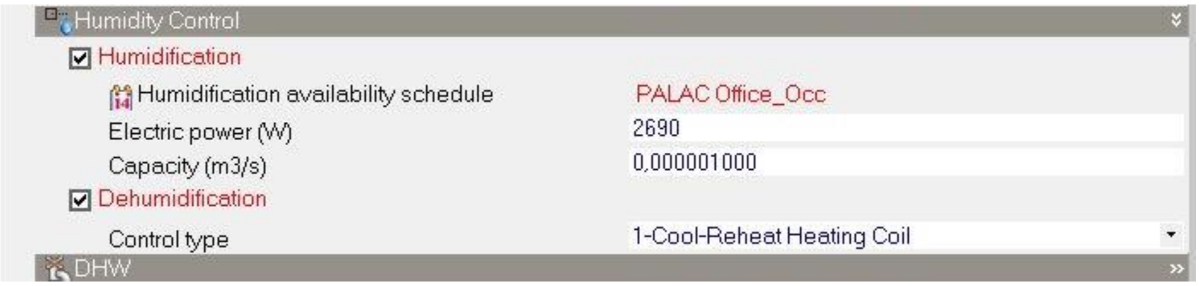


FIGURE 45 - HVAC TEMPLATE (HUMIDITY CONTROL)

The air circulation and renewal is ensured both naturally through the doors and windows as well as through the mechanical system. There is forced ventilation in every room.

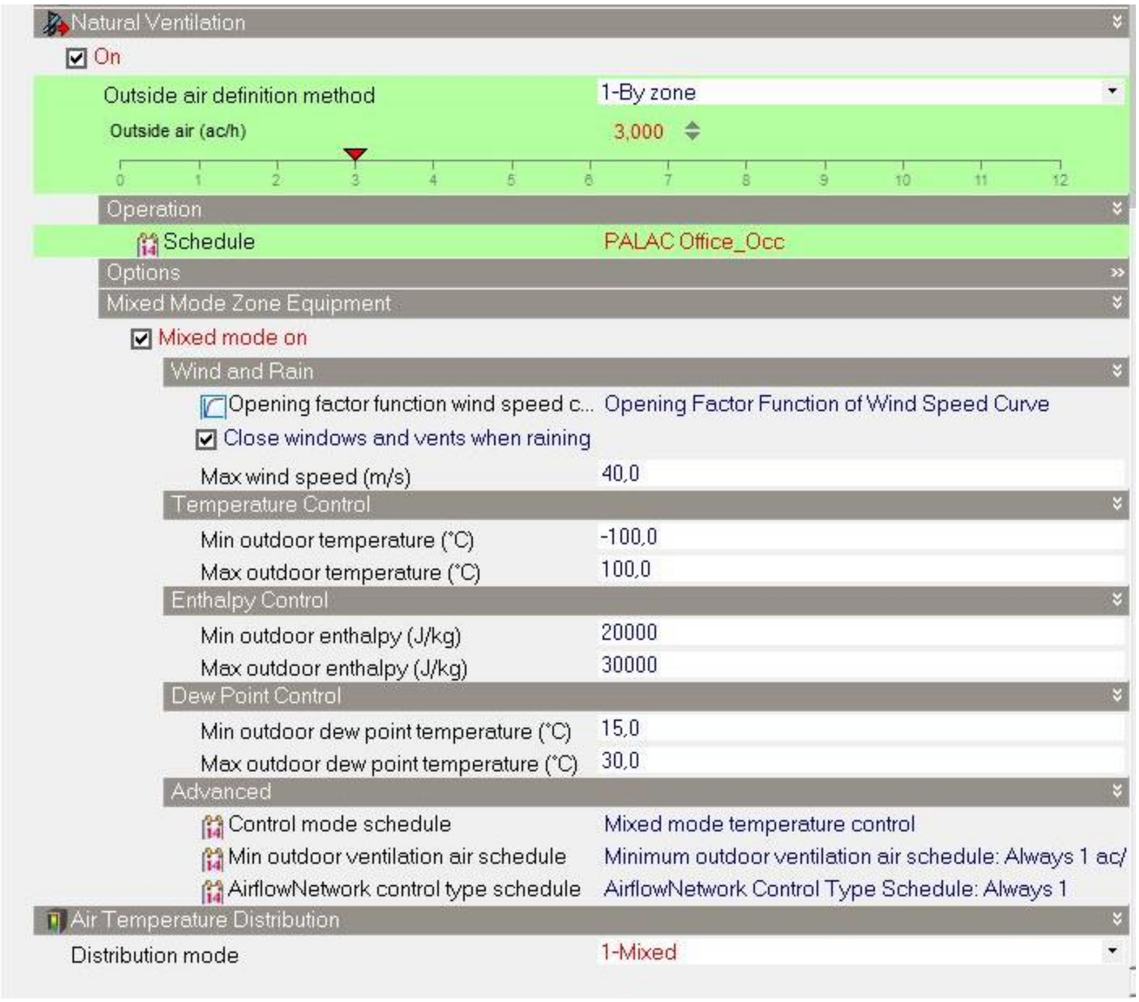


FIGURE 46 - HVAC TEMPLATE

2.2.2. LIGHTING

The building has many different types of lamps, all of fluorescent type.

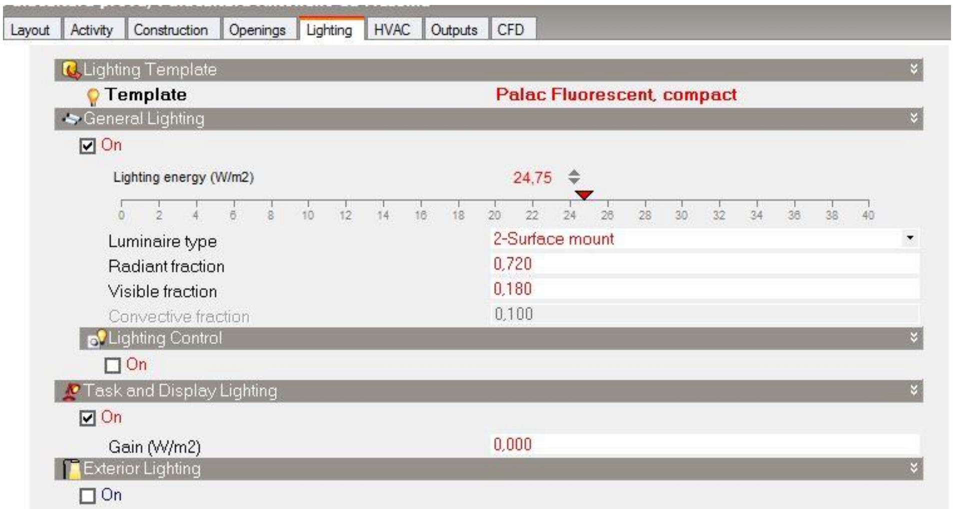


FIGURE 47 - LIGHTING TYPE

FIGURE 48 - LIGHTING IN OFFICES

FIGURE 49 - PARTICULAR LIGHT IN THE MUSEUM

FIGURE 50 - LIGHTING IN MUSEUM AREAS

FIGURE 51 - LIGHTING IN CIRCULATION AREAS

FIGURE 52 - LIGHTING ON THE ROOF OF THE TEATHER

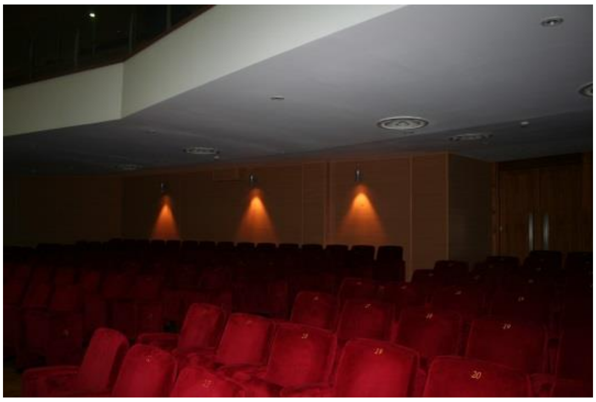


FIGURE 53 - LIGHTING IN AUDITORIUM

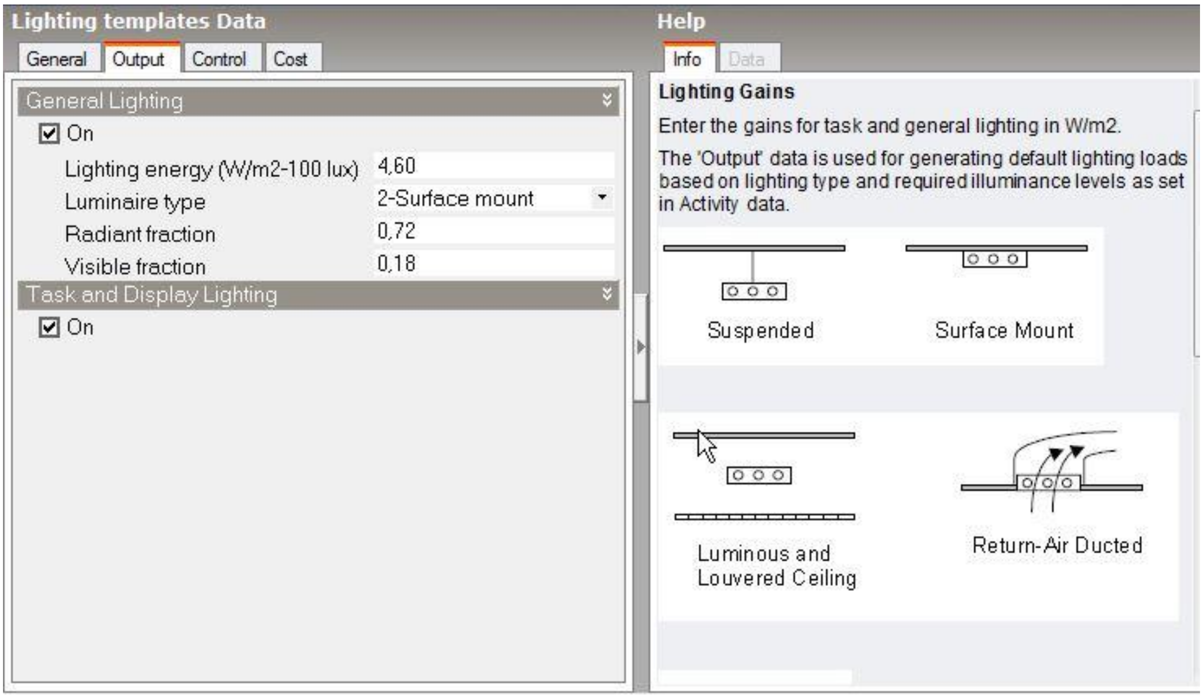


FIGURE 54 - LIGHTING TEMPLATE DATA

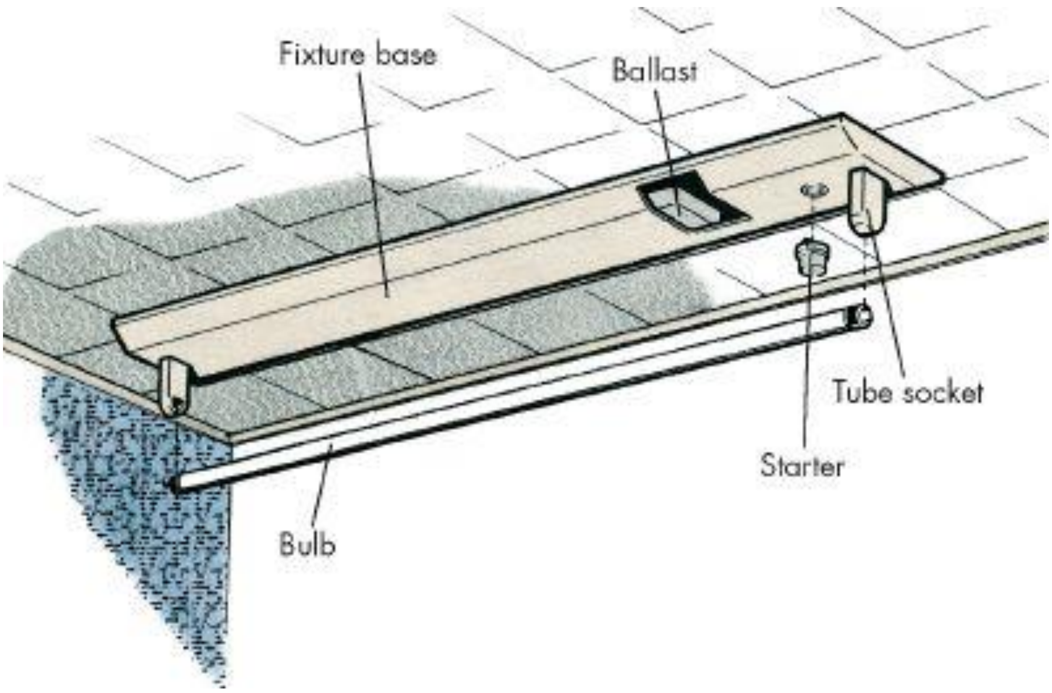


FIGURE 55 - AN EXAMPLE OF FLUORESCENT LAMP

There is no mechanism to control lighting and installations are dated. During closed hours only emergency lighting is on.

TABLE 3 - LAMPS CALCULATION

Piano	Rounded Light Ø230mm 2x26W	Rounded Light Ø190mm 26W	Light at wall 100W	Square Suspended 2x26 W	Prismatic Light 1x18W	Prismatic Light 2x36W	Lamellar Light 4x18W	Prismatic Light 1x36W	Emergency lighting 24W	schermat a 28 W	Spotlight 90W	Spotlight 50W	Applique 75W	Light at floor and at wall 80W	Light at wall 26W	Plafone lettura 58W	Suspended Spotlight 150W	Suspended Spotlight75 W	External Lighting 70W	Light for the path 24W		
Height-4,75 - Garage						48	2		21													
Height-1,25 - Deposit books and Technical rooms		13			4	93	6		14													
Height 2,25) Hall - Auditorium - Sala 70 posti	6	54	21	115		13	4			22	35	41	14	18	4							
Height 7,25)Reading Room - Art Gallery - Room 140 seats	4	40	19	120		9	4	9	29	36				6		32						
Height 12,25) Auditorium Lighting-External Lighting	6	42	11	27		6	4		10		25			3	37		18	36				
Height 15,85) Arena Esterna		4																	26	53		
Height 15,85) Offices	87	43					4		9													
Height 19,45) Offices	100	47					4		9													
Height 23,05) Offices	130	23					4		9													
Height 27,00) Roof - Technical Rooms		32				14			2													
TOTAL	333	298	51	262	4	183	32	9	103	58	60	41	14	27	41	32	18	36	26	53	**1681**	NUMBER
Total/partial number	52	26	100	52	18	72	72	36	24	28	90	50	75	80	26	58	150	75	70	24		
Watt Tot.Partial	17316	7748	5100	13624	72	13176	2304	324	2472	1624	5400	2050	1050	2160	1066	1856	2700	2700	1820	1272	**85834,00**	WATT TOT.

2.2.3. ICT

All offices have computers and printers and in the basement there is a server room. There is an internal circuit for security.

There are photocopier machines, tv screens, video projectors and other electrical equipment used for the museum and the theater.

2.2.4. OTHERS

The building has lifts. The use of such lifts is massive because they serve both the public and employees.

Lift and other equipment connected to plugs such as individual electric heaters, vending machines, photocopier machines, computers and printers (when not connected to the UPSs) etc, were flagged as "other".

For calculating their consumption usage profiles have been created directly through the Design Builder software.

2.3. ENERGY CONSUMPTION & ENERGY GENERATION

2.3.1. ELECTRICITY CONSUMPTION

The building receives electricity in Low Voltage. Following a summary table of power consumption.

TABLE 4 - ELECTRICITY CONSUMPTION

ELECTRICITY CONSUMPTION	kWh per year (2013)	kWh per year (2014)
Palace of Culture		
V.le Boccetta is. 373/374 - MESSINA		Survey performed on days in mid-June in 2014. Average consumption with average outdoor temperatures of 27 C during operation.
Number of User - IT001E91358706	€ 153,957,82	507,259 kWh

There is a central generation for heating and cooling system. To set the calculation of the model the general information are:

TABLE 5 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	** Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	13580.56
Principal Heating Source	District Heat

The following figures show the heat balance of Palace of Culture of Messina, divided according to the contribution types:

- Occupancy,
- Task Lighting,
- General Lighting,
- Computer + Equipment,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

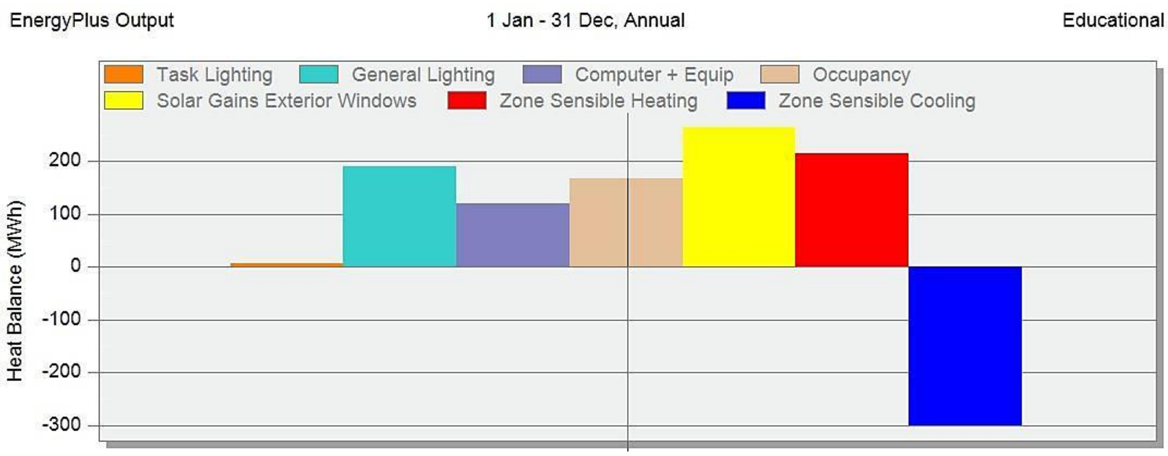


FIGURE 56 - ANNUAL HEAT BALANCE

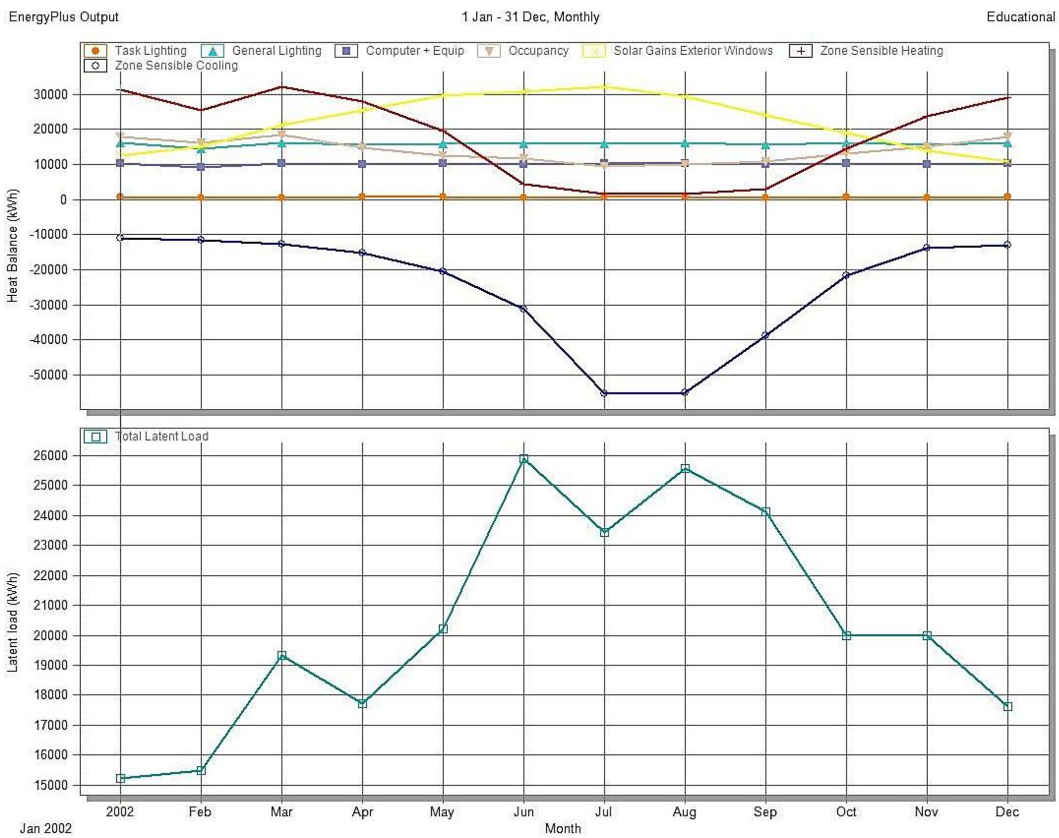


FIGURE 57 - ANNUAL HEAT BALANCE, ACCORDING OF SINGLE MONTHS

The following figures show heat balance of Palace of Culture, divided according to the contribution types, during four months in particular January, April, July and September:

- Occupancy,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

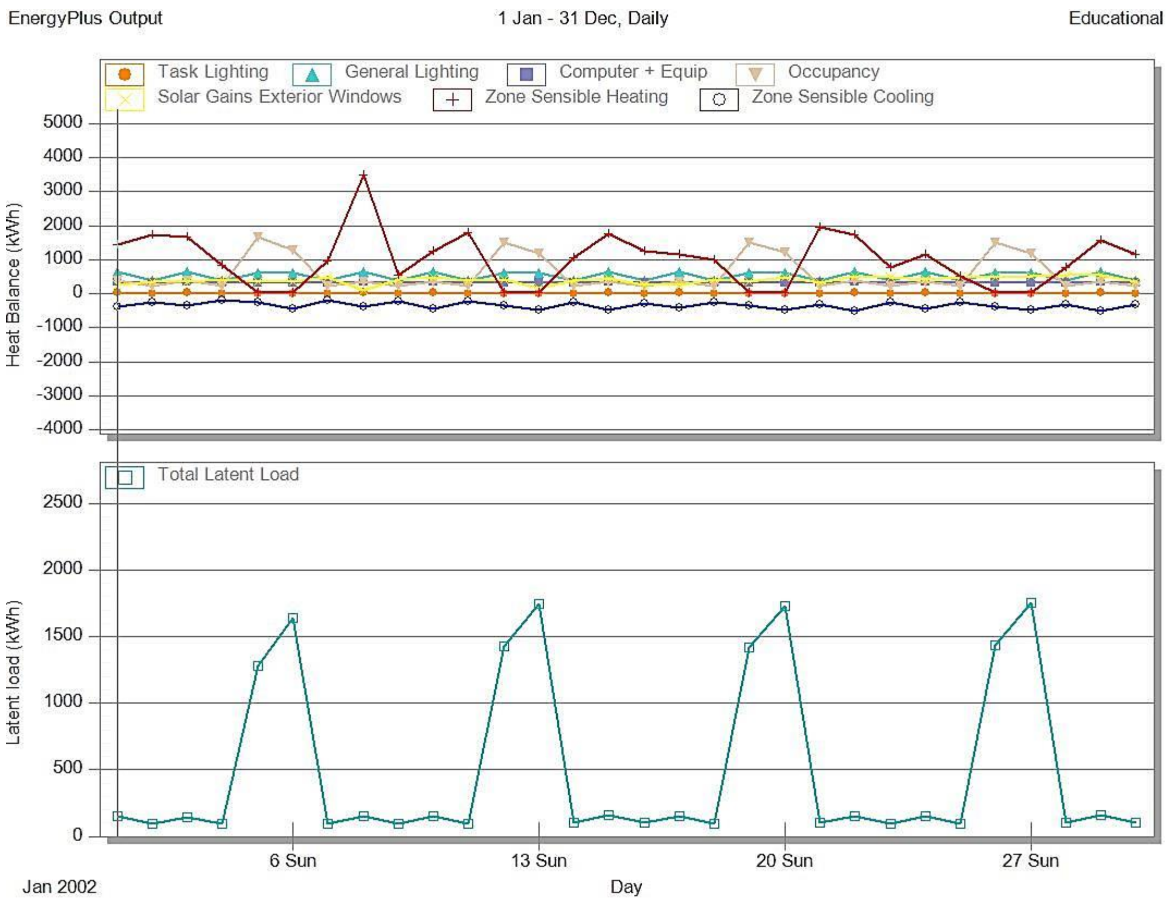


FIGURE 58 - HEAT BALANCE DURING JANUARY

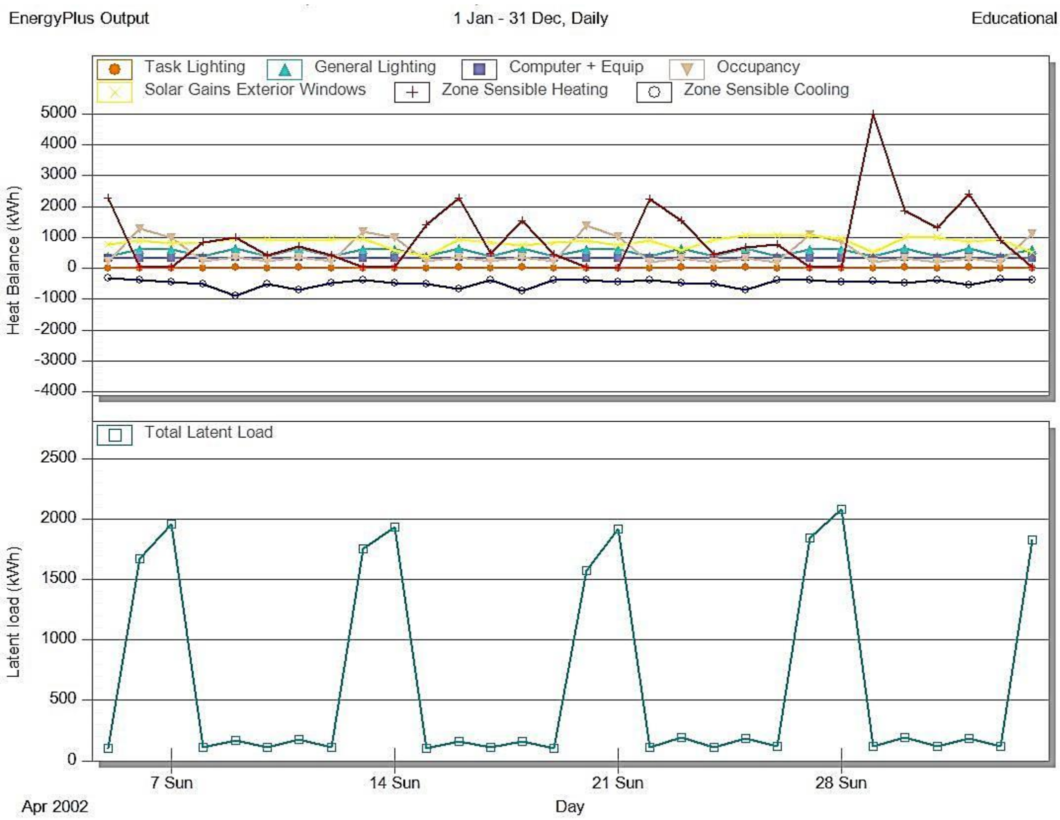


FIGURE 59 - HEAT BALANCE DURING APRIL

FIGURE 60 - HEAT BALANCE DURING JULY

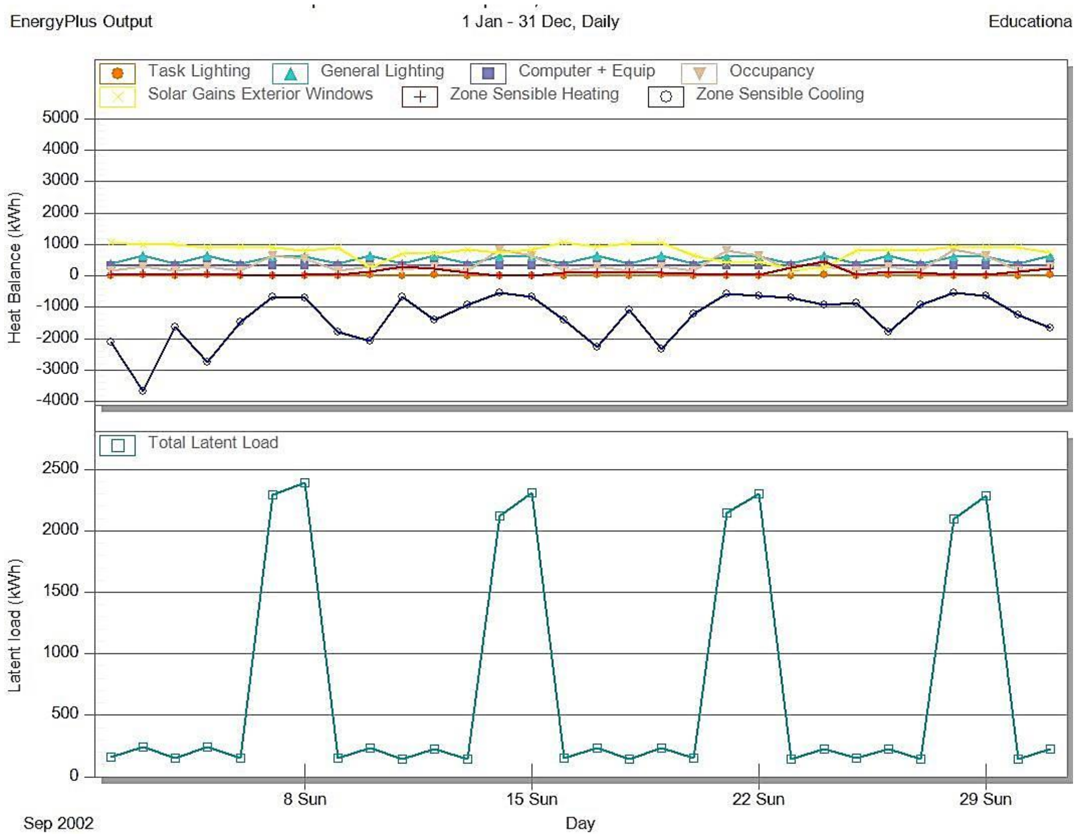


FIGURE 61 - HEAT BALANCE DURING SEPTEMBER

2.3.2. GAS/OIL CONSUMPTION

The building does not have any gas consumption.

2.3.3. RENEWABLE ENERGY SOURCES

The building does not have any RES plant.

2.3.4. OTHER GENERATION

Other data that influence thermal balance come from building envelope.

The considered data are:

- External air
- Internal Natural ventilation
- Mechanical Ventilation + Infiltration

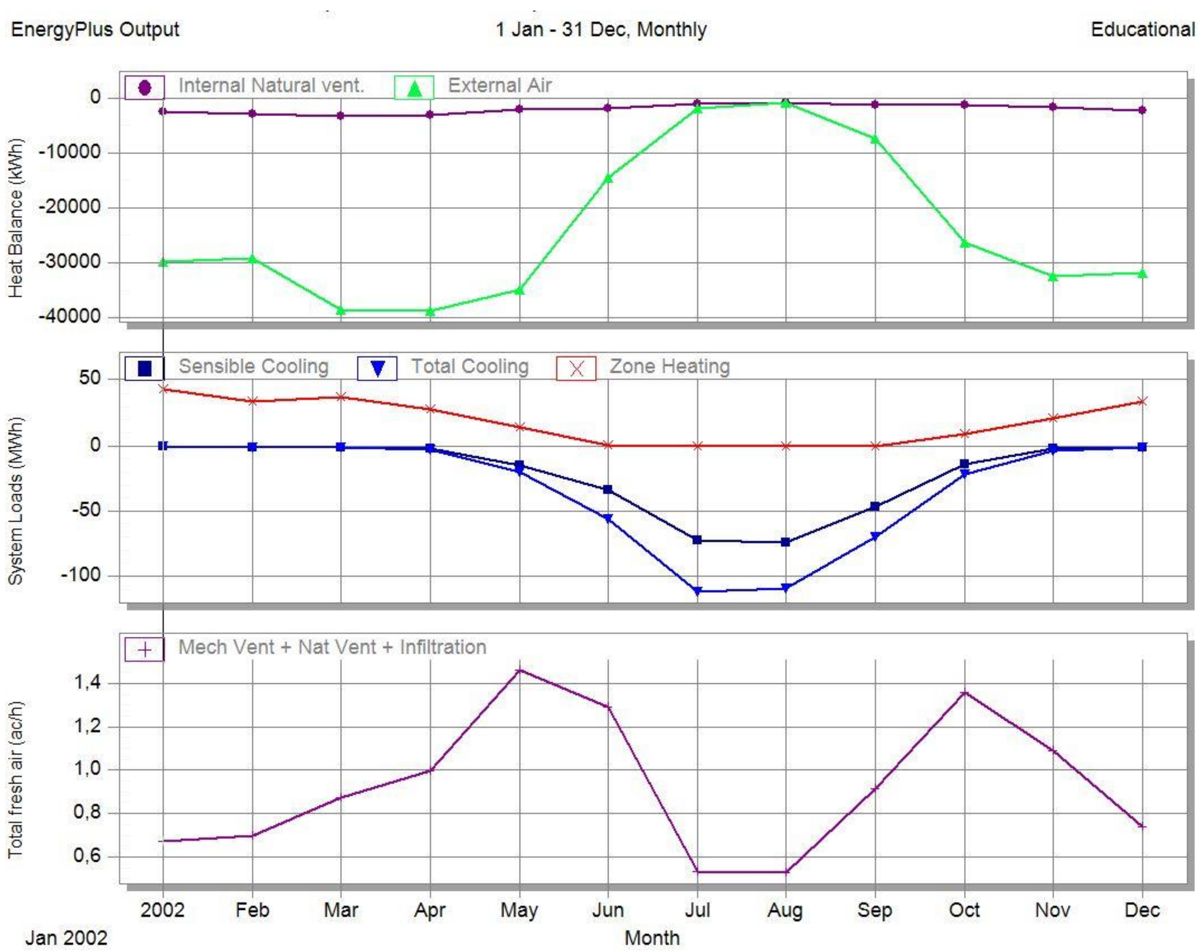


FIGURE 62 - ANNUAL HEAT BALANCE , ACCORDING OF SINGLE MONTHS

The following figures shows annual comfort value of Palace of Culture of Messina, divided according to the contribution types.

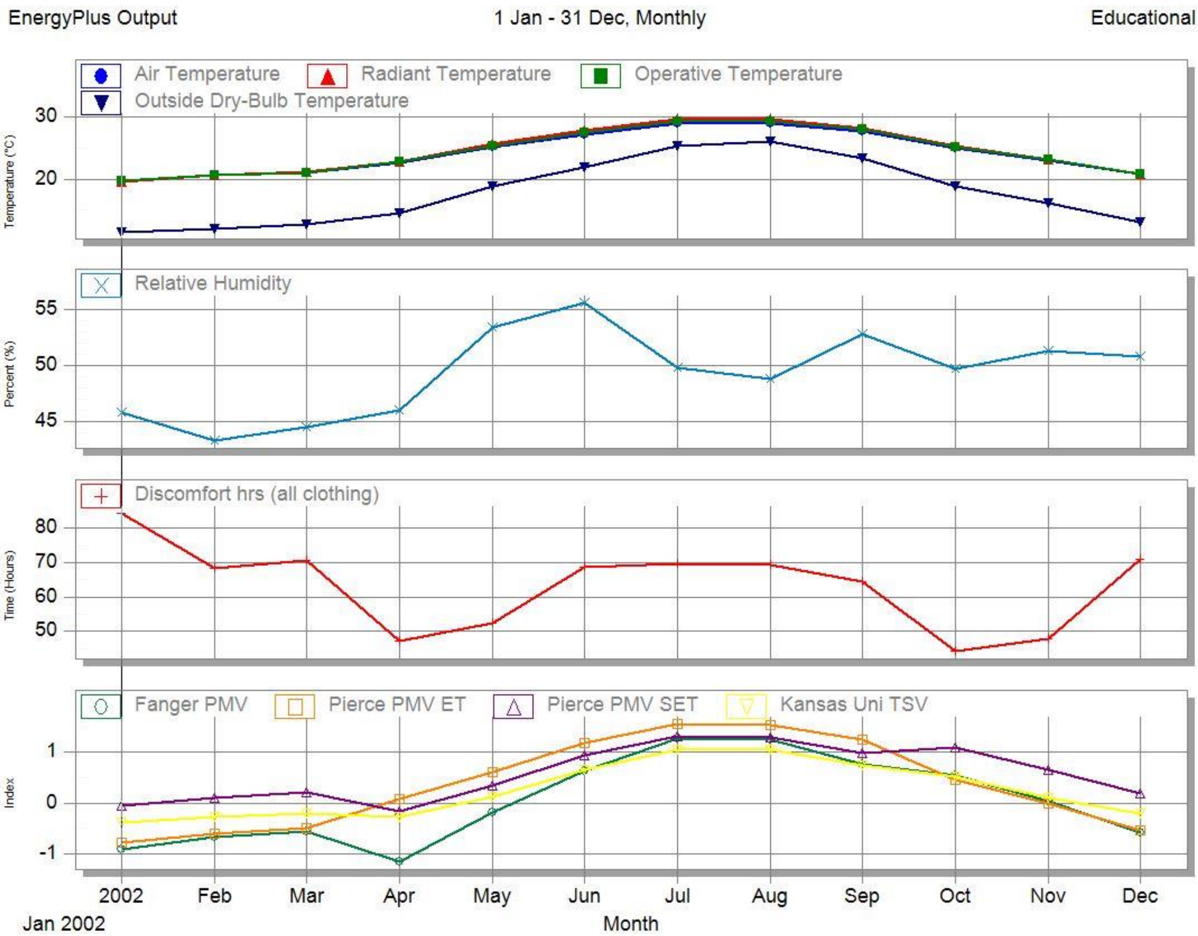


FIGURE 63 - ANNUAL COMFORT VALUE

2.3.5. Final Energy Consumption And CO_2 Emissions

TABLE 6 - BUILDING AREA

	Area [m2]
Total Building Area	10274.89
Net Conditioned Building Area	10274.89
Unconditioned Building Area	0

In this building only electricity is consumed, as depicted by the following table

TABLE 7 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/m2]
HVAC	121.95
Total	121.95

TABLE 8 - END USE CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	223,362.48	0.00	0.00	0.00	0.00	0.00
Cooling	217,049.09	0.00	0.00	0.00	0.00	0.00
Interior Lighting	196,858.13	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	120,275.15	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	127,924.50	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	885,469.36	0.00	0.00	0.00	0.00	0.00

Note: Electricity appears to be the principal heating source based on energy usage.

TABLE 9 - END USE CONSUMPTION IN DETAIL

	Electricity [kWh]
Heating	223,362.48
Cooling	217,049.09
Interior Lighting	196,858.13
Interior Equipment	120,275.15
Fans	127,924.50
Total End Uses	885,469.36

Simulation data shows that the building has an electricity consumption of 885,469.36 kWh.

Parameters were assessed considering the following conversion factors:

- electricity to primary energy - 2.174 (standard value approved for Italy)
- electricity to CO_2 emissions - 510.00 g/kWh (average emissions associated with the electricity consumed in Italy during 2012, according ENEL environmental report 2012);

3. RENOVATION SCHEME

3.1. Aim Of The Renovation Plan

In Italy, the NZEBs (nearly zero energy buildings) don't meet national specific legislation but this is now being defined, according to Directive 2012/27/UE. NZEB design is aimed at achieving high performance standards in terms of energy and environment.

Specific attention should be devoted to the reduction of energy consumption of the building, guiding the design on three key areas:

1. Maximizing the building envelope passive behaviour
2. Use high efficiency systems
3. Use of systems for the renewable thermal energy exploitation and photovoltaic systems for the electricity production from solar sources.

The aim is to minimize energy contribution from the external electricity grid. The objective of the renovation plan is to achieve an average primary energy reduction between 75% and 80% of the current demand and to ensure that between 50% and 90% of the remaining energy consumtion is generated on site.

A building envelope is called passive if it is conformant to the following values:

- Thermal transmittance very low (0.0167/0.227 W/m^{2}K)
- Low values of attenuation factor (<0.1), resulting in high phase shift values (>11.5 hours)
- Windows with transmittance less than 1.6 W/m^{2}K
- System efficiency that can reduce by 70% the maximum solar radiation on transparent surfaces.

To achieve these aims some difficulties or constraints should be considered in the implementation.

The following global constraints were taken into account in the design of the renovation plan:

The buildings have an intensive utilization, receiving a large number of visitors, and are the working place for a large number of Municipal employees. Such activities cannot be interrupted since it is not easy to temporarily move the services to another building. Therefore, renovation options requiring major construction works needs a plan that takes into account the needs of both workers and visitors. For example, the renovation works may be performed in different steps by closing small areas in turn without hindering the normal daily activities.

The buildings have an intensive utilization, receiving a large number of visitors, and are the working place for a large number of Municipal employees. Such activities cannot be interrupted since it is not easy to temporarily move the services to another building. Therefore, renovation options requiring major construction works need a plan that takes into account the needs of both workers and visitors.

Planned integrations modify the architecture of the building, but without changing the functions. Being a historical building it was quite complicated inserting renewable sources and determining appropriate spaces to allocate them. Also, an intervention difficult to predict was that related to the new air conditioning system.

The assumptions for improvement have been inserted using the Design Builder software that simulates with Energy Plus Databases. Considering the environmental conditions of Messina, greater consumption for Palace of Culture, is by the use of electricity for cooling in the summer period, therefore it was decided to insert solutions also covering a constant ventilation of the building.

3.2. Energy Demand Reduction

3.2.1. Opaque Envelope

An important task in the renewal plan is targeted to envelope. Where possible internal insulation will be added to the walls. The internal coat it will be possible with a new layer with high insulation value. In the state of the art, the walls are not properly put in place for an error due to the workers.

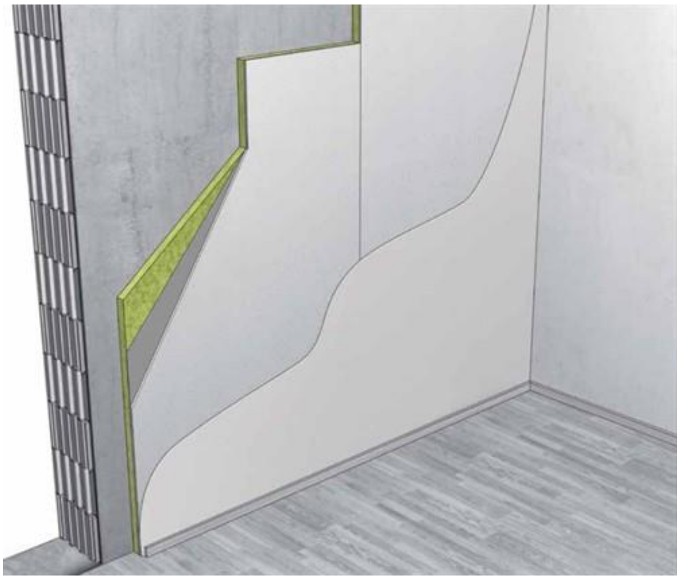


FIGURE 64- NEW LAYER AS INTERNAL INSULATION

The insertion of an internal insulation decreases the floor area of the building but it is the only possible solution in the case of a prospect with the external geometry as difficult as that of the Palace of Culture.

The renovation will be using panels of cork and plasterboard with a thickness up to 4 cm. Installation of an outer coat does not typically create particular problems in terms of physical and technical issues related to building physics. However, the installation of the inner coat requires careful attention to avoid the risk of formation of interstitial condensation, mould growth and/or the onset of potential events of decay of the structures.

The cork is self-expanded with a structure that can be described as "closed cell", it is rot-proof and therefore the risk of decay is almost insignificant. To understand the origin of this event we can start looking at the development of the internal temperatures to the wall under three different conditions: pre-intervention wall, wall with inner coat (4 and 6 cm) and with outer coat (4 and 6 cm).

Green roof has ancient historical precedent, such as the hanging gardens of Babylon, built by King Nabucondonosor, is a first strategy used in Eco-building to limit the environmental impact of the construction. This is one of the best known examples, it is recommended by all the associations that promote sustainable building for several reasons: it helps reduce a building's energy requirements and CO_2 emissions and brings many other economic and ecological benefits.

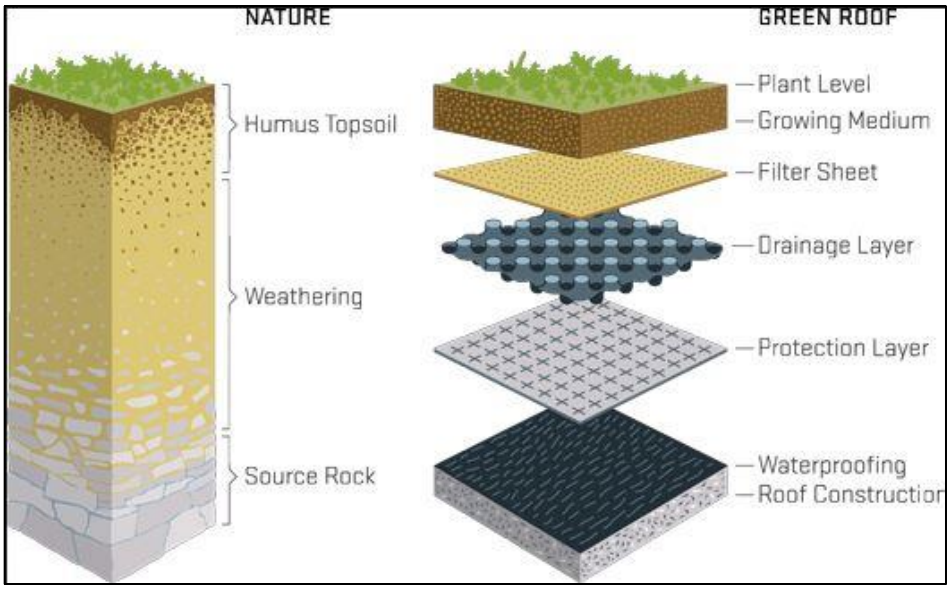


FIGURE 65 - GREEN ROOF

For example:

Temporarily it absorbs rainwater and releases it slowly to prevent flooding by overflowing of the sewer system and slows the obsolescence of the same due to the new urban settlements.

- It filters urban pollution and reduces carbon dioxide
- It filters polluted rainwater
- It cools the air by evaporation of water vapour
- It reduces wind speed
- It promotes the settlement of animals ecosystems
- It reduces noise transmission within the building
- It reduces the effect of "urban heat islands"
- It increases the thermal inertia of the roof
- It increases the thermal resistance of the roof
- It protects the waterproofing membrane and prolongs its life
- It is a tool of new architectural languages.

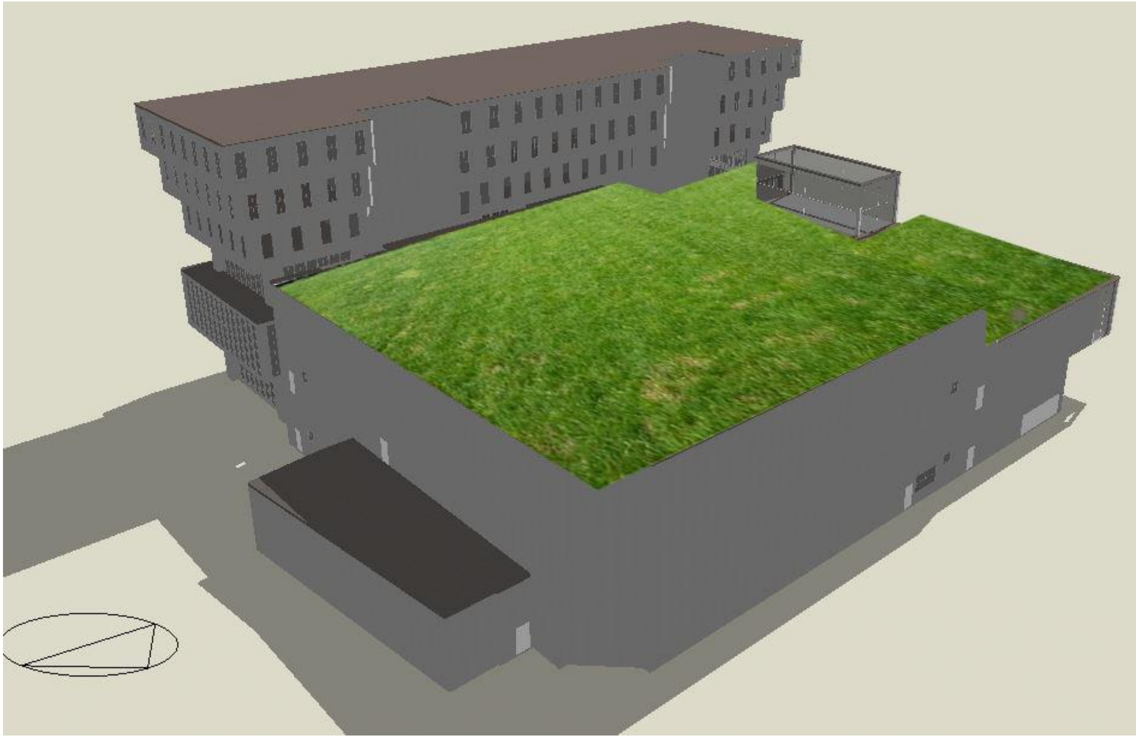


FIGURE 66 - RENDER OF THE GREEN ROOF

3.2.2. OPENINGS

At the state of art, all windows are in single glass with PVC frame. It is expected to replace all windows of Palace of Culture, inserting selective glasses and modifying PVC frames.

It is also important to study new forms of glass to optimize reflective surface and to insert new shading element.

Also, the existing glazing and frames (with U_g-value of 5.80 W/m^{2}K and U_f-value of 2.8 W/m^{2}K) will be replaced selective glazing and thermal break frame in PVC with total U_f-value 2.0 W/m^{2}K and U_g-value of 1.9 W/m^{2}K, Regarding the frames is chosen to include window frames with thermal break, in this case the value of frame transmittance (U_f) improves. It is chosen to use windows with PVC frames. Glasses chosen are selective double glazing with air chamber 6/13 mm.

FIGURE 67 - PARTICULAR OF PVC FRAME

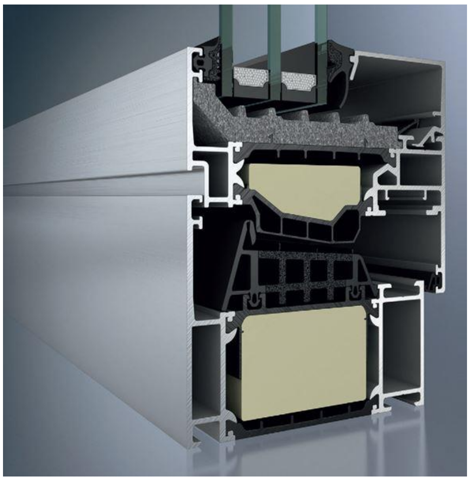


FIGURE 68 - EXAMPLE OF THERMAL BREAK

FIGURE 69 - ACTUAL REFLECTIVE SURFACE

FIGURE 70 -ACTUAL WINDOW

FIGURE 71 - ACTUAL WINDOW AT FIRST FLOOR

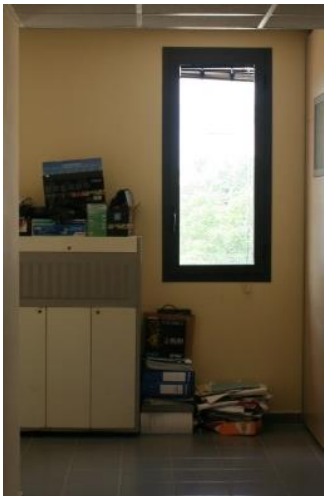


FIGURE 72 - SKYLIGHT IN CIRCULATION AIR

FIGURE 73 - SKYLIGHT IN THE STAIRWELL CENTRAL

FIGURE 74 - ENTRANCE DOOR

3.2.3. SHADING

It was chosen to define as many shadings internal and external necessary to model the correct shading conditions. Shading types can be seen from the following table.

FIGURE 75 – SHADING

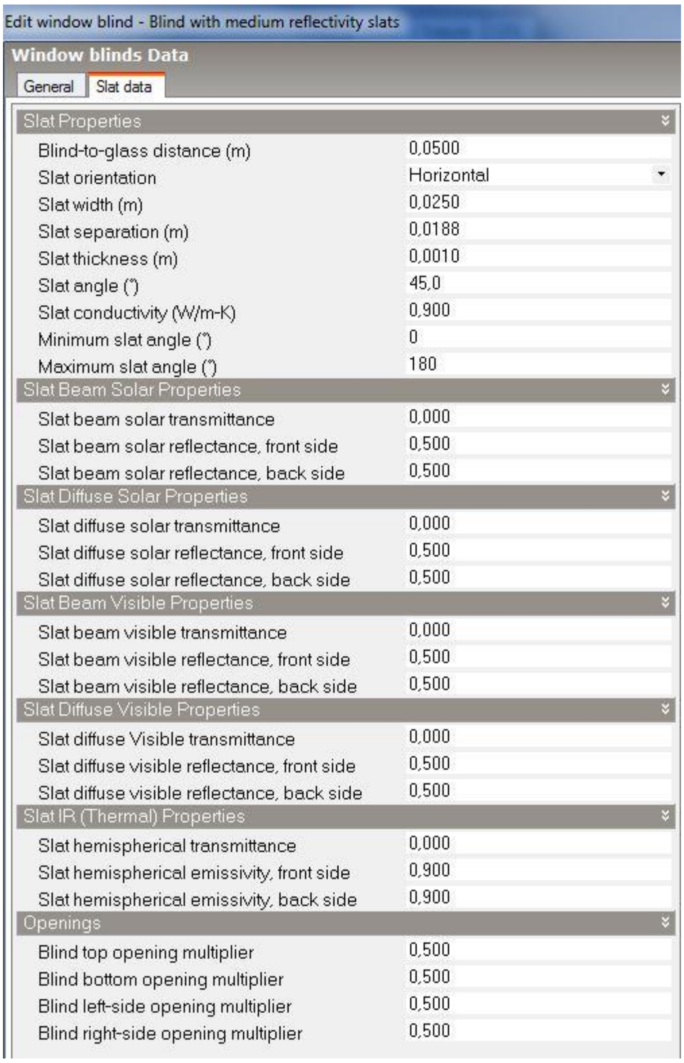


FIGURE 76 - BLIND WITH MEDIUM REFLECTIVITY SLATS

3.2.4. Other Strategies

The skylights in stairwells will be equipped with sensors that will govern the opening, according to the irradiation and the need for external ventilation.

3.3. Energy Systems

3.3.1. Lighting System

It is expected to replace the existing lighting with LED lamps and, where it is possible (for example in meeting rooms or council room), with intelligent on/off system, to adapt the lighting depending on sunlight.

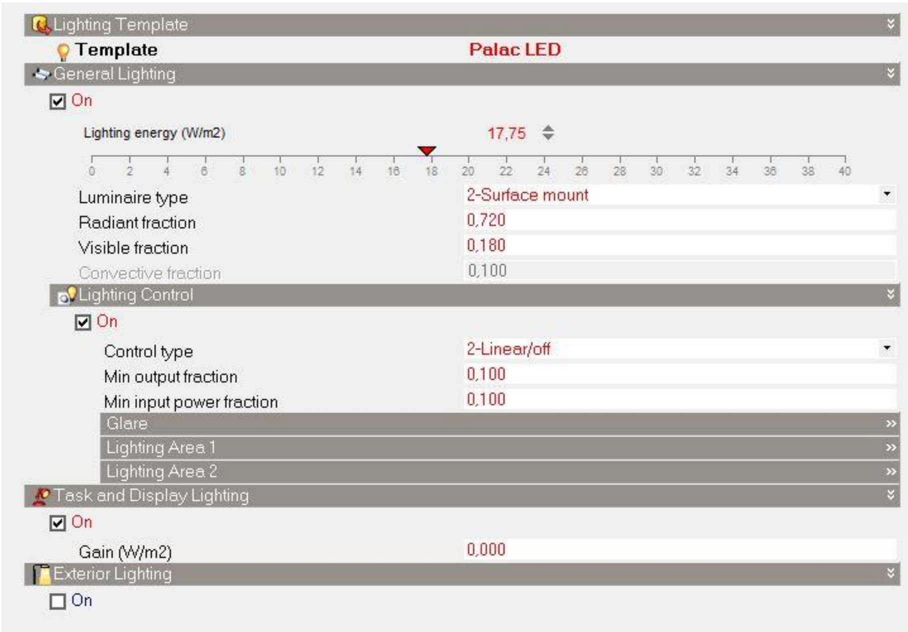


FIGURE 77 - LIGHTING TEMPLATE

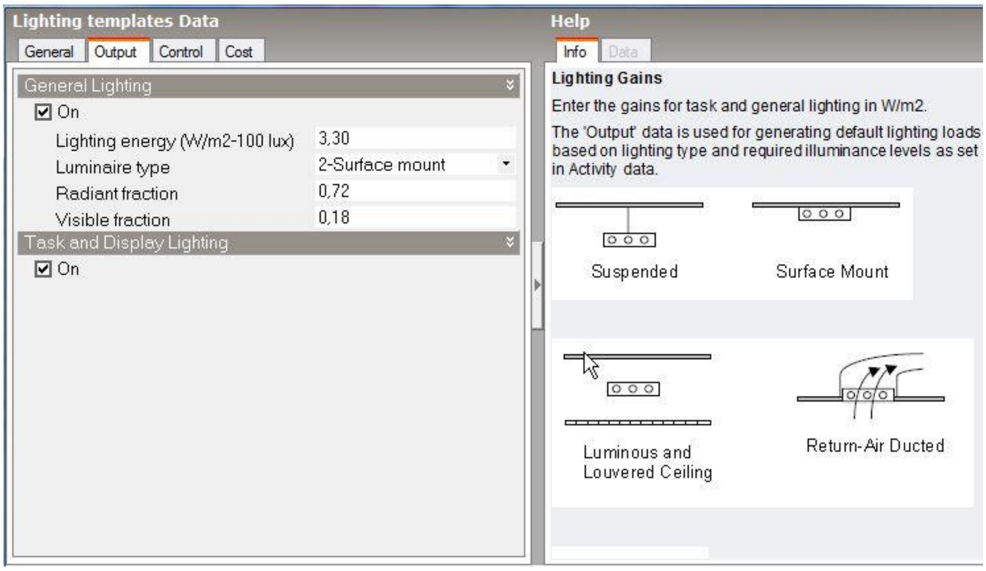


FIGURE 78 - LIGTHING TEMPLATE

3.3.2. HVAC SYSTEM

Almost all working rooms, as well as all the receiving rooms, and the circulation area have an air conditioning system. In the renovation scheme the HVAC Template remain the same of the state of the art.

FIGURE 79 – HVAC

3.4. RENEWABLE ENERGY SOURCES

The building is in a densely built area and district heating systems are not possible. The use of more environmental friendly HVAC systems was investigated but VRV appeared to be the most suitable choice.

The Variable Refrigerant Volume (VRV) HVAC System is a relatively new technology. New VRV systems offer high levels of energy efficiency, as well as flexibility. They operate quietly and provide the user full control of the environmental temperatures. While traditional HVAC systems are often limited to one condensing unit, one compressor and one evaporator, a VRV system can be designed to specifically meet the needs of the building. One condensing unit can be connected to several evaporators, each of which are individually controlled. In a traditional HVAC system, the system kicks on when a room is too warm or cold; however, a VRV system constantly adjusts the amount of refrigerant being sent to each evaporator and takes advantage of existing heat or cool air in the building. This varying speed allows the system to work only as needed in each area to maintain the comfort level. The result is a custom-designed HVAC system that keeps all areas of the building comfortable at a fraction of the energy cost.

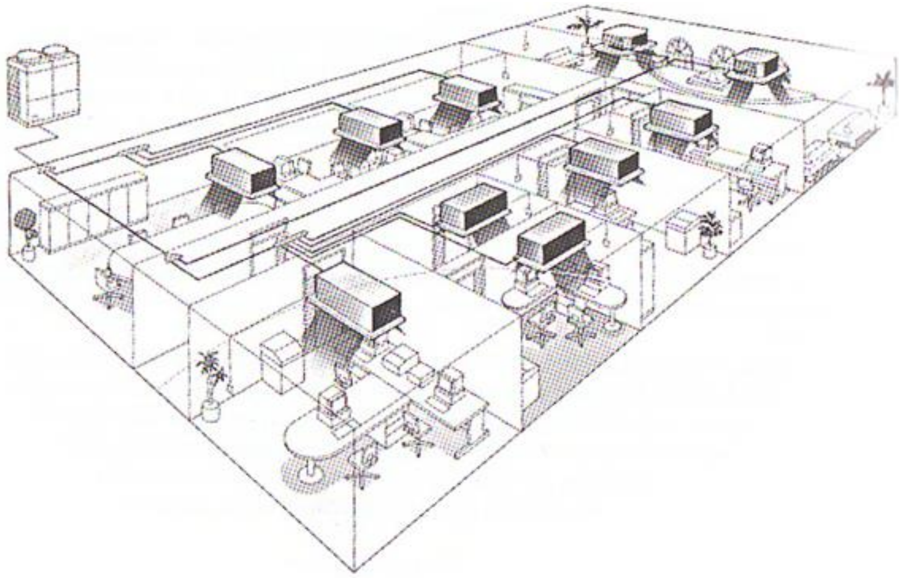


FIGURE 80 - VRV SYSTEM

Different proposals have been studied for renewable energy systems but in the end it was decided to use a photovoltaic system.

3.4.1. PV GENERATION SYSTEM

On the roof of the building will be installed a photovoltaic plant of 28 kW_p: this size ensures just over 40% of current consumption of electricity. The structure has four areas available for positioning the photovoltaic system.

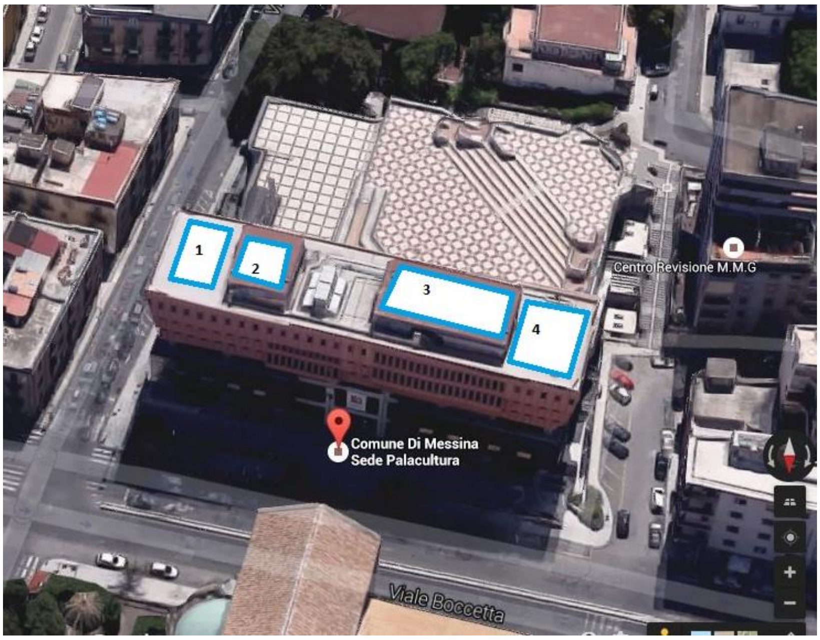


FIGURE 81 - FOUR AREAS AVAILABLE FOR THE PV SYSTEM INSTALLATION

The PV panels will be placed nearly due South with a fixed slope of 30° and azimuth of 0°. The system will be connected to the low voltage grid via three-phase power.

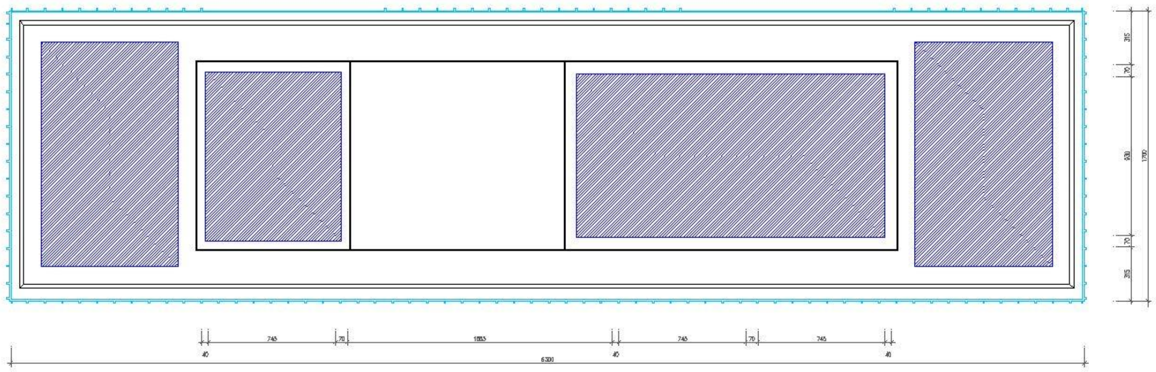


FIGURE 82 - PV DISTRIBUTION

In Italy, to access the financial benefits for installing PV modules one must submit a request to the Energy Services Manager, GSE S.p.A. Therefore, it leads to compensation between the economic value associated to the electricity produced and fed into the grid and the theoretical economic value associated to withdrawn electricity and consumed in a period different from the one in which production takes place.

The calculation of the PV system was estimated by using Classic PVGIS, a piece of software developed by The Joint Research Centre of the European Commission in ISPRA, Italy.

To perform this calculation it is necessary to define some conditions:

TABLE 10 - CONDITION TO SIMULATION WITH CLASSIC PVGIS

Optimal inclination angle is: 31 degrees
Annual irradiation deficit due to shadowing (horizontal): 0.1 %
Location: 38°11'38" North, 15°33'17" East, Elevation: 15 m a.s.l.,
Nominal power of the PV system: 28.0 kWp (crystalline silicon)
Estimated losses due to temperature and low irradiance: 9.9% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.5%
Other losses (cables, inverter etc.): 14.0%
Combined PV system losses: 24.4%

The monthly and annual solar radiation in the area based on the classic PVGIS database is presented in the following table.

TABLE 11 - SOLAR RADIATION AT THE AREA OF MESSINA

Month	H_h	H_{opt}	H(90)	I_{opt}	T_D	T_{24h}
Jan	1,990	2,980	2,900	59	11.0	10.2
Feb	2,700	3,630	3,130	51	10.6	9.7
Mar	4,020	4,860	3,470	40	13.2	12.0
Apr	5,420	5,830	3,190	26	15.4	14.2
May	6,410	6,280	2,630	13	19.1	17.9
Jun	6,910	6,470	2,310	6	23.1	21.8
Jul	6,830	6,530	2,470	9	25.9	24.6
Aug	6,190	6,420	3,100	21	26.2	24.7
Sep	5,000	5,880	3,830	36	22.9	21.7
Oct	3,510	4,690	3,860	49	19.8	18.6
Nov	2,250	3,320	3,160	58	16.2	15.1
Dec	1,760	2,740	2,770	61	12.6	11.6
Year	4,430	4,980	3,070	31	18.0	16.8

Legend:
Hh: Irradiation on horizontal plane (Wh/m^2/day)
Hopt: Irradiation on optimally inclined plane (Wh/m^2/day)
H(90): Irradiation on plane at angle: 90 deg. (Wh/m^2/day)
Iopt: Optimal inclination (deg.)
TD: Average daytime temperature (°C)
T24h: 24 hour average of temperature (°C)

SOURCE: CLASSIC PVGIS DATABASE (KWH/ M2/MONTH) AT 30°

TABLE 12 - AVERAGE ELECTRICITY PRODUCTION

Month	E_d	E_m
Jan	63.28	1,963
Feb	75.88	2,128
Mar	99.12	3,080
Apr	117.60	3,528
May	124.32	3,864
Jun	125.72	3,780
Jul	125.44	3,892
Aug	122.64	3,808
Sep	115.36	3,444
Oct	94.08	2,912
Nov	68.60	2,058
Dec	57.40	1,778
Yearly average	**99.12**	**3,020**
Total for year		**36,235**

Annual global radiation on the inclined surface = 1,950 kWh/m^2
Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)

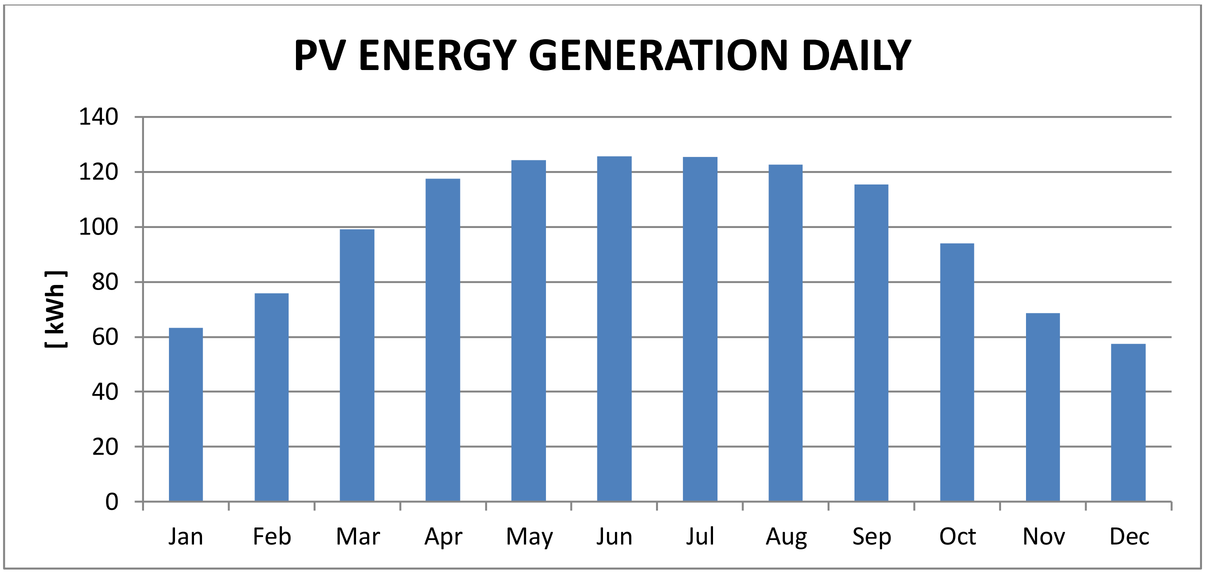


FIGURE 83 - DAILY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

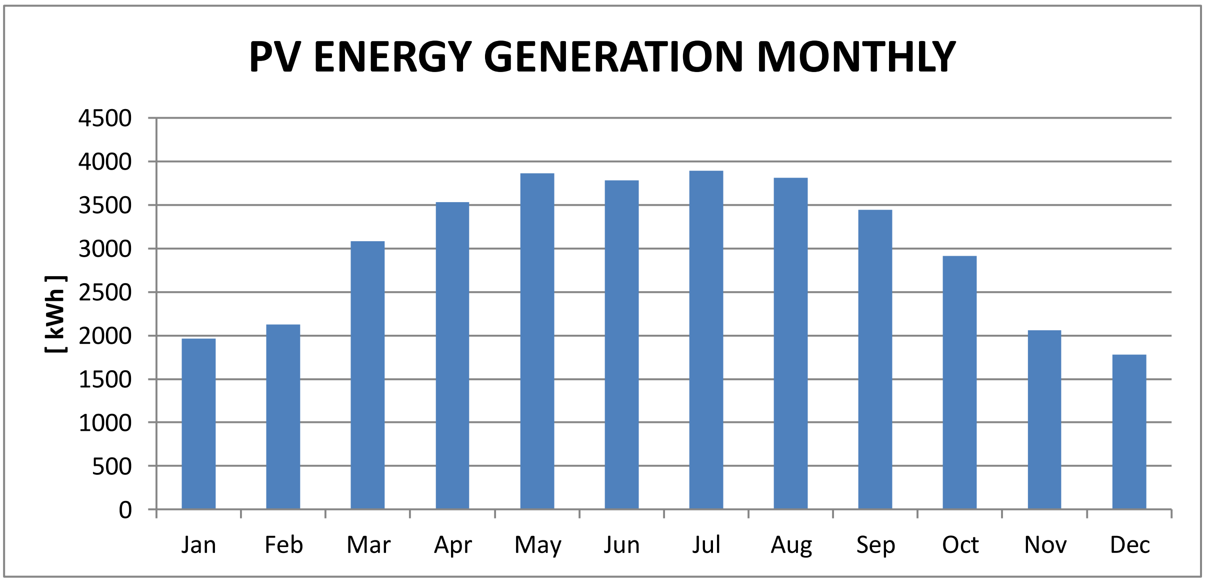


FIGURE 84 - MONTHLY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

3.5. Energy Management System

To monitor the building electrical consumption of lighting, ventilation and HVAC system, a building automation control sensor (BACS) will be installed. The BACS improve occupant's comfort, efficient operation of building systems, and reduction of energy consumption and of operating costs.

The system will perform the following operations:

- Control each air conditioning unit separately to stabilize the desired internal air temperature and humidity in every office.
- Internal lighting control according to external irradiation and lux value in each room (Dimming lamps).

- Daily scheduling of air conditioning and lighting to optimize their use.
- Management of the flow temperature according to the outdoor temperature.
- Identification of electrical equipment turned on beyond normal working hours.
- Error identification or warnings in case of electrical overloads.
- Control of windows and doors opening, to minimize the use of VRV plant.
- The BACS ensure values of humidity and temperature in agreement with the optimum comfort conditions, also through appropriate air exchange. They are also useful for energy saving both in terms of lighting and rooms conditioning.

3.6. Total Impact Of The Renovation Scheme

3.6.1. Energy Performance

The energy analysis of the building was carried out using the software Design Builder v. 3.4.0.033. The building was described in detail, through architectural drawings and with an illustrated report on the state of facts and photographic documentation.
The result with the new solution is as follows. In the renovation scheme it has a VRV system plant for heating, cooling and air circulation.
To set the calculation of the model the general information are:

TABLE 13 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	** Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	13,580.56
Principal Heating Source	District Heating

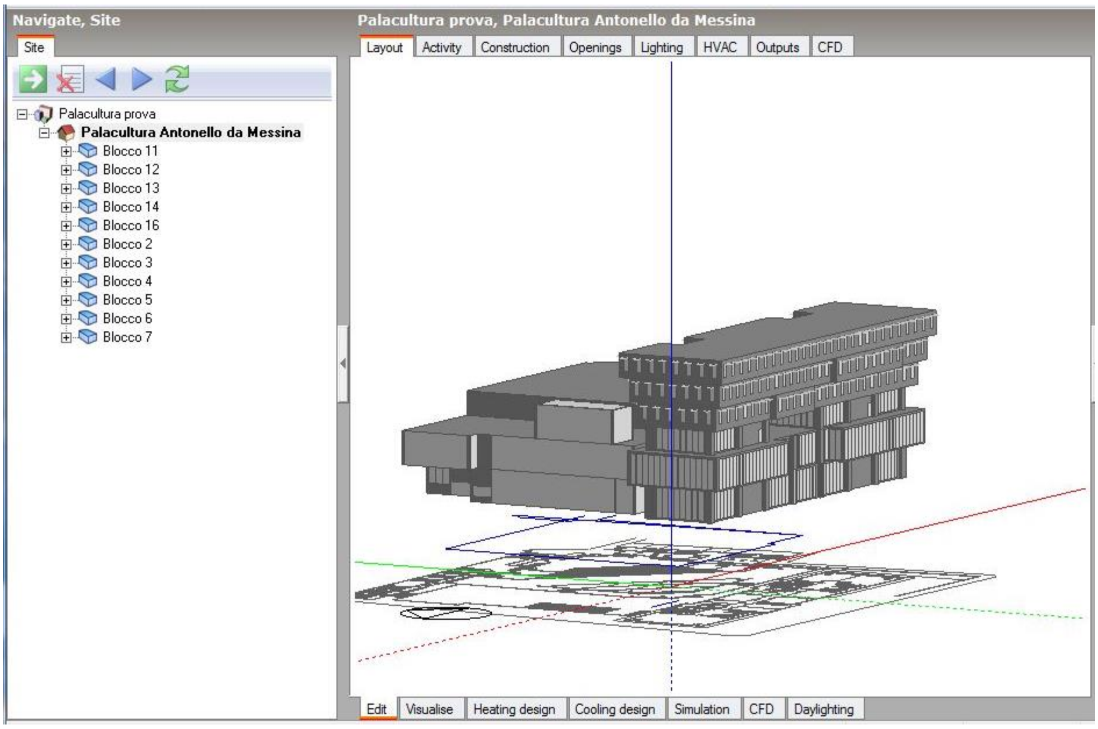


FIGURE 85 - EDIT SCHEME

The following figures shows the heat balance of Palace of Culture Post renovation, divided according to the contribution types:

- Occupancy,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

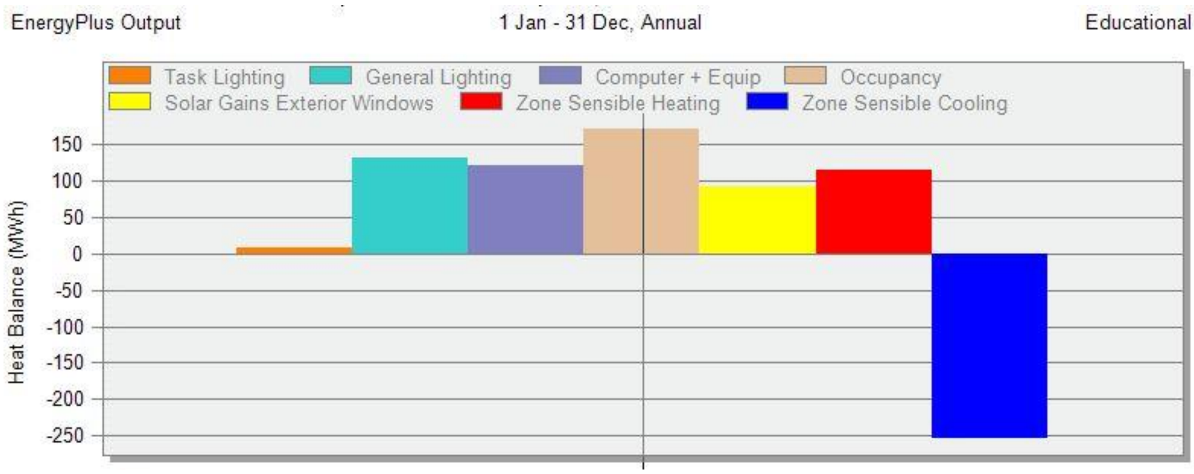


FIGURE 86 - ANNUAL HEAT BALANCE

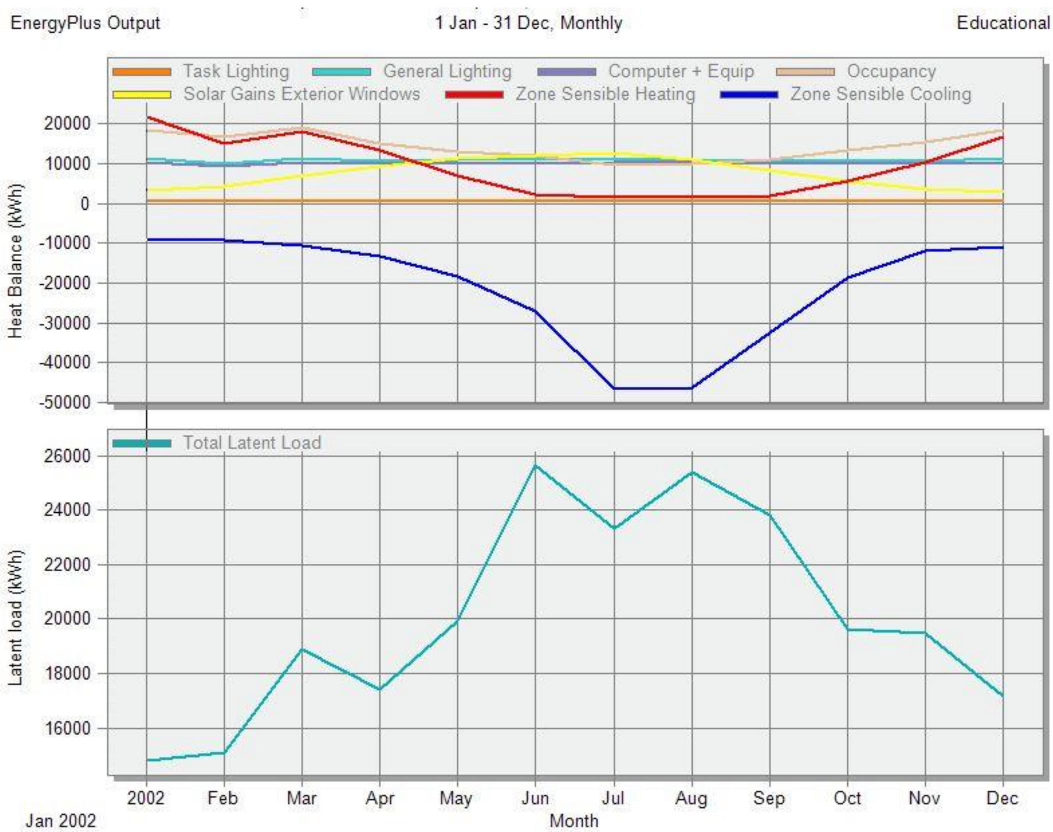


FIGURE 87 - ANNUAL HEAT BALANCE ACCORDING SINGLE MONTH

Two following figures shows monthly total fuel use of Palace of Culture, divided according to the contribution of electricity.

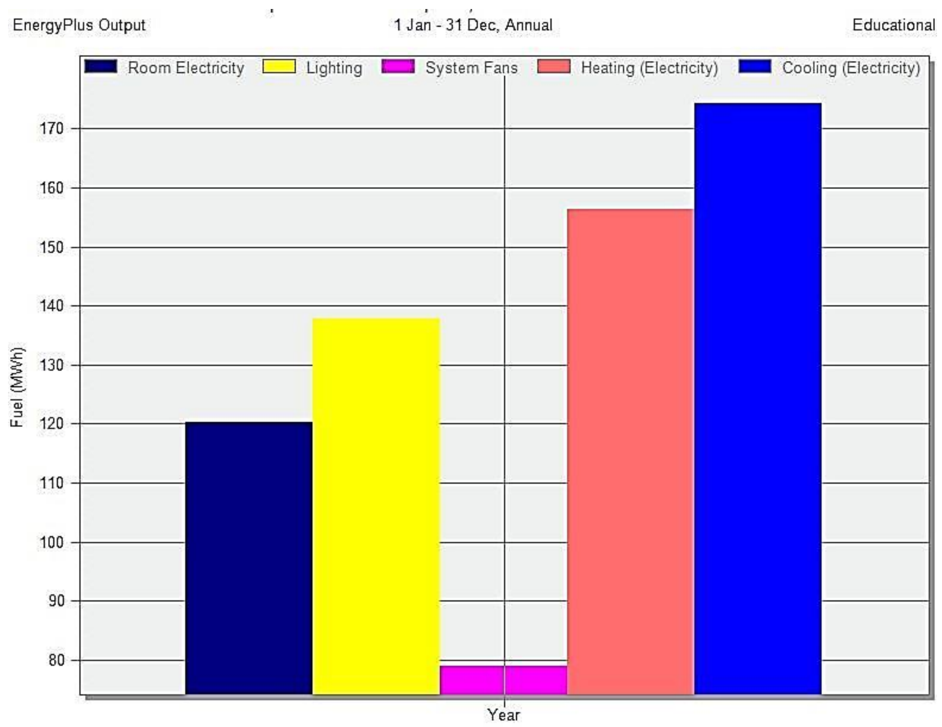


FIGURE 88 - ANNUAL USE OF FUEL TOTAL

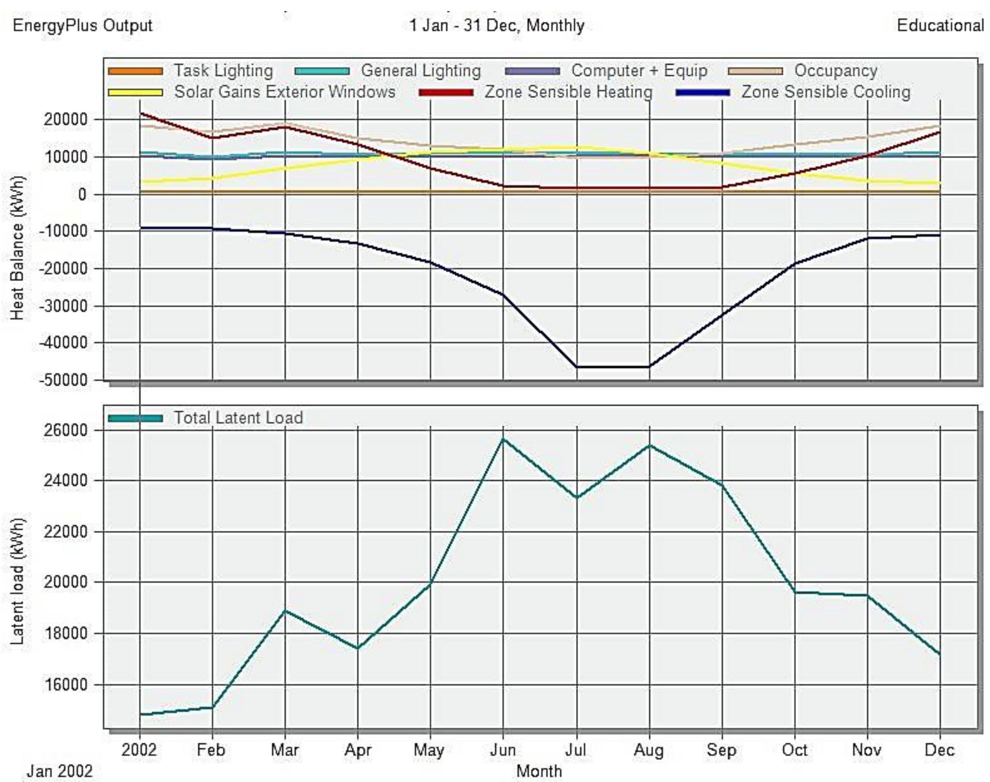


FIGURE 89 - MONTHLY USE OF FUEL TOTAL

3.6.2. Environmental Performance

The following table shows the consumption before and after the implementation of all the proposed interventions in the building.

TABLE 14 - BUILDING AREA

	Area [m2]
Total Building Area	10,274.89
Net Conditioned Building Area	10,274.89
Unconditioned Building Area	0.00

TABLE 15 - END USES CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	156,457.77	0.00	0.00	0.00	0.00	0.00
Cooling	174,272.46	0.00	0.00	0.00	0.00	0.00
Interior Lighting	137,800.57	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	120,275.15	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	79,019.74	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	667,825.69	0.00	0.00	0.00	0.00	0.00

Note: Electricity appears to be the principal heating source based on energy usage.

TABLE 16 - END USE CONSUMPTION IN DETAILS

	Electricity [kWh]
Heating	156,457.77
Cooling	174,272.46
Interior Lighting	137,800.57
Interior Equipment	120,275.15
Fans	79,019.74
Total End Uses	667,825.69
Total End Uses - PV	627,825.69

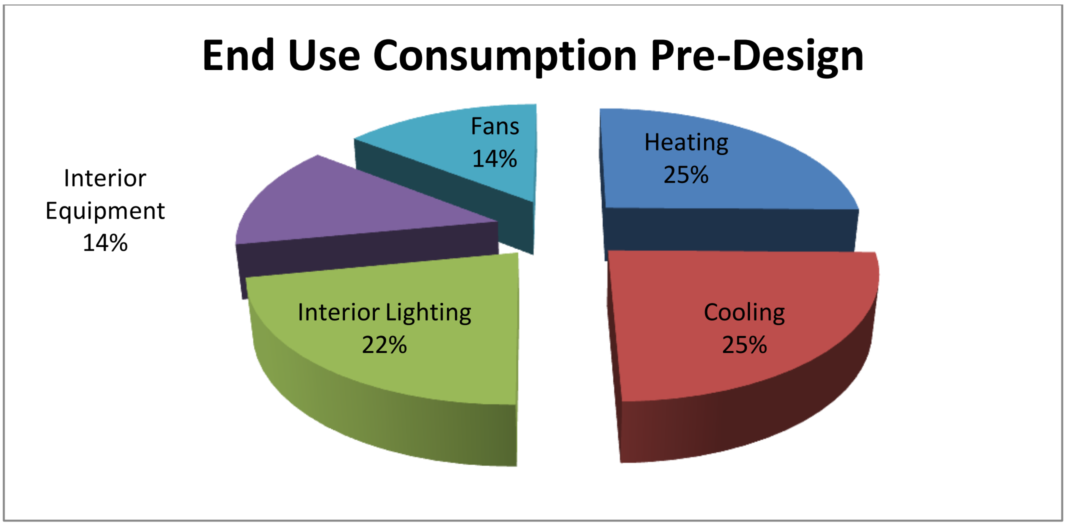


FIGURE 90 - END USE CONSUMPTION PRE DESIGN

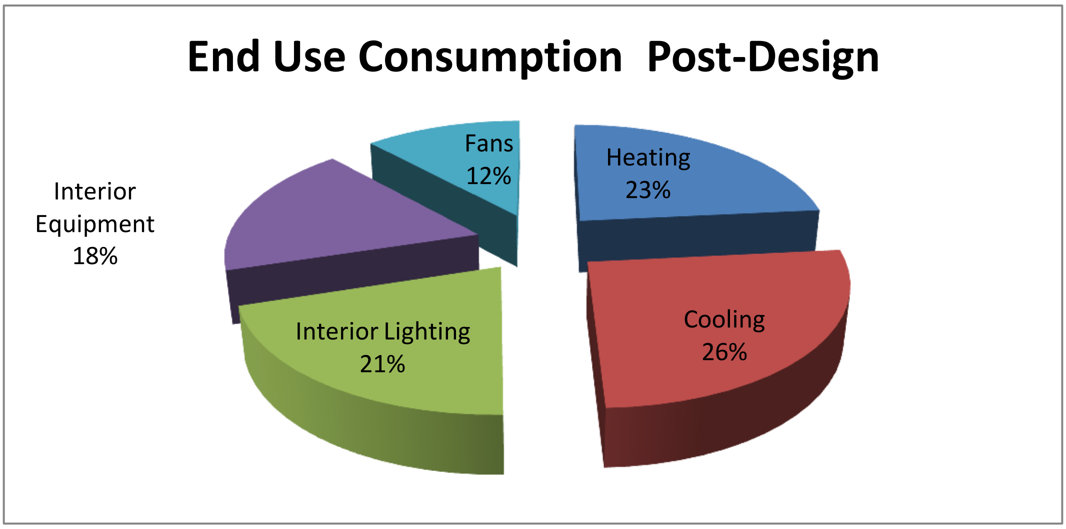


FIGURE 91 - END USE CONSUMPTION POST DESIGN

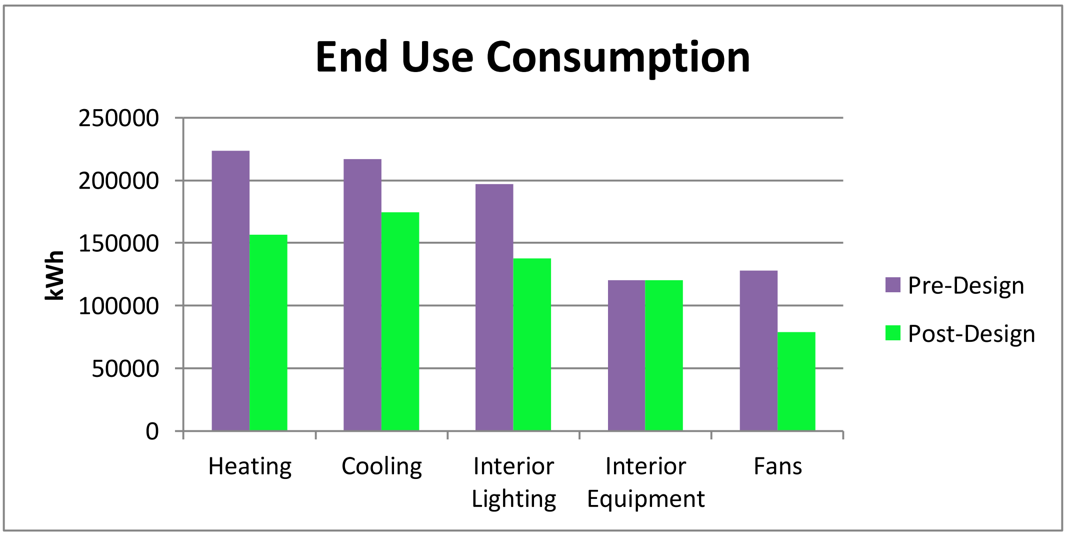


FIGURE 92 - END USE COMPARATION

4. ECONOMIC EVALUATION OF THE PROPOSED RENOVATION SCHEME

4.1. Assumptions, Cost Figures

The cost of the interventions is estimated based on current market prices of the equipment and the installation works. Special meetings with suppliers were held to present the project and request offers for the preliminary renovation design. Offers were collected and assessed.

For each intervention, the cost has been calculated as the sum of costs for equipment, installation, operation and maintenance. These values have been organised in an Excel file prepared by Sinloc, a partner of the CERtuS consortium (see deliverable D2.5). ANNEX H, gives the cost information.

The economic appraisal of the renovation design was performed by means of a tool produced by ETVA VIPE, also a partner of the consortium. A detailed description of the tool is presented in the deliverable D2.5. The appraisal can be performed only for the whole design. The tool also allows examining various financing schemes ranging from single financing source to multiple, combining bank loans, ESCOs, subsidies and municipality's own equity.

The data used for the calculations are tabulated below, divided according to the unit of measure concerned and the unit price

TABLE 17 - DETAIL OF COST

WORKINGS	*VOICE*	*UNIT COST*	*U.M.*	*DIMENSION*	*COST*
Building Envelope	INTERNAL INSULATION OF WALLS and COVER BLOCK ESCALATORS - GREEN ROOF	/	/	/	**€ 354,210.00**
Building envelope	PHOTOVOLTAIC PANELS PV PLANT	€ 2,000.00	kWp	28	**€ 56,000.00**
Windows	DOUBLE GLASS NEW WINDOWS + CURTAIN FILM	€ 650.00	sqm	320	**€ 208,000,00**
Plants	RELAMPING with LED (AUTOMATION CONTROL)	€ 200.00	units	1,681.0	**€ 336,200.00**
		TOTAL WORK COST			**€ 954,410.00**

Results

The following table gives the total savings, depending on the application for the renovation scheme, applied in full (with all suggested interventions).

TABLE 18 – DEPENDING ON THE APPLICATION FOR THE RENOVATION SCHEME APPLIED IN FULL

ENERGY EFFICIENCY MEASURES		SAVINGS
Building Envelope	• INTERNAL INSULATION OF WALLS • WALL AND COVER BLOCK CONCERNING ESCALATORS • REPLACEMENT WINDOWS (FRAMES, GLASSES AND SHADING) • GREEN ROOF	• Following Table
Energy Systems	• LED lighting with automation control • PV	

TABLE 19 - END USES PRE DESIGN

	Electricity [kWh]
Heating	223,362.48
Cooling	217,049.09
Interior Lighting	196,858.13
Interior Equipment	120,275.15
Fans	127,924.5
Total End Uses	**885,469.35**

TABLE 20 - END USES POST DESIGN

	Electricity [kWh]
Heating	156,457.77
Cooling	174,272.46
Interior Lighting	137,800.57
Interior Equipment	120,275.15
Fans	79,019.74
Total End Uses	**667,825.69**

TABLE 21 - END USE SAVING

	SAVING [kWh]
Heating	29,95
Cooling	19,71
Interior Lighting	30
Interior Equipment	38,9
Fans	38,23
Total	**31,71**

End use post- design with Pv contribution = 667,825.69 - 36,235 = 631,590.69 kWh

END USE PRE DESIGN (kWh)	END USE POST DESIGN (kWh)	SAVING (%)
885,469.35	631,590.69	28,67 *(253,878.66 kWh)*

The savings resulting from the interventions on envelope and plants is equal to 28.67%. The saving is so much content because it is a new building and can't be material changes to its geometry.

The traditional interventions are the use of new windows and to a system of thermal insulation for the facade.

In the evaluation of the lighting savings it was considered the average cost of the electricity. The lifetime was assessed considering the average hours of use for the lamps and its maximum total hours of operation. As can be seen in following table, with such conditions the renovation options ensures savings from maintenance of 4,687 €/year and has a simple payback period of 22.50 years.

TABLE 22: ECONOMIC PARAMETERS OF THE RENOVATION – LIGHTING

Energy Savings	59,058 kWh
Price - Saved Energy	0.18 €/kWh
Costs	336,200 €
Potential savings from maintenance (post intervention)	4,687 €/year
Simple Payback	22.50 years
Lifetime	20 years
CO_2 Savings	42.73 tons/year

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy, since in a working day during the time slots. As can be seen in following table, with such conditions it has a simple payback period of 9.81 years.

TABLE 23 - ECONOMIC PARAMETERS OF THE RENOVATION – PV

Energy Generation	36,235 kWh
Energy - Self-Consumption	90%
Energy - Injected Into Grid	10%
Price – Self-Consumption	0.18 €/kWh
Price - Injected Into Grid	0.06 €/kWh
Costs	56,000 €
Simple Payback	9.81 years
Lifetime	30 years
CO_2 Savings	23.78 tons/year

The following table presents the aggregation of the renovation option. As can be seen, the total of the renovation plan ensures savings of 12,019 €/year and has a simple payback period of 3.76 years.

TABLE 24 - ECONOMIC PARAMETERS OF THE RENOVATION – TOTAL

Energy Savings	253,878.66 kWh
Costs	954,410 €
Savings	12,019 €/year
Simple Payback	20.88 years
CO_2 Savings	142.32 tons/year

REFERENCES 1

/1/ DesignBuilder Software Ltd specialises in developing high-quality, easy-to-use and affordable simulation software tools for assessing the environmental performance of building designs. http://www.designbuilder.co.uk/

/2/ PVGIS, Photovoltaic Geographical Information System, a software developed by The Joint Research Centre of the European Commission in ISPRA, Italy. http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

/3/ CERtuS Deliverable D2.5 *"Twelve economic evaluation reports"*

5. ANNEX A: BUILDING DRAWINGS

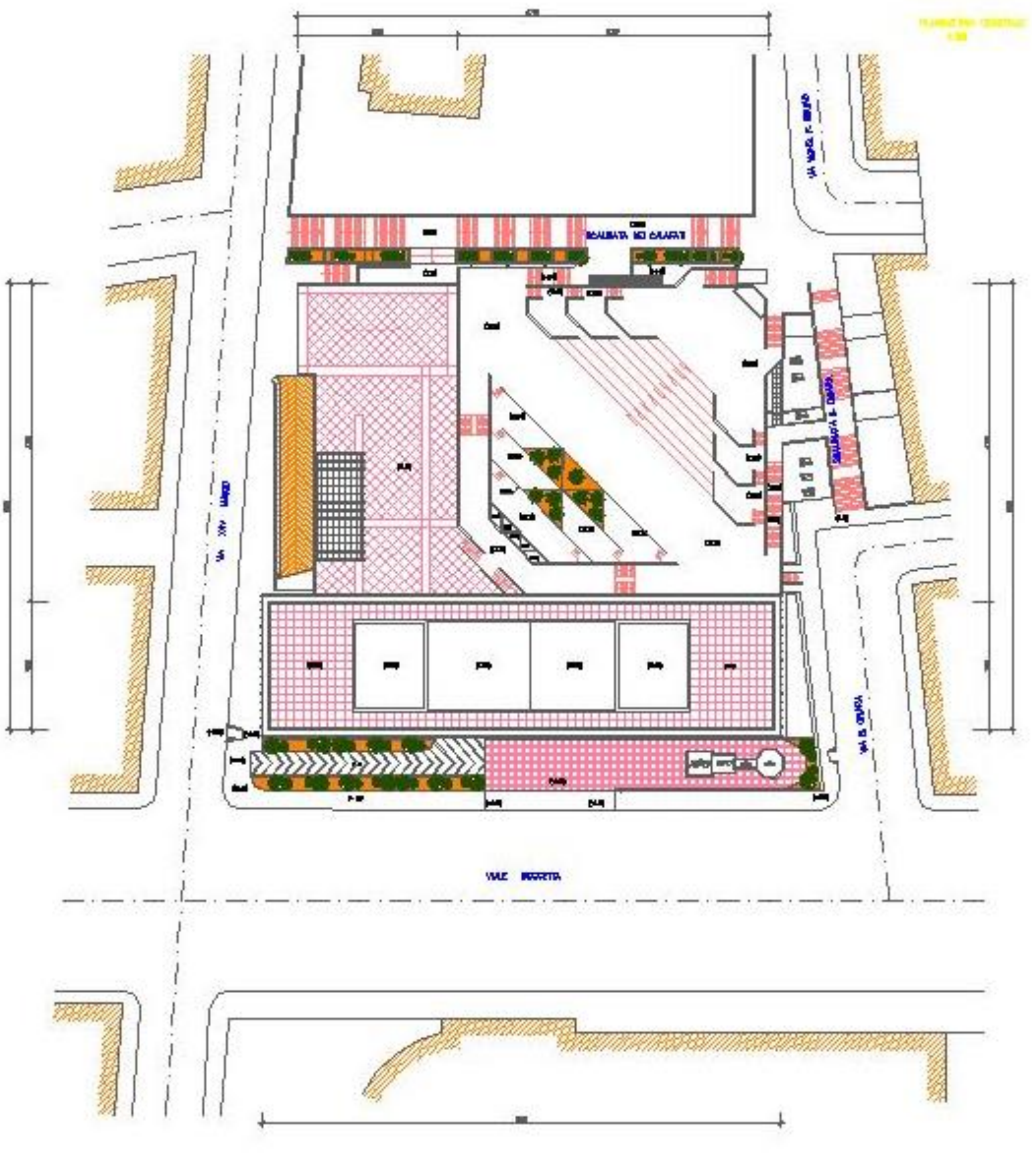


FIGURE 93 - GENERAL PLANT

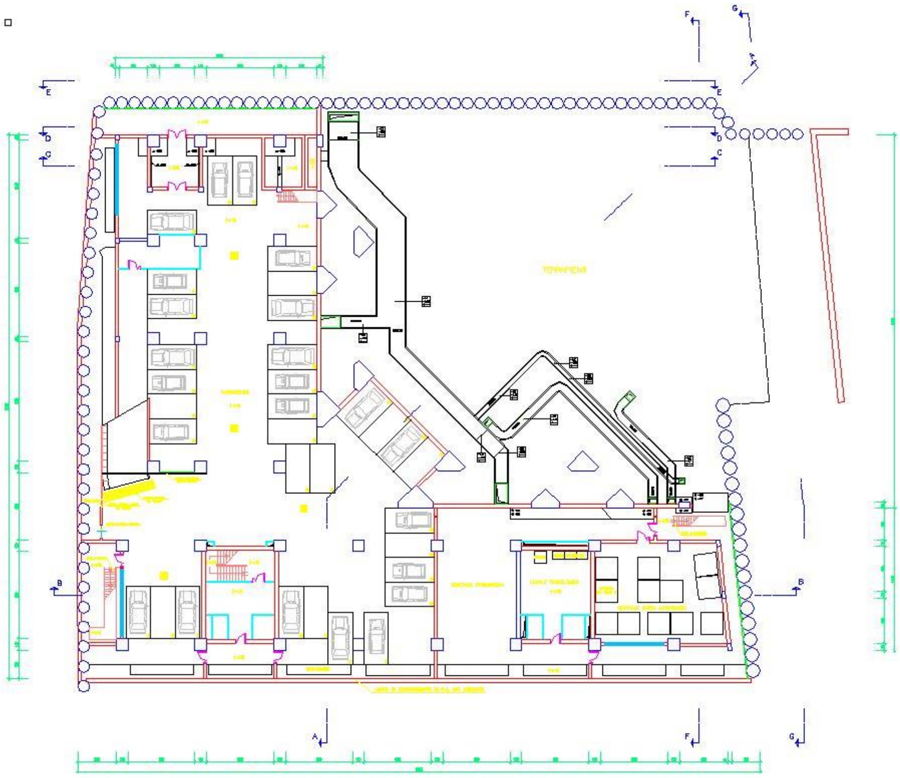


FIGURE 94 - PLANT H. -4.75

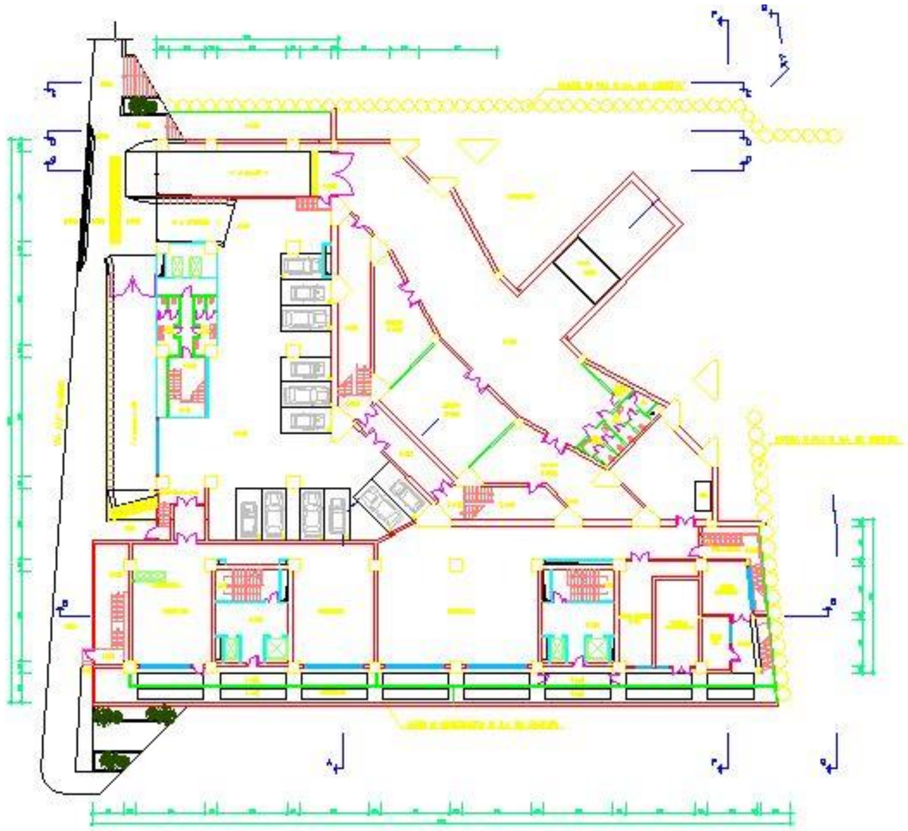


FIGURE 95 - PLANT H. -1.25

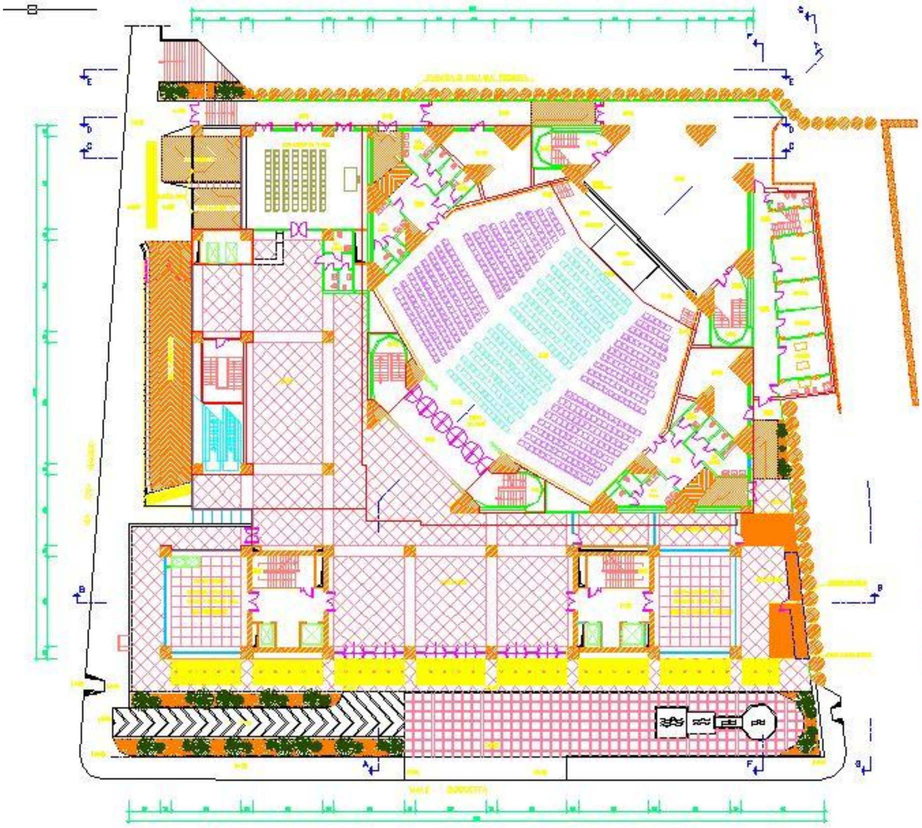


FIGURE 96 - PLANT H.2.25

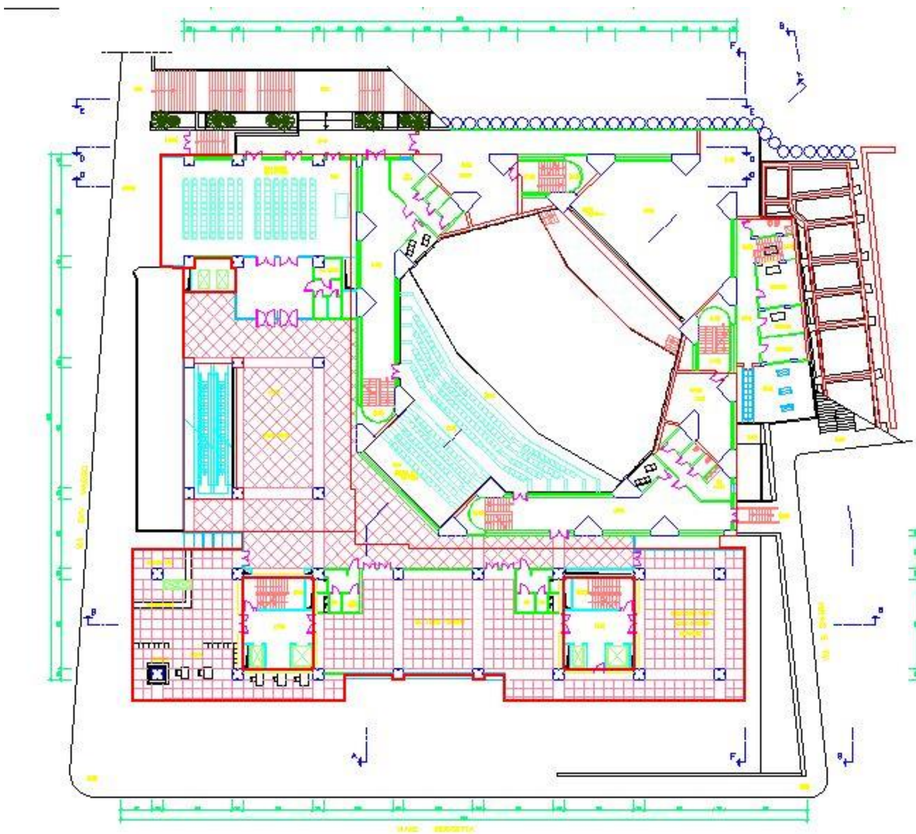


FIGURE 97 - PLANT H.7.25

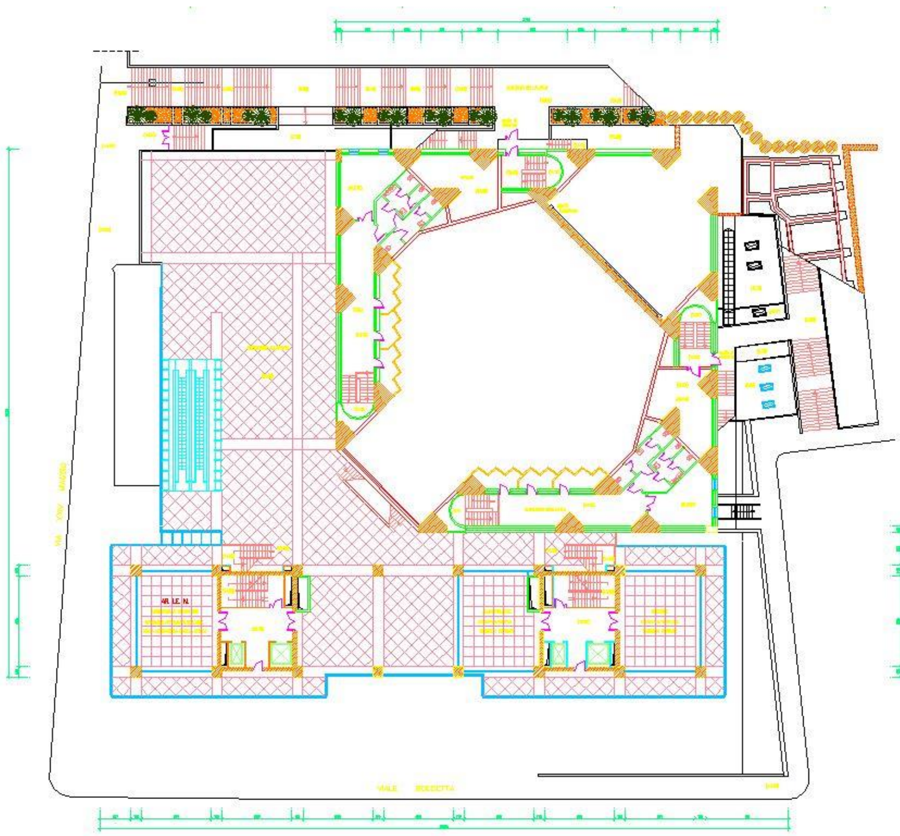


FIGURE 98 - PLANT H. 12.25

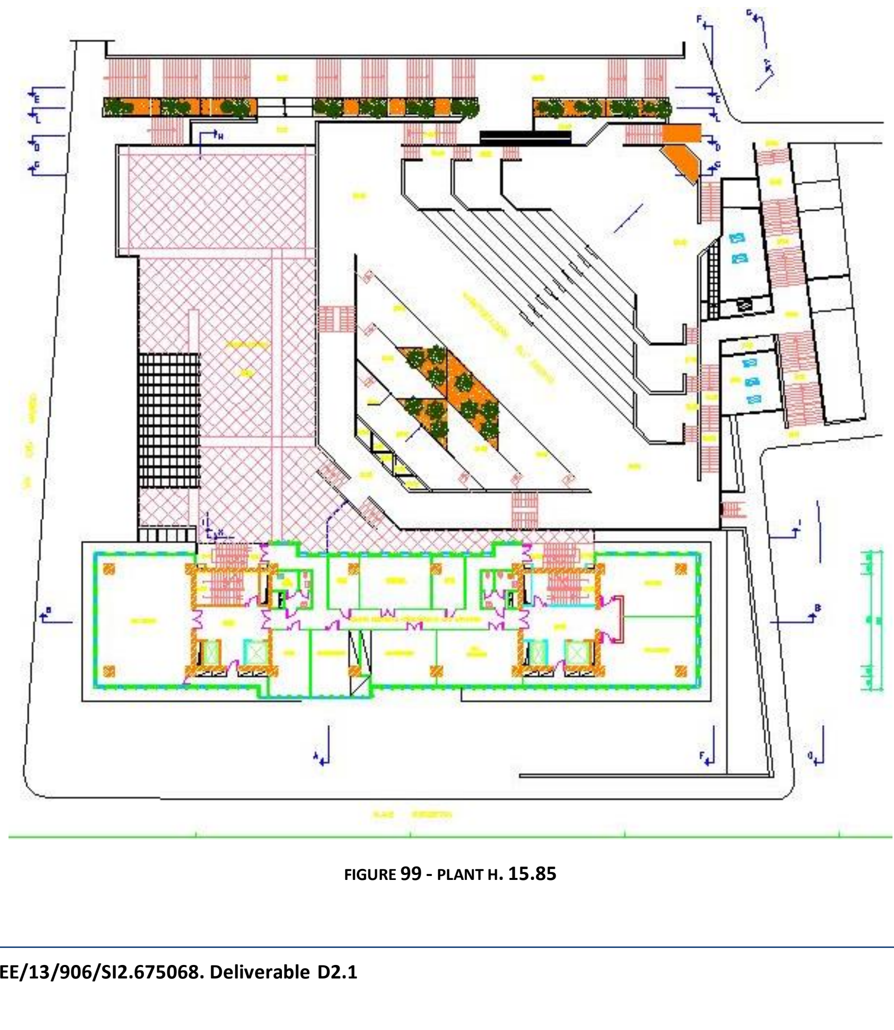


FIGURE 99 - PLANT H. 15.85

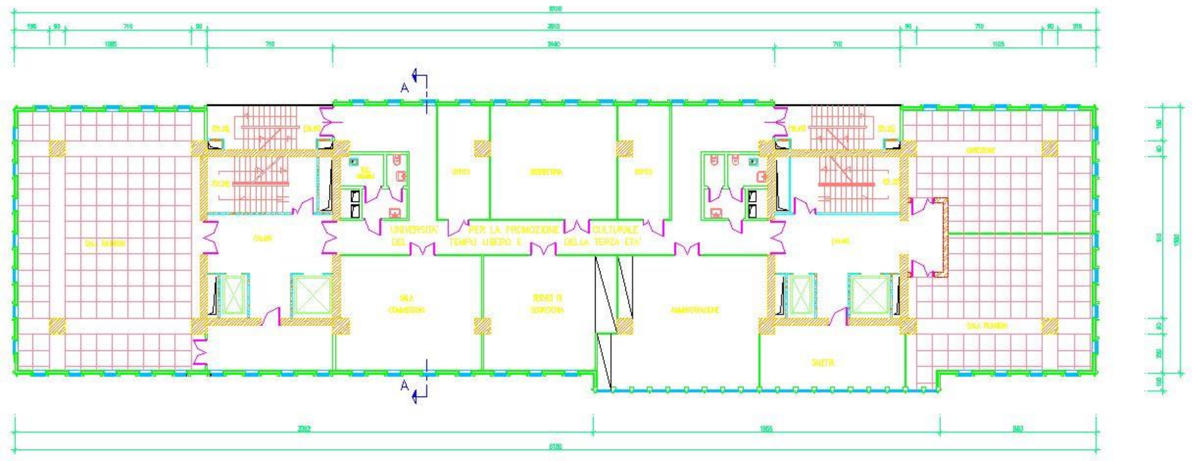


FIGURE 100 - PLANT H. 19.45

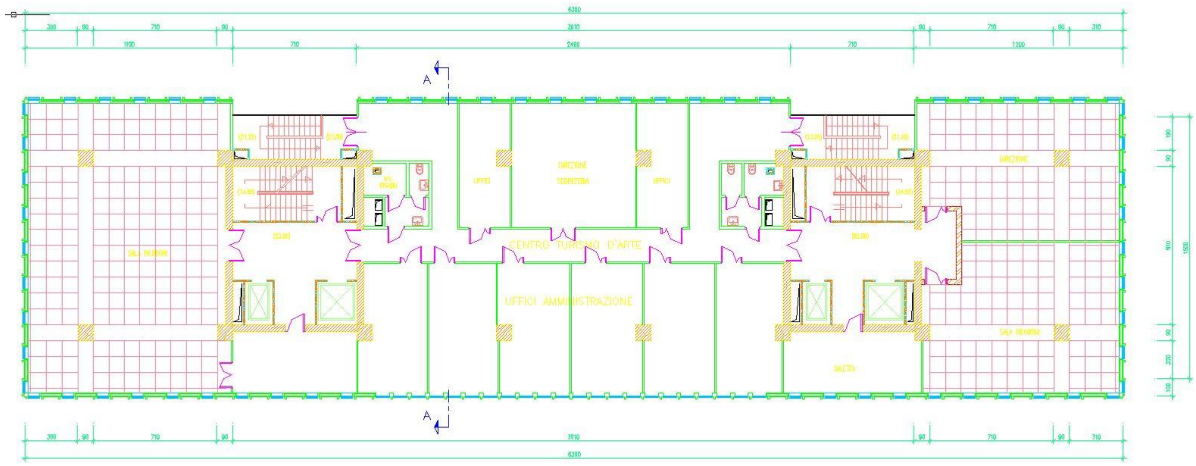


FIGURE 101 - PLANT H. 23.05

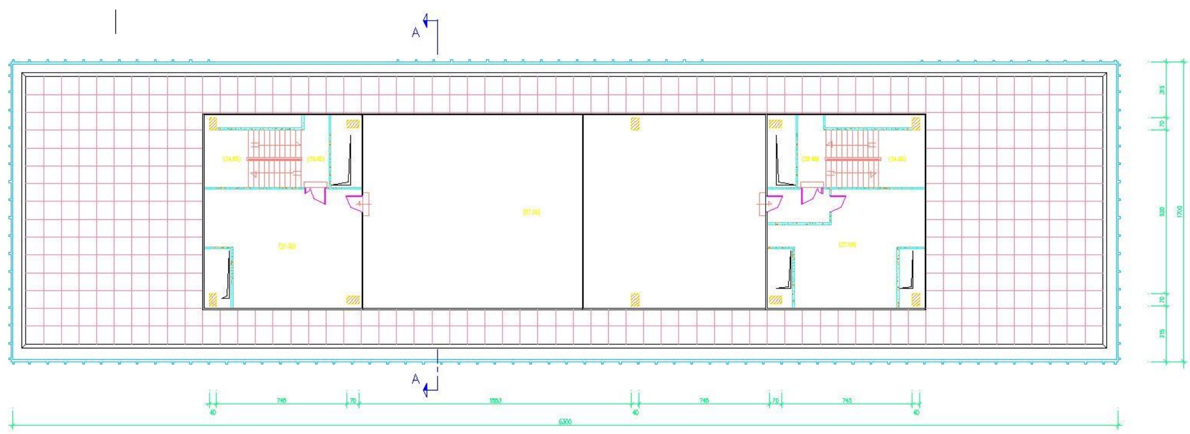


FIGURE 102 - PLANT H. 27.00

FIGURE 103 - ROOF PLAN

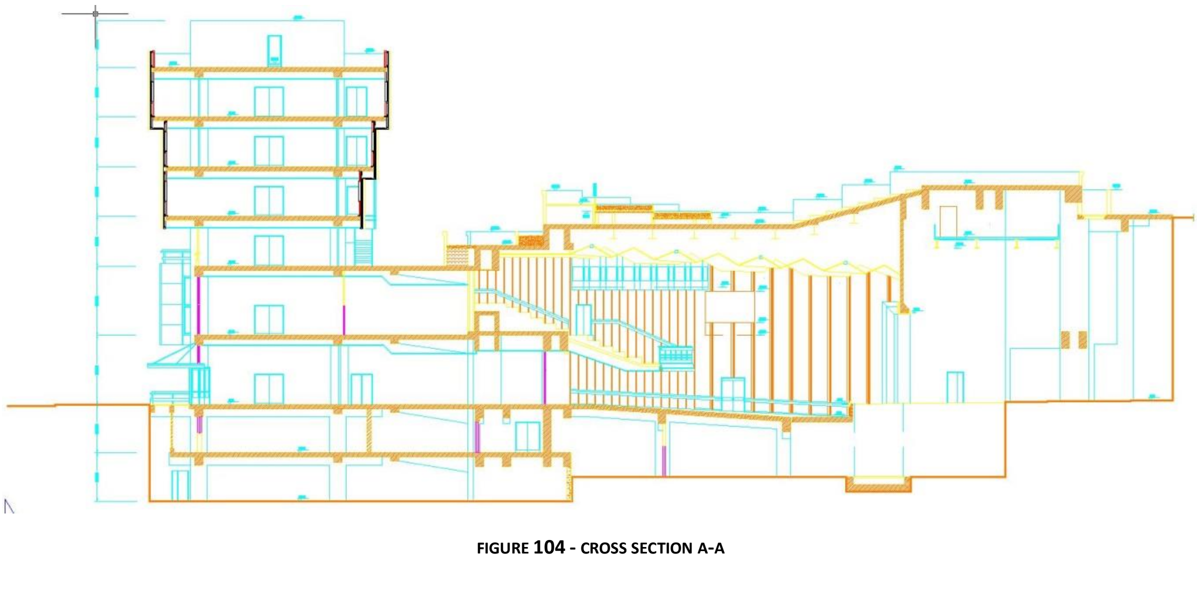


FIGURE 104 - CROSS SECTION A-A

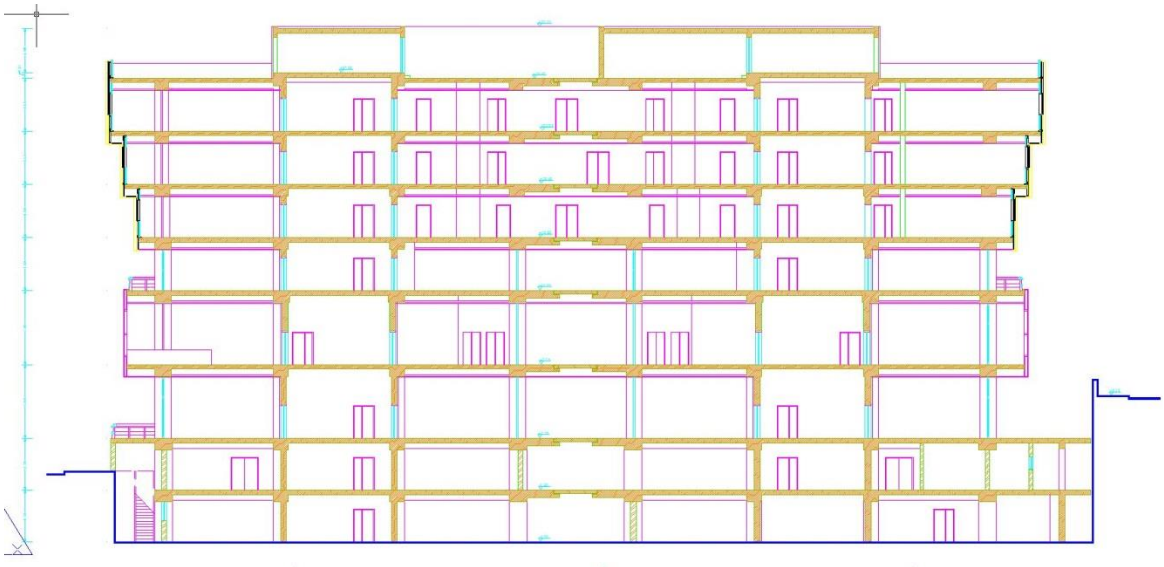


FIGURE 105 - CROSS SECTION B-B

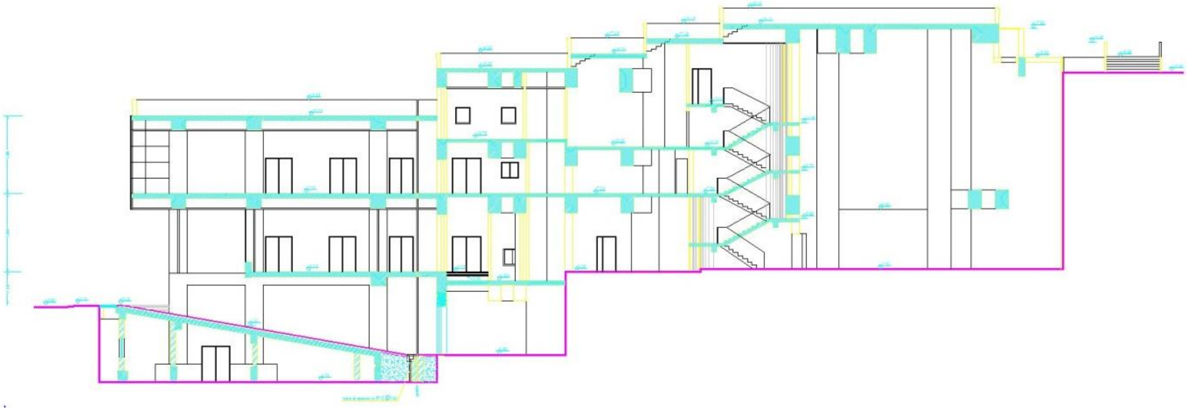


FIGURE 106 - CROSS SECTION C-C

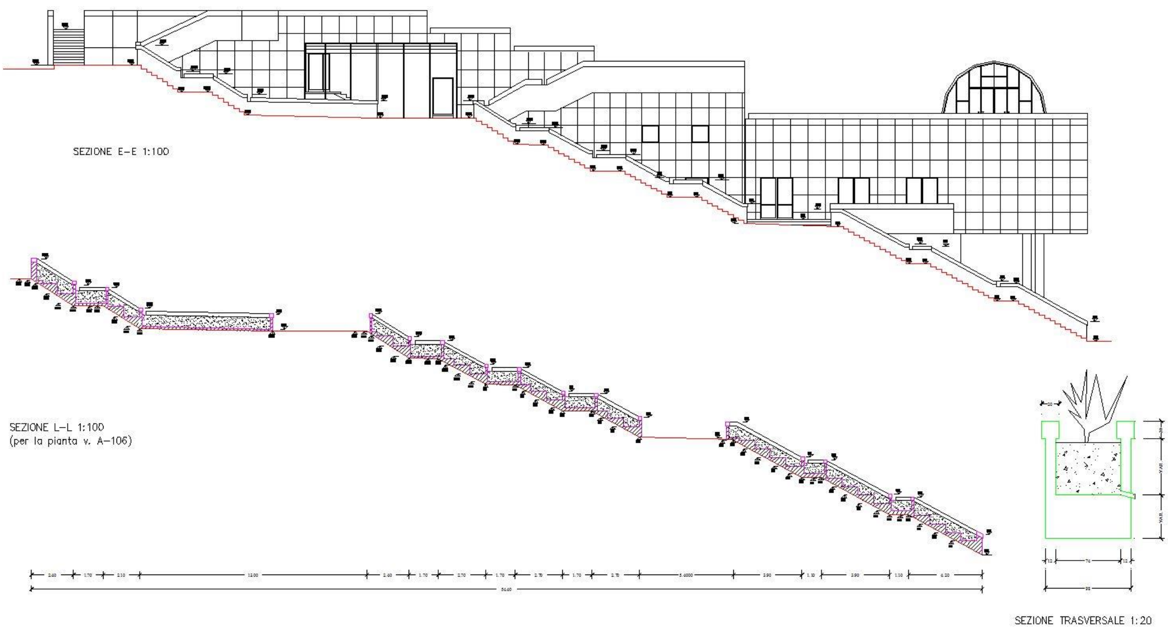


FIGURE 107 - CROSS SECTION D-D

6. ANNEX B: BUILDINGS DESIGN

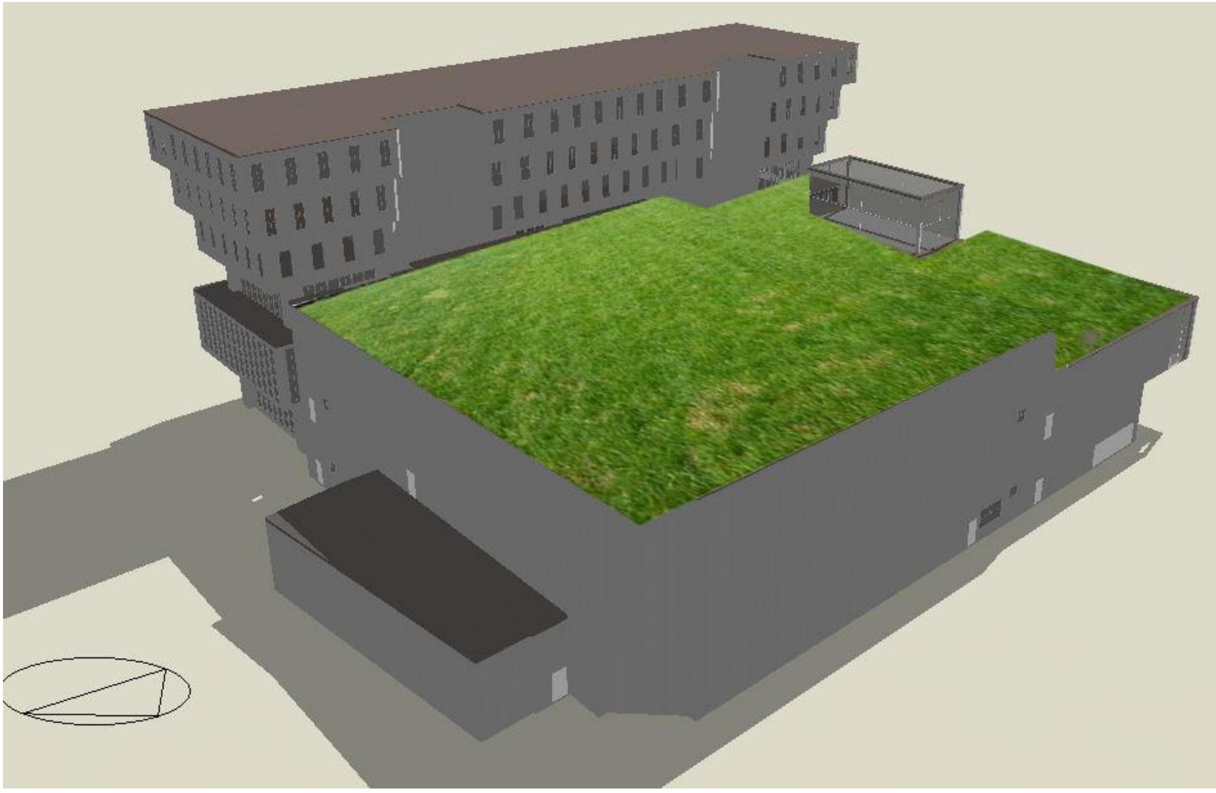


FIGURE 108 - RENDER OF THE GREEN ROOF

7. ANNEX C: DESIGN BUILDER PARAMETERS

TABLE 25 - GENERAL VALUE

	Value
Program Version and Build	EnergyPlusDLL-32 8.1.0.008, 30/06/2015 16:49
RunPeriod	PALACULTURA Enea
Weather File	Messina - ITA IGDG WMO#=164200
Latitude [deg]	38.20
Longitude [deg]	15.55
Elevation [m]	59.00
Time Zone	1.00
North Axis Angle [deg]	0.00
Rotation for Appendix G [deg]	0.00
Hours Simulated [hrs]	8760.00

TABLE 26 - END USES BY SUBCATEGORY

	Subcategory	Electricity [kWh]	Nat. Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	General	156,457.77	0.00	0.00	0.00	0.00	0.00
Cooling	General	174,272.46	0.00	0.00	0.00	0.00	0.00
Interior Lighting	ELECTRIC EQUIPMENT#Blocco11:Zona9#GeneralLights	184.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona9#TaskLights	56.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona1#GeneralLights	24,512.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona1#TaskLights	1,640.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona23#GeneralLights	295.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona23#TaskLights	89.67	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	10,638.74	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco11:Zona19#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco11:Zona60#GeneralLights	1,683.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona60#TaskLights	102.05	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona55#GeneralLights	357.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona55#TaskLights	108.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona15#GeneralLights	928.74	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona15#TaskLights	140.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona8#GeneralLights	199.62	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona8#TaskLights	60.49	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona24#GeneralLights	1,091.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona24#TaskLights	166.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona20#GeneralLights	271.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl	82.22	0.00	0.00	0.00	0.00	0.00

	occo11:Zona20# TaskLights						
	ELECTRIC EQUIPMENT#Bl occo11:Zona12# GeneralLights	692.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona12# TaskLights	41.97	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona2# GeneralLights	45.30	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona2#T askLights	35.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona7# GeneralLights	230.08	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona7#T askLights	34.86	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona38# GeneralLights	1,176.89	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona38# TaskLights	178.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona16# GeneralLights	387.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona16# TaskLights	117.28	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona6# GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl occo11:Zona6#T	0.00	0.00	0.00	0.00	0.00	0.00

	askLights						
	ELECTRIC EQUIPMENT#Blocco11:Zona17#GeneralLights	70.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona17#TaskLights	10.73	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona25#GeneralLights	451.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona25#TaskLights	27.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona39#GeneralLights	1,598.80	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona39#TaskLights	97.64	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona49#GeneralLights	256.23	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona49#TaskLights	77.64	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona5#GeneralLights	441.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona5#TaskLights	133.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona13#GeneralLights	506.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona13#TaskLights	153.34	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco11:Zona18#GeneralLights	1,041.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona18#TaskLights	315.46	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona14#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona14#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona4#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona4#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona10#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona10#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona53#GeneralLights	279.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona53#TaskLights	84.61	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona4#GeneralLights	421.97	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona4#TaskLights	127.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	457.86	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco12:Zona5#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco12:Zona5#TaskLights	138.74	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona2#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona2#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona1#GeneralLights	165.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona1#TaskLights	25.14	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona3#GeneralLights	177.73	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona3#TaskLights	26.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona1#GeneralLights	110.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona1#TaskLights	33.43	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona4#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona4#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl	221.82	0.00	0.00	0.00	0.00	0.00

	occo13:Zona3#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco13:Zona3#TaskLights	33.61	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona2#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona2#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona1#GeneralLights	11,068.19	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona2#GeneralLights	802.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona2#TaskLights	243.30	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona3#GeneralLights	506.81	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona3#TaskLights	77.45	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona4#GeneralLights	1,445.30	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona5#GeneralLights	260.64	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona5#TaskLights	78.98	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona7#	384.09	0.00	0.00	0.00	0.00	0.00

	GeneralLights						
	ELECTRIC EQUIPMENT#Blocco14:Zona8#GeneralLights	255.29	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona8#TaskLights	77.36	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona9#GeneralLights	713.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona10#GeneralLights	414.38	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona10#TaskLights	63.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona6#GeneralLights	832.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona6#TaskLights	252.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona11#GeneralLights	635.56	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona11#TaskLights	192.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco16:Zona1#GeneralLights	11.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco16:Zona1#TaskLights	136.83	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona3#GeneralLights	2,501.91	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco4:Zona2#GeneralLights	514.34	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona2#TaskLights	155.86	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona1#GeneralLights	2,664.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona2#GeneralLights	459.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona2#TaskLights	139.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona1#GeneralLights	2,792.23	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona8#GeneralLights	571.17	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona8#TaskLights	175.70	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona2#GeneralLights	199.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona2#TaskLights	30.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona3#GeneralLights	458.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona3#TaskLights	138.89	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	0.00	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco7:Zona6#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco7:Zona6#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona11#GeneralLights	5,824.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona5#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona5#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona7#GeneralLights	458.31	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona7#TaskLights	138.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona4#GeneralLights	209.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona4#TaskLights	31.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona1#GeneralLights	3,050.15	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona10#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona10#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl	0.00	0.00	0.00	0.00	0.00	0.00

	occo7:Zona9#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco7:Zona9#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona4#GeneralLights	451.02	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona4#TaskLights	136.67	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona3#GeneralLights	223.29	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona3#TaskLights	33.83	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona10#GeneralLights	631.58	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona10#TaskLights	195.51	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona5#GeneralLights	3,454.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona9#GeneralLights	217.97	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona9#TaskLights	33.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona11#GeneralLights	456.08	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona11#T	138.21	0.00	0.00	0.00	0.00	0.00

	askLights						
	ELECTRIC EQUIPMENT#Blocco2:Zona8#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona8#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona7#GeneralLights	6,504.28	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona2#GeneralLights	126.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona2#TaskLights	56.21	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona6#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona6#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona1#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona1#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona11#GeneralLights	458.31	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona11#TaskLights	138.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona9#GeneralLights	5,815.72	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco6:Zona22#GeneralLights	458.30	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona22#TaskLights	138.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona17#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona17#TaskLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona18#GeneralLights	522.10	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona18#TaskLights	159.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona5#GeneralLights	209.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona5#TaskLights	31.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona1#GeneralLights	2,454.52	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona15#GeneralLights	199.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona15#TaskLights	30.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona7#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	0.00	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco6:Zona7#TaskLights						
	ELECTRIC EQUIPMENT#Blocco3:Zona1#GeneralLights	22,519.96	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	General	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	ELECTRIC EQUIPMENT#Blocco11:Zona9#05	111.99	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona23#05	179.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona19#05	2,149.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona55#05	216.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona8#05	120.98	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona20#05	164.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona2#05	70.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona6#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona49#05	155.29	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona5#05	267.80	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco11:Zona13#05	306.68	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona18#05	22,081.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona14#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona4#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona10#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona53#05	169.23	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona4#05	255.74	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona5#05	277.49	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona2#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona1#05	66.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona4#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco13:Zona2#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	2,236.00	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco14:Zona1#05						
	ELECTRIC EQUIPMENT#Blocco14:Zona2#05	486.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona4#05	30,657.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona5#05	157.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona8#05	154.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona9#05	30,224.51	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona6#05	504.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco14:Zona11#05	385.19	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco16:Zona1#05	273.67	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona3#05	1,590.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona2#05	311.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona1#05	1,590.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona2#05	278.18	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl	1,743.78	0.00	0.00	0.00	0.00	0.00

	occo5:Zona1#05						
	ELECTRIC EQUIPMENT#Blocco7:Zona8#05	351.41	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona3#05	277.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona6#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona11#05	3,386.17	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona5#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona7#05	277.76	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona1#05	1,736.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona10#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco7:Zona9#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona4#05	273.35	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona10#05	391.02	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona5#05	1,970.76	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona11#05	276.41	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona8#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bl	3,798.72	0.00	0.00	0.00	0.00	0.00

	occo2:Zona7#05						
	ELECTRIC EQUIPMENT#Blocco2:Zona2#05	112.42	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona6#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona1#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona11#05	277.76	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona9#05	3,405.18	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona22#05	277.76	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona17#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona18#05	319.83	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona1#05	1,401.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona7#05	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco3:Zona1#05	4,549.49	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	General	0.00	0.00	0.00	0.00	0.00	0.00
Fans	General	79,019.74	0.00	0.00	0.00	0.00	0.00
Pumps	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	General	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	General	0.00	0.00	0.00	0.00	0.00	0.00
Water	General	0.00	0.00	0.00	0.00	0.00	0.00

Systems							
Refrigeration	General	0.00	0.00	0.00	0.00	0.00	0.00
Generators	General	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 27 - TABULAR VIEW FOR TEMPERATURE AND PRECIPITATION PER MONTH

	Temperature			Precipitation
Months	**Normal**	**Warmest**	**Coldest**	**Normal**
January	12.3°C	14.4°C	10.1°C	10
February	12.2°C	14.7°C	9.8°C	9
March	13.5°C	16.1°C	10.9°C	8
April	15.4°C	18.3°C	12.5°C	8
May	19.5°C	22.5°C	16.4°C	3
June	23.6°C	26.8°C	20.4°C	1
July	26.7°C	30.0°C	23.4°C	1
August	27.3°C	30.5°C	24.2°C	2
September	24.5°C	27.5°C	21.5°C	5
October	20.5°C	23.2°C	17.8°C	8
November	16.4°C	18.7°C	14.1°C	10
December	13.7°C	15.8°C	11.6°C	10

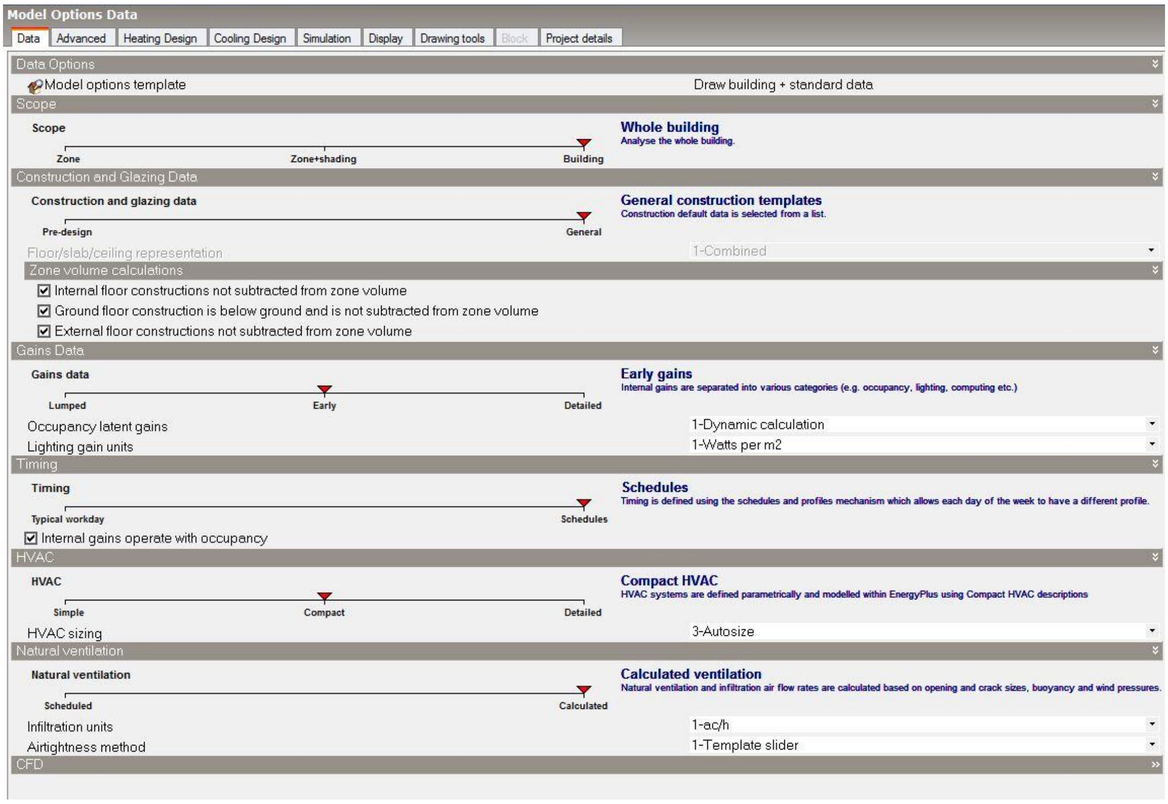


FIGURE 109 - MODEL OPTIONS DATA

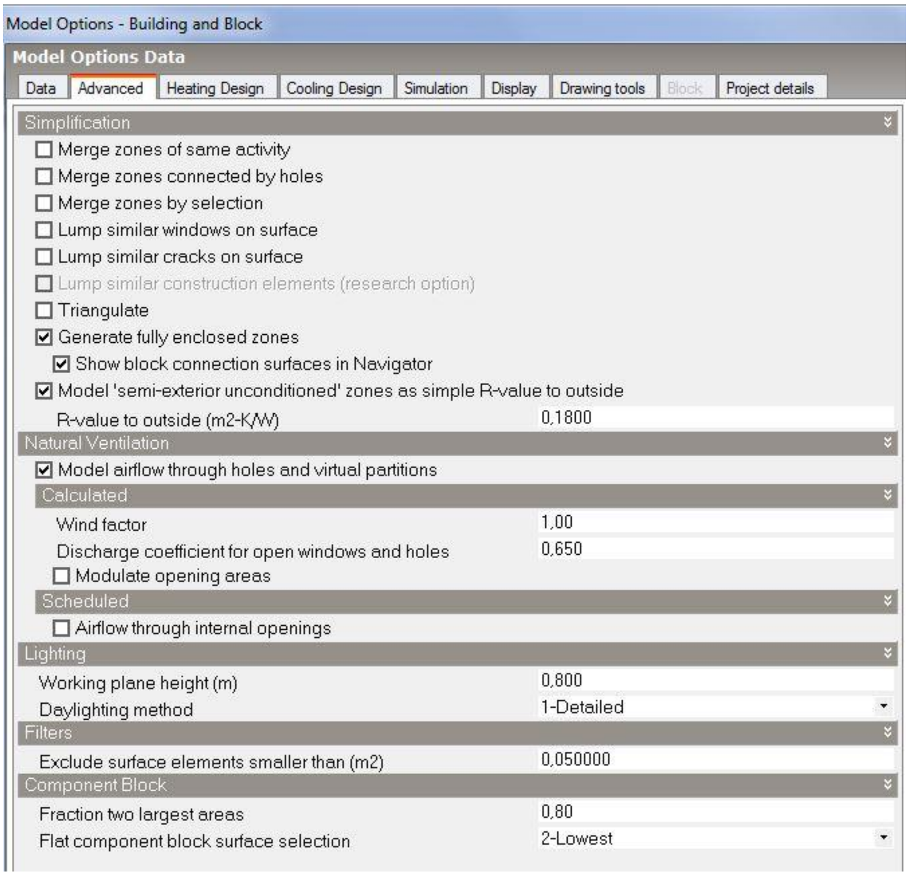


FIGURE 110 - MODEL OPTIONS DATA

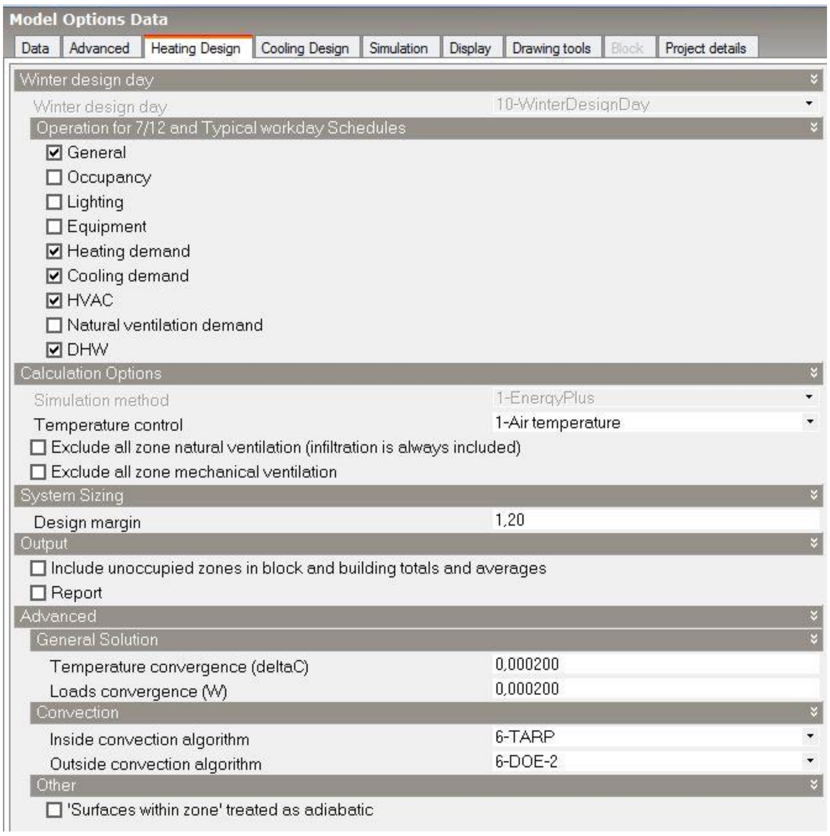


FIGURE 111 - MODEL OPTIONS DATA

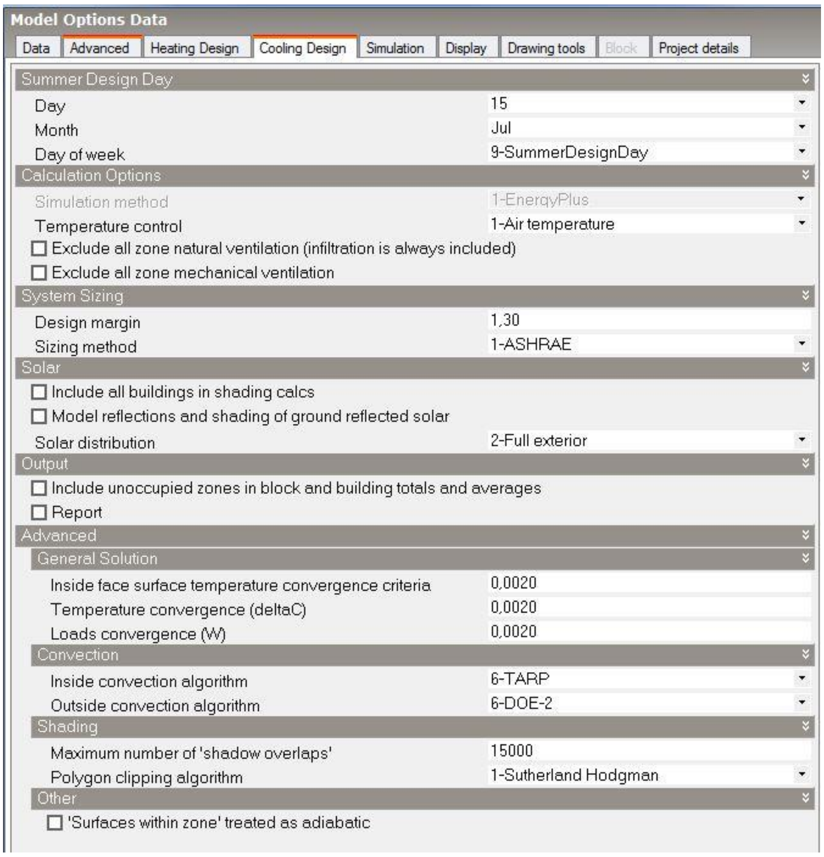


FIGURE 112 - MODEL OPTIONS DATA

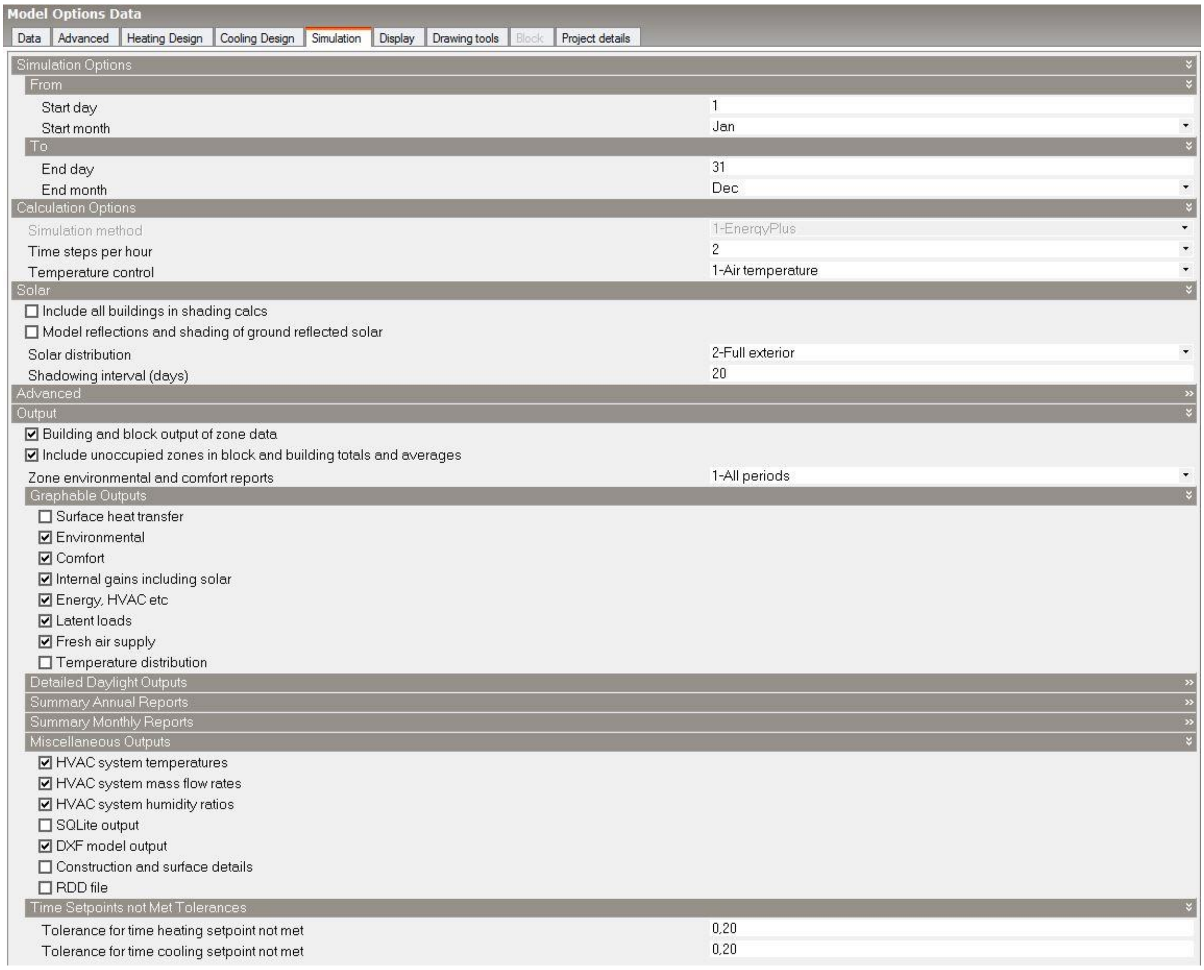


FIGURE 113 - MODEL OPTIONS DATA

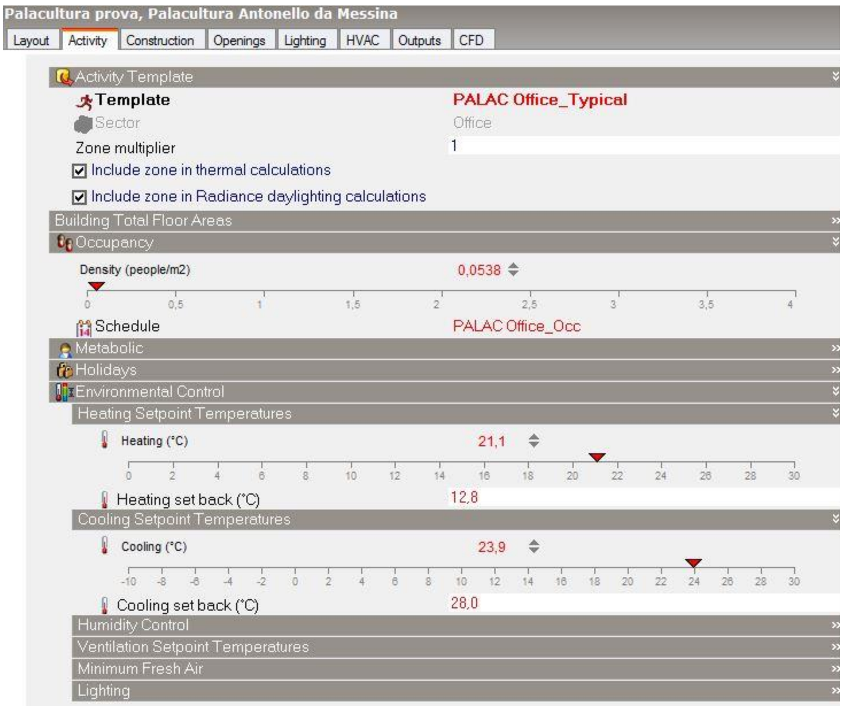


FIGURE 114 - PALCE OF CULTURE ACTIVITY SCHEDULE

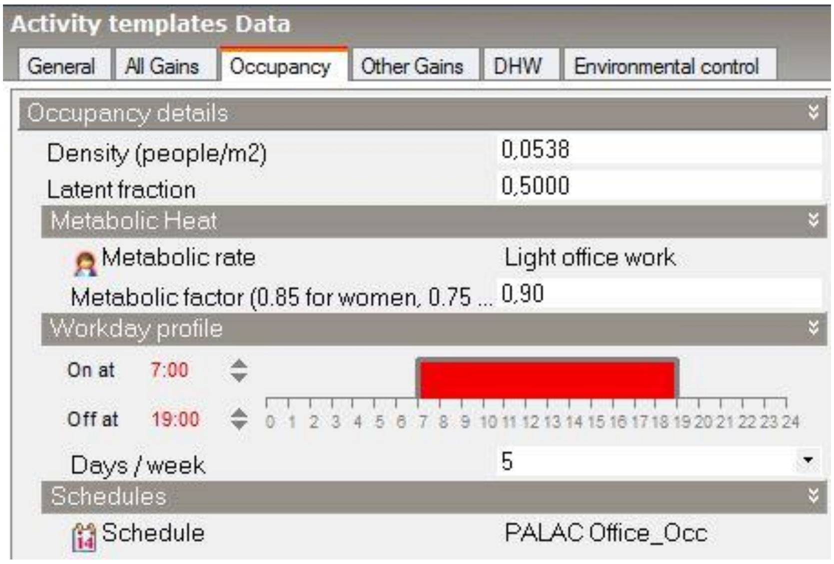


FIGURE 115 - PALCE OF CULTURE OCCUPANCY

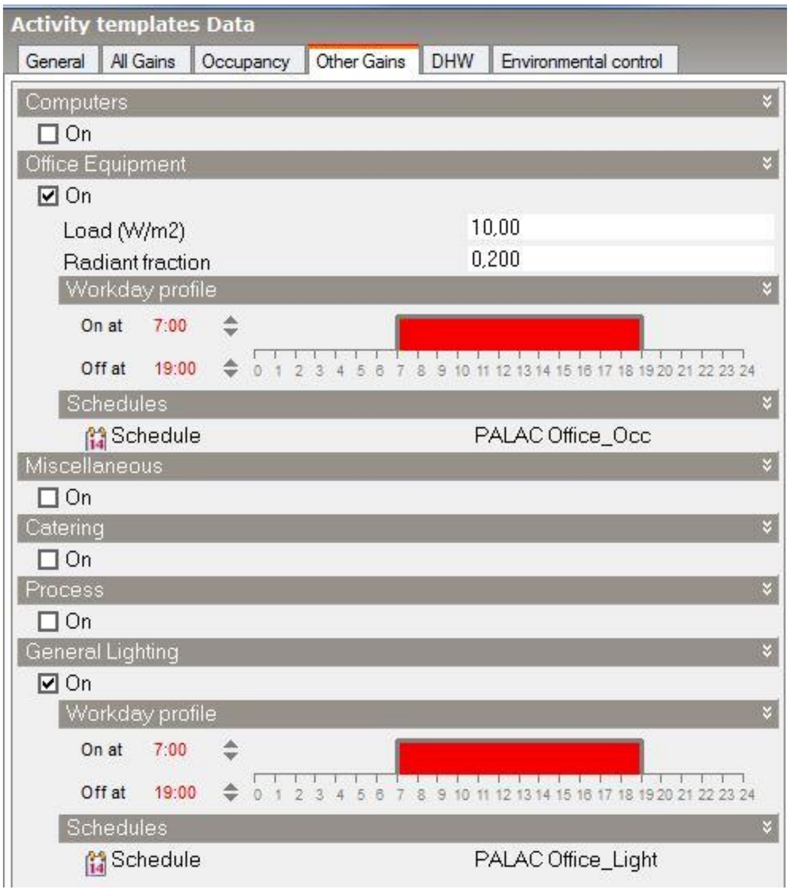


FIGURE 116 - PALCE OF CULURE OTHER GAINS

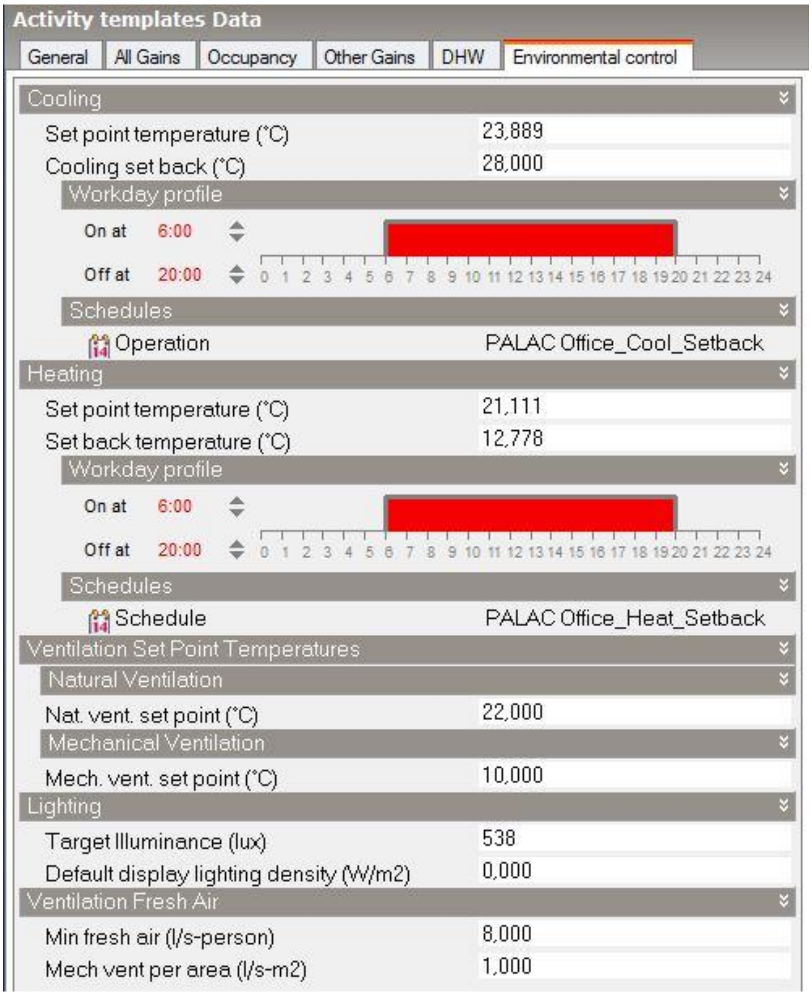


FIGURE 117 - PALACE OF CULURE OFFICE ENVIRONMENTAL CONTROL

8. ANNEX D: RENOVATION OPTION MATRIX BY SINLOC

TABLE 28 - ECONOMIC EVALUATION OF INTERVENTIONS

						Work timing						CAPEX				
				Installed power or size of intervention		Start date	Final date	Construction Period	Compulsory connection with other technologies/ layers	Specify which technologies are needed to realize this layer	Specify which technologies can be realized only after this layer	Investment cost			Investment payback period (preliminary)	Lifetime (year of replacement - revamping)
Renovation options	**Types**	**Technologies / Layers**	**Code**	**Unit of measure**	**Value**	**dd/mm/yy**	**dd/mm/yy**	**Months**	**Yes/No**	**Code/codes (ascending order)**	**Code/codes (ascending order)**	**Unit of measure**	**Unit cost**	**Value calculated**	**Years**	**Years**
			7													
	Ventilation system	**Heat recovery**	8													
			9													
		Heating pumps with geothermal sonde Georthermal heat pumps	10													
		[…]	11													
Casing	**External insulation - Internal insulation**	**New facades -** *-INTERNAL INSULATION OF WALLS and COVER BLOCK ESCALATORS - GREEN ROOF*	**12**	sqm	500	X	X	12	Yes		19	total	€ 354'210,00	€ 354'210	38,10	50
Building skin			13													
	Shielding elements		14													
	Bioclimatic	[…]	15													
		[…]	16													
Windows	Windows	PVC	17													
		[…]	18													
	Glass windows	*Double glass NEW WINDOWS + curtain film*	**19**	sqm	320	X	X	6	Yes	12		€/mq	€ 650,00	€ 208'000,00	12,81	30
	Glass windows	Triple glass	20													
		[…]	21													
Lighting systems (internal)	**Replacement of lamps (and luminaries, ballast)**	**LED**	22													
		Internal RELAMPING	**23**	units	1681	X	X	4	No			€/unit	€ 200,00	€ 336'200	22,50	20
Lighting systems (external)	Replacement of lamps (and luminaries, ballast)	LED	24													
			25													
Renewable energy	Biomass	Biomass heating systems	26													
	Solar	*Photovoltaic panels PV PLANT*	**27**	KWp	28	X	X	6	No			€/KWp	€ 2'000,00	€ 56'000	9,81	30
		Solar thermal panels	27													
Control systems	Thermal	Automatic regolation of internal temperature	28													
		Thermostatic valves	29													
		Individual thermal energy consumption accounting	30													
	Lighting	Light flux regulators (internal)	31													
		Light flux regulators (external)	32													
			33													
			34													
			35													
			36													

TABLE 29 - ECONOMIC EVALUATION OF INTERVENTIONS

	OPEX														
	Energy consumption (after each single energy renovation option)								Labor/Management and ordinary maintenance contracts			Extraordinary maintenance			
									Cost of components	Cost of personnel	Total	Frequency	Cost of intervention	Cost of personnel	Total
Renovation options	Source 1	Unit of measure	Consumption/year	€/year	Source 2	Unit of measure	Consumption/year	€/year	€/year	€/year	€/year	years	€	€/year	€
Casing Building skin	no				no				€ 3'719	€ 6'907	€ 10'626	10	€ 17'500	€ 1'500	€ 32'500
Windows	no				no				€ 1'456	€ 2'704	€ 4'160	10	€ 17'500	€ 1'500	€ 32'500
Lighting systems (internal)	electric	KWHe	137'800	€ 24'804,00	no				€ 1'177	€ 2'185	€ 3'362	7	€ 10'000	€ 100	€ 10'700
Lighting systems (external)															
Renewable energy	no				no				€ 980	€ 1'820	€ 2'800	5	€ 7'000	€ 3'000	€ 22'000
Control systems															

TABLE 30 - ECONOMIC EVALUATION OF INTERVENTIONS

	SAVINGS													
	Potential energy savings expected from the intervention										Potential savings from maintenance (post intervention)		Potential savings of CO2	
	Electric energy consumption					Thermal energy consumption								
Renovation options	%, first year	kWhe/year, first year	%, last year	kWhe/year, last year	Decrease characteristics (linear, nonlinear, etc.)	%, first year	kWhe/year, first year	%, last year	kWhe/year, last year	Decrease characteristics (linear, nonlinear, etc.)	%	€/year	%	Equivalent tons/year
Casing Building skin	12,5%	54'841	11,0%	48'445	linear						0%	€ 0	11,73%	38,732
Windows	12,5%	54'841	10,0%	44'041	linear						20%	€ 7'332	11,23%	37,08
Lighting systems (internal)	30,1%	59'058	28,0%	54'880	linear						25%	€ 4'687	29,07%	42,73
Lighting systems (external)														
Renewable energy	100,0%	36'235	75,0%	27'176	linear						0%	€ 0	87,50%	23,78
Control systems														

B. CITY HALL - ZANCA PALACE

9. BUILDING GENERAL DESCRIPTION

9.1. LOCATION

Palazzo Zanca is the municipal building of Messina. The building is located at the same place of the historic town hall building, which was destroyed twice before by earthquakes in 1783 and then definitively in 1908. Rebuilt after the earthquake of 1908, its construction is part of the reconstructions plan of the city, that relocated public buildings nearby the sea.

It is the first building designed and built according to the first anti-seismic regulations, drawn up in 1909. This figure shows the front facade of the building.

FIGURE 118 - PALAZZO ZANCA

The project suffered from numerous changes and additions by the local building committee. Significant difficulties have been reported concerning the choice of coating material: the natural stone was too expensive, so they chose to use a cement mixture, similar in appearance to natural stone but cheaper.

FIGURE 119 - PALAZZO ZANCA

FIGURE 120 - EXCAVATIONS PALAZZO ZANCA

The reconstruction works began in December 1914 under the direction of Antonio Zanca, a famous architect from Palermo. His history is recent but very complicated. The reconstruction was initiated in 1914 and completed in 1924 after several changes, both stylistic and structural. There were two main constraints: firstly, the building had to respect the seismic regulations; secondly, it had to be simple, representative, and inspired by the past. Antonio Zanca worked about twelve or more years on this project and in the end he did not get paid. He designed the entire building from structure to interior. The building style is neoclassical and covers an area of about 12,000 m2; Palazzo Zanca is the temple of Italian cement for architectural experimentation. Table 1 presents the main location data of the building.

TABLE 31 - LOCATION DATA OF THE BUILDING

Address	European Union Square, 41 98122 Messina (ME), Italy
Coordinates	LAT. 38°11'10.46"N - LONG. 15°33'38.93"E
Google Maps	https://www.google.it/maps/@38.19355,15.556405,17z/data=!3m1!4b1!4m2!3m1!1s0x13144e787d10204b:0x7b452af4ef65eb61

The building is located on the seafront, near the marina of the city. These figures show the location in the city map and aerial view.

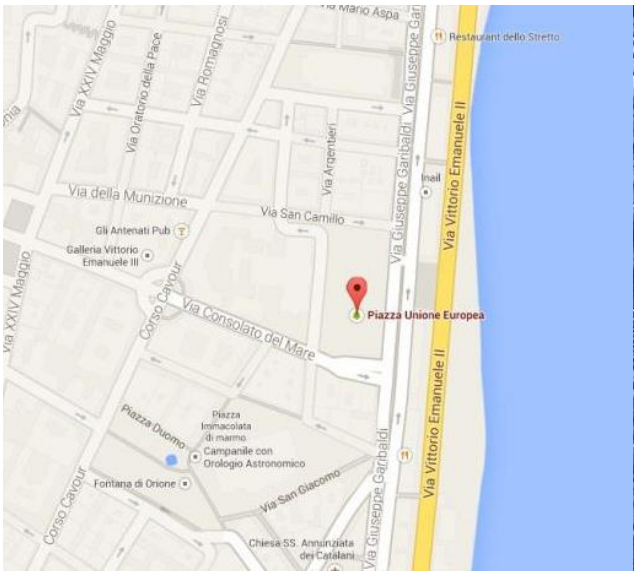


FIGURE 121 - LOCATION IN THE CITY (MAP)

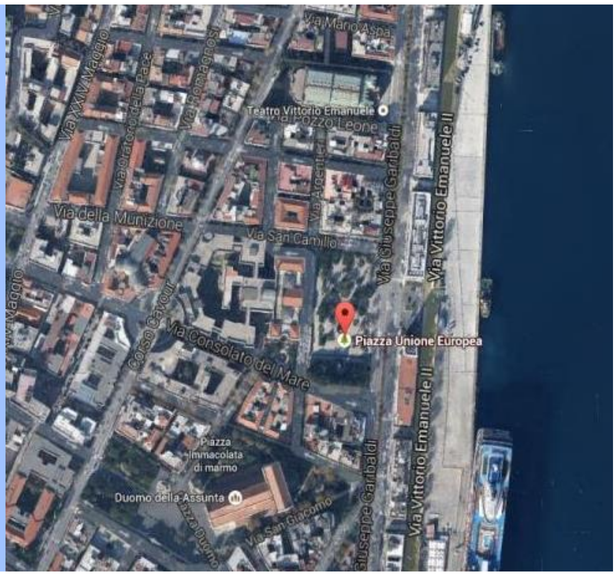


FIGURE 122 - LOCATION IN THE CITY (AERIAL VIEW)

TABLE 32 - DATA OF THE SYSTEM CONSIDERED

Degree days	707											
Minimum temperature of project	5.0 °C											
Altitude	3 m s.l.m.											
Climatic Zone	B											
Heating days	121											
Wind speed	2.8 m/s											
Wind zone	2											
Province of reference	Messina - Reggio di Calabria											
Average monthly temperatures(°C)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	11.7	12.0	13.2	15.7	19.2	23.5	26.4	26.5	24.2	20.3	16.6	13.3
Averages monthly raditions (MJ/m²)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	7.2	10.8	15.2	20.3	24.4	27.3	27.2	24.6	19.0	12.9	8.9	6.6
	10.8	12.9	12.9	11.5	9.9	9.2	9.7	11.8	14.0	14.2	13.2	10.3
	8.6	11.1	12.7	13.6	13.6	13.8	14.3	15.3	14.9	12.6	10.7	8.2
	5.4	7.9	10.5	13.4	15.6	17.1	17.2	16.2	13.1	9.3	6.7	5.0
	2.7	4.2	6.6	9.7	12.5	14.5	14.1	11.8	8.2	5.1	3.2	2.4
	2.4	3.2	4.3	5.9	8.4	10.2	9.5	6.8	4.6	3.6	2.6	2.2

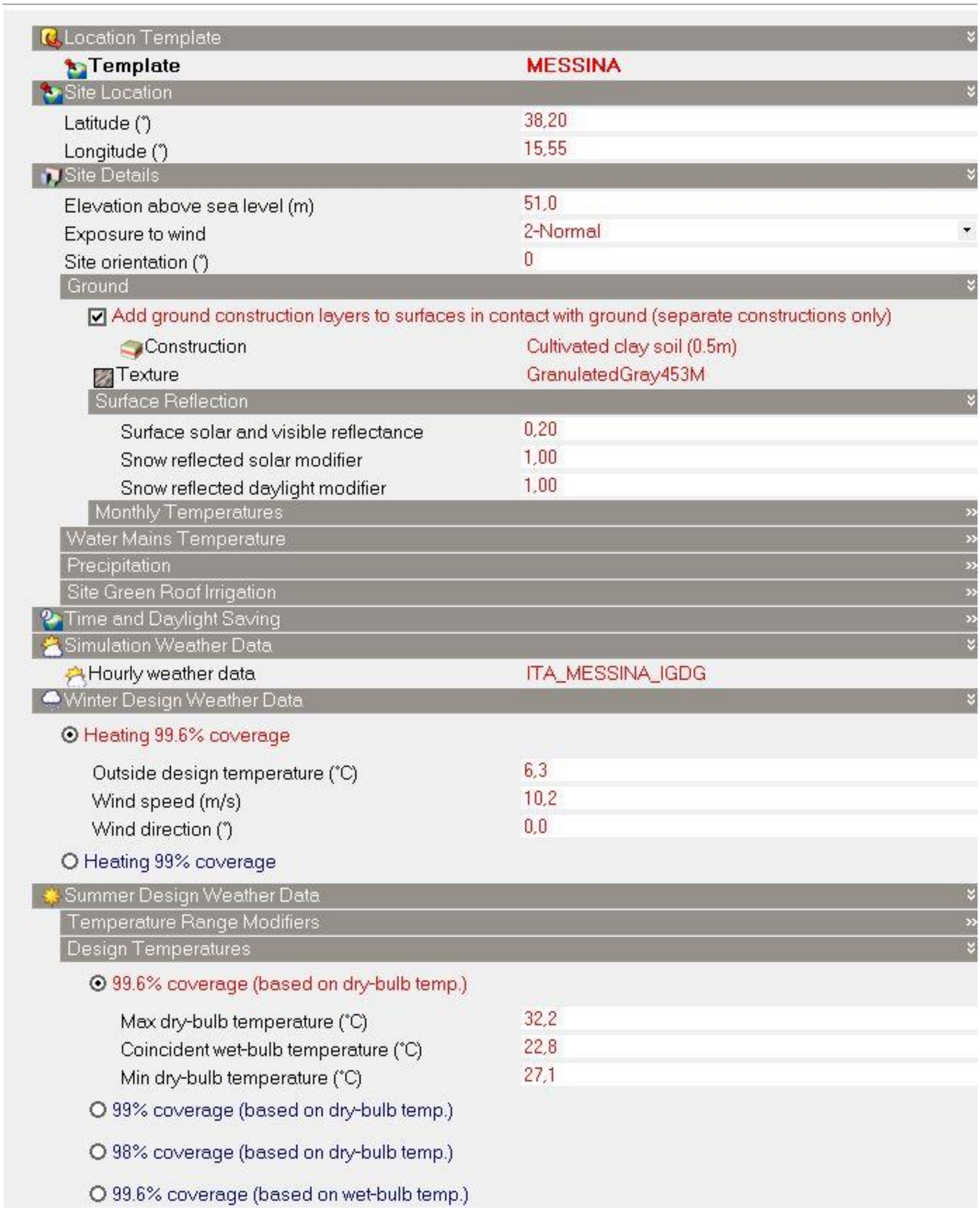


FIGURE 123 - DATA FOR THE SIMULATION WITH DESIGN BUILDER SOFTWARE

9.2. Shape And Orientation

This building is constituted from a building of 2 floors above ground. The dimensions are the same for each floor.
It is possible attach a road network scheme and a urban setting of the studied area.

FIGURE 124 - ROAD NETWORK SCHEME

FIGURE 125 - URBAN SETTING OF STUDIED AREA

9.3. Area And Volume

The building has a total area of about 13,500 m^2 (about 7,000 m^2 to plan) and a volume of about 55,000 m^3 .

9.4. Current Use

Palazzo Zanca is a municipal building, in which there are multiple functions of public utility.

On the ground floor there is the access to the building with hall and reception. All rooms are now used as municipal offices, with the exception of the bathrooms, deposits and some offices of municipal councillors.

FIGURE 126 - GROUND FLOOR

On the first floors there are numerous municipal offices, Mayor's and assessors rooms, municipal council hall, reception hall, a bar, bathrooms and archives.

FIGURE 127 - RECEPTION HALL NAMED "HALL OF FLAGS"

In the basement there are large rooms and many of them are intended for systems and server rooms.

The building is usually busy between 0h00 and 24h00 from Monday to Sunday, because here is the registry office of the city, but the public activities of employees carried out only between 7h30 and

19h30. Public access depends on the type of service provided and is between 08h30 and 13h30 from Monday to Friday, also between 14h30 and 16h30 on Tuesday and Thursdays.

The building hosts about 750 employees and it is visited by an large number of visitors.

For the simulation of Palazzo Zanca with Design Builder, the building was divided into 8 blocks (named 1,2,4,5,6,10,11,12).

The size of the windows is not real but has been dimensioned according to the percentage of openings per square meter of wall surface.

The following image shows the Home screen of the software.

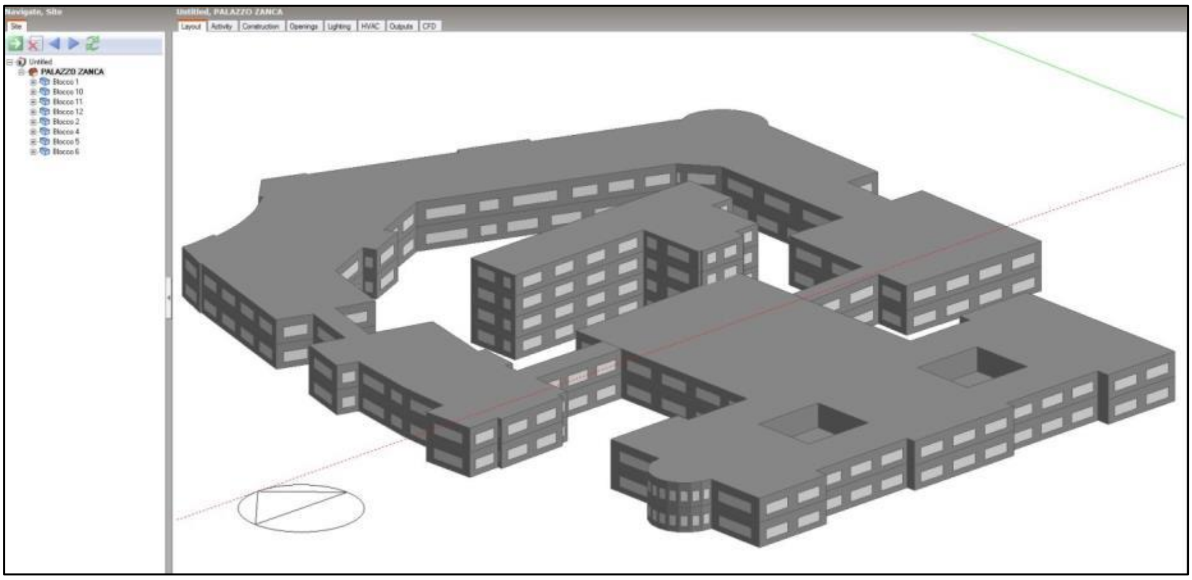


FIGURE 128 - HOME SCREEN OF THE SOFTWARE

The following figures show the floor plans of the blocks, as shown in the simulation software, that have been determined by different areas, depending on the intended use. Therefore different usage profiles were created.

For the Palazzo Zanca, historical building, there are: block 1 and block 4 at the ground floor; block 2 and block 6 at the first floor.

For the modern building, built in the seventies and placed in centre of the monumental excavations, there are: blocks 5,10,11,12.

Block 1 has:

- Zanca Office Typical
- Zanca Circulation
- Zanca Office Toilet
- Zanca Office Meeting room
- Office Tea

FIGURE 129 - PLAN OF BLOCK 1

Block 4 has:

- Zanca Office Typical
- Zanca Circulation
- Zanca Office Toilet

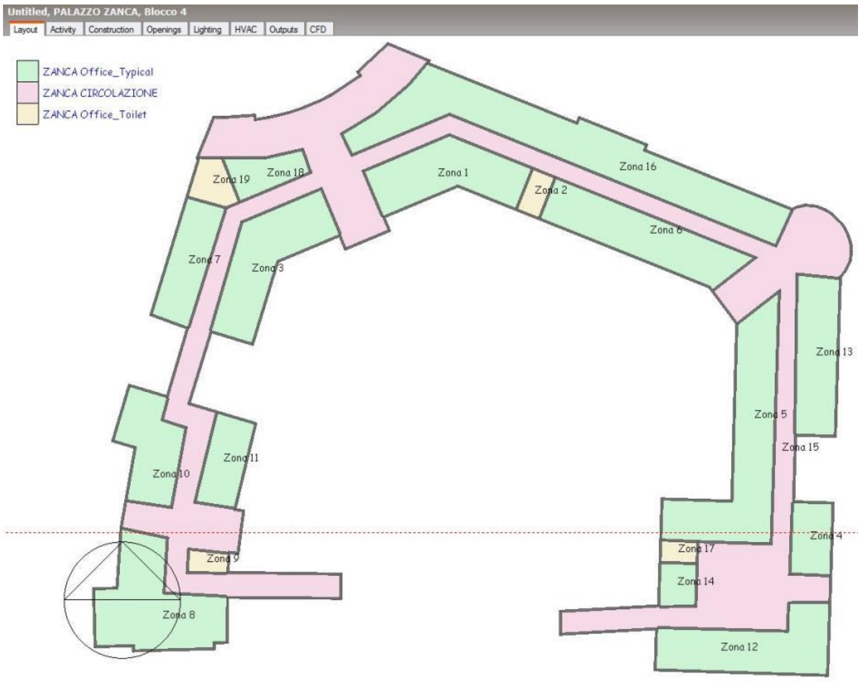


FIGURE 130 - PLAN OF BLOCK 4

Block 2 has:

- Zanca Office Typical
- Zanca Circulation
- Zanca Office Toilet

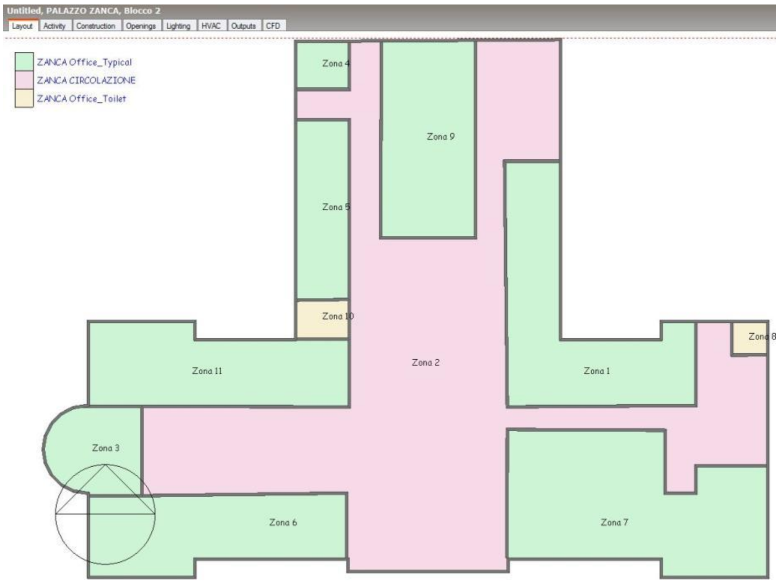


FIGURE 131 - PLAN OF BLOCK 2

Block 6 has:

- Zanca Office Typical
- Zanca Circulation
- Zanca Office Toilet

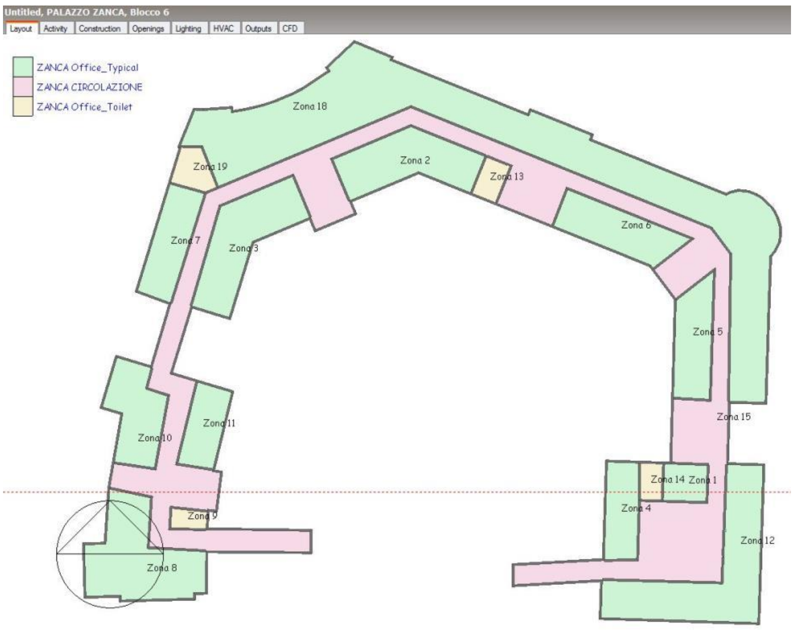


FIGURE 132 - PLAN OF BLOCK 6

Blocks 5, 10, 11, 12 have the same functional rooms in each floor:

- Zanca Office Typical
- Zanca Circulation
- Zanca Office Toilet

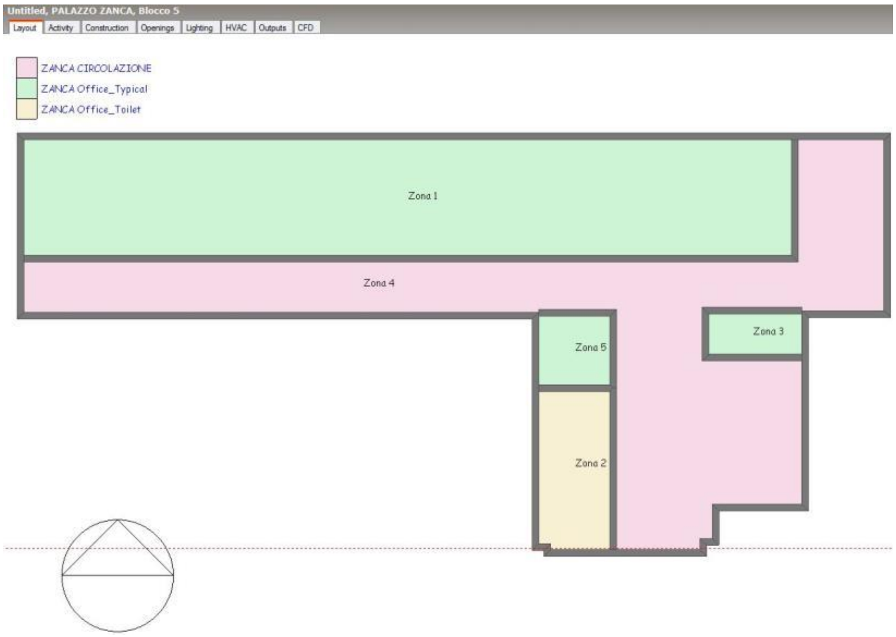


FIGURE 133 - PLAN OF BLOCK 5

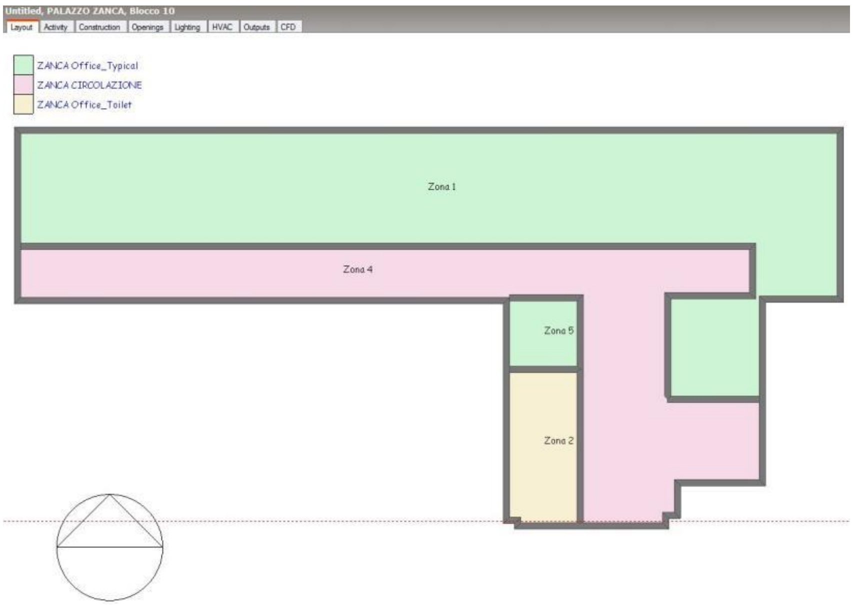


FIGURE 134- PLAN OF BLOCK 10

FIGURE 135 - PLAN OF BLOCK 11

FIGURE 136 - PLAN OF BLOCK 12

10. CURRENT BUILDING CONDITIONS

10.1. Constructive Building Characteristics

Palazzo Zanca respects the seismic regulations, which were written in the early twentieth century, after the earthquake of 1908, that destroyed completely the city of Messina. The building structure was built according to the "Hennebique" system in reinforced concrete (Portland cement), commonly used for the reconstruction of the city of Messina. The diameter of the "smooth irons" is 25 mm.

The pavilions 1, 2 and 5 are a continuous system of masonry in reinforced concrete (0,60-0,80 m), conversely, the pavilions 3 and 4 are a frame system (pillar 0,60 x 0,60 m) with bricks, as infill wall.

The external part of the envelope is in "fake stone", used mainly for decorations in "Liberty Style".

The following figure presents the site plan of the building.

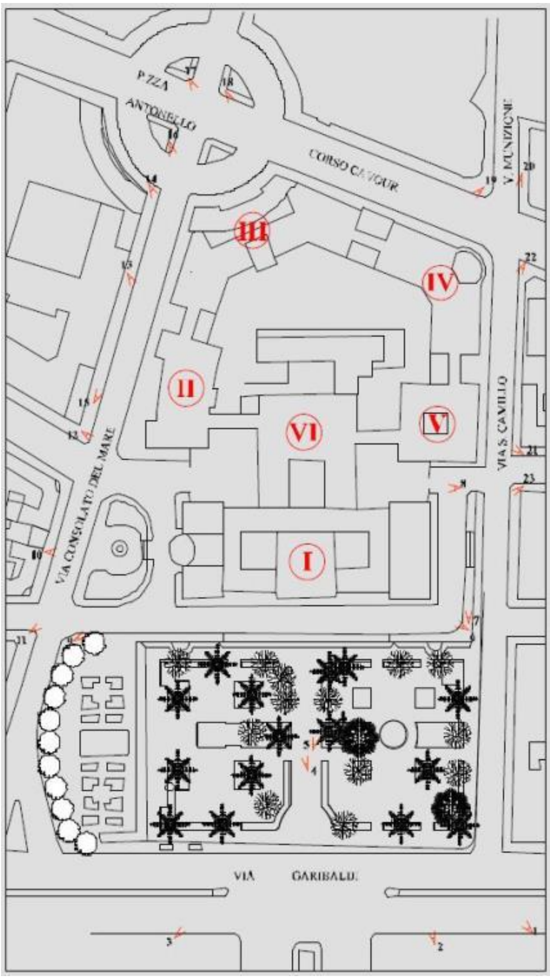


FIGURE 137 - SITE PLAN

On the ground floor there are the offices open to the public, the electoral offices and finally the municipal archives.

On the first floor are administrative functions of the city of Messina and the rooms of the Mayor and Municipal Council.

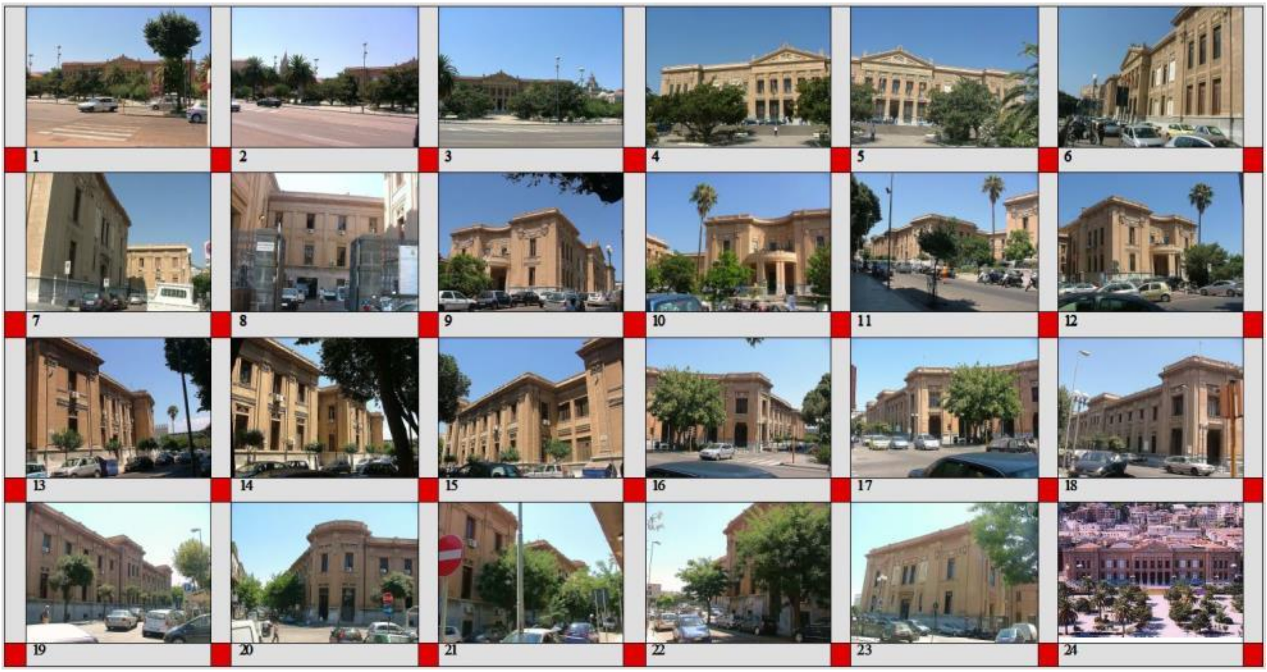


FIGURE 138 - OPTICAL CONES

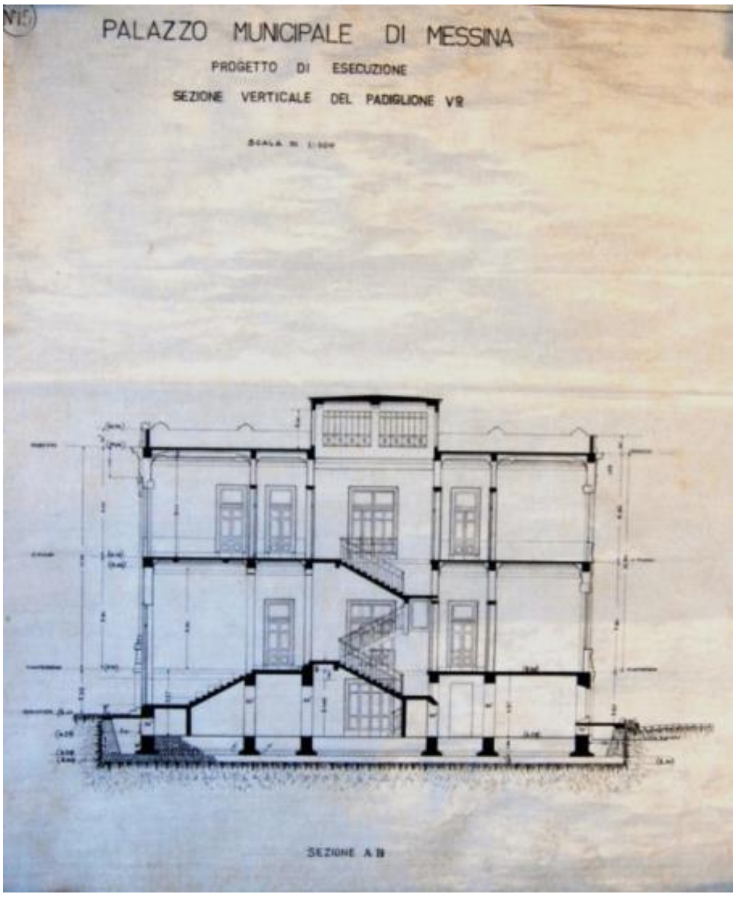


FIGURE 139 - ARCHITECTURAL SECTION OF PALAZZO ZANCA

The next figure shows the main facade orientation of the building, exposed to the North.

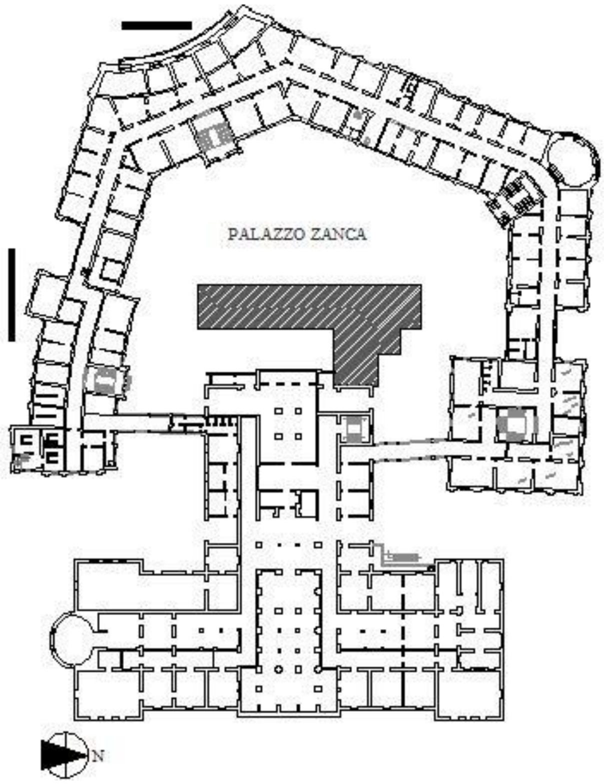


FIGURE 140 - ORIENTATION OF THE MAIN FAÇADE

10.1.1. Envelope Elements

The palace is a courtyard building, divided in five pavilions: in the main pavilion, T pavillon, the most important activities of the towns council takes place; in the pavillon 2, 3, 4, 5 other administrative functions are housed.

Antonio Zanca chose for his palace a Neo-Renaissance classic style , where ornaments, in fake stone, are tied to local traditions.

FIGURE 141 - FRONT OF PALAZZO ZANCA

In the figure above, the allegorical figures on the tympanum represent the Peloro's queen with two sirens (Comiso's stone); dolphins on the capitals represent the marine origin of the city ; allegories representing the prows of ships represent too the origin of the city (Comiso's stone).

The main façade is inspired by the Parthenon .

Directly on site were realized casts to build ornate, capitals, allegorical figures, shelves and frames.

FIGURE 142 - EXAMPLE OF PALAZZO ZANCA ORNATES

On the façade, sculptures can be seen linked to the symbolism of the city, and also many headstones that commemorate most important events. The elevation of Via San Camillo show two bas-reliefs depicting Dina and Clarenza, two female legendary characters in the history of Messina.

10.1.2. WINDOWS

All the windows have single glazing with wooden frames. The doors have the same characteristics of the windows with the exception of 3 doors on the ground floor, which are in glass and metal.

All the windows have simple shutters (Figure 32). Almost all rooms have opaque cloth curtains, dark in color.

FIGURE 143 - WINDOWS WITH SHUTTERS

The steady shading is ensured by other buildings in Via San Camillo and by the evergreen trees in Via Consolato del Mare.

The front façade facing European Union Square is not subject to any shading, as can be seen from the following figure.

FIGURE 144 - EUROPEAN UNION SQUARE

Windows of ground floor are the same of the first floor, with a fixed fanlight. The extra height is 60 cm (outer frame).

TABLE 33 - WINDOWS

FLOOR	WINDOW	NUMBER
FIRST	F9	*SEE DRAWING*
TOT. DIMENSION (sqcm)	HIGH h	width l
35,090	242	145
HEIGHT WOOD FRAME (HOR.)	*HEIGHT WOOD FRAME (VERT.)*	*THICKNESS FRAME*
12	8	5
Wood Area	*Single glass Area of 3 mm*	*% Glasses*
7,352	27,738	79.5%

FLOOR	WINDOW	NUMBER
FIRST	F9.1	*SEE DRAWING*
TOT. DIMENSION (sqcm)	HIGH h	width l
35,500	250	142

HEIGHT WOOD FRAME (HOR.)	*HEIGHT WOOD FRAME (VERT.)*	*THICKNESS FRAME*
18	18	5
Wood Area	*Single glass Area of 3 mm*	*% Glasses*
14,112	21,388	60.25%

FLOOR	**WINDOW**	**NUMBER**
FIRST	**F8**	*SEE DRAWING*
TOT. DIMENSION (sqcm)	HIGH h	width l
41,664	248	168
HEIGHT WOOD FRAME (HOR.)	*HEIGHT WOOD FRAME (VERT.)*	*THICKNESS FRAME*
18	18	5
Wood Area	*Single glass Area of 3 mm*	*% Glasses*
14,976	26,688	64.06%

FLOOR	**WINDOW**	**NUMBER**
FIRST	**F8.1**	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
72,416	248	292
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
18	18	5
Wood Area	Single glass Area of 3 mm	% Glasses
19,440	52,976	73.16%

FLOOR	**WINDOW**	**NUMBER**
FIRST	**F7**	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
60,021	247	243
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
18	18	5
Wood Area	Single glass Area of 3 mm	% Glasses
17,640	42,381	70.61%

FLOOR	**WINDOW**	**NUMBER**
FIRST	**F1**	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
31,200	240	130
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
12	15	5
Wood Area	Single glass Area of 3 mm	% Glasses
10,320	20,880	66.92%

FLOOR	WINDOW	NUMBER
FIRST	F1.1	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
38,100	300	127
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
12	15	5
Wood Area	Single glass Area of 3 mm	% Glasses
12,048	26,052	68.38%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair A (short)	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
20,000	250	80
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0
Area	Single glass Area of 3 mm	% Glasses
0	20,000	100.00%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair A (large)	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
35,000	250	140
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0
Area	Single glass Area of 3 mm	% Glasses
0	35,000	100.00%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair B (short)	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
31,000	250	124
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0
Area	Single glass Area of 3 mm	% Glasses
0	31,000	100.00%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair B (large)	SEE DRAWING

TOT. DIMENSION (sqcm)	HIGH h	width l
36,250	250	145
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0
Area	Single glass Area of 3 mm	% Glasses
0	36,250	100.00%

FLOOR	WINDOW	NUMBER
FIRST	F8.2	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
58,764	249	236
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
18	18	5
Wood Area	Single glass Area of 3 mm	% Glasses
17,460	41,304	70.29%

FLOOR	WINDOW	NUMBER
FIRST	Stair B top glass	13
TOT. DIMENSION (sqcm)	HIGH h	width l
22,400	140	160
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
12	12	5
Wood Area	Single glass Area of 3 mm	% Glasses
7,200	15,200	67.86%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair C (short)	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
217.5	375	0.58
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0
Area	Single glass Area of 3 mm	% Glasses
0	218	100.00%

FLOOR	WINDOW metal frame fixed 8 cm	NUMBER
FIRST	F stair C (large)	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
79,500	375	212
HEIGHT FRAME (HOR.)	HEIGHT FRAME (VERT.)	THICKNESS FRAME
0	0	0

Area	Single glass Area of 3 mm	% Glasses
0	79500	100,00%

FLOOR	WINDOW	NUMBER
FIRST	F1.2	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
43,250	250	173
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
18	18	5
Wood Area	Single glass Area of 3 mm	% Glasses
15,228	28,022	64.79%

FLOOR	WINDOW	NUMBER
FIRST	F10	SEE DRAWING
TOT. DIMENSION (sqcm)	HIGH h	width l
50,400	360	140
HEIGHT WOOD FRAME (HOR.)	HEIGHT WOOD FRAME (VERT.)	THICKNESS FRAME
12	15	5
Wood Area	Single glass Area of 3 mm	% Glasses
14,160	36,240	71.90%

FIGURE 145 - GROUND FLOOR PLANT OF WINDOWS

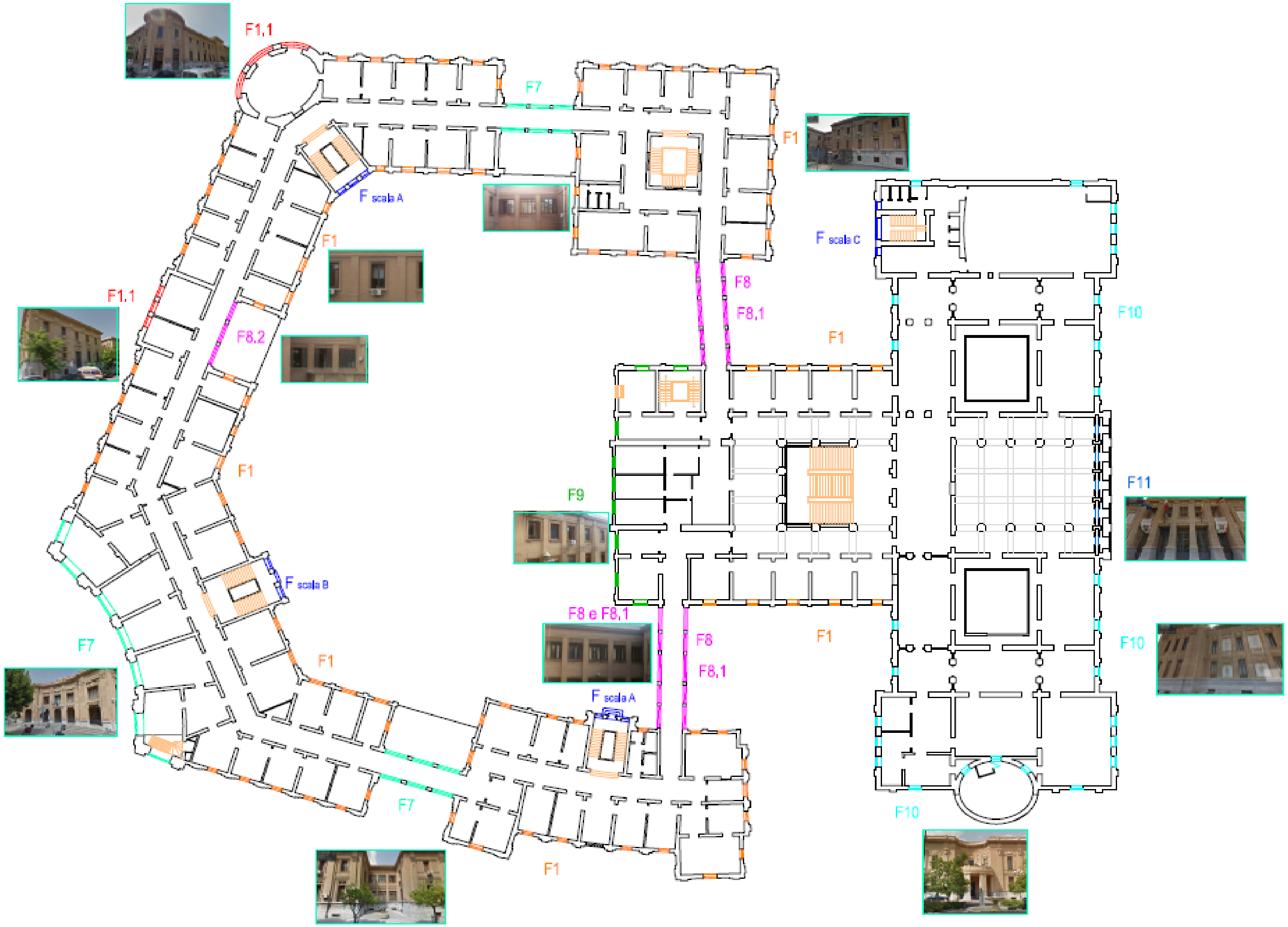


FIGURE 146 - FIRST FLOOR PLANT OF WINDOWS

10.1.3. Airflows And Pathologies

TABLE 34 - AIRFLOWS AND PATHOLOGIES

Detail	Alteration	Pathogen	Failure consequence
	1- Discolouration	At the expense of components of the material, the parameters that define the color.	Natural variation
	2- Crumbling	The natur is usually physical, suach as rising damp or crystallization of salts (thesis supported by the proximity to the coast)	Presence of cavities of variable size and shape, called alveoli, often interconnected and with non-uniform distribution
	3- Colonization biological	Poor site care	Presence detectable with evidence on the surfaces (algae, fungi, lichens, mosses, plants)
	4- Lack	The absence of human intervention	Loss of three-dimensional elements
	7- Anthropogenic deterioration	Inappropriate placement of cables, technological, lack of maintenance, inappropriate use of building materials.	Change of conservation state of property or of the context in which it is inserted.
	5- Formation of saline substances due water loss	Cohesion problems	Superficial formation crystalline or powdery or filamentous, usually whitish.
	11- Dietachent	Solution of continuity of material	Solution of continuity between layers of a plaster, both between themselves and with respect to the substrate, which preludes, in general, to the fall of the layers themselves.

 	*7- Anthropic decay*	*Vandalistic graffiti - Improper placement of technological elements*	*Change of conservation state of property of the context.*
	9- Stain	*Presence of particular natural material components (concentration of pyrite in the marble) and presence of foreign materials (water, oxidation products of metallic materials)*	*Color change on the surface.*
	*8- Gap*	*Loss of continuity of the surface.*	*Concrete cover spalling.*
	10- Pitting	Sometimes caused by microorganisms present in the stone that feed on carbon	Formation of blind hol
	12- Fracturing or cracking	Solution of continuity	Mutual displacement of parts
	13- corrosion of iron bars	Variazione delle condizioni igrometriche standard : (T ~25°C ; UR ~ 50%, ; Pres. ~ 1 bar)	Alteration of the colours, and the structural strength of the material, thickening of the surface and drilling of parts of the same. Rust.

A previous study analysed the envelope with thermal imaging with an external air temperature of about 17°C.

The following figure shows the general image of the thermal performance of the envelope: the walls present a good thermal performance.

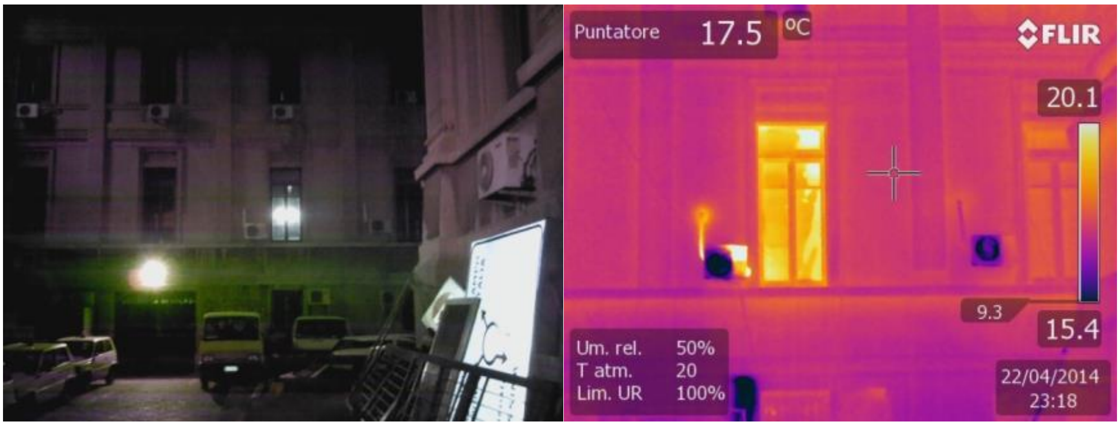


FIGURE 147 - THERMAL VIEW

The next figures show the thermal losses of the windows. The windows, with single glazing and wood frames, present insulation problems, aggravated by aging.

FIGURE 148 - THERMAL LOSSES IN THE WINDOWS AND WINDOW INVISIBLE TO THE NAKED EYE

The thermal losses due to thermal bridges in the corner of the room are also shown.

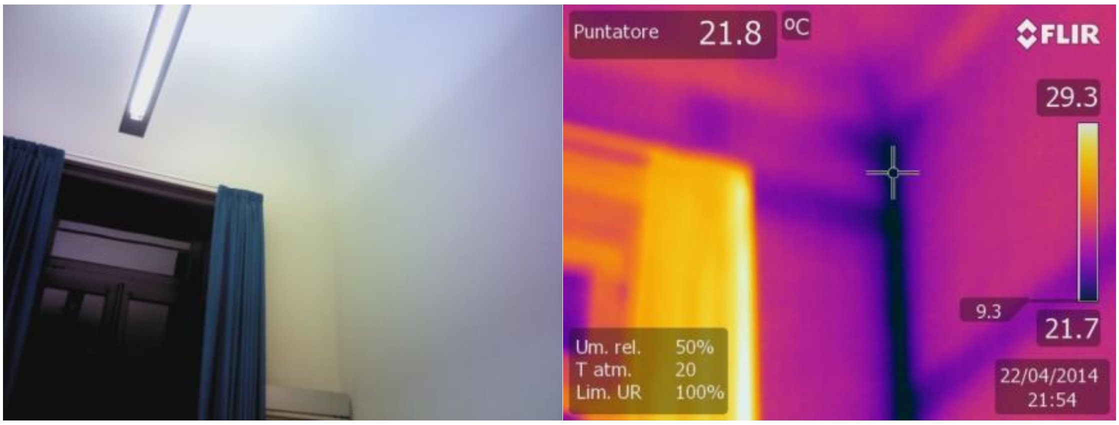


FIGURE 149 - THERMAL BRIDGES

Some characteristics of the building contribute to a bad thermal performance:

- The orientation is bad, requiring additional energy consumption with heating during the winter (mainly in the north areas) and with cooling during the summer (mainly in the west areas without any direct protection from the direct radiation).
- The walls with high thermal inertia and large ceiling height provide advantages during the summer, but disadvantages during winter, since the building does not have users in the night period and weekends which leads to a high temperature decrease.
- The windows have a low level of airtightness, enabling a high level of air infiltration, which is not controllable and undesirable, mainly during the winter.
- The doors are old and have a high thermal transmittance.
- The building presents many pathologies, such as condensation and mould growth.

10.2. Energy Systems

10.2.1. HVAC

The HVAC is ensured with several heat pumps, which have been installed gradually over the years. Therefore, there are several different types of equipment with different characteristics and performance. In total, there is at least one split in every room and the total number is summarized in the following table.

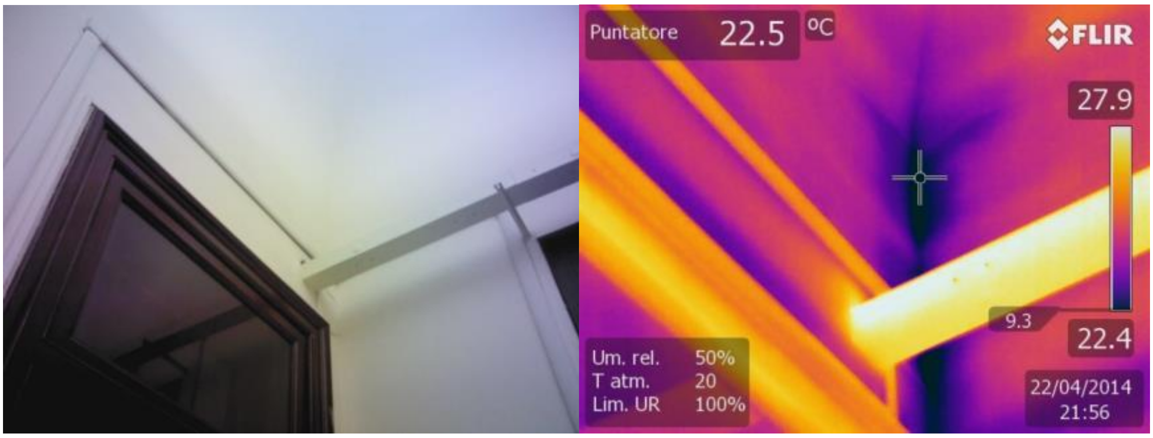


FIGURE 150 - THERMOGRAPHY OF AN AIR CONDITIONER ON

Almost all the areas of permanent use have HVAC, being the control ensured locally with individual control units. It is therefore an obsolete plant, splits have more than fifteen years now, and their efficiency is reduced.

TABLE 35 - HEAT PUMPS AND AHU CALCULATION

Heat Pumps and AHU calculation				
Type	***Thermal Power BTU/H***	***Reference Area***	***Number***	***TOT.***
Heat pump	9,000.00	Offices - first floor	42	378,000.00
Heat pump	12,000.00	Offices - first floor	26	312,000.00
AHU	24,000.00	Council locals	1	24,000.00
Heat pump	207,670.00	Local council/mayor/cabinet office/salon of the flags/bar/	includes many split	207,670.00
Heat pump	18,000.00	Offices first floor accounting - protocol	1	18,000.00
Heat pump	18,000.00	Offices first floor accounting - director	1	18,000.00
Heat pump	9,000.00	Offices ground floor	48	432,000.00
Heat pump	12,000.00	Offices ground floor	30	360,000.00
Heat pump	24,000.00	Offices URP ground floor	1	24,000.00
			BTU/hr	1,773,670.00
			KW thermal	519.83

The air circulation and renewal is ensured naturally through the doors and windows. There aren't systems of forced ventilation in rooms.

10.2.2. Lighting

In the building there are 2 different types of lamp: incandescent and fluorescent.

FIGURE 151 - LIGHTING IN ROOMS

FIGURE 152 - LIGHTING IN ALL AREAS

FIGURE 153 - LIGHTING IN CIRCULATION AREAS

There is no mechanism to control lighting and plants are dated. During close time only emergency lighting is on.

TABLE 36 - LAMPS CALCULATION

LAMPS CALCULATION				
Type	***Power (Watt)***	***Reference Area***	***Number***	***TOT.***
GROUND FLOOR				
Fluorescent 2x58	116.00	Offices ground floor	177	20,532.00
Fluorescent 2x36	72.00	Services and circulation ground floor	115	8,280.00
Fluorescent 1x54	54.00	All ground floor	280	15,120.00
Fluorescent 2x58	116.00	Offices CED	30	3,480.00
Fluorescent 2x58	116.00	Offices URP/Anagrafe	30	3,480.00
Fluorescent 2x36	72.00	Stairs and entrances ground floor	35	2,520.00
FIRST FLOOR				
Fluorescent 1x54	54.00	Rooms: administration. mayor. council. salons	526	28,400.00
Incandescence 1x150	150.00	Council room	84	12,600.00
Incandescence 1x60	60.00	Council room	39	2,340.00
Fluorescent 2x58	116.00	Offices - first floor	209	24,244.00
Fluorescent 2x36	72.00	Services and circulation first floor	80	5,760.00
WATT electrical				126,760.00

10.2.3. ICT

Most of the offices and rooms have computers and printers and there is a room with servers and an internal circuit of building for security.

There are photocopier machines. tv-screens. video projectors in some rooms and equipment for the exclusive use of the bar.

10.2.4. OTHERS

The building has 5 lifts. The usage rate of the lifts is high since they serve rooms with much public and employee attendance. but the contribution to total consumption is negligible.

Lifts and other small appliances connected to plugs such as individual electric heaters. vending machines. photocopier machines. computers and printers (when not connected to the UPSs). etc. were flagged as “other”.

For calculating the energy consumption usage profiles have been created directly through the Design Builder software for individual electric equipment.

10.3. Energy Consumption & Energy Generation

10.3.1. Electricity Consumption

The building receives electricity in Low Voltage. Following a summary table of power consumption.

TABLE 37 - ELECTRICITY CONSUMPTION

ELECTRICITY CONSUMPTION	kWh per year 2013	kWh per year 2012	kWh per year 2014
Zanca Palace			Survey performed on days in mid-June in 2014. Average consumption with average outdoor temperatures of 27 C during operation.
Via S. Camillo. 5 - Messina			
IT001E96237725	2,886 kWh	1,789 kWh	
Via S. Camillo. SN - Messina			
IT001E00239947	1,482,357 kWh	1,500,548 kWh	

There is not a central system for heating and cooling. but there are many emission systems (split). different in shape. performance. brand and model.
To set the calculation of the model the general information are:

TABLE 38 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	13,580.56
Principal Heating Source	District Heat

TABLE 39 - ENERGY USE INTENSITY - ELECTRICITY

	Electricty [MJ/m^2]
Interior Lighting	281.50
Space Heating	0.00
Space Cooling	0.00
Fans-Interior	0.00
Service Water Heating	0.00
Receptacle Equipment	86.51
Miscellaneous	0.00
Subtotal	368.01

TABLE 40 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/m2]	Natural Gas Intensity [kWh/m2]	Additional Fuel Intensity [kWh/m2]	District Cooling Intensity [kWh/m2]	District Heating Intensity [kWh/m2]	Water Intensity [m3/m2]
Lighting	78.19	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	92.38	19.89	0.00
Other	24.03	0.00	0.00	0.00	0.00	0.00
Total	102.23	0.00	0.00	92.38	19.89	0.00

TABLE 41 - END USE CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	270,143.40	0.00
Cooling	0.00	0.00	0.00	1,254,508.77	0.00	0.00
Interior Lighting	1,061,927.55	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	326,353.11	0.00	0.00	0.00	0.00	0.00
Total End Uses	1,388,280.66	0.00	0.00	1,254,508.77	270,143.40	0.00
Total	2,912,932.83					

TABLE 42 - END USE PERCENTAGE

	Percent [%]
Interior Lighting	36.46
Space Heating	9.27
Space Cooling	43.07
Fans-Interior	0.00
Service Water Heating	0.00
Receptacle Equipment	11.20
Miscellaneous	0.00

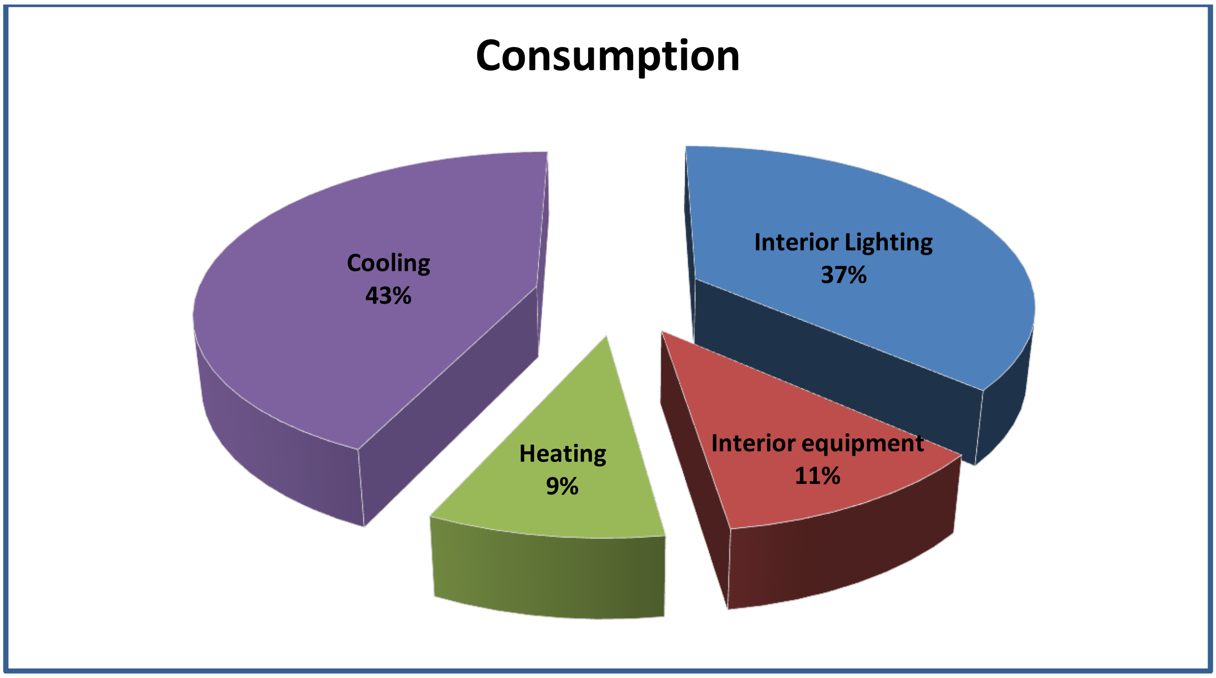


FIGURE 154 - DISAGGREGATION OF ELECTRICITY CONSUMPTION BETWEEN USES

The following figures show the heat balance of Palazzo Zanca. divided according to the contribution types:

- General Lighting.
- Computer + Equipment.
- Occupancy.
- Solar Gans Exterior Windows.
- Zone Sensible Heating.
- Zone Sensible Cooling.

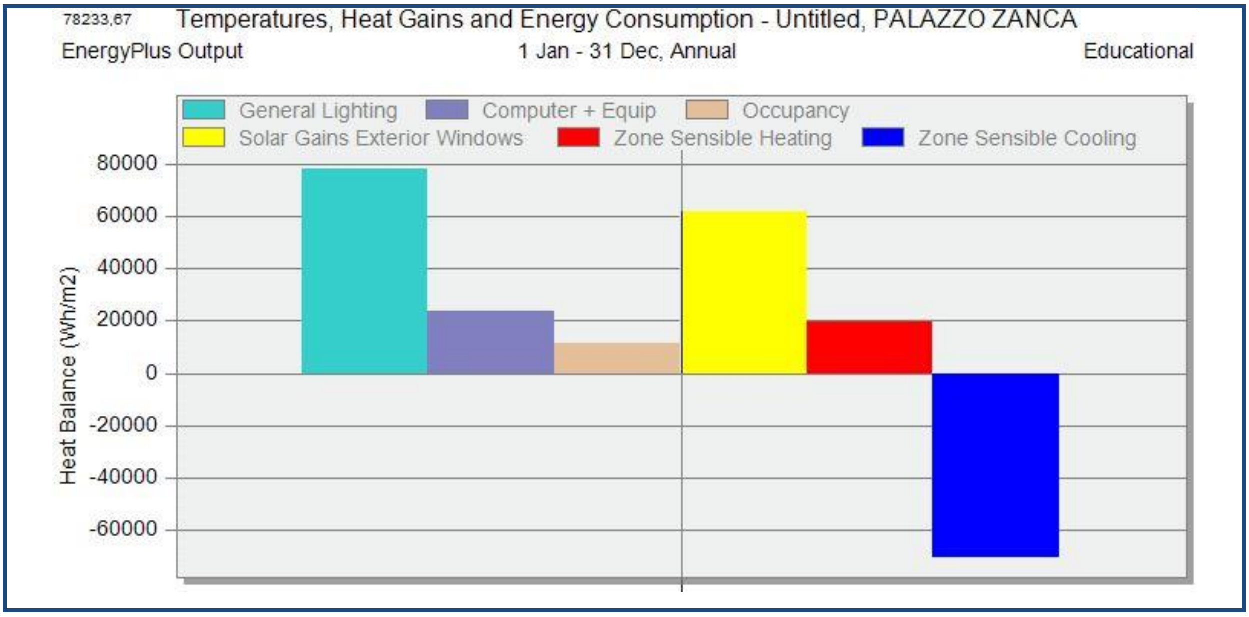


FIGURE 155 - ANNUAL HEAT BALANCE

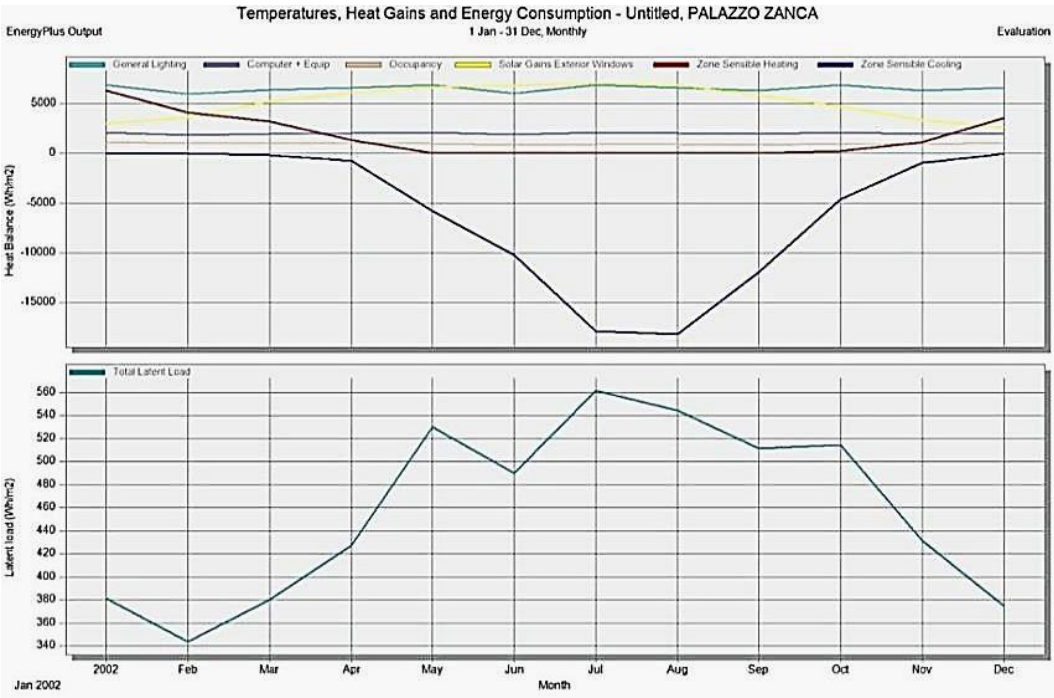


FIGURE 156 - ANNUAL HEAT BALANCE. ACCORDING OF SINGLE MONTHS

Two following figures show the monthly total fuel use of Palazzo Zanca. divided according to the contribution types:

- Room Electricity.
- Lighting.
- Auxiliary Energy.
- Heating (Electricity).
- Cooling (Electricity).

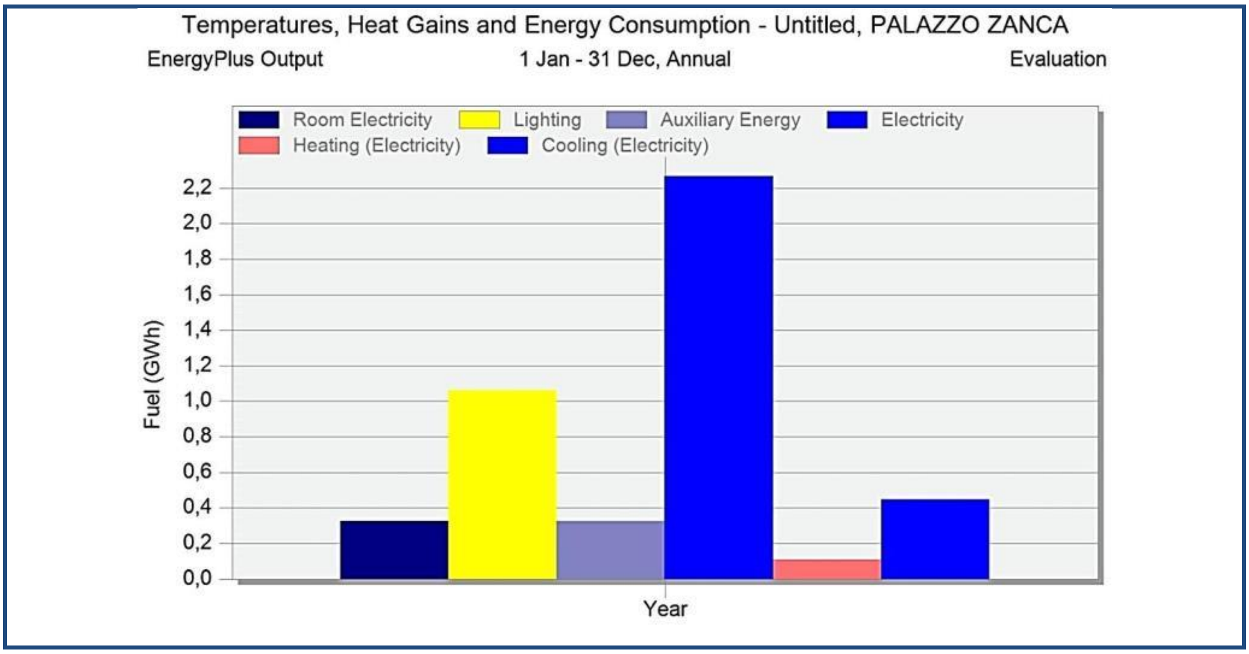


FIGURE 157 - ANNUAL USE OF FUEL TOTAL

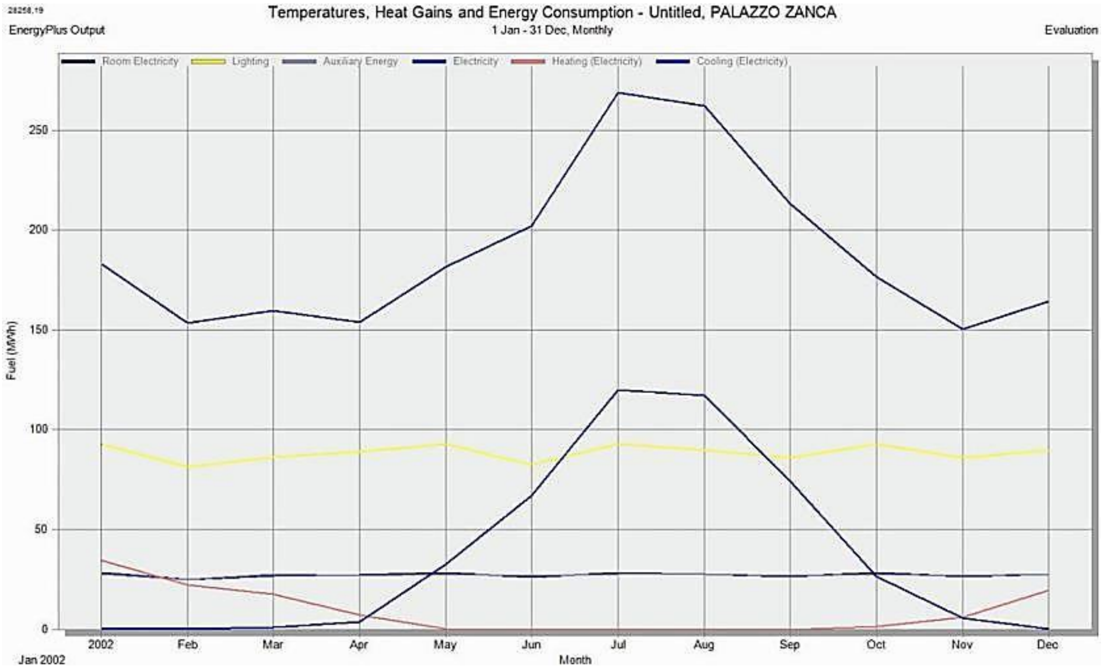


FIGURE 158 -MONTHLY USE OF FUEL TOTAL

The following figures show heat balance of Palazzo Zanca. divided according to the contribution types. during four months in particular January. April. July and September:

- General Lighting.
- Computer + Equipment.
- Occupancy.
- Solar Gans Exterior Windows.
- Zone Sensible Heating.
- Zone Sensible Cooling.

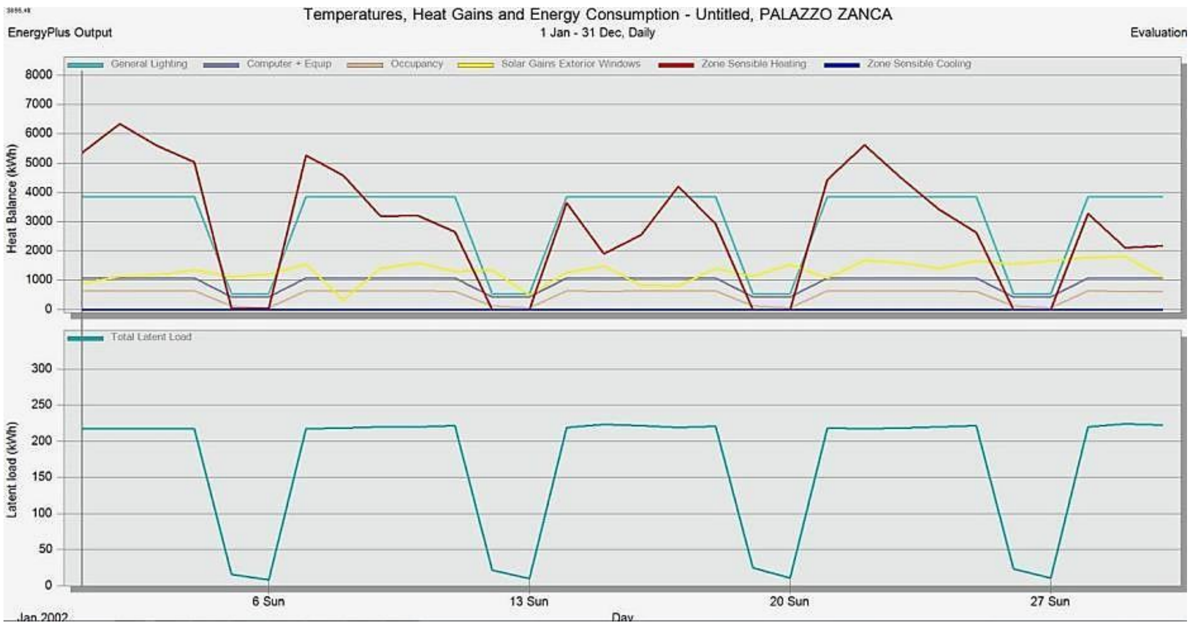


FIGURE 159 - HEAT BALANCE DURING JANUARY

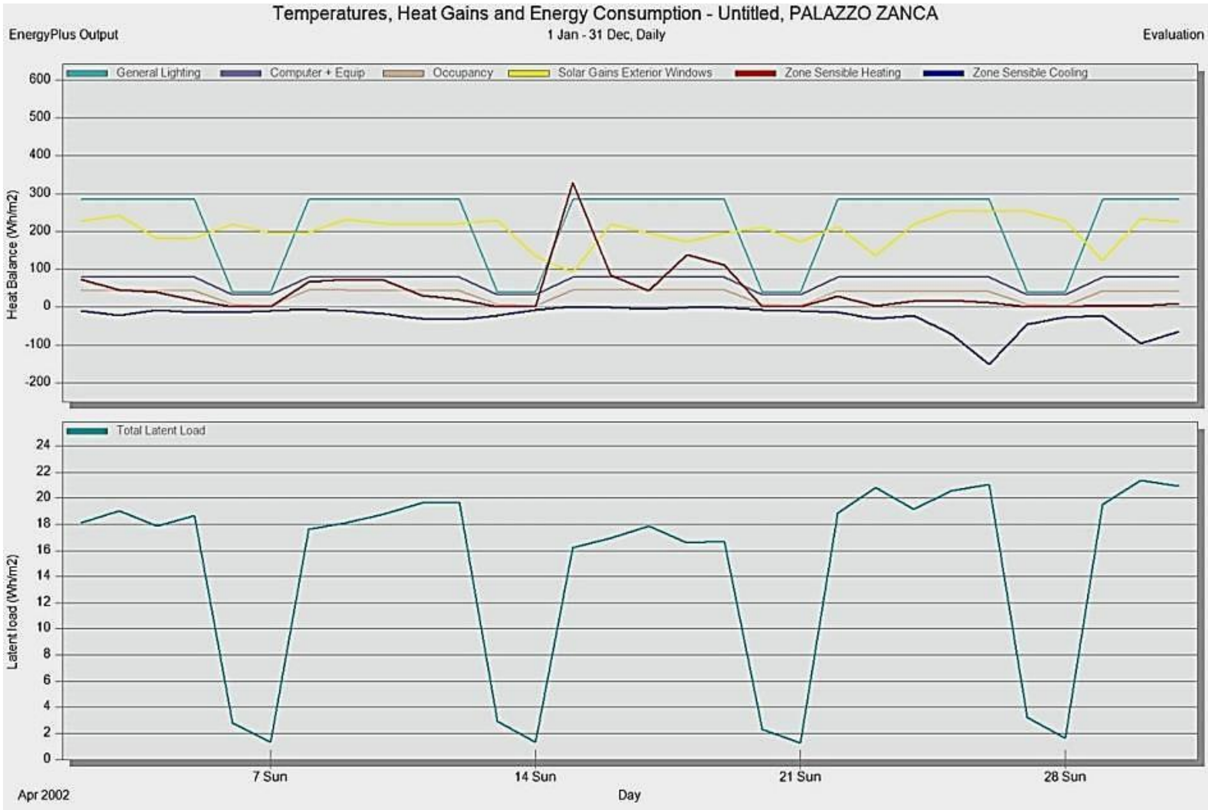


FIGURE 160 - HEAT BALANCE DURING APRIL

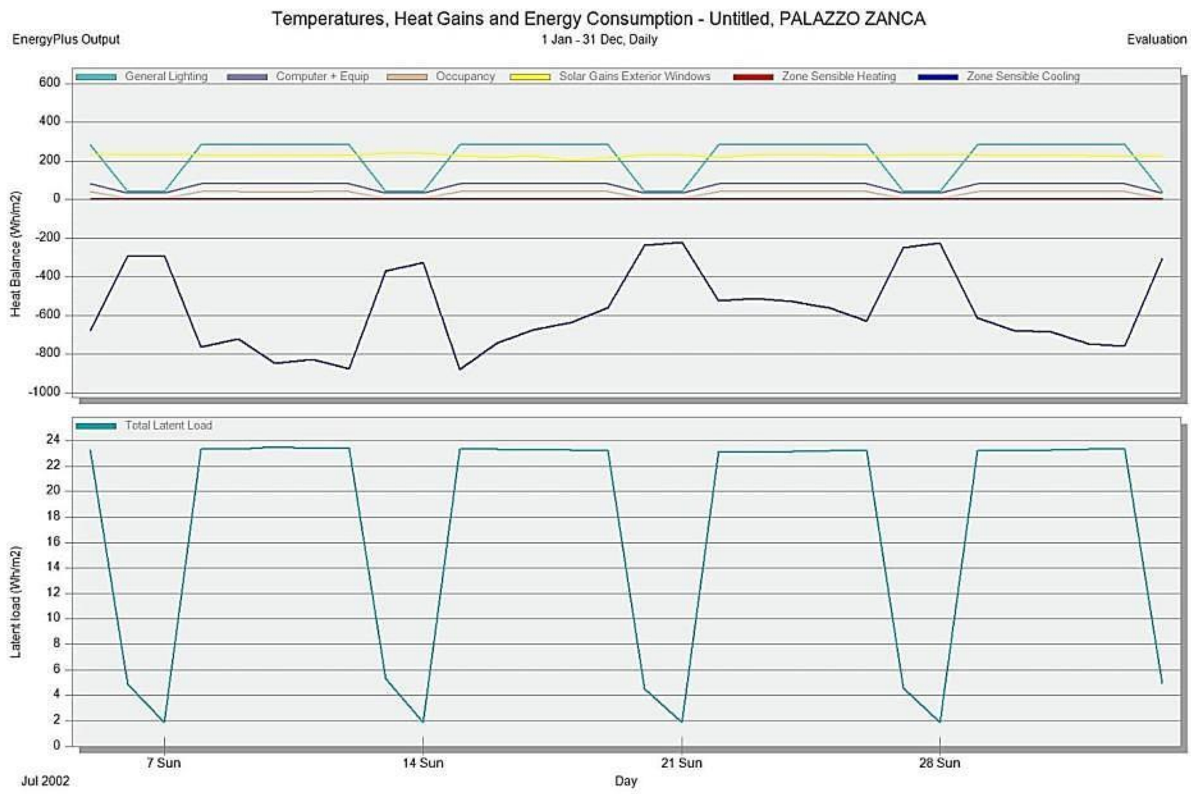


FIGURE 161 - HEAT BALANCE DURING JULY

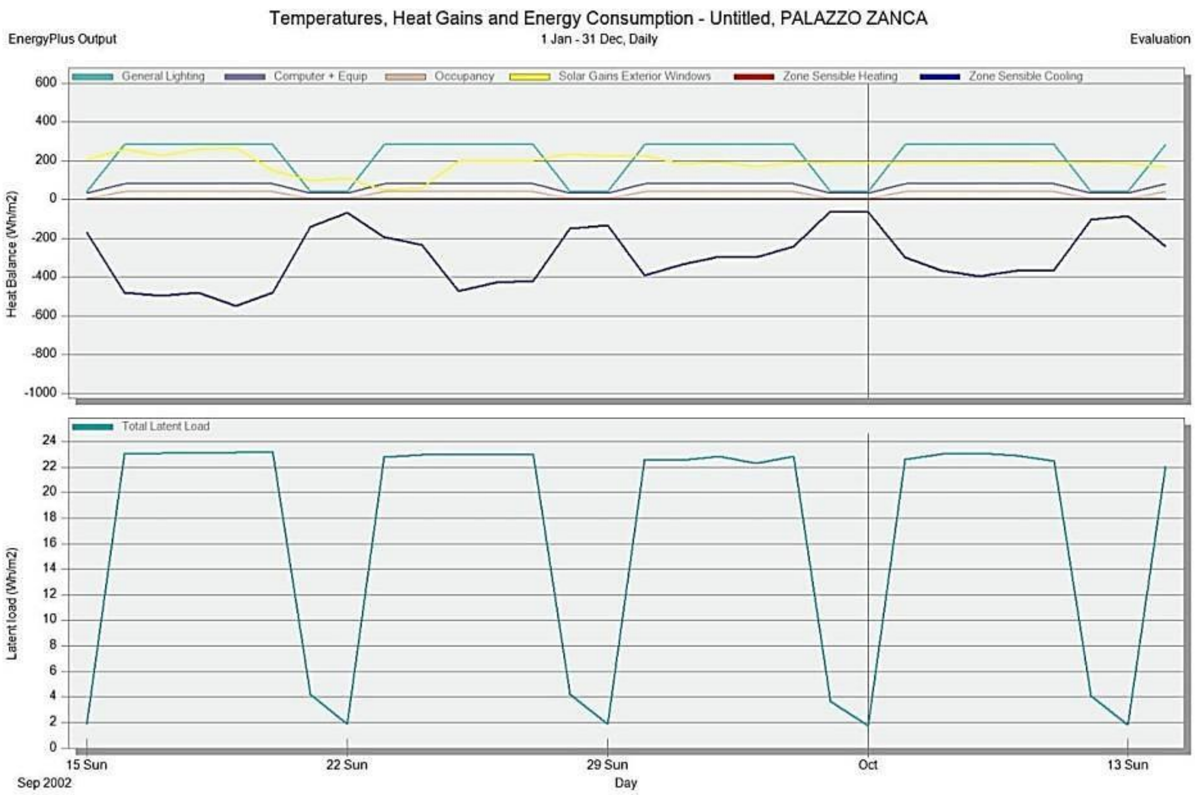


FIGURE 162 - HEAT BALANCE DURING SEPTEMBER

10.3.2. Gas/Oil Consumption

The building does not have any gas consumption.

10.3.3. Renewable Energy Sources

The building does not have any RES plant.

10.3.4. Other Generation

Other data that influence thermal balance come from building envelope.

Considered data are:

- Glazing
- Walls
- Ceilings (internal)
- Floors (internal)
- Ground floors
- Partitions (internal)

- Roofs
- Floors (external)
- External infiltration
- External ventilation

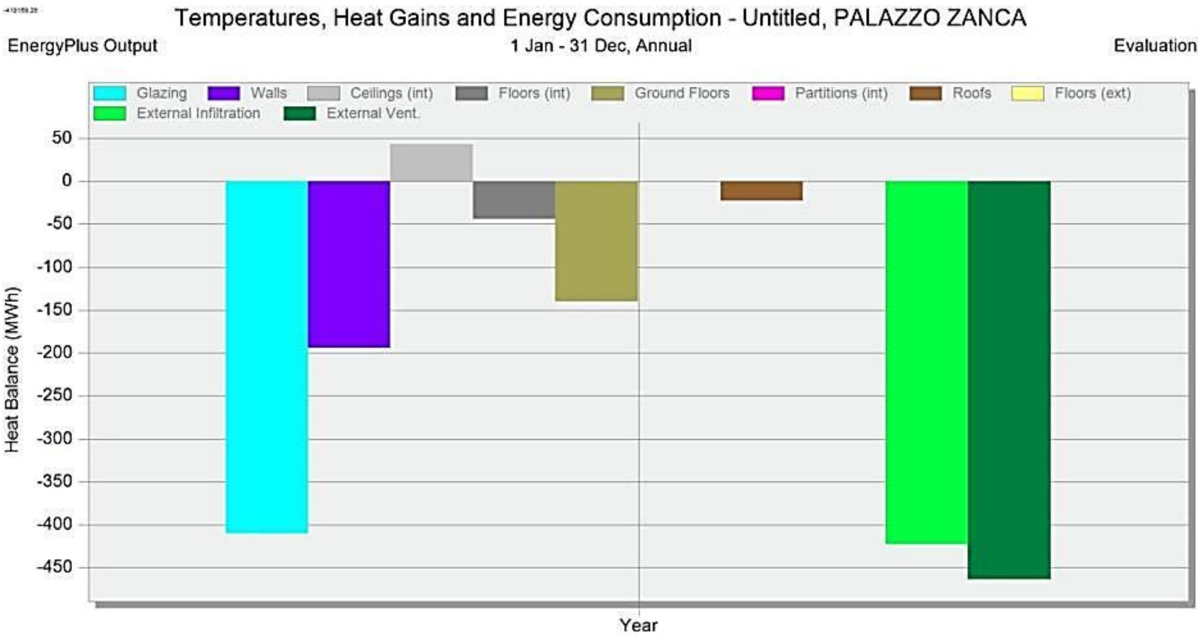


FIGURE 163 - ANNUAL HEAT BALANCE (FABRIC AND VENTILATION)

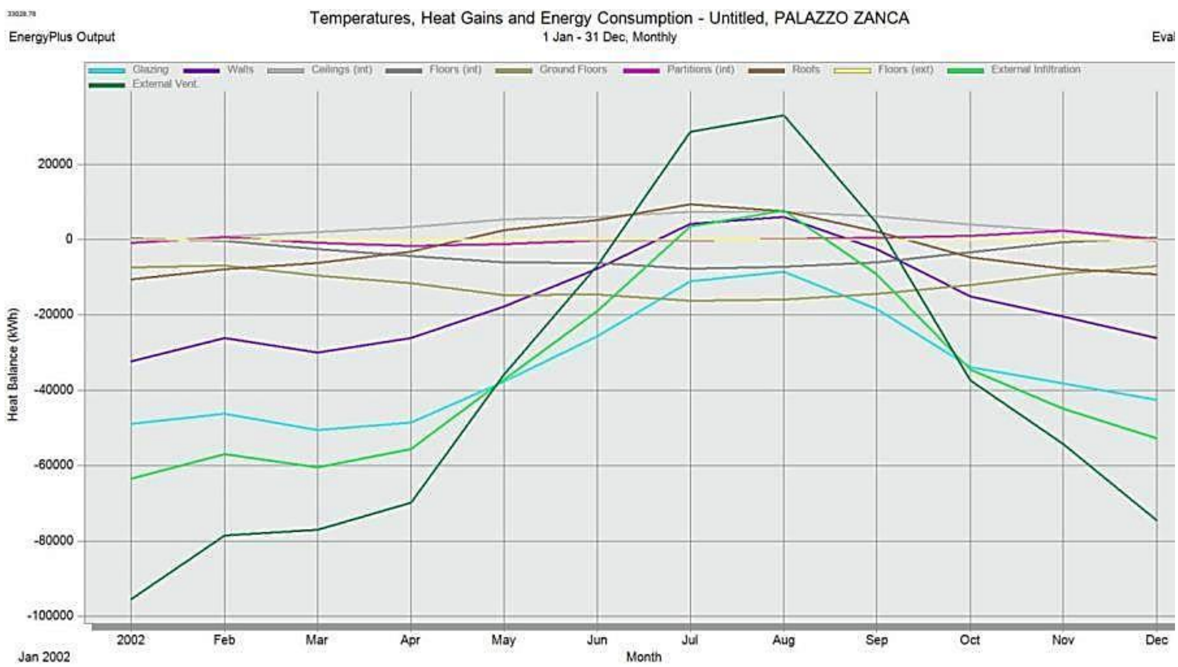


FIGURE 164 - ANNUAL HEAT BALANCE (FABRIC AND VENTILATION). ACCORDING OF SINGLE MONTHS

The following figures shows heat balance (fabric and ventilation) of Palazzo Zanca. divided according to the contribution types. during four months in particular January. April. July and September.

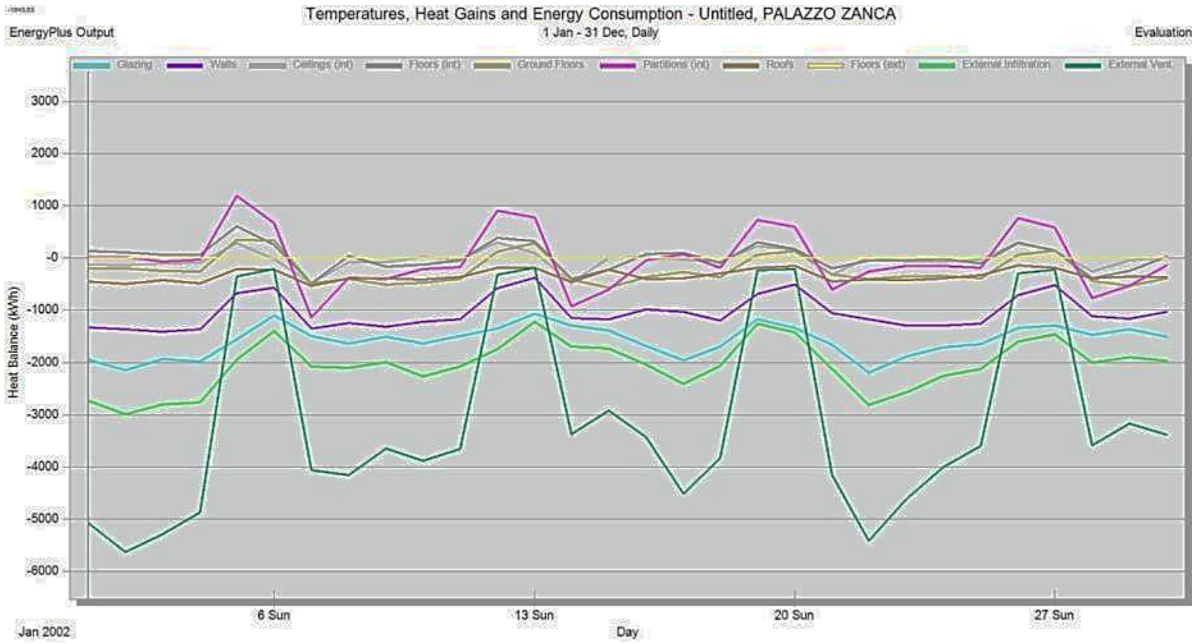


FIGURE 165 - HEAT BALANCE DURING JANUARY (FABRIC AND VENTILATION)

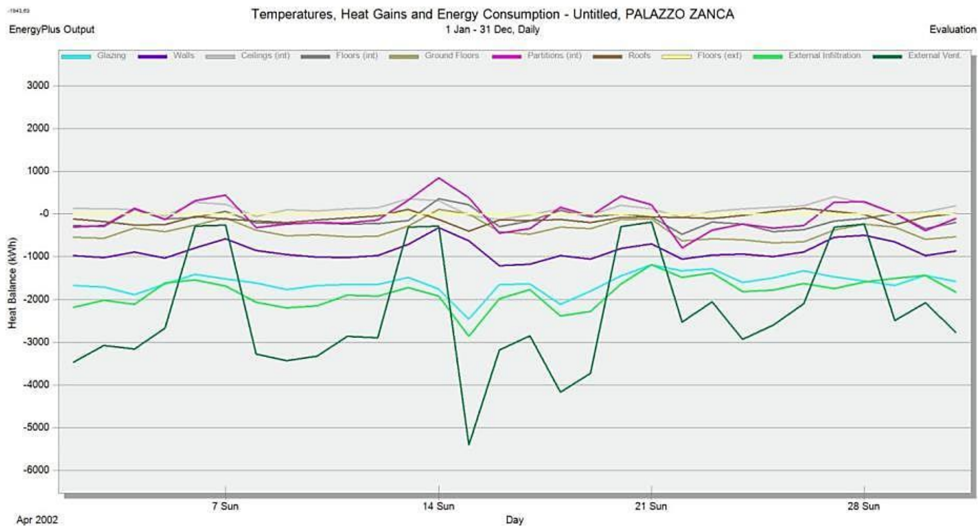


FIGURE 166 - HEAT BALANCE DURING APRIL (FABRIC AND VENTILATION)

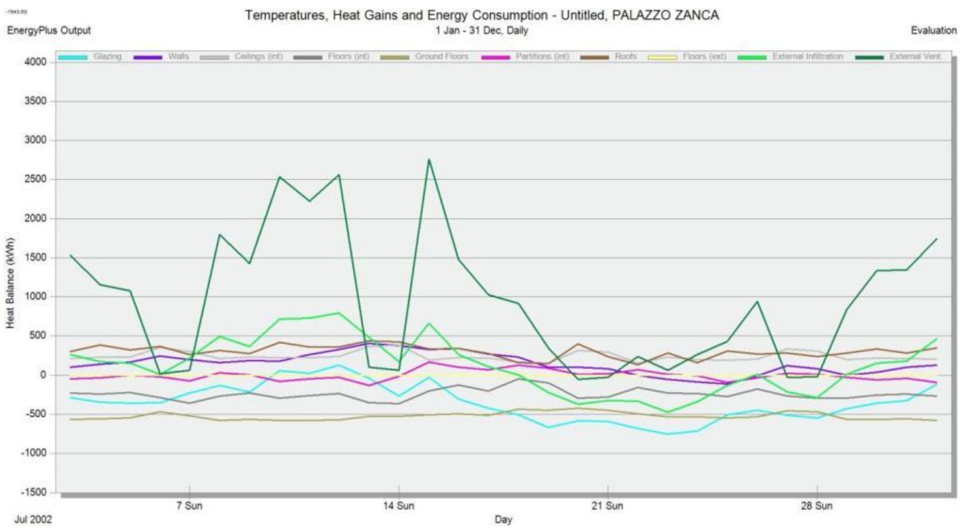


FIGURE 167 - HEAT BALANCE DURING JULY (FABRIC AND VENTILATION)

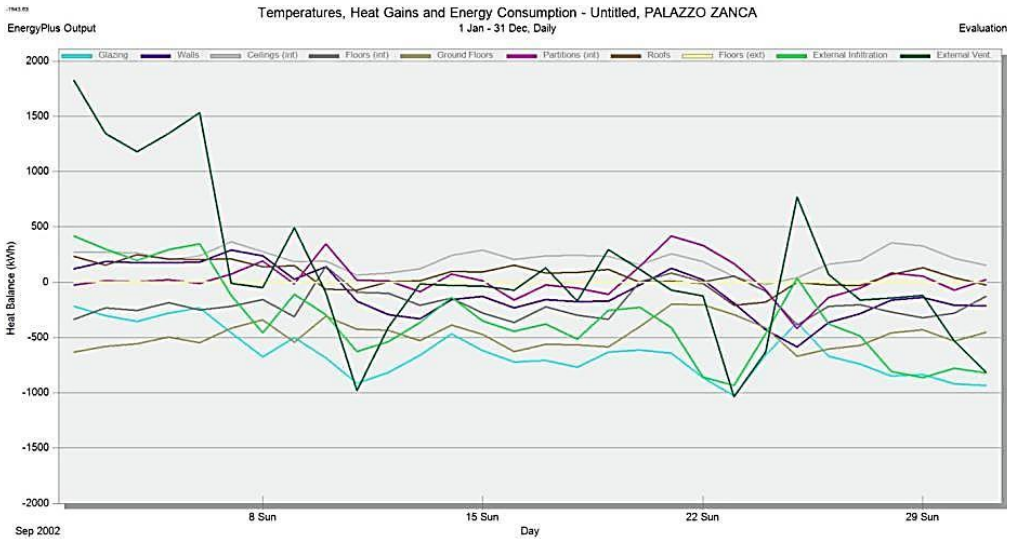


FIGURE 168 - HEAT BALANCE DURING SEPTEMBER (FABRIC AND VENTILATION)

10.3.5. Final Energy Consumption And CO_2 Emissions

In this building only electricity is consumed. as depicted in the following table.

TABLE 43 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/m2]	Natural Gas Intensity [kWh/m2]	Additional Fuel Intensity [kWh/m2]	District Cooling Intensity [kWh/m2]	District Heating Intensity [kWh/m2]	Water Intensity [m3/m2]
Lighting	78.19	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	92.38	19.89	0.00
Other	24.03	0.00	0.00	0.00	0.00	0.00
Total	102.23	0.00	0.00	92.38	19.89	0.00

TABLE 44 - END USE CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	**270,143.40**	0.00
Cooling	0.00	0.00	0.00	**1,254,508.77**	0.00	0.00
Interior Lighting	**1,061,927.55**	0.00	0.00	0.00	0.00	0.00
Interior Equipment	**326,353.11**	0.00	0.00	0.00	0.00	0.00
Total End Uses	**1,388,280.66**	0.00	0.00	**1,254,508.77**	**270,143.40**	0.00
Total	**2,912,932.83**					

Simulation data shows that the building has electricity consumption of 2,912,932.83 kWh and below percentages are summarized percentages of individual consumption.

TABLE 45 - END USE PERCENTAGE

	Percent [%]
Interior Lighting	**36.46**
Space Heating	**9.27**
Space Cooling	**43.07**
Receptacle Equipment	**11.20**

The last Table presents the main energy parameters of the building which were considered as baseline. Such parameters were assessed considering the following conversion factors:

- electricity to primary energy - 2.174 (standard value approved for Italy);
- electricity to CO_2 emissions - 510.00 g/kWh (average emissions associated with the electricity consumed in Italy during 2012 according ENEL environmental report 2012);

11. RENOVATION SCHEME

11.1. AIM OF THE RENOVATION PLAN

In Italy, the NZEBs (nearly zero energy buildings) don't meet national specific legislation but this is now being defined, according to Directive 2012/27/UE. NZEB design is aimed at achieving high performance standards in terms of energy and environment.

Specific attention should be devoted to the reduction of energy consumption of the building. Guiding the design on three key areas:

- Maximizing the building envelope passive behaviour
- Use high efficiency systems

- Use of systems for the renewable thermal energy exploitation and photovoltaic systems for the electricity production from solar sources.

The aim is to minimize energy contribution from the external electricity grid. The objective of the renovation plan is to achieve an average primary energy reduction between 75% and 80% of the current demand and to ensure that between 50% and 90% of the consumed energy is generated on site.

A building envelope is called passive if it is conformant to the following values:

- Thermal transmittance very low (0.0167/0.227 W/m^{2}K)
- Low values of attenuation factor (<0.1). resulting in high phase shift values (>11.5 hours)
- Windows with transmittance less than 1.6 W/m^{2}K
- System efficiency that can reduce by 70% the maximum solar radiation on transparent surfaces.

To achieve these aims some difficulties or constraints should be considered in the implementation.

The following global constraints were taken into account in the design of the renovation plan:

- Since the building is inscribed on the List of building constrained by the Superintendence of Cultural Heritage. Several strong restrictions are applied in the renovation of such building due to the protection rules. Since it is not possible to implement any change in the building envelope able to cause any visual impact or modify historical integrity of the building. Therefore. The renovation option with a high visual impact is not possible.
- The buildings have an intensive utilization. Receiving a large number of visitors and are the working place for a large number of Municipal employees. Such activities cannot be interrupted since it is not easy to temporarily move the services to another building. Therefore, renovation options requiring major construction works need a plan that takes into account the needs of workers and visitors.

Planned integrations modify the architecture of the building, but without changing the functions. Being a historical building it was quite complicated inserting renewable sources and determining appropriate space to allocate them. An intervention difficult to predict was that related to the new air conditioning system.

The assumptions for improvement have been inserted using the Design Builder software that simulates with Energy Plus Databases. For Zanca Palace, considering the environmental conditions of Messina, greater consumption is by the use of electricity for cooling in the summer period, therefore it was decided to insert solutions also covering a constant ventilation of the building.

11.2. Energy Demand Reduction

11.2.1. Opaque Envelope

An important task in the renewal plan is targeted to the building envelope. Among the actions planned, there is the facades renovation. it is planned to ensure the safety of unsafe parts (eg unsafe cornice) and, where necessary, make injections with binding materials. Another change concerns the reconstruction of the plaster of the facades, using a thermal insulation plaster. UNI EN 998-1 “Mortars for internal and external” defines insulating plaster as “a mortar with guaranteed performance with specific insulating properties”. According to UNI EN 998-1 mortar must ensure thermal values of l (thermal conductivity) of less than 0.1 W/mK, then with high insulating performance. There are plasters with better performance but with the same texture and the same color of plaster used previously.

Obviously, it is expected to remove from prospects all present compressors and restore the facades in its entirety. Envelope treated with these plasters improves their transmittance value.

Among other interventions there is the waterproofing of the roof, by a fibre-reinforced bituminous membrane under the floor

Detail	Alteration	Pathogen	Failure consequence	Solution
	*1- Discolouration*	*At the expense of components of the material. the parameters that define the color.*	*Natural variation*	*Cleaning with water spray: is a spray low pressure water spray at room temperature by means of hydraulic spray nozzles.whose effectiveness is due to the ability of small particles of water to penetrate the surface deposits. for this reason should be carefully assessed the distance between the nozzle and the surface to be cleaned.*
	2- Crumbling	*The natur is usually physical. suach as rising damp or crystallization of salts (thesis supported by the proximity to the coast)*	*Presence of cavities of variable size and shape. called alveoli. often interconnected and with non-uniform distribution*	*1. On the surface is applied by brush a biocidal product and is removed with a soft bristle brush and with the aid of a scalpel* *2. Cleaning the surface deposit. with application of gel supporting tablets soaked in organic solvents and / or of a saturated solution of ammonium carbonate* *3. Removal of defective grout. performed during previous interventions. which have lost their conservative function* *4. Grouting of injuries. fractures. lacks to be made with the application of mortar made of hydraulic lime and aggregates suitable for color and grain size* *5. Surface protection to be made with polysiloxane applied by spray or brush.*
	*3- Colonization biological*	*Poor site care*	*Presence detectable with evidence on the surfaces (algae. fungi. lichens. mosses. plants)*	*Extirpation braking: extirpation mechanics that does not alter the materials from which mansory; all species tree and herbaceous plants will be uprooted in the winter.* *Chemical weeding: is the operation of the control and elimination of natural vegetation that should be conducted with great care by using chemicals to complete extirpation of mechanical intervention.*

	4- Lack	*The absence of human intervention*	*Loss of three-dimensional elements*	*Integration of concrete respecting the existing masonry, always taking care to highlight the new integration than the existing material, form, colour or application technique.*
	7- Anthropogenic deterioration	*Inappropriate placement of cables. technological. lack of maintenance. inappropriate use of building materials.*	*Change of conservation state of property or of the context in which it is inserted.*	*- Deleting previous intervention.* *- Cleaning with spray of water at low pressure.* *- Reinstatement according to the type of degradation*
	*5- Formation of saline substances due water loss*	*Cohesion problems*	*Superficial formation crystalline or powdery or filamentous. usually whitish.*	*Cleaning with water spray - Are used ion exchange resins to maintain the washing water continuously deionized and therefore with greater solvent power. The project, aimed at the elimination of salts. is believed to be managed with the achievement of the neutral pH.*
	11- Dietachent	*Solution of continuity of material*	*Solution of continuity between layers of a plaster. both between themselves and with respect to the substrate. which preludes. in general. to the fall of the layers themselves.*	*Scraping with soft brushes, degraded surface layer, limiting it to those parts detached or flaking, avoiding nicking less superficial layers of plaster. The parts of plaster possibly very degraded, now damaged seriously, will be removed also only superficially. Consolidating, by impregnating the structural basis of ethyl silicate.* *Application can be done or by brush or spraying. product is passed repeatedly until saturation and excess will be removed with washes at the base of dolituion solvent.*

 	*7- Anthropic decay*	*Vandalistic graffiti - Improper placement of technological elements*	*Change of conservation state of property of the context.*	
	9- Stain	*Presence of particular natural material components (concentration of pyrite in the marble) and presence of foreign materials (water. oxidation products of metallic materials)*	*Color change on the surface.*	*Cleaning with gel. to be chosen according to the type of material to be treated and the type of paint or ink to remove; can be applied directly on graffiti by spray or by brush.*
	*8- Gap*	*Loss of continuity of the surface.*	*Concrete cover spalling.*	*Cleaning of irons, their coating and finally rebuild missing parts.*
	10- Pitting	*Sometimes caused by microorganisms present in the stone that feed on carbon*	Formation of blind hol	*A preventive treatment with HNO3 ~ 10% produces a passive layer. Pitting resistance. Defusing of pitting: intervention of foreign ions and repassivation of the surface.*
	12- Fracturing or cracking	Solution of continuity	Mutual displacement of parts	*Plastering with lime mortar doped epoxy. Superficially making a seal using lime mortar free from soluble salts possibly loaded with acrylic resin. For the exterior finish is used as aggregate, powder made from the same material that you have to fill. It is good that the intervention of grouting includes both filling the gaps of greater extent both the slots of smaller dimensions, as it may facilitate the penetration of water.*

	13- corrosion of iron bars	*Variation of conditions humidity standards: (T ~25°C ; UR ~ 50%. ; Pres. ~ 1 bar)*	Alteration of the colours, and the structural strength of the material, thickening of the surface and drilling of parts of the same. Rust.	*Cleaning of the irons, their coating and finally rebuild missing parts.* *The removal of oxides from rusted iron is very important, and can be done by sandblasting or by careful brushing irons leading them to the white metal. Once cleaned up the iron, you can proceed to the application of protective products. This is typically slurries passivating applicable brush.*

11.2.2. Openings

At present, all windows are in single glass with hardwood frames. It is expected that all windows of Zanca Palace will be replaced, inserting selective glasses and modifying wood frames.

It is also important to study new forms of glass to optimize reflective surface.

FIGURE 169 - ACTUAL REFLECTIVE SURFACE

FIGURE 170 -ACTUAL WINDOW

FIGURE 171 - ACTUAL WINDOW AT FIRST FLOOR

FIGURE 172 - SKYLIGHT IN LATERAL STAIRWELL

FIGURE 173 - SKYLIGHT IN THE STAIRWELL CENTRAL

FIGURE 174 - ENTRANCE DOOR

For the frames there are tree hypotheses:

1- Choosing frames with a thermal break and clothing them with a layer made from old frame, in this case the U-value of the frame (U_f) is significantly improved.

FIGURE 175 - FIRST HYPOTHESIS OF CHANGE OF WINDOWS FRAME

2 - Restoring the old window frames by specialized workers and appropriate technologies, but in this case U-values of the frames (U_f) remain the same.

FIGURE 176 - ACTUAL WINDOWS FRAME

3 - Using windows with Corten steel frames, also used for historic buildings in Venice. Glasses are selective double glazing with air chamber 6/13 mm.

FIGURE 177 - EXAMPLE OF CORTEN STEEL WINDOWS IN HISTORICAL BUILDING

Hypothesis 3 has been chosen for the simulation that provides for total replacement of the old frames.

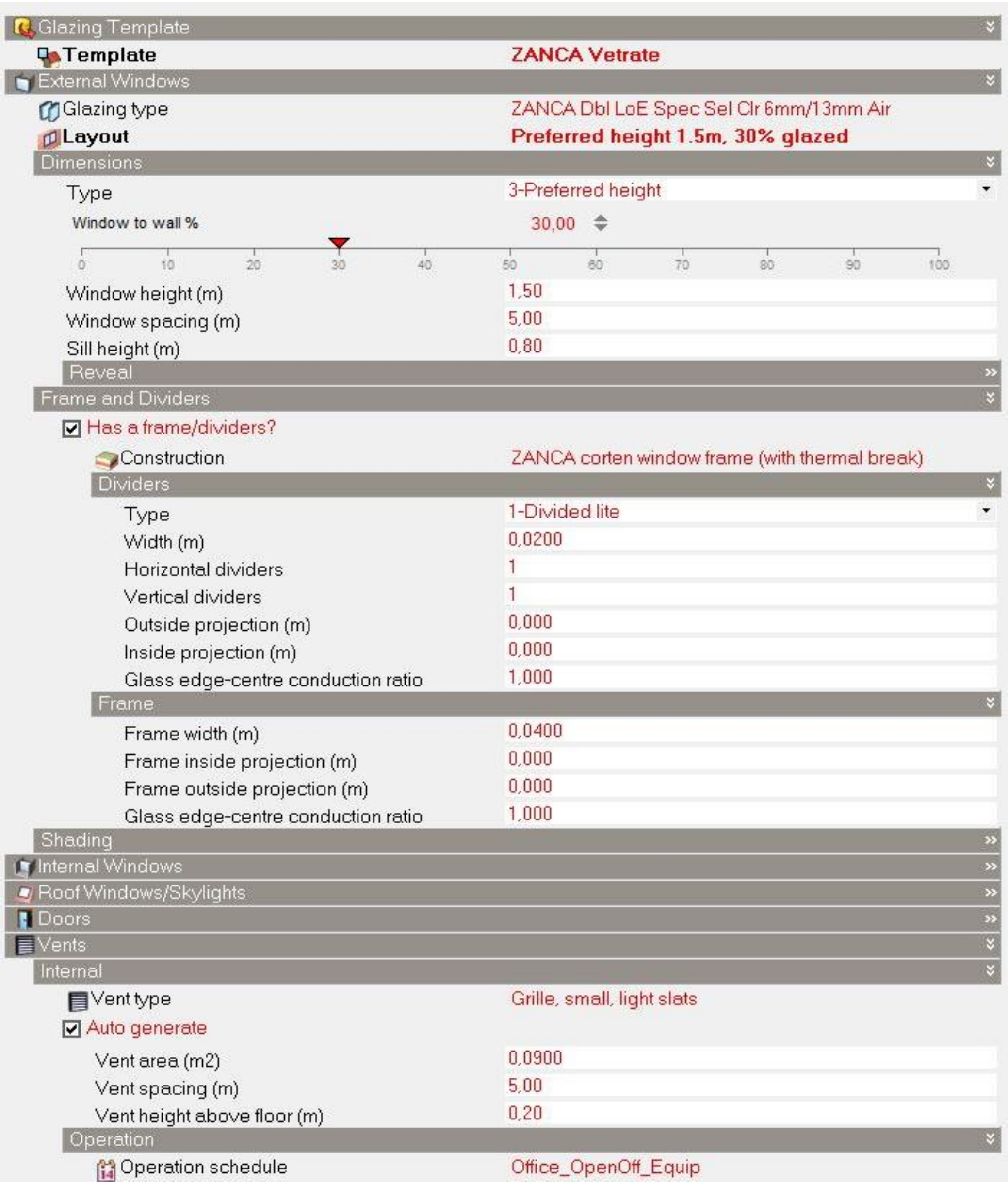


FIGURE 178 - WINDOWS TEMPLATE

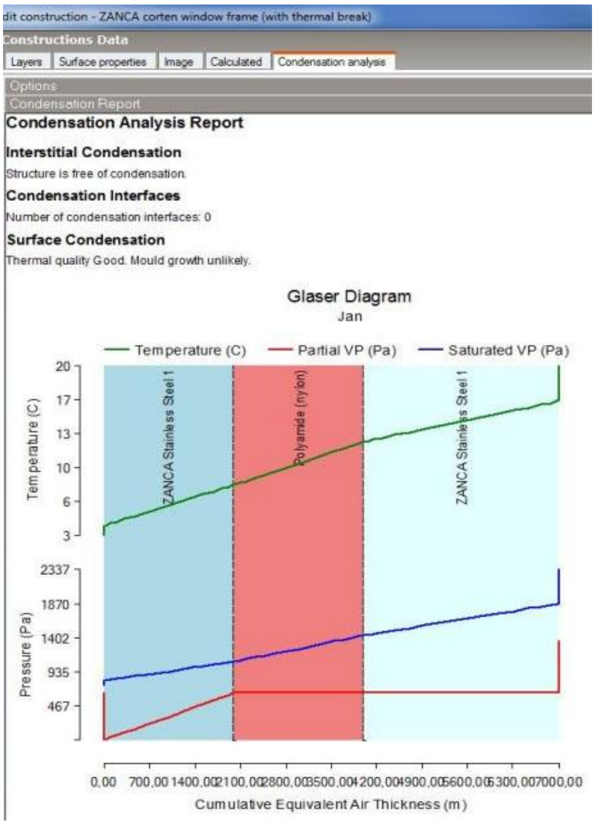
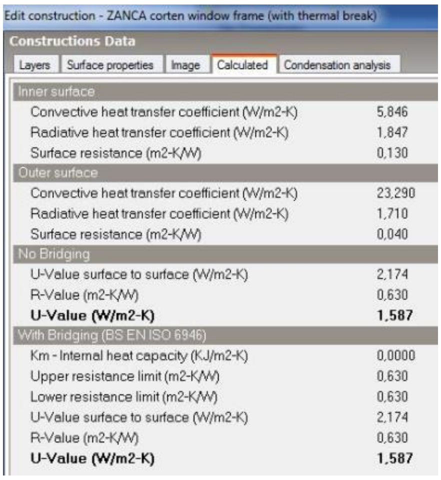


FIGURE 179 - GLASER DIAGRAM OF CORTEN STEEL WINDOWS


Edit construction - ZANCA corten window frame (with thermal break)

Constructions Data

Layers | Surface properties | Image | Calculated | Condensation analysis

Inner surface	
Convective heat transfer coefficient (W/m2-K)	5,846
Radiative heat transfer coefficient (W/m2-K)	1,847
Surface resistance (m2-K/W)	0,130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	23,290
Radiative heat transfer coefficient (W/m2-K)	1,710
Surface resistance (m2-K/W)	0,040
No Bridging	
U-Value surface to surface (W/m2-K)	2,174
R-Value (m2-K/W)	0,630
U-Value (W/m2-K)	**1,587**
With Bridging (BS EN ISO 6946)	
Km - Internal heat capacity (KJ/m2-K)	0,0000
Upper resistance limit (m2-K/W)	0,630
Lower resistance limit (m2-K/W)	0,630
U-Value surface to surface (W/m2-K)	2,174
R-Value (m2-K/W)	0,630
U-Value (W/m2-K)	**1,587**

FIGURE 180 - CORTEN STEEL WINDOWS CONSTRUCTION DATA

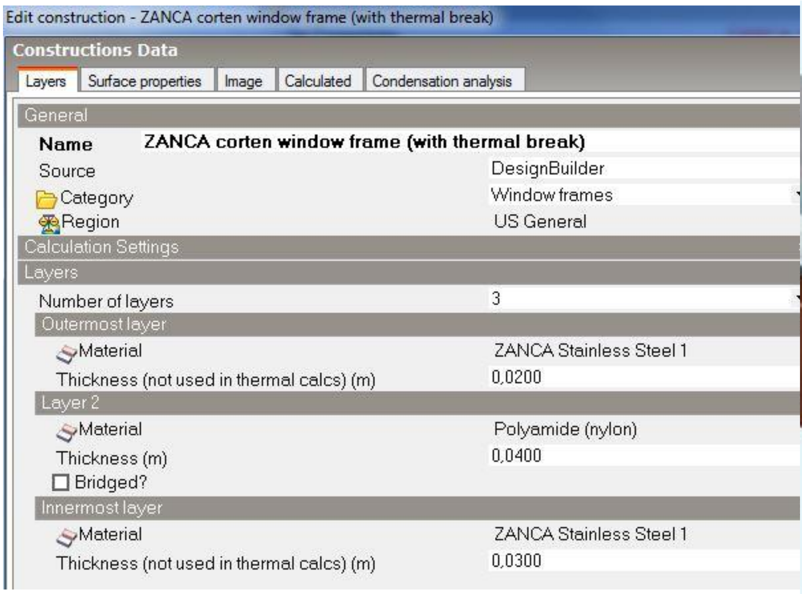


FIGURE 181 - DETAIL OF CORTEN STEEL FRAME

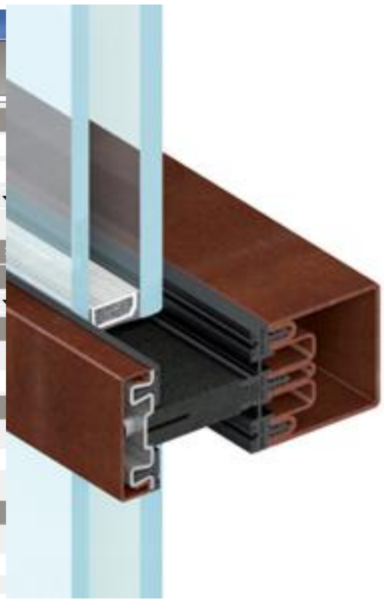


FIGURE 182 - PARTICULAR OF CORTEN STEEL FRAME

11.2.3. Shading

There is no fixed or mobile shading. because they integrate poorly with the historical memory of the building.

11.2.4. Other Strategies

The skylights in stairwells will be equipped with sensors that will govern the opening, according to the irradiation and the need for external ventilation.

11.3. Energy Systems

11.3.1. Lighting System

It is expected to replace the existing lighting with LED lamps and. where it is possible (for example in meeting rooms or council room), with intelligent on/off system. to adapt the lighting depending on sunlight.

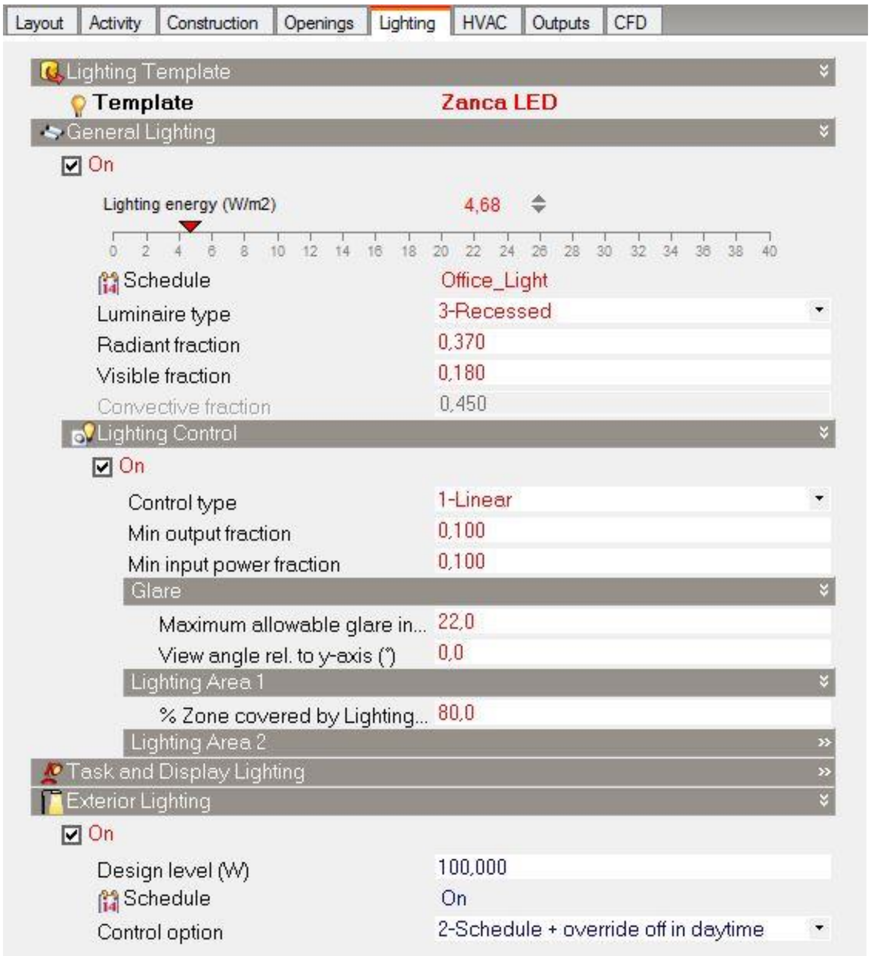


FIGURE 183 - LIGHTING TEMPLATE

11.3.2. HVAC SYSTEM

Almost all working rooms. as well as all the receiving rooms. and the circulation area have an air conditioning system. It is expected to insert a false ceiling in all circulation area and. where possible in all rooms of the building. The results are: decrease net height to be heated and creation of a channel for heating and lighting plants.

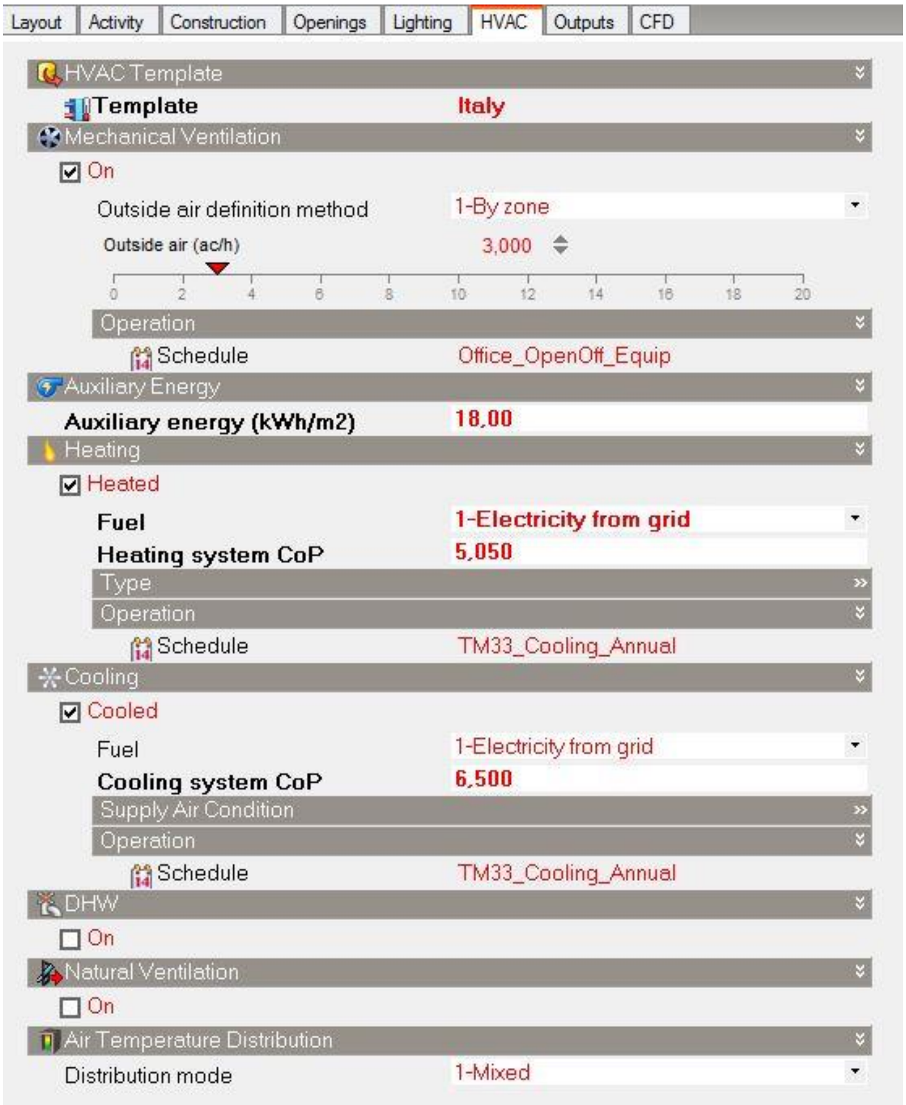


FIGURE 184 - HVAC TEMPLATE

11.4. RENEWABLE ENERGY SOURCES

The building is in a densely built area and district heating systems are not available. The use of more environmental friendly HVAC systems was investigated but VRV appeared to be the most suitable choice. Different proposals have been studied for renewable energy systems but in the end it was decided to use a photovoltaic system.

It is also thought to include wind energy as a renewable energy but the Superintendent did not like this type of intervention, because it would alter building architecture.

11.5. PV GENERATION SYSTEM

On the roof of the building a photovoltaic plant of 61 kW_p will be installed: this value ensures just over 40% of current consumption of electricity. The structure has six areas available for positioning the photovoltaic system.

FIGURE 185 - SIX AREAS AVAILABLE FOR THE PV SYSTEM INSTALLATION

The PV panels will be placed nearly due South with a fixed slope of 30° and azimuth of 0°. The system will be connected to the low voltage grid via three-phase power.

In Italy, to access to the financial benefits for installing PV modules one must submit a request to the Energy Services Manager, GSE S.p.A. Therefore, it leads to compensation between the economic value associated to the electricity produced and fed into the grid and the theoretical economic value associated to withdrawn electricity and consumed in a period different from the one in which production takes place. The calculation of the PV system was estimated by using Classic PVGIS, a piece of software developed by The Joint Research Centre of the European Commission in ISPRA. Italy.

To make this calculation it is necessary to define some conditions:

TABLE 46 - CONDITION TO SIMULATION WITH CLASSIC PVGIS

Optimal inclination angle is: 31 degrees
Annual irradiation deficit due to shadowing (horizontal): 0.1 %
Location: 38°11'38" North. 15°33'17" East. Elevation: 15 m a.s.l..
Nominal power of the PV system: 61.0 kWp (crystalline silicon)
Estimated losses due to temperature and low irradiance: 9.9% (using local ambient temperature)
Estimated loss due to angular reflectance effects: 2.5%
Other losses (cables. inverter etc.): 15.0%
Combined PV system losses: 25.3%

The monthly and annual solar radiation in the area based on the classic PVGIS database is presented in the following table.

TABLE 47 - SOLAR RADIATION AT THE AREA OF MESSINA

Month	H_h	H_{opt}	H(90)	I_{opt}	T_D	T_{24h}
Jan	1,990	2,980	2,900	59	11.0	10.2
Feb	2,700	3,630	3,130	51	10.6	9.7
Mar	4,020	4,860	3,470	40	13.2	12.0
Apr	5,420	5,830	3,190	26	15.4	14.2
May	6,410	6,280	2,630	13	19.1	17.9
Jun	6,910	6,470	2,310	6	23.1	21.8
Jul	6,830	6,530	2,470	9	25.9	24.6
Aug	6,190	6,420	3,100	21	26.2	24.7
Sep	5,000	5,880	3,830	36	22.9	21.7
Oct	3,510	4,690	3,860	49	19.8	18.6
Nov	2,250	3,320	3,160	58	16.2	15.1
Dec	1,760	2,740	2,770	61	12.6	11.6
Year	4,430	4,980	3,070	31	18.0	16.8

Legend:
Hh: Irradiation on horizontal plane (Wh/m^2/day)
Hopt: Irradiation on optimally inclined plane (Wh/m^2/day)
H(90): Irradiation on plane at angle: 90deg. (Wh/m^2/day)
Iopt: Optimal inclination (deg.)
TD: Average daytime temperature (°C)
T24h: 24 hour average of temperature (°C)

SOURCE: CLASSIC PVGIS DATABASE (KWH/ M^2/MONTH) AT 30°

TABLE 48 - AVERAGE ELECTRICITY PRODUCTION

Month	E_d	E_m
Jan	153.72	4,770.2
Feb	186.66	5,227.7
Mar	253.15	7,808.0
Apr	275.11	8,235.0
May	300.12	9,272.0
Jun	317.2	9,516.0
Jul	328.18	10,187.0
Aug	319.64	9,882.0
Sep	258.03	7,747.0
Oct	222.65	6,893.0
Nov	172.02	5,166.7
Dec	136.64	4,239.5
Yearly average	**244**	**7,412.0**
Total for year		**88,944.0**

Annual global radiation on the inclined surface = 1,960 kWh/m^2
Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)

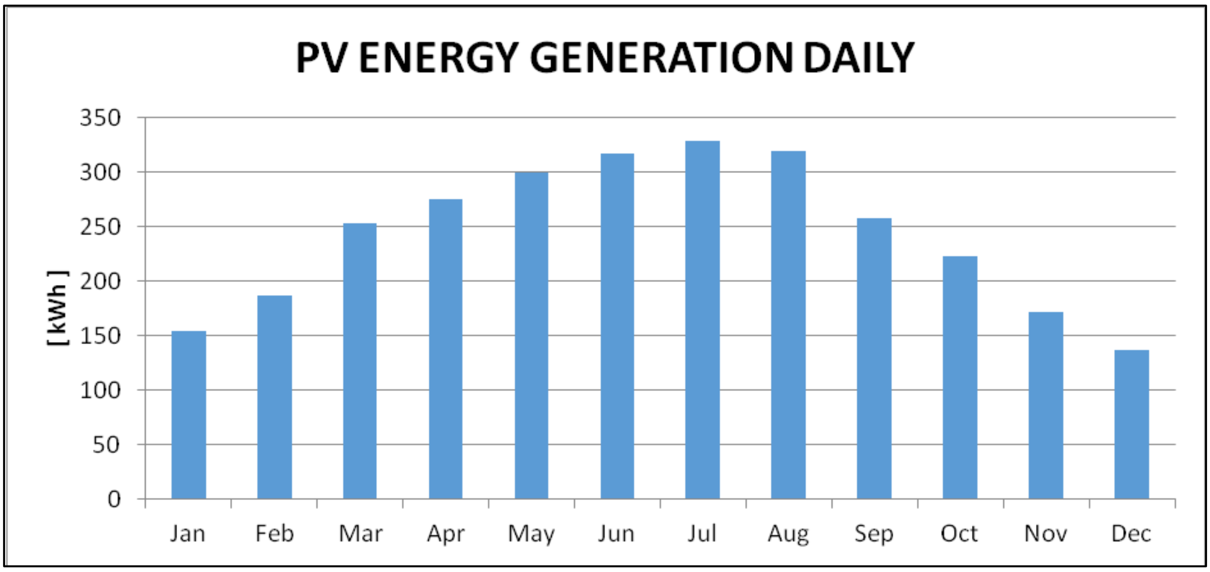


FIGURE 186 - DAILY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

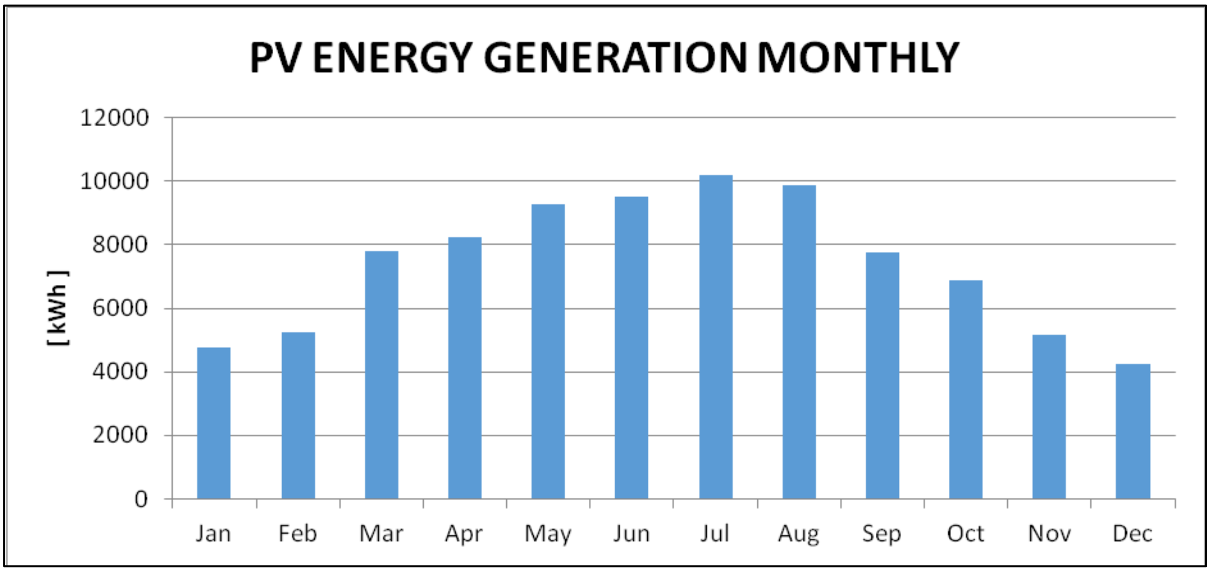


FIGURE 187 - MONTHLY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

FIGURE 188 - PV PANELS INSTALLED ON THE ROOF

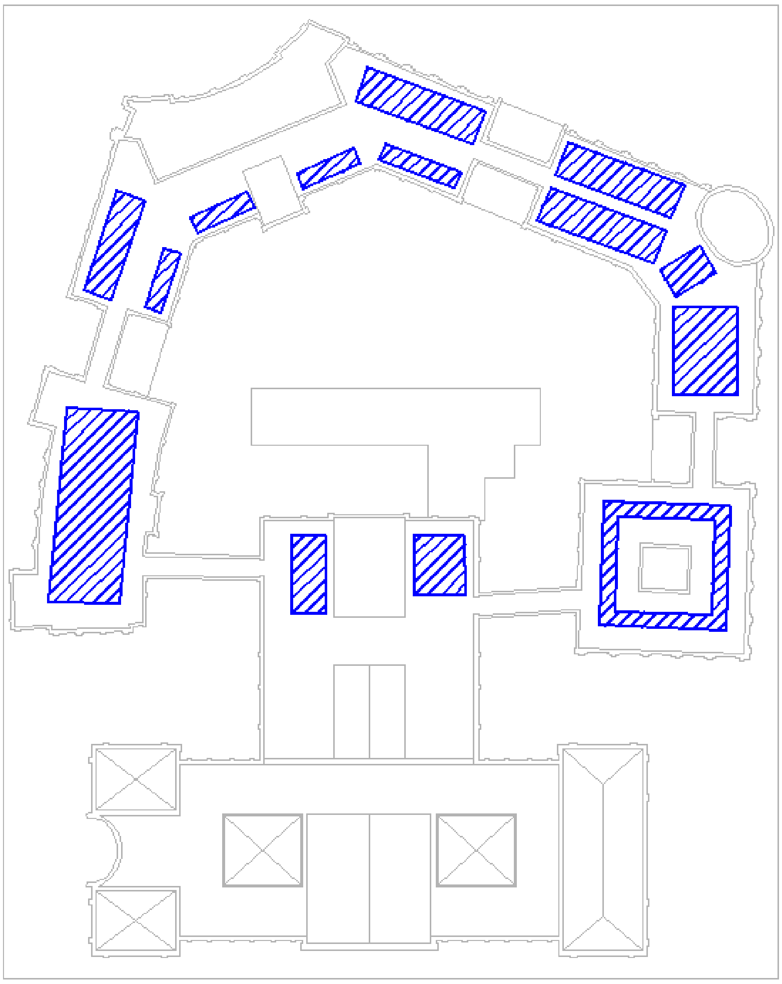


FIGURE 189- PV DISTRIBUTION

11.6. Energy Management System

To monitor the building electrical consumption of lighting, ventilation and HVAC system, a building automation control sensors (BACS) will be installed. The BACS improve occupant's comfort, efficient operation of building systems, and reduction of energy consumption and of operating costs.

The system will perform the following operations:

- Control each air conditioning unit separately to stabilize the desired internal air temperature and humidity in every office.
- Internal lighting control according to external irradiation and lux value in each room (Dimming lamps).
- Daily scheduling of air conditioning and lighting to optimize their use.
- Management of the flow temperature according to the outdoor temperature.
- Identification of electrical equipment turned on beyond normal working hours.
- Error identification or warnings in case of electrical overloads.
- Control of windows and doors opening, to minimize the use of VRV plant.

The BACS ensure therefore values of humidity and temperature in agreement with the optimum comfort conditions, and also ensures appropriate levels of air exchange. They are also useful for energy saving both in terms of lighting and rooms conditioning.

11.7. Total Impact Of The Renovation Scheme

11.7.1. Energy Performance

The energy analysis of the building was carried out using the software Design Builder v. 3.4.0.033. The building was described in detail, through architectural drawings and with an illustrated report on the state of facts and photographic documentation.

The result with the new solution is as follows. In the renovation scheme it has a VRV system plant for heating, cooling and air circulation.

To set the calculation of the model the general information are:

TABLE 49 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	** Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	13,580.56
Principal Heating Source	District Heat

TABLE 50 - BUILDING AREA

	Area [m²]
Total Building Area	11,876.95
Net Conditioned Building Area	11,876.95
Unconditioned Building Area	0.00

The following figures shows the heat balance of Palazzo Zanca Post-design. divided according to the contribution types:

- General Lighting.
- Computer + Equipment.
- Occupancy.
- Solar Gans Exterior Windows.
- Zone Sensible Heating.
- Zone Sensible Cooling.

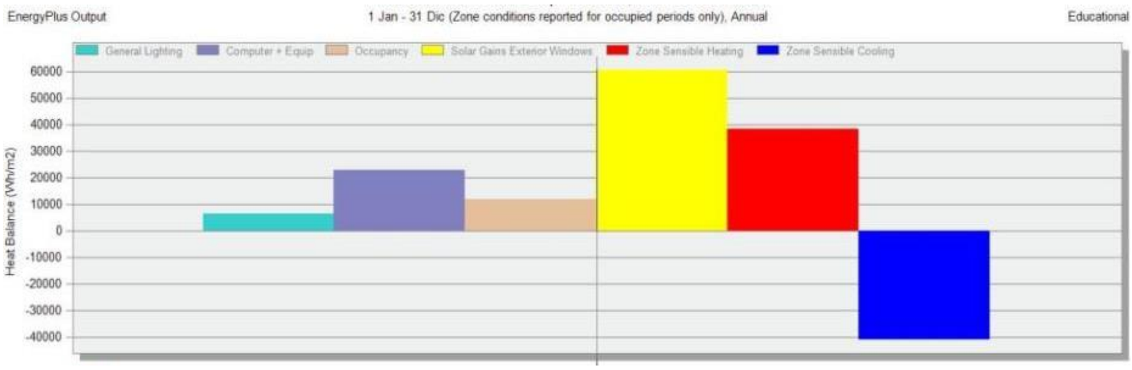


FIGURE 190 - ANNUAL HEAT BALANCE

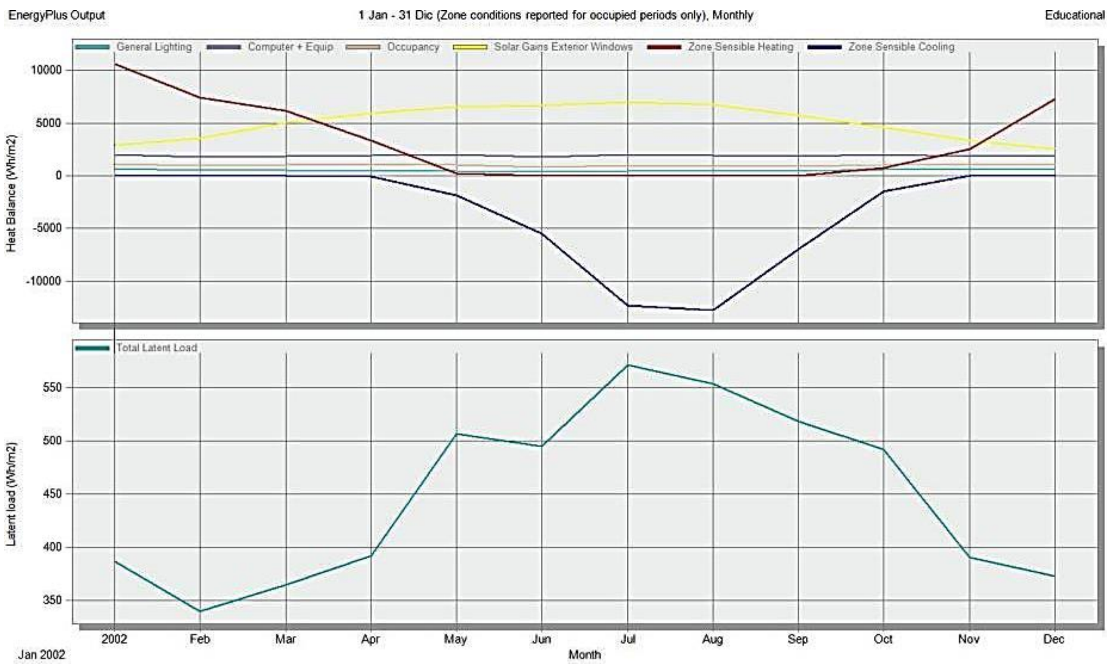


FIGURE 191 - ANNUAL HEAT BALANCE ACCORDING SINGLE MONTH

Two following figures shows monthly total fuel use of Palazzo Zanca.divided according to the contribution types:

- Room Electricity.
- Lighting.
- Auxiliary Energy.
- Heating (Electricity).
- Cooling (Electricity).

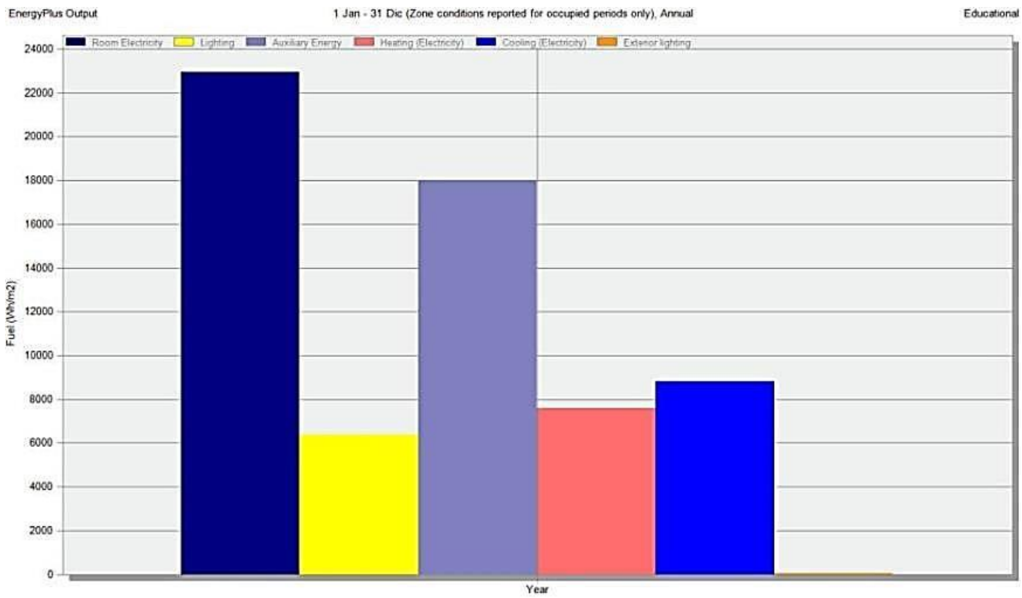


FIGURE 192 - ANNUAL USE OF FUEL TOTAL

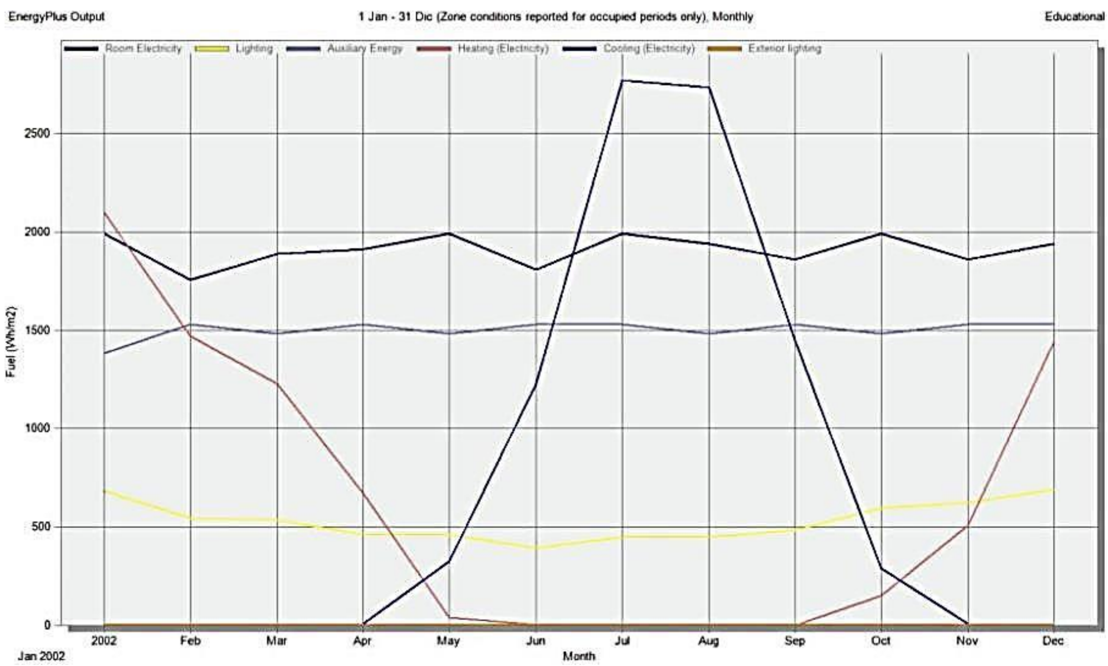


FIGURE 193 - MONTHLY USE OF FUEL TOTAL

Other data that influence thermal balance come from building envelope.

Considered data are:

- Glazing
- Walls
- Ceilings (internal)
- Floors (internal)
- Ground floors
- Partitions (internal)
- Roofs
- Floors (external)
- External infiltration
- External ventilation

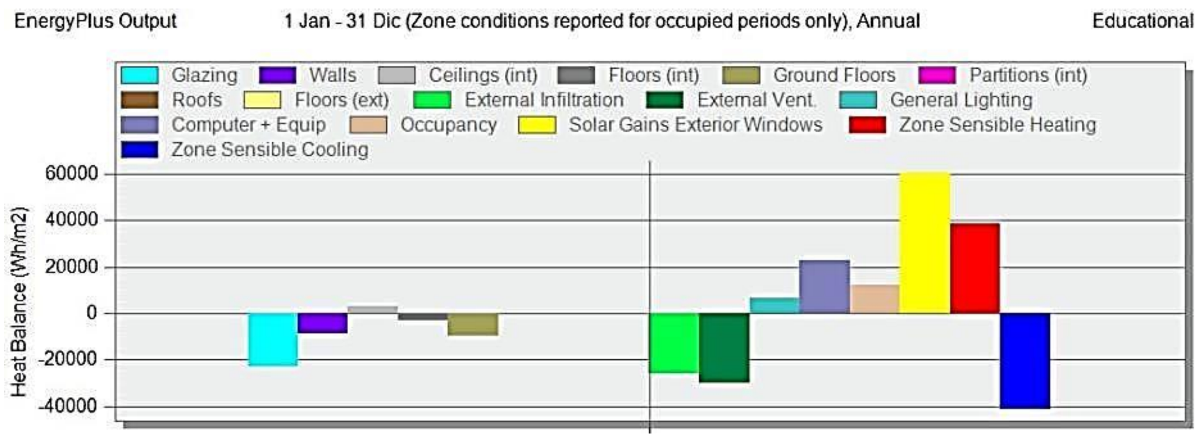


FIGURE 194 - HEAT BALANCE ACCORDING OPAQUE ELEMENT OF ENVELOPE

11.7.2. ENVIRONMENTAL PERFORMANCE

The following table shows the consumption before and after the implementation of all the proposed interventions in the building.

TABLE 51 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/m2]	Natural Gas Intensity [kWh/m2]	Additional Fuel Intensity [kWh/m2]	District Cooling Intensity [kWh/m2]	District Heating Intensity [kWh/m2]	Water Intensity [m3/m2]
Lighting	6.40	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	57.21	38.38	0.00
Other	22.92	0.00	0.00	0.00	0.00	0.00
Total	29.32	0.00	0.00	57.21	38.38	0.00

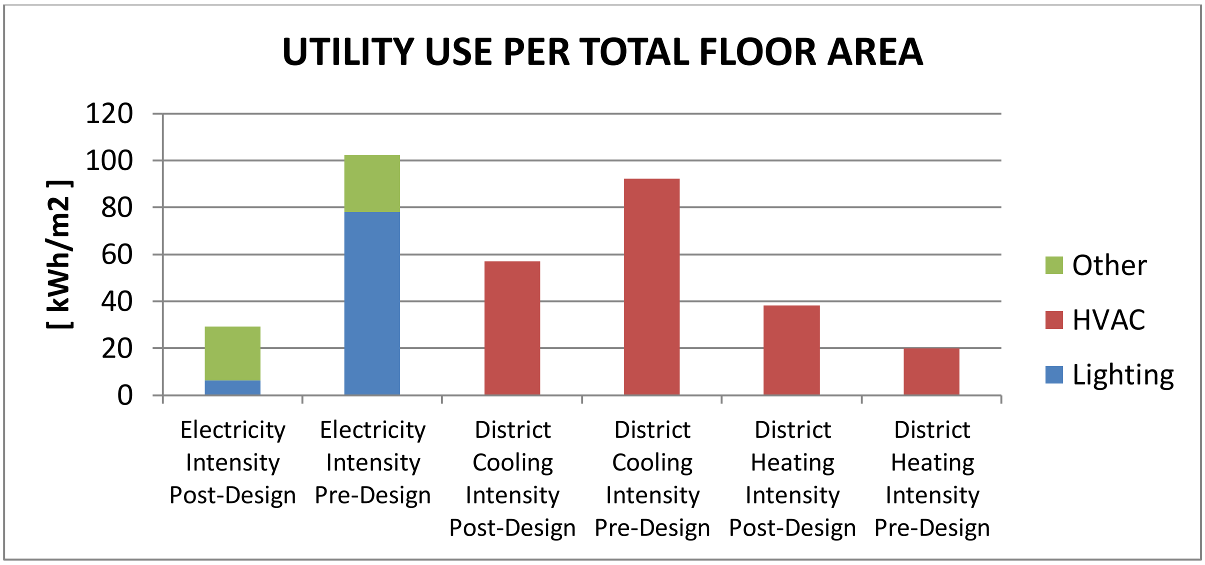


FIGURE 195 - UTILITY USE PER TOTAL FLOOR AREA PRE/POST-DESIGN

TABLE 52 - END USE CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	455,813.14	0.00
Cooling	0.00	0.00	0.00	679,470.83	0.00	0.00
Interior Lighting	75,530.09	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	435.90	0.00	0.00	0.00	0.00	0.00
Interior Equipment	272,247.54	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	0.00	0.00	0.00	0.00	0.00	0.00
Fans	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	**348,213.53**	**0.00**	**0.00**	**679,470.83**	**455,813.14**	**0.00**

Note: District heat appears to be the principal heating source based on energy usage.

TABLE 53 - END USE CONSUMPTION

	Electricity [kWh]	District Cooling [kWh]	District Heating [kWh]
Heating	0.00	0.00	455,813.14
Cooling	0.00	679,470.83	0.00
Interior Lighting	75,530.09	0.00	0.00
Exterior Lighting	435.90	0.00	0.00
Interior Equipment	272,247.54	0.00	0.00
Total End Uses	348,213.53	679,470.83	455,813.14
Total value	1,483,497.50		

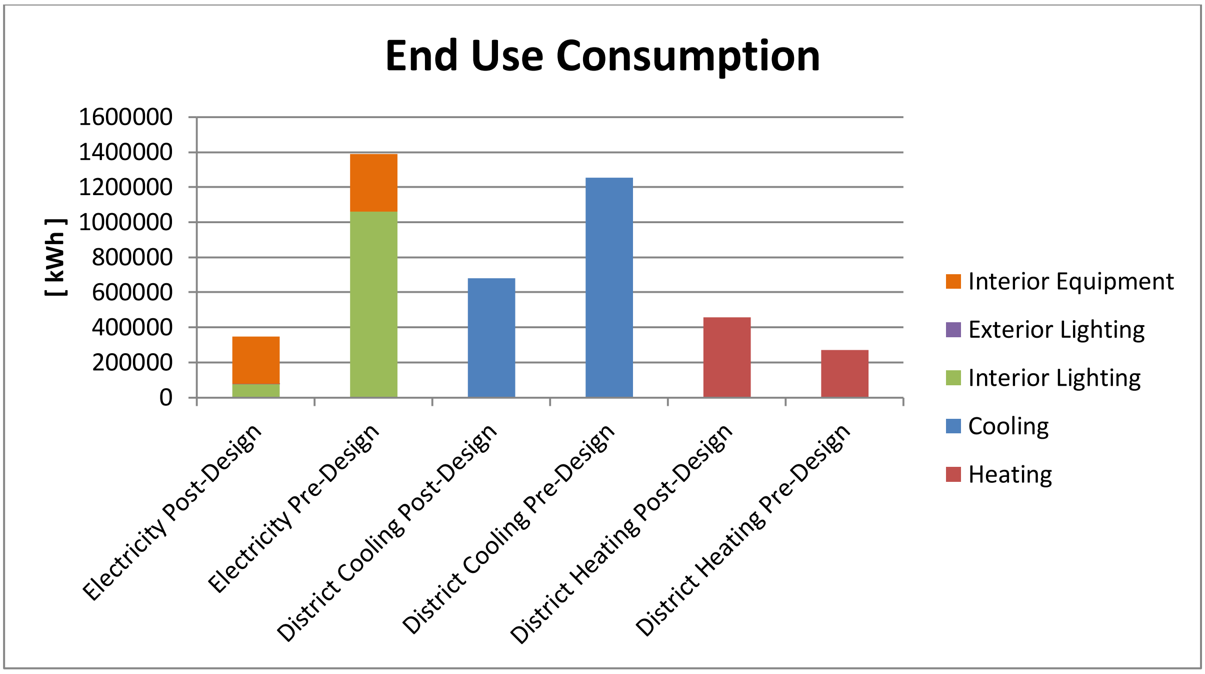


FIGURE 196 - END USE CONSUMPTION PRE/POST-DESIGN

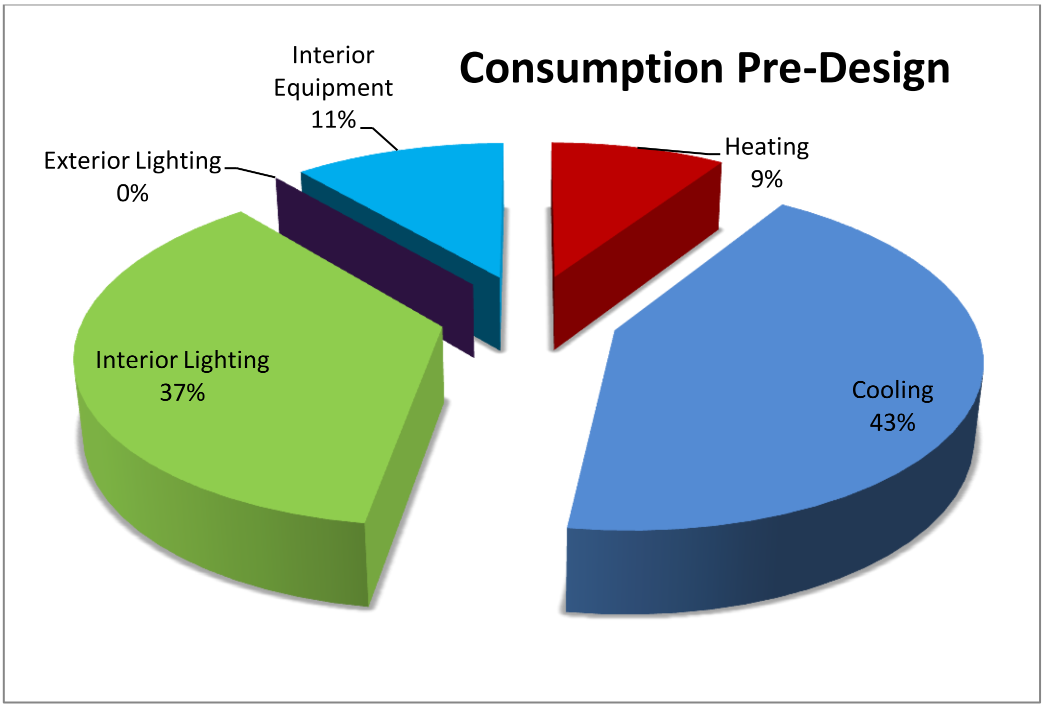


FIGURE 197 - CONSUMPTION PRE-DESIGN

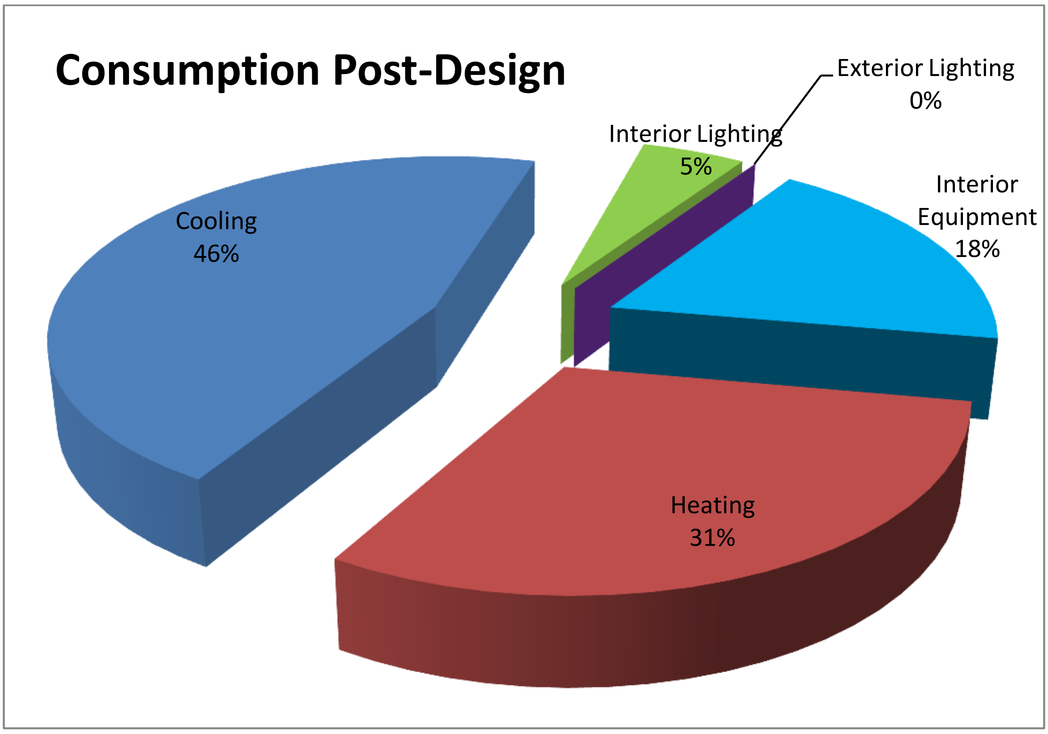


FIGURE 198 - CONSUMPTION POST-DESIGN

The energy consumption for heating increased because in the state of facts the heating is not present in circulation areas while in the renovation scheme is present in the entire building.

12. ECONOMIC EVALUATION OF THE PROPOSED RENOVATION SCHEME

12.1. ASSUMPTIONS, COST FIGURES

The cost of the interventions is estimated based on current market prices of the equipment and the installation works. Special meetings with suppliers were held to present the project and request offers for the preliminary renovation design. Offers were collected and assessed.

For each intervention, the cost has been calculated as the sum of costs for equipment, installation, operation and maintenance. These values have been organised in an Excel file prepared by Sinloc, a partner of the CERtuS consortium (see deliverable D2.5). ANNEX H. gives the cost information.

The economic appraisal of the renovation design was performed by means of a tool produced by ETVA VIPE, also a partner of the consortium. A detailed description of the tool is presented in the deliverable D2.5. The appraisal can be performed only for the whole design.

The tool also allows to examine various financing schemes ranging from single financing source to multiple, combining bank loans, ESCOs, Subsidies, municipality's own equity.

The data used for the calculations are tabulated below, divided according to the unit of measure concerned and the unit price

TABLE 54 - DETAIL OF THE COST

WORKINGS	*VOICE*	*U.M.*	*Value*	*Unit Cost*	*COST*
Plants	*Compression heat pumps - VRV system - OFFICES AREAS*	KW	918.08	€ 428	€ 393,361
Plants	*Compression heat pumps - VRV system - NEW CIRCULATION AREAS*	KW	786.92	€ 704	€ 553,846
Plants	*Compression heat pumps - VRV system - OFFICES AREAS*	KW	590	€ 428	€ 252,793
Building envelope	*Horizontal structures on roofs - False Ceiling OFFICE AREAS*	MQ	5,166	€ 47.30	244,352
Building envelope	*Horizontal structures on roofs - False Ceiling CIRCULATION AREAS*	MQ	1,599	€ 47.30	75,633
Building envelope	*Double glass*	MQ	1,321	€ 1,150.00	1,519,150
Plants	*Internal Relamping*	units	1,605	€ 200.00	€ 321,000
Plants	*Photovoltaic panels*	KWp	61	€ 2,000.00	€ 122,000
Sensors	BACS	unit	1	€ 25,000.00	€ 25,000
				TOTAL WORK COST	**€ 3.507.135**

12.2. Results

The proposals cover both the envelope that heating and electrical systems.

ENERGY EFFICIENCY MEASURES		SAVINGS
Building Envelope	• Plaster Restoration • Replacement Windows • False Ceiling in entire Building	***table saving post renovation**
Energy Systems	• VRV System • LED lighting • BACS	**HVAC = 23%** **Lighting = 93%**
RES	• PV system	

TABLE 55 - HEAT BALANCE STATE OF ART

Glazing (Wh/m^2)	Year	-23,014.10
Walls (Wh/m2)	Year	-8,729.33
Ceilings (int) (Wh/m2)	Year	3,101.76
Floors (int) (Wh/m2)	Year	-3,113.00
Ground Floors (Wh/m2)	Year	-9,506.93
Partitions (int) (Wh/m2)	Year	-0.92
Roofs (Wh/m2)	Year	-237.85
Floors (ext) (Wh/m2)	Year	0.00

TABLE 56 - HEAT BALANCE RENOVATION SCHEME

Glazing (Wh/m2)	Year	-30,217
Walls (Wh/m2)	Year	-14,290.39
Ceilings (int) (Wh/m2)	Year	3,195.08
Floors (int) (Wh/m2)	Year	-3,208.52
Ground Floors (Wh/m2)	Year	-10,277.13
Partitions (int) (Wh/m2)	Year	4.03
Roofs (Wh/m2)	Year	-1,640.73
Floors (ext) (Wh/m2)	Year	-0.01

TABLE 57 - SAVINGS POST RENOVATION (ENVELOPE)

		%
Glazing (Wh/m2)	Year	23.84
Walls (Wh/m2)	Year	38.91468322
Ceilings (int) (Wh/m2)	Year	2.920740639
Floors (int) (Wh/m2)	Year	2.977073542
Ground Floors (Wh/m2)	Year	7.494310182
Partitions (int) (Wh/m2)	Year	122.8287841
Roofs (Wh/m2)	Year	85.50340397
Floors (ext) (Wh/m2)	Year	100
	SAVINGS	48.05952995

TABLE 58 - SAVINGS POST RENOVATION (TOTAL)

		%
Glazing (Wh/m2)	Year	23.83724
Walls (Wh/m2)	Year	38.91468
Ceilings (int) (Wh/m2)	Year	2.920741
Floors (int) (Wh/m2)	Year	2.977074
Ground Floors (Wh/m2)	Year	7.49431
Partitions (int) (Wh/m2)	Year	122.8288
Roofs (Wh/m2)	Year	85.5034
Floors (ext) (Wh/m2)	Year	100
	SAVINGS	26.89653

PV SAVING TOTAL = 88,944.0 kWh
End Use with Pv contribution = 1,483,497.50 - 88,944.0 = 1,394,553.50 kWh

END USE PRE DESIGN (kWh)	END USE POST DESIGN (kWh)	SAVING (%)
2,912,932.83	1,394,553.50	52.13 (1,518,379.33 *kWh)*

The savings resulting from the interventions on envelope and plants is equal to 52.13%. The savings is contained because it had to implement the HVAC system throughout the building entering where not present (for example in the corridors).

This project involves the need to air-condition a larger area by 43% compared to the air-conditioned state of the art. The traditional interventions are the use of new windows.

In the evaluation of the lighting savings it was considered the average cost of the electricity. The lifetime was assessed considering the average hours of use for the lamps and its maximum total hours of operation. As can be seen in following table, with such conditions the renovation options ensures savings from maintenance of 4,737 €/year and has a simple payback period of 1.99 years.

TABLE 59: ECONOMIC PARAMETERS OF THE RENOVATION – LIGHTING

Energy Savings	986,397 kWh
Price - Saved Energy	0.18 €/kWh
Costs	321,000 €
Potential savings from maintenance (post intervention)	4,737 €/year
Simple Payback	1.99 years
Lifetime	20 years
CO_2 Savings	653.14 tons/year

In the evaluation of the HVAC savings it was considered the cost of the electricity during the mid-peak period. The savings for VRV are divided into 3 different values and it is possible view them in the Sinloc matrix in attachment (Chapter 16-Annex I)

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy, since in a working day during the time slots. As can be seen in following table, with such conditions it has a simple payback period of 8.71 years.

TABLE 60 - ECONOMIC PARAMETERS OF THE RENOVATION – PV

Energy Generation	88,944 kWh
Energy - Self-Consumption	90%
Energy - Injected Into Grid	10%
Price – Self-Consumption	0.18 €/kWh
Price - Injected Into Grid	0.06 €/kWh
Costs	122,000 €
Simple Payback	8.71 years
Lifetime	30 years
CO_2 Savings	58.37 tons/year

The following table presents the aggregation of the renovation option. As can be seen, the total of the renovation plan ensures savings of 55,256 €/year and has a simple payback period of 12.83 years.

TABLE 61: ECONOMIC PARAMETERS OF THE RENOVATION – TOTAL

Energy Savings	1,518,379.33 kWh
Costs	3,507,135 €
Potential savings from maintenance (post intervention)	55,256 €/year
Simple Payback	12.83 years
CO_2 Savings	991.48 tons/year

REFERENCES 2

/1/ DesignBuilder Software Ltd specialises in developing high-quality, easy-to-use and affordable simulation software tools for assessing the environmental performance of building designs. http://www.designbuilder.co.uk/

/2/ PVGIS, Photovoltaic Geographical Information System, a software developed by The Joint Research Centre of the European Commission in ISPRA, Italy. http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

/3/ CERtuS Deliverable D2.5 *"Twelve economic evaluation reports"*

13. ANNEX A: BUILDING DRAWINGS

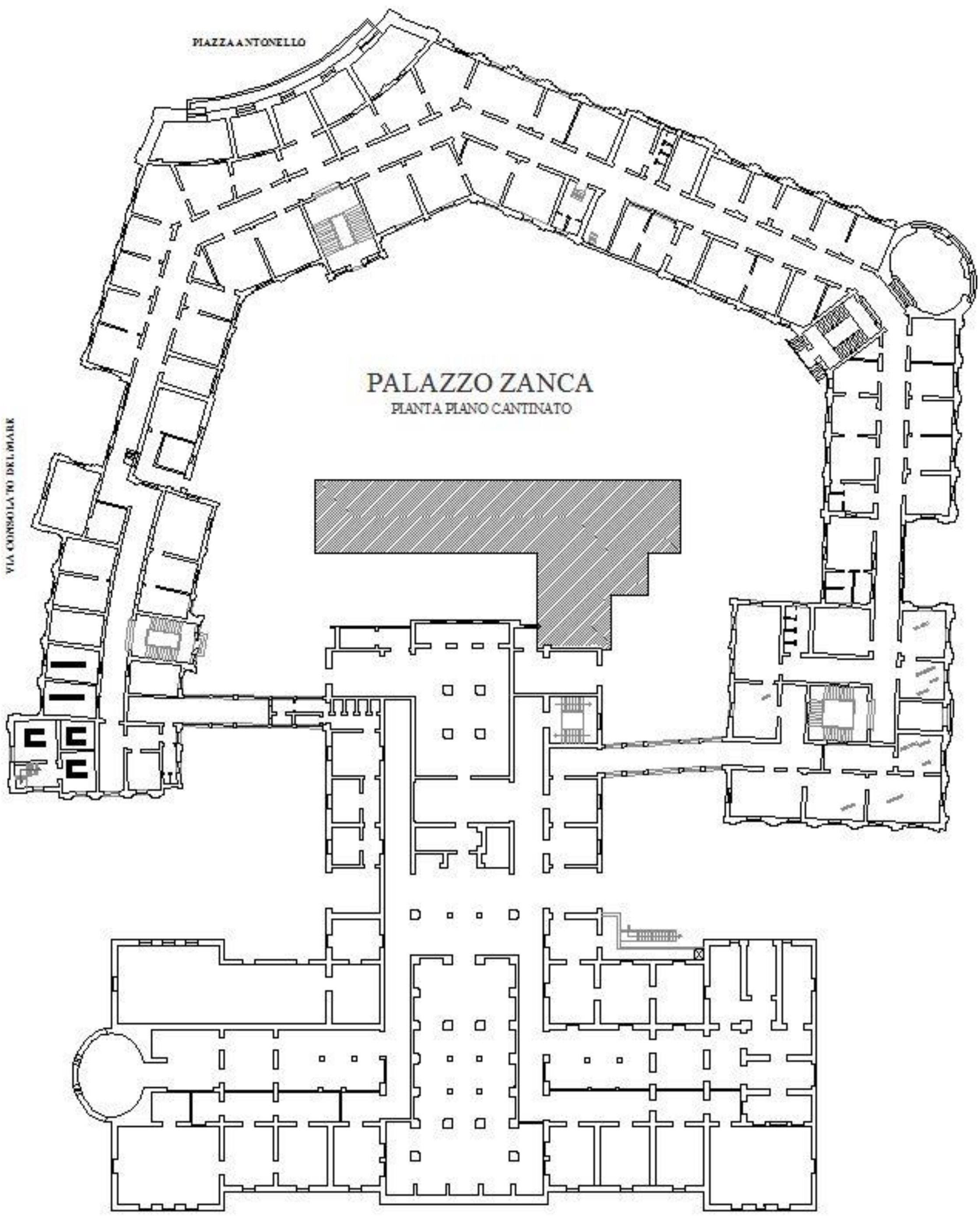


FIGURE 199 - BASAMENT FLOOR PLAN

FIGURE 200 - GROUND FLOOR PLAN

FIGURE 201 - FIRST FLOOR PLAN

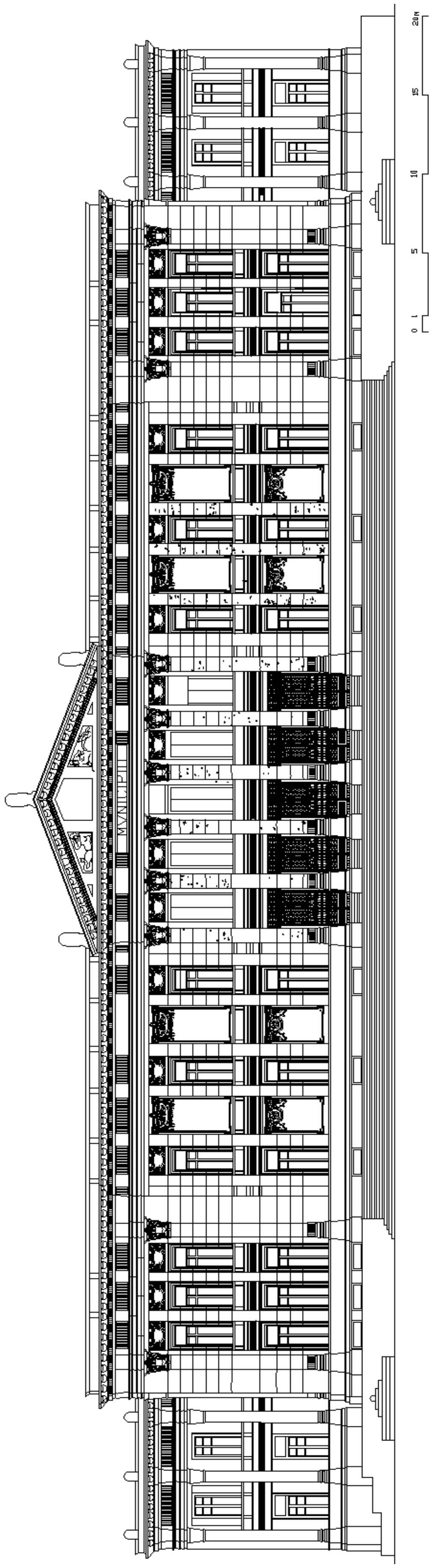


FIGURE 202 - ELEVATION PLAN FROM EUROPEAN UNION SQUARE

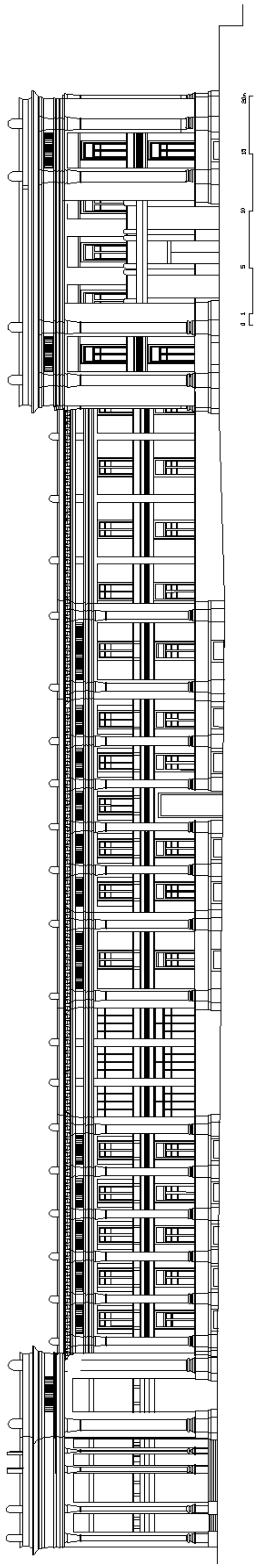


FIGURE 203 - ELEVATION PLAN FROM VIA CONSOLATO DEL MARE

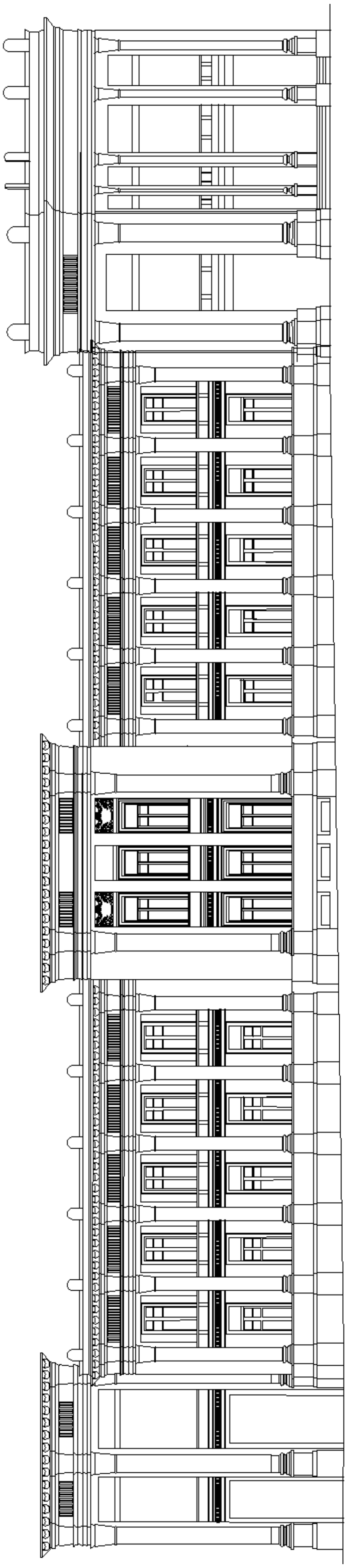


FIGURE 204 - ELEVATION PLAN FROM VIA CAVOUR

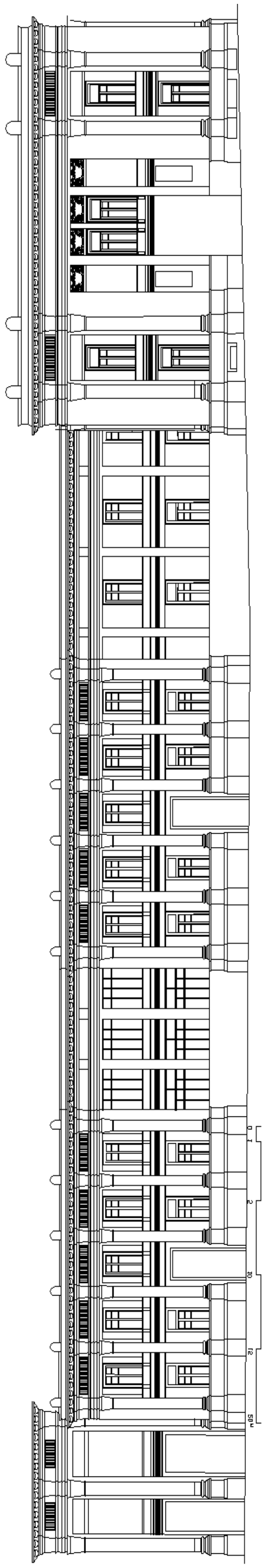


FIGURE 205 - ELAVUATION PLAN FROM VIA SAN CAMILLO

14. ANNEX B: BUILDINGS DESIGN

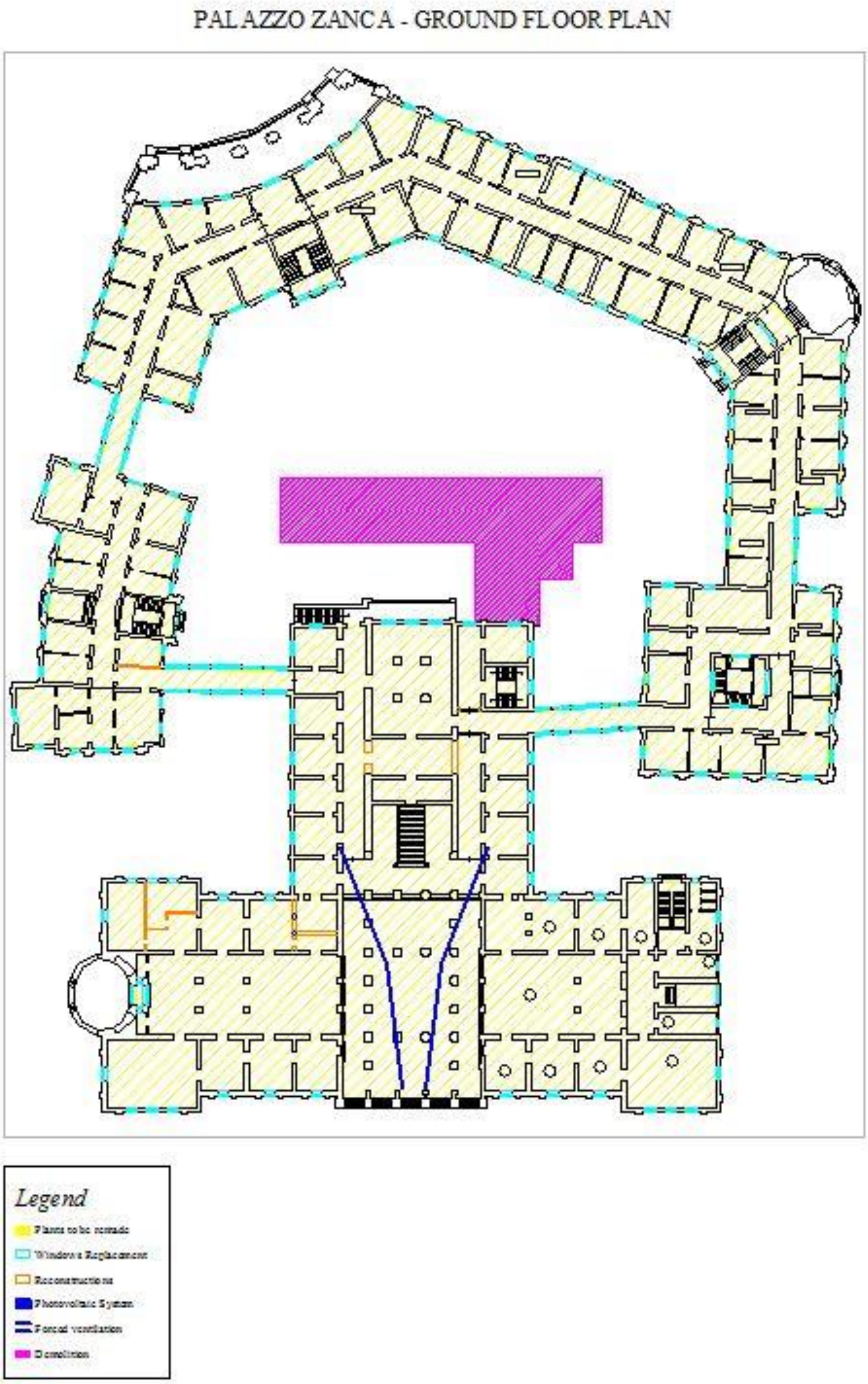


FIGURE 206 - GROUND FLOOR BUILDING DESIGN

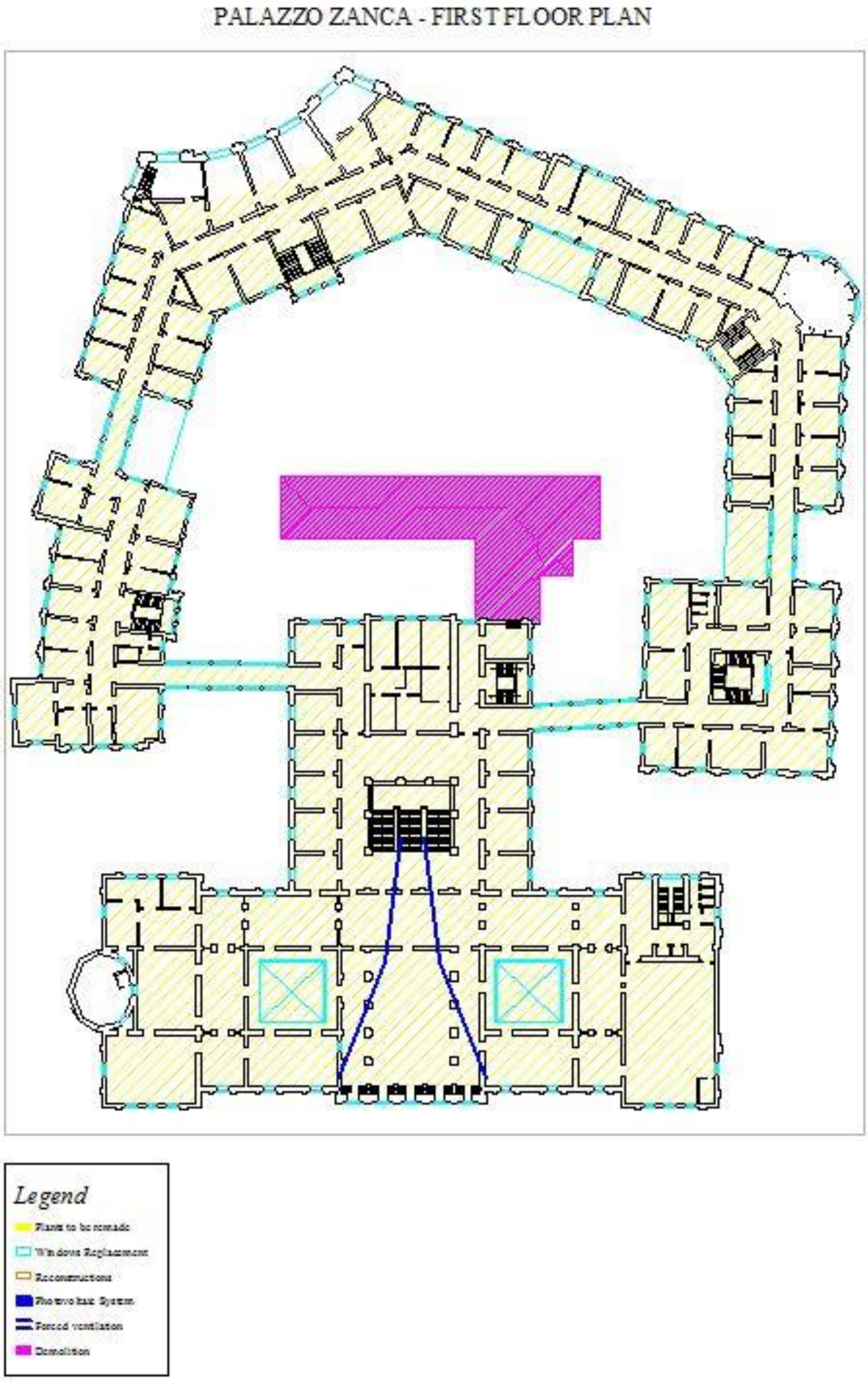


FIGURE 207 - FIRST FLOOR BUILDING DESIGN

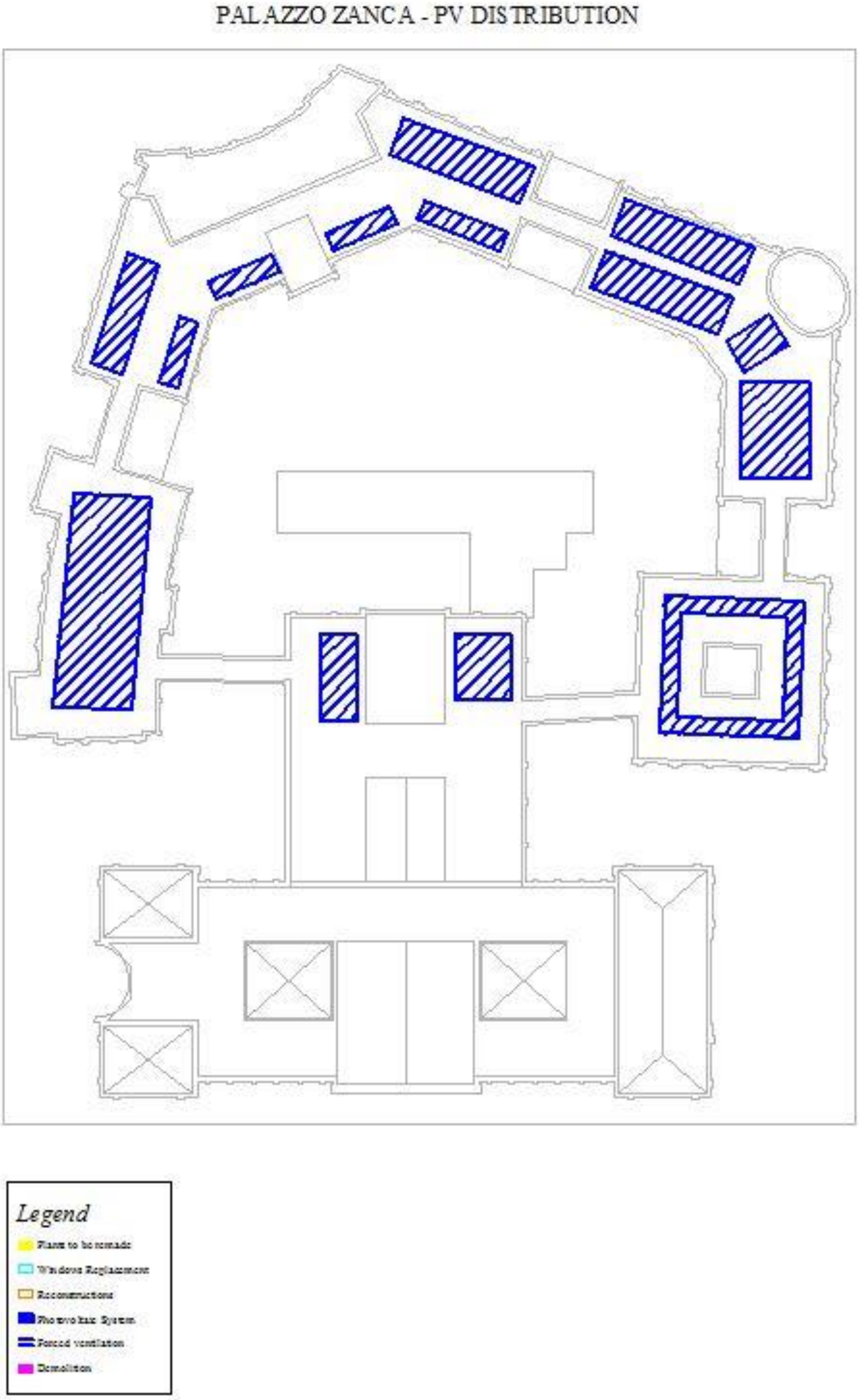


FIGURE 208 - PV DISTRIBUTION ON THE CEILING

15. ANNEX C: DESIGN BUILDER PARAMETERS

TABLE 62 - GENERAL VALUE

	Value
Program Version and Build	EnergyPlusDLL-32 8.1.0.008.
RunPeriod	PALACULTURA Enea
Weather File	Messina - ITA IGDG WMO#=164200
Latitude [deg]	38.20
Longitude [deg]	15.55
Elevation [m]	59.00
Time Zone	1.00
North Axis Angle [deg]	0.00
Rotation for Appendix G [deg]	0.00
Hours Simulated [hrs]	8,760.00

TABLE 63 - TABULAR VIEW FOR TEMPERATURE AND PRECIPITATION PER MONTH

	Temperature			Precipitation
Months	**Normal**	**Warmest**	**Coldest**	**Normal**
January	12.3°C	14.4°C	10.1°C	10
February	12.2°C	14.7°C	9.8°C	9
March	13.5°C	16.1°C	10.9°C	8
April	15.4°C	18.3°C	12.5°C	8
May	19.5°C	22.5°C	16.4°C	3
June	23.6°C	26.8°C	20.4°C	1
July	26.7°C	30.0°C	23.4°C	1
August	27.3°C	30.5°C	24.2°C	2
September	24.5°C	27.5°C	21.5°C	5
October	20.5°C	23.2°C	17.8°C	8
November	16.4°C	18.7°C	14.1°C	10
December	13.7°C	15.8°C	11.6°C	10

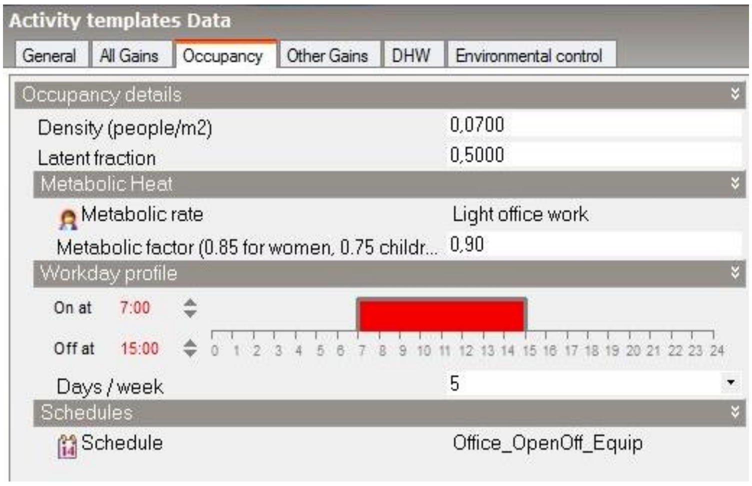


FIGURE 209 - ZANCA OFFICE OCCUPANCY

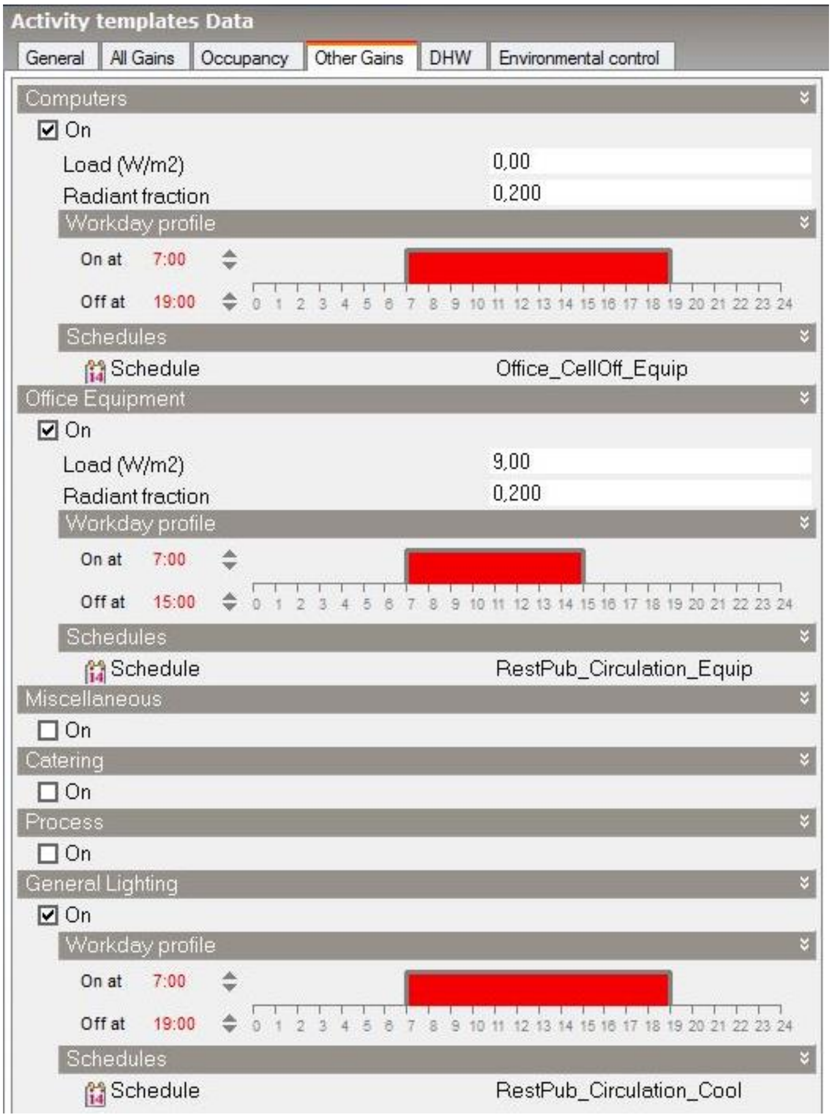


FIGURE 210 - ZANCA OFFICE OTHER GAINS

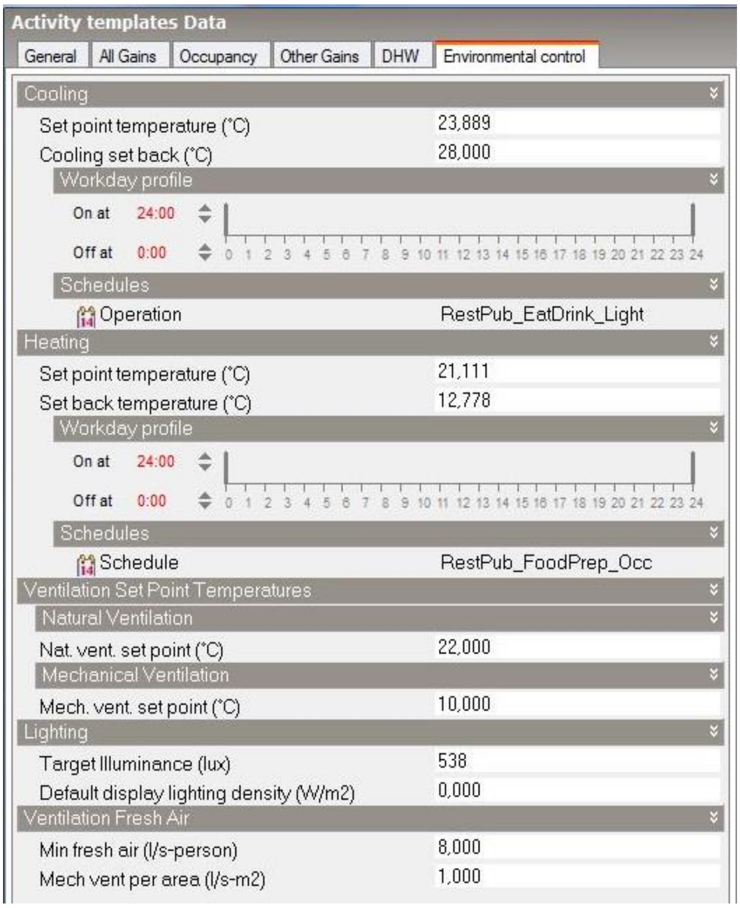


FIGURE 211 - ZANCA OFFICE ENVIRONMENTAL CONTROL

TABLE 64 - END USES BY SUBCATEGORY

	Subcategory	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	General	0.00	0.00	0.00	0.00	270,143.40	0.00
Cooling	General	0.00	0.00	0.00	1,254,508.77	0.00	0.00
Interior Lighting	ELECTRIC EQUIPMENT#Blocco2:Zona3#GeneralLights	6,634.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona2#GeneralLights	101,924.37	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona7#GeneralLights	26,463.63	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona5#GeneralLights	8,177.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	16,008.15	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco2:Zona9#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco2:Zona1#GeneralLights	19,565.16	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona10#GeneralLights	1,805.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona11#GeneralLights	16,477.63	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona6#GeneralLights	15,657.92	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona8#GeneralLights	977.74	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona4#GeneralLights	2,118.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona18#GeneralLights	3,437.71	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona15#GeneralLights	92,810.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona1#GeneralLights	10,029.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona16#GeneralLights	24,376.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona8#GeneralLights	12,864.36	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona9#GeneralLights	1,150.58	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona14#GeneralLights	2,058.23	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco4:Zona4#GeneralLights	3,739.94	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona17#GeneralLights	1,070.43	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona10#GeneralLights	7,165.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona11#GeneralLights	4,627.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona5#GeneralLights	16,108.02	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona13#GeneralLights	8,518.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona19#GeneralLights	2,303.12	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona3#GeneralLights	10,734.40	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona2#GeneralLights	1,423.07	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona6#GeneralLights	11,551.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona12#GeneralLights	10,858.46	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona7#GeneralLights	6,372.54	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona5#GeneralLights	8,177.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona1#Gener	78,242.44	0.00	0.00	0.00	0.00	0.00

	alLights						
	ELECTRIC EQUIPMENT#Blocco1:Zona9#GeneralLights	16,008.15	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona12#GeneralLights	8,370.56	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona10#GeneralLights	1,805.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona14#GeneralLights	16,907.68	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona6#GeneralLights	14,078.52	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona2#GeneralLights	5,547.83	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona7#GeneralLights	5,535.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona8#GeneralLights	6,069.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona13#GeneralLights	1,844.29	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona15#GeneralLights	1,612.48	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona3#GeneralLights	25,418.19	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona4#GeneralLights	2,118.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona8#GeneralLights	12,864.36	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bloc	79,054.66	0.00	0.00	0.00	0.00	0.00

	co6:Zona15#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco6:Zona9#GeneralLights	1,150.58	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona4#GeneralLights	4,988.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona12#GeneralLights	16,064.68	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona10#GeneralLights	7,165.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona11#GeneralLights	4,627.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona5#GeneralLights	6,587.61	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona18#GeneralLights	54,685.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona19#GeneralLights	2,303.12	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona3#GeneralLights	10,734.40	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona2#GeneralLights	9,934.19	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona13#GeneralLights	1,697.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona6#GeneralLights	7,634.41	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona1#GeneralLights	2,625.73	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	1,374.46	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco6:Zona14#GeneralLights						
	ELECTRIC EQUIPMENT#Blocco6:Zona7#GeneralLights	6,372.54	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona4#GeneralLights	14,985.12	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona3#GeneralLights	662.36	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona1#GeneralLights	13,353.56	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona5#GeneralLights	814.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona2#GeneralLights	1,766.75	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona1#GeneralLights	39,768.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona4#GeneralLights	11,559.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona5#GeneralLights	814.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona2#GeneralLights	1,766.75	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona1#GeneralLights	39,768.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona4#GeneralLights	11,559.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona5#GeneralLights	814.78	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco11:Zona2#GeneralLights	1,766.75	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona1#GeneralLights	39,768.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona4#GeneralLights	11,559.55	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona5#GeneralLights	814.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona2#GeneralLights	1,766.75	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	General	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	ELECTRIC EQUIPMENT#Blocco2:Zona3#05	3,223.40	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona2#05	8,886.56	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona7#05	12,856.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona5#05	3,973.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona9#05	7,777.10	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona1#05	9,505.17	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona10#05	398.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona11#05	8,005.19	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona6#05	7,606.95	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona8#05	215.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco2:Zona4#05	1,029.41	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco4:Zona18#05	1,670.11	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona15#05	8,091.92	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona1#05	4,872.37	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona16#05	11,842.76	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona8#05	6,249.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona9#05	253.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona14#05	999.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona4#05	1,816.94	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona17#05	236.04	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona10#05	3,481.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona11#05	2,247.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona5#05	7,825.62	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona13#05	4,138.49	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona19#05	507.86	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona3#05	5,215.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona2#05	313.80	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona6#05	5,611.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco4:Zona12#05	5,275.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	3,095.92	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Blocco4:Zona7#05						
	ELECTRIC EQUIPMENT#Blocco1:Zona5#05	3,973.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona1#05	6,821.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona9#05	7,777.10	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona12#05	4,066.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona10#05	398.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona14#05	3,921.81	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona6#05	6,839.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona2#05	2,695.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona7#05	2,689.45	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona8#05	3,518.17	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona13#05	160.80	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona15#05	355.57	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona3#05	12,348.70	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco1:Zona4#05	1,029.41	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona8#05	6,249.78	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona15#05	6,892.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona9#05	253.72	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Bloc	2,423.50	0.00	0.00	0.00	0.00	0.00

	co6:Zona4#05						
	ELECTRIC EQUIPMENT#Blocco6:Zona12#05	7,804.56	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona10#05	3,481.33	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona11#05	2,247.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona5#05	3,200.40	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona18#05	26,567.26	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona19#05	507.86	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona3#05	5,215.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona2#05	4,826.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona13#05	374.41	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona6#05	3,708.96	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona1#05	1,275.64	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona14#05	303.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco6:Zona7#05	3,095.92	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona4#05	1,306.52	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona3#05	321.79	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona1#05	6,487.44	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona5#05	395.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco5:Zona2#05	389.59	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Blocco10:Zona1#05	13,274.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona4#05	1,007.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona5#05	395.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco10:Zona2#05	389.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona1#05	13,274.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona4#05	1,007.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona5#05	395.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco11:Zona2#05	389.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona1#05	13,274.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona4#05	1,007.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona5#05	395.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Blocco12:Zona2#05	389.59	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	General	0.00	0.00	0.00	0.00	0.00	0.00
Fans	Ventilation (simple)	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	General	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	General	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	General	0.00	0.00	0.00	0.00	0.00	0.00
Refrigeration	General	0.00	0.00	0.00	0.00	0.00	0.00
Generators	General	0.00	0.00	0.00	0.00	0.00	0.00

16. ANNEX D: RENOVATION OPTION MATRIX BY SINLOC

TABLE 65 - ECONOMIC EVALUATION OF INTERVENTIONS

Renovation options	Types	Technologies / Layers	Code	Installed power or size of intervention – Unit of measure	Installed power or size of intervention – Value	Work timing – Start date (dd/mm/yy)	Work timing – Final date (dd/mm/yy)	Work timing – Construction Period (Months)	Work timing – Compulsory connection with other technologies/ layers (Yes/No)	Work timing – Specify which technologies are needed to realize this layer (Code/codes (ascending order))	Work timing – Specify which technologies can be realized only after this layer (Code/codes (ascending order))	CAPEX – Investment cost – Unit of measure	CAPEX – Investment cost – Unit cost	CAPEX – Investment cost – Value calculated per share of use	CAPEX – Investment payback period (preliminary) (Years)	CAPEX – Lifetime (year of replacement - revamping) (Years)
		Cogeneration	2													
	Heating pumps	*Compression heat pumps - VRV system - OFFICES AREAS*	3	KW	918,1	X	X	12	Yes	18-25	41	/KW	428	393'361	15,59	25
	Heating pumps	*Compression heat pumps - VRV system - NEW CIRCULATION AR*	4	KW	786,9	X	X	12	Yes	19-25	41	/KW	704	553'846	n.a.	25
	Replacement of cooling plants	**High-efficiency air conditioners**	5													
	Cooling pumps	*Compression heat pumps - VRV system - OFFICES AREAS*	6	KW	590	X	X	12	Yes	18-25	41	/KW	428	252'793	4,56	25
	Replacement of water heating systems	Solar thermal	7													
		[...]	8													
	Insulation of distribution networks	[...]	9													
			10													
	Ventilation system	**Heat recovery**	11													
			12													
		Heating pumps with geothermal sonde Georthermal heat pumps	13													
		[...]	14													
Casing	External insulation	[...]	15													
Building skin	Internal insulation	[...]	16													
	Shielding elements	**Fixed/mobile/combined vertical structures**	17													
		Horizontal structures on roofs - False Ceiling OFFICE AREAS	18	MQ	5166	X	X	12	Yes		3-6	/MQ	47,30	244'352	15,37	40
		Horizontal structures on roofs - False Ceiling CIRCULATION AREA	19	MQ	1599	X	X	12	Yes		4	/MQ	47,30	75'633	no	40
		Horizontal structures on floors	20													
	Bioclimatic	[...]	21													
		[...]	22													
Windows	Windows	PVC	23													
		[...]	24													
	Glass windows	*Double glass*	25	MQ	1321	X	X	12	Yes		3-4-6	/MQ	1'150,00	1'519'150	71,69	40
	Glass windows	Triple glass	26													
		[...]	27													
Lighting systems (internal)	**Replacement of lamps (and luminaries**	**LED**	28													
		Internal Relamping	29	units	1605	X	X	4	No			/unit	200,00	321'000	1,99	20
Lighting systems (external)	Replacement of lamps (and luminaries, ballas	LED	30													
			31													
Renewable energy	Biomass	Biomass heating systems	32													
	Solar	*Photovoltaic panels*	33	KWp	61	X	X	6	No			/KWp	2'000,00	122'000	8,71	30
		Solar thermal panels	34													
Control systems	Thermal	Automatic regolation of internal temperature	35													
		Thermostatic valves	36													
		Individual thermal energy consumption accounting	37													
	Lighting	Light flux regulators (internal)	38													
		Light flux regulators (external)	39													
	Control System	**BACS**	40	unit	1	X	X	2	Yes	3-4-6		/unit	25'000,00	25'000	no	20
			41													

TABLE 66 - ECONOMIC EVALUATION OF INTERVENTIONS

	OPEX																SAVINGS													
	Energy consumption (after each single energy renovation option)								Labor/Management and ordinary maintenance contracts			Extraordinary maintenance				Potential energy savings expected from the intervention										Potential savings from maintenance (post intervention)		Potential savings of CO2	
									components	personnel	Total	Frequency	intervention	personnel	Total	Electric energy consumption					Thermal energy consumption								
Renovation options	Source 1	Unit of measure	Consumption/year	/year	Source 2	Unit of measure	Consumption/year	/year	/year	/year	/year	years	-	/year	-	%, first year	kWhe/year, first year	%, last year	kWhe/year, last year	Decrease characteristics (linear, nonlinear,	%, first year	kWh/year, first year	%, last year	kWh/year, last year	Decrease characteristics (linear, nonlinear, etc.)	%	/year	%	Equivalent tons/year
	electric	KWHe	245'437,8	44'178,81	no				2'754	5'114	7'867	7	16'154	1'615	27'462	3,6%	9'734	3,3%	8'910	linear						40%	23'553	3%	6,992
	electric	KWHe	210'375,3	37'867,55	no				3'877	7'200	11'077	7	27'692	2'538	45'462		n.a.			linear							n.a.		
	electric	KWHe	679'471	122'304,75	no				1'770	3'286	5'056	7	16'154	1'615	27'462	15,4%	192'737	14,5%	181'830	linear						40%	21'678	15%	140,5
Casing Building skin																													
	no				no				855	1'588	2'444	10	20'000	2'000	40'000	10,1%	93'448	9,0%	83'242	linear						0%	0	9,6%	66,26
	no				no				265	492	756	10	7'000	1'000	17'000		not applicable is linked to a new equipment									0%	0	0,0%	
Windows																													
	no				no				2'659	4'937	7'596	10	20'000	2'000	40'000	10,1%	93'448	9,0%	83'242	linear						10%	5'288	9,6%	66,26
Lighting systems (internal)	electric	KWHe	75'530,1	13'595,42	no				1'124	2'087	3'210	7	4'000	1'000	11'000	1306,0%	986'397	1000,0%	755'301	linear						25%	4'737	1153,0%	653,1
Lighting systems (external)																													
Renewable energy	no				no				2'135	3'965	6'100	5	7'000	3'000	22'000	100,0%	88944	75,0%	66708	linear						0%	0	87,5%	58,37
Control systems																													
	no				no				263	488	750	3	750	500	2'250		not applicable is linked to a new equipment									0%	0	0,0%	

C. SATELLITE PALACE

17. BUILDING GENERAL DESCRIPTION

17.1. LOCATION

Palazzo Satellite is the municipal building of Messina. The building is located in the historic center of the city, near the central station.

This figure shows the front facade of the building.

FIGURE 212 - PALAZZO SATELLITE

The building has no architectural value and in the original design was designed to residences.

FIGURE 213 - PALAZZO SATELLITE

The building includes many functions of municipal government, including the Local Health Unit, the municipal Police management and several Municipal Departments.

Building style is modern and the total area is 6,874.93 m^2, Palazzo Satellite is an example of a frame structure made of reinforced concrete. The walls are made of mansory and the floors are in slab and masonry. Table 1 presents the main location data of the building.

TABLE 67 - LOCATION DATA OF THE BUILDING

Address	Republic Square, 1 98122 Messina (ME), Italy
Coordinates	LAT. 38°11'10.50"N - LONG. 15°33'38.67"E
Google Maps	https://www.google.it/maps/place/@38.186251,15.560743,17z/data=!4m2!3m1!1s0x13144e706cf26d71:0x3fc19b5ae161ada1

These figures show the location in the city map and aerial view.

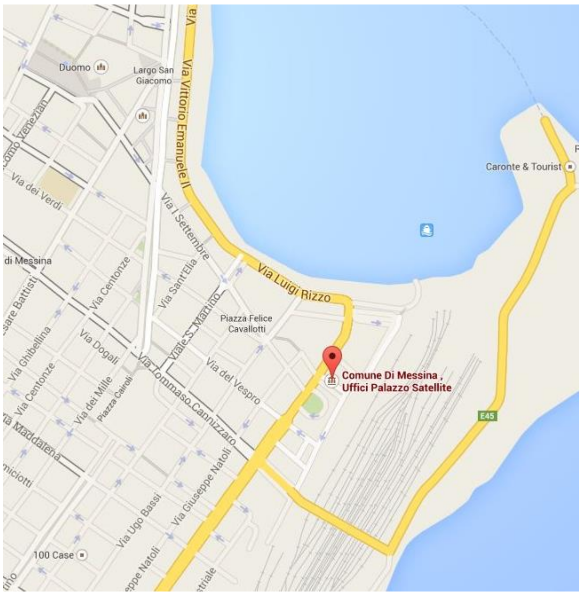


FIGURE 214 - LOCATION IN THE CITY (MAP)

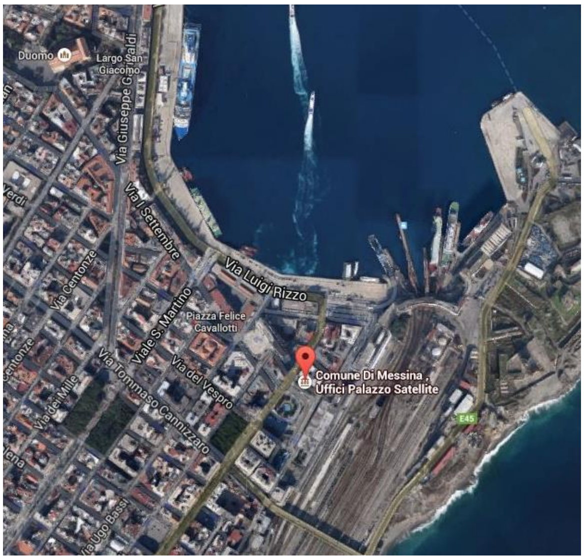


FIGURE 215 - LOCATION IN THE CITY (AERIAL VIEW)

TABLE 68 - DATA OF THE SYSTEM CONSIDERED

Degree days	707
Minimum temperature of project	5.0 °C
Altitude	3 m s.l.m.
Climatic Zone	B
Heating days	121
Wind speed	2.8 m/s
Wind zone	2
Province of	Messina - Reggio di Calabria

reference												
Average monthly temperatures(°C)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	11.7	12.0	13.2	15.7	19.2	23.5	26.4	26.5	24.2	20.3	16.6	13.3
Averages monthly raditions (MJ/m²)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	7.2	10.8	15.2	20.3	24.4	27.3	27.2	24.6	19.0	12.9	8.9	6.6
	10.8	12.9	12.9	11.5	9.9	9.2	9.7	11.8	14.0	14.2	13.2	10.3
	8.6	11.1	12.7	13.6	13.6	13.8	14.3	15.3	14.9	12.6	10.7	8.2
	5.4	7.9	10.5	13.4	15.6	17.1	17.2	16.2	13.1	9.3	6.7	5.0
	2.7	4.2	6.6	9.7	12.5	14.5	14.1	11.8	8.2	5.1	3.2	2.4
	2.4	3.2	4.3	5.9	8.4	10.2	9.5	6.8	4.6	3.6	2.6	2.2

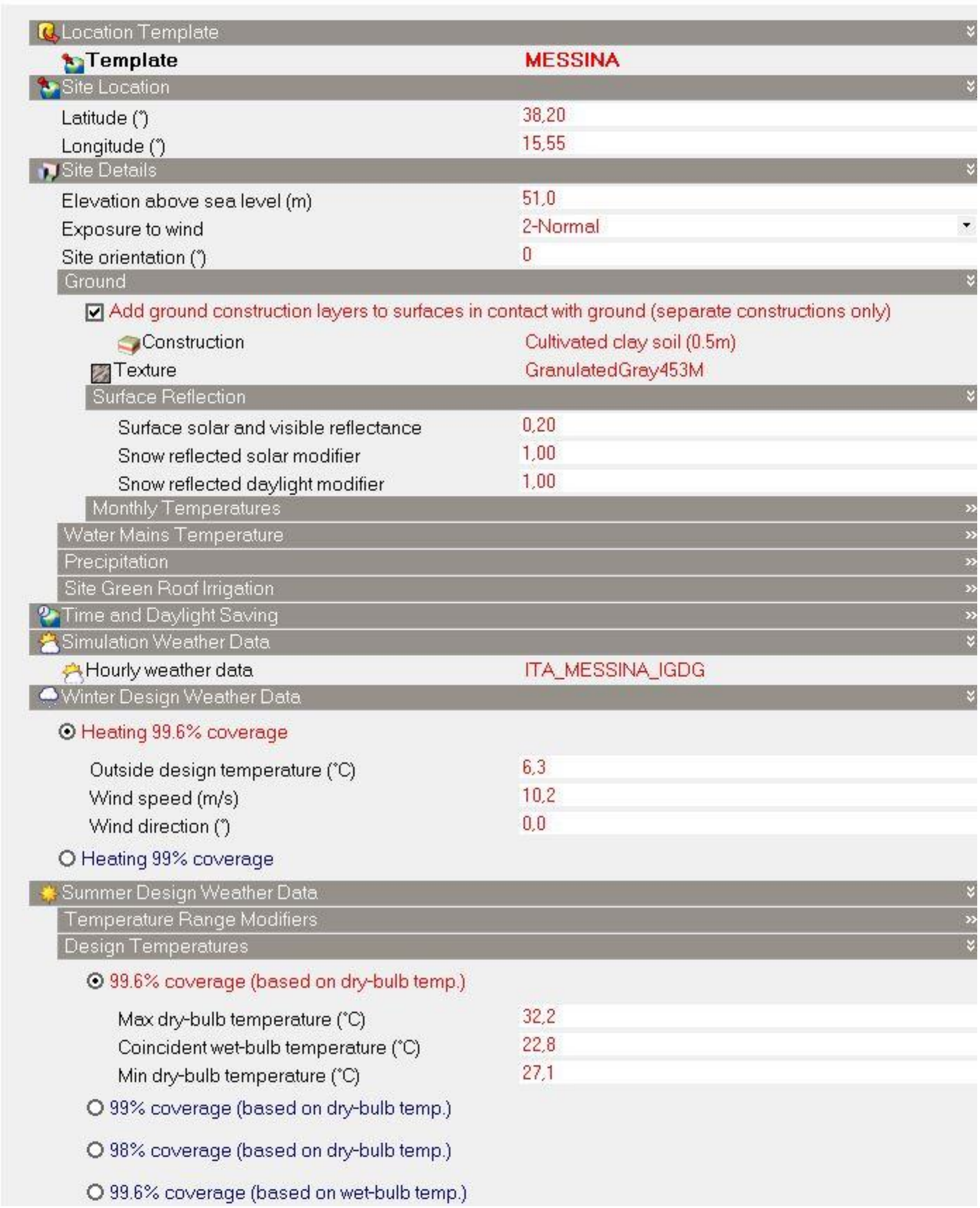


FIGURE 216 - DATA FOR THE SIMULATION WITH DESIGN BUILDER SOFTWARE

17.2. Shape And Orientation

This building is constituted of 5 floors above ground. The dimensions are the same for each floor.

17.3. Area And Volume

The building has a total area of about 6,870 m^2 (about 1,350 m^2 to plan) and a volume of about 18,550 m^3 .

17.4. Current Use

Palazzo Satellite is a municipal building, in which there are multiple functions of public utility.

On the ground floor is access to the building and also a hall and reception. All rooms are now used as municipal offices, with the exception of bathrooms and deposits.

FIGURE 217 - GROUND FLOOR

On the first floor there are the same functions as for the others floors except ground floor, in which there are also some retail areas (stores).

The basement floor has small rooms and many of them are intended for systems and server rooms.

The building usually has occupation between 0h00 and 24h00 from Monday to Sunday, because of the municipal police management, but the public activities of employees are carried out only between 7h30 and 19h30. Public access depends on the type of service provided and is between 08h30 and 13h30 from Monday to Friday, also between 14h30 and 16h30 on Tuesday and Thursdays.

The building has about 200 employees and it is visited by an indeterminate number of public.

For the simulation of Palazzo Satellite with Design Builder software, the building was divided into 5 blocks (named 1,2,4,5).

The size of the windows are not optimal but has been dimensioned according to the percentage of openings per square meter of wall surface, i.e. the building originally meant for housing.

The following image shows the Home screen of the software.

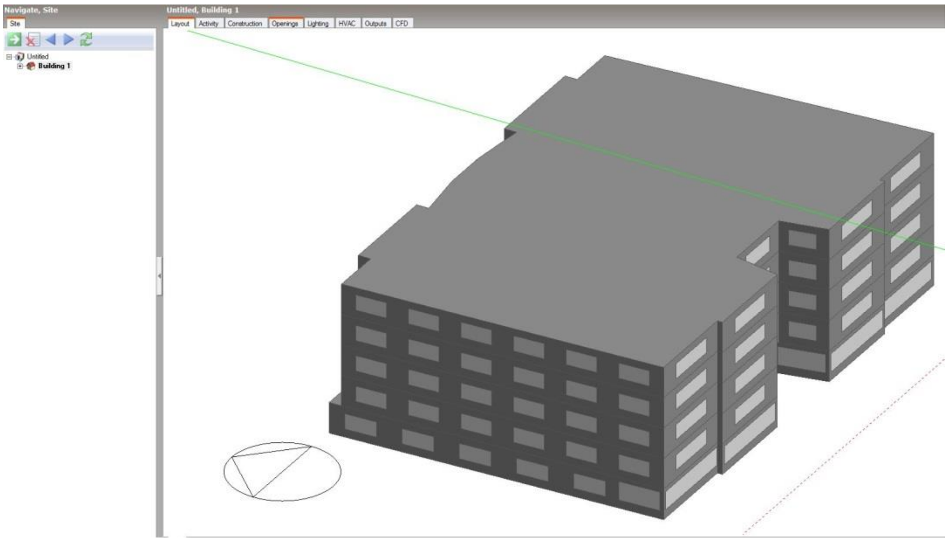


FIGURE 218 - HOME SCREEN OF THE SOFTWARE

The following figures show floor plans of the blocks, as shown in the simulation software. Floors are divided into different areas, depending on the intended use and different usage profiles were created for each area.

For the Palazzo Satellite there are: block 1 refers on the first floor, block 2 on the second floor, block 3 on the third floor, block 4 on the fourth floor and block 5 on the ground floor.
For Block 1 it has:

- Satellite Office Typical
- Satellite Circulation
- Satellite Unoccupied area
- Satellite Office Toilet

FIGURE 219 - PLAN OF BLOCK 1

For Block 2 it has:

- Police Office Typical
- Satellite Circulation
- Satellite Unoccupied area
- Satellite Office Toilet

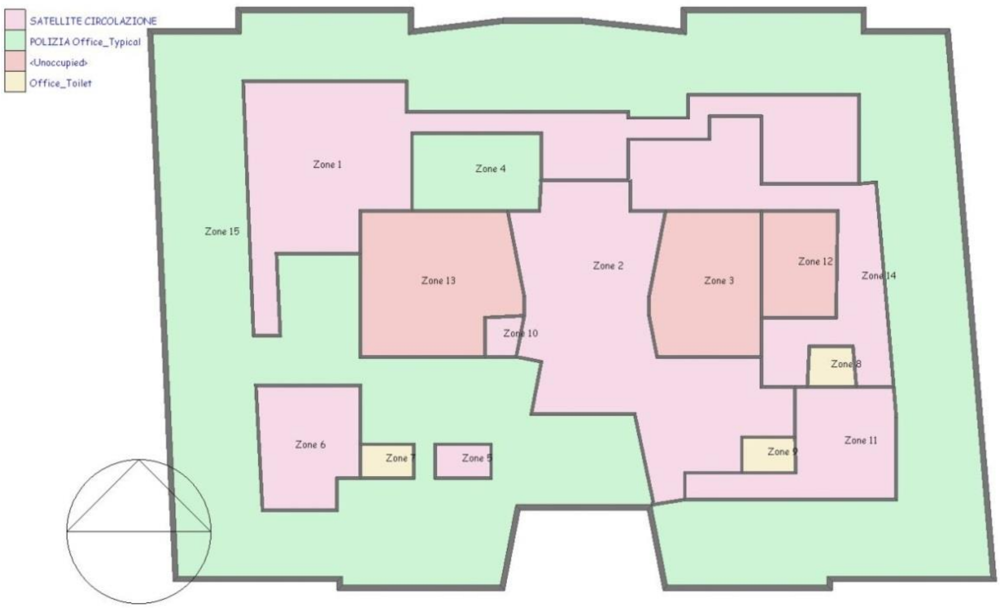


FIGURE 220 - PLAN OF BLOCK 2

For Block 3 it has:

- Satellite Office Typical
- Satellite Circulation
- Satellite Unoccupied area
- Satellite Office Toilet

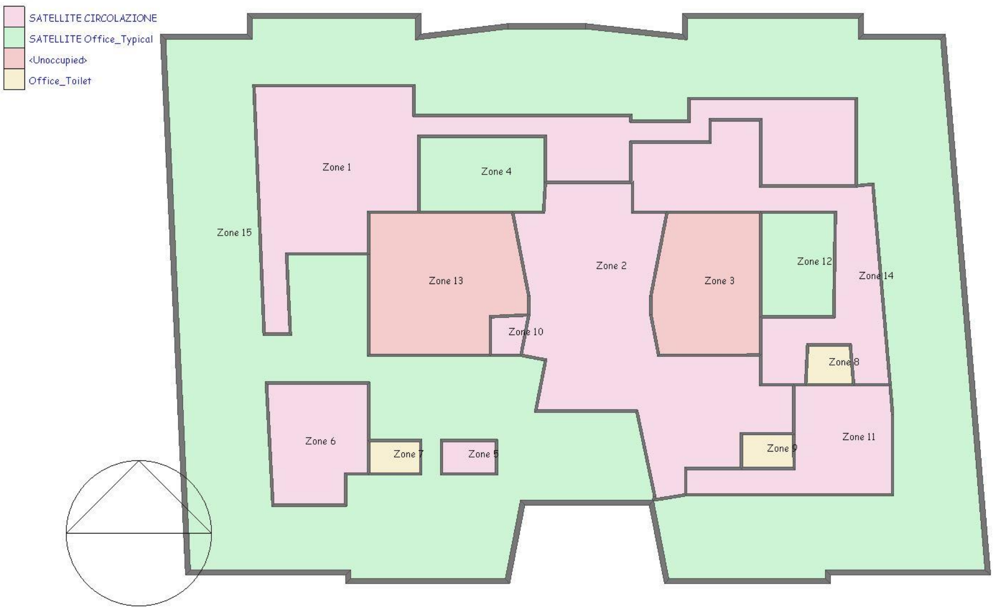


FIGURE 221 - PLAN OF BLOCK 3

For Block 4 it has:

- Satellite Office Typical
- Satellite Circulation
- Satellite Unoccupied area
- Satellite Office Toilet

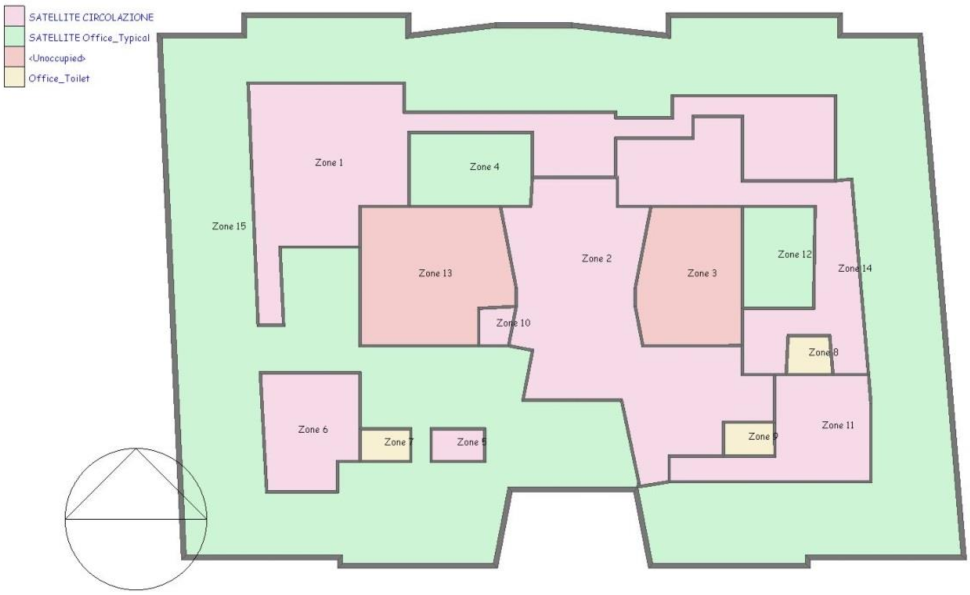


FIGURE 222 - PLAN OF BLOCK 4

For Block 5 it has:

- Satellite Office Typical and Police Office Typical
- Satellite Circulation
- Satellite Unoccupied area
- Satellite Office Toilet
- Retail

FIGURE 223 - PLAN OF BLOCK 5

18. CURRENT BUILDING CONDITIONS

18.1. CONSTRUCTIVE BUILDING CHARACTERISTICS

Palazzo Satellite observes the seismic codes. The building structure was built according to the frame system in reinforced concrete, commonly used for Messina buildings.

Not much information have been found on the original design of the building, because it was built by a private contractor and then sold to the municipality, which has made it a public building.

18.1.1. ENVELOPE ELEMENTS

For the modeling of the actual state of the building a template is defined for the characteristics of the building envelope. The template is divided into internal partitions (vertical and horizontal), external partitions (opaque and glazed).

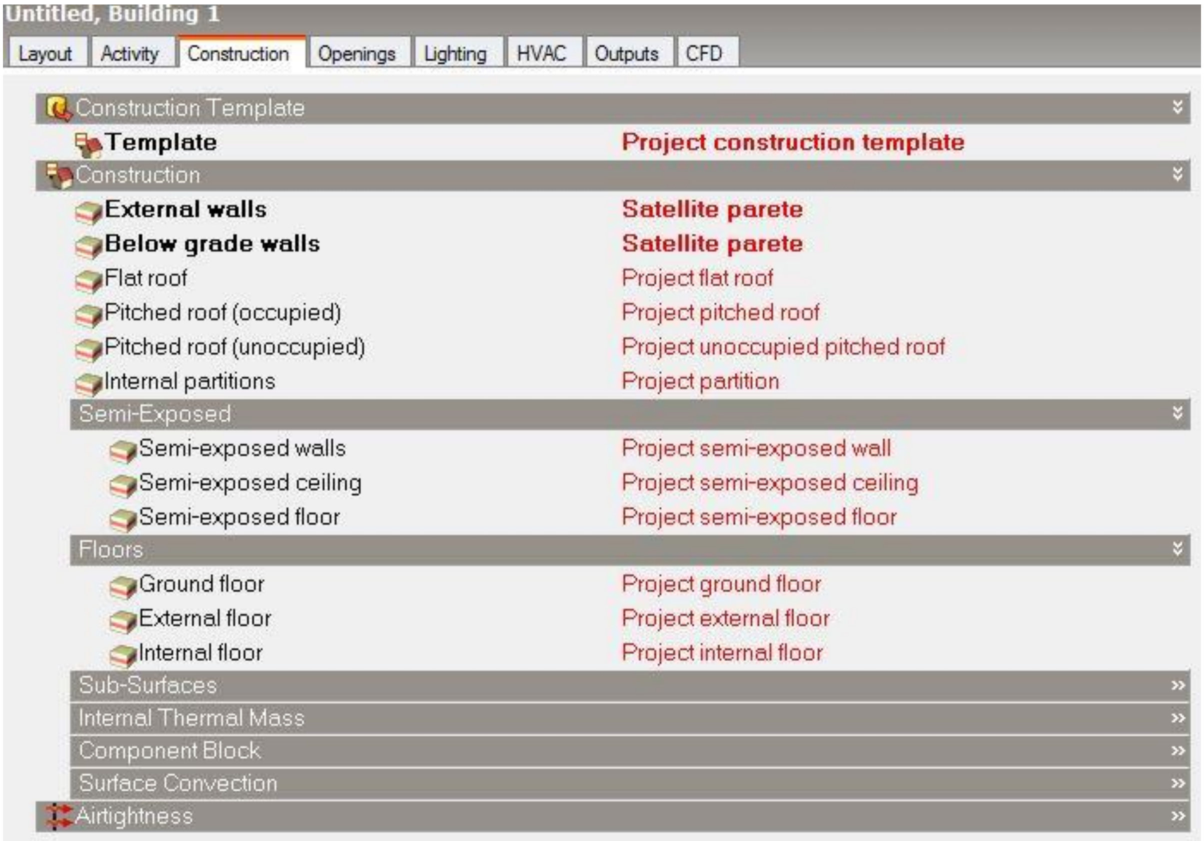


FIGURE 224 - CONSTRUCTION TEMPLATE

Following figure shows the characteristics of the partitions (external and some of internal).

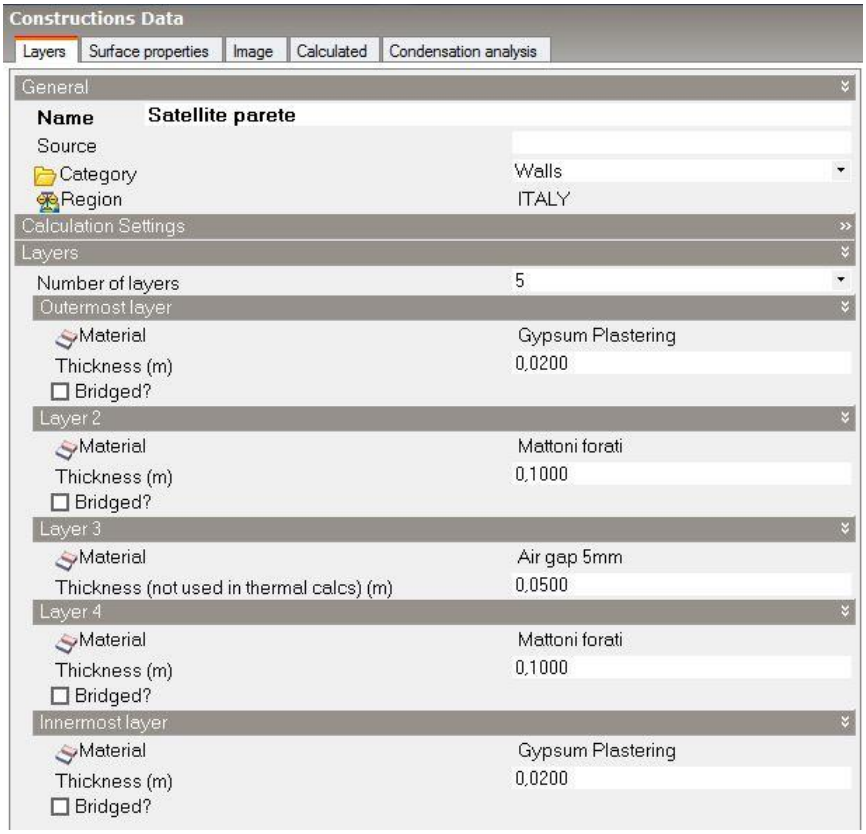


FIGURE 225 - CONSTRUCTION DATA OF PARTITION

18.1.2. WINDOWS

All the windows have single glazing with aluminium frames. The doors have the same characteristics as the windows with the exception of some doors on the ground floor, which are only in metal.

FIGURE 226 - DOOR ON THE GROUND FLOOR

All the windows have rolling shutters in PVC. Only some rooms have transparent cloth curtains, light in color.

FIGURE 227 - WINDOWS WITHOUT SHUTTERS

The fixed shading is ensured by other building in Via Tommaso Capra, by the evergreen trees in Via La Farina. The front façade on Repubblic Square is subject to some shading, as can be seen from the following figure.

FIGURE 228 - EUROPEAN UNION SQUARE

The windows of the ground floor are the same as for other floors.

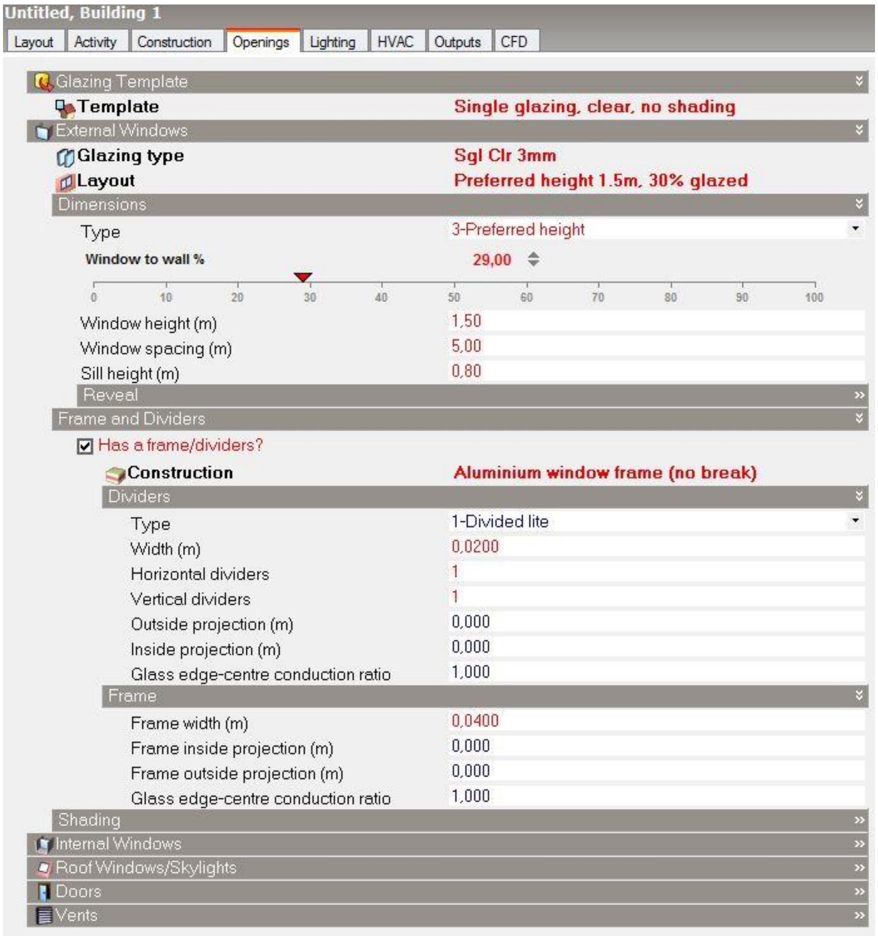


FIGURE 229 - GLAZING TEMPLATE

18.1.3. Airflows and Pathologies

A previous study analysed the envelope with thermal imaging with an external air temperature of about 17°C.

The following figure shows the general image of the thermal performance of the envelope. As can be seen the walls present a good thermal performance.

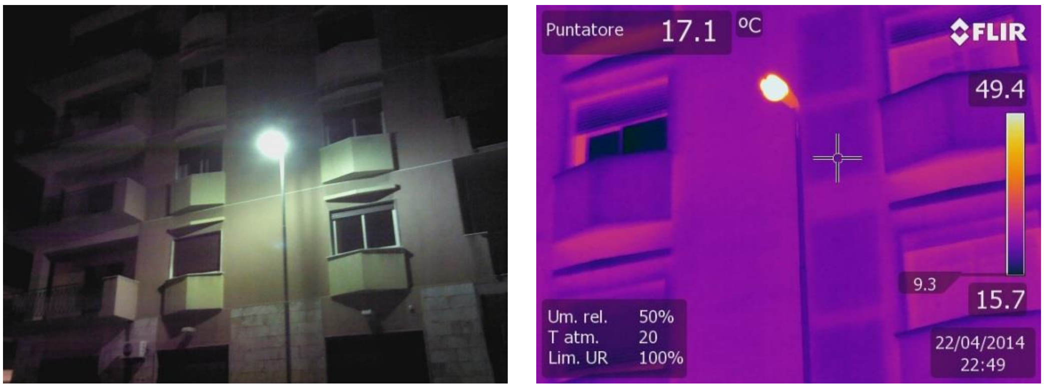


FIGURE 230 - THERMAL VIEW

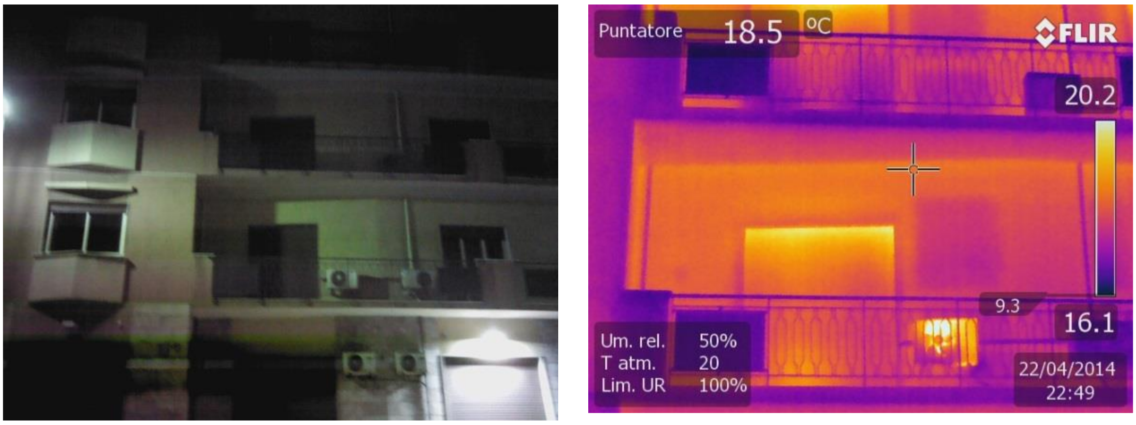


FIGURE 231 - THERMAL VIEW

The following figure shows the thermal losses in the windows. The windows, with single glazing with aluminium frames, present insulation problems, aggravated by aging.

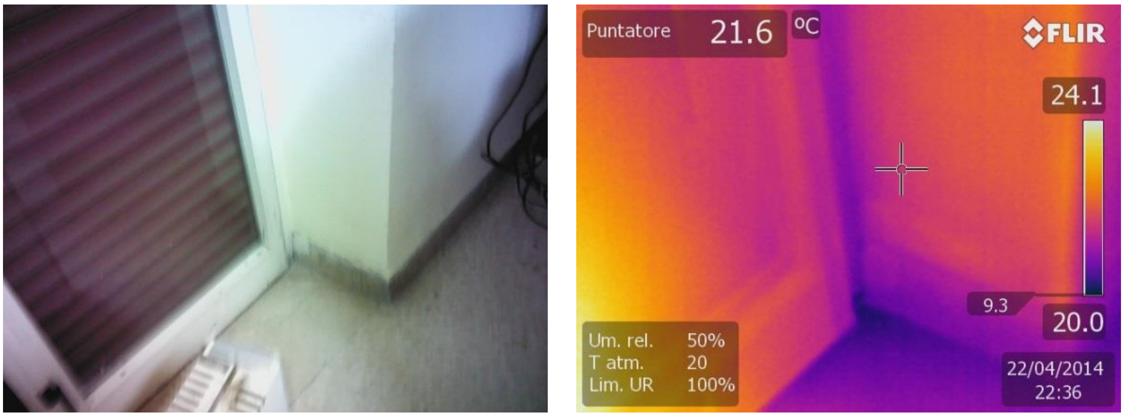


FIGURE 232 - THERMAL LOSSES IN THE WINDOWS AND WINDOW INVISIBLE TO THE NAKED EYE

This figure shows the thermal losses due to thermal bridges in the corner of the room.

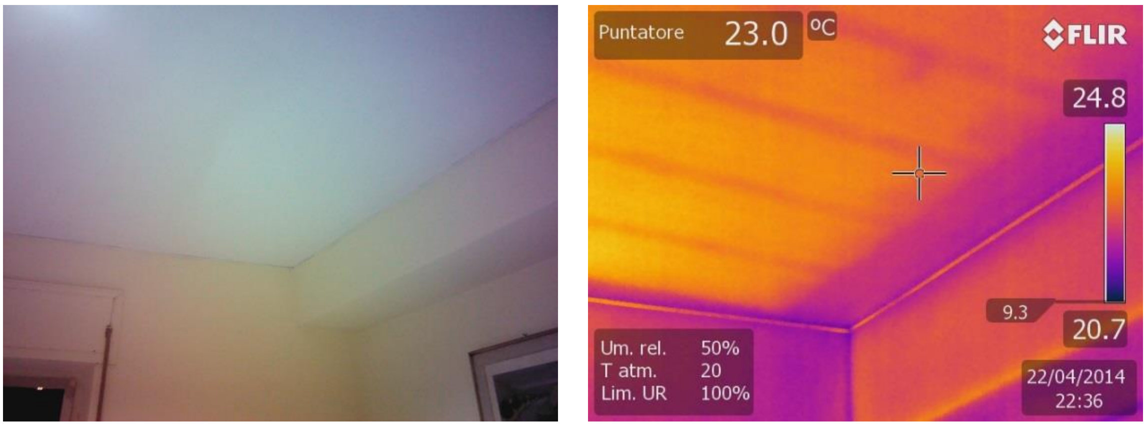


FIGURE 233 - THERMAL BRIDGES

Some characteristics of the building contribute to a bad thermal performance:

- The orientation is not optimal, requiring additional energy consumption with heating during the winter (mainly in the north areas) and with cooling during the summer (mainly in the west areas without any direct protection from the direct radiation).
- The walls with high thermal inertia and large ceiling height provide advantages during the summer, but disadvantages during winter, since the building does not have users in the night period and weekends which leads to a high temperature decrease.
- The windows have bad leak tightness, enabling a high level of air infiltration, which is not controllable and undesirable, mainly during the winter.
- The doors are old and poorly insulated.
- The building presents many pathologies, such as condensation or mould growth.

18.2. Energy Systems

18.2.1. HVAC

The HVAC is ensured with several heat pumps, which were installed gradually over the years. Therefore, there are several types of equipment with different characteristics and performance. In total, there is at least one split in every room and the total number is summarized in the following table.

FIGURE 234 - THERMOGRAPHY OF AN AIR CONDITIONER ON

Almost all the areas of permanent use have HVAC, where the control is local with units of individual control.

TABLE 69 - HEAT PUMPS CALCULATION

Heat Pumps calculation		
Thermal Power BTU/H	9,000	12,000
Ground Floor	10	24
First Floor	4	29
Second Floor	8	28
Third Floor	3	30
Fourth Floor	4	30
Total	**29**	**141**

The air circulation and renewal is ensured naturally through the doors and windows. There are no systems of forced ventilation in rooms.

18.2.2. Lighting

The building has the same types of fluorescent lamps in all rooms and they are adjacent to the ceiling.

FIGURE 235 - LIGHTING IN CIRCULATION AREA

There is no mechanism to control lighting and plants are dated. During hours when the building is not open to the public there are only lamps for emergency lighting.

TABLE 70 - LAMPS CALCULATION

LAMPS CALCULATION				
LAMPS	*2X18*	*4X18*	*2X36*	*2X58*
Basement Floor	3	2	43	
Ground Floor	49	7	21	17
First Floor	49	5	22	3
Second Floor	47	5	33	3
Third Floor	46	5	34	3
Fourth Floor	46	5	35	3
Emergency stairs		20		
Total	**240**	**49**	**188**	**29**

18.2.3. ICT

Most of the offices and rooms have computers and printers and there is a room with servers and an internal circuit for building security.

There are photocopier machines, tv screens, video projectors in some rooms and equipment for the exclusive use of the bar.

18.2.4. OTHERS

The building has 3 lifts. The usage rate of lifts is high since they serve rooms with a significant amount of public and employee visits. In the calculation of the energy consumption, the contribution of the 3 lifts are, however negligible.

Lifts and other small appliances connected to plugs such as individual electric heaters, vending machines, photocopier machines, computers and printers (when not connected to the UPSs), etc. were considered as "others" in the modelling.
For calculating their consumption usage profiles have been created directly through the Design Builder software.

18.3. Energy Consumption & Energy Generation

18.3.1. Electricity Consumption

The building receives electricity in Low Voltage. Following a summary table of power consumption.

TABLE 71 - ELECTRICITY CONSUMPTION

ELECTRICITY CONSUMPTION	kWh per year 2013	kWh per year 2012	kWh per year 2014
Republic Square, 1 - Messina			Survey performed on days in mid-June in 2014. Average consumption with average outdoor temperatures of 27 C during operation.
IT001E96239138	9,143 kWh	4,187 kWh	
IT001E96239124	711 kWh	0 kWh	
IT001E96239123	1,482,357 kWh	1;500,548 kWh	

There is not a central unit for heating and cooling, but there are many emission systems (split), different in shape, performance, brand and model.

To set the calculation of the model the general information fixed are:

TABLE 72 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	** Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	6,874.93
Principal Heating Source	District Heating

TABLE 73- UTILITY USE PER CONDITIONED FLOOR AREA

	Electricity Intensity [kWh/m2]	Natural Gas Intensity [kWh/m2]	Additional Fuel Intensity [kWh/m2]	District Cooling Intensity [kWh/m2]	District Heating Intensity [kWh/m2]	Water Intensity [m3/m2]
Lighting	136.10	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	126.16	1.29	0.02
Other	35.46	0.00	0.00	0.00	0.00	0.00
Total	171.56	0.00	0.00	126.16	1.29	0.02

TABLE 74 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/m2]	Natural Gas Intensity [kWh/m2]	Additional Fuel Intensity [kWh/m2]	District Cooling Intensity [kWh/m2]	District Heating Intensity [kWh/m2]	Water Intensity [m3/m2]
Lighting	124.00	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	114.95	1.17	0.02
Other	32.31	0.00	0.00	0.00	0.00	0.00
Total	156.31	0.00	0.00	114.95	1.17	0.02

TABLE 75 - END USE CONSUMPTION

	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.00	0.00	2,714.76	0.00
Cooling	0.00	0.00	0.00	790,256.80	0.00	0.00
Interior Lighting	852,503.17	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	222,119.61	0.00	0.00	0.00	0.00	0.00
Water Systems	0.00	0.00	0.00	0.00	5,349.45	143.97
Refrigeration	0.00	0.00	0.00	0.00	0.00	0.00
Generators	0.00	0.00	0.00	0.00	0.00	0.00
Total End Uses	1,074,622.78	0.00	0.00	790,256.80	8,064.20	143.97

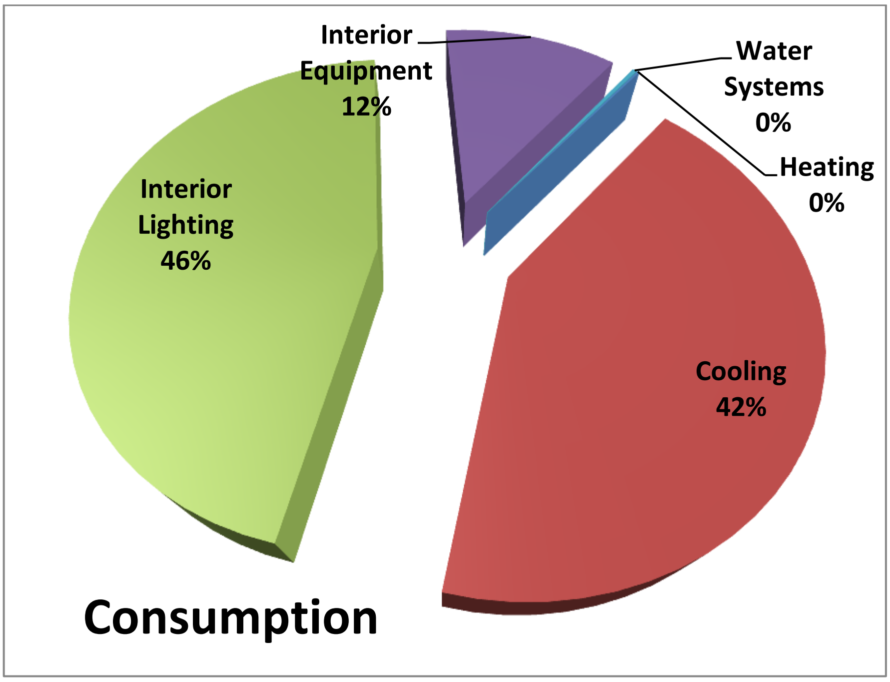


FIGURE 236 - DISAGGREGATION OF ELECTRICITY CONSUMPTION BETWEEN USES

The following figures shows the heat balance of Palazzo Zanca,divided according to the contributions:

- General Lighting,
- Computer + Equipment,
- Occupancy,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

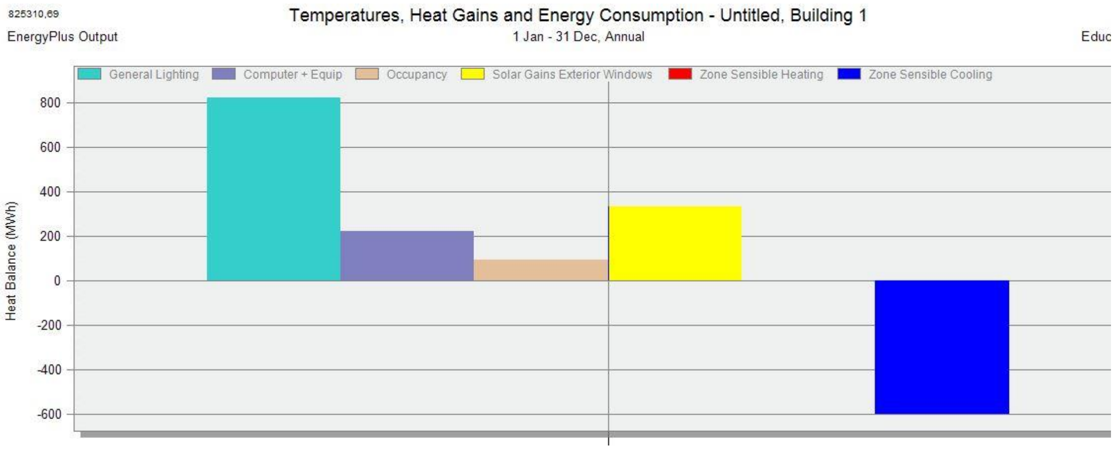


FIGURE 237 - ANNUAL HEAT BALANCE

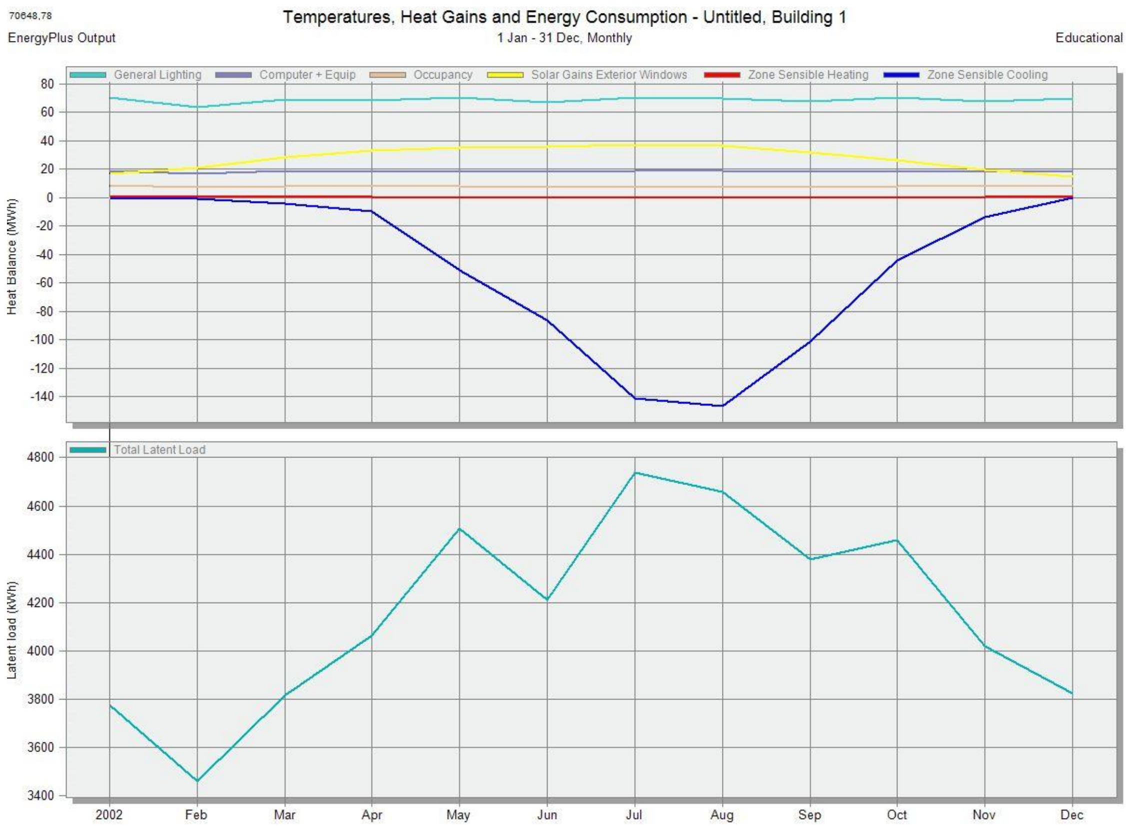


FIGURE 238 - ANNUAL HEAT BALANCE, ACCORDING OF SINGLE MONTHS

Two following figures shows monthly total fuel use of Palazzo Zanca, divided according to the contributions:

- Room Electricity,
- Lighting,
- Auxiliary Energy,
- Heating (Electricity),
- Cooling (Electricity).

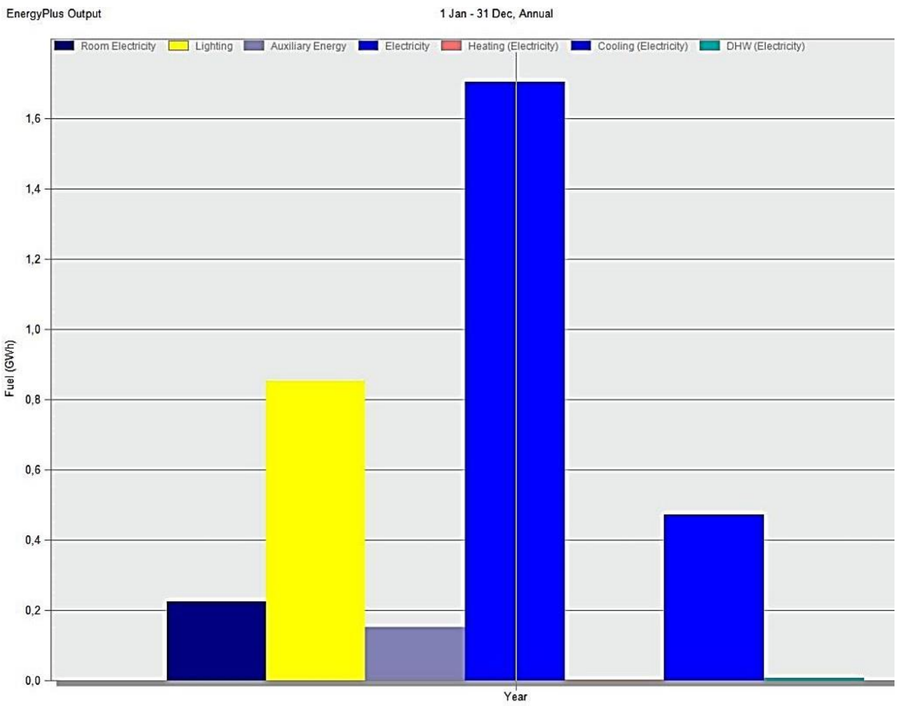


FIGURE 239 - ANNUAL USE OF FUEL TOTAL

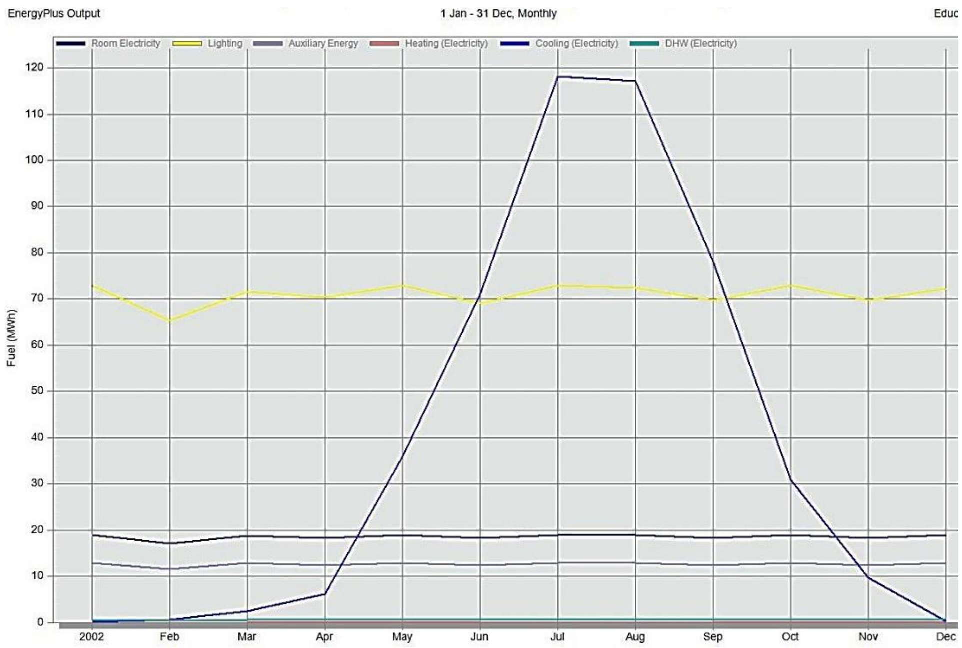


FIGURE 240 - MONTHLY USE OF FUEL TOTAL

Four following figures shows heat balance of Palazzo Zanca, divided according to the contributions, during four months in particular January, April, July and September:

- General Lighting,
- Computer + Equipment,
- Occupancy,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

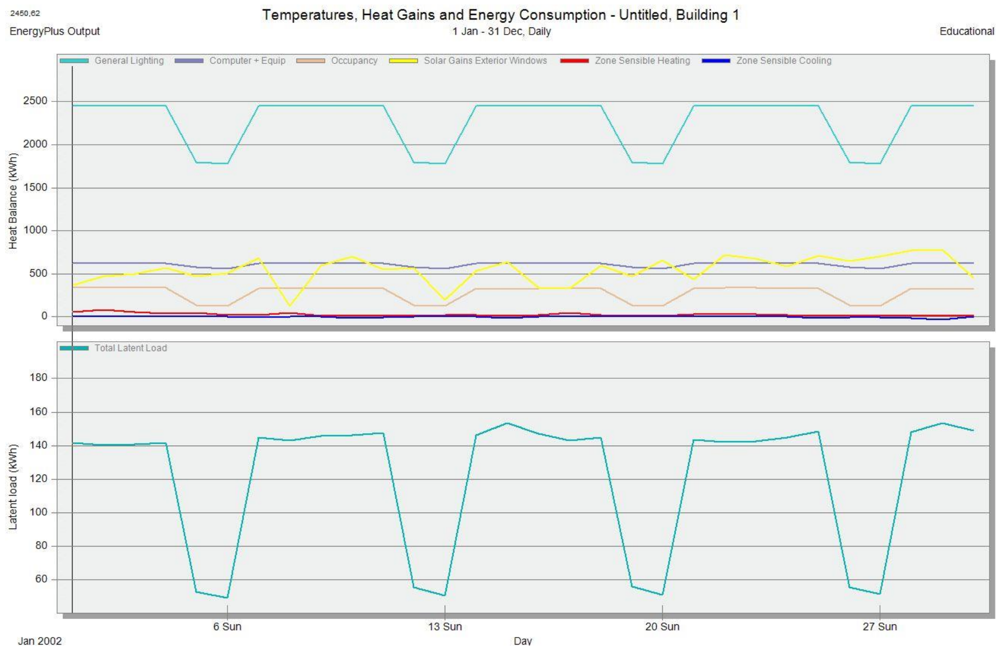


FIGURE 241 - HEAT BALANCE DURING JANUARY

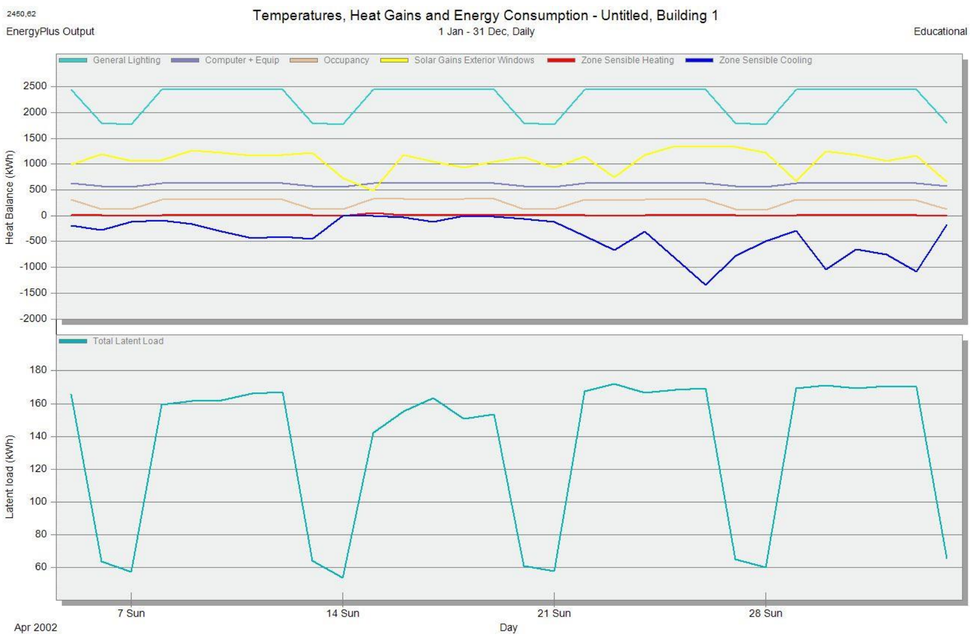


FIGURE 242 - HEAT BALANCE DURING APRIL

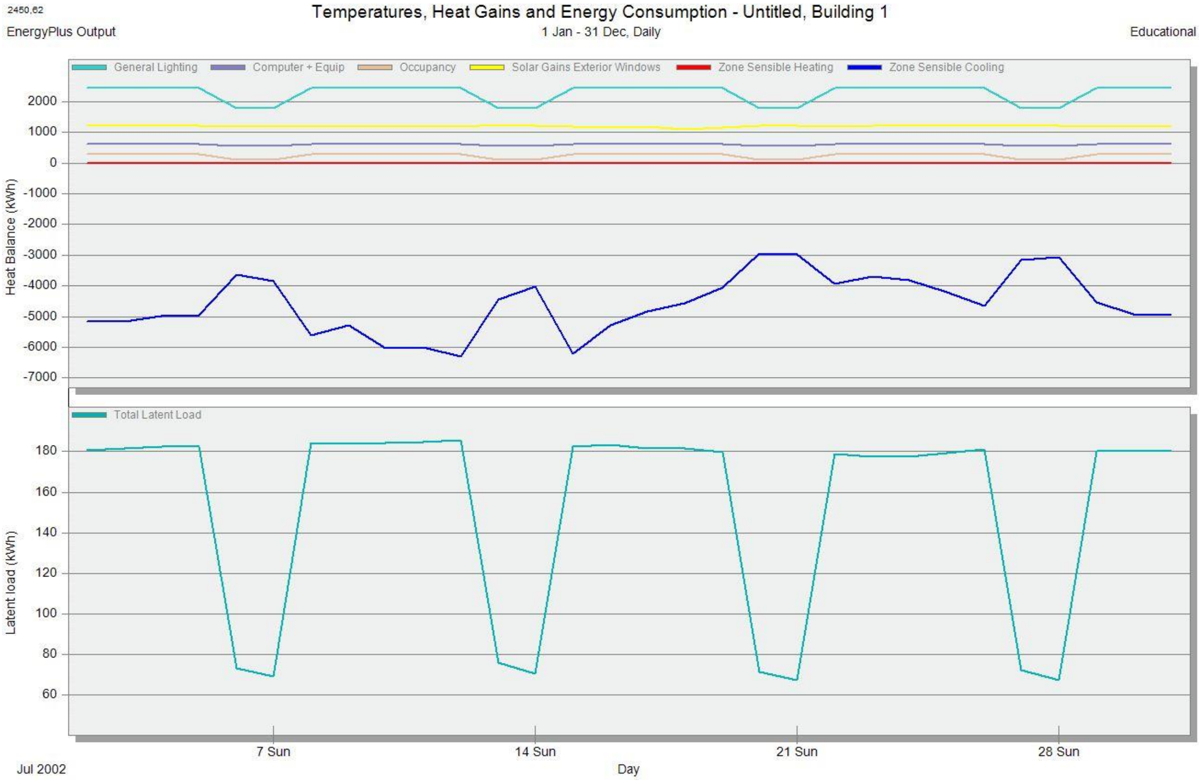


FIGURE 243 - HEAT BALANCE DURING JULY

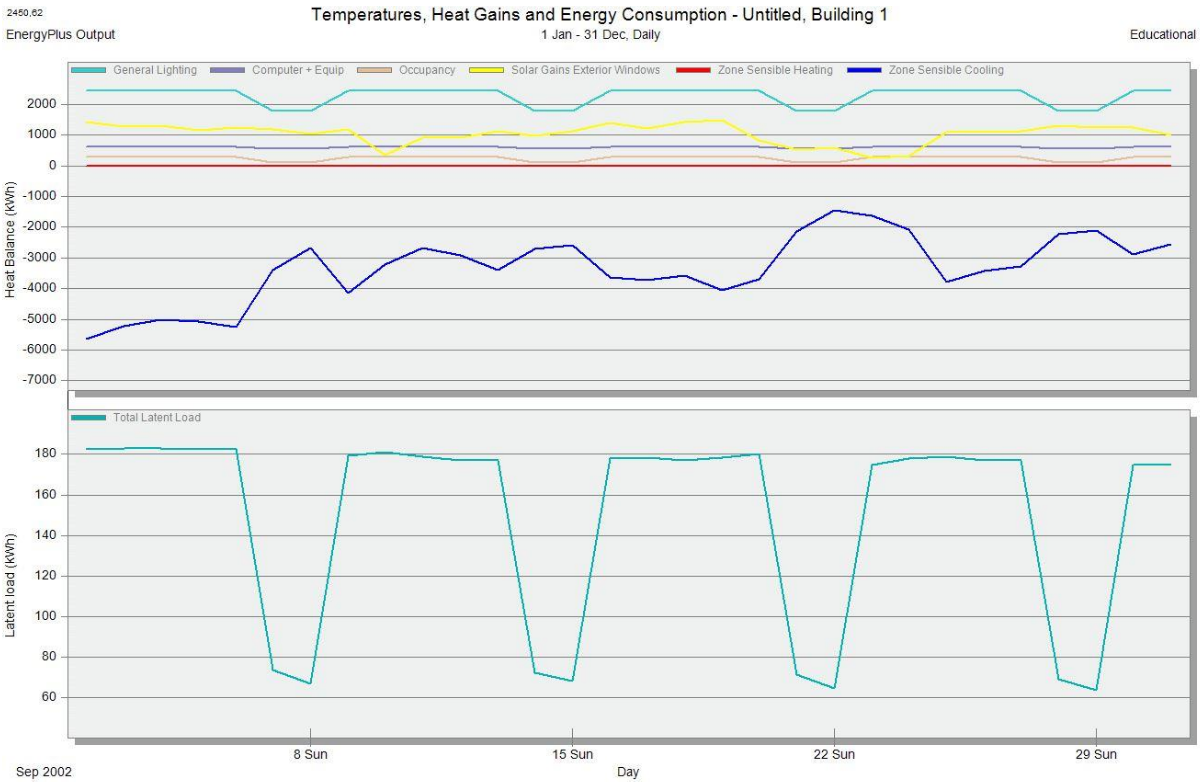


FIGURE 244 - HEAT BALANCE DURING SEPTEMBER

18.3.2. Gas/Oil Consumption

The building does not have any gas consumption.

18.3.3. Renewable Energy Sources

The building does not have any RES plant.

18.3.4. Other Generation

Other data that influence thermal balance come from building envelope.

Considered data are:

- Glazing
- Walls
- Ceilings (internal)
- Floors (internal)
- Ground floors
- Partitions (internal)
- Roofs
- Floors (external)
- External infiltration
- External ventilation

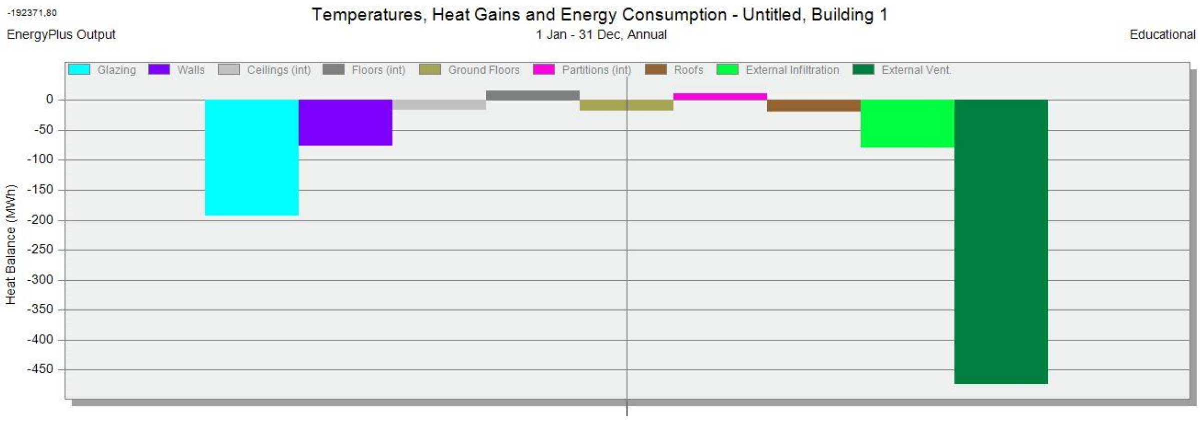


FIGURE 245 - ANNUAL HEAT BALANCE (FABRIC AND VENTILATION)

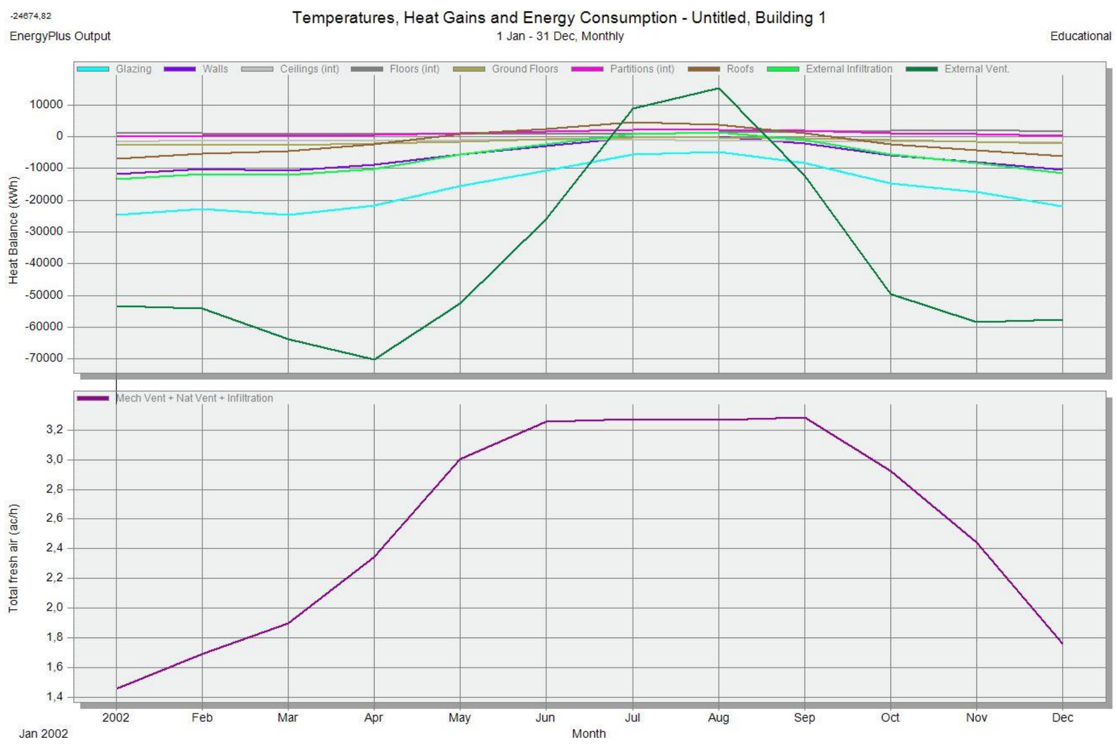


FIGURE 246 - ANNUAL HEAT BALANCE (FABRIC AND VENTILATION), ACCORDING OF SINGLE MONTHS

Four following figures shows heat balance (fabric and ventilation) of Palazzo Zanca, divided according to the contributions, during four month in particular January, April, July and September.

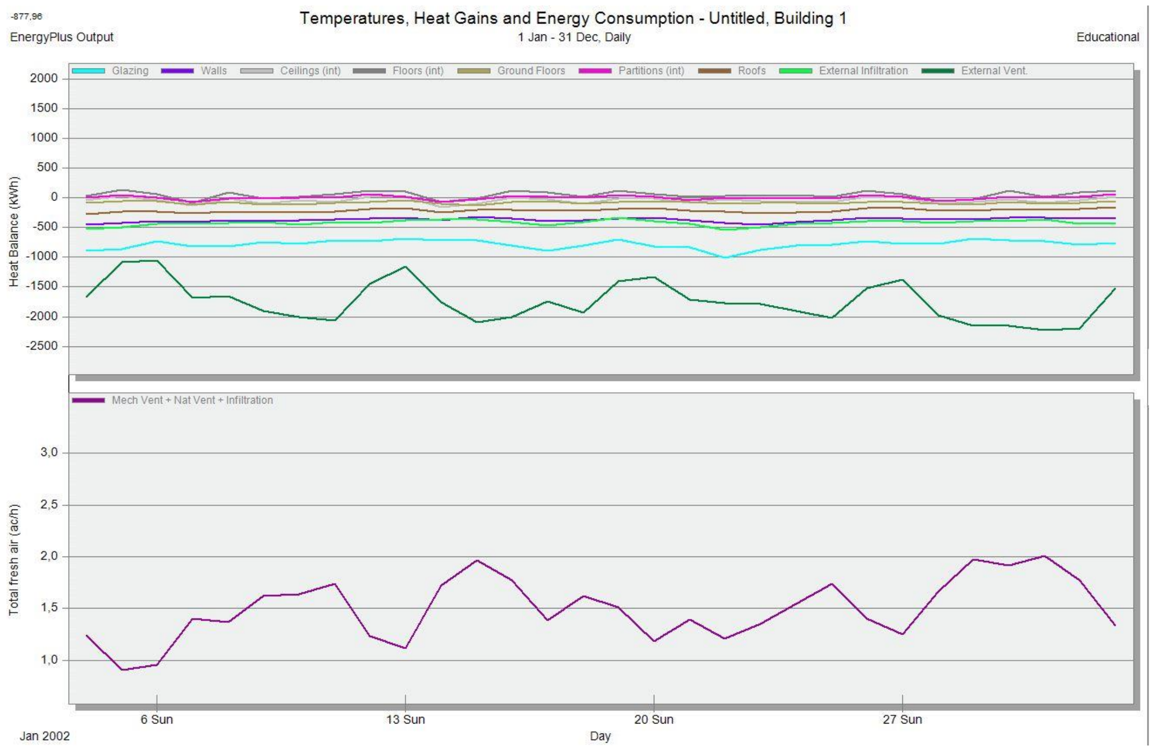


FIGURE 247 - HEAT BALANCE DURING JANUARY (FABRIC AND VENTILATION)

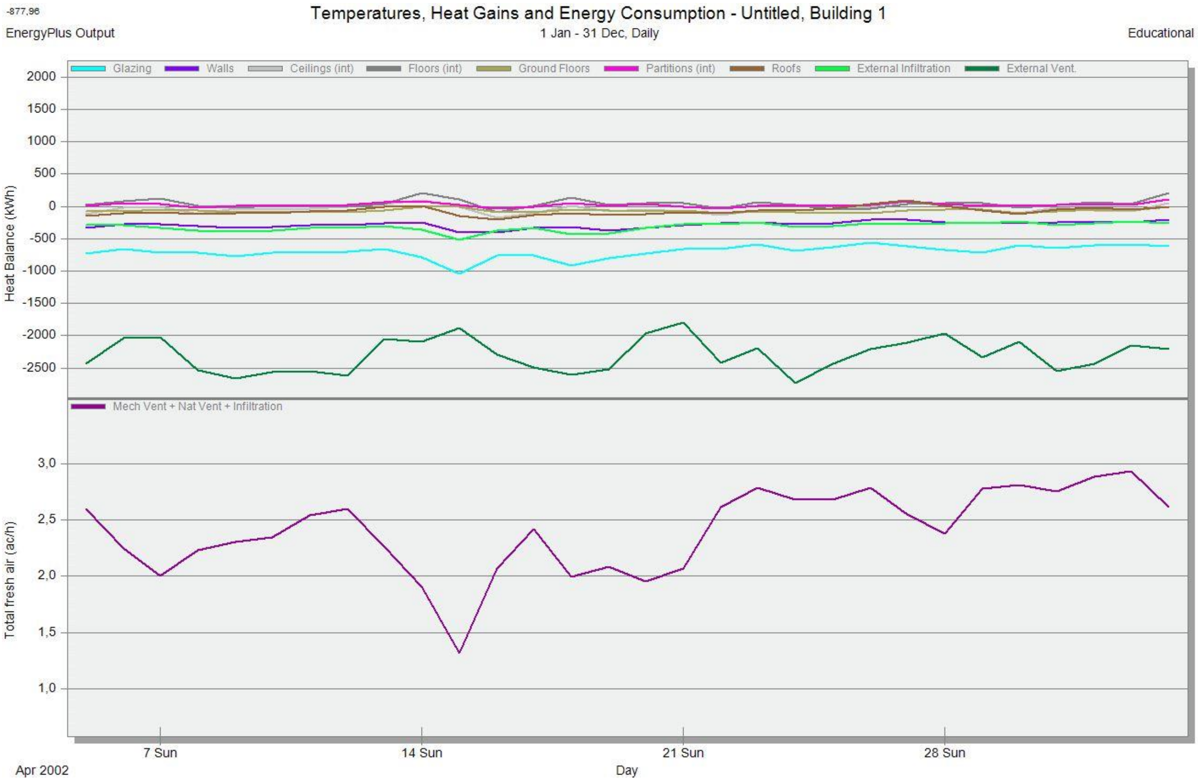


FIGURE 248 - HEAT BALANCE DURING APRIL (FABRIC AND VENTILATION)

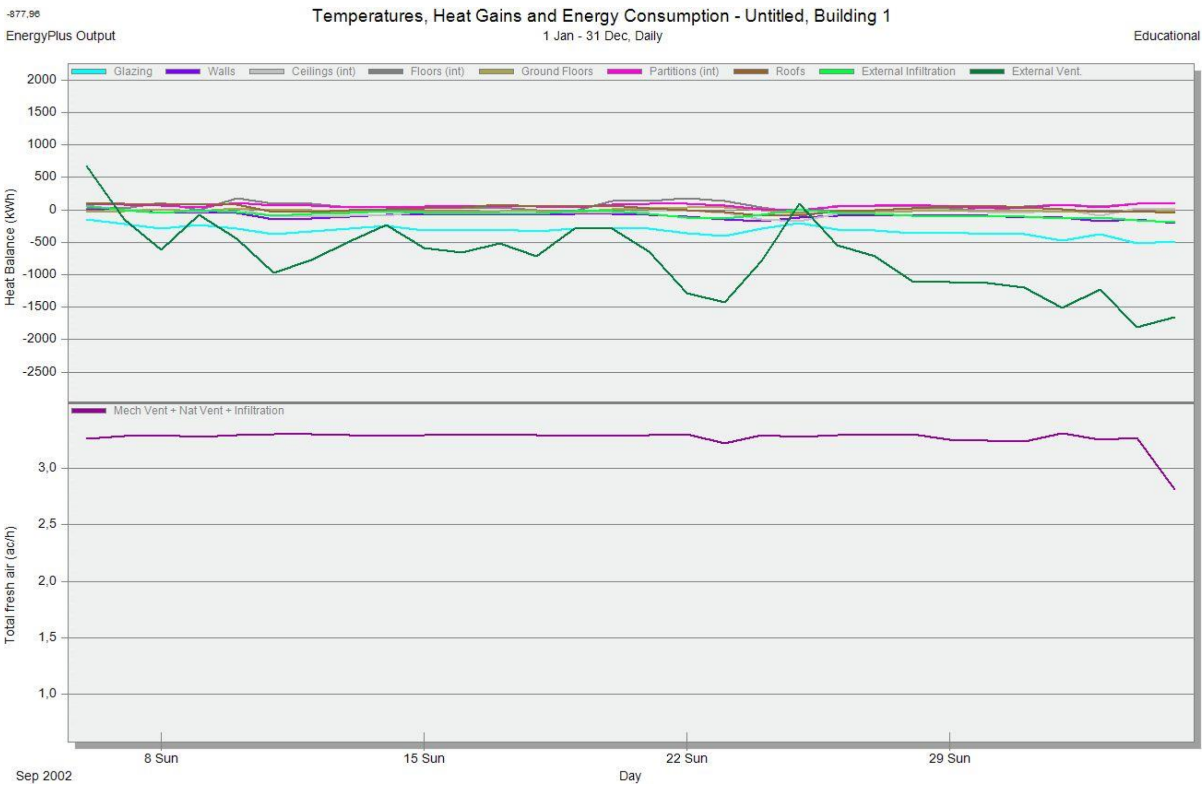


FIGURE 249 - HEAT BALANCE DURING SEPTEMBER (FABRIC AND VENTILATION)

18.3.5. Final energy consumption and CO_2 emissions

In this building you only have electricity consumption.

TABLE 76 - BUILDING AREA

	Area [m²]
Total Building Area	6,874.93
Net Conditioned Building Area	6,806.64
Unconditioned Building Area	68.29

As it can see in the section on electricity consumption are deduced the following data.

TABLE 77 - END USE CONSUMPTION

	Electricity [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m³]
Heating	0.00	0.00	0.07	0.00
Cooling	0.00	434,108.33	0.00	0.00
Interior Lighting	111,437.37	0.00	0.00	0.00
Interior Equipment	187,364.76	0.00	0.00	0.00
Water Systems			5,349.45	143.97
Total End Uses	298,802.13	434,108.33	5,349.45	143.97
Total	738,403.94			

Simulation shows that the building has electricity consumption of 738,403.94 kWh and below percentages are summarized percentages of individual consumption.

TABLE 78 - END USE PERCENTAGE

	Percent [%]
Interior Lighting	**15**
Heating	**1**
Cooling	**59**
Interior Equipment	**25**

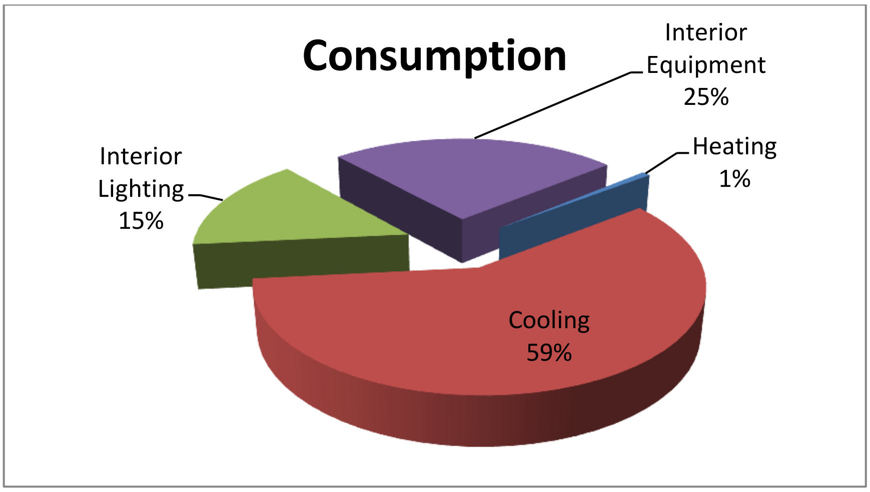


FIGURE 250 - DISAGGREGATION OF ELECTRICITY CONSUMPTION BETWEEN USES

The last Table presents the main energy parameters of the building which were considered as baseline. Such parameters were assessed considering the following conversion factors:

- electricity to primary energy - 2,174 (standard value approved for Italy);
- electricity to CO_2 emissions - 510,00 g/kWh (average emissions associated with the electricity consumed in Italy during 2012, according ENEL environmental report 2012);

19. RENOVATION SCHEME

19.1. AIM OF THE RENOVATION PLAN

In Italy, the nZEB (nearly zero energy buildings) don't meet national specific legislation but this is now being defined, according to Directive 2012/27/UE. NZEB design is aimed at achieving high performance standards in terms of energy and environment.

Specific attention should be devoted to the reduction of energy consumption of the building, guiding the design on three key areas:

- Maximizing the building envelope passive behaviour
- Use high efficiency systems
- Use of systems for the renewable thermal energy exploitation and photovoltaic systems for the electricity production from solar sources.

The aim is to minimize energy removal from external electricity grid. The objective of the renovation plan is to achieve an average primary energy reduction between 75% and 80% of the current demand and to ensure that between 50% and 90% of the consumed energy is generated.

A building envelope is called passive if it is conforms to the following values:

- Thermal transmittance very low (0,0167/0,227 W/m^2K)
- Low values of attenuation factor (<0,1), resulting in high phase shift values (>11,5 hours)
- Windows with transmittance less than 1,6 W/m^2K

- System efficiency that can reduce by 70% the maximum solar radiation on transparent surfaces.

To achieve these aims it should be considered if there are some difficulties or constraints in the implementation of a design that concerns the building.

The following global constraints were taken into account in the design of the renovation plan:

- The neighborhood is the core of an intense traffic flow hosts many activities including train station, bus station, port for transit trade and military port; so it is very important that the renovation of the building does not interrupt normal activities.
- The building has an intensive utilization, receiving a large number of visitors, and is the working place for a large number of Municipal employees and such activities cannot be interrupted since it is not easy to temporarily move the services to another building. Therefore, for renovation options requiring major construction works it will be necessary to draw up a renovation plan that takes into account the needs of both workers and visitors.

Integrations are planned distinctly to change the architecture of the building, but without changing the functions. An intervention difficult to predict was that relating to the new air conditioning system centralized to be included, because at the time the building does not have one , but there are only so many split air conditioner in each single room .

To achieve the goal of NZEB it is considered a methodology that would optimize the design considering energy efficiency, energy conservation, functionality, technological risks and actual costs. Under consideration is an electronic control system for heating, cooling and lighting.

The assumptions for improvement have been inserted using the Design Builder software that simulates with Energy Plus Databases. For Satellite Palace, considering the environmental conditions of Messina, the main energy consumption is by the use of electricity for cooling in summer period, therefore it was decided to insert solutions also covering a constant ventilation of the building.

19.2. Energy Demand Reduction

19.2.1. Opaque Envelope

An important role in the renewal plan is targeted to the building envelope. Among the actions planned, there is the facade renovation, it is planned to ensure the safety of unsafe parts (eg parapets unsafe) and, where necessary, to do an important refurbishment. Another change concerns the reconstruction of the plaster of the facades, using a thermal insulation plaster. There are plasters with better performance but with the same texture and the same color of plaster used previously.

Obviously it is expected to remove from prospects all compressors present and restore the facades in its entirety; envelope treated with these plasters reduces their thermal transmittance.

Among other interventions there is waterproofing of the roof, so it is expected to enter under the floor of a fiber-reinforced bituminous membrane.

FIGURE 251 - SATELLITE DESIGN

19.2.2. OPENINGS

At the state of fact, all windows are in single glass with metal frame. It is expected to replace all windows of Satellite Palace, inserting selective glasses and modifying PVC frames.
It is also important to study new form of glass to optimize reflective surface.

FIGURE 252 - ACTUAL REFLECTIVE SURFACE IN CIRCULATION AREA

FIGURE 253 - ACTUAL WINDOW AT FIRST FLOOR

FIGURE 254 - ACTUAL REFLECTIVE SURFACE IN OFFICES

Regarding the frames is chosen to include window frames with a thermal break , in this case the value of frame transmittance (U_f) significantly improves. It is however chosen for the simulation that provides for total replacement of the old frames. It is chosen to use windows with PVC frames. Glasses chosen are selective double glazing with air chamber 6/13 mm.

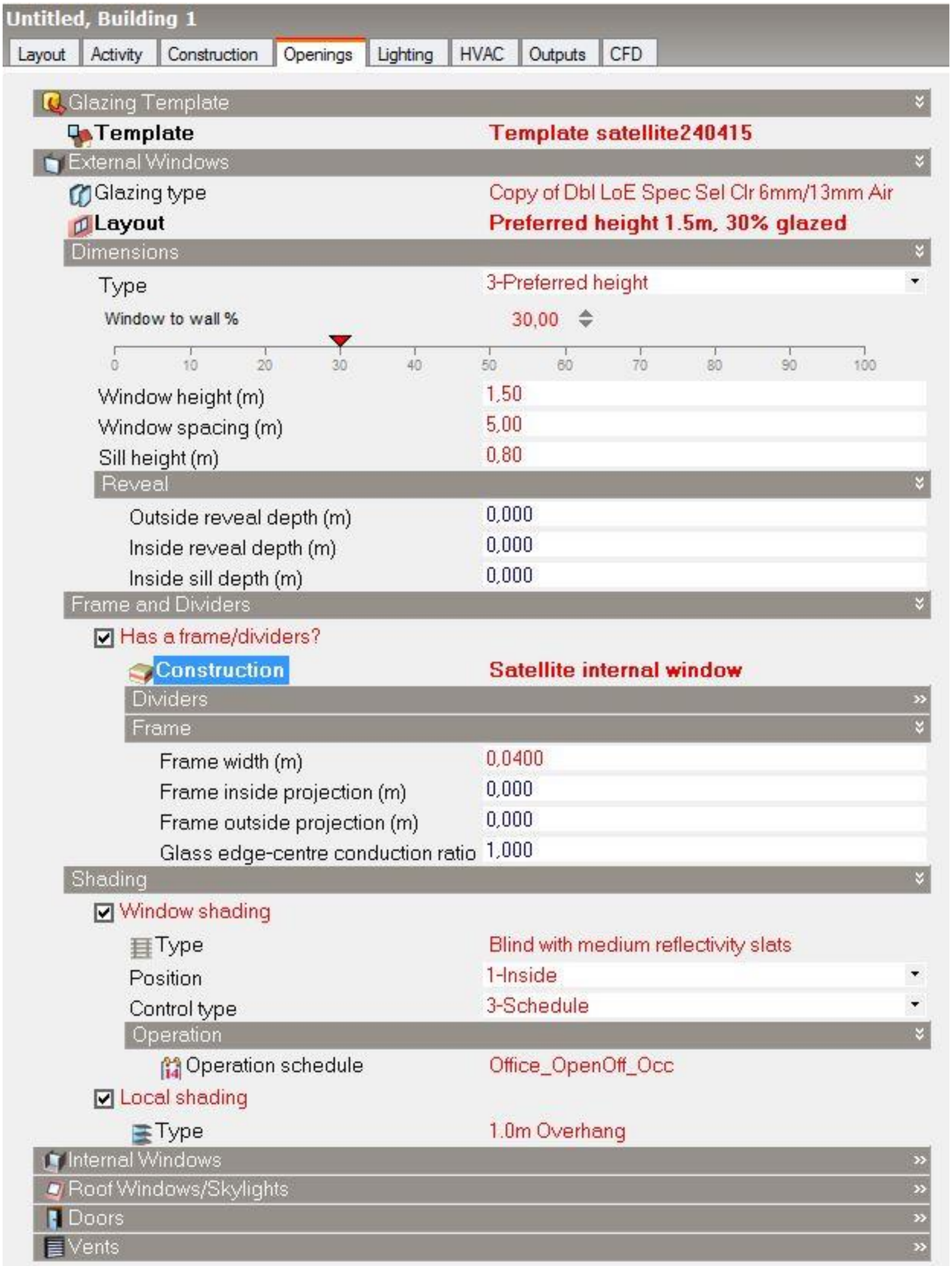


FIGURE 255 - GLAZING TEMPLATE

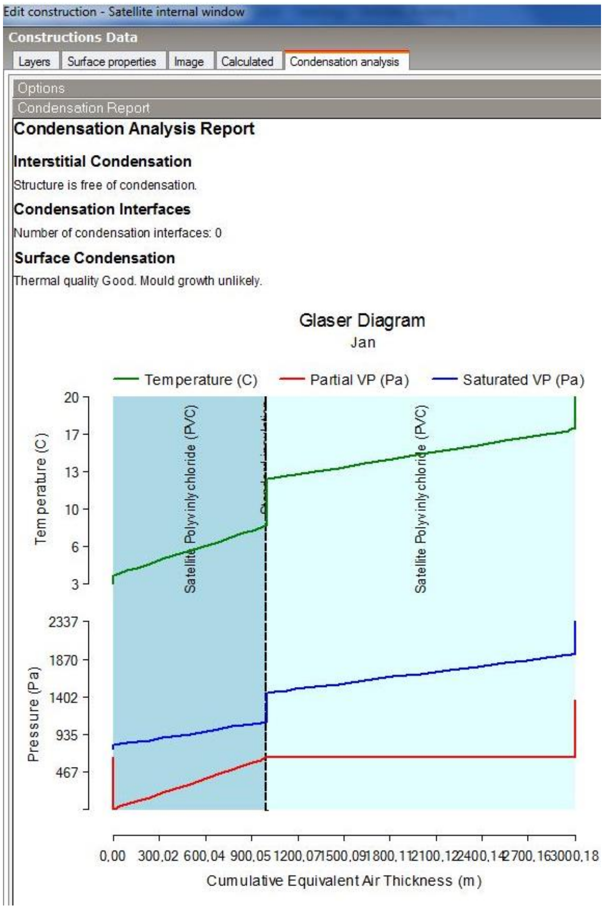
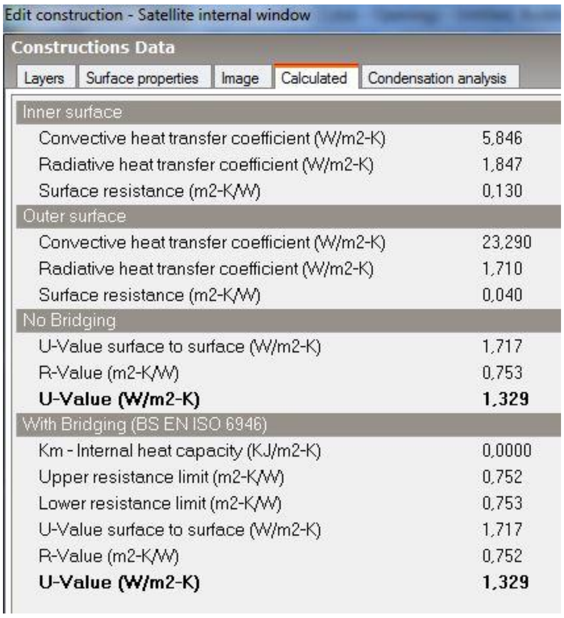


FIGURE 256 - GLASER DIAGRAM OF CORTEN STEEL WINDOWS



Inner surface	
Convective heat transfer coefficient (W/m2-K)	5,846
Radiative heat transfer coefficient (W/m2-K)	1,847
Surface resistance (m2-K/W)	0,130
Outer surface	
Convective heat transfer coefficient (W/m2-K)	23,290
Radiative heat transfer coefficient (W/m2-K)	1,710
Surface resistance (m2-K/W)	0,040
No Bridging	
U-Value surface to surface (W/m2-K)	1,717
R-Value (m2-K/W)	0,753
U-Value (W/m2-K)	**1,329**
With Bridging (BS EN ISO 6946)	
Km - Internal heat capacity (KJ/m2-K)	0,0000
Upper resistance limit (m2-K/W)	0,752
Lower resistance limit (m2-K/W)	0,753
U-Value surface to surface (W/m2-K)	1,717
R-Value (m2-K/W)	0,752
U-Value (W/m2-K)	**1,329**

FIGURE 257 - PVC WINDOWS CONSTRUCTION DATA

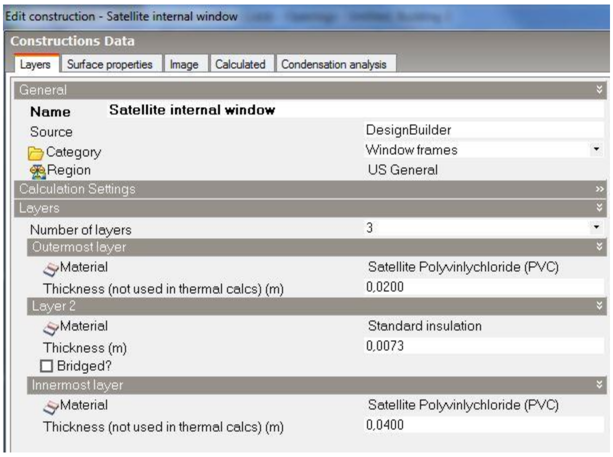


FIGURE 258 - DETAIL OF FRAME

FIGURE 259 - PARTICULAR OF PVC FRAME

19.2.3. SHADING

It has been chosen to enter all shadings both internal and external as can be seen from the following table.

FIGURE 260 – SHADING

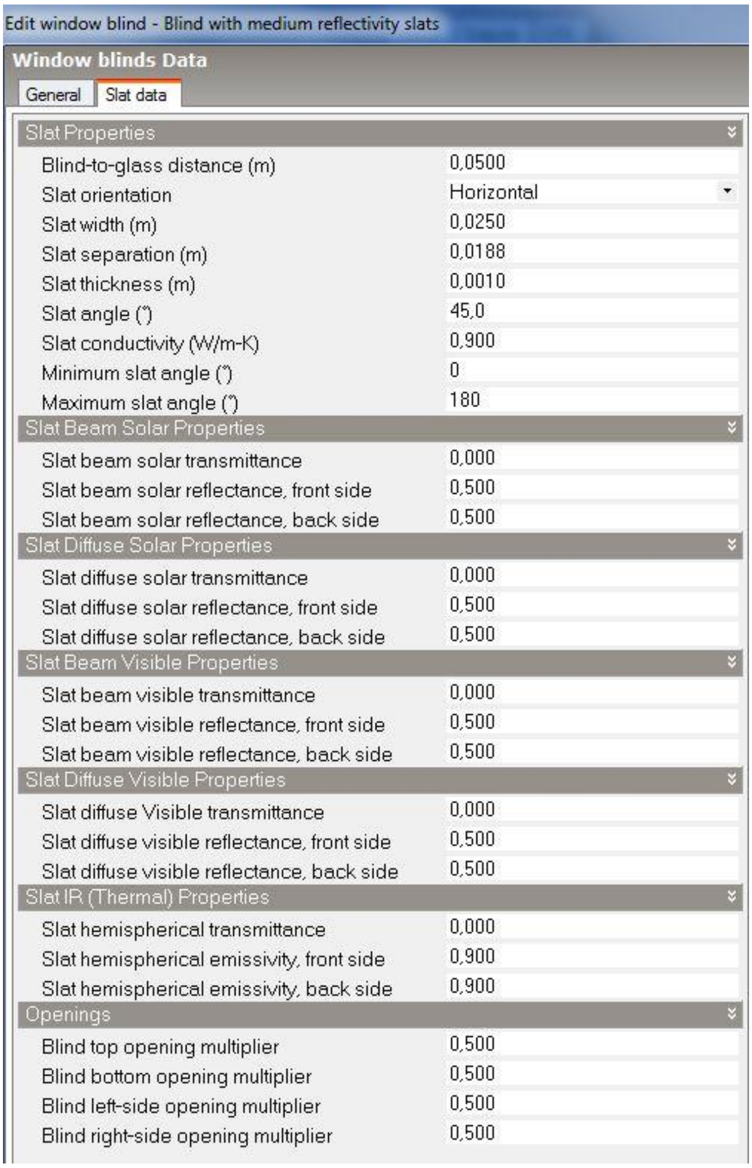


FIGURE 261 - BLIND WITH MEDIUM REFLECTIVITY SLATS

19.2.4. Other Strategies

The skylights in stairwells will be equipped with sensors (BACS) that will govern the opening, according to the irradiation and the need for ventilation.

19.3. Energy Systems

19.3.1. Lighting System

It is expected to replace the existing lighting with the introduction of LED lamps and, where possible, to insert intelligent on/off systems, which adapt depending sunlight.

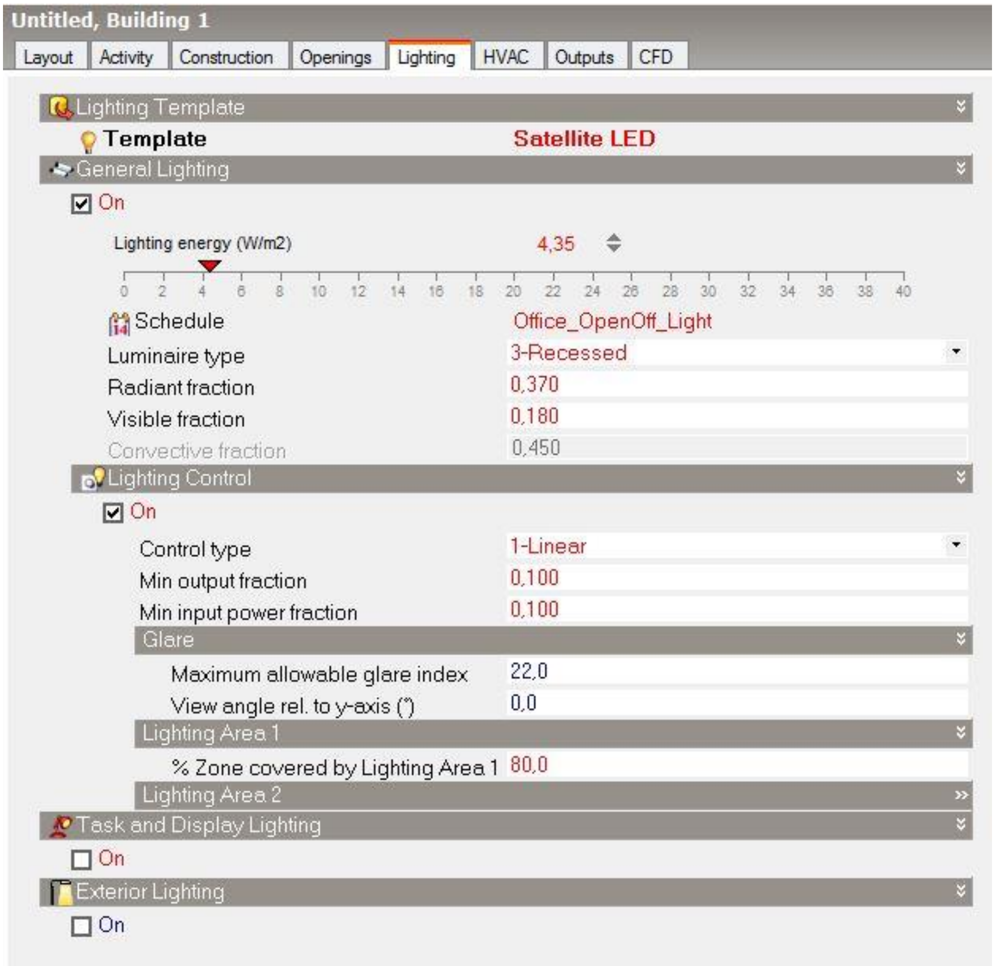


FIGURE 262 - LIGHTING TEMPLATE

19.3.2. HVAC System

Almost all working rooms, as well as all the rooms receiving the circulation areas have air conditioning systems. It is expected to insert a false ceiling in all circulation areas and, where possible in all rooms of the building. The result is a decrease in the net height of the rooms to be heated and creation of a channel for heating and lighting installations.

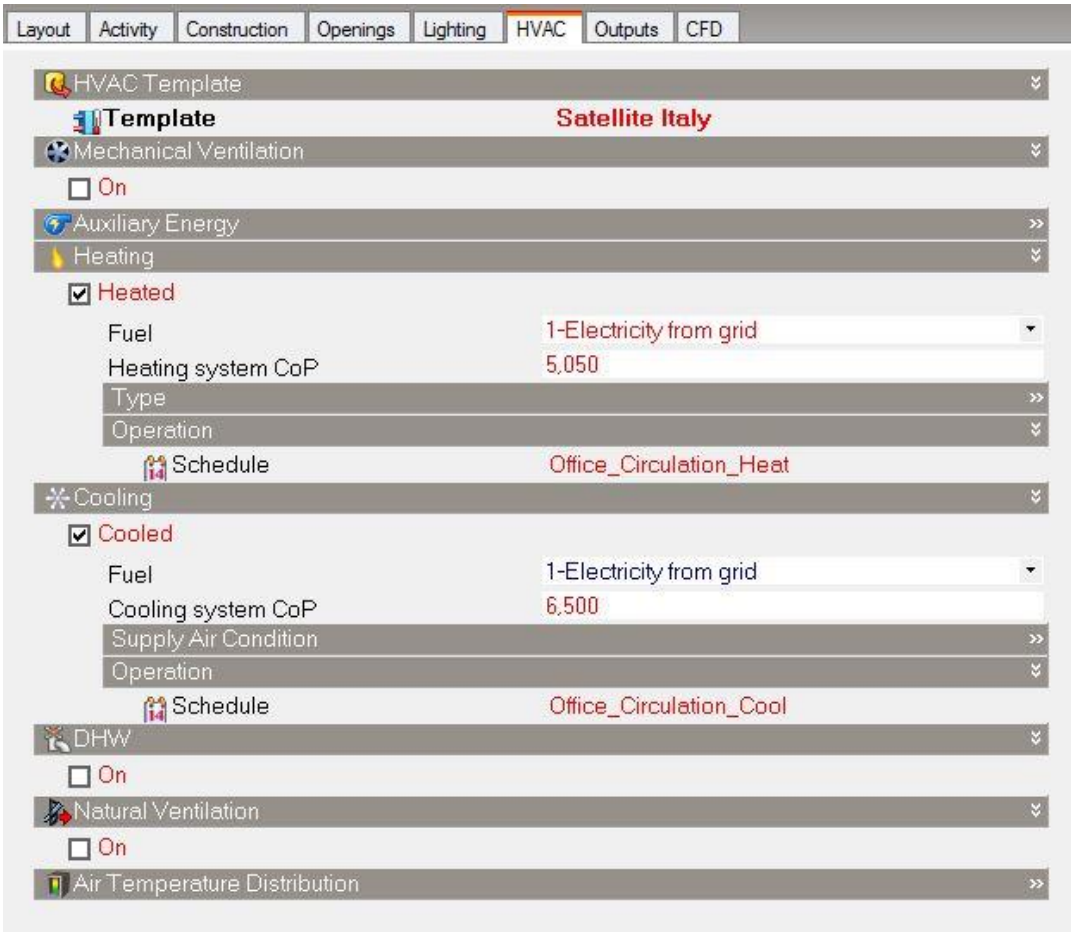


FIGURE 263 - HVAC TEMPLATE

19.4. Renewable Energy Sources

The building is in a densely built area and district heating is not available. The use of more environmentally friendly HVAC systems was investigated but VRV appeared to be the most suitable choice. Having studied different proposals for renewable energy systems in the end it was decided to use a photovoltaic system.

It is also thought to include wind energy as a renewable energy but the technical department did not like this type of intervention, because it would influence the view from adjacent buildings.

19.4.1. PV Generation System

On the roof of the building three photovoltaic plants of 60 kW_p, 50 kW_p e 45 kW_p will be installed. This ensures just over 30% of current consumption of electricity. The structure has two areas available to position the photovoltaic system, one on the roof and other on the facade. The PV panels will be placed almost due South with a fixed slope of 30° and azimuth of 0°. The system will be connected to the low voltage grid via three-phase power.

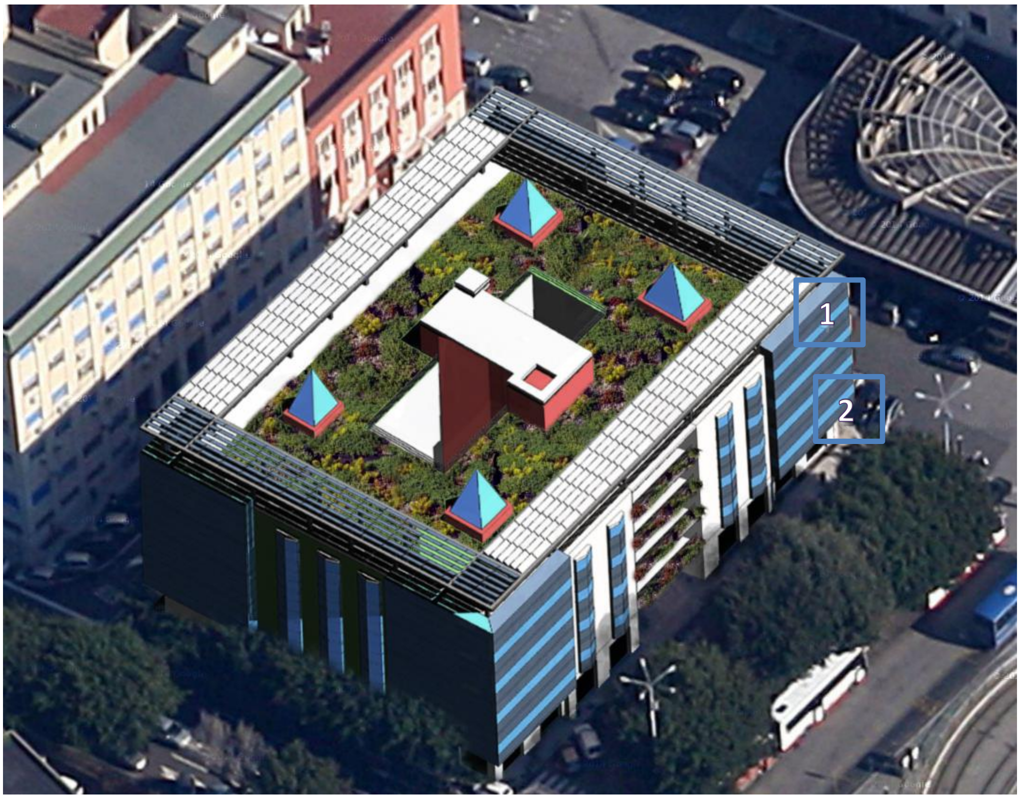


FIGURE 264 - AREAS AVAILABLE FOR THE PV SYSTEM INSTALLATION

A photovoltaic system uses photovoltaic modules to absorb solar energy and convert it into electricity for the daily needs. When it produces more energy than it consumes, the excess is entered into the power grid. It is a mechanism that allows for economically exploiting the electricity produced in excess by the PV system.

In Italy, to access the financial benefits of the net metering it must submit a request to the Energy Services Manager, GSE S.p.A. Therefore, it leads to compensation between the economic value associated to the electricity produced and fed into the grid and the theoretical economic value associated to withdrawn electricity and consumed in a period different from the one in which production takes place.

The calculation of the PV system was estimated using Classic PVGIS, software developed by The Joint Research Centre of the European Commission in ISPRA, Italy.

The monthly and annual solar radiation in the area based on the classic PVGIS database is presented in the following table.

TABLE 79 - SOLAR RADIATION AT THE AREA OF MESSINA

Month	H_h	H_{opt}	H(90)	I_{opt}	T_D	T_{24h}
Jan	1,990	2,980	2,900	59	11.0	10.2
Feb	2,700	3,630	3,130	51	10.6	9.7
Mar	4,020	4,860	3,470	40	13.2	12.0

Apr	5,420	5,830	3,190	26	15.4	14.2
May	6,410	6,280	2,630	13	19.1	17.9
Jun	6,910	6,470	2,310	6	23.1	21.8
Jul	6,830	6,530	2,470	9	25.9	24.6
Aug	6,190	6,420	3,100	21	26.2	24.7
Sep	5,000	5,880	3,830	36	22.9	21.7
Oct	3,510	4,690	3,860	49	19.8	18.6
Nov	2,250	3,320	3,160	58	16.2	15.1
Dec	1,760	2,740	2,770	61	12.6	11.6
Year	4,430	4,980	3,070	31	18.0	16.8

Legend:
Hh: Irradiation on horizontal plane (Wh/m^2/day)
Hopt: Irradiation on optimally inclined plane (Wh/m^2/day)
H(90): Irradiation on plane at angle: 90deg. (Wh/m^2/day)
Iopt: Optimal inclination (deg.)
TD: Average daytime temperature (°C)
T24h: 24 hour average of temperature (°C)

SOURCE: CLASSIC PVGIS DATABASE (KWH/ M^2/MONTH) AT 30°

TABLE 80 - CONDITION TO SIMULATION WITH CLASSIC PVGIS

Estimated losses due to temperature and low irradiance: 10.7%
Estimated loss due to angular reflectance effects: 5.8%
Other losses (cables, inverter etc.): 15.0%
Combined PV system losses: 28.5%

TABLE 81 - ANNUAL GLOBAL RADIATION ON THE SURFACE

Month	E_d	E_m
Jan	110.5	3,420
Feb	118	3,300
Mar	128.5	3,980
Apr	114	3,420
May	88	2,725
Jun	73.5	2,205
Jul	78.5	2,430
Aug	103	3,185
Sep	134.5	4,035
Oct	139.5	4,330
Nov	116.5	3,500
Dec	104	3,225
Yearly average	**109.04**	**3,312.,92**
Total for year		**39,755**

Annual global radiation on the surface = **1,950** kWh/m^2
Ed: Average daily electricity production from the given system (kWh)
Em: Average monthly electricity production from the given system (kWh)

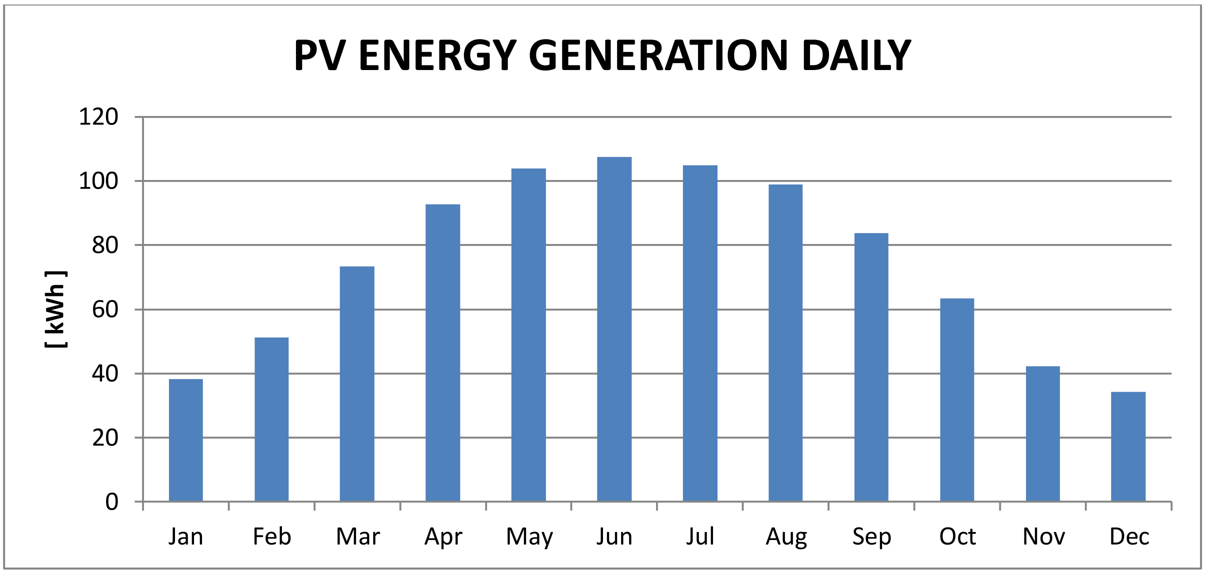


FIGURE 265 - DAILY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

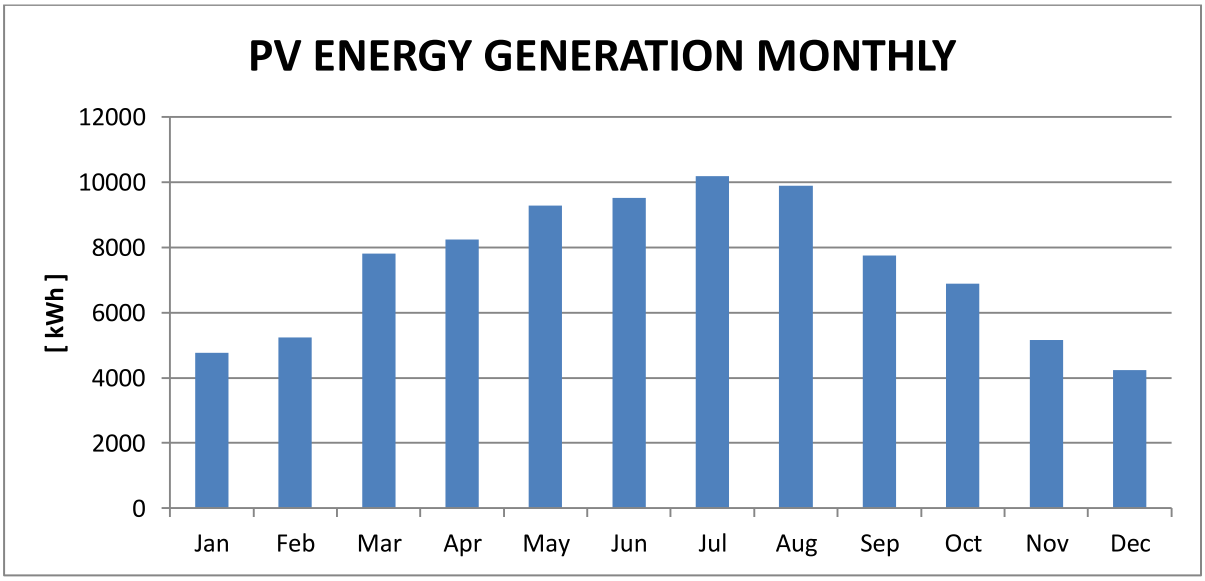


FIGURE 266 - MONTHLY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

The PV System on the east façade has 45 kW_p and the following data are used for the calculation:

TABLE 82 - CONDITION TO SIMULATION WITH CLASSIC PVGIS

Estimated losses due to temperature and low irradiance: 12.7%
Estimated loss due to angular reflectance effects: 4.3%
Other losses (cables, inverter etc.): 15.0%
Combined PV system losses: 29.0%

TABLE 83 - ANNUAL GLOBAL RADIATION ON THE SURFACE

Month	E_d	E_m
Jan	38.25	1,183.5
Feb	51.30	1,431
Mar	73.35	2,277
Apr	92.70	2,785.5
May	103.95	3,226.5
Jun	107.55	3,226.5
Jul	104.85	3,253.5
Aug	99.00	3,064.5
Sep	83.70	2,515.5
Oct	63.45	1,966.5
Nov	42.30	1,273.5
Dec	34.20	1,062
Yearly average	**74.55**	**2,272.125**
Total for year		**27,265.5**
Annual global radiation on the surface = 1,950 kWh/m² *Ed: Average daily electricity production from the given system (kWh)* *Em: Average monthly electricity production from the given system (kWh)*		

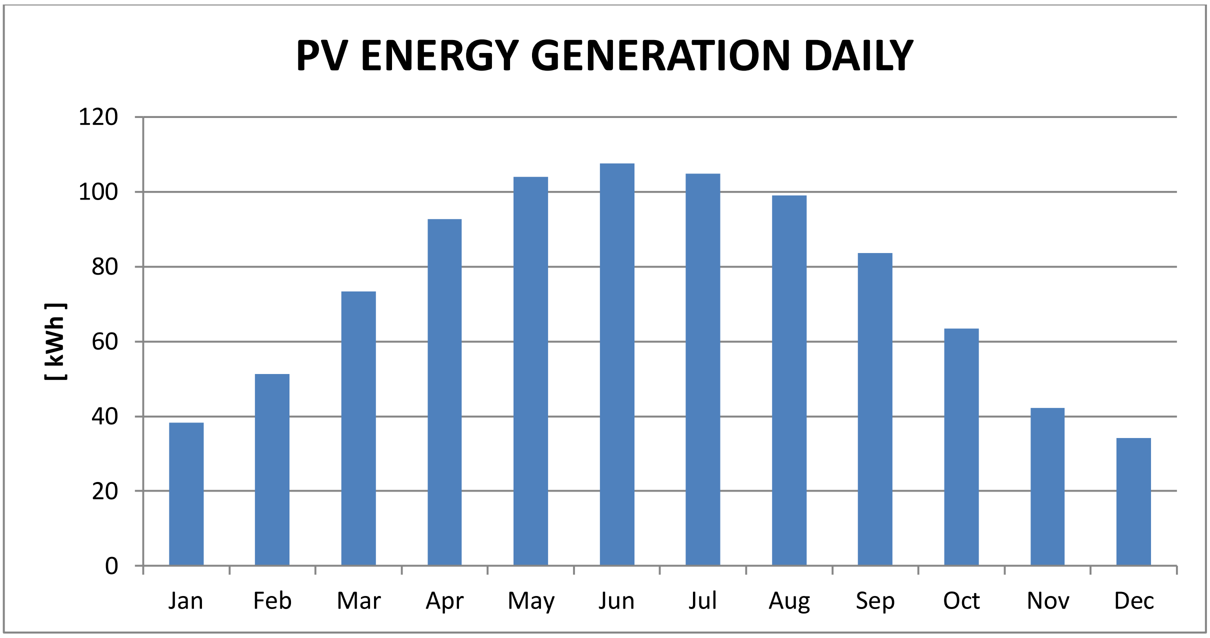


FIGURE 267 - DAILY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

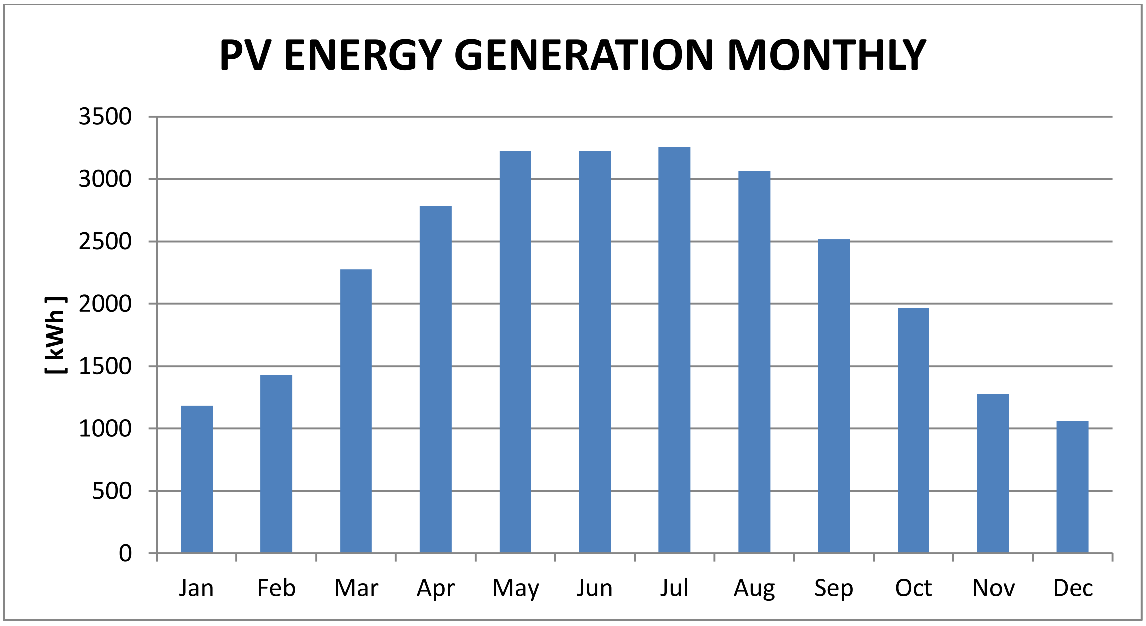


FIGURE 268 - MONTHLY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

The PV System on the roof has 60 kW_p and the following data are used for the calculation:

TABLE 84 - CONDITION TO SIMULATION WITH CLASSIC PVGIS

Estimated losses due to temperature and low irradiance: 9.8%
Estimated loss due to angular reflectance effects: 2.7%
Other losses (cables, inverter etc.): 15.0%
Combined PV system losses: 25.4%

TABLE 85 - ANNUAL GLOBAL RADIATION ON THE SURFACE

Month	E_d	E_m
Jan	130.80	4,044.00
Feb	161.40	4,518.00
Mar	216.60	6,720.00
Apr	264.60	7,920.00
May	285.60	8,880.00
Jun	292.80	8,760.00
Jul	290.40	9,000.00
Aug	279.00	8,640.00
Sep	253.20	7,620.00
Oct	200.40	6,180.00
Nov	142.20	4,260.00
Dec	118.20	3,660.00
Yearly average	**208.70**	**6,683.5**
Total for year		**80,202**
Annual global radiation on the surface = 1,950 kWh/m^2 *Ed: Average daily electricity production from the given system (kWh)* *Em: Average monthly electricity production from the given system (kWh)*		

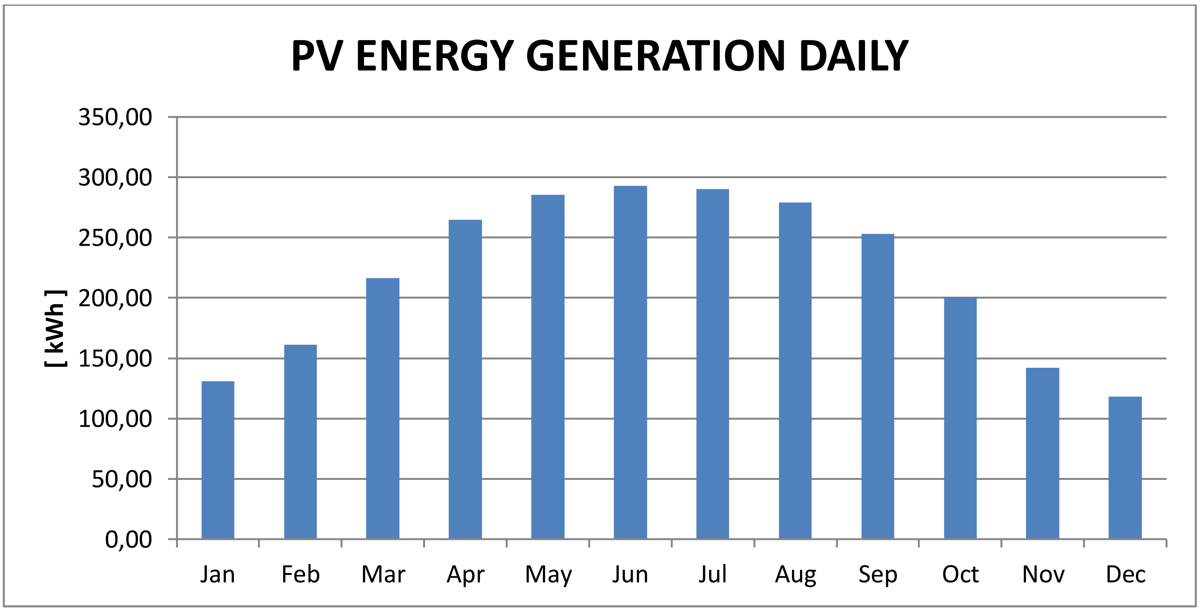


FIGURE 269- DAILY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

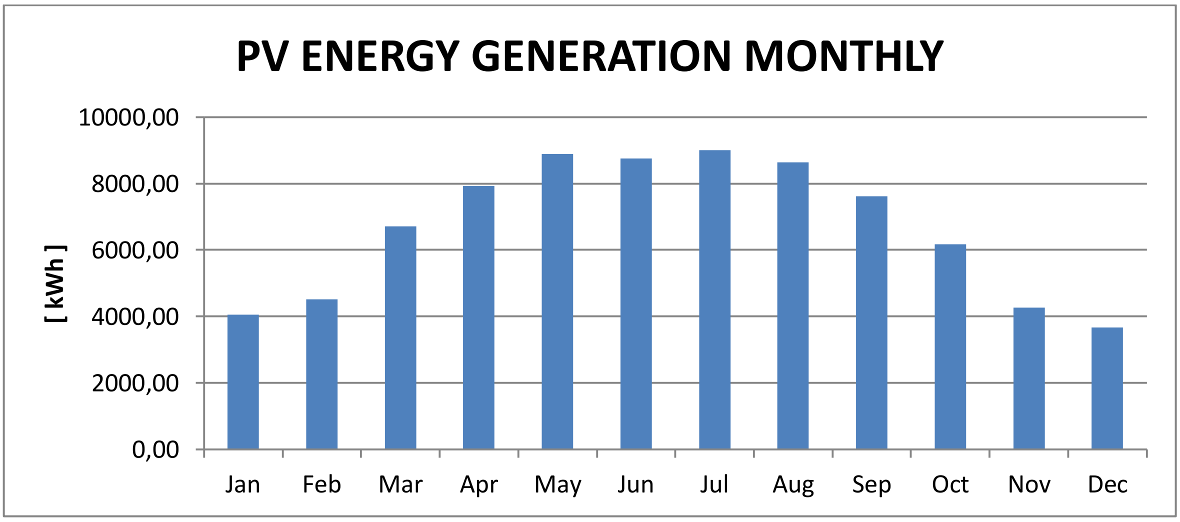


FIGURE 270 - MONTHLY ENERGY INJECTED INTO GRID FROM THE PV SYSTEM

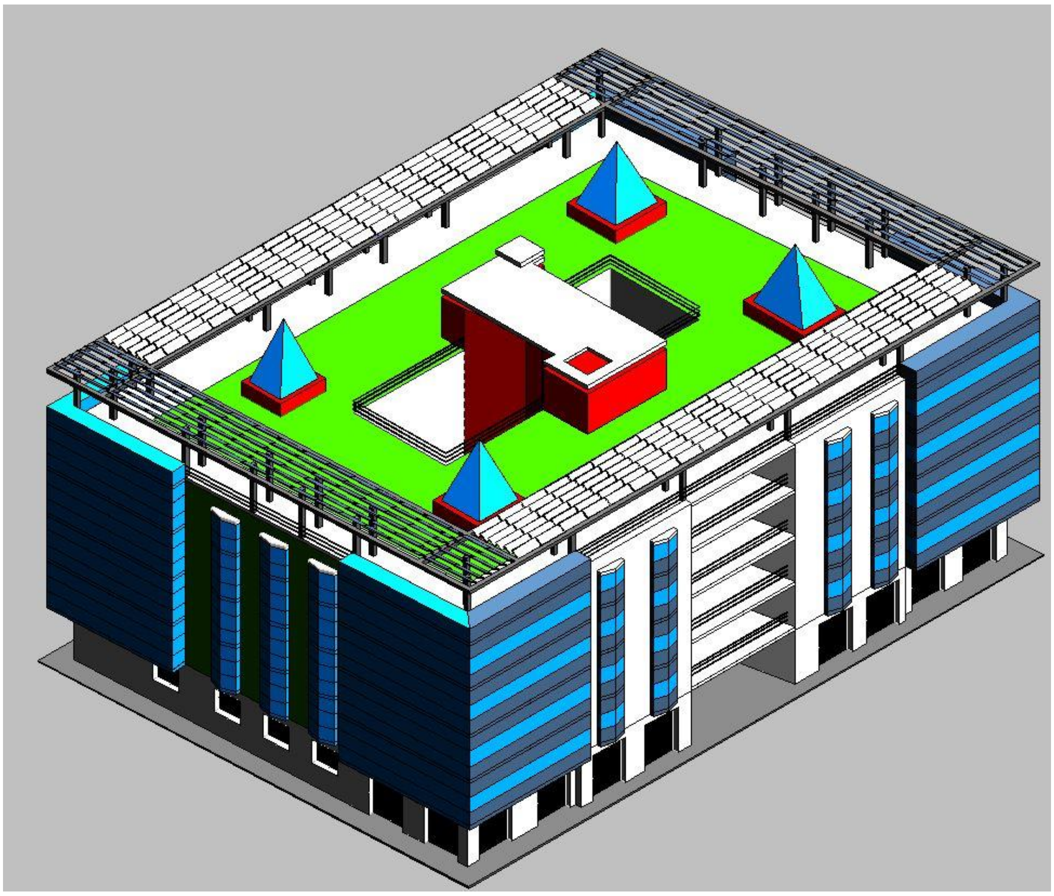


FIGURE 271 - PV PANELS INSTALLED

FIGURE 272- EXAMPLE OF PV DISTRIBUTION, LIKE SATELLITE PV DISTRIBUTION ON THE ROOF

19.5. ENERGY MANAGEMENT SYSTEM

To monitor the building electrical consumption of lighting, of ventilation and of HVAC system, building automation control sensors (BACS) will be installed. The BACS are improved occupant comfort, efficient operation of building systems, and reduction in energy consumption and operating costs.

The system will perform the following operations:

- Control for each air conditioning unit separately to maintain in every office the desired internal air temperature and humidity stables.
- Internal lighting control according external irradiation and lux value in each room (Dimming lamps).
- Daily scheduling of air conditioning and lighting to optimize their use.
- Management of the flow temperature according to the outdoor temperature.
- Identification of electrical equipment turn on beyond normal working hours.
- Identification errors or alarms in case of electrical overloads.
- Control of windows and doors opening, to minimize the use VRV plant.

The BACS ensure therefore values of humidity and temperature in agreement with the optimum comfort conditions for the employees, also by administering appropriate air exchanges. They are also useful for energy saving both in terms of lighting and rooms conditioning.

19.6. Total Impact Of The Renovation Scheme

19.6.1. Energy Performance

The energy analysis of the building was carried out using the software Design Builder v. 3.4.0.033. The building was described in detail, following through architectural drawings and with an illustrated report on the state of fact and photographic documentation.

The result for the new solution is described in the following. In the renovation scheme it has a VRV system plant for heating, cooling and air circulation.

To set the calculation of the model the general information fixed are:

TABLE 86 - GENERAL INFORMATION FOR SIMULATION

	Data
Weather File	** Messina - ITA IGDG WMO#=164200
HDD and CDD data source	Weather File Stat
Total gross floor area [m2]	6874.93
Principal Heating Source	District Heating

The following figures shows the heat balance of Palazzo Satellite Post-design, divided according to the contributions:

- General Lighting,
- Computer + Equipment,
- Occupancy,
- Solar Gans Exterior Windows,
- Zone Sensible Heating,
- Zone Sensible Cooling.

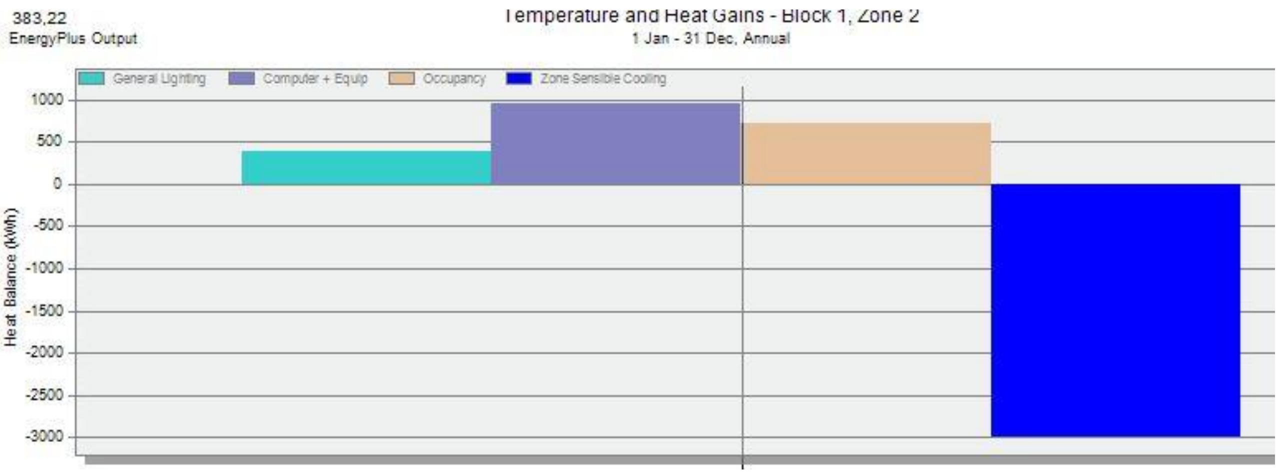


FIGURE 273 - ANNUAL HEAT BALANCE

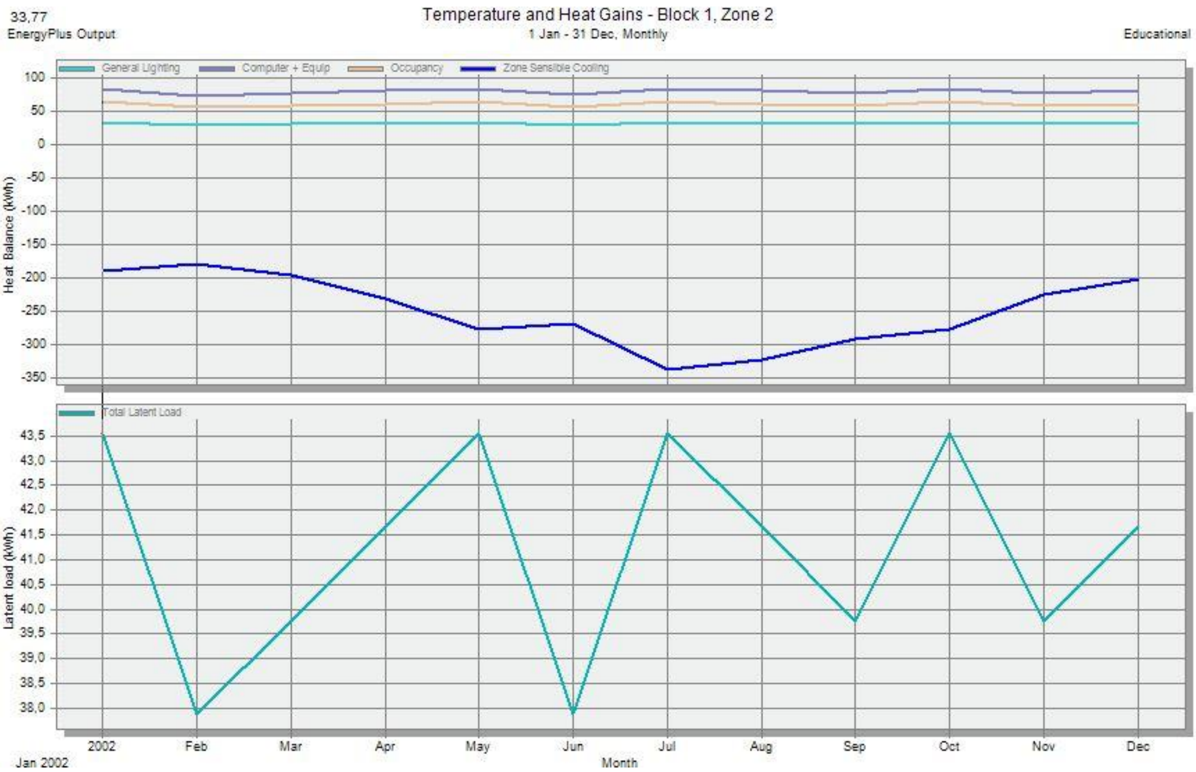


FIGURE 274 - ANNUAL HEAT BALANCE ACCORDING SINGLE MONTH

Two following figures shows annual heat balance of Palazzo Satellite, divided according to the contributions:

- RoCeilings
- Floors
- Partitions
- General Lighting
- Computer + Equipment
- Occupancy

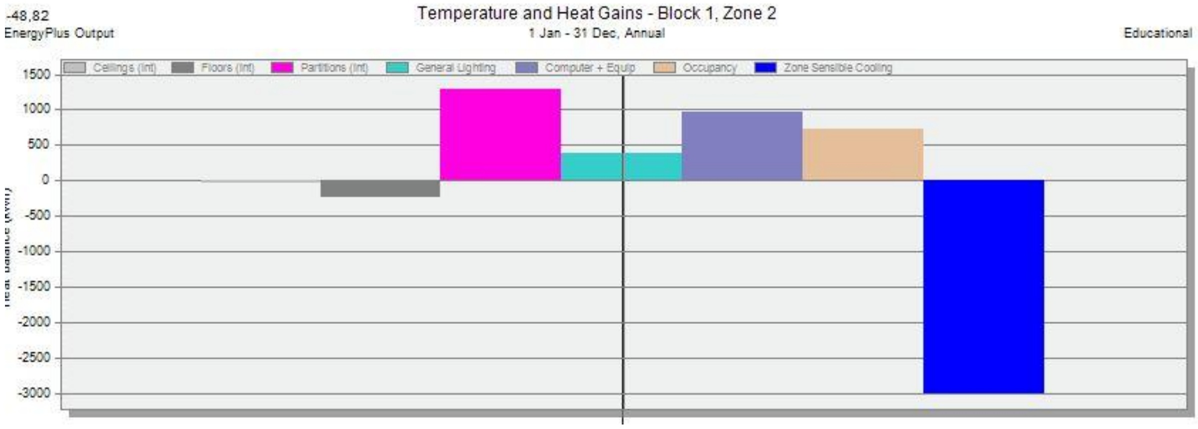


FIGURE 275 - ANNUAL CONTRIBUTION OF ENVELOPE

19.6.2. Environmental Performance

The following table shows the initial and the final consumption after implementing all the proposed interventions in the building.

TABLE 87 - UTILITY USE PER CONDITIONED FLOOR AREA

	Electricity Intensity [kWh/m^2]	Natural Gas Intensity [kWh/m^2]	Additional Fuel Intensity [kWh/ m^2]	District Cooling Intensity [kWh/ m^2]	District Heating Intensity [kWh/ m^2]	Water Intensity [m^3/ m^2]
Lighting	16.37	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	63.78	0.79	0.02
Other	27.53	0.00	0.00	0.00	0.00	0.00
Total	43.90	0.00	0.00	63.78	0.79	0.02

TABLE 88 - UTILITY USE PER TOTAL FLOOR AREA

	Electricity Intensity [kWh/ m^2]	Natural Gas Intensity [kWh/ m^2]	Additional Fuel Intensity [kWh/ m^2]	District Cooling Intensity [kWh/ m^2]	District Heating Intensity [kWh/ m^2]	Water Intensity [m^3/ m^2]
Lighting	16.21	0.00	0.00	0.00	0.00	0.00
HVAC	0.00	0.00	0.00	63.14	0.78	0.02
Other	27.25	0.00	0.00	0.00	0.00	0.00
Total	43.46	0.00	0.00	63.14	0.78	0.02

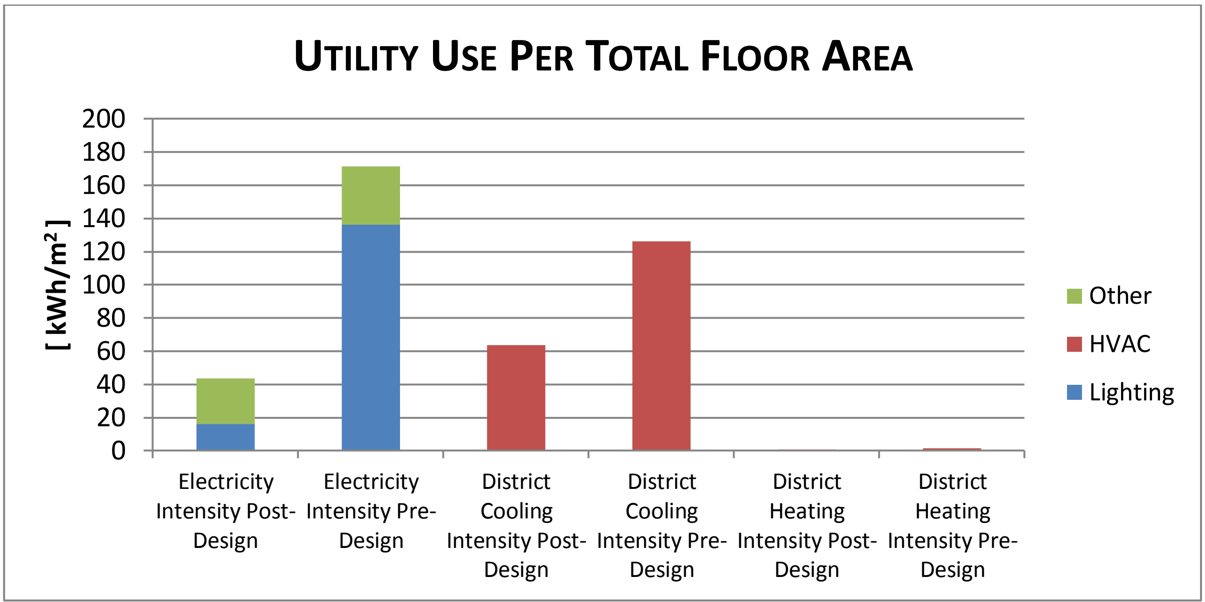


FIGURE 276 - UTILITY USE PER TOTAL FLOOR AREA PRE/POST-DESIGN

TABLE 89 - END USE CONSUMPTION

	Electricity [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	0.00	0.00	0.07	
Cooling	0.00	434,108.33	0.00	
Interior Lighting	111,437.37	0.00	0.00	
Water Systems	0.00	0.00	5,349.45	143.97
Interior Equipment	187,364.76	0.00	0.00	
Total Source Energy End Use Components	298,802.13	434,108.33	5,349.51	143.97

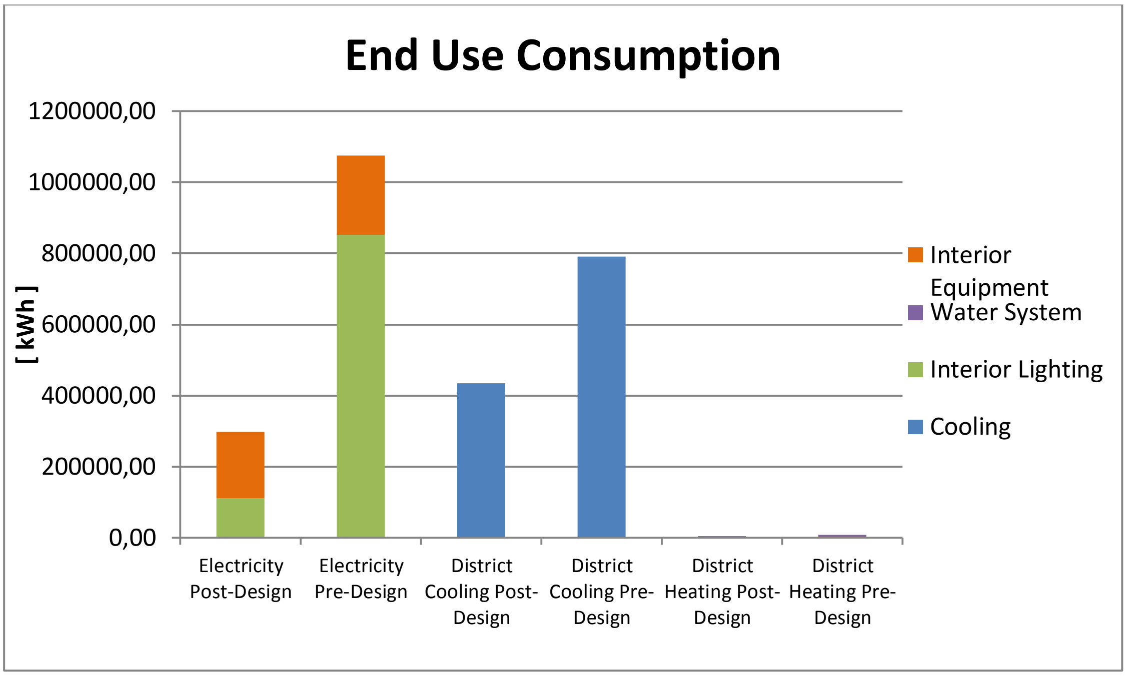


FIGURE 277 - END USE CONSUMPTION PRE/POST-DESIGN

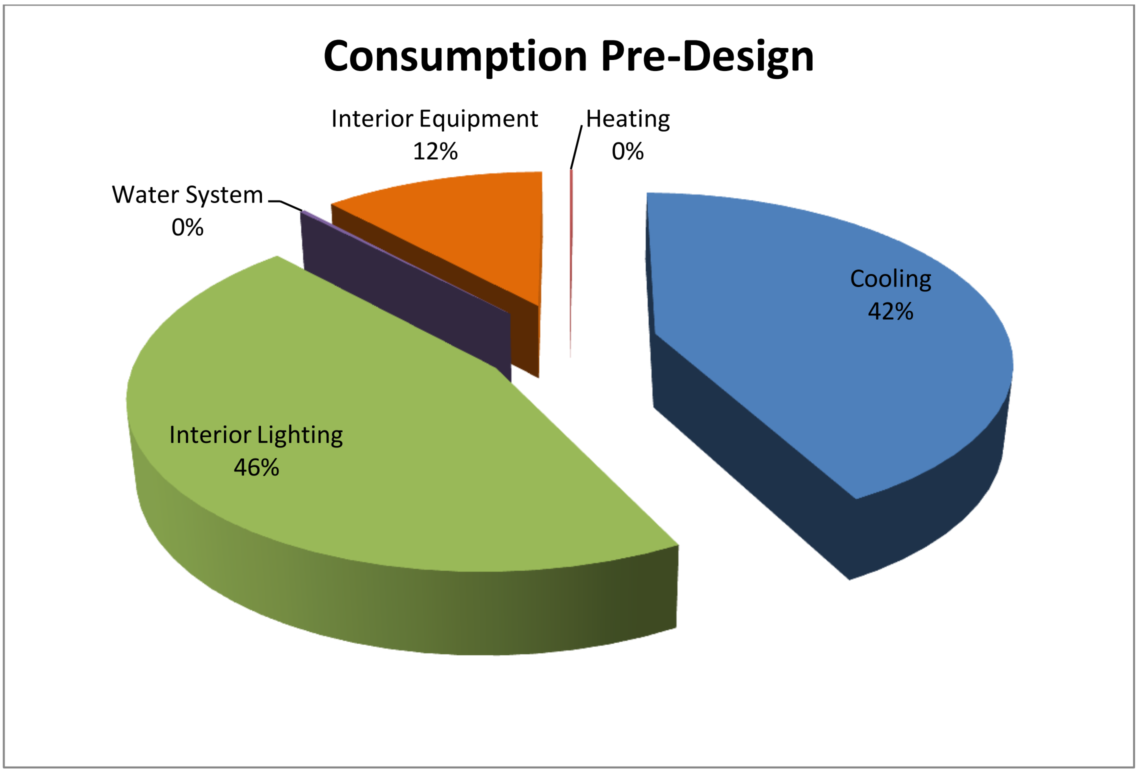


FIGURE 278 - CONSUMPTION PRE-DESIGN

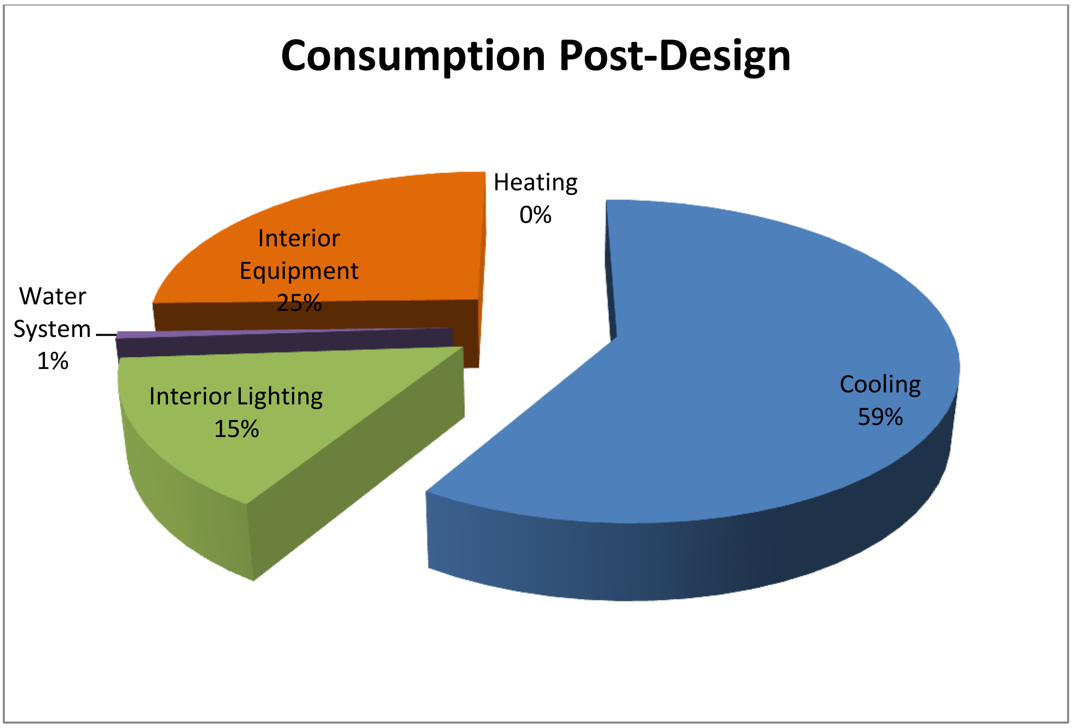


FIGURE 279 - CONSUMPTION POST-DESIGN

The energy consumption for interior equipment increased because the control system, for the building, were not present before the renovation.

With appropriate modifications on the envelope, heating consumption is near zero.

20. ECONOMIC EVALUATION OF THE PROPOSED RENOVATION SCHEME

20.1. ASSUMPTIONS, COST FIGURES

The cost of the interventions is estimated based on current market prices of the equipment and the installation works. Special meetings with suppliers were held to present the project and request offers for the preliminary renovation design. Offers were collected and assessed.

For each intervention, the cost has been calculated as the sum of costs for equipment, installation, operation and maintenance. These values have been organised in an Excel file prepared by Sinloc, a partner of the CERtuS consortium (see deliverable D2.5). ANNEX H, gives the cost information.

The economic appraisal of the renovation design was performed by means of a tool produced by ETVA VIPE, also a partner of the consortium. A detailed description of the tool is presented in the deliverable D2.5. The appraisal can be performed only for the whole design. The tool also allows to examine various financing schemes ranging from single financing source to multiple, combining bank loans, ESCOs, subsidies, municipality's own equity.

The data used for the calculations are tabulated below, divided according to the unit of measure concerned and the unit price

TABLE 90 - COST DESIGN

WORKINGS	*VOICE*	*UNIT COST*	*U.M.*	*DIMENSION*	*COST*
Building envelope	**EXTERNAL WALL – GREEN WALL**	€ 869.69	sqmx sqcm	1,190.0	**€ 1,014,929.00**
Building envelope	**NEW PV COVER SHELTER**	€ 266.67	sqm	1,350.0	**€ 360,000.00**
Building envelope	**WATERPROOFING FOUNDATIONS AND FOUNDATIONS STRUCTURAL RENOVATION**	€ 869.69	sqm	363,702	**€ 316,308**
Plants	**BACS**	€ 20,000.00	total	1	**€ 20,000.00**
Plants	**VRV SYSTEM**	€ 1,408.45	KW	355	**€ 500,000.00**
Plants	**RELAMPING**	€ 200.00	units	506.0	**€ 101,200.00**
Plants	**PV plant**	€ 2,000.00	kWp	155	**€ 310,000.00**
		TOTAL WORK COST			**€ 2,622,437.00**

20.2. Results

The proposals cover both the envelope that heating and electrical systems.

Building Envelope	• External Wall Demolition • New Internal Layout • Thermal Insulation Cover • Waterproofing Foundations • Replacement Windows • New Curtain Wall • Green roof and green wall	***table saving post renovation**
Energy Systems	• VRV System • LED lighting • BACS	
RES	• PV system (roof and walls)	

TABLE 91 - END USE CONSUMPTION PRE DESIGN

	Electricity [kWh]	District Cooling [kWh]	District Heating [kWh]
Heating	0	0	2,714.76
Cooling	0	790,256.8	0
Interior Lighting	852,503.17	0	0
Interior Equipment	222,119.61	0	0
Total End Uses	**1,074,622.78**	**790,256.8**	**2,714.76**

TABLE 92 -END USE CONSUMPTION POST DESIGN

	Electricity [kWh]	District Cooling [kWh]	District Heating [kWh]
Heating	0	0	0.07
Cooling	0	434,108.33	0
Interior Lighting	111,437.4	0	0
Interior Equipment	187,364.8	0	0
Total End Uses	**298,802.1**	**434,108.33**	**0.07**

TABLE 93 - SAVING WITHOUT PV

	Saving without PV (%)
Heating	99.99742
Cooling	45.06744
Interior Lighting	86.,92822
Interior Equipment	15.64691
Total End Uses	61.91

PV SAVING TOTAL = 147,222.5 kWh (3 PV Systems)

END USE PRE DESIGN (kWh)	END USE POST DESIGN (kWh)	SAVING (%)
1,867,594.34	585,688.03	68.63944 *(1,281,906.31 kWh)*

The saving are significant (69%) because 3 Photovoltaic systems have been installed. The green roofs and green wall are considered as renewable and environmentally friendly types of intervention. The traditional interventions are the use of new windows and to a system of thermal insulation for the facade.

In the evaluation of the lighting savings it was considered the average cost of the electricity. The lifetime was assessed considering the average hours of use for the lamps and its maximum total hours of operation. As can be seen in following table, with such conditions the renovation options ensures savings from maintenance of 2,508 €/year and has a simple payback period of 0.8 years.

TABLE 94: ECONOMIC PARAMETERS OF THE RENOVATION – LIGHTING

Energy Savings	741,066 kWh
Price - Saved Energy	0.18 €/kWh
Costs	101,200 €
Potential savings from maintenance (post intervention)	2508 €/year
Simple Payback	0.8 years
Lifetime	20 years
CO_2 Savings	517.67 tons/year

In the evaluation of the HVAC savings it was considered the cost of the electricity during the mid-peak period. As can be seen in following table, with such conditions the renovation options ensures savings from maintenance of 23,667 €/year and has a simple payback period of 11.96 years.

TABLE 95: ECONOMIC PARAMETERS OF THE RENOVATION – HVAC

Energy Savings	106,844 kWh
Price - Saved Energy	0.18 €/kWh
Costs	500,000 €
Potential savings from maintenance (post intervention)	23,667 €/year
Simple Payback	11.96 years
Lifetime	25 years
CO_2 Savings	75.63 tons/year

In the evaluation of the PV generation it was considered the self-consumption of 90% of the energy, since in a working day during the time slots. As can be seen in following table, with such conditions it has a simple payback period of 9.77 years.

TABLE 96 - ECONOMIC PARAMETERS OF THE RENOVATION – PV

Energy Generation	201,500 kWh
Energy - Self-Consumption	90%
Energy - Injected Into Grid	10%
Price – Self-Consumption	0.18 €/kWh
Price - Injected Into Grid	0.06 €/kWh
Costs	310,000 €
Simple Payback	9.77 years
Lifetime	30 years
CO_2 Savings	132.23 tons/year

The following table presents the aggregation of the renovation option. As can be seen, the total of the renovation plan ensures savings of 26,175 €/year and has a simple payback period of 11.37 years.

TABLE 97: ECONOMIC PARAMETERS OF THE RENOVATION – TOTAL

Energy Savings	1,298,714 kWh
Costs	2,622,437 €
Savings	26,175 €/year
Simple Payback	11.37 years
CO_2 Savings	905.85 tons/year

REFERENCES 3

/1/ DesignBuilder Software Ltd specialises in developing high-quality, easy-to-use and affordable simulation software tools for assessing the environmental performance of building designs.
http://www.designbuilder.co.uk/

/2/ PVGIS, Photovoltaic Geographical Information System, a software developed by The Joint Research Centre of the European Commission in ISPRA, Italy.
http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php

/3/ CERtuS Deliverable D2.5 *“Twelve economic evaluation reports”*

21. ANNEX A: BUILDING DRAWINGS

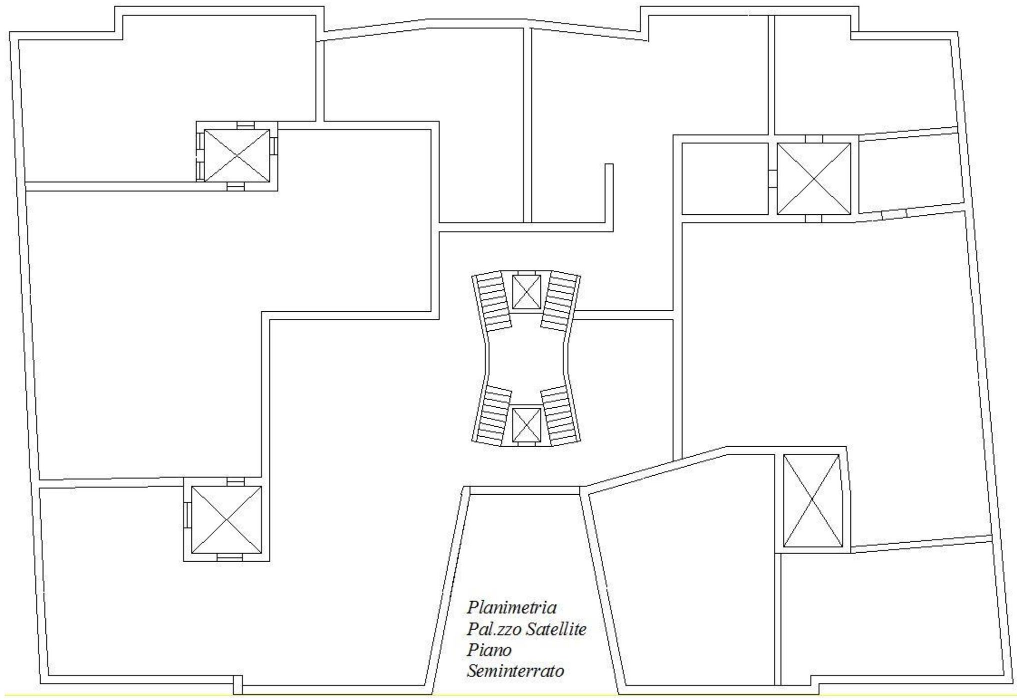


FIGURE 280 - BASAMENT FLOOR

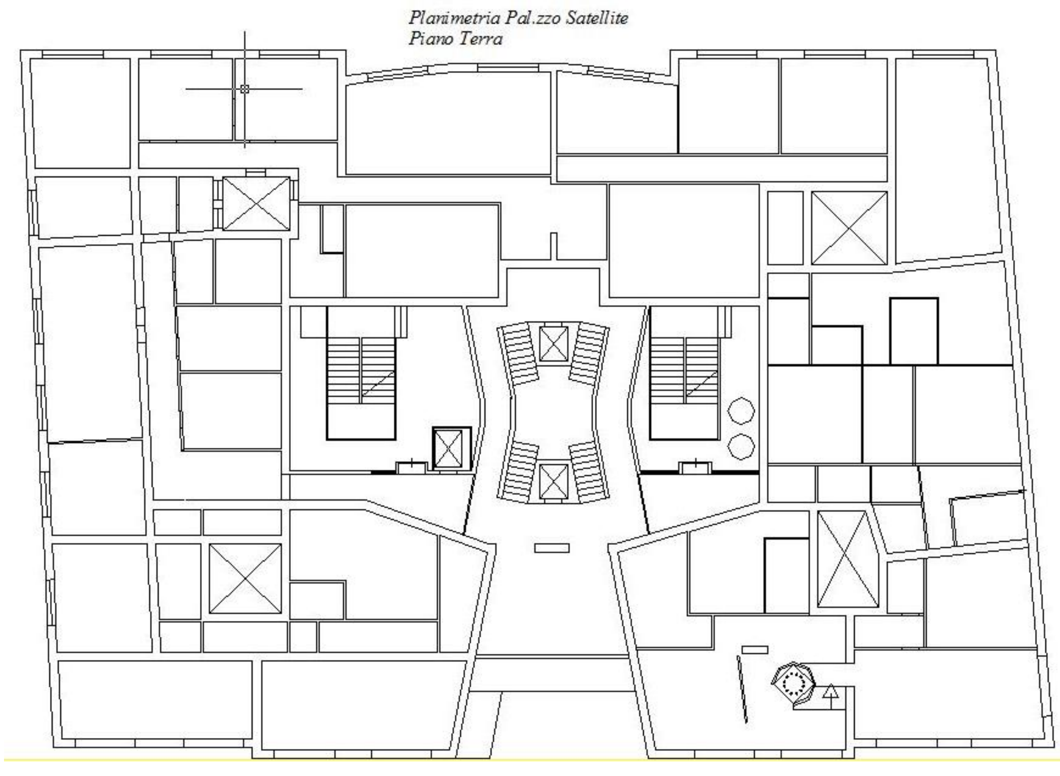


FIGURE 281 - GROUND FLOOR

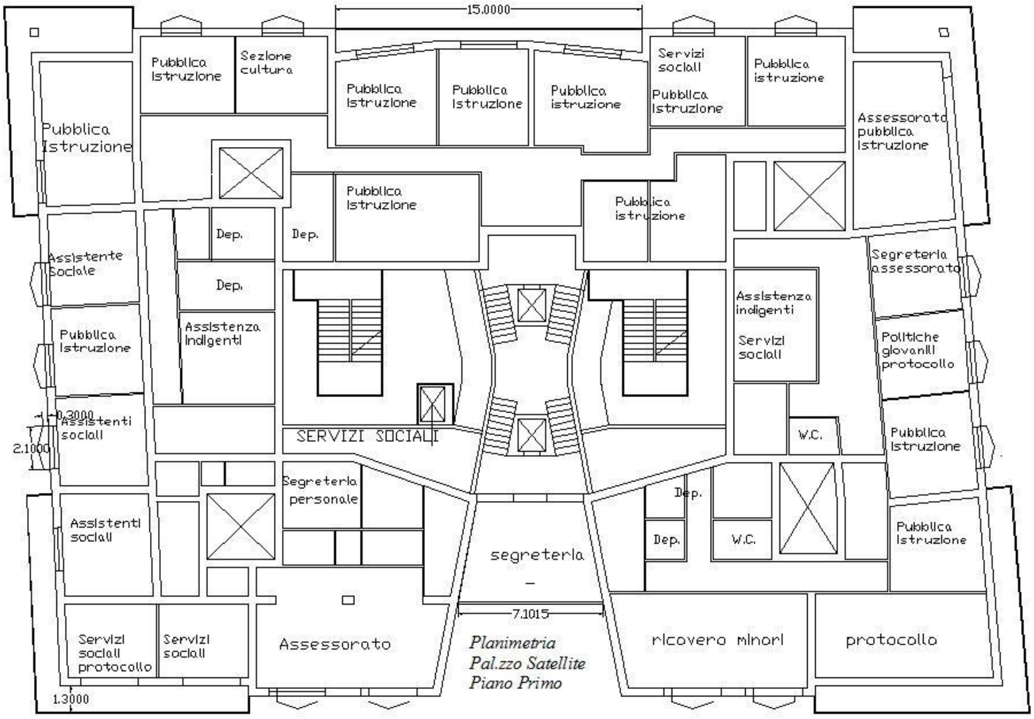


FIGURE 282 - FIRST FLOOR

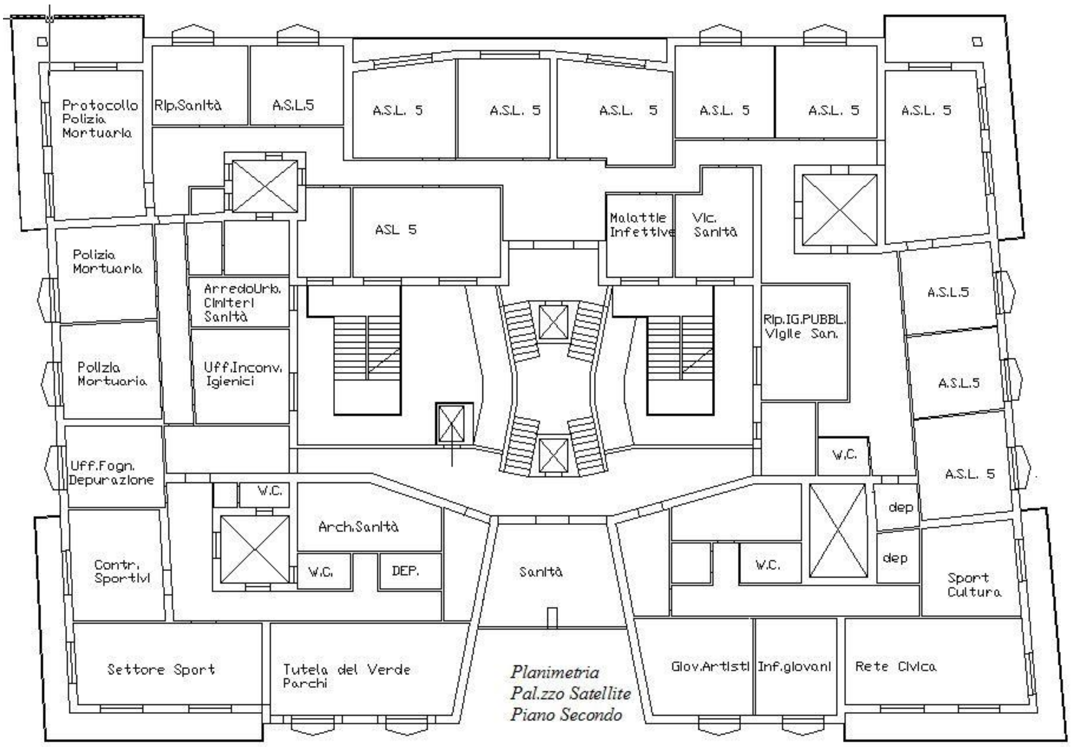


FIGURE 283 - SECOND FLOOR

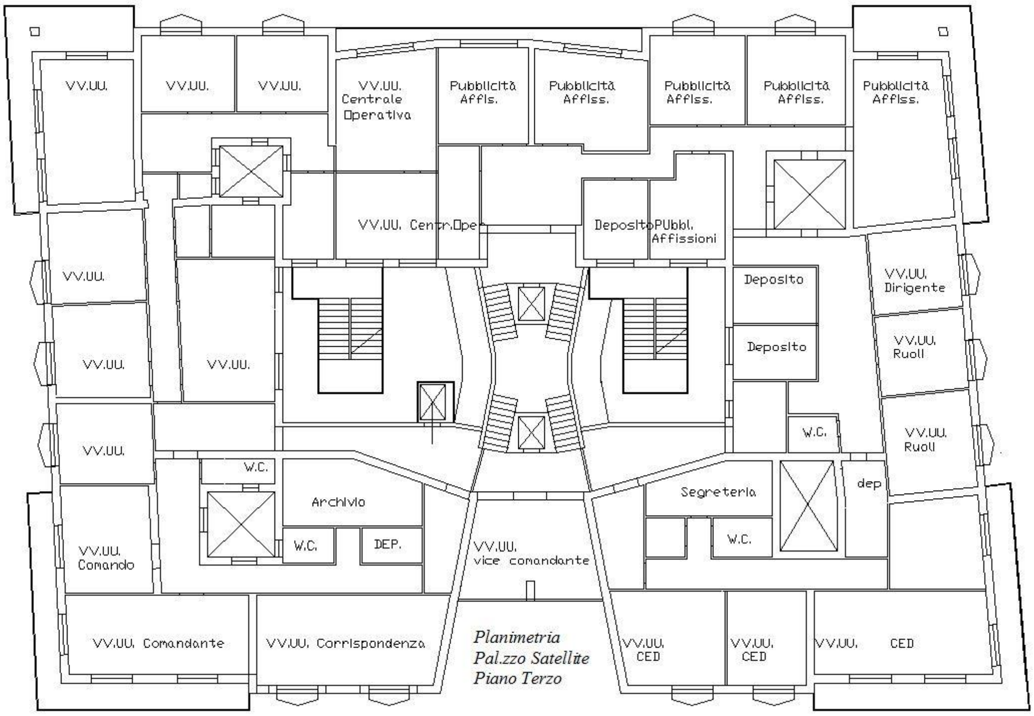


FIGURE 284 - THIRD FLOOR

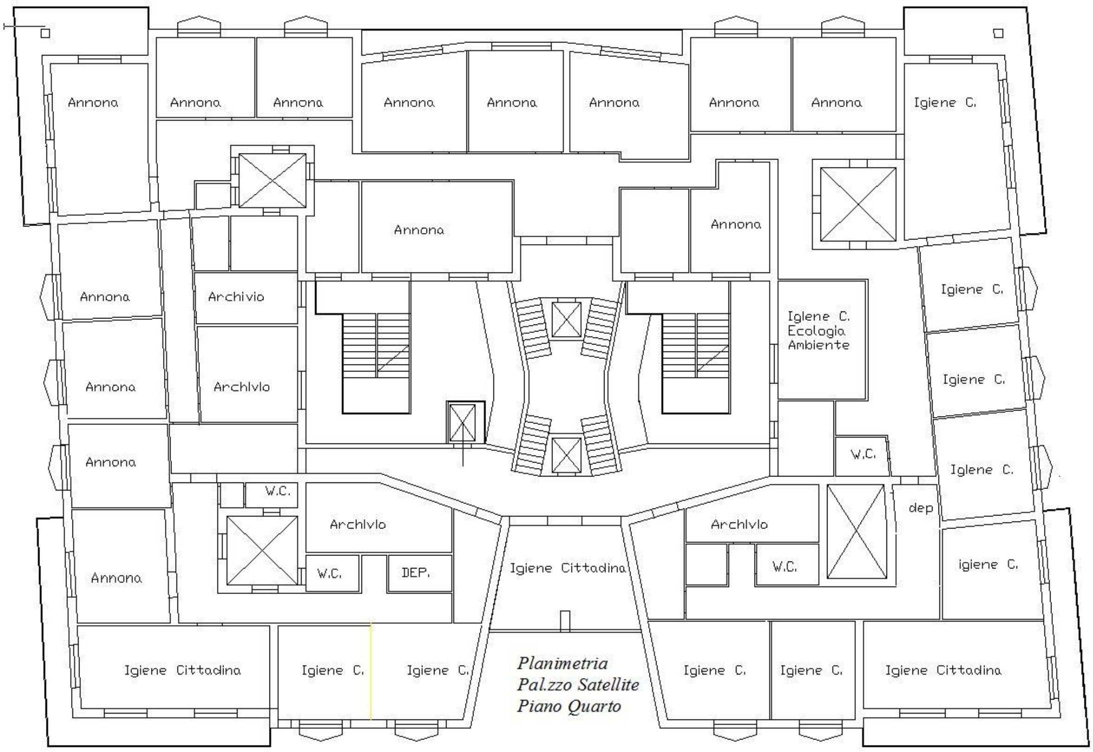


FIGURE 285 - FOURTH FLOOR

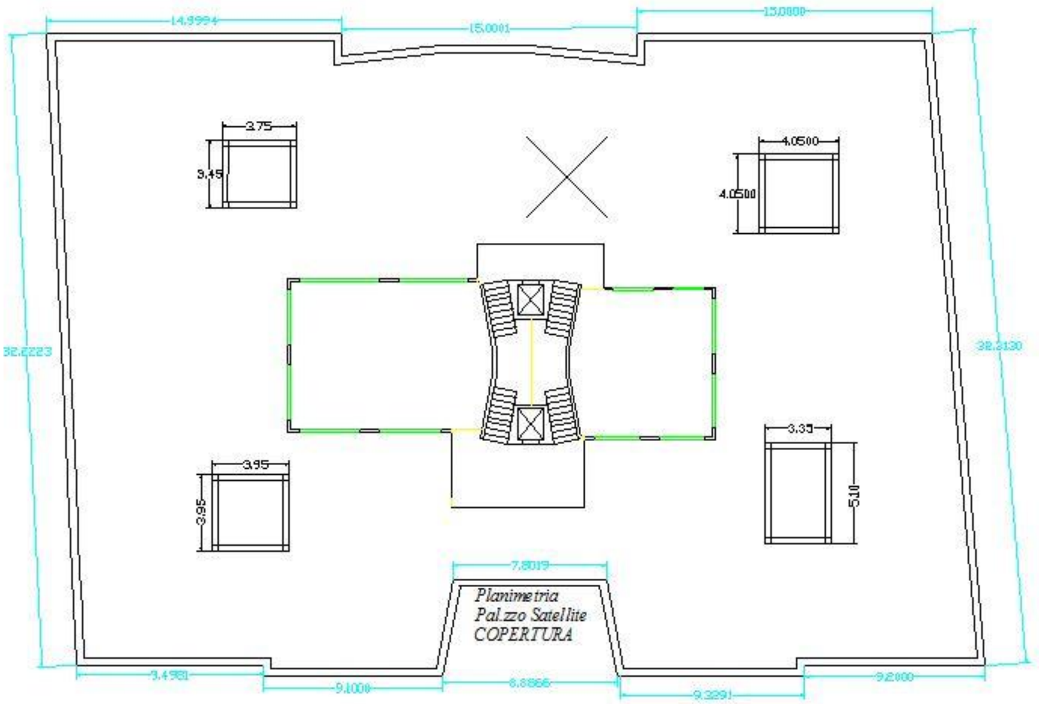


FIGURE 286 - COVER FLOOR

FIGURE 287 - FRONT DESIGN

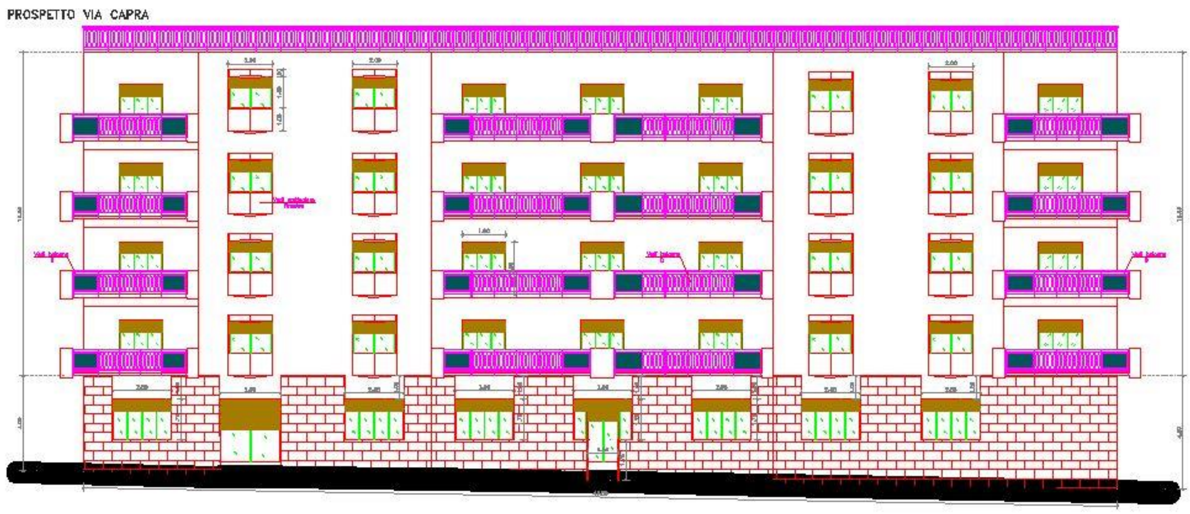


FIGURE 288 - FRONT DESIGN

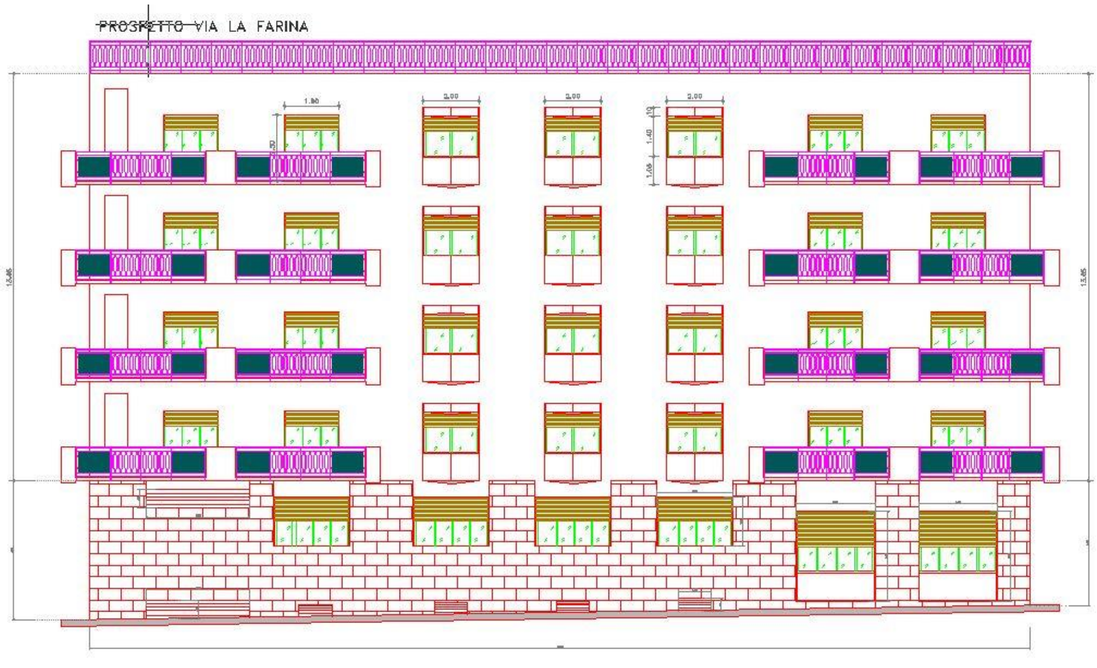


FIGURE 289 - FRONT DESIGN

FIGURE 290 - FRONT DESIGN

22. ANNEX B: BUILDINGS DESIGN

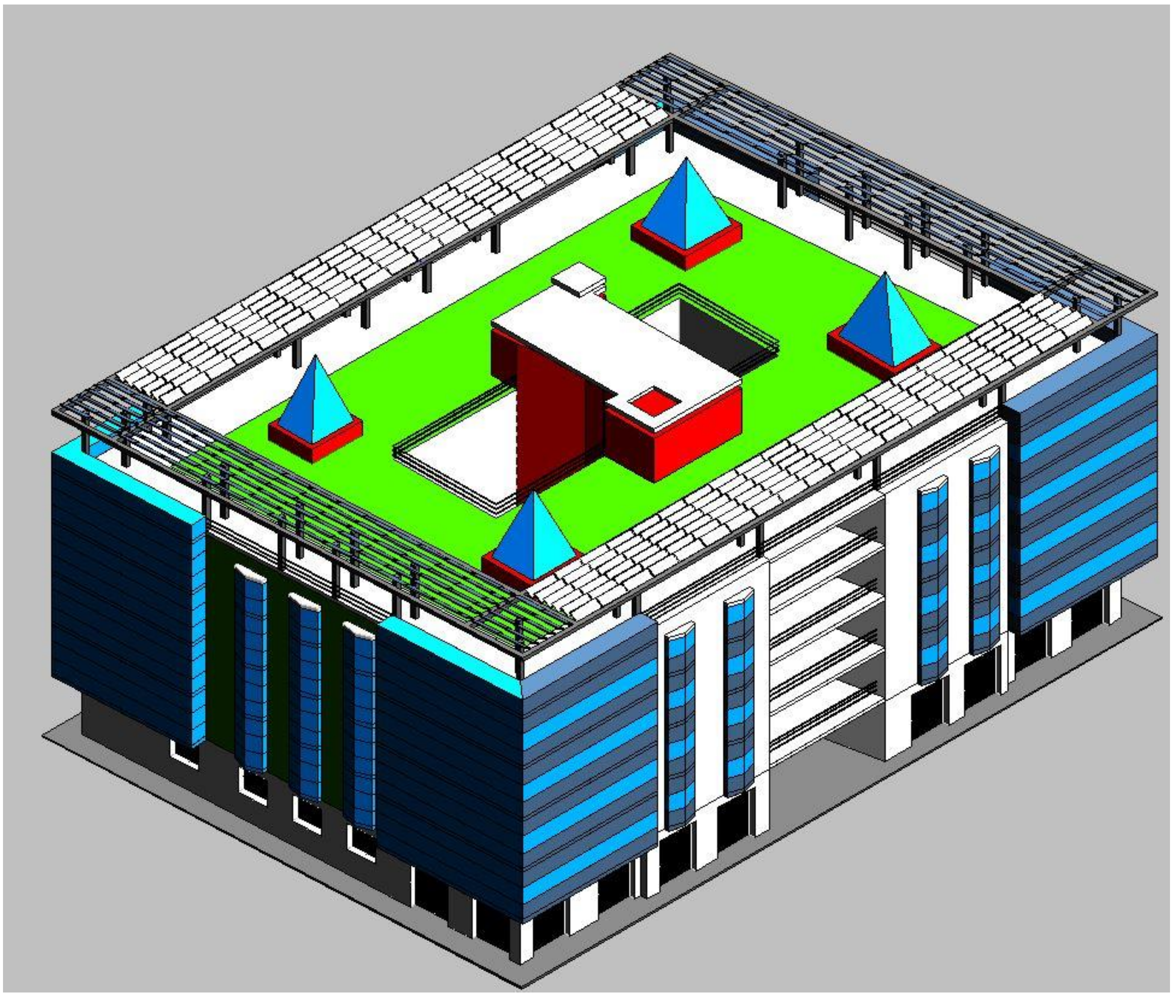


FIGURE 291 - RENDER

23. ANNEX C: DESIGN BUILDER PARAMETERS

TABLE 98 - GENERAL VALUE

	Value
Program Version and Build	EnergyPlusDLL-32 8.1.0.008, 30/06/2015 16:49
RunPeriod	PALACULTURA Enea
Weather File	Messina - ITA IGDG WMO#=164200
Latitude [deg]	38.20
Longitude [deg]	15.55
Elevation [m]	59.00
Time Zone	1.00
North Axis Angle [deg]	0.00
Rotation for Appendix G [deg]	0.00
Hours Simulated [hrs]	8,760.00

TABLE 99 - END USES BY SUBCATEGORY

	Subcategory	Electricity [kWh]	Natural Gas [kWh]	Additional Fuel [kWh]	District Cooling [kWh]	District Heating [kWh]	Water [m3]
Heating	General	0.00	0.00	0.00	0.00	0.07	0.00
Cooling	General	0.00	0.00	0.00	434108.33	0.00	0.00
Interior Lighting	ELECTRIC EQUIPMENT#Block5:Zone 9#GeneralLights	130.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 3#GeneralLights	263.30	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 15#GeneralLights	16,786.81	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 4#GeneralLights	422.10	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 6#GeneralLights	278.94	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 14#GeneralLights	381.02	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 7#GeneralLights	199.69	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 5#GeneralLights	973.99	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 1#GeneralLights	817.87	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone	12.02	0.00	0.00	0.00	0.00	0.00

	13#GeneralLights						
	ELECTRIC EQUIPMENT#Block5:Zone 8#GeneralLights	13.67	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 12#GeneralLights	19.02	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 10#GeneralLights	98.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 11#GeneralLights	14.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 2#GeneralLights	880.88	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 1#GeneralLights	4,747.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 4#GeneralLights	966.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 2#GeneralLights	383.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 14#GeneralLights	221.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 15#GeneralLights	18,188.67	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 13#GeneralLights	278.66	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 3#GeneralLights	0.00	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 12#GeneralLights	783.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 10#GeneralLights	12.16	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 8#GeneralLights	14.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 11#GeneralLights	122.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 9#GeneralLights	15.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 5#GeneralLights	16.25	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Block1:Zone 6#GeneralLights	101.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 7#GeneralLights	14.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 1#GeneralLights	420.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 4#GeneralLights	966.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 2#GeneralLights	383.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 14#GeneralLights	221.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 15#GeneralLights	18,184.28	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 13#GeneralLights	278.66	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 3#GeneralLights	199.69	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 12#GeneralLights	104.04	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 10#GeneralLights	12.16	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 8#GeneralLights	14.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 11#GeneralLights	122.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 9#GeneralLights	15.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 5#GeneralLights	16.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 6#GeneralLights	101.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 7#GeneralLights	14.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 1#GeneralLights	420.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	966.91	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Block3:Zone 4#GeneralLights						
	ELECTRIC EQUIPMENT#Block3:Zone 2#GeneralLights	383.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 14#GeneralLights	221.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 15#GeneralLights	18,184.86	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 13#GeneralLights	278.66	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 3#GeneralLights	199.69	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 12#GeneralLights	783.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 10#GeneralLights	12.16	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 8#GeneralLights	14.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 11#GeneralLights	122.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 9#GeneralLights	15.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 5#GeneralLights	16.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 6#GeneralLights	101.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 7#GeneralLights	14.24	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 1#GeneralLights	420.65	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 4#GeneralLights	966.91	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 2#GeneralLights	383.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 14#GeneralLights	221.03	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone	17,938.74	0.00	0.00	0.00	0.00	0.00

	15#GeneralLights						
	ELECTRIC EQUIPMENT#Block4:Zone 13#GeneralLights	278.66	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 3#GeneralLights	199.69	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 12#GeneralLights	783.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 10#GeneralLights	12.16	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 8#GeneralLights	14.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 11#GeneralLights	122.32	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 9#GeneralLights	15.01	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 5#GeneralLights	16.25	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 6#GeneralLights	101.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 7#GeneralLights	14.24	0.00	0.00	0.00	0.00	0.00
Exterior Lighting	General	0.00	0.00	0.00	0.00	0.00	0.00
Interior Equipment	ELECTRIC EQUIPMENT#Block5:Zone 9#05	327.95	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 3#05	1,359.14	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 15#05	27,668.93	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 4#05	1,057.53	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 14#05	954.60	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 5#05	1,736.52	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 1#05	4,379.61	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	30.12	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Block5:Zone 13#05						
	ELECTRIC EQUIPMENT#Block5:Zone 8#05	86.64	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 12#05	120.53	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 10#05	245.85	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 11#05	90.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block5:Zone 2#05	4,505.43	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 1#05	4,702.20	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 4#05	1,723.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 2#05	960.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 14#05	553.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 15#05	8,677.84	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 12#05	775.82	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 10#05	30.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 8#05	94.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 11#05	306.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 9#05	95.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 5#05	40.71	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone 6#05	254.98	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block1:Zone	90.22	0.00	0.00	0.00	0.00	0.00

	7#05						
	ELECTRIC EQUIPMENT#Block2:Zone 1#05	1,053.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 4#05	1,340.81	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 2#05	960.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 14#05	553.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 15#05	30,372.43	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 10#05	30.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 8#05	94.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 11#05	306.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 9#05	95.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 5#05	40.71	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 6#05	254.98	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block2:Zone 7#05	90.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 1#05	1,053.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 4#05	1,723.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 2#05	960.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 14#05	553.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 15#05	39,050.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 12#05	1,396.48	0.00	0.00	0.00	0.00	0.00

	ELECTRIC EQUIPMENT#Block3:Zone 10#05	30.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 8#05	94.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 11#05	306.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 9#05	95.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 5#05	40.71	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 6#05	254.98	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block3:Zone 7#05	90.22	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 1#05	1,053.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 4#05	1,723.90	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 2#05	960.13	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 14#05	553.77	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 15#05	39,050.27	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 12#05	1,396.48	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 10#05	30.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 8#05	94.59	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 11#05	306.47	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 9#05	95.09	0.00	0.00	0.00	0.00	0.00
	ELECTRIC EQUIPMENT#Block4:Zone 5#05	40.71	0.00	0.00	0.00	0.00	0.00
	ELECTRIC	254.98	0.00	0.00	0.00	0.00	0.00

	EQUIPMENT#Block4:Zone 6#05						
	ELECTRIC EQUIPMENT#Block4:Zone 7#05	90.22	0.00	0.00	0.00	0.00	0.00
Exterior Equipment	General	0.00	0.00	0.00	0.00	0.00	0.00
Fans	General	0.00	0.00	0.00	0.00	0.00	0.00
Pumps	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Rejection	General	0.00	0.00	0.00	0.00	0.00	0.00
Humidification	General	0.00	0.00	0.00	0.00	0.00	0.00
Heat Recovery	General	0.00	0.00	0.00	0.00	0.00	0.00
Water Systems	DHW Block5:Zone3	0.00	0.00	0.00	0.00	111.35	3.00
	DHW Block5:Zone5	0.00	0.00	0.00	0.00	4,510.18	121.39
	DHW Block5:Zone1	0.00	0.00	0.00	0.00	358.81	9.66
	DHW Block5:Zone2	0.00	0.00	0.00	0.00	369.11	9.93
Refrigeration	General	0.00	0.00	0.00	0.00	0.00	0.00
Generators	General	0.00	0.00	0.00	0.00	0.00	0.00

TABLE 100 - TABULAR VIEW FOR TEMPERATURE AND PRECIPITATION PER MONTH

	Temperature			Precipitation
Months	**Normal**	**Warmest**	**Coldest**	**Normal**
January	12.3°C	14.4°C	10.1°C	10
February	12.2°C	14.7°C	9.8°C	9
March	13.5°C	16.1°C	10.9°C	8
April	15.4°C	18.3°C	12.5°C	8
May	19.5°C	22.5°C	16.4°C	3
June	23.6°C	26.8°C	20.4°C	1
July	26.7°C	30.0°C	23.4°C	1
August	27.3°C	30.5°C	24.2°C	2
September	24.5°C	27.5°C	21.5°C	5
October	20.5°C	23.2°C	17.8°C	8
November	16.4°C	18.7°C	14.1°C	10
December	13.7°C	15.8°C	11.6°C	10

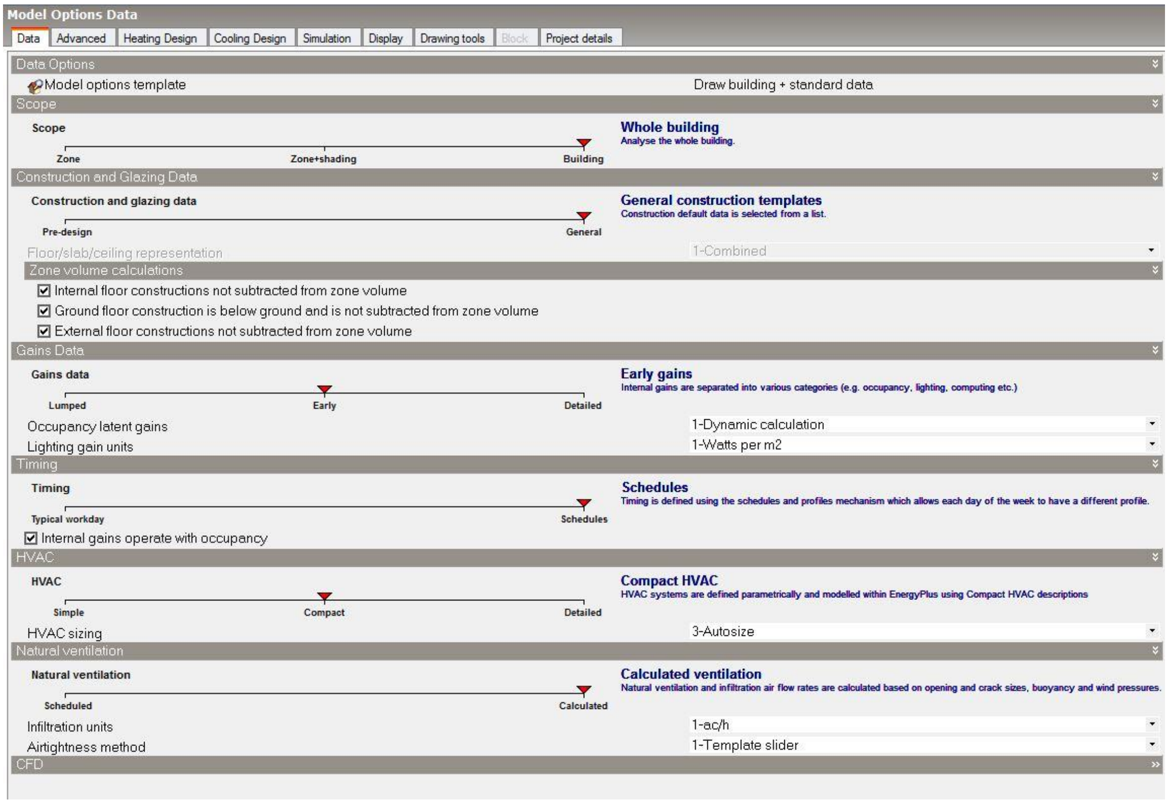


FIGURE 292 - MODEL OPTIONS DATA

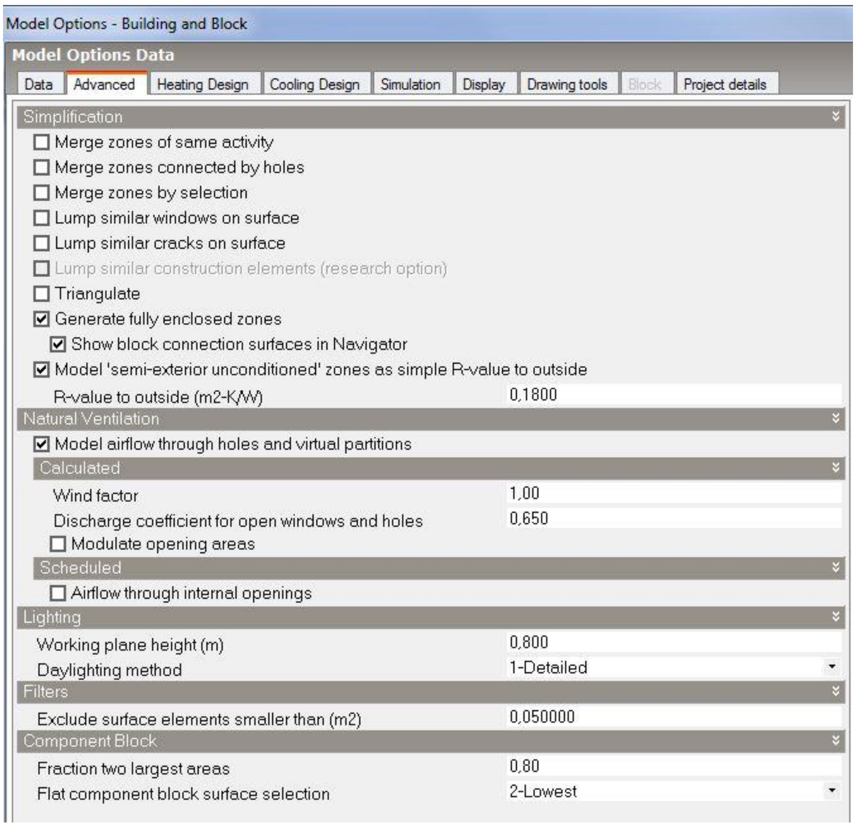


FIGURE 293 - MODEL OPTIONS DATA

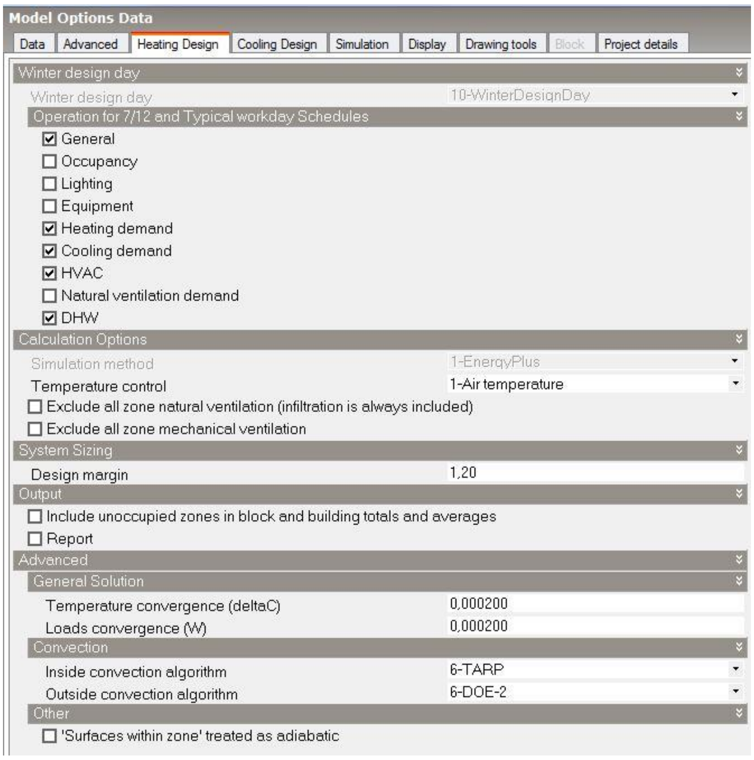


FIGURE 294 - MODEL OPTIONS DATA

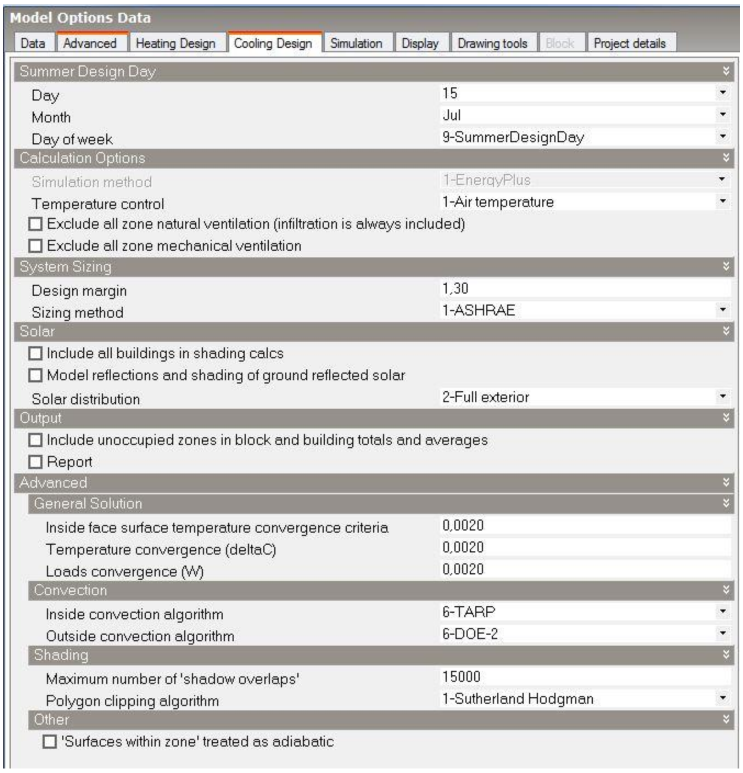


FIGURE 295 - MODEL OPTIONS DATA

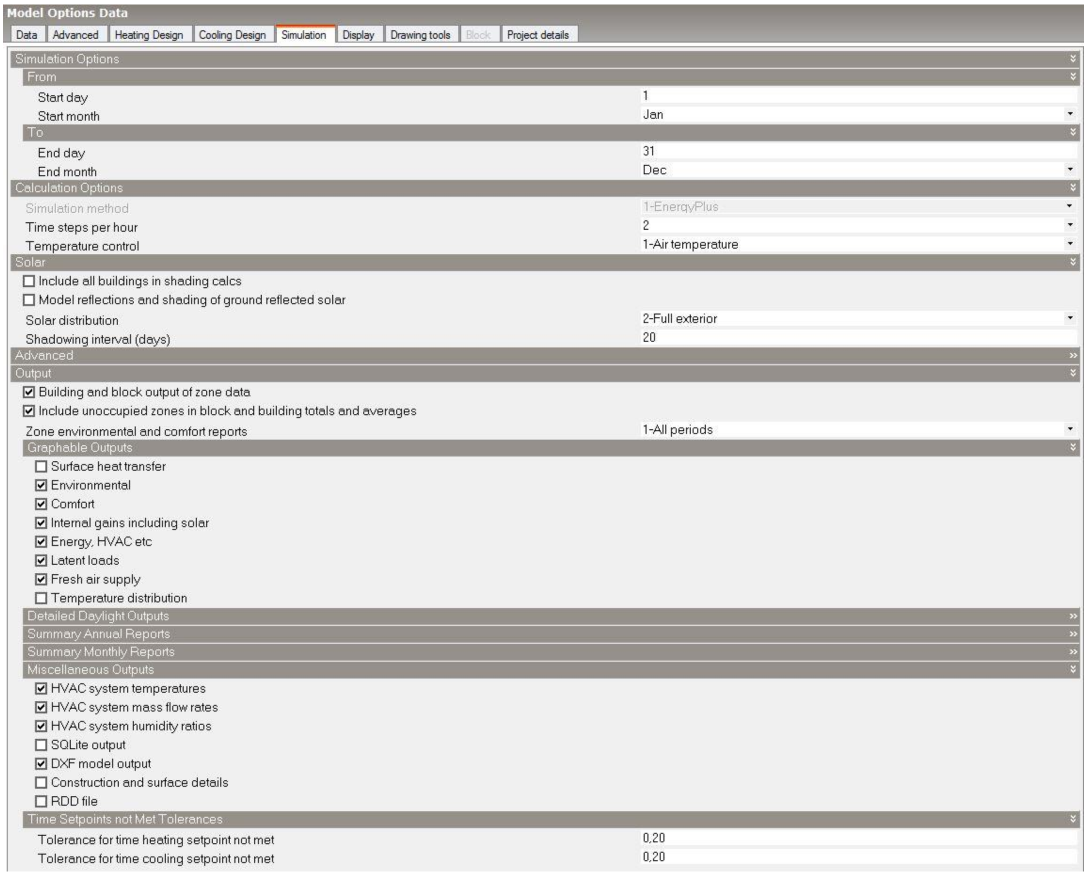


FIGURE 296 - MODEL OPTIONS DATA

24. ANNEX D: RENOVATION OPTION MATRIX BY SINLOC

TABLE 101 - ECONOMIC EVALUATION OF INTERVENTIONS

						Work timing						CAPEX				
				Installed power or size of intervention		Start date	Final date	Construction Period	Compulsory connection with other technologies/ layers	Specify which technologies are needed to realize this layer	Specify which technologies can be realized only after this layer	Investment cost			Investment payback period (preliminary)	Lifetime (year of replacement - revamping)
Renovation options	Types	Technologies / Layers	Code	Unit of measure	Value	dd/mm/yy	dd/mm/yy	Months	Yes/No	Code/codes (ascending order)	Code/codes (ascending order)	Unit of measure	Unit cost	Value calculated	Years	Years
	Cooling pumps	*Compression heat pumps - VRV system - OFFICES AREAS*	4	KW	355	X	X	12	Yes	13-16-17	37	€/KW	€ 1'408,45	€ 500'000	11,96	25
	Replacement of water heating systems	Solar thermal	5													
		[...]	6													
	Insulation of distribution networks	[...]	7													
			8													
	Ventilation system	**Heat recovery**	9													
			10													
		Heating pumps with geothermal sonde Georthermal heat pumps	11													
		[...]	12													
Casing	**External insulation**	**New facades** - *External wall, windows, green wall*	13	sqm	1190	X	X	18	Yes		4	€/sqm	€ 869,69	€ 1'014'929	41,33	60
Building skin	Internal insulation	[...]	14													
	Shielding elements	Fixed/mobile/combined vertical structures	15													
		Horizontal structures on roofs - *NEW PV COVER SHELTER*	16	sqm	1350	X	X	10	Yes		4	€/sqm	€ 266,67	€ 360'000	37,33	60
		Horizontal structures on floors - *WATERPROOFING FOUNDATIONS and FOUNDATIONS STRUCTURAL RENOVATION*	17	sqm	363,7	X	X	10	Yes		4	€/sqm	€ 869,69	€ 316'308	104,56	60
	Bioclimatic	[...]	18													
		[...]	19													
Windows	Windows	PVC	20													
		[...]	21													
	Glass windows	Double glass	22													
	Glass windows	Triple glass	23													
		[...]	24													
Lighting systems (internal)	**Replacement of lamps (and luminaries, ballast)**	**LED**	25													
		Internal Relamping	26	units	506	X	X	3	No			€/unit	€ 200,00	€ 101'200	0,80	20
Lighting systems (external)	Replacement of lamps (and luminaries, ballast)	LED	27													
			28													
Renewable energy	Biomass	Biomass heating systems	29													
	Solar	*Photovoltaic panels*	30	KWp	155	X	X	6	No			€/KWp	€ 2'000,00	€ 310'000	9,77	30
		Solar thermal panels	31													
Control systems	Thermal	Automatic regolation of internal temperature	32													
		Thermostatic valves	33													

TABLE 102 - ECONOMIC EVALUATION OF INTERVENTIONS

Renovation options	OPEX – Energy consumption (after each single energy renovation option): Source 1	Unit of measure	Consumption/year	€/year	Source 2	Unit of measure	Consumption/year	€/year	Labor/Management and ordinary maintenance contracts: Cost of components €/year	Cost of personnel €/year	Total €/year	Extraordinary maintenance: Frequency years	Cost of intervention €	Cost of personnel €/year	Total €	SAVINGS – Potential energy savings expected from the intervention – Electric energy consumption: %, first year	kWhe/year, first year	%, last year	kWhe/year, last year	Decrease characteristics (linear, nonlinear, etc.)	Thermal energy consumption: %, first year	kWhe/year, first year	%, last year	kWhe/year, last year	Decrease characteristics (linear, nonlinear, etc.)	Potential savings from maintenance (post intervention) %	€/year	Potential savings of CO2 %	Equivalent tons/year
	electric	KWHe	434'108	€ 78'139,44	no				€ 3'500	€ 6'500	€ 10'000	7	€ 15'000	€ 1'500	€ 25'500	13,5%	106'844	12,0%	94'831	linear						40%	€ 23'667	12,8%	75,63
Casing Building skin	no				no				€ 7'105	€ 13'194	€ 20'299	10	€ 25'000	€ 3'000	€ 55'000	18,0%	142'459	16,5%	130'392	linear						0%	€ 0	17,3%	102,32
	no				no				€ 4'410	€ 8'190	€ 12'600	15	€ 15'000	€ 1'000	€ 30'000	6,8%	53'422	6,8%	53'737	linear						0%	€ 0	6,8%	40,18
	no				no				€ 2'214	€ 4'112	€ 6'326	15	€ 10'000	€ 1'000	€ 25'000	2,25%	17'807	2,00%	15'805	linear						0%	€ 0	2,1%	12,60
Windows																													
Lighting systems (internal)																													
	electric	KWHe	111'437	€ 20'058,66	no				€ 708	€ 1'316	€ 2'024	7	€ 2'000	€ 500	€ 5'500	87%	741'066	75%	639'377	linear						25%	€ 2'508	81,0%	517,67
Lighting systems (external)																													
Renewable energy																													
	no				no				€ 5'425	€ 10'075	€ 15'500	5	€ 15'000	€ 4'000	€ 35'000	100%	201'500	75%	151'125	linear						0%	€ 0	87,5%	132,23
Control systems																													

ENEA - Italian National Agency for New Technologies, Energy and Sustainable Economic Development (IT)

Municipality of Messina (IT)

Municipality of Errenteria (ES)

Municipality of Coimbra (PT)

Municipality of Alimos (EL)

ISR University of Coimbra (PT)

SINLOC - Sistema Iniziative Locali Spa (IT)

ETVA VI.PE. S.A. (EL)

TECNALIA Research & Innovation Foundation (ES)

EUDITI Energy and Environmental Design LTD (EL)

Innova B.I.C. Business Innovation Centre S.r.l. (IT)

Danish Building Research Institute, Aalborg University Copenhagen - SBi/AAU (DK)

ASSISTAL (IT)

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