Toolkit for Innovative and Eco-sustainable Renovation Processes

Best practices

Med-EcoSuRe

Mediterranean University as Catalyst for Eco-Sustainable Renovation

The Toolkit for Innovative and Eco-Sustainable Renovation Processes has been developed in the framework of the Med-EcoSure project - Mediterranean University as catalyst for Eco-Sustainable Renovation, by the research group beXLab (building environmental eXperience) at the DIDA Department of Architecture of the University of Florence.

The Toolkit has been delivered as output of the Med-EcoSuRe project in **November 2022.**

The authors of the Toolkit are:
Antonella Trombadore | Gisella Calcagno | Giacomo Pierucci | Lucia Montoni | Camilo Olano

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Introduction

The document is one of the output of the Med-EcoSuRe Project (Mediterranean University as Catalyst for Eco-Sustainable Renovation), that has been developed by the UNIFI / University of Florence Team inside the beXLab (building environmental experience laboratory), based in Florence. It is part of the "Toolkit of Passive Solutions Design for Higher Education Buildings Retrofitting" – WP 3's output.

The selection of case studies related to building interventions in high educational institutions regarded both renovation and new constructions projects in the European region, joined by their attention towards energy efficiency. The insertion of new construction projects is justified by the objective to study the design approach and the use of technology towards energy efficient buildings and to reduced operational costs, which in the case of new buildings are more easily reached.
The research selected, analysed and catalogued a total of 18 case studies, concerning 9 university complexes built from scratch and 9 cases of energy modernization and restructuring.
Considering both qualitative and quantitative data, a set of indicators were defined as basis for the evaluation of the case studies, which allowed for the definition of a base-line for the subsequent comparison between them.
In order to catalogue the case studies and to perform the analysis on their energy performances, but also to allow user to extend the list adding new examples, a data collection sheet has been defined, containing two main parts: the general data and information on the building and the performance indicators.

General data of the building:
the year of construction and refurbishment
the location and the climatic zone to which it belongs
the orientation of the building
the number of students it can host
the construction typology
the architects
the intended use of the building
the subdivision of its internal environments and its development in plan and elevation
the retrofit interventions also describing the state of the building before the intervention

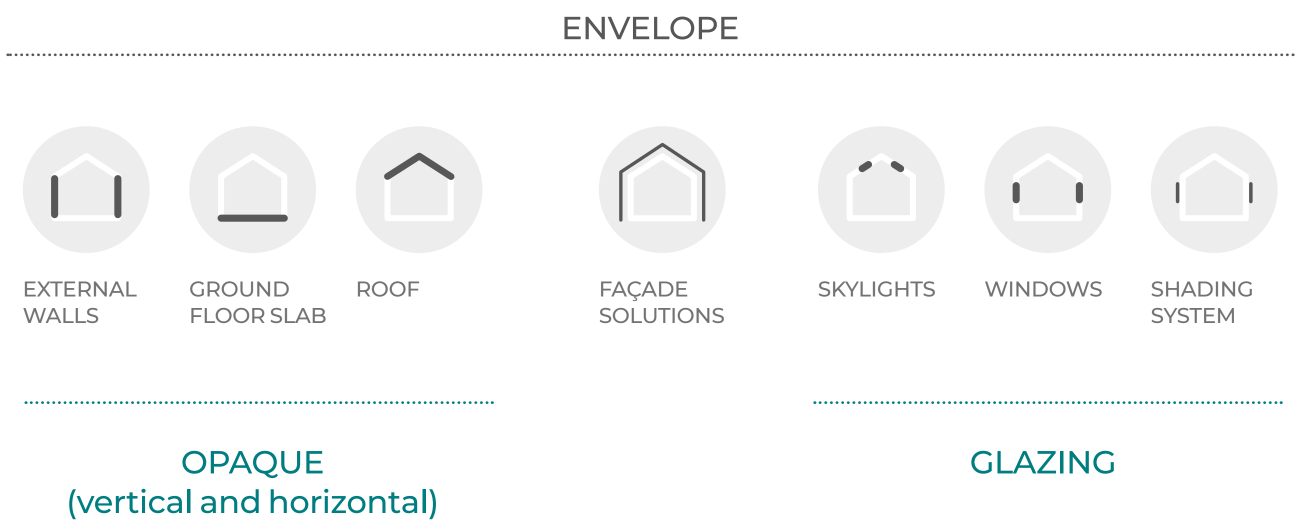
Performance indicators
Performance indicators are intended to analyse the technological aspects and strategies of the retrofitting and new construction interventions, permitting to highlight the benefits and improvements from an energy point of view.
Two aspects to analyse have been identified, one concerning the envelope and the other concerning the energy system.
The building envelope is an element that delimits the building on the perimeter and has the function of separating/connecting the inside from the outside, and consists of technological units and technical elements that have structural and non-structural functions. The elements identified as indicators within this aspect were:
VERTICAL OPAQUE CLOSURES (walls);
HORIZONTAL OPAQUE CLOSURES (roof and ground floor slab);
GLAZING (windows and transparent elements);
FAÇADE SOLUTION.

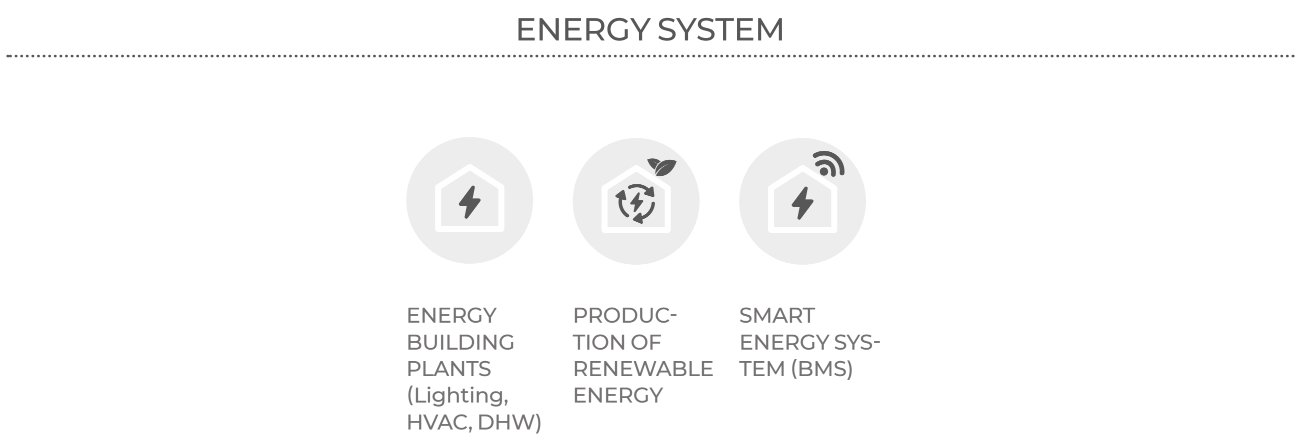
In order to understand the energy consumption, also the energy system of the projects has been analyzed. Within this aspect, the following elements have been analysed:
LIGHTING;
HEATING VENTILATION & AIR CONDITIONING;

DOMESTIC HOT WATER;
RENEWABLE ENERGY;
BULDING MANAGEMENT SYSTEM.

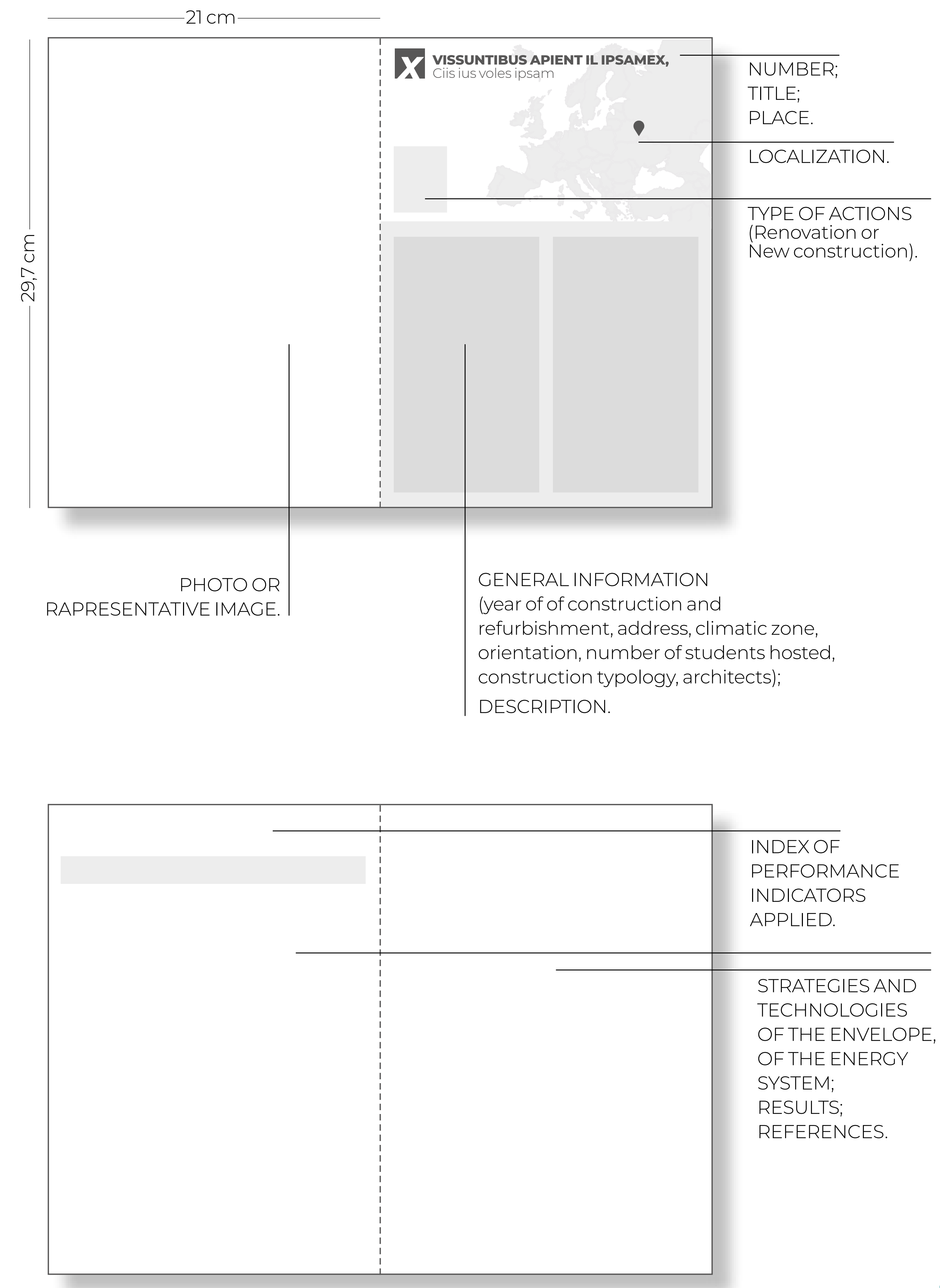
Finally, for each project, a synthetic indicator called “Result” (resulting from the combination of the envelope and plant systems) has been defined in two way according to the type of project. For new constructions, the result is the foreseen energy consumptions, for renovations, the indicator refers to the energy saving achieved in comparison to the previous building.
The data collection sheet is reported in the annexes [Annex I]. It has been used to analyse all the selected projects [Annex II and Annex III].
In order to catalogue the case studies in a more formal and descriptive way, and to achieve an effective communication, also a graphic organization of the projects' material has been developed, as reported in the annexes [Annex IV on renovation projects, and Annex V on new construction projects].

PERFORMANCE INDICATORS SCHEME

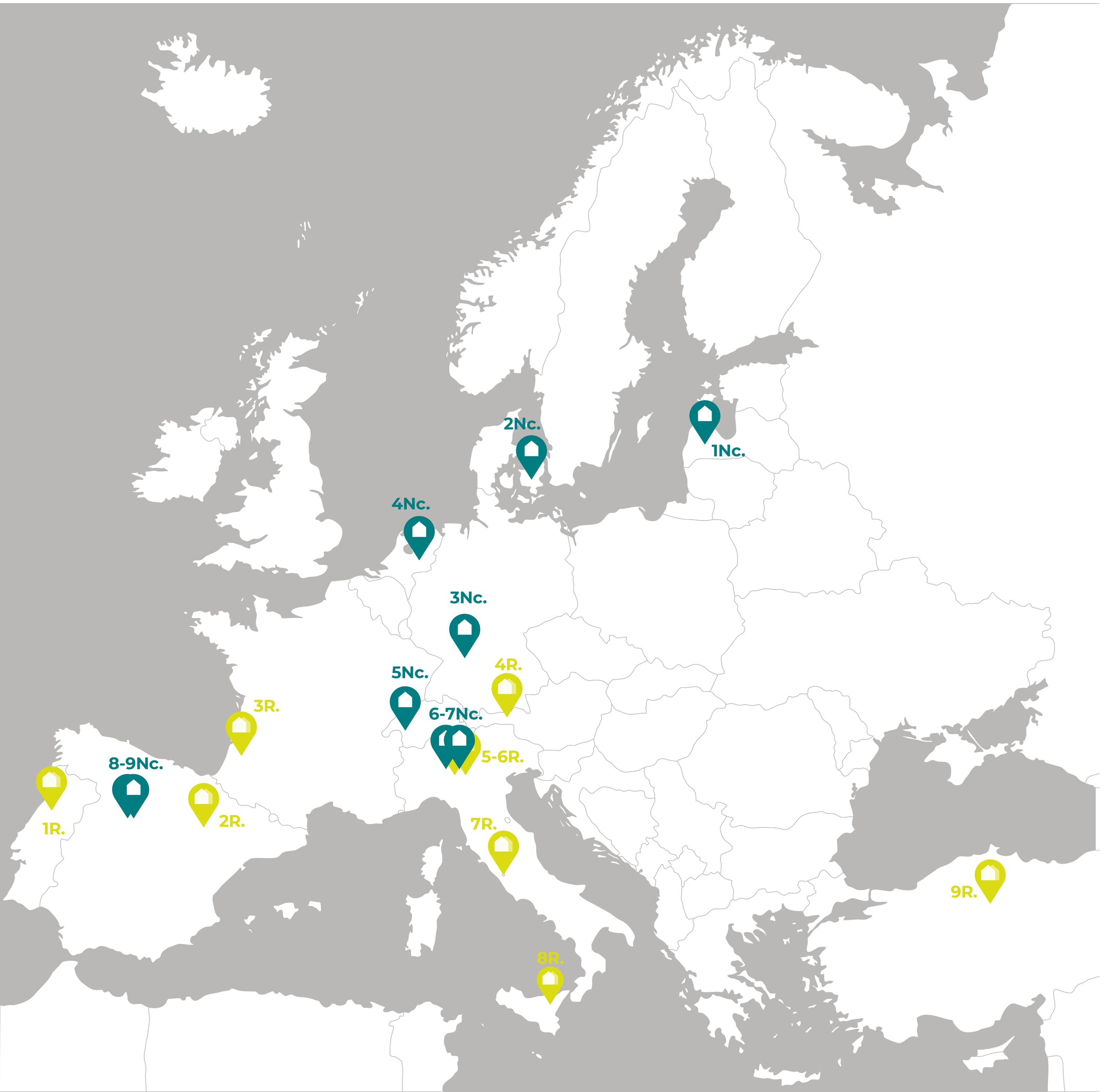




SHEET LAYOUT



Interactive map



RENOVATION

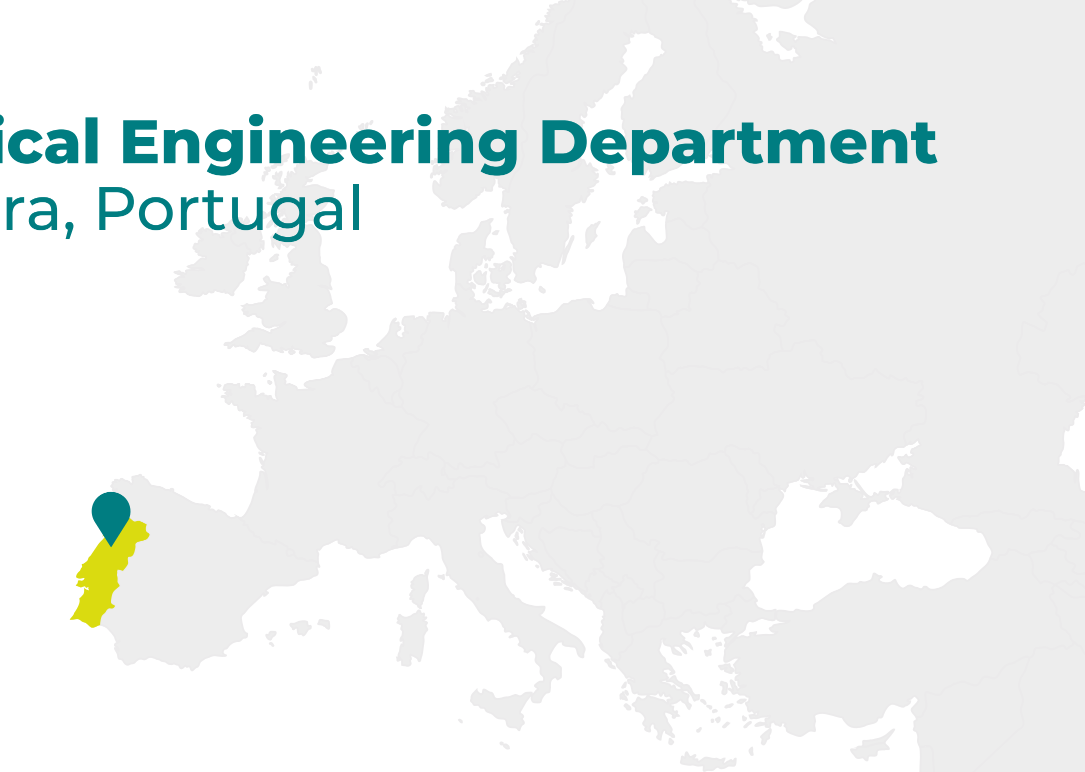
1R. Electrical Engineering Department - Coimbra, Portugal
2R. EHU Building Biscay Campus - Leioa (Bilbao), Spain
3R. Scientific University - Bordeaux, France
4R. Department of Technical Sciences - Innsbruck, Austria
5R. UNIMI University campus - Milan, Italy
6R. Department of Electronics, Information and Bioengineering (DEIB) - Milan, Italy
7R. Orthopaedic and Traumatological Institute - Rome, Italy
8R. Department of Civil Engineering and Architecture - Catania, Italy
9R. Aflivadem vocational school - Ankara, Turkey

NEW CONSTRUCTION

1Nc. Music School and Concert Hall - Ventspils, Latvia
2Nc. Green Lighthouse building - Copenhagen, Denmark
3Nc. Alnatura Campus - Darmstadt, Germany
4Nc. The Edge University Building - Zuidas (Amsterdam), Netherlands
5Nc. Laboratory Building Agora - Lausanne, Switzerland
6Nc. Humanitas University Campus - Milan, Italy
7Nc. Luigi Bocconi new Campus - Milan, Italy
8Nc. Aulario Induva campus - Valladolid, Spain
9Nc. LUCIA building - Valladolid, Spain

Renovation

Electrical Engineering Department
Coimbra, Portugal



TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1996

YEAR OF REFURBISHMENT: 2016

ORIENTATION: S - SE

DIMENSION: 10.000 m^2

STUDENTS: 70

CLIMATE ZONE: Oceanic climatic area

DESCRIPTION

The Electrical Engineering Department building comprises classrooms, professors' offices, laboratories, administrative services, study rooms, bar, copy shop and garage.

The building is constituted by two main blocks: one larger and composed by nine floors divided in five towers, and another one smaller and divided in three towers.

The walls were built in concrete with outside thermal insulation and masonry of perforated brick with inside thermal insulation. The flat horizontal coverage had a thermal insulation too.

There was no central heating, cooling or ventilation system running; the heating system powered by natural gas has been out of order for many years. Heating was based on individual heating devices (resistance and fan-ventilators) powered by heat pumps and controlled manually, according to each individual comfort standard and wish.

The previous lighting system consists of T8 linear fluorescent lamps, compact fluorescent lamps with separate magnetic ballasts, halogen spots and halogen spotlights.

ENERGY SYSTEM

ENERGY BUILDING PLANTS

Replacement of the existing lighting system with new LED lamps, ensuring a decrease on the total installed power of 51,55 kW.

PRODUCTION OF RENEWABLE ENERGY

Installation of **392 photovoltaic panels** facing south and south-west with a slope of 13° and 25° in order to minimize the visual impact and exploit the areas without shading.
Moreover, the **energy storage system** is able to reduce the energy injected into the grid, maximising the use of renewable energy produced on-site.

Structure of the PV panels installed in area 2 (a) and in areas 1, 3 and 4 (b).

PV Panels Areas Scenario

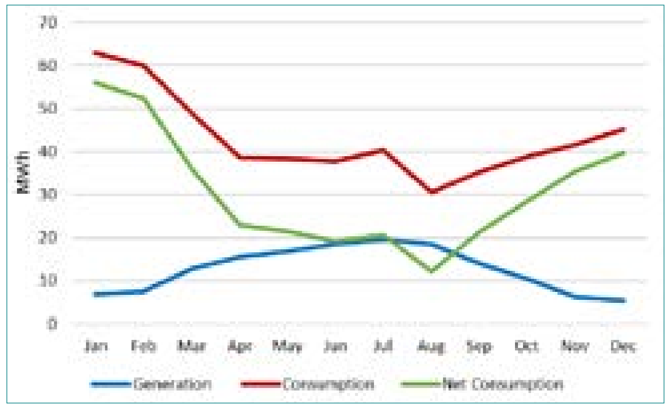
RESULTS

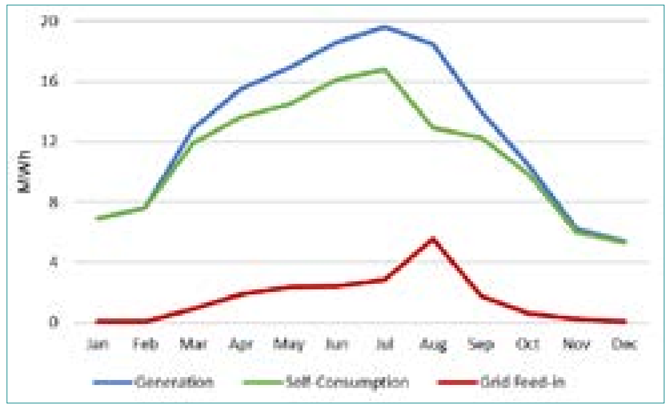
The main measure implemented in the short term is the large scale replacement of existing and high consuming lamps with LEDs.
With the total renewal of the lighting **20% of energy savings** are obtained and the installed renewable generation is able to guarantee **36.8% of the consumption**, reducing the net energy consumption to 50,5% on the baseline.
The results were also assessed in terms of final energy, specific energy and CO2 emissions, considering a conversion factor from electricity to CO2 emissions of 139.89 g of CO2/kWh.
The tangible improvement measures ensure **savings of 49.5%**, reducing the energy density of the building to just 26.18 kWh/mq per year.

-20% of energy savings with LED Lighting

+36,8% of energy consumption with PV system

+49,5% of total savings on the net-energy consumption





The tables present the yearly variation of the energy generation and demand, as well as the net-energy demand, being visible as the low net-energy demand during summer (mainly in August). The distribution between the energy generation used for self-consumption and injected into the grid is also presented. As can be seen, during winter months almost all the generation is used for self-consumption. However, during summer a higher share of the energy has to be injected into the grid, owing to the simultaneous increase of solar radiation and decrease of electricity demand. The injection of generated energy into the grid is mainly concentrated during weekends, owing to the low electricity demand in those periods.

References

Fonseca, P., Moura, P., Jorge, H. and de Almeida, A. (2018), *"Sustainability in university campus: options for achieving nearly zero energy goals"*, International Journal of Sustainability in Higher Education, *Vol. 19 No. 4, pp. 790-816. https://doi.org/10.1108/IJSHE-09-2017-0145*

Fonseca, P., Moura, P., Jorge, H. and de Almeida, A. (2018), *Achieving university campus sustainability with nearly zero energy building retrofits, ECEEE 2017 Summer School – Consumption, Efficiency and Limits*, online: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2017/5-buildings-and-construction-technologies-and-systems/achieving-university-campus-sustainability-with-nearly-zero-energy-building-retrofits/ [Accessed 29 Mar. 2022].

BACK to the map

EHU Building Biscay Campus
Leioa (Bilbao), Spain

TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1970
YEAR OF REFURBISHMENT: 2016
DIMENSION: 8.973 m^2
ORIENTATION: N - S
NUMBER OF STUDENTS: 15.000
CLIMATE ZONE: Oceanic climatic area
CONTRACTORS: A2PBEER

DESCRIPTION

The case study is the central rectors' office building of the Leioa University Campus, at 11 km from Bilbao. It is surrounded by several buildings with similar constructive characteristics but with different uses (sport centre, university building, etc.).

The building is large 110 x 22 m, with a maximum height of 18 m.
It is made up of 3 building blocks, with a common ground floor and elevating from two to four-storeys. The central and western buildings are connected via a common staircase access whilst the eastern and central blocks are connected by a corridor.
The majority of the facade was built with precast concrete panels without air gap, while other walls consisted of a prefabricated concrete frame with infill concrete block and faced brick or a finishing layer of plaster. Main criticality of the external façades were thermal bridges and the different finishes inconsistent with each other.
There were different types of windows: wood frame and single glazing; aluminium frame with ot without thermal break and double glazing.
Regarding horizontal elements, the roof was constructed with prefabricated concrete and finished with a PVC coating, the floors were built with reinforced concrete providing a high thermal mass to the building, and the ground floor was originally a car park and, later, has been adapted for increasing the offices' area. So, different finishes were found in that part of the south facade.
The entire complex was connected to a district heating system. The district plant - consisting of 7 natural gas fired condensing boilers - was centrally located within the campus. The heat production and distribution temperature ranged from 80 to 100°C.
There was no centralized cooling system and only a small number of buildings localised cooling systems (DX system and compression cycle based chillers). Moreover, there was no mechanical ventilation provision, apart from the extract ventilation the toilets.

ENVELOPE

EXTERNAL WALLS

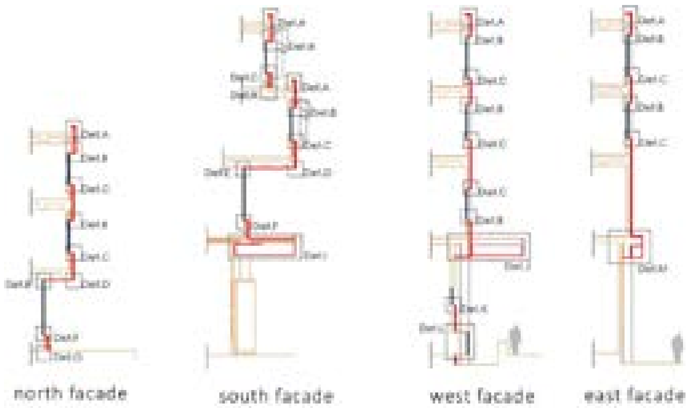
The whole opaque façade is covered with an **external ventilated façade containing vacuum insulation panels** (VIPs). The VIP is divided in: PVC clip system mounting to the wall; 1100x700x30 mm insulation panels finished with protection rubber.

WINDOWS

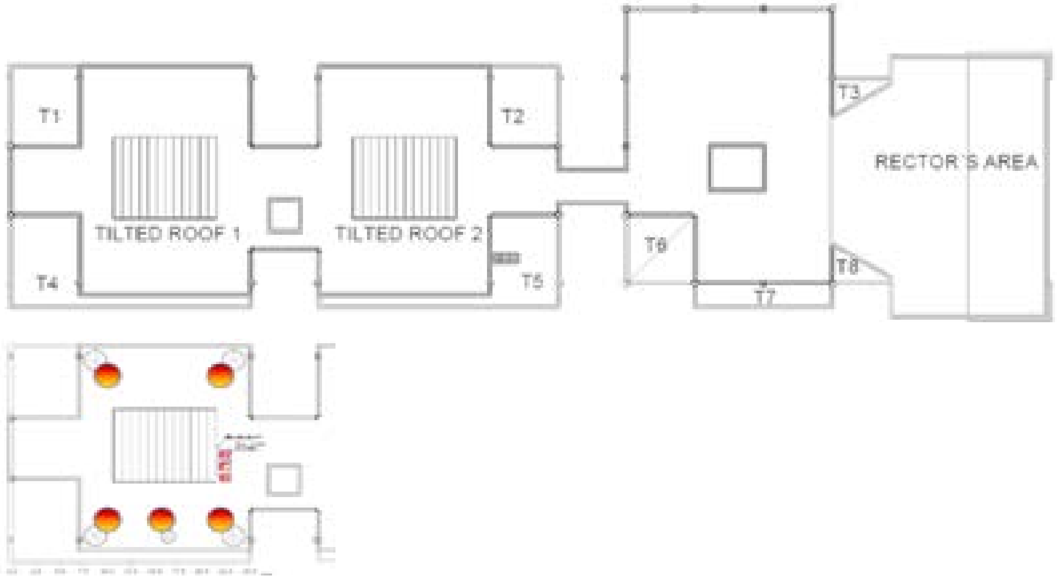
Replacement of some windows with **innovative reversible windows** (modifying solar heat gains depending on the season) and others with **low-E windows**. Windows utilize a closing mechanism, witch allows the windows sash to be turned around 180 or 360 degrees and locked in the opposite position.

ROOF

The new roof is totally **covered with 5 cm XPS tiles** and, in some areas, VIPs has been installed.



Vertical sections of the external insulation distribution and details of VipS panels.



Roof and solar collector's collocation

South façade

ENERGY SYSTEM

ENERGY BUILDING PLANTS

As regard building plants has been installed a new **LED lighting system**, a **solar collector** system for cooling and the **district heating network**.

PRODUCTION OF RENEWABLE ENERGY

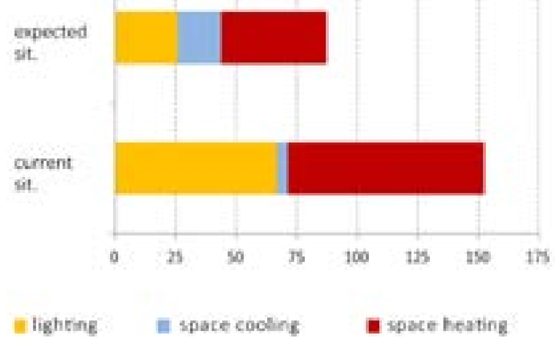
Installation of **solar thermal collector system** to produce the required water temperatures combining heating, cooling and energy storage.

SMART ENERGY SYSTEM

The smart lighting systems aim to reduce the use of electricity by introducing **LED controlled lighting** depending on available natural light.
Additional **thermostatic control valves** is installed on the radiators and automatic actuators is fitted in order to enable presence detection and window status driven control strategies.

RESULTS

The expected **energy savings** as regard lighting are about 62% and as reagard space heating are about 46%.
Regarding space cooling, the energy consumed by the fans for the ventilation has been included as "space cooling" in the table; for that reason, no energy savings on space cooling are resulted.
Total savings are 42,5% while the total budget of the project is 1.160.000 €.



Energy consumption (kWh PE/m2 year)

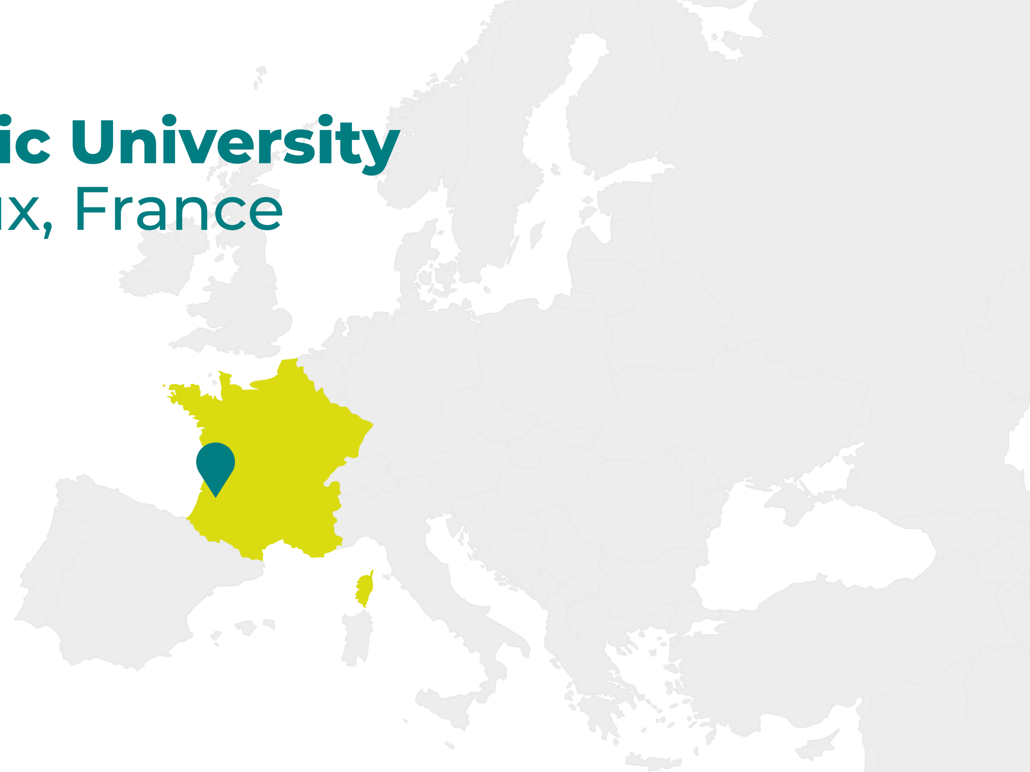
References

Barreiro, E. (2013), *PROJECT FINAL REPORT A2PBEER - Affordable and Adaptable Public Buildings through Energy Efficient Retrofitting*, online: https://cordis.europa.eu/docs/results/609/609060/final1-a2pbeer-finalreport-total.pdf [Accessed 29 Mar. 2022].

Pensado-Mariño, M., Febrero-Garrido, L., Pérez-Iribarren, E., Oller, P.E. and Granada-Álvarez, E. (2021), *Estimation of Heat Loss Coefficient and Thermal Demands of In-Use Building by Capturing Thermal Inertia Using LSTM Neural Networks. Energies*, 14(16), online: https://doi.org/10.3390/en14165188

BACK to the map

Scientific University
Bordeaux, France



TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1961

ORIENTATION: S - SE

DIMENSION: 87.000 m^2

STUDENTS: 13.000

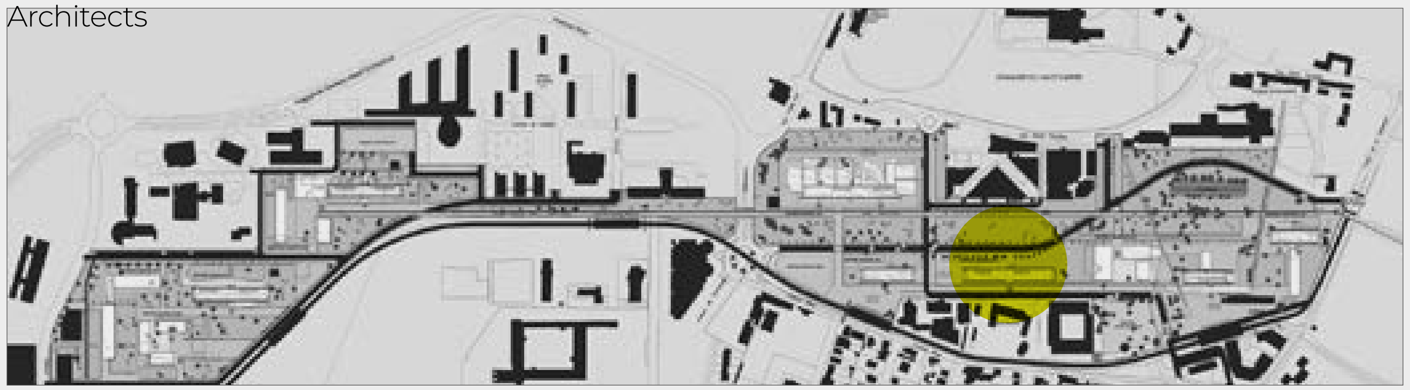
CLIMATE ZONE: Oceanic climatic area

YEAR OF REFURBISHMENT: 2015

ARCHITECTS: Debarre Duplantiers, Ronald Sirio Architects

DESCRIPTION

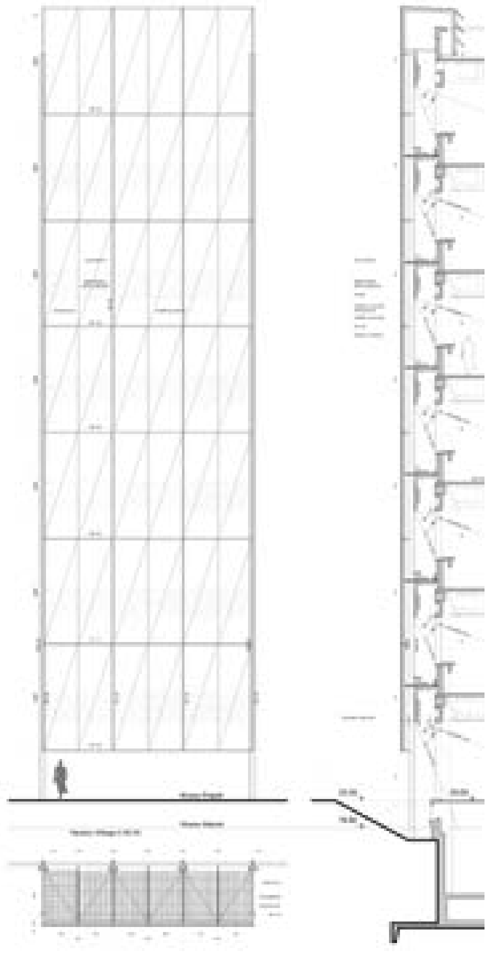
The project fits into the urban environment of the existing campus of the University of Bordeaux, which presents a homogeneous heritage.
The buildings had a concrete frame structure and an energy system already developed with urban network, heat pumps, water radiator but no cooling system.
The intention of the designers was to maintain the urban and architectural identity that connects all the buildings of the Campus, spread over almost 2 km, and to enhance the existing buildings qualities.
So the existing buildings were renewed and the new functions were addressed in new buildings constructed in the site of some demolished buildings.
Designing the external area, have been created new plots and the access to public transport in order to facilitate the movement of users.



ENVELOPE

FAÇADE SOLUTIONS

A bioclimatic and glazed double skin has been installed for the façade of six buildings.
The large existing openings of the internal facade - that provides a generous natural light in all classrooms - with the new double skin achieve a renewal of the **indoor comfort**.
The new **buffer space** created between the glass skin and the existing façade improve energy performance.
In winter the glass facade absorbs solar radiation and can passively heat the interior of the building.
In summer, the buffer space, with the motion of the air, naturally cools and ventilates interior spaces.



ENERGY SYSTEM

ENERGY BUILDING PLANTS

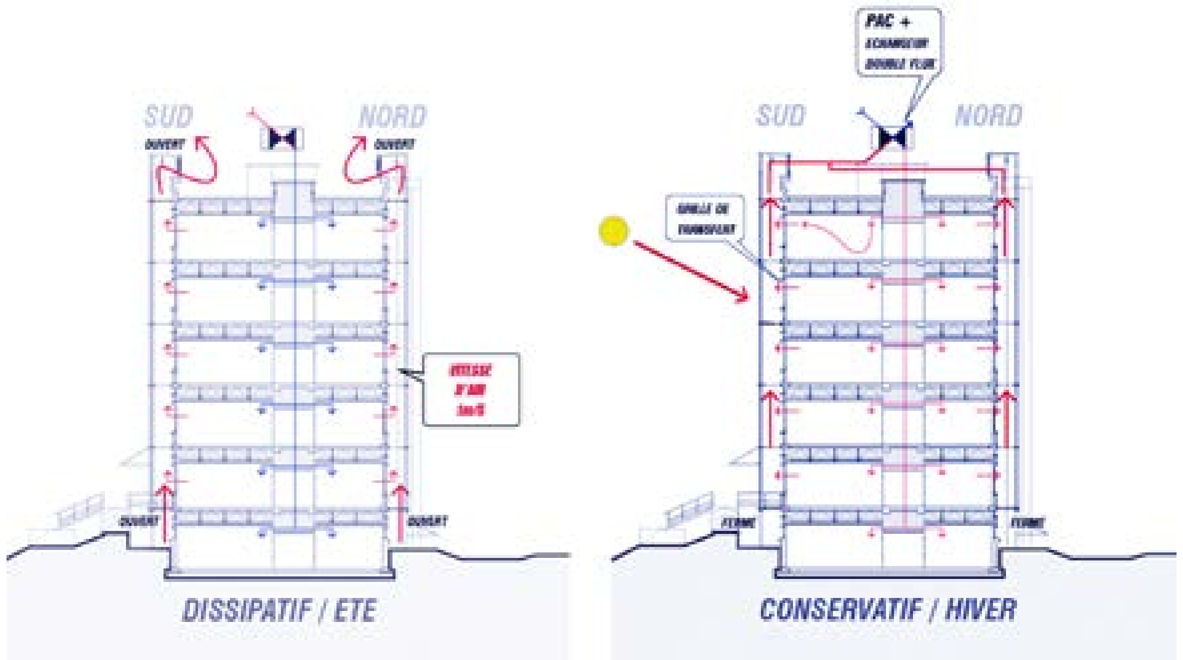
For the lighting has been fitted a **fiber optic with LED** in the second floor.
Moreover, a **mechanical ventilation**, with double flow heat exchanger, **and thermostatic controvalves** was installed.

SMART ENERGY SYSTEM

A **smart control LED** lighting depending on the natural lighting availability is installed.

opposite page
Section of the bioclimatic façade and picture of the entrance

➔
Schemes of the buildings during summer and winter (dissipative vs conservative behavior)



RESULTS

The bioclimatic façade is an evolving principle during the year: it is adaptive, it evolves with climate.
This solution reduces heating requirements by a factor of 5 to 10, primary energy consuption ≤ Cep ref -40 % within the meaning of thermal regulations
The total cost of the project is 95 MLN €.

References

www.construction21.org/case-studies/fr/scientific-university-of-bordeaux.html.
https://paulchemetov.com/projets/universite-bordeaux-1-sciences-et-technologie.
Scientific university of Bordeaux_constuction21 (PDF).

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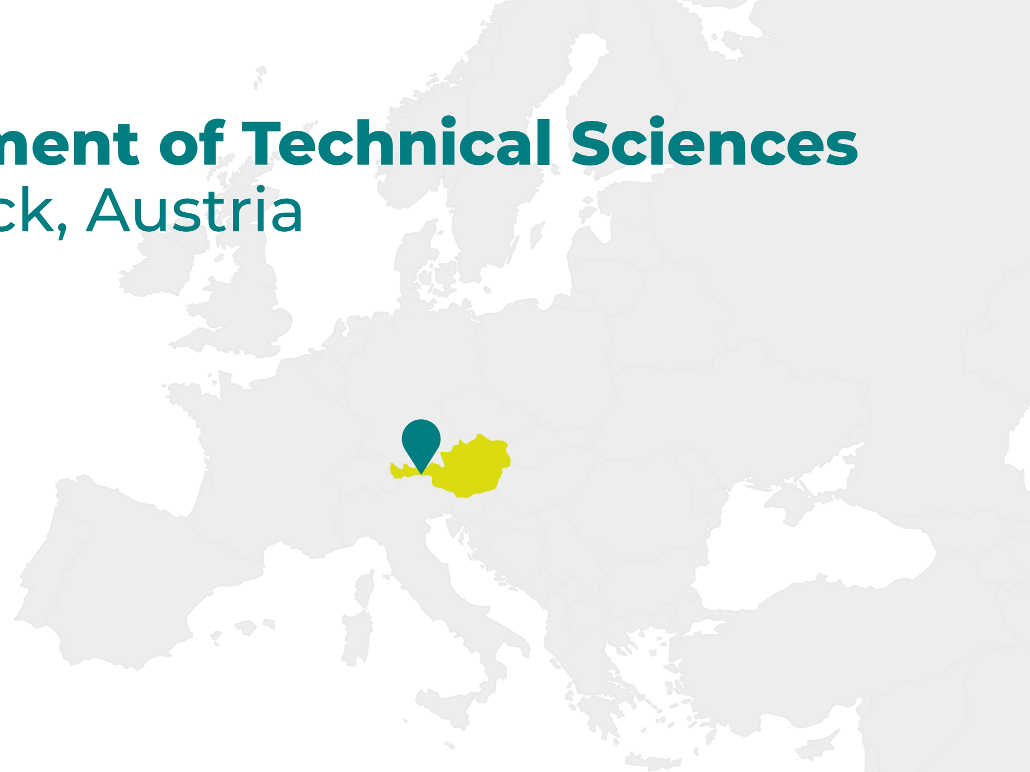
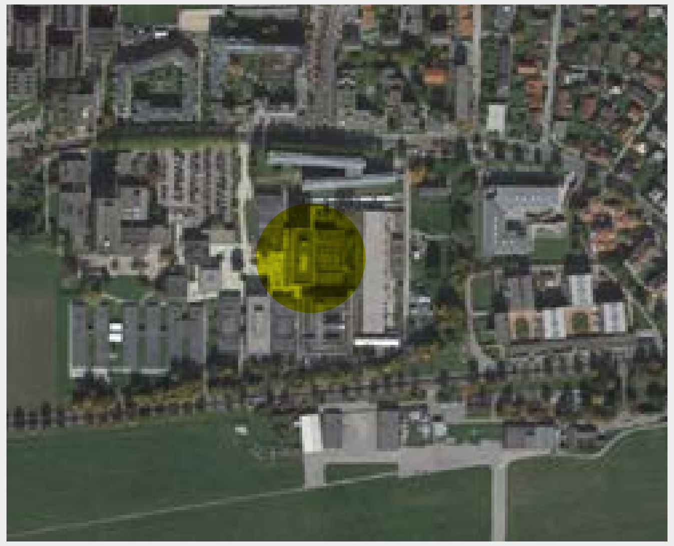
Department of Technical Sciences
Innsbruck, Austria



TYPE OF ACTIONS

Renovation

GENERAL INFORMATION



YEAR OF CONSTRUCTION: 1968
YEAR OF REFURBISHMENT: 2014
DIMENSION: 8.897 m^2
ORIENTATION: E - W
STUDENTS: 720
CLIMATE ZONE: Mediterranean climatic area
ARCHITECTS: ATP architects

DESCRIPTION

The building has a rectangular shape and is located in the Innsbruck university campus, close to the canteen, the library, the auditorium and the architecture department.
The eight-storey building had a mixed structure in wood and masonry and a reinforced concrete structure consisted of ceilings and supports that are retained in the renovation project. The project consisted, infact, on a great increase in energy efficiency and improved occupant comfort.
The calculation has been made with the PHPP (Passive House Planning Package) design tool, which is necessary for EnerPHit certification and provides reliable energy values for a building. Due to their features of refurbishment projects, the energy relevant criteria apply for individual building components. Exceeding the respective limit values is allowed if the building has a maximum heating demand of 25 KWh/(m^2a) despite this.

ENVELOPE

EXTERNAL WALLS

The building envelope is completely overhauled by a **new coating**:
- mineral wool for ventilated façades renewed 240 mm;
- normal cement stock 60 mm;
- PU 40 mm;
- reinforced concrete 100 mm.

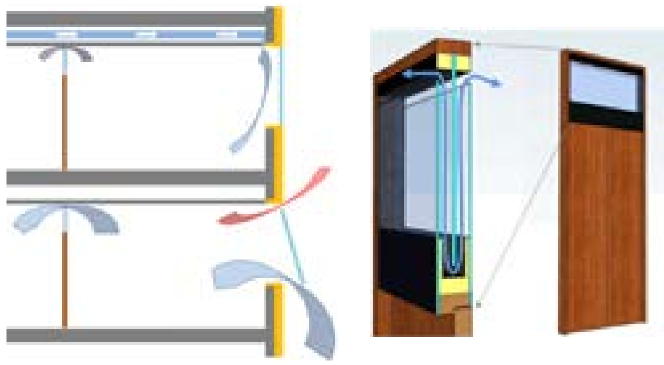
WINDOWS

Old openings has been replaced with **aluminium frame structure** with thermally separated profiles and hinged door with 50% of fixed glasses.

GROUND FLOOR SLABS & ROOF

New slabs are made with:
- Reinforced concrete 180 mm;
- Heralan TW 200 mm;
- Screed 30 mm.

The ceiling are totally renovated.



Scheme of the window with the air flow trend and diagram of the door frame.

Internal spaces of the Faculty of Engineering Science

Opposite page
University building before and after the retrofitting project

ENERGY SYSTEM

ENERGY BUILDING PLANTS

New wall radiators equipped with **thermostatic valves**.
Moreover, a central ventilation system with 2 ventilation units is installed.

SMART ENERGY SYSTEM

New **automatic control** of artificial light.
The heating recovery system is reinforced with an optimized economizer for free cooling through **automatically controlled passive cooling** at night via windows (in summer).

RESULTS

The project meets the criteria of the EnerPHit Standard for retrofits with Passive House components.
The EnerPHit Standard, introduced by the Passive House Institute is specially tailored to the particularities of retrofit projects and it is a guideline for effective and cost-effective refurbishments.
Besides energy efficiency, the aspects of healthy living, building preservation and lifecycle costs are also taken into account. The overarching object is quality assurance; with EnerPHit certification building owners can be sure that an optimal standard of thermal protection is actually ensured. This is particularly important because subsequent correction of inadequate thermal protection measures is almost always uneconomical.
The successful results of the project regard the **significant improvement in comfort in summer**.
The heating demand of the building was reduced from 180 kWh/m²a to just 21 kWh/m²a.

-80% of heating demand

References

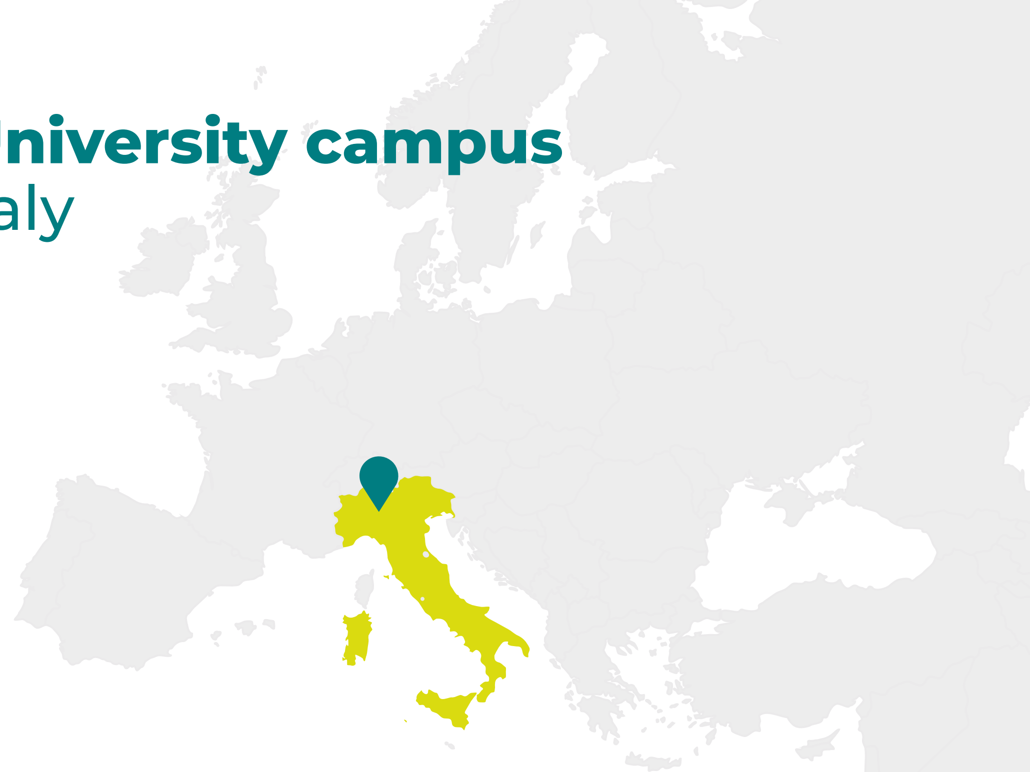
www.buildup.eu/en/news/worlds-largest-enerphit-project-innsbruck-austria.

www.buildup.eu/en/practices/cases/faculty-technical-sciences-building-innsbruck-university.

www.passivehouse-database.org/index.php?lang=en#d_4200.

BACK to the map

UNIMI University campus
Milan, Italy



TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1915 - 1927
ORIENTATION: W - E
DIMENSION: 1.162 m^2
STUDENTS: 90
CLIMATE ZONE: Mediterranean climatic area
CONTRACTORS: MEEBER

DESCRIPTION

The building was designed in 1913 by two architects Augusto Brusconi and Gaetano Moretti.
It is composed by a basement and two floors above ground, occupied by offices, laboratories and classrooms. The load-bearing is made of structural masonries composed of two rows of bricks. Ceiling and floors have different structure, the second floor has an arched ceiling made with bricks, while the other floors are made of hollow brick. The wooden roof was without insulation. The façades are practically devoid of ornament, the use of 'humble' materials is typical of the local architecture and it represents the desire to keep public architecture free of luxury. The façades were uninsulated and the openings were made with wood frame and single glazing.
The building area amount in 1162 m2 for around 90 daily users (considering students, professors and temporary visitors or services).
UNIMI promoted the "Città Studi Campus Sostenibile" project with the aim to transform the whole campus neighborhood into an urban area which can serve as an urban model in Milan with respect to life quality and environmental sustainability. In particular, the project focuses on the sustainability performance of buildings to minimize environmental impacts and to optimize the integration of the built and natural environments.
The final project consists in the best scenario came out from the assessment of the criticalities of the building and the study of different solutions.
The engineering students used two different software for the analysis: a steady state CENED +, and a dynamic simulation tool Sefaira.

ENVELOPE

EXTERNAL WALLS & ROOF

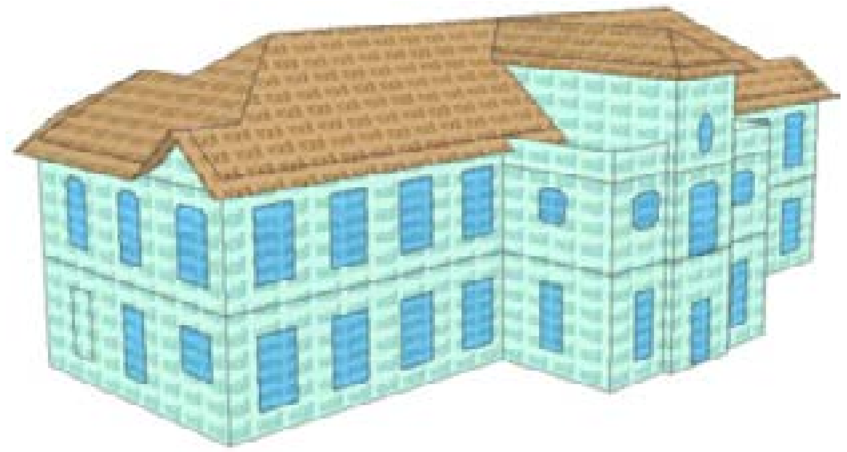
Insulation of the existing wall with a **coating of 10 cm** and the wood structure of the roof.

WINDOWS

Replacement of the existing windows with performance **aluminium frame** and **double glazing**.

Historical picture of the façade of the Faculty of Veterinary Medicine, when it was still High School, seen from via Celoria.

Picture of the building from outside.



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Building model developed in SketchUp.

ENERGY SYSTEM

ENERGY BUILDING PLANTS

Installation of an efficient lighting system with **LED** and introduction of **mechanical ventilation system** with heat recovery.

RESULTS

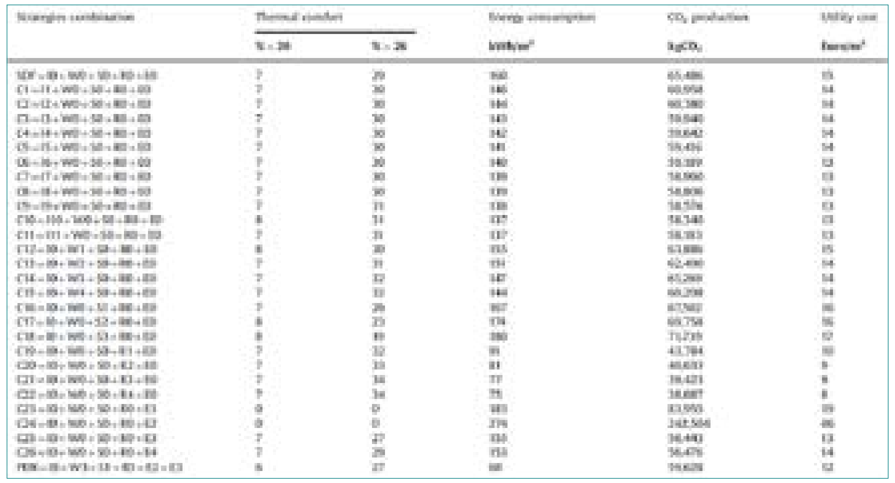


Table 1
Summary and identification of retrofitting strategies.
Table 2
Simulated scenarios for the phase 4 of the case study with Sefaira.

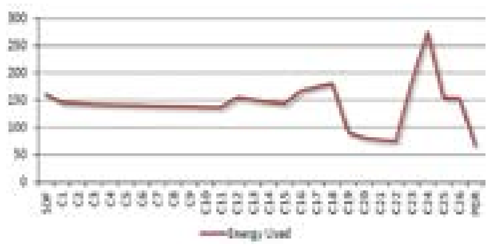


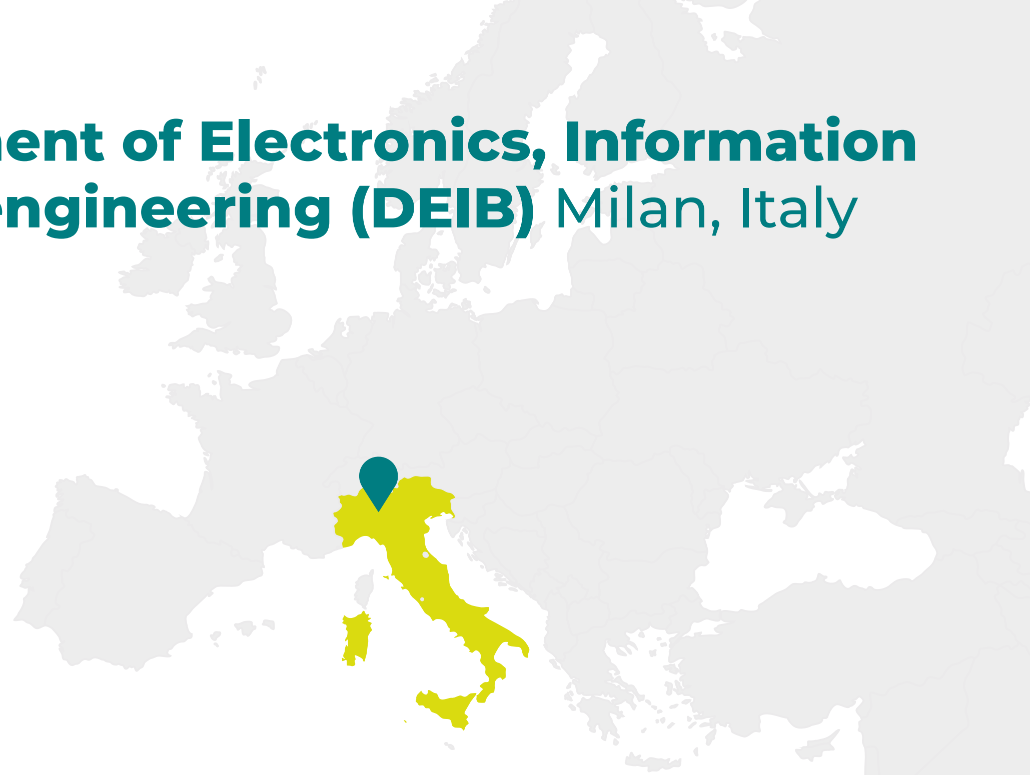
Diagram of Energy used in kWh/m2y for all the analized scenarios in the table 2.

References

Marta Maria Sesana, Manuela Grecchi, Graziano Salvalai, Caterina Rasica, (2016), *Methodology of energy efficient building refurbishment: Application on two university campus-building case studies in Italy with engineering students, Journal of Building Engineering*, 6, pp. 54-64, ISSN 2352-7102, https://doi.org/10.1016/j.jobe.2016.02.006.

BACK to the map

6R Department of Electronics, Information and Bioengineering (DEIB) Milan, Italy



TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1965 / 1991
YEAR OF REFURBISHMENT: 2016
ORIENTATION: N - S
DIMENSION: 1.350 m^2
STUDENTS: 150
CLIMATE ZONE: Mediterranean climatic area
CONTRACTORS: MEEBER

DESCRIPTION

Building 20 of the Politecnico di Milano (POLIMI), which houses the D.E.I.B. - Department of Electronics, Information and Bioengineering - is a building complex dating back to the second half of the 1960s that is located at the Bassini Campus, east of the University's original settlement located in Città Studi.

The building has a regular rectangular plan, oriented along the north–south direction. It is structured into a basement and four floors above ground, in which there are meeting rooms, offices and workshops for teaching and research and a large classroom in the header.

The inadequacy of the envelope was evident from the overall poor performance of the façades and the iron and glass elements of enclosing and curtain walling. The existing windows and doors, in particular, were characterized by a low level of thermal and acoustic insulation and represented "dispersing" surfaces that were not suitable for retaining heat inside the building, with obsolete shading systems and glazing that lacked filtering and reflective properties.

POLIMI promoted the "Citta Studi Campus Sostenibile" project with the aim to transform the whole campus neighborhood into an urban area which can serve as an urban model in Milan with respect to life quality and environmental sustainability. In particular, the project focuses on the sustainability performance of buildings on campus to minimize environmental impacts and to optimize the integration of the built and natural environments.

ENVELOPE

EXTERNAL WALLS

Improvement of the energy efficiency through the **new envelope** as a ventilated second skin.

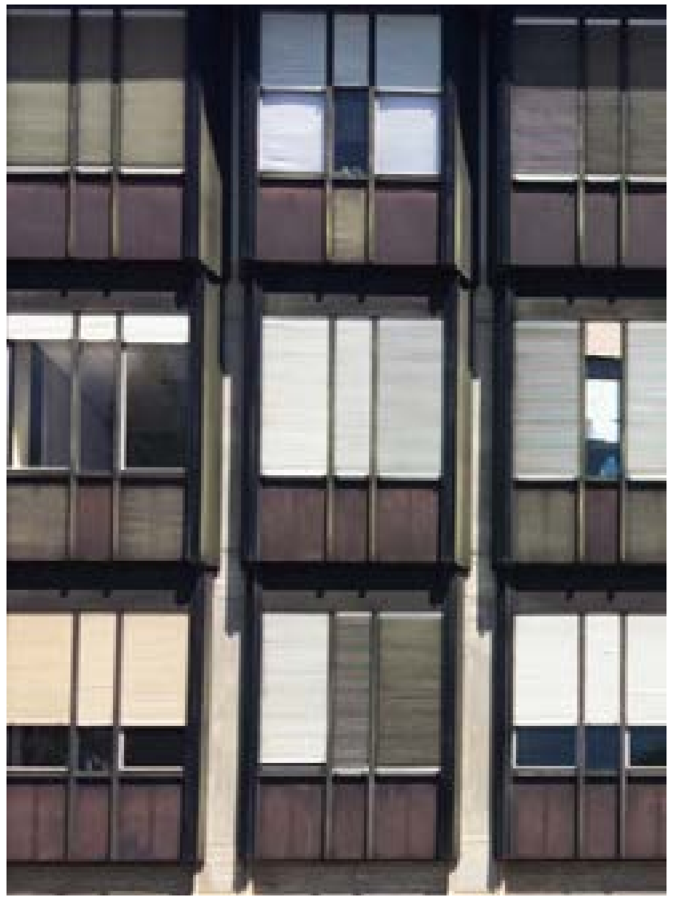
WINDOWS

Substitution of the old windows and frames with new **high quality fixtures** that provide a better indoor environmental control in terms of lighting, temperature, acoustic and security.

ROOF

Waterproofing intervention to resolve some cases of infiltration in the roof.

Before (left) and after (right) the intervention.



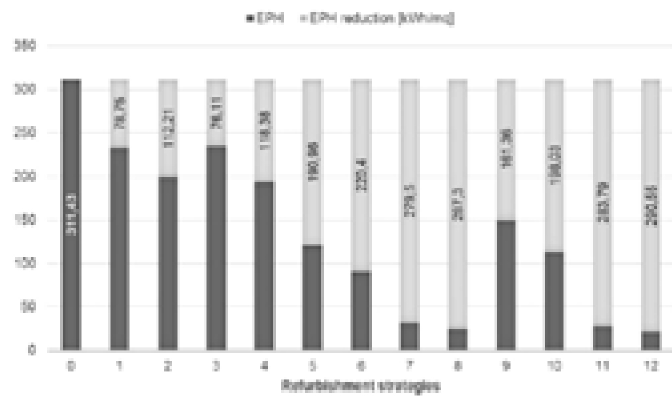
ENERGY SYSTEM

ENERGY BUILDING PLANTS

Necessary **increase of the overall efficiency of the heating system**, varying the efficiency of the sub-system and introduction of **mechanical ventilation system** with heat recovery.

	Refurbishment strategies (RS) n.	Refurbishment description	Performance objective	% energy saving for EPH	Energy label
a	1	Change of windows	$U_w = 0.5$	25	E
a	2	Envelope insulation addition	$U_{op} < 0.27$	36	D
c	3	Condensing boiler integration	$\eta_g = 0.93$	24	E
b	4	Heat recovery ventilation	$\eta_r = 0.7$	38	D
a	5	Strategies n. (1+2)	$U_w = 0.5$, $U_{op} < 0.27$	61	C
a+c	6	Strategies n. (1+2+3)	$U_w = 0.5$, $U_{op} < 0.27$, $\eta_g = 0.93$	71	C
a+b	7	Strategies n. (1+2+4)	$U_w = 0.5$, $U_{op} < 0.27$, $\eta_r = 0.7$	90	B
a+b+c	8	Strategies n. (1+2+3+4)	$U_w = 0.5$, $U_{op} < 0.27$, $\eta_g = 0.93$, $\eta_r = 0.7$	92	A
a	9	New ventilated facade	$U_w = 0.5$, $U_{op} < 0.27$	52	D
c+a	10	Strategies n. (3+9)	$\eta_g = 0.93$	64	C
b+a	11	Strategies n. (4+9)	$\eta_r = 0.7$, $U_w = 0.5$, $U_{op} < 0.27$	91	A
c+b+a	12	Strategies n. (3+4+9)	$\eta_g = 0.93$, $\eta_r = 0.7$, $U_w = 0.5$, $U_{op} < 0.27$	93	A

Table with the main results of the 12 simulated scenarios conducted with CENED+.



Comparison of the EPH value before the retrofitting (scenario 0) with the whole sensivity analyses (scenarios 1-12).

References

Methodology of energy efficient building refurbishment: Application on two university campus - building case studies in Italy with engineering students (PDF).

https://it.saint-gobain-building-glass.com/it/print/pdf/node/97861 (PDF).

BACK to the map

7R Orthopaedic and Traumatological Institute Rome, Italy

TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1933

YEAR OF REFURBISHMENT: 2017

ORIENTATION: NW - SE

STUDENTS: 1.500

CLIMATE ZONE: Mediterranean climatic area

ARCHITECTS: Francesco Mancini, Carola Clemente, Elisa Carbonara, Sara Fraioli

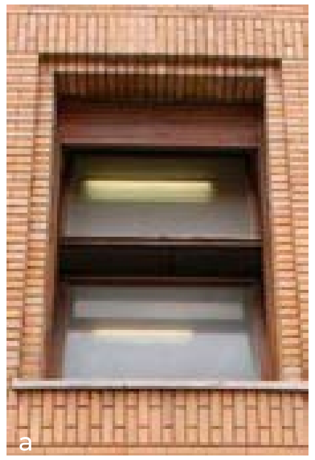
DESCRIPTION

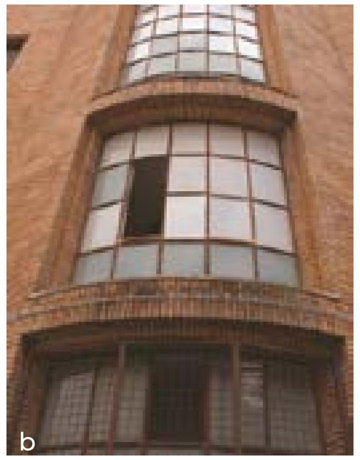
The building is located within the Sapienza University campus and is composed by a main axis and a large central square. The Orthopaedic and Traumatological Clinic Institute building was designed by Arnaldo Foschini and it is located at the main entrance of the campus.
The case study is a protected building by the law and this makes more complex the renewable integration and efficient thermal management in its refurbishment. The design proposal, infact, must be based on minimum intervention and reversibility to preserve its historical architectural values. The distribution of the buildings inside the campus is strictly symmetrical and each volume remains independent.
The envelope was made with bricks partially covered with yellow lithoceramic and travertine, but without insulation. The flat roof is walkable but weakly insulated as it is covered by cellulite. Windows are made by pitch-pine, a kind of laricus coming from United States very resinous and compact. The largest openings are characterized by iron structure and are located in the assembly hall and in the ground floor.The smallest windows were replaced by modern PVC or aluminium-based ones.
The existent split system based on air to air heat pump and Air Handling units gave an overheating during winter season, entailing high energy expenditure and low system efficiency.
According to energy labelling, the building belonged to category E since its fossil primary energy consumption is 132.2 kWh/m^{2}y. A series of energy retrofitting measures are designed starting from the analysis of the energy performance, by observing the constraint of compability with respect of the architectural features of the building.

ENVELOPE

EXTERNAL WALLS & ROOF

To improve the thermo-physical properties of the building envelope, an **insulation layer** was designed to be installed **indoor** to avoid modifications on the elevations' appearance. It was installed also in the roof.
Aeragel panels were chosen as technological solution for indoor insulation layer, with a thickness of 5 cm. While, **expanded glass wool panels** were chosen for ground floor insulation, with a thickness of 9 cm.





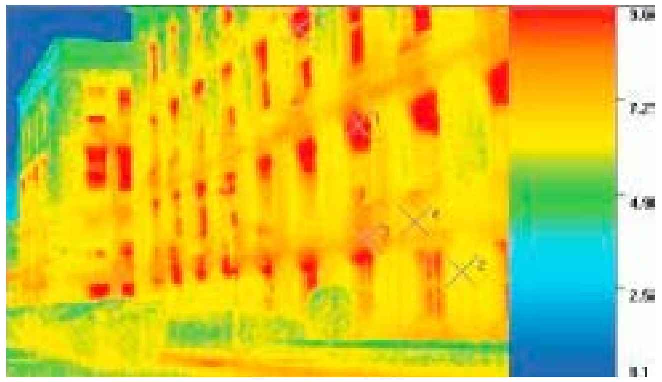
WINDOWS

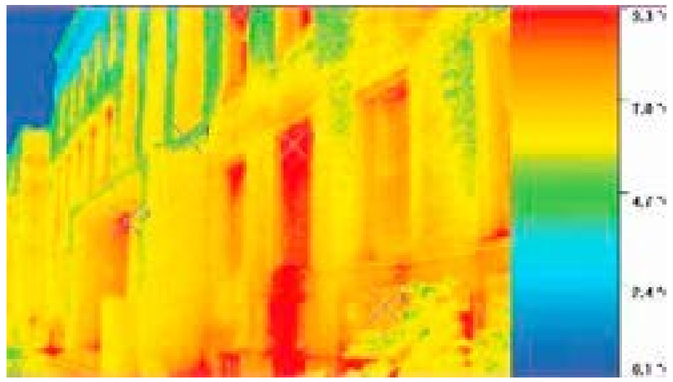
The original frames were preserved but the historical glasses and connection to the fixtures were replaced. In this way the transparent surface could have **better performance to solar radiation** without changing its original design.

Windows:
(a) Original wooden window;
(b) original iron window; (c)
modern aluminium window;
(d) modern PVC window.

Thermographic pictures.

Opposite page
PV array allocation.





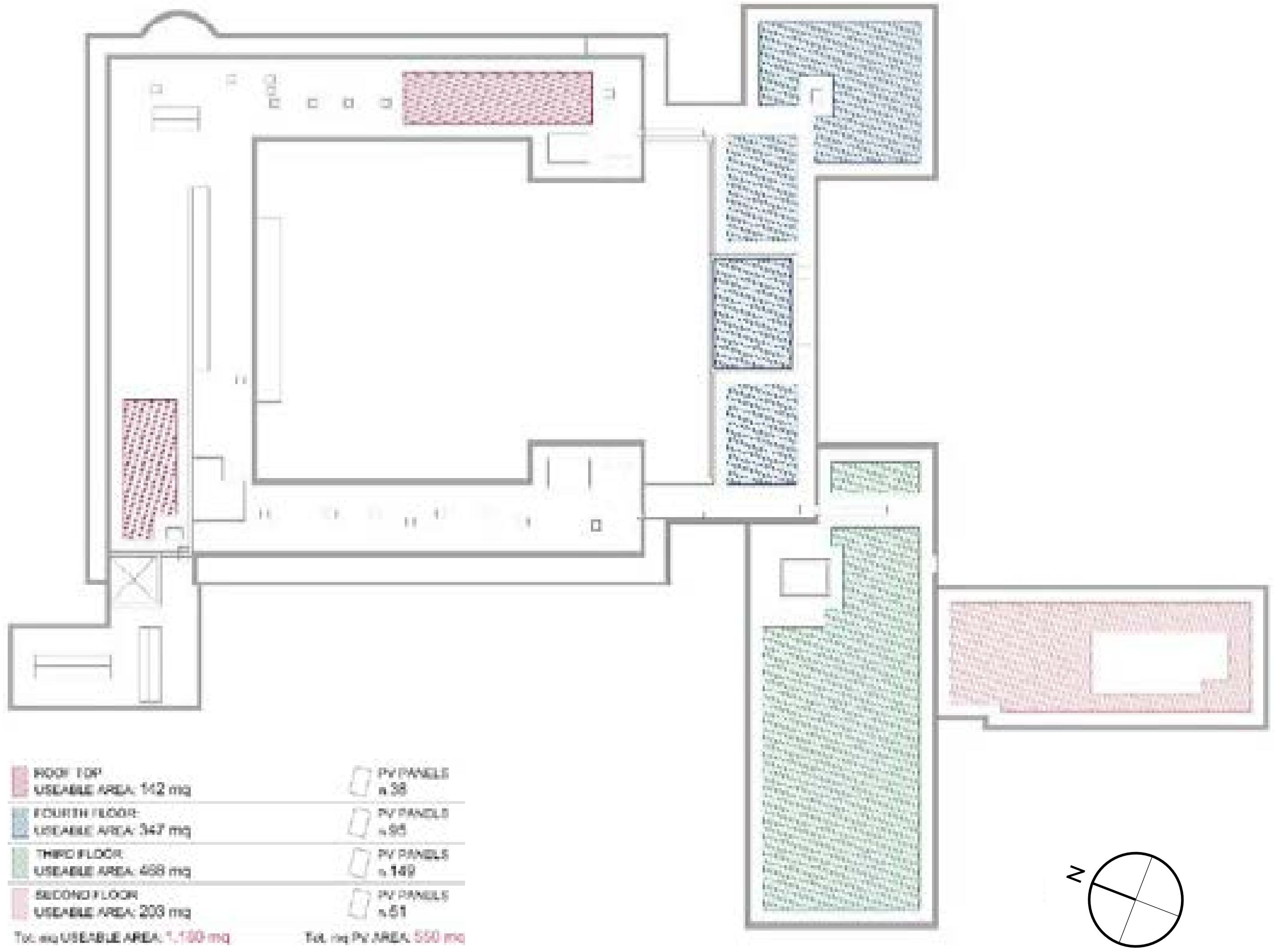
ENERGY SYSTEM

ENERGY BUILDING PLANTS

A **centralized heating system** is replaced with an individual one, both for heat and water.

PRODUCTION OF RENEWABLE ENERGY

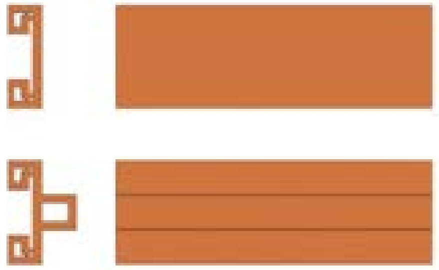
An **integrated photovoltaic field** has been designed to be placed on the roof and on the terraces.

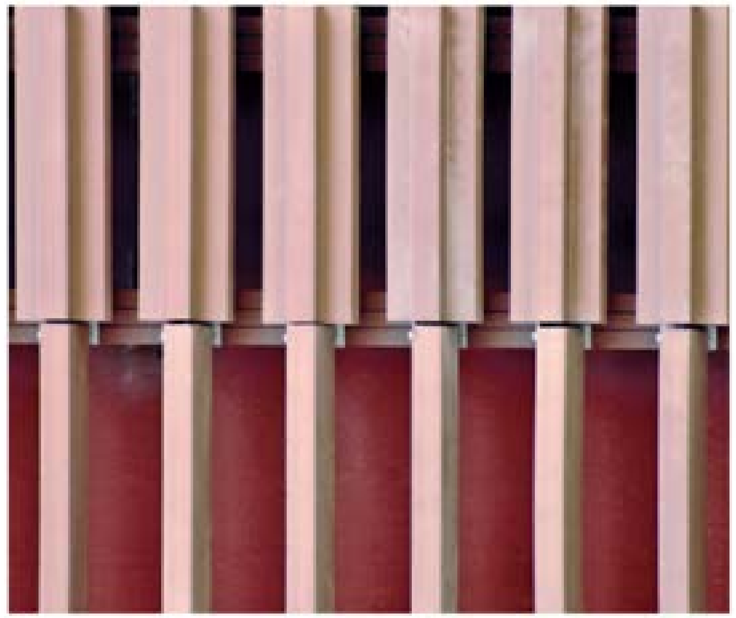


References

Mancini, F., Clemente, C., Carbonara, E. and Fraioli, S., (2017), *Energy and environmental retrofitting of the university building of Orthopaedic and Traumatological Clinic within Sapienza Città Universitaria.* Energy Procedia, 126, pp.195-202.

BACK to the map





Department of Civil Engineering and Architecture Catania, Italy

TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1982

YEAR OF THE PROJECT: 2013

DIMENSION: 5.380 m^2

ORIENTATION: NE - SW

STUDENTS: 200

CLIMATE ZONE: Mediterranean climatic area

ARCHITECTS: G. Caruso, G. Evola, G. Margani

DESCRIPTION

The building is the department of Civil Engineering and Architecture of Catania, three levels highs. It is an example of cloistered typology with a square plan and central square courtyard.
The classrooms are located on the ground floor and the first floor, while the teachers' room and administrative offices are located on the second floor.
The project is preceded by a thorough analysis of the existing building. To assess the energy needs of the building, calculations have been made in a dynamic regime, where emerged that the most dispersing casing elements are the opaque vertical closures. The façades developed on an area of approximately 3,080 m^2 show the load-bearing structure in exposed reinforced concrete, punctuated by a regular grid of beams-veils and protruding pillars.
The infill consisted of a "box" masonry, formed by the succession of the 5 layers listed below, proceeding from the outside: prefabricated concrete panel (3.5 cm); cement mortar (2 cm); blocks (12 cm); air gap (4.5 cm); hollow bricks (8 cm); and internal plaster (2 cm).
The roof of the first floor had the following stratigraphy, proceeding from the bottom: plaster (2 cm); attic in reinforced concrete (ribs of 60 or 19 cm); screed of slopes (average thickness 10 cm); plasto-bituminous sheath; bedding mortar (2 cm); flooring (2.5 cm). The same stratigraphy was applied to the roofing of the second floor, with some additional layer for the insulation and waterproofing (in fiberglass).
The fixtures affected the facade for a total area of 840 m^2 and were made with anodized aluminium frames (without thermal break) and single glass 4 mm thick.
All the architectural elements had a thermal transmittance (U) higher than the limits prescribed by current legislation in cases of renovation.
The internal rooms are not equipped with mechanical ventilation systems, therefore air changes are carried out by manually opening the windows. On the roof, photovoltaic (PV) panels have been recently installed, whose annual electricity productivity has so far been approximately 110,000 kWh.
The entire building is equipped with a centralized hot water heating system with cast iron radiators, powered by a traditional oil-fired boiler, which serves several buildings in the "Citta Universitaria".

ENVELOPE

EXTERNAL WALLS

Addition of a new skin made of insulation and finishing in brick slats. The **insulation** with rock wool (10 cm thick) is applied directly on the current coating, in prefabricated panels and on concrete elements reinforced at sight, by gluing and tessellation. The **brick modules** selected for the renovation are of two types: flat stave and shaped extrados stave. Clay is a tested and resistant material that manages to combine traditional and innovation. The slats are fixed by means of mechanical steel anchoring systems. Choices made for optimizing its energy performance, achieve significant economic savings and, at the same time, renew the architectural image.

ROOF

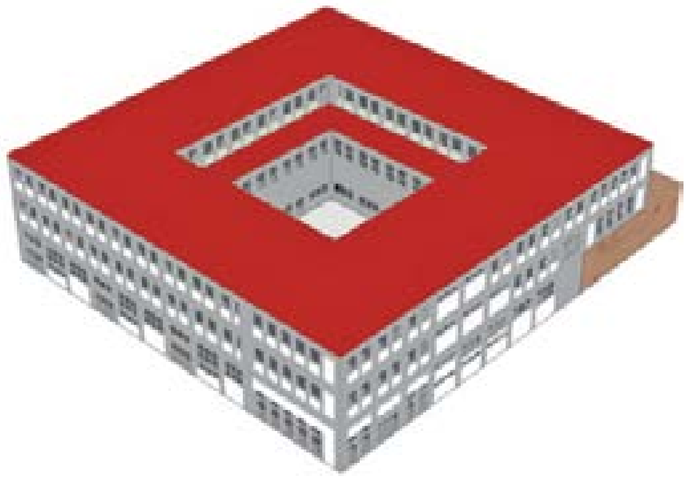
On the terrace of the first floor, substitution of previous pavement and waterproofing with **new roof stratification**:

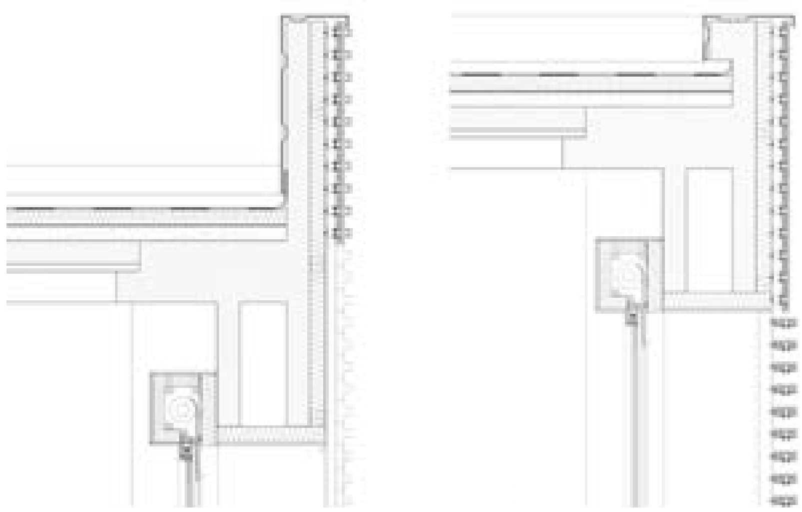
1. polyethylene vapour barrier (0.2 mm);
2. rigid panels in high density rock wool (10 cm);
3. bituminous waterproofing membrane (5 mm);
4. distribution screed 4 cm;
5. bedding and flooring mortar.

Same stripping works for the second floor with the addition of a waterproof fibreglass covering and no flooring.

WINDOWS

Replacement of fixtures with **new aluminium thermal break frames**: 4-16-4 mm double-glazed windows, with argon filling and low-emissivity treatment on the internal plate (e = 0.05)





previous page
Details of the flat stave and shaped extrados, and east and south elevations.

Model of the building created with *Design Builder*.

Vertical sections at the entrances on the east front and between the east front and the entrances.

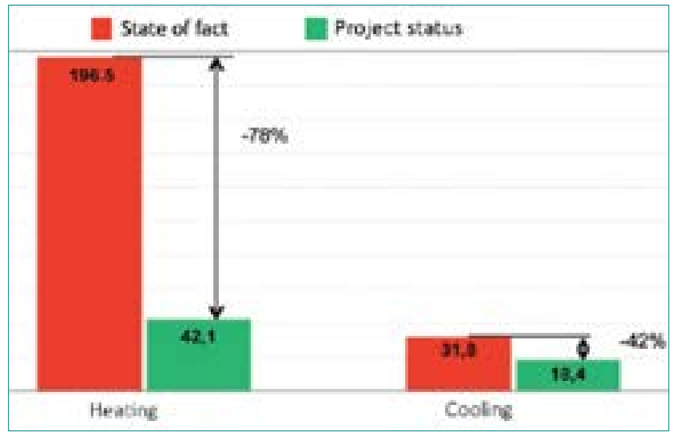
ENERGY SYSTEM

ENERGY BUILDING PLANTS

Second floor is equipped with summer cooling system, consisting of autonomous air conditioners.

RESULTS

Thank to the proposed interventions, the overall **energy requirements related to heating and cooling would be reduced by 78% and 42%** respectively. **CO2 emissions would also decrease** by 23% compared to the current state.
The building would reach an energy class A, instead of the current class F. The redeveloped building could be classified as nZEB , as the primary energy requirement, relating to the heating, lighting, DHW and cooling, net of the photovoltaic contribution, would be less than zero.
Regarding the potential savings, annual costs for the energy system would be reduced around 70% per year. But it should be stressed the high cost of the intervention.
Final considerations reveal that an energetic redevelopment of public buildings, based mainly in the improvement of the thermal performance of the envelope, is economically convenient especially in regions with colder climates. In buildings located in southern Italy could be more convenient to intervene on the systems, for example by replacing the heat generator with a high-efficiency condensing boiler, or by improving the management and control of the systems. However, not all benefits can be monetized: in fact, environmental, aesthetic and educational issues must also be considered. In this sense, a significant aspect is the exemplary role that all public buildings, and even more so the headquarters of the DICAr, should assume in the socio-cultural and ecological management of resources.



Perspective view of the building and aerial view of the existing PV.

Consumption due to air conditioning in the actual and project state.

References

Margani, Giuseppe, Evola, G., Caruso, Giorgia. (2015), *Il recladding di un edificio pubblico in clima mediterraneo. COSTRUIRE IN LATERIZIO. 161. 56-62.*

BACK to the map

9R Aflivadem vocational school
Ankara, Turkey

TYPE OF ACTIONS

Renovation

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 1964

YEAR OF REFURBISHMENT: 2016

DIMENSION: 1.016 m² (cafeteria) + 1.032 m² (campus)

ORIENTATION: N - S

STUDENTS: 200

CLIMATE ZONE: Mediterranean climatic area

CONTRACTORS: A2PBEER

DESCRIPTION

The project mainly concerns the buildings of the university cafeteria and the boys' dormitory, located in the campus of the vocational school in Ankara (Turkey). The dormitory block ranges between two to four storeys in height. The bedrooms and bathrooms occupy the upper floor while the offices and main entrance occupy the ground floor. Instead, the cafeteria is a single-storey building, raised from the ground by a staircase, and it has a flat roof.

The main structure consisted of reinforced concrete construction with external render finished with poor insulating qualities.

The hipped roof had limited mineral wool insulation along the ceiling Joists. The ground floor was made with standard concrete construction again with minimal insulation. All the windows were standard double glazed with aluminium frames and no external shading devices.

There were not cooling or mechanical ventilation except in sports hall and conference hall. The centralized cooling and mechanical ventilation system in the sports hall was not being used due to unoccupancy during summer but mechanical ventilation system in the conference hall was used. Heating occured by radiators and there was no centralized cooling system.

The building wasn't equipped with a thermal solar collector system and the lighting system was poorly performing.

ENVELOPE

EXTERNAL WALLS

The whole opaque façade has been covered with an **external ventilated façade** with vacuum insulation panels (VIPs), to improve energy performance with panel covering that it offers the most cost-effective solutions to maximaze the energy saving.
The panels: PVC clip system mounting to the wall; 1100x700x300 mm insulation panels finished with protection rubber.

WINDOWS

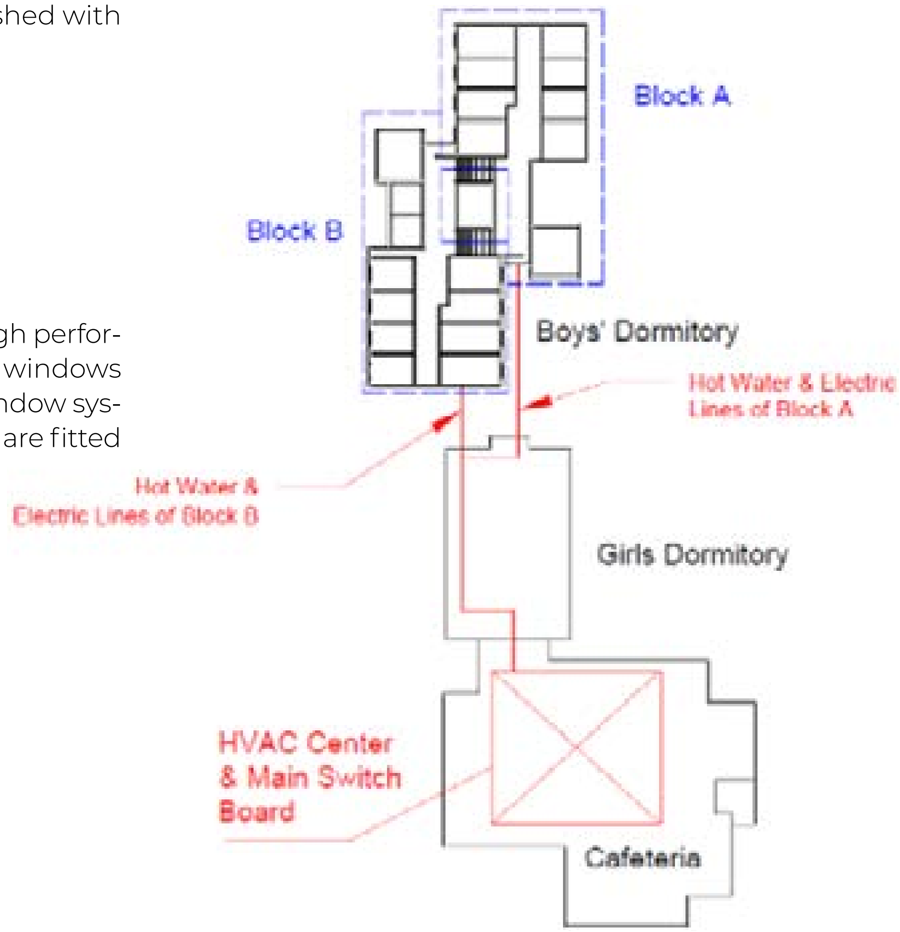
Installation of **reversible windows** with high performance windows: in the south facade the windows are replaced with the reversible smart window system and solar control; in the north facade are fitted Low-E glazing units.

previous page
North-east corner of the girls' dormitory;
Beck of the cafeteria building.

➔
Systems layout.

➔
Solar collector systems.

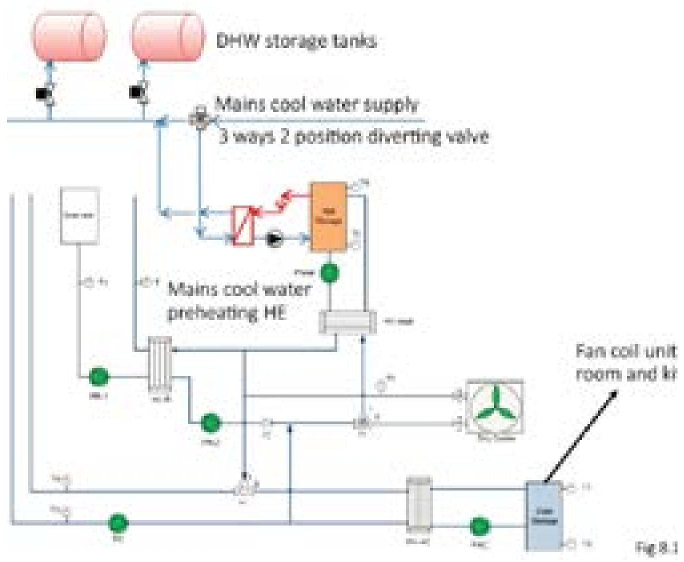
Opposite page
Coupling collectors system to existing installation;
Collectors system scheme 2.



ENERGY SYSTEM

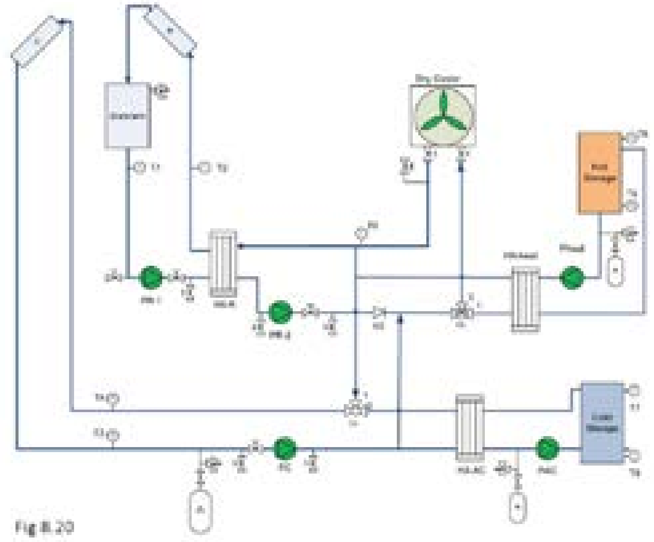
ENERGY BUILDING PLANTS & SMART ENERGY SYSTEM

Installation of **solar lighting technologies** provided by light-emitting diodes (LEDs) and intelligent systems: solar light collector and fiber optic system; hybrid luminaries with LEDs and diffusers; controllers of presence and light intensity detector.
Cooling is provided by the **new solar collector system** and the **district heating network**. Additional thermostatic control valves are installed on the radiators and automated actuators are fitted in order to enable presence detection and window status driven control strategies.
Placing of new mechanical ventilation system that includes heat recovery and economizer operation.



PRODUCTION OF RENEWABLE ENERGY

A **solar collector system** is installed in the sports hall building roof with optimized orientation and tilt.
The system provides the base load for the DHW (Domestic Hot Water) supply and supplement hot water required by the heating system of the building.



RESULTS

Some performance evaluations regard the benefits from solar cooling collectors that give suitable temperatures during the warmest months and use less natural gas for the DHW. The operational data are collected during the one year and will be compared with simulated data.
Ankara Demo site establishes a platform for the testing of a Sorption Solar Collectors.

-45% of cooling demand

-16% of natural gas for Domestic Hot Water

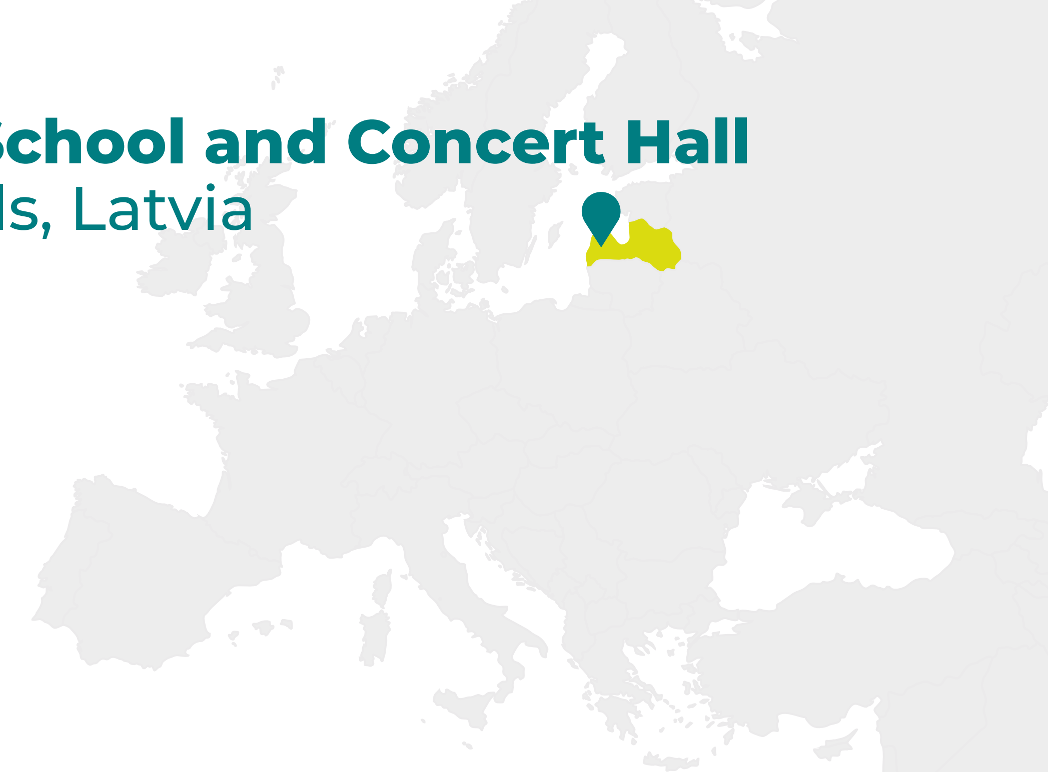
References

cordis.europa.eu/docs/results/609/609060/final1-a2pbeer-finalreport-total.pdf (PDF).

BACK to the map

New construction

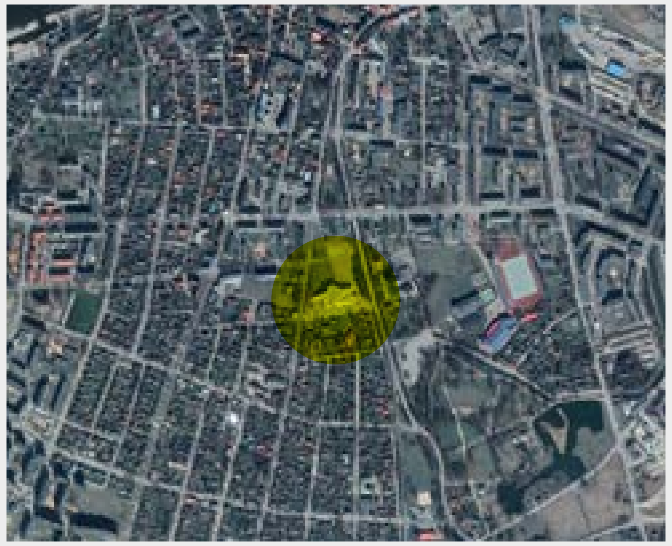
Music School and Concert Hall
Ventspils, Latvia



TYPE OF ACTIONS

New construction

GENERAL INFORMATION



YEAR OF CONSTRUCTION: 2019

ORIENTATION: N - S

DIMENSION: 8.483 m^2

STUDENTS: 500

CLIMATE ZONE: Eastern-continental climatic area

ARCHITECTS: Freie Architekten PartG mbB / haas cook zemmrich / STUDIO 2050

DESCRIPTION

Music plays an essential role in Latvian culture, giving communities district identities. The new music school in the Baltic town of Ventspils offers to the Region a centre for teaching and performing music. The goal is to maintain a unique and iconic building, both in terms of quality of stay and energy efficiency, optimized for the local climate.
The music school offers a range of publicly accessible exhibition spaces, with a classic concert hall (600 seats), accompanied by a smaller "black box" theatre, a music library, an outdoor stage and an amphitheatre. Several backstage facilities are housed on 3 floors that surround the concert hall stage. All internal spaces are developed according to the highest acoustic standards with insulation that allows the undisturbed staging of parallel events in the 2 rooms.
The interiors of the building are distinguished by the contrast between the simple rectilinear shape of the concert hall and the informal arrangement of the surrounding foyers that open onto the Lielais, in the form of terraces and balconies. The foyers are flanked by a cafeteria, music library, green room, recording studio and extensive teaching facilities.
A distinctive feature of the concert hall is the striking pipe organ, designed in collaboration with Orgelbau Klais.
An innovative energy concept combines The exploitation of geothermal energy, decentralized ventilation units and extensive heat recovery with a high-performance casing to drastically reduce operating costs.

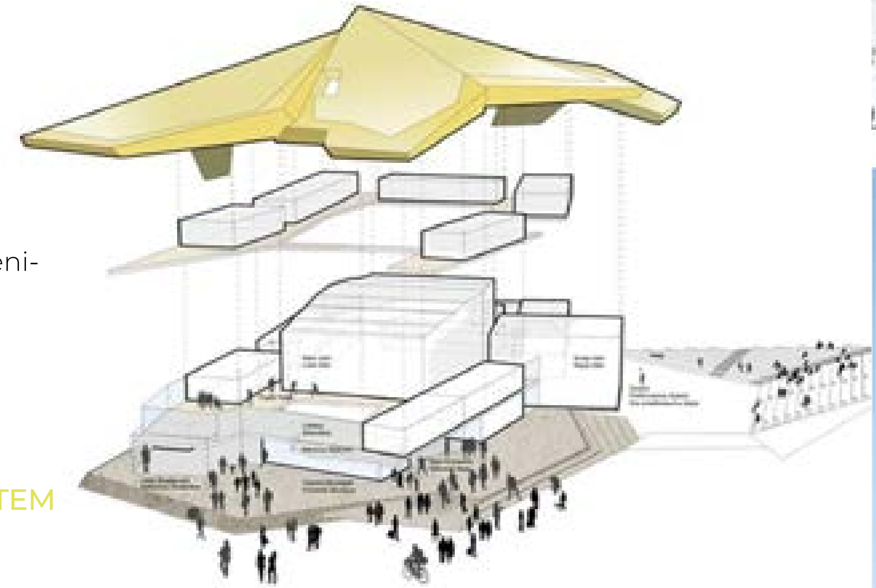
ENVELOPE

ROOF

The distinctive roof protects various spaces, both internal and external, giving the building an immediately recognizable distinctive appearance.

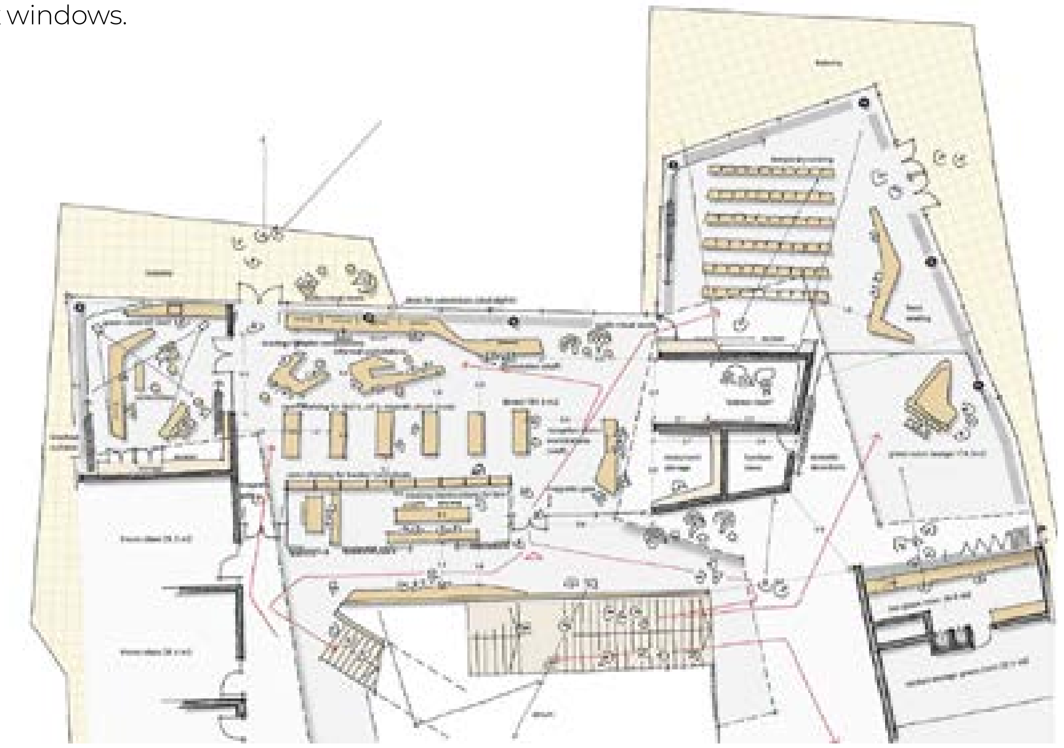
SKYLIGHTS

A **large skylight** allows the concert hall to be zenitally lit.



WINDOWS & SHADOW SYSTEM

Hermetic façades are highly thermally insulated with **triple glazing** and combined with **movable shading system** in the box windows.



Axonometric exploded view and floorplan of the building

ENERGY SYSTEM

ENERGY BUILDING PLANTS

Heat pumps from geothermal source provides underfloor heating in winter and cooling in summer for conditioning the room.
An **high efficiency heat recovery system** consent to save sensitive and latent energy in the large pavilions, thanks to the transfer of the air humidity from the exhaust air in the supply air. Ventilation is ensured by **decentralized mechanical units**.

PRODUCTION OF RENEWABLE ENERGY

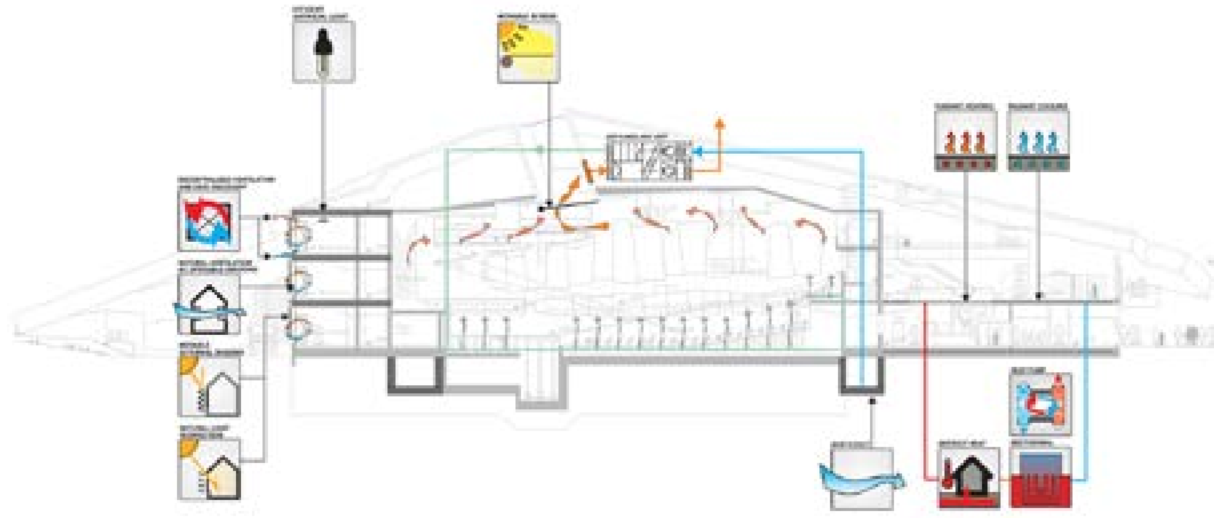
Renewable energy is provided by **geothermal energy** through water transport pipes integrated in the foundation piles.

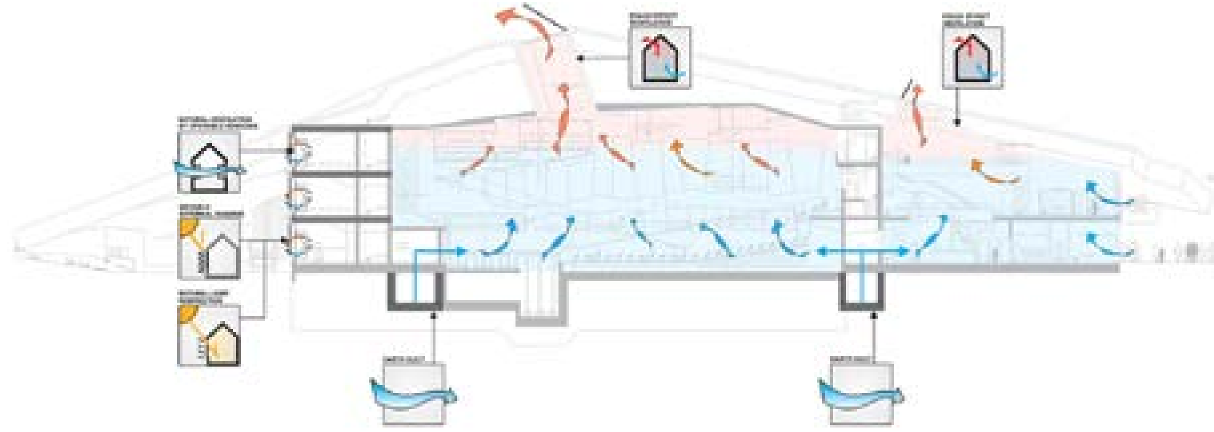
SMART ENERGY SYSTEM

With thermal daytime simulations the project of the Music School and concert hall was developed and optimized during the entire planning process.
The building is equipped with **hybrid ventilation**, i.e. natural ventilation with manually operated openings combined with mechanical ventilation units, activated when required. Users can directly influence ventilation, if necessary for acoustic reasons or to improve air quality.
The displays provide users with feedbacks on the energy consumption and current conditions in the respective room.

RESULTS

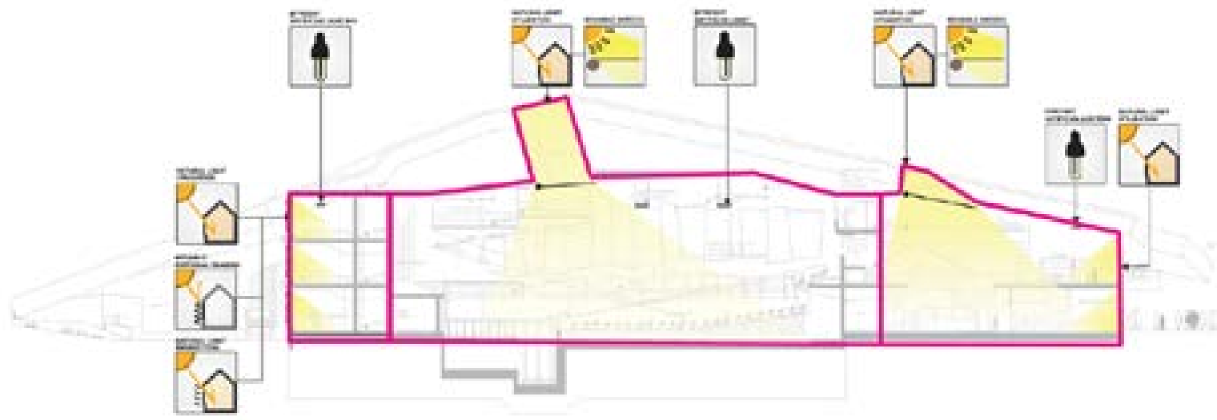
NEAR ZERO ENERGY BUILDING. The innovative solutions guarantee energy self-sufficiency on an annual basis and the absence of harmful emissions.





↑ Active mode scheme and natural mode scheme.

↓ Lighting control strategies scheme.



References

www.haascookzemmrich.com/en/projekte/musik-schule-und-konzertsaal.

www.sbp.de/en/project/music-school-and-concert-hall-ventspils.

www.siga.swiss/global_en/projects/music-school-ventpils.

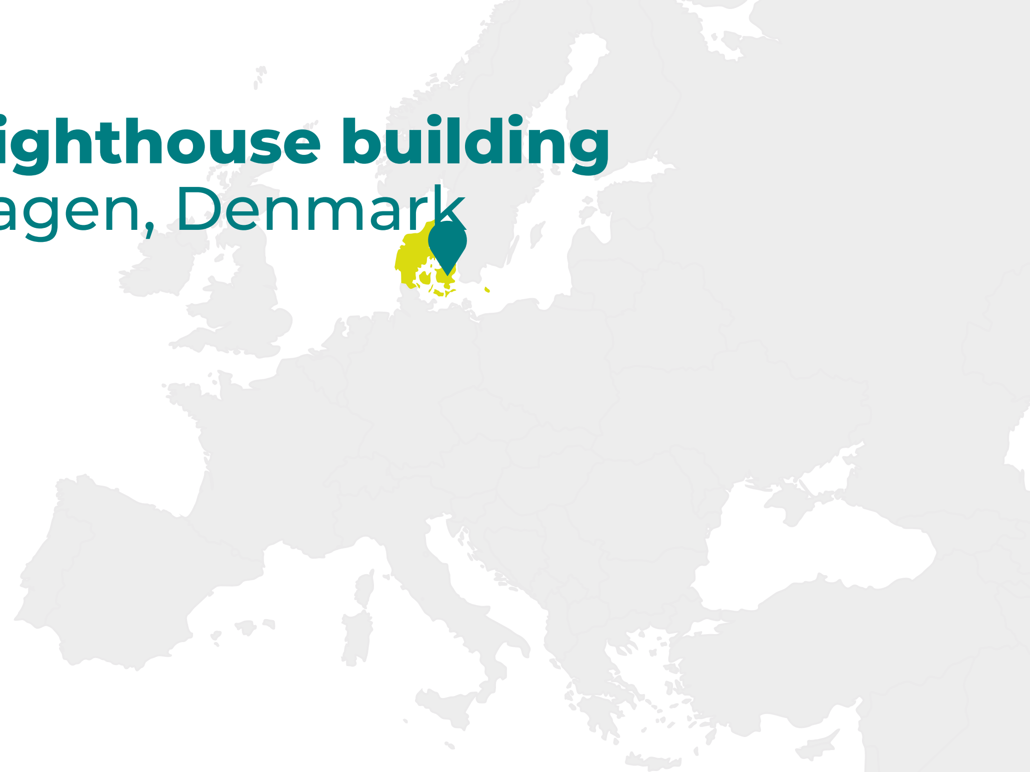
www.transsolar.com/projects/ventspils-music-school-and-concert-hall.

www.world-architects.com/en/architecture-news/works/ventspils-regional-music-schooland-concert-hall.

www.muellerbbm.com/fileadmin/user_upload/gmbh/Downloads/Konzertsaele/M112713_Konzertsaal_Ventspils_e.pdf (PDF).

BACK to the map

2Nc Green Lighthouse building
Copenhagen, Denmark



TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2009
DIMENSION: 950 m2 (total building)
STUDENTS: 37
CLIMATE ZONE: Oceanic climatic area
ARCHITECTS: Christensen & Co Architects

DESCRIPTION

Green Lighthouse is Denmark's first public carbon-neutral building, which houses the Copenhagen University of Sciences. The building has been built in less than a year in a close public/private partnership.
Green Lighthouse is an energy-efficent builiding of great architectural merit, with a high influx of daylight.
Ground floor and first floor destination is administration / guidance offices. The second floor has been used as faculty lounge for meetings with students and other people on campus.
From an architectural point of view, the design of the builing is inspired by the sundial, and so the movement of the sun inside the building. The building is circular and has an internal core, which simultaneously holds the central staircase, attracting a lot of daylight trhough the house from the skylights. The integration of daylight in the building is the main reason for the very low energy consumption obtained.
The round, sculptural building, Green Lighthouse features high celings and an open, spacius floorplan. It is designed in a way that reduces energy compsumption by 70% utilizing renewable energy, natural ventilation and daylight, and with a highly efficient climate envelope. The internal atrium ensures natural light and ventilation, where the users can follow the seasonal changing. The indoor climate of workspaces can be adapted individually.
As sustainable as it is healthy, the building relies on district heating, solar cells, solar heating and cooling, seasonal storage and innovative architecture to create a magnificient CO2-free building.

ENVELOPE

EXTERNAL WALLS

The external skin façade is covered with panels that are made of a **composite fibreglass** material of 30% glass and 70% polymer that is extremely **light and strong.** In fact, the entire façade weighs only six tonnes. By comparison, a similar solution in tile would have weighed more than 175 tonnes and been considerably thicker.

WINDOWS & SKYLIGHTS

The skylights in the roof provide for an optimal natural ventilation exploiting the stack effect.
Efficent smart windows minimize heat loss and maximize passive solar gain.

SLABS & ROOF

The roof plays an **active role** in the building's energy profile, capturing the sun's energy using both solar panels and solar PV cells.
Moreover, the ground floor slab is characterized by an **high thermoactive capacity.**

SHADING SYSTEM

Dynamic sunscreens let the users to directly influence their working area through **venetian blinds**. The curtains have different settings; sunlight can be blocked, while the slits still carry daylight deep into the building. The slits are **painted white** to optimize this effect.

Perspective sections of the window's frame. Users can individually change the indoor climate.
1. sun's energy
2. natural ventilation across the hopper window
3. exterior sun protection
4. insulated frame
5. fixed window
6. double glass
7. night insulation
8. control system

Façade and section of the building, showing the PV panels on the roof and the skylights

ENERGY SYSTEM

ENERGY BUILDING PLANTS

The building mainly uses natural lighting or lighting system powered only by the photovoltaic system.
Eco-friendly district heating, heat pump, solar thermal are all systems for system for distributing heat from a central position to several buildings or rooms, through an underground network of well-insulated pipes.
Cooling and ventilation systems are fed from Solar Thermal system and a special adsorption chiller aggregate to turn heat into cold by fluid-fluid flow in an efficient process.
Natural ventilation and night cooling passive systems for the summer period are combined with mechanical ventilation and dual flow heat exchange controlled by indoor air quality (IAQ) during the winter.
District heating, heat pump and solar thermal system guarantee for the domestic hot water production plant.

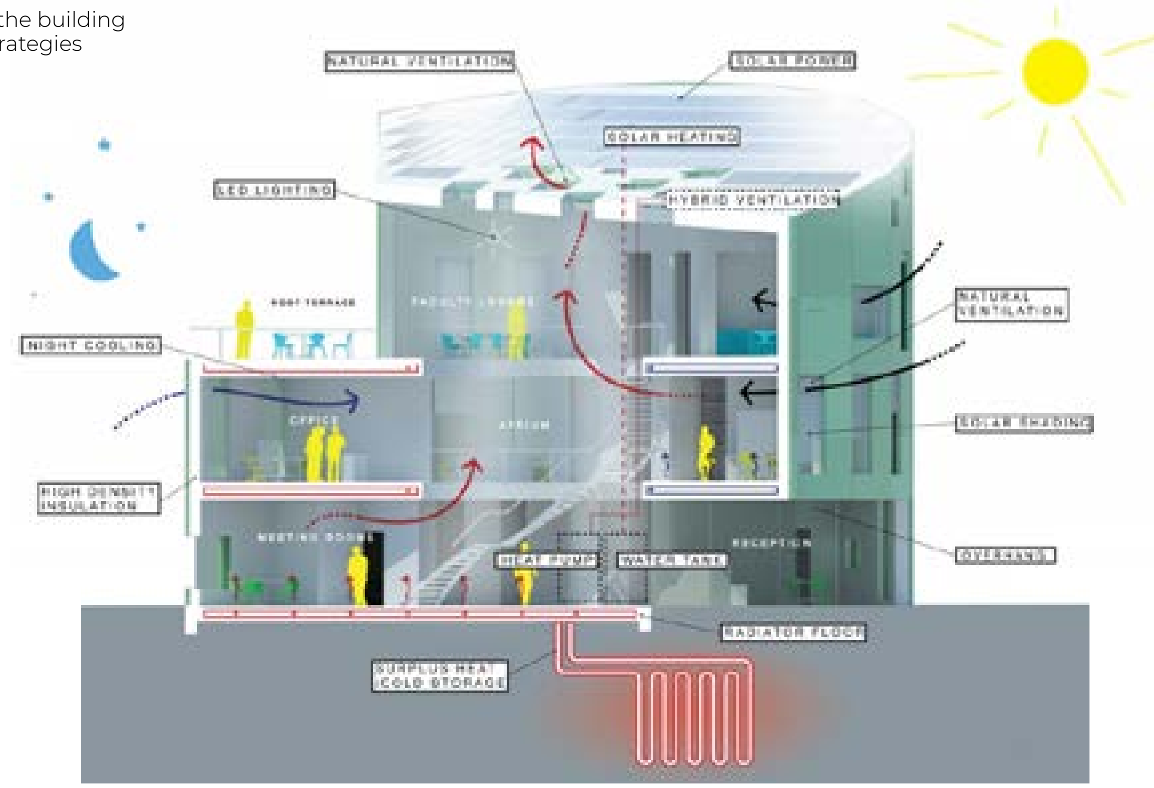
PRODUCTION OF RENEWABLE ENERGY

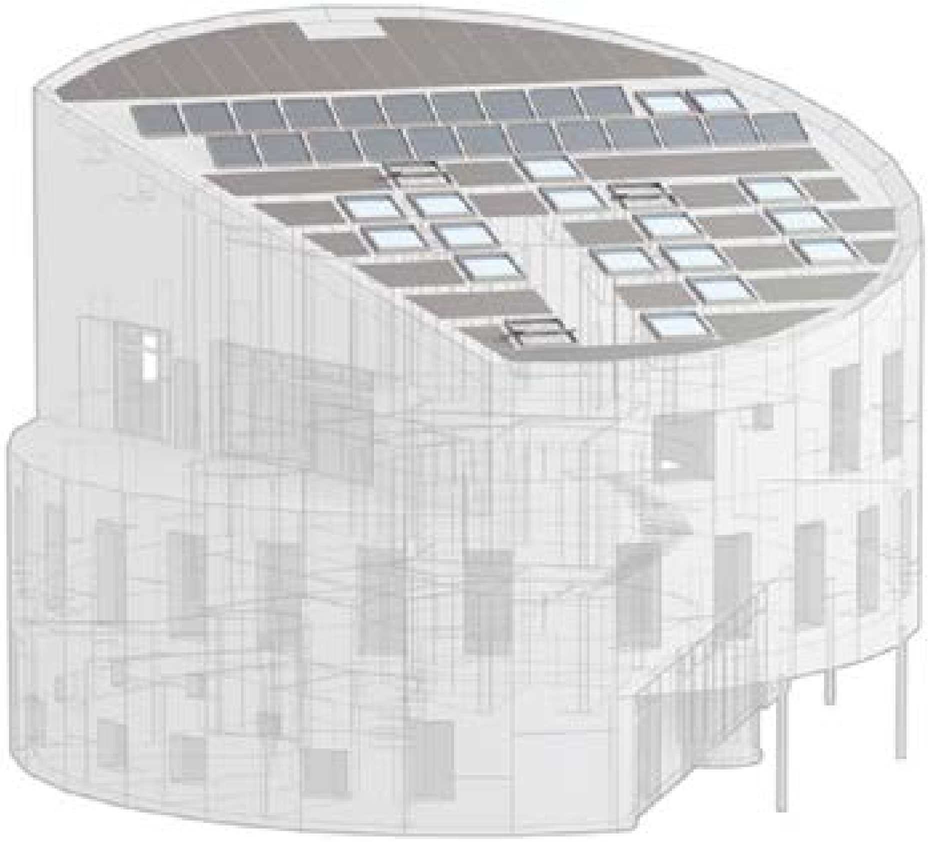
The building is equipped with a thermal and photovoltaic systems, and energy recovery from the waste.
Photovoltaic panels guarantee 100% of the building's lighting needs 35% of the building's energy efficiency.
The sun is the building's main energy source, providing passive solar gain, hot water and electricity.

SMART ENERGY SYSTEM

The building management system (BMS) controls the shading and sun protection of the windows, based on the principles of relative comfort (EN 15251).
Users can adjust the indoor climate by controlling the equipment and sensors for lighting, shading and ventilation.

Section of the building with the strategies underlined





3D model of the building, showing the PV on the roof

RESULTS

ZERO CO2 EMISSION BUILDING. It is designed in a way that reduces energy consumppon by 70% utilizing renewable energy, natural ventilation and light.

References

www.buildup.eu/en/practices/cases/green-light-house-denmarks-first-public-carbon-neutral-building

www.construction21.org/case-studies/h/green-lighthouse.html

www.youtube.com/watch?v=uzx3u83z8KQ (VIDEO)

www.youtube.com/watch?v=AWIfB-5GqyA (VIDEO)

BACK to the map

3Nc Alnatura Working Environment Campus Darmstadt, Germany

TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2019

ORIENTATION: NE - SW

DIMENSION: 10.000 m^2 (total building)

STUDENTS: 500

CLIMATE ZONE: Continental climatic area

ARCHITECTS: HAAS COOK ZEMMRICH STUDIO 2050

DESCRIPTION

The space serves for a public Waldorf kindergarten, a vegetarian organic restaurant, an organic supermarket and also for school and utility gardens to show the cultivation of organic food from sowing to the finished product and finally not least for the heart, the largest building for university offices in Europe with façades made of clay.
Alnatura Working Environment in the city of Darmstadt has achieved an architectural milestone in terms of sustainability, material efficiency, openness and new ways of working in an office building. The Alnatura Campus building offers special features such as the use of an innovative clay facade and it is the first worldwide application for the use of geothermal wall heating. Also noteworthy is the sound-absorbing wooden slat ceiling, which crosses the atrium and the fully open office space.
The building on the site of the former US Army barracks Kelley hardly resembles a conventional office building and offers space for up to 500 employees on three floors with an area of approximately 10,000 sqm. From an architectural point of view, the building should not intimidate, but welcome and integrate the environment, new ideas and people. It is an impressive laboratory of ideas for its simplicity. The new Campus thrives on its internal networks with bridges, stairs and walk-ways linking the different levels and pervading the space as intermeshing pathways, and creating horizontal and vertical neighbourhoods. The façades form earthen walls on the long side and two pillared glass façades on the front. The continuous roof window prevents the opposite roof supports from connecting to each other in a blocking way. This creates two decoupled systems made with wooden trusses on filigree reinforced concrete columns, one with a large overhang on the atrium.
All three office levels are interconnected in a playful manner. The working environment is not divided endlessly into individual departments, enclosed compartments, or confusing corridors. Instead the building comprises a single large space extending between the façades from the ground floor up to the roof without any interfering partitions.
Workplaces are identified by their location in very diverse spatial situations: "private" work areas, such as the alcoves, contrast with "public" areas. Meeting areas can be screened off with the help of acoustically insulating curtains.
Open "kitchen-ettes" are available on all floors and function as meeting rooms for cross-functional teams.

ENVELOPE

EXTERNAL WALLS

Rammed earth blocks (3.5m by 1.0m) were stacked along the northern and southern facades to form 16 wall segments, each 12m high.
Insolated opaque facade and absorbent strips integrated into the concrete soffits ensurance stable and balanced temperatures.
Open pores of the clay and micro-performed panels at the core of the building have excellent acoustic properties.
Horizontal erosion barriers consisting of clay and trass lime were integrated every 30 to 60cm in order to stem the surface erosion of rammed earth.
The rammed earth elements have an insulated core: 17cm of insulation consisting of foam glass gravel, a recycling product.

ROOF

The roof is composed by **two decoupled systems** made with wooden trusses on filigree reinforced concrete columns, one with a large overhang on the atrium, necessary due to the presence of the skylight. It is higly insulated from a thermal point of view.
Moreover, the slatted ceiling concrete and the wooden roof guarantee **acoustic quality**.

WINDOWS & SKYLIGHTS

Windows and skylight are characterized by **transparent triple glasses** ensuring thermal protection and visual quality.

Materials used - stone, wood, carpet, components, spelled, rammed earth - and some views of the building under construction

ENERGY SYSTEM

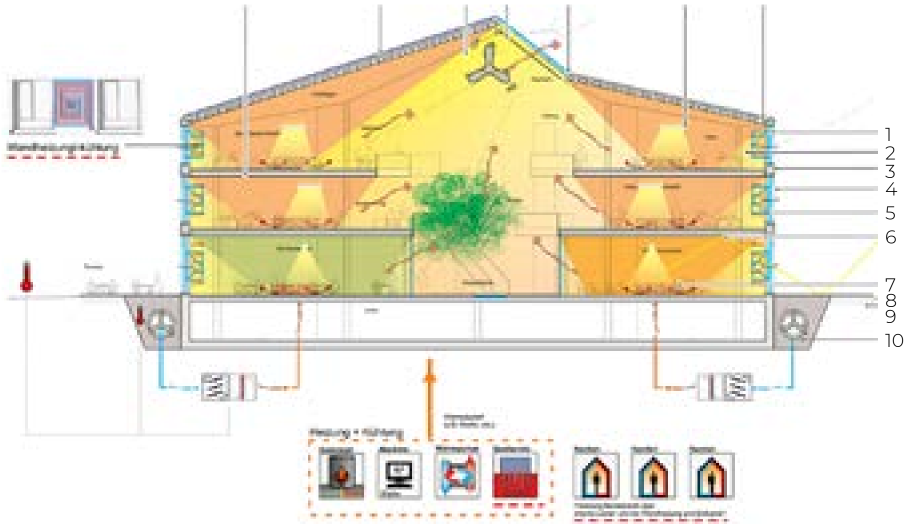
ENERGY BUILDING PLANTS

The first worldwide use of **geothermal wall heating system** integrated into a dry loam wall.
Thanks to the pre-conditioned air supplied by an earth duct, the need for additional heating and cooling is reduced to a minimum.
Natural ventilation in the building throughout the year avoids the use of HVAC, ceiling fan.

PRODUCTION OF RENEWABLE ENERGY

478 m² of photovoltaic collectors and geothermal wall heating.

Section of the building.
1. triple glass
2. desktop pc with monitor
3. isolated opaque facade
4. sun protection
5. window ventilation
6. clear surfaces reflection of daylight
7. air outlet
8. bright exterior surfaces
9. earth channel as ventilation
10. heating register
11. thermal insulation
12. artificial light control
13. triple glass opening skylight
14. protection from sunlight
15. ceiling fan
16. photovoltaic collector
17. thermal mass exposed



RESULTS

References

www.haascookzemmrich.com/de/projekte/alnatura-campus

www.transsolar.com/projects/alnatura-campus

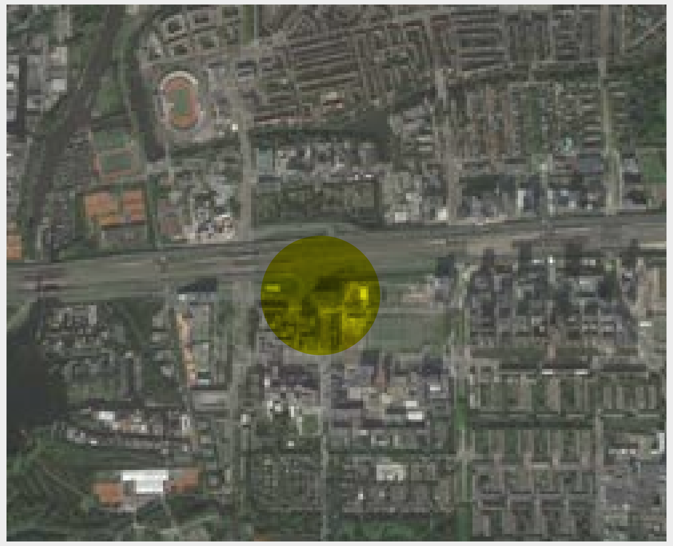
BACK to the map

The Edge University Building
Zuidas (Amsterdam), Netherlands

TYPE OF ACTIONS

New construction

GENERAL INFORMATION



YEAR OF CONSTRUCTION: 2014
ORIENTATION: N - S
DIMENSION: 40.000 m^2
STUDENTS: 372
CLIMATE ZONE: Oceanic climatic area
ARCHITECTS: PLP Architecture Ldt

DESCRIPTION

The Edge is a 15-storey office building connected with the University of Amsterdam. The building is currently considered the greenest building in the world, according to BREEAM ecological buildings certification scheme.
The building is located in a low environmental impact site and the green space that separates the building from the nearby highway acts as an ecological corridor that allows animals and insects to safety cross the site.
The North-facing atrium that covers the building (58m high), with a particular shape and orientation, acts as a buffer between the workspace and the external environment. It has an important role for the natural lighting of the working area and for the ventilation system. 95% of the material used have a responsible and demonstrable origin. (All the Edge wood is Forest Stewardship Council certified).
The building uses information technology (intelligent room control HC RT) and the user can control climate and lighting (both combined) at the room level via a mobile app. The Edge is wired with a vast network of two different types of pipes: one that contains data (Ethernet cables); and another that contains water. Behind each ceiling panel there is a huge coil of thin blue pipes that provides water to and from underground water storage for radiant heating and cooling.
The columns made up of welded steel plates of the façade are connected with the two walkways and horizontal support, while the beams are built in one or two prefabricated pieces.
Pedestrian and bicycle safety is considered within the building. Public transport (train, tram, bus) is nearby and there is a charging point for the electric cars, scooters and bicycles. The bike parking is large enough to provide space for employee bicycles. The parking is also accessible to the external public.

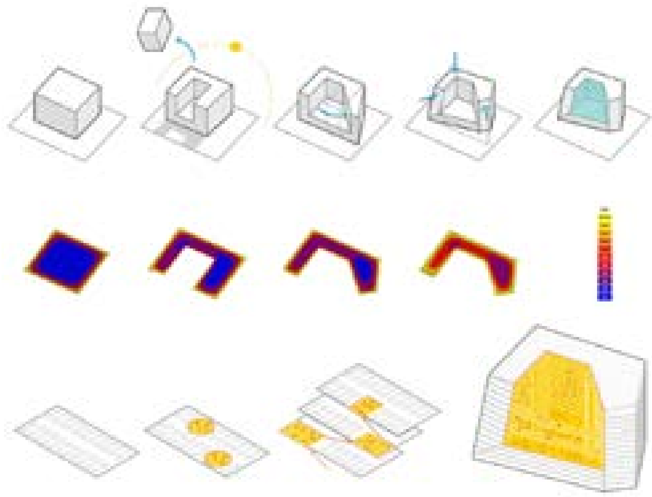
ENVELOPE

EXTERNAL WALLS

Façade are made by 13.000 m² of **glass with high acoustic insulation performance** and thin columns made of welded steel plates.
East and West side is made by 45% glass and 55% cement, which provides thermal mass.
South side is a load-bearing facade (40% glass), equipped with solar panels.
North-facing atrium comprises 70% glass, allowing the interior to benefit from indirect sunlight without overheating.

WINDOWS & SHADING SYSTEM

The building is built with approximately 13,000 m² of glass on the façades. The glass with different shapes and sizes is divided by horizontal rows of solid plumes with aluminium panels.
The working area has openings that guarantee the natural lighting and ventilation system even on grey days.

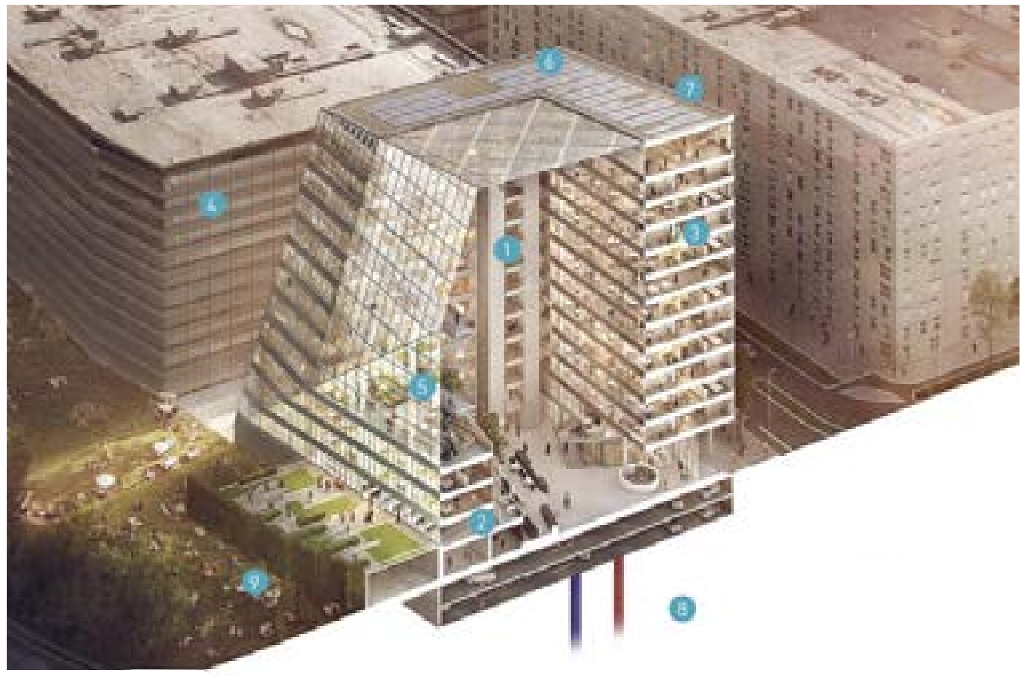


ROOF

The steel structure of the roof is designed in such a way that 30m of beams appear as thin as possible and accomplished by placing pokes in a diagonal grid connection.
Rainwater collection and solar panels are installed on the roof.

Project concept

Axonometric section of the building. Legend:
1. The atrium
2. Flexible workspaces
3. Activity based working
4. Orientation
5. Facades
6. Solar panel roof
7. Rain water reuse
8. Thermal energy storage
9. Ecological corridor



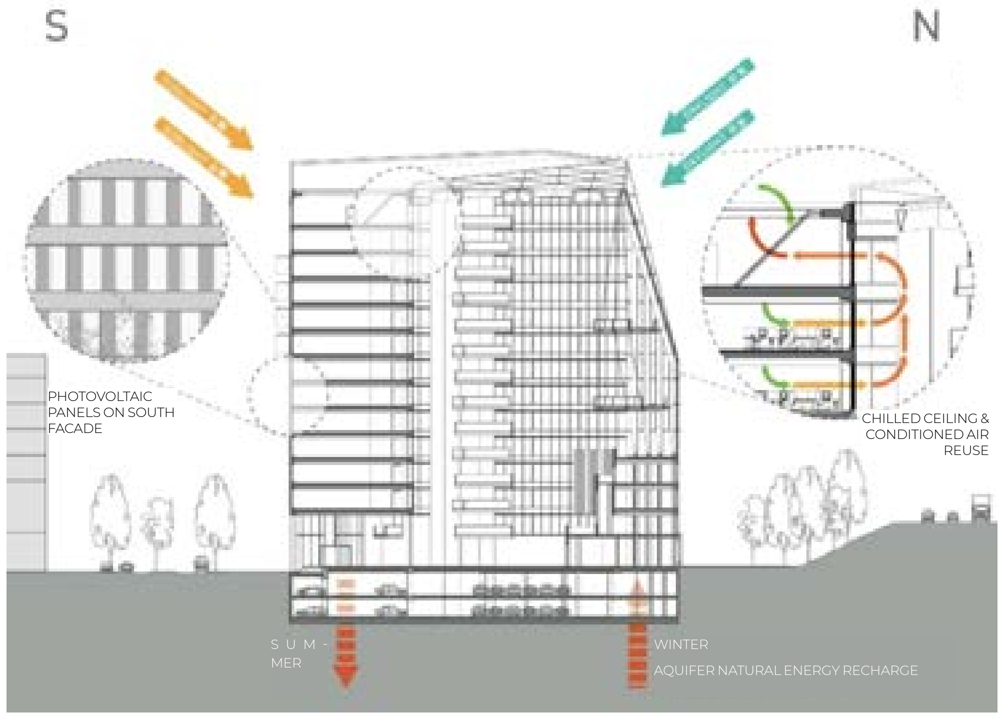


Diagram of the building

ENERGY SYSTEM

ENERGY BUILDING PLANTS

The lighting system is an Ethernet powered LED lighting system called LoE (Light over Ethernet). This connected lighting system has a range of around 30.000 sensors that record daylight, occupancy, movement, humidity, temperature and CO2. The system allows employees to use an application on their smartphones or tablet to adjust the climate and light on individual work areas.
A geothermal system based on the thermal accumulation of aquifers that pumps cold/hot water inside/outside the building, depending on the internal or external climate.
The pumps and the evaporator unit can be powered by fossil or renewable energy.
Natural ventilation (window panels that open automatically on the South facade) and mechanical ventilation (dual flow heat exchanger), optimized through the upper part of the atrium where air passes through a heat exchanger to take advantage of any heat.
A rainwater collection system that covers the water requirement of sanitary hot water in toilets. The recycling water is also used for the irrigation of the green terraces and the garden that surrounds the entire building,

PRODUCTION OF RENEWABLE ENERGY

Photovoltaic and solar thermal system on the South facade and on the roof.
The solar panels covering the roof provide electricity for the accumulation of thermal energy from the aquifer which generates the energy for heating and cooling. The solar panels on the South facade provide sustainable electricity to power smartphones, laptops and electric cars.
+ geothermal (thermal aquifer at 130 m).

SMART ENERGY SYSTEM

The Edge building is the greenest building in the world.
The building management system provides that the intelligent HC RT room control and the LoE (Light over Ethernet) lighting system are fully integrated with each other.
The user can control the climate and lighting (both combined) at the room level via a smartphone or tablet app. There are integrated LoE devices with 30,000 daylight, occupancy, movement humidity, temperature and CO2 sensors.

RESULTS

Edge is considered to be an energy neutral building and the first project in the Netherlands that uses surface-based measurements for production. Edge is self-sufficThe building is self-sufficient when it comes to energy supply and can produce up to 102% of its energy consumption.

References

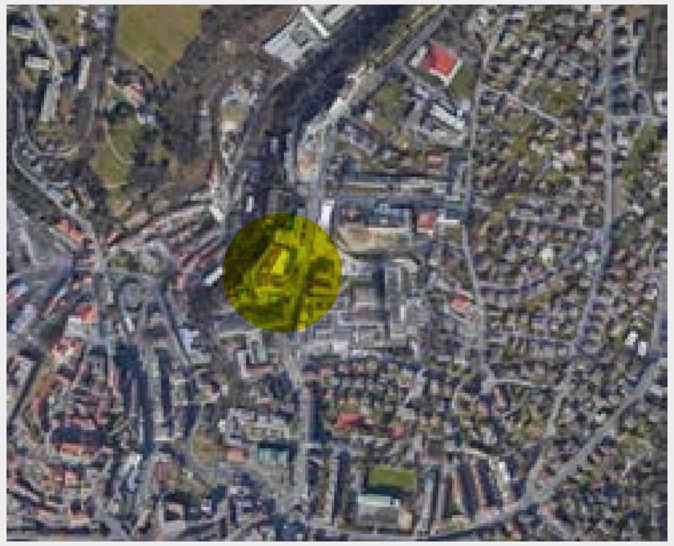
www.breeam.com/case-studies/offices/the-edge-amsterdam/

Laboratory Building Agora
Lausanne, Switzerland

TYPE OF ACTIONS

New construction

GENERAL INFORMATION



YEAR OF CONSTRUCTION: 2018
ORIENTATION: NW - SE
DIMENSION: 22.500 m^2
STUDENTS: 400
CLIMATE ZONE: Continental climatic area
ARCHITECTS: Behnisch Architekten, Stuugart

DESCRIPTION

The AGORA Translational Cancer Research Center is located in Lausanne with a view to lake Geneva. The visual connections existing on the site and towards the landscape were crucial for a cautious formulation and adaptation of the mass of the building.
Connecting the most diverse requirements into an extremely heterogeneous and tight urban fabric places great demands on the architectural and programmatic concept. The decision to link to an existing building on the one side while creating a harmonious transition to nature on the other, informs the building's structure without adversely affecting the site's existing programmatic functions.
Spatial qualities, directly perceived through daylight, proportion, and materiality, are equally visible in public areas and in the highly technical laboratories. During the development of the comfort and energy concept, different variants in combination with a hybrid ventilation were evaluated with the help of thermal simulations of several room types and a system comparison with the software TRNSYS.
The Agora area, the public level of the Cancer Research Center, connects the campus's existing pathways to the laboratory and office levels via interconnected communication areas and informal workplaces. The Atrium, main entrance of the building, offers public meeting points and enables exceptional events to take place.
The building skin is designed to enhance daylight use in the depth of the building. This provides for a better individual climate control. Daylight enhancement systems, optimized sunlight protection, the responsible management of natural resources in the construction and maintenance of the building, as well as the use of both renewable and existing energy systems on site are preconditions for a successful and sustainable working environment.

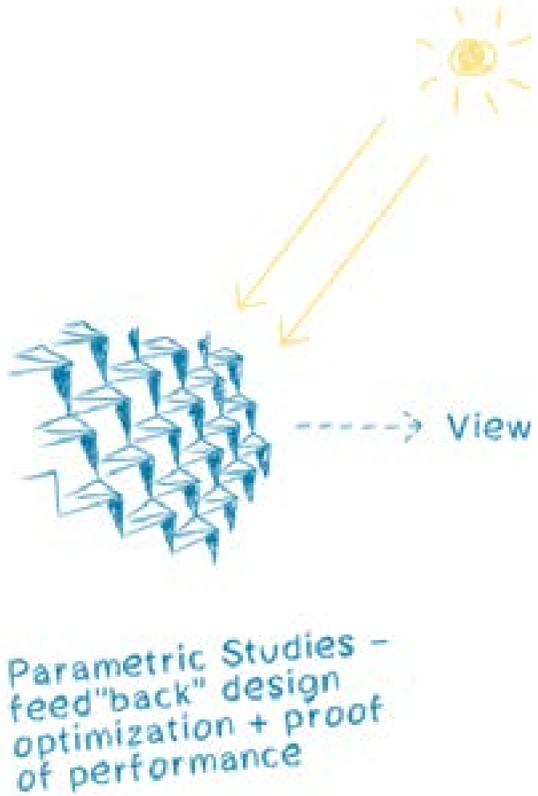
ENVELOPE

ROOF

The roof is insolated with **stone wool and solid ceilings** to absorb thermal loads.

WINDOWS & SHADOW SYSTEM

Windows with **dual component silicon**: glass, aluminum and PVB.
External shadings control the entry of daylight in the interior space thanks to parametric studies for the shape of the elements. **Internal glare protection** completes the protection against direct solar rays (for light and heat).



ENERGY SYSTEM

ENERGY BUILDING PLANTS

Heating and cooling of both offices and work areas is provided by the **activation of the components** integrated into the concrete.
A **reversible heat pump system** allows synergistic heat recovery from laboratories to non-laboratory rooms.
Natural ventilation of all non-laboratory rooms serves as both the supply of fresh air and night air flushing of the rooms. In all non-laboratory rooms, **solid ceilings** are exposed to absorb thermal loads.
The laboratory areas are supplied with air only mechanically.

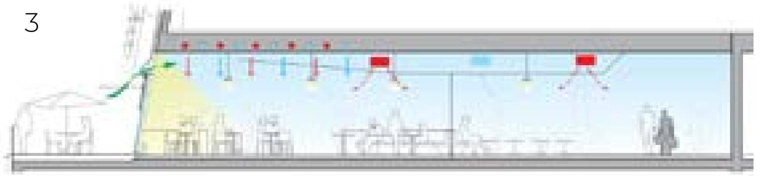
PRODUCTION OF RENEWABLE ENERGY

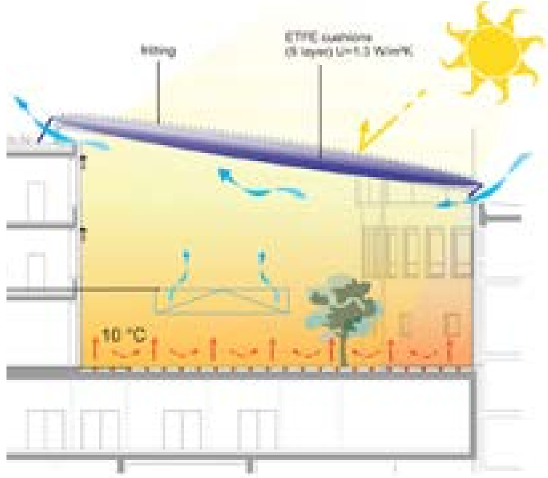
On the roof of the buildings have been installed **solar panels** for the production of energy and for the pre-heating of water.

Schemes of the laboratory (1,3), office (2), auditorium (3), and atrium (4)

1


2


3




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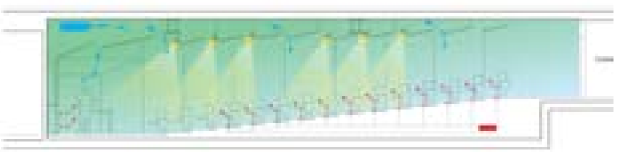
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References

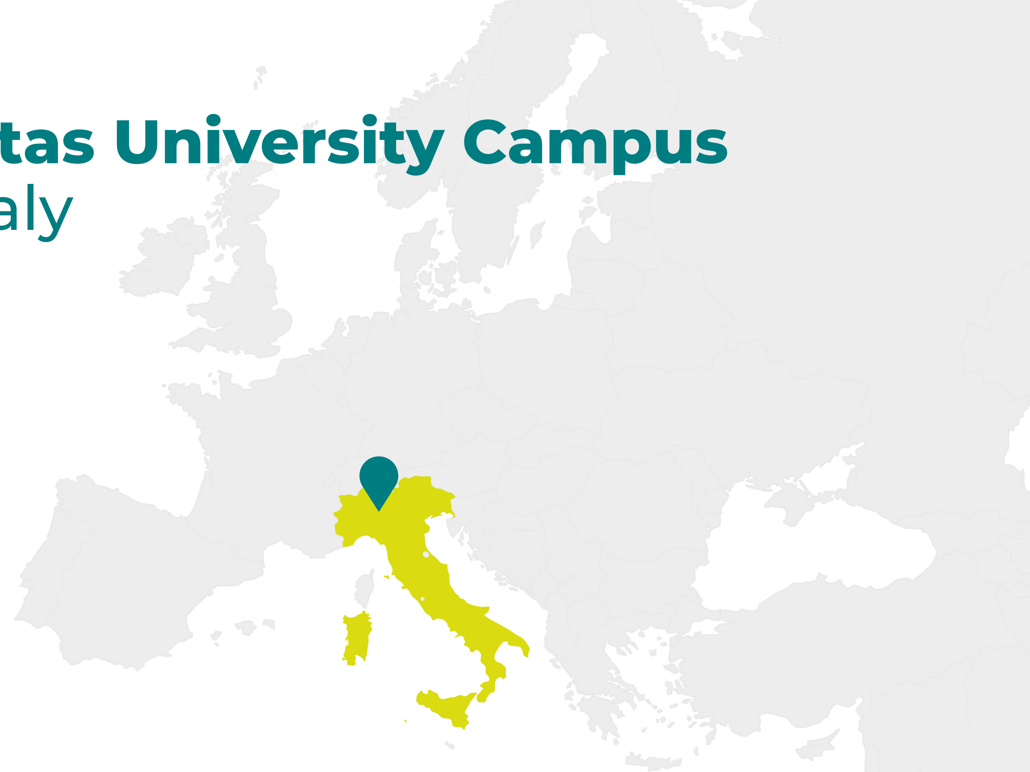
www.archdaily.com/907557/agora-pole-de-recherche-sur-le-cancer-behnisch-architekten

hhps://behnisch.com/work/projects/1030

www.theplan.it/eng/award-2019-educaaon/agora-ple-de-recherche-sur-le-cancer-1

hhps://transsolar.com/projects/lausanne-agora 1030_agora-lausanne_e (PDF)

Humanitas University Campus
Milan, Italy



TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2017
ORIENTATION: N - S
DIMENSION: 12.676 m^2 (total building)
STUDENTS: 1.000
CLIMATE ZONE: Mediterranean climatic area
ARCHITECTS: Francesco Taidetti

DESCRIPTION

The basic principle of the project is the composition of volumes of warm shades that open to allow natural light to enter or to protect against direct insulation of the glass parts in a play of different heights depending on the exposure. All interiors - halls, corridors and rest areas - have a gabled floor with staggered stairs on the short side, which continues outside, near the buildings and the courtyard.

The use of Italian stoneware is due to the intrinsic characteristic of the material resistant to weather and thermal shocks, and sustainability, as local material.
The campus, surrounded by a large-scale park, makes the most of its position through a masterplan based on pedestrian paths, offering a harmonious relationship with the surrounding greenery.
A Building Management System (BMS) has been created for the university campus which is responsible for supervising and, if necessary, remote control of the following subsystems:

- automatic regulation system for air conditioning;
- realizing the automation of air conditioning and electrical systems by allowing a centralized control;
- planning and controlling the maintenance of systems and equipment;
- realize, and document, all necessary energy saving strategies for waste-sensitive management;
- make available all consumption data for further processing, with the eventual charge to the different cost centers.

For the external appearance of the campus buildings, a type of colored paste stoneware tiles was chosen, on the color range of the earth, with a natural surface. Three colors with a slight "hue" on warm tones cover the buildings and make the play of their volumes more dynamic according to the hours of the day.
The module of the ventilated facade becomes the basic basis for the study of the holes in all buildings.

ENVELOPE

EXTERNAL WALLS

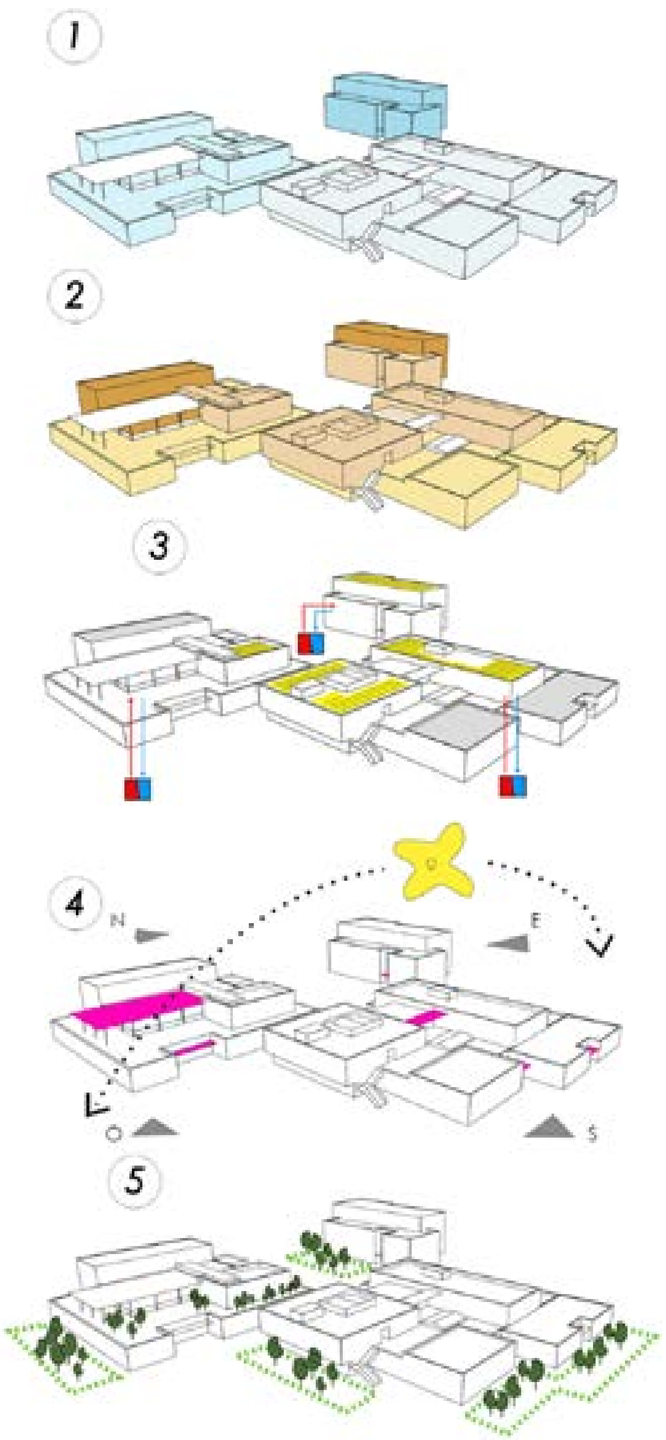
External wall are covered with **stoneware ventilated façade** and **shading systems**.
The material combines aesthetic of the stone monoliths with the energy performance of ventilation and insulation of the casing and the easy maintenance of the facade.
The wall sound absorbing system is made with MDF slats.

ROOF

The roof is equipped by photovoltaic and solar thermal panels.

WINDOWS & SHADING SYSTEM

Ventilated glass façade are equipped with **thermal break, venetian blind** and **brisee-soleil** for internal shading of the courtyard.



Schemes. Legend:

1. Volumes: decreasing heights = optimal orientation
2. Ventilated facade: < winter dispersion > internal insulation
3. Active systems: PV and solar thermal panels on the roof, heat pump with ground water, low temperature radiant panels
4. Shading: containment of direct radiation from the S-W glazed facades
5. Green: new planting for environmental mitigation and shading.

Section of the didactic and general front.

Section of the hub and South front.

ENERGY SYSTEM

ENERGY BUILDING PLANTS

Lighting with low energy consumption LEDs and light wells for natural lighting at the main distribution point.
The HVAC system is self-regulating and composed by geothermal heat pump with cold beam, radiant floor heating system and heat pump with ground water pumping.

PRODUCTION OF RENEWABLE ENERGY

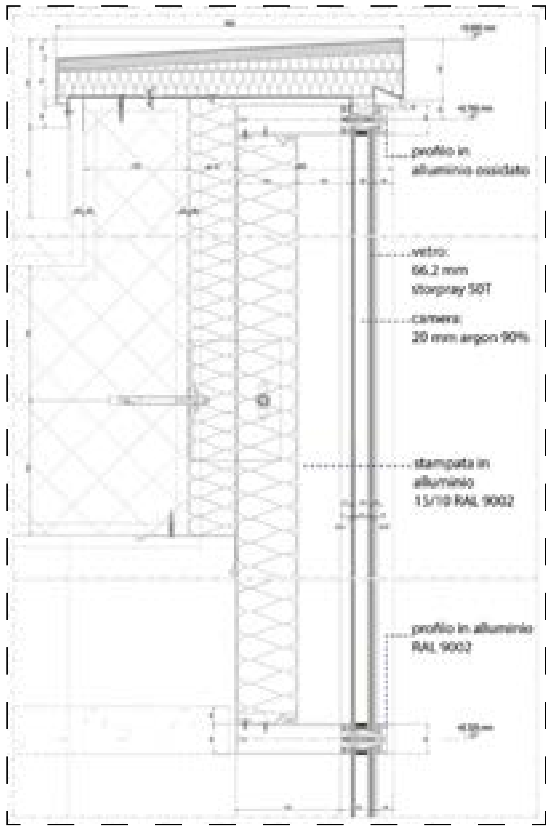
The building is equipped with a thermal, photovoltaic and geothermal systems.

SMART ENERGY SYSTEM

Automatic regulation system for air conditioning systems and electrical systems.

Construction detail of the curtain wall (1) and the window (2)

1.



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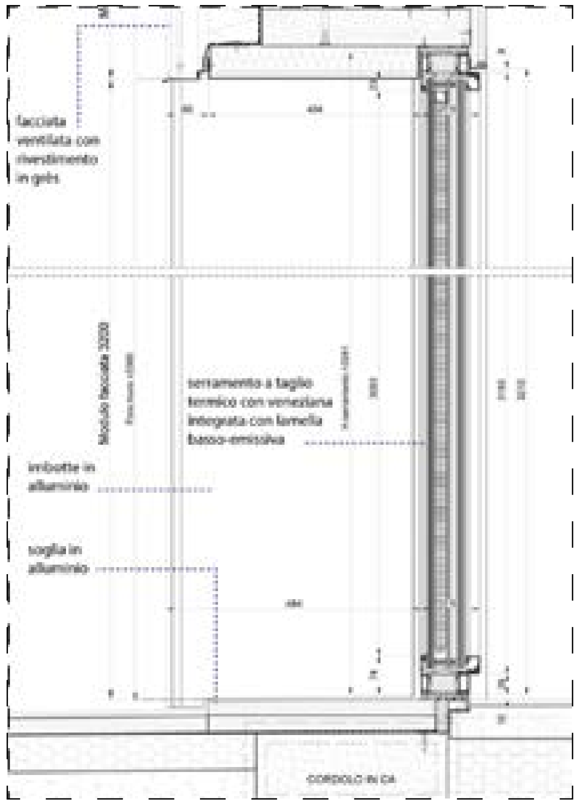


References

https://archello.com/it/project/humanitas-university-campus

www.impresedilinews.it/campus-humanitas-university-residenze-per-studenti/

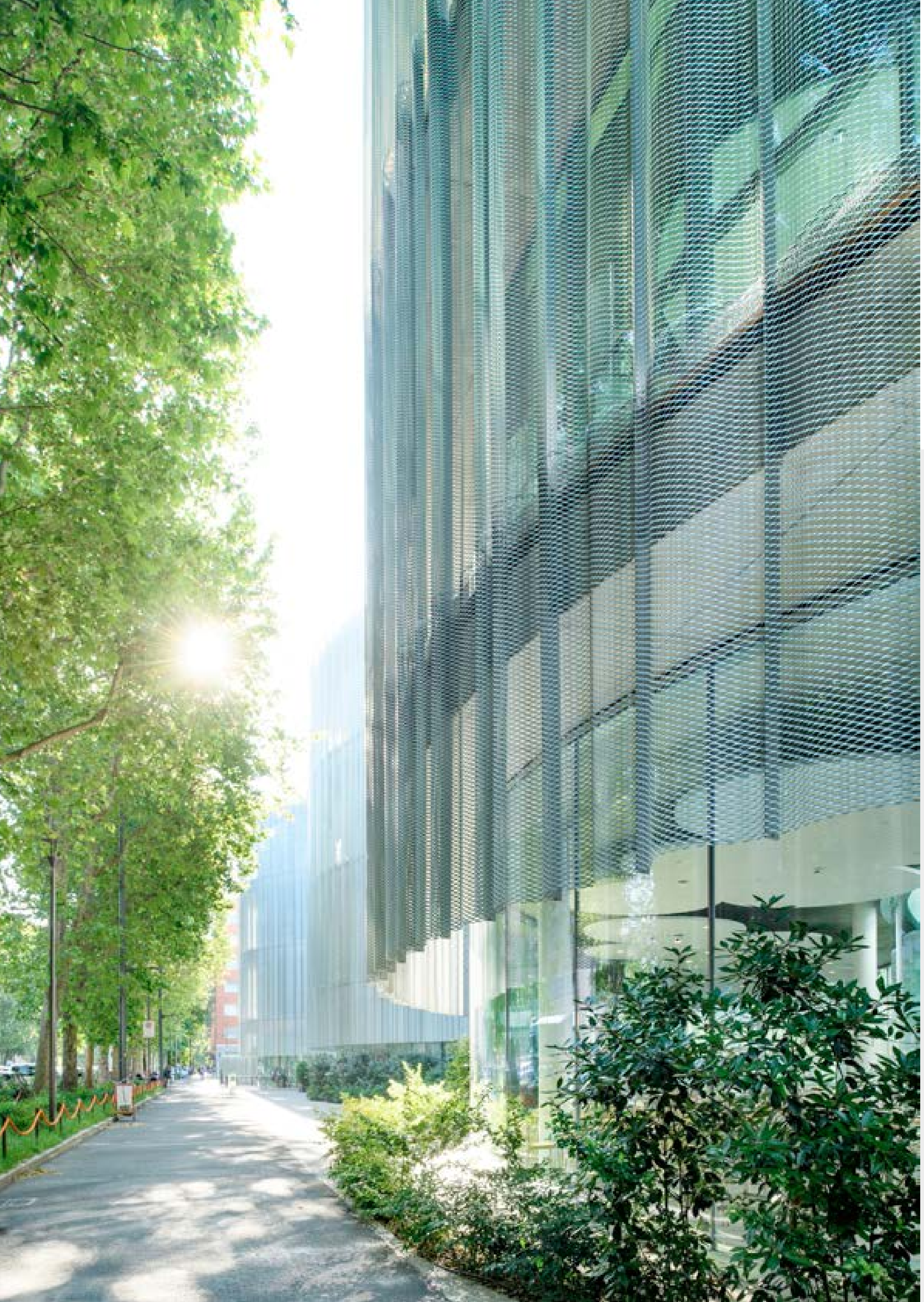
www.infobuild.it/progetti/campus-humanitas-university/

www.mpartner.it/projects/humanitas-university-campus/

www.sceproject.it/it/humanitas-university-campus/

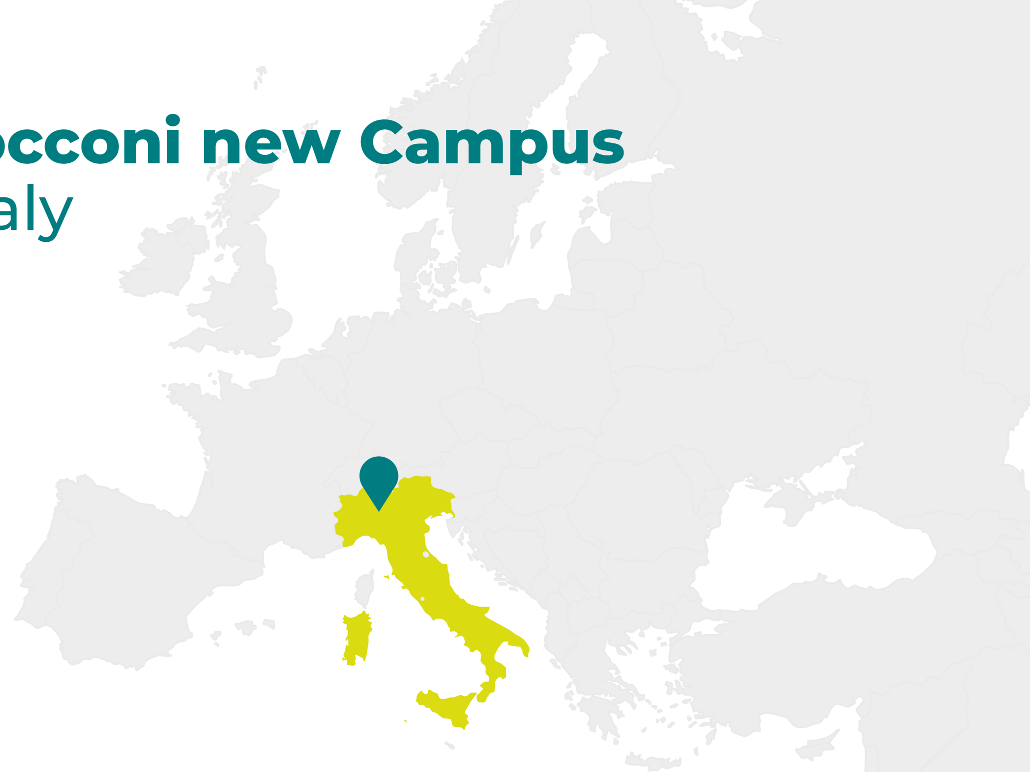
www.theplan.it/architettura/campus-humanitas-university-di-fta

BACK to the map



7 Nc

Luigi Bocconi new Campus
Milan, Italy



TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2012-2018

DIMENSION: 35.000 m^2 (total building)

STUDENTS: 300

CLIMATE ZONE: Mediterranean climatic area

ARCHITECTS: Studio SANAA / Kazuyo Sejima + Ryue Nishizawa

DESCRIPTION

The Bocconi University of Milan has always developed in parts and, over time, has become a metropolitan campus made up of historic sites and new spaces in a large area close to the city center.
The complex is fragmented and composed of several buildings and after the Irish Grafton Architects project, the construction of the new Campus began. The project of the New Campus is composed of a set of separate building volumes characterized by curved and soft lines.
The main objective of the designers was to create a transparent campus open to the city, through a series of stylistic choices such as the arcades on which all the buildings rest, the sequence of columns, glazed spaces and trees.
The arcades and cloisters are a stylistic choice realated to the typical architecture of Milan, often equipped with internal green courtyards in relation to each other. These paths meet and allow an easy route between the various volumes and through the park. The different nuclei are designed in order to create easy passages between the buildings. This determines a continuous perimeter that seals the School from the outside, making it safe and easy to manage.
The project, winner of an international competition, therefore presents great attention to the aspects of energy efficiency and energy saving for all the buildings included in it. It can be defined as NZEB, Near Zero Energy Buildings, as defined by the European EPCB Directive (2010/10/EU) early adopted in 2016 by the Lombardy Region, first Italian region. Lombardy, infact, was the first Italian region to implement the provisions of the EU EPCB Directive.

ENVELOPE

EXTERNAL WALLS

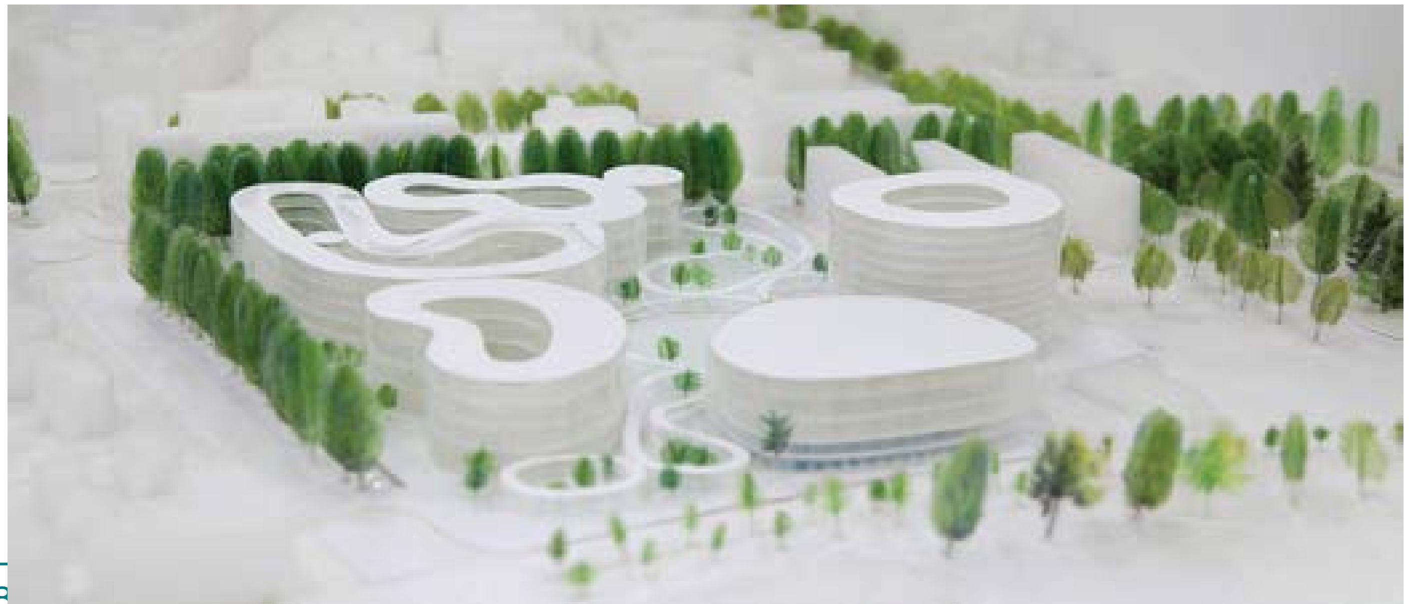
A first external skin in anodized aluminium expanded metal followed by a second glazed skin and thermal break aluminium.
Full-height glass façades the external walls are 50% opaque and 50% transparent and provide optimal insulation, air layering, natural lighting, further reducing energy consumption and costs.

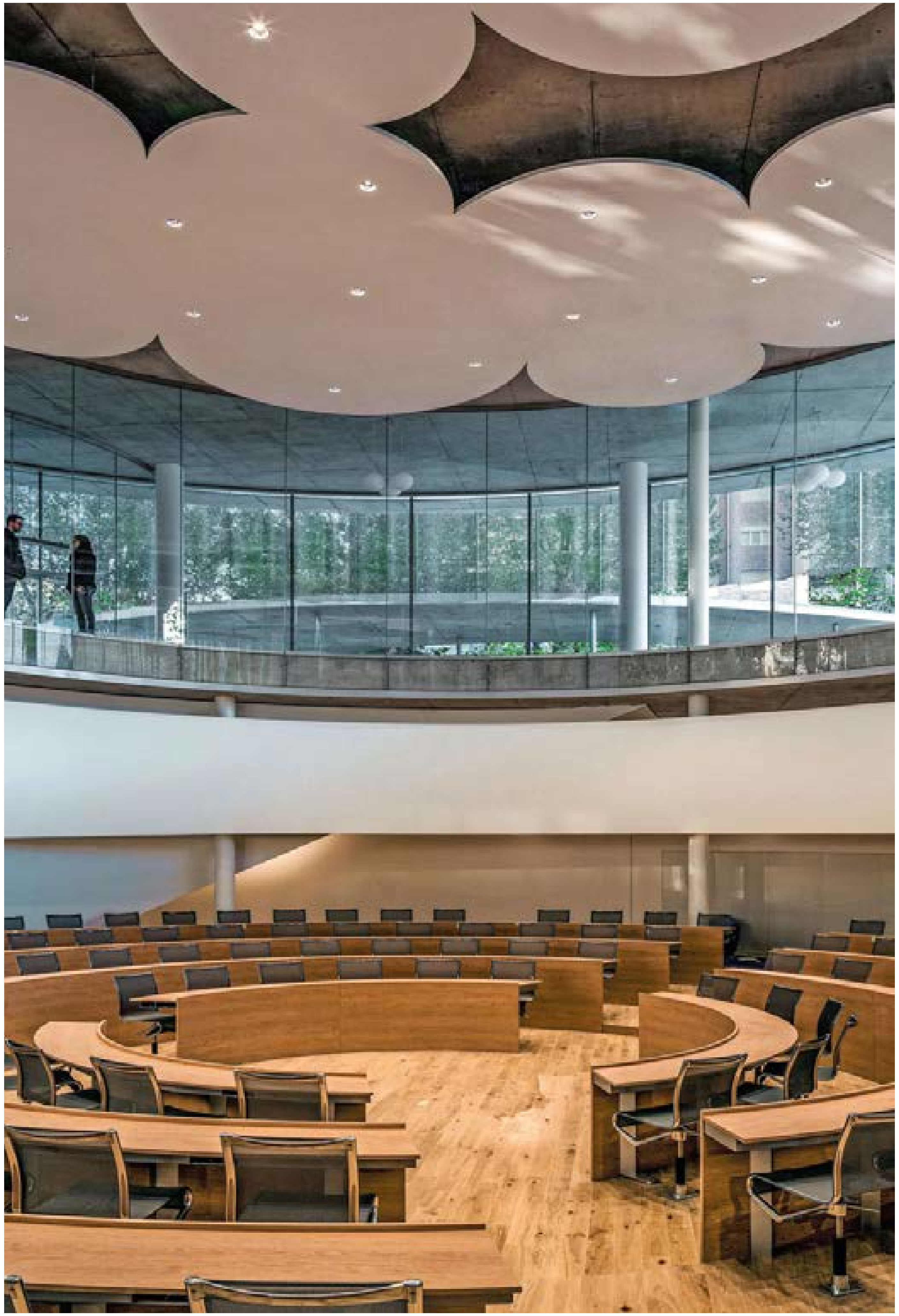
ROOF

All the roofs of the buildings are equipped with high efficiency photovoltaic panels.

SHADING SYSTEM

Metal truss canopies combined with sun protection elements that limit the accumulation of solar heat but allow the entrance of daylight.





ENERGY SYSTEM

ENERGY BUILDING PLANTS

Maximum contribution of light exposure to the interior of each core.
Advanced lighting management system with automatic control of the brightness levels in every space.
Heat pumps and water-powered refrigeration units to balance the thermal needs. The refrigeration units take and return water from the Ticinello stream without the physical consumption of water.
Creation of an electricity, heating and cooling system interconnected and cogenerated between the different university sites. Cogeneration with gas engines.
Use of the underground water sources or rainwater recicling systems.

PRODUCTION OF RENEWABLE ENERGY

The building is equipped with high efficiency photovoltaic panels in the roof.

References

www.unibocconi.eu/wps/wcm/connect/Bocconi/SitoPubblico_EN/Navigation+Tree/Home/About+Us/Statute+Regulations+and+Documents/Bocconi+Green/Get++involved%21/Useful+resources/Sustainability+Report+2012/Bocconi+and+Milan/

https://www.lifegate.it/universita-bocconi-nuovo-campus-sanaa

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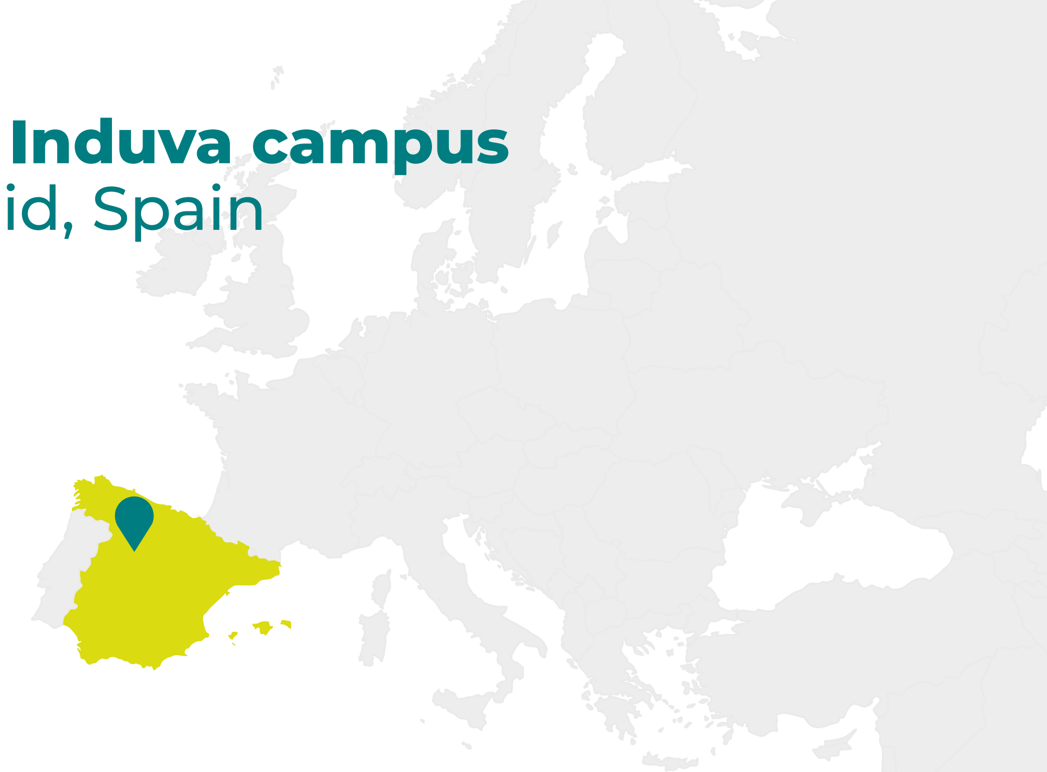
Aulario Induva campus
Valladolid, Spain



TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2017
ORIENTATION: NE - SW
DIMENSION: 1.229 m²
STUDENTS: 2.500
CLIMATE ZONE: Mediterranean climatic area
ARCHITECTS: Francisco Valbuena y equipo

DESCRIPTION

The construction of the Aulario building for University of Valladolid's School of Industrial Engineering represents a great opportunity for research and improvement of technics already applied on net zero energy buildings of the campus.
The building, while completely new, is already connected to the other buildings and installations of the campus, where a global refurbishment and sustainability intervention is being carried out.
It is a building of monolithic volume, with its own distinctive and personal language, in which elements such as modulation and colour are integrated, strong and remarkable as an identity element of the building. They are supported by an absolute and radical technical functionality seeking the comfort of the students.
The final image of the building reflects the complete coordination between traditional elements of the environment (the garden, the connection with other buildings), with techniques adapted to new forms of learning in terms of environmental architecture.
The overall building, of which the case study represents a portion, accommodates up to 2500 students in 34 classrooms, for a total built area of 5845 m².
It is located within the headquarters of Mergelina, a university area that hosts other buildings such as workshops, laboratories, residential centres and also includes gardens, recreation areas and parking.
The campus has two main characteristics:
- The first one is its status as an autonomous building but annexed and linked to the general university complex and the main building, whose exploitation and coordinated use should be part of it.
This main building in which it depends will be rehabilitated, which requires some coherence in geometry, distributions, and connections in terms of facilities and operation.
- The second characteristic lies in its assigned parcel, which has a specific interest and is the subject of detailed study.
The building and its environment have taken into account the widest possible accessibility as one of the design goals. Communication technologies (ICT) have been employed in the project and will offer more opportunities for continuous access to learning and will complement internationalization.
In order to reach their zero energy goal, the design team was guided by strong passive principles plus other innovative systems.

ENVELOPE

EXTERNAL WALLS

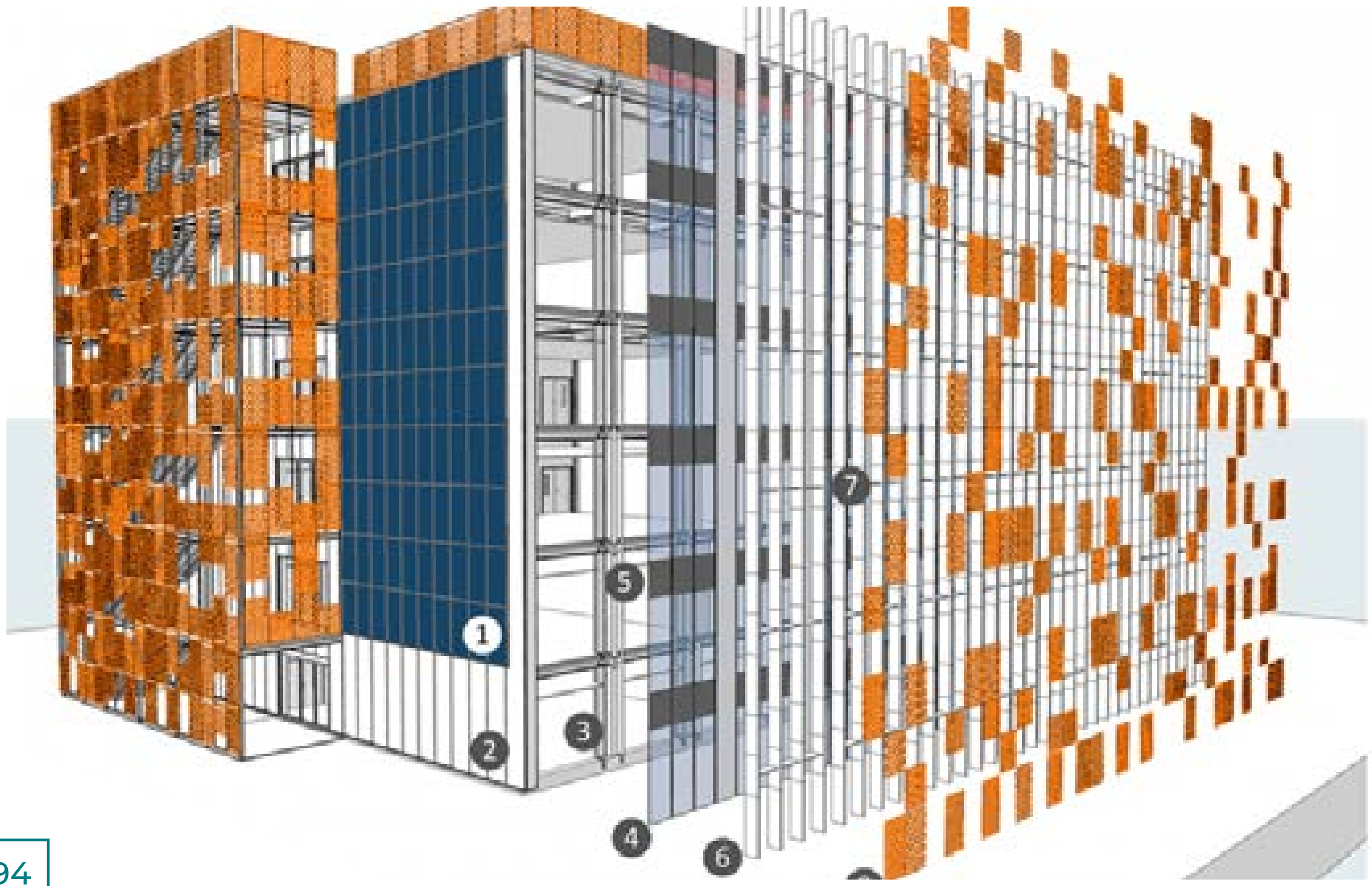
Use of phase **change materials** (micronal material in laminated plasterboard) in some parts of the building, where it is considered important to improve the thermal inertia to balance the thermal jumps. It consists in the use of gypsum which contains micropsules with phase change material.

FAÇADE SOLUTIONS & SHADING SYSTEM

Widows with solar control and curtain wall with **filtering screen** that controls the sunlight.

ROOF

Intensive green roof.
The green roof, the vegetation and the open access areas with filter flooring have an important bioclimatic function because they **reduce the heat island effect** and above all contribute both to creating a favourable microclimate and to maintaining the existing **biodiversity.**
It was chosen a specific vegetable cover for various varieties of indigenous sedum: a mixture of at least five varieties is proposed.



ENERGY SYSTEM

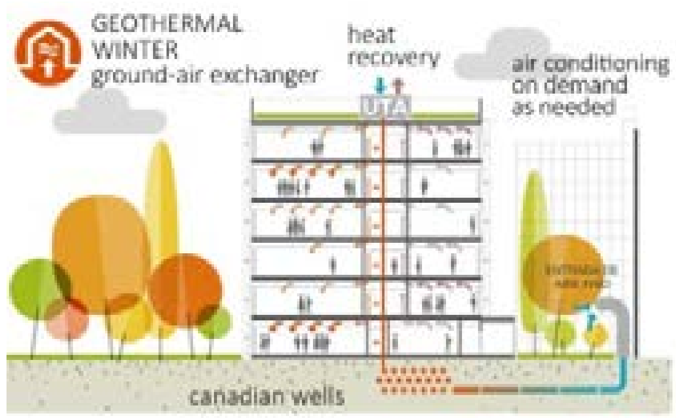
ENERGY BUILDING PLANTS

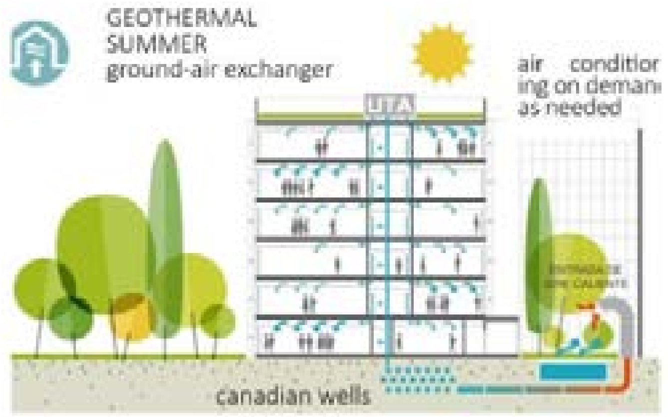
Natural interior lighting is supported by **fiber optic transmission systems**.
A system of **Canadian tubes** (geothermal) supporting the heating system by UTA. In winter the canadian wells system converts outdoor cold air into indoor heating. In summer the canadian wells system converts outdoor hot air into indoor air conditioning. To ensure a healthy indoor environment while maintaining energy saving objectives, ventilation demand control systems have been installed using **CO_2 probes and temperature sensors.**
The draining soil and the appropriate drainage wells allow the **reuse of waste water** from the **building's internal systems and rainwater** that filters after irrigating the green roof.

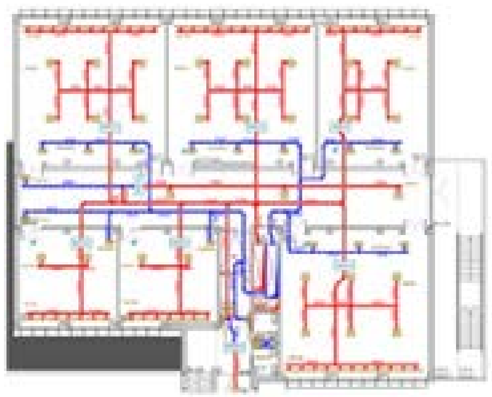
PRODUCTION OF RENEWABLE ENERGY

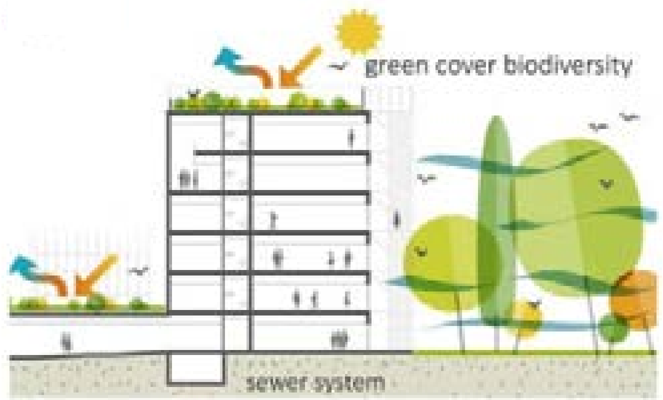
There are coordinated renewable energy production systems as in addition: **urban biomass heating network, geothermal** (on the ground-air exchenger) and **photovoltaic energies** (on the SE facade).
It will be externally certified through the GREEN GBCe, LEED, and Well certifications

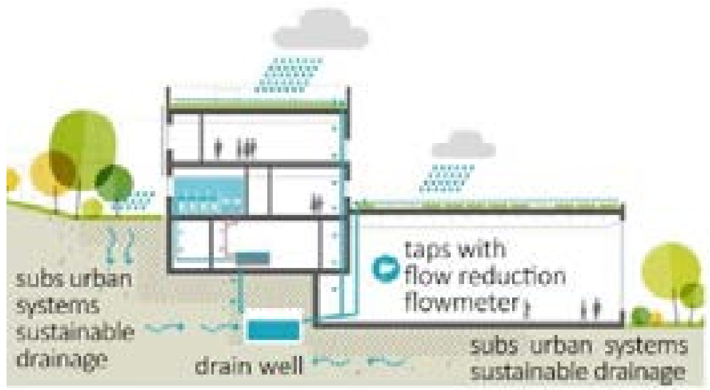
Exploded axonometric.
1. green roof
2. shared parking
3. recovery of existing garden
4. runoff management
5. bicycle parking
6. filter pavements
7. phase change materials
8. rainwater storage
9. canadian wells
10. emergency staircase as shading for the south facade

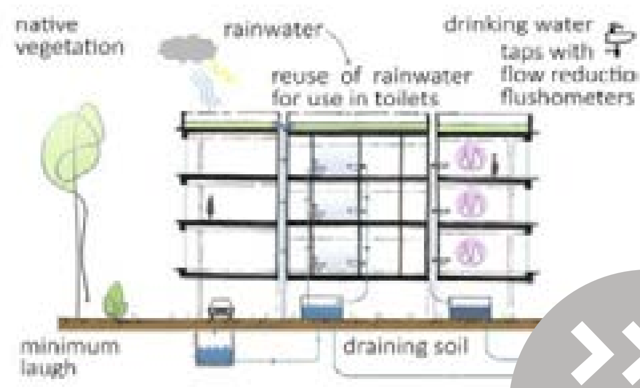












References

https://www.construction21.org/case-studies/es/aulario-induva.html#

https://www.buildup.eu/en/practices/cases/aulario-induva-valladolid-spain

Construction 21 Italia_ Aulario IndUVA (PDF)

Estrategias de diseno para un EECN en el àmbito universitario: el Aulario IndUVA de Valladolid (PDF)

Modelado numérico del sistema de ventilación del edificio Aulario IndUVa mediante un modelo zonal (PDF)

Scientific material taken from Combinaciòn de tecnologìas en la edificaciòn: Edificio LUCIA y Aulario IndUVA (PDF)

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9Nc LUCIA building
Valladolid, Spain

TYPE OF ACTIONS

New construction

GENERAL INFORMATION

YEAR OF CONSTRUCTION: 2013
ORIENTATION: NE - SW
DIMENSION: 5.560 m^2 (total building)
STUDENTS: 177
CLIMATE ZONE: Mediterranean climatic area
ARCHITECTS: Francisco Valbuena Gardìa

DESCRIPTION

The LUCIA building of the University of Valladolid is a Zero CO2 emissions and Zero Energy building because of its passive and bioclimatic design strategies using only renewable energy on site.

The building has a reinforced concrete structure and consists of four floors, including the ground floor comprising an arcade. The walls have protruding buttresses designed to shield sunlight where necessary and the constructive compactness of the building is very remarkable.
LUCIA showcases the construction of sustainability with the management and production of autonomous local renewable energies and is recognized as the best result in Europe at the LEED Platinum level with 98 points.
Since user occupation, LUCIA has been monitored in order to test hypotheses that will provide the basis for environmental methods and assessment for future construction towards zero-energy or near-zero buildings and communities in zero energy.
Elements such as orientations, volumetry, arrangement and dimensions of the openings of the facades and roof, creation of volumes for self-shading effect, increased natural lighting are analysed. They have been treated in a combined and integrated way to achieve the best interior conditions of habitability, comfort and well-being for users, and with this the objectives in economic and environmental matters have been achieved.
It will provide the springboard for research into social aspects of building sustainability and it will constitute a prototype on which to test the bases for environmental methods and assessment for buildings.
The LUCIA building will offer a model for conducting research into areas that will shed light on other as yet unexplored methods. It will use biomass, a surplus resource in the region where the building is being constructed, which has a major socio-economic impact, and will lead not only to job creation but also to enhanced self-sufficiency in energy.

ENVELOPE

EXTERNAL WALLS

Low value of the coefficients of insulation on the facade with 100% natural material.
The jagged surface of the building facing South and East achieve thermal gains in winter and a self-shadow effect in summer to reduce cooling loads without limiting natural lighting.

Layers of the vertical envelope:

- Reinforced concrete panel - 5 cm
- EPS - 6 cm
- Reinforced concrete panel - 5 cm
- Insulation Imv -14 cm
- Air chamber - 5 cm
- Plaster panel - 1.5 cm

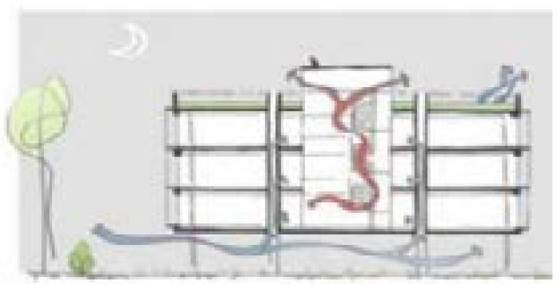
SKYLIGHTS & ROOF

73.5 % of the roof covered by **green roof** with intensive vegetation roof.
Skylights for the lighting of circulation space, stairs and elevators.
Layers of the horizontal envelope:

- Reinforced concrete - 30 cm
- Light reinforced concrete - 6 cm
- Impermeable layer
- Felt
- XPS - 20 cm
- Drainage layer - 2 cm
- Felt
- Vegetable soil - 0.1 - 0.69 cm

FAÇADE SOLUTIONS & SHADING SYSTEM

Double skin curtain wall on the south-east facade is designed with a ventilated interior space that avoids thermal solar gain in summer and fosters it in winter. Inclination and positioning of the openings to improve solar intake and shading.



ENERGY BUILDING PLANTS

Natural lighting of the internal areas using **tubular daylighting devices** - 27 solar tubes - and skylights above the stars.
Study of the orientation, volume, layout and dimensions of the façades and roof openings for self-shading effect and increase in natural lighting are analysed.
Rain water recovery system is installed in the roof.
100% of the grey waters subjected to a recycling process with nets to separate those from the laboratory water to be processed before draining, bathroom facilities equipped with electronic taps for the flow regulation and the choose of native vegetation that does not required irrigation.

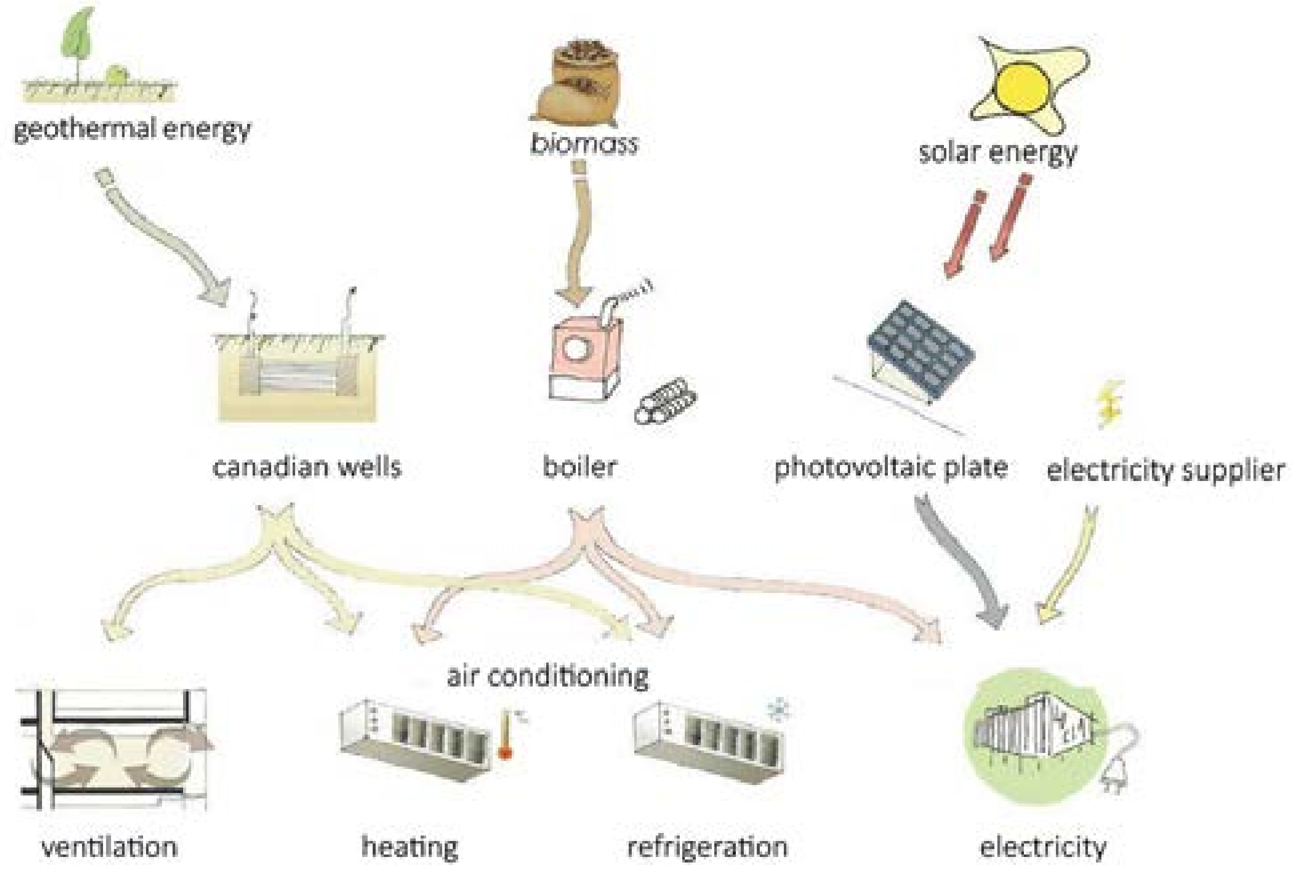
PRODUCTION OF RENEWABLE ENERGY

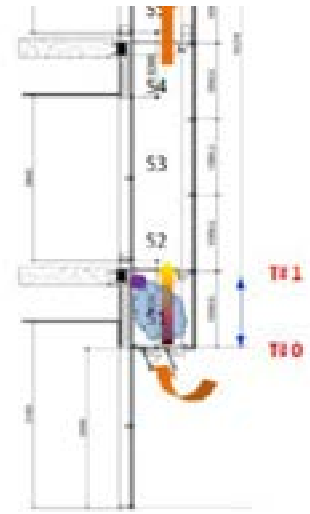
The two skylights and the double skin curtain wall on the South-West integrate **photovoltaic system** to produce electrical energy. The double skin facade produces 5.000 kWh annually and the skylights 5.500 kWh.
System of Canadian wells (terrestrial geothermal) installed outside the building. This innovative system naturally conditions the outside air before introducing it into the ventilation system.
Use a **biomass cogeneration system** for the total production of the building's air conditioning (heating and cooling) and electricity production

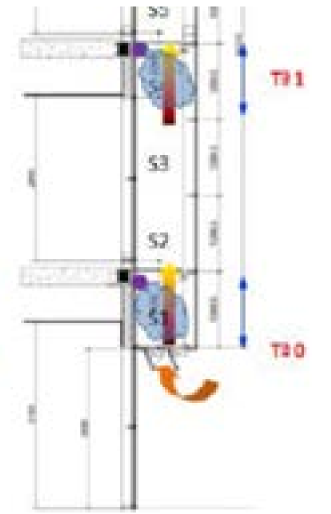
SMART ENERGY SYSTEM

To achieve the harmonization of all energy systems with those of any building related to access control, security, monitoring and remote management, etc., there will be a **Building Management System** integrated into BMS. It will integrate the subsystems of control of the air conditioning, control of the illumination, central of alarms, control of accesses, database, etc., by means of the corresponding protocols that operate in the different areas of management like illumination, air conditioning, etc., along with those of the University's own development such as access control, anti-intrusion systems or video surveillance, through the programming and operating instructions controlled by the UVa from its command post.

The thermal insulation used and the other measured produces a **90% reduction in heating demand** (kW/m² year)







References
https://www.buildup.eu/en/praccces/cases/lucia-pioneer-energy-autonomous-public-building-spain
https://www.construccon21.org/case-studies/es/lucia-lanzadera-universitaria-de-centros-de-invessgacion-aplicada.html
https://lucia-building.blogspot.com/
https://www.youtube.com/watch?v=MkMN5yh-6vSA&feature=youtu.be (VIDEO)
https://www.usgbc.org/projects/lucia-buildingconama-lucia-25-10-2012 (PDF)
Microsoo Word -porada.docx (PDF)
101106-LUCIA-doblepiel-final (PDF)

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Synoptic overview

		EXTERNAL WALLS	GROUND FLOOR SLABS	ROOF	FAÇADE SOLUTIONS	SKYLIGHTS	WINDOWS	SHADING SYSTEM	ENERGY BUILDING PLANTS	RENEW. ENERGY PRODUCTION	SMART ENERGY SYSTEM
1R	Electrical Engineering Department - Coimbra, Portugal								x	x	
2R	EHU Building Biscay Campus - Bilbao, Spain	x		x		x			x	x	x
3R	Scientific University - Bordeaux, France				x				x		x
4R	Department of Technical Sciences - Innsbruck, Austria	x	x	x			x		x		x
5R	UNIMI University campus - Milan, Italy	x		x			x		x		
6R	POLIMI Leonardo campus - Milan, Italy	x		x			x		x		
7R	Orthopaedic and Traumatological Institute - Rome, Italy	x		x			x		x	x	
8R	Department of Civil Engineering and Architecture - Catania, Italy	x		x			x		x		
9R	Aflivadem vocational school - Ankara, Turkey	x					x		x	x	x
1Nc	Music School and Concert Hall - Ventspils, Latvia			x		x	x	x	x	x	x
2Nc	Green Lighthouse building - Copenhagen, Denmark	x	x	x		x	x	x	x	x	x
3Nc	Alnatura Campus - Darmstadt, Germany	x		x		x	x		x	x	
4Nc	The Edge University Building - Zuidas (Amsterdam), Netherlands	x		x			x	x	x	x	x
5Nc	Laboratory Building Agora - Lausanne, Switzerland			x			x	x	x	x	
6Nc	Humanitas University Campus - Milan, Italy	x		x			x	x	x	x	x
7Nc	Luigi Bocconi new Campus - Milan, Italy	x		x				x	x	x	
8Nc	Aulario Induva campus - Valladolid, Spain	x		x	x			x	x	x	
9Nc	LUCIA building - Valladolid, Spain	x		x	x	x		x	x	x	x