POLICY AND PROJECT TOOLS FOR ENERGY-EFFICIENCY RETROFIT IN HIGHER EDUCATION BUILDINGS

Exploitation of the decision aid tool

Elaborated by Università della Campania "L. Vanvitelli

WP4. POLICY AND PROJECT TOOLS FOR ENERGY-EFFICIENCY RETROFIT IN HIGHER EDUCATION BUILDINGS

Within the framework of WP4 and objective WP4.1 Policy and Project tools for Energy-Efficiency retrofit in Higher Education, the Vanvitelli University was involved to give its technical contribution in the analysis of the Mediterranean University Buildings energy performance profiling.

Mediterranean University buildings energy performance profiling

Universities are the main centres where the drivers of innovation for sustainability and decarbonisation of the built heritage are investigated and developed. Universities have the primary task of investing in research and development of innovative technologies aimed to mitigate climate change. As centers where the drivers of innovation are studied and designed, they intrinsically have the role of demonstrators of the feasibility and effectiveness of policies for sustainability and decarbonization of the built environment.

From a scenario analysis to think structurally about the challenges that universities might face in the long run, an interesting characterization of the typological identity found emerges: there are universities with an orientation mainly close to society (open to life acting as a financially strong cooperative partner), universities rather distant from society (conservative maintaining a niche existence) and universities with a mainly instrumental role (market-oriented generating profitable knowledge). (Barth et al., 2011)

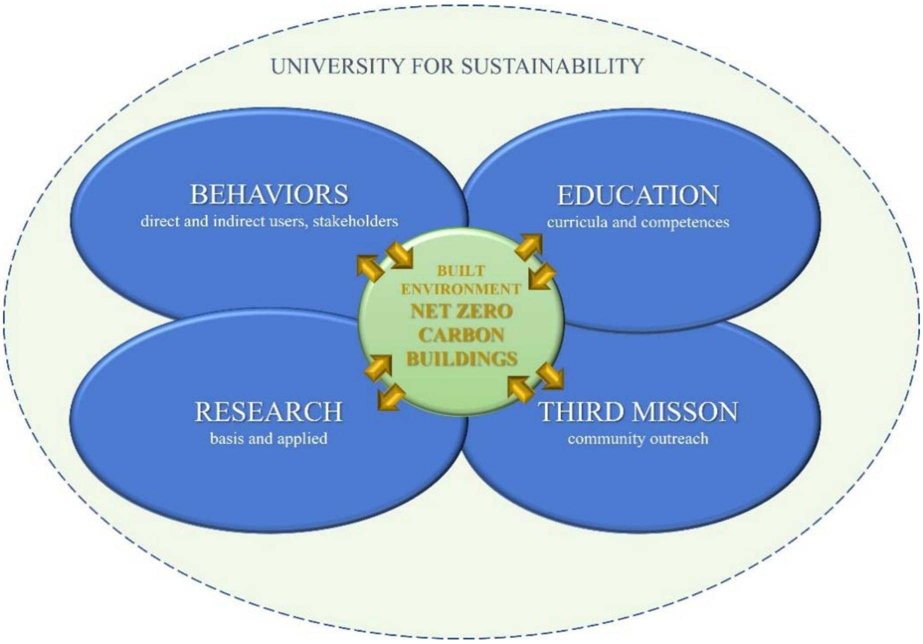


Fig. 1. University for Sustainability: the central role of the net zero carbon built environment

The Committee for International Cooperation (CIC) highlighted that universities' commitment to sustainability is academic and involves its three missions: Education, Research, and Third Mission, and it is not implementable separately by the interested actors. (Alonso-Almeida et al. 2015)

The scientific work carried out by the DADI-Vanvitelli and ANEA research groups as part of the Project "Mediterranean University as Catalyst for Eco-Sustainable Renovation" (MedEcoSuRe), funded by the European Union under the ENI CBC MED Program, focuses on the environmental aspects of sustainability, in particular the management of energy and natural resources in university buildings.

In WP4 - Policy and Project tools for Energy-Efficiency retrofit in Higher Education Buildings, DADI-Vanvitelli research group different analyzed and compared some university sustainability assessment methodologies in order to extrapolate the most effective indicators to assess the environmental and energy performance of existing buildings, not only to highlight the truly virtuous buildings, but also to identify the strengths and weaknesses of the university building stock in order to implement the most appropriate renovation strategies that would be able to make them sustainable in the fullest sense of the term. According to the Renovation Wave Strategy, these strategies are intended to improve not only the energy performance of buildings but also the quality of life of people who live in and use university buildings. This is consistent with what was already stated by the Stockholm Declaration (1972) and reiterated by the Talloires Declaration (1990), which advocated the direct correlation between people and their living/studying/working environment, giving university buildings a key educating role in achieving environmental sustainability.

Tools for assessment of sustainability in universities

The international strategies promoted by the European Green Deal and the New European Bauhaus lead us to question the environmental energy performance of the built heritage. If carbon neutral buildings are to be our goal in 2050, we need to understand: what is the current carbon footprint of university buildings? And how can we measure it? Almost all the investigated tools deal with the theme in a complex way, not separating the environmental energy assessment of the built environment from the ways of using it and from the awareness taught in these places of knowledge, giving strength to the concept that the habitat in which the human being lives, conditions in a biunivocal way his behaviors.

However, in many cases, there is a strong gap between the sustainability taught in the different courses of study, and the real performance (in terms of ecological footprint) of the buildings where they take place. For this reason, a series of operational tools, tested in different cultural areas of the world, have been studied in order to highlight not only the recurring non-negligible features, but also the strategies to enhance the best practices to implement a Cross Border Strategic Plan for University Building Retrofitting (WP 4.2). The research highlighted that several tools for assessing the sustainability of universities have been developed around the world over the past two decades.

Dalal-Clayton &Bass (2002) describe three main approaches to measure and analyze sustainability:

- Accounts (raw data that are then converted to a common unit: (monetary, area or energy),
- Narrative assessments (that combine text, maps, graphics and tabular data and might use indicators),
- Indicator-based.

Indicator-based appraisal is certainly preferable for tackling the sustainability assessment challenge of university buildings. This kind of approach involves a comprehensive process of prioritization and ensures better strategy advancement, performance follows up and genuine decision-making and most importantly describes strengths and weaknesses. (Adenle et al, 2020)

In most of the instruments analyzed, the indicators are generally divided into thematic categories, which attempt to assess, through multi-objective (qualitative-quantitative) criteria, all the aspects that make a University more or less sustainable. Usually, the indicators should cover the entire system to address: Education (referring to Courses and Curricula), Research, Campus operations, Community outreach and Assessment and reporting. (Lozano, 2006)

In the MedEcoSuRe research project, net zero carbon buildings assume a central role in this quadrilateral of convergence towards sustainability, promoting cross-sector dialogue between institutions on sustainability and stimulating environmentally conscious behavior and learning.

In the United States, for the past two decades, academics and environmentalists have sought to evaluate places of knowledge based on their sustainable practices and policies, primarily through the tools proposed by three organizations: Association for the Advancement of Sustainability in Higher Education (AASHE), The Princeton Review, and Sierra Club (Albis, 2017). Among the tools developed, the one proposed by AASHE

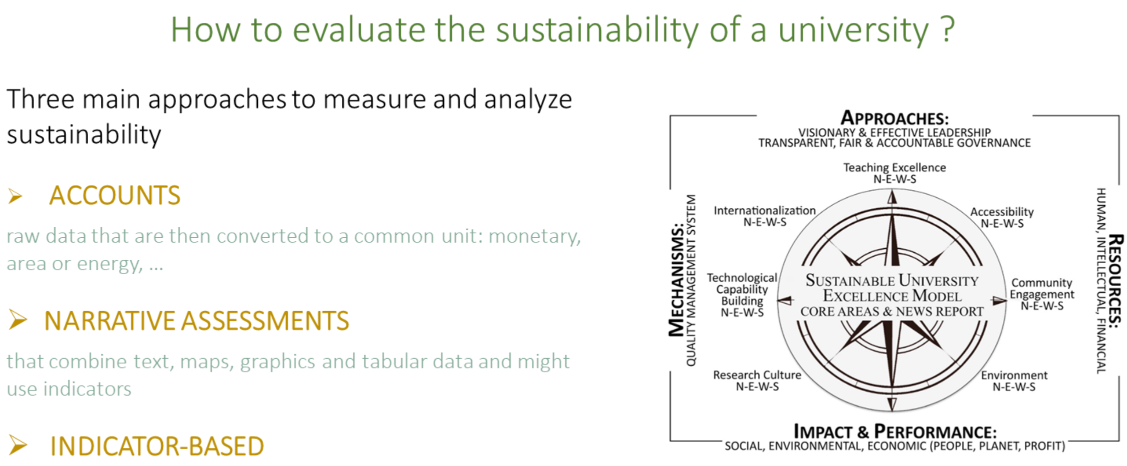
(Sustainability Tracking, Assessment & Rating System™ - STARS®) is one of the most exhaustive, as well as being one of the first assessment systems specifically geared to assessing the sustainability of universities (Adenle, 2020). This is a voluntary and transparent self-assessment framework, active since 2006, based on a well-structured set of indicators and used to assess a wide range of actions from energy use to transportation, procurement to academic offerings in the field of sustainability, against six main categories: Institutional Characteristics, Academics, Engagement, Operations, Planning & Administration, and Innovation & Leadership. Instead, the Princeton Review, which publishes an annual green guide with rankings of America's sustainable universities (see https://www.princetonreview.com/press/green-guide/press-release-2022), assigns the score through a Green Rating. In the questionnaire administered to students, the questions regarding the energy-environmental performance of buildings are as follows:

1. Are school buildings that were constructed or underwent major renovations in the past three years LEED certified?

2. Does the school have a formal plan to mitigate its greenhouse gas emissions?

3. What percentage of the school's energy consumption is derived from renewable resources?

Therefore, Princeton Review includes more energy-related questions than any other topic (Albis 2017). Assessing the efforts made towards sustainable development by universities is also covered by the Global Reporting Initiative (GRI): a voluntary tool, born in a predominantly corporate environment (Hahn and Kuhnen, 2013), which offers a comprehensive set of standards for reporting impacts related to the three dimensions, economic, environmental and social, aimed at 40 different sectors, divided into 4 main groups. Universities belong to Group 4: Other services and light manufacturing - Educational services Education services at all levels, including online education. This tool can also be used by universities (Lozano 2011), to communicate to the outside community how they address the dual mission of providing students with new skills to create a more sustainable society and reducing the environmental impact of their activities. In this second mission, the role of buildings and how they are designed, upgraded, and managed takes on strategic importance. Although at the global university level the adoption of reporting standards through the GRI framework is not yet sufficiently widespread, European universities can still be considered pioneers in the adoption of such standards (Alonso-Almeida et al. 2015)



Dalal-Clayton e Bass, 2002

Results: analytical, propositional and debate aspects

The literature review of the major tools indicated that the most comprehensive tool for assessing building performance is Sustainability Tracking, Assessment, and Rating Systems (STARS®). Only Sustainability index Model - DPSEEA (Waheed et al., 2011), Sustainable Campus Assessment System (SCAS) (Hokkaido University, 2013), and STARS® have extensively included spatial indicators at both indicator and sub-indicator levels. (Adenle et al, 2020).

The indicators used by STARS® to assess the energy-environmental performance of university buildings, and the use of renewable energy, are contained in the Operation category and are listed in Table 1, where for each credit are indicated Points available, Applicable to, Minimum requirement.

Table 1. Credit, Applicability, Criteria and scoring in STARS ® 2.2 Technical Manual

Credit, Number and Title	Points available	Applicable to	Minimum requirement
OP3 Building Design and Construction	3	Institutions that have new construction and/or major renovation projects completed within the previous five years	Own new or renovated buildings that were designed and built in accordance with a published green building code, policy/guideline, or rating system.
OP4 Building Operations and Maintenance	5	All institutions	Own buildings that are operated and maintained in accordance with a sustainable management policy/program or a green building rating system focused on the operations and maintenance of existing buildings.
OP5 Building Energy Efficiency	6	All institutions	Have data on grid-purchased electricity, electricity from on-site renewables, utility-provided steam and hot water, and stationary fuels and other energy products.
OP6 Clean and Renewable Energy	4	All institutions	Support the development and use of clean and renewable energy sources.

With respect to indicators OP3 and OP4, the score is attributed, according to STARS ® 2.2 Technical Manual, to the buildings that were constructed or underwent major renovations (in the previous five years) were designed and built in accordance with a published green building code, policy/guideline, and/or rating system.

Green building codes, policies/guidelines, and rating systems may be:

- Multi-attribute
- Single-attribute: focusing predominantly on one aspect of sustainability such as energy/water efficiency, human health and wellbeing, or sustainable sites.

Third-party certification under a multi-attribute green building rating system developed/ administered by a WorldGBC member Green Building Council (GBC) is weighted more heavily for scoring purposes.

Table 2. Relation between credit ad rating system in STARS ® 2.2 Technical Manual

Credit	Type of rating system	Rating system

OP3 Building Design and Construction	Multi-attribute GBC rating systems	BREEAM, CASBEE, DGNB, Green Star, LEED BD+C, LEED ID+C, Living Building Certification, Parksmart
	Multi-attribute non-GBC rating systems	Green Globes NC
	Single-attribute rating systems	EDGE, Fitwell, Living Building Petal Certification, Net Zero Energy, Passive House / Passivhaus, WELL, ZCB-Design
OP4 Building Operations and Maintenance	Multi-attribute GBC rating systems	BREEAM-In Use, CASBEE for Existing Buildings, DGNB, Green Star Performance, LEED O+M, Parksmart Pioneer
	Multi-attribute non-GBC rating systems	BOMA BEST, Green Globes EB
	Single-attribute rating systems	EDGE, ENERGY STAR, Fitwell, TRUE, WELL, ZCB-Performance

"Each rating system also has criteria related to LEED/sustainable certified buildings. STARS and Sierra Club go as far to measure percentage of certified sustainable building space" (Albis 2017).

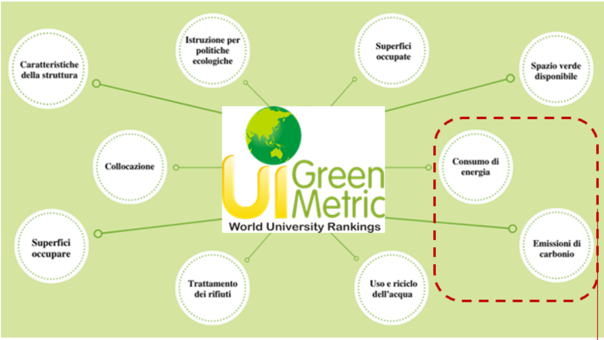
Global Reporting Initiative (GRI) uses the following indicators to assess energy sustainability:

- GRI 302-1 Energy consumed within the organization.
- GRI 302-2 Energy consumed outside the organization
- GRI 302-3 Energy intensity
- GRI 302-4 Reduction in energy consumption
- GRI 302-5 Reduction in the energy requirements of products and services

The Green Metric, promoted in 2010 by the University of Indonesia and whose reference for Italy is the University of Bologna, was also studied as part of the research. This tool groups indicators into six macro-categories to which a specific weight is attributed:

1. Setting and Infrastructure (15%)
2. Energy and climate change (21%)
3. Waste management (18%)
4. Water use (10%)
5. Means of transport (18%)
6. Education and research (18%).

Within the Italian Network of Sustainable Universities (RUS), a simplified methodology based on the verification of some minimum requirements related to automation, energy, water, indoor comfort, lighting and security, developed by the Energy Working Group of RUS, coordinated by the Polytechnic of Turin, has been adopted.



2. Energy and Climate Change (EC)

- 2.1. The use of energy-efficient appliances that replace conventional ones (lighting and household appliances)
- 2.4. Electricity use per year Total energy used for all purposes such as lighting, heating, cooling
- 2.6. Presence of green solutions in all construction and renovation policies
  - [1] None
  - [2] Natural ventilation
  - [3] Natural lighting throughout the day
  - [4] Existence of a building energy manager
  - [5] Green building
- 2.8. The total carbon footprint (CO2 emission in the past 12 months)

Field		Requirement		Description
B	Automation	B1	BMS	Presence of Building Management System (BMS) / Building Information Modelling (BIM) / Building Automation System (BAS) / Facility Management System (FMS) **(recommended requirement)**
		B2	APP	Interactive support for users via APP or online service
S	Safety	S1	Intruder Alarm System	Intruder alarm system (recommended: interfaced with BMS)
		S2	Fire-fighting	Fire-fighting system (recommended: interfaced with BMS)
		S3	Video surveillance	Video surveillance system (recommended: interfaced with BMS)
		S4	Anti-flooding	Anti-flooding system (recommended: interfaced with BMS)
E	Energy	E1	Monitoring	Automatic acquisition and logging system of energy consumption (recommended: interfaced with BMS)
		E2	Management	Automatic management system for energy supplies and production (recommended: interfaced with BMS)
A	Water	A1	Monitoring	Automatic acquisition and logging system of water consumption (recommended: interfaced with BMS)
		A2	Recovery	Rainwater recovery system for covering the flushing and irrigation
I	Indoor environment	I1	Thermal comfort	Monitoring (recommended: interfaced with BMS) of environmental parameters related to thermo-hygrometric comfort (e.g. air temperature, relative humidity, air velocity, etc.)
		I2	Air quality	Monitoring (recommended: interfaced with BMS)of pollutants (e.g. VOC, PM, CO2 ...)
		I3	Real-time	Programming and management in real time according to the occupancy profile of the premises (recommended: interfaced with BMS)
		I4	Passive system	Passive cooling and/or exploitation/limitation systems for free supplies
L	Lighting	L1	LEDs	High-efficiency luminaires (LEDs)
		L2	Sensors	Automatic lighting control (recommended: presence/illuminance sensors interfaced with BMS)
		L3	Shielding	Shielding adjustment and solar control
		L4	Natural light	Passive systems for natural light exploitation

Adapted from 'UI GreenMetric 2018: Guidelines for compiling energy and climate change', by RUS Energia, 2019.

Assessing the sustainability of university buildings has to take into account multiple aspects that relate not only to the environmental and functional performance of buildings, but also to direct user satisfaction (providing a safe, healthy, comfortable environment for students, teachers, and staff).

The evaluation of environmental and functional performance of educational buildings should ensure that the effectiveness of buildings is maximized not just in terms of occupancy costs but also with respect to user satisfaction (Ekekezie et al. 2021).

However, the analysis of the analyzed tools showed that the centrality of the direct user and his perception of sustainability and comfort is not among the evaluation indicators. Moreover, the evaluation of the green potential of the building, that can be defined as the "capacity to refurbish a conventional building into a green building (green refurbishment) through architectural interventions" (Ben Avraham & Capeluto 2011) is delegated to other assessment tools.

In the light of these considerations, in the MedEcoSuRe research we see the need to

- investigation of direct users: identification of critical issues in relation to specific modes of use
- verification phase of the green potential of buildings.

In fact, the research considered multiple aspects concerning not only the environmental and functional performance of buildings, but also the direct satisfaction of users (providing a safe, healthy and comfortable environment for students, teachers and staff) and the strategies to manage energy, water, green and material resources during the operational phase (Xue et al, 2020)..

A questionnaire was administered to the students based on indicators both related to indoor environmental quality (air quality, temperature, ventilation, room acoustics, natural and artificial lighting) and related to obvious performance/functional deficiencies of the building as directly encountered by the end user. These aspects played an important part of the Participatory Energy Audit (Violano et al, 2021) in which students were involved during the workshop. However, it was not possible to collect all the data necessary for a thorough evaluation because the workshop took place during the Covid 19 pandemic and the students were not allowed to attend the university continuously and under normal conditions to do an appropriate direct evaluation. For this reason, the research work has been delayed and is currently in progress.

Among the many aspects that affect the environmental and functional performance of buildings, the research also brought out the need to consider the satisfaction of direct users (providing a safe, healthy, and comfortable environment for students, teachers, and staff). In fact, evaluating the energy and environmental performance of places of knowledge should ensure that the effectiveness of buildings is maximized not only in terms of occupancy costs, but also with respect to user satisfaction (Ekekezie et al. 2021). Providing a fundamental tool to support the decision maker (energy manager), this user satisfaction analysis should help identify functional and environmental inadequacies of building performance in universities, and most importantly, it should be aimed at improving the quality of life of people living in and using university buildings.

This research yielded three significant findings. It analyzed and discretized several possible approaches to assessing the sustainability of universities, comparing some of the most widely used tools. Second, it has unequivocally shown that the way buildings are designed (energy and environmental performance) is relevant to overall sustainability. Finally, it provides methodological indications for the decision-maker (primarily the Energy Manager) in the energy and environmental upgrading of university buildings, proposing criteria for defining priorities both in the choice of interventions and in the buildings on which to intervene.

In conclusion, the green transition requires the improvement of the quality of the built environment by incorporating the principles of sustainability (Humblet et al., 2010), the creation of healthy living and learning environments by establishing policies and regulations that encourage sustainable practices in daily activities and decision-making processes (Alsharif et al, 2020) and a reduction of environmental impacts that depend directly on the policies and actions of universities (Creighton, 1998). Guidance can be derived from this analysis to support administrators and energy managers in both assessing priorities for action and the best strategies that can be implemented.

Some Cases of Study in Europe

University of Wageningen in The Netherlands

The Wageni campus occupies the first position in the Green Metric. It is located in the area around the Droevendaalsesteeg and the Bornsesteeg and hosts research and education facilities, academic research organisations such as NIOO-KNAW, a university for vocational education in nature and agriculture (STOAS). The ambition of the partners is to develop a highly attractive sustainable campus where they collaborate in the fields of research and education, valorisation, sustainable park management, the campus site and public awareness. Wageningen UR aims to fully integrate sustainability into operational management. The ambitions are supported by the Green Campus Office that aims to promote sustainability on the Wageningen campus. This is a student-run organisation, supported by the Facility Department of Wageningen UR.

It is one of the most sustainable in the Netherlands and is 100 per cent energy neutral thanks to its own wind farm, geothermal energy storage system and impressive roof area covered by solar panels. In most buildings on the campus, waste is meticulously recycled and all new buildings meet high sustainability standards.

"They are expressed in our mission 'Exploring nature's potential to improve the quality of life' and our ambition to take the lead in the field of sustainable operational management."

Wageningen University & Research (WUR) with the practice called 'Campus as Living Lab' seeks to make the most of nature on campus and use it for education and research. A wide range of projects has been established on Campus as Living Lab, including ecological gardens, which focus primarily on biodiversity. Projects such as the Twitter tree, the construction of a bio-based bicycle path and an orchard at the Genetic Resource Centre.

Short- and long-term ambitions have been formulated to achieve sustainability goals and are supported by a Green Office. A major innovation is the heat and cold storage (WKO) is used in the Forum, Radix, Atlas, Action, Impulse, Helix and Orion buildings, all on the Wageningen UR campus. This TES reduces CO2 emissions.

According to the Principle of Heat and Cold Storage (WKO), heat and cold are stored in a sand package that carries water between 40 and 90 metres deep in the ground. In summer, a building is cooled with water. The heated water with a temperature of about 17 °C is stored in the hot spring. In winter, the hot water is pumped out again and used to heat the ventilation air. The water cools down to about 6 °C and is then stored in the cold source. Groundwater is then pumped back and forth between the cold source and the hot source.

TES on Campus

The TES system on Campus now comprises six hot and six cold sources; at Forum, Radix, Atlas, Actio Impulse, Helix and Orion. One cold source plus one hot source is called a doublet. In the future, expansion to 19 doublets is possible. The options are described in a Windows plan by Wageningen UR and a consultant. Among other things, attention has been paid to the optimal and sustainable use of the available subsoil. Taking into account expected new construction and renovation, the location of 19 hot and cold sources has been defined in the window plan. Consultations are ongoing with the province and the municipality of Wageningen to ensure that the window plan is properly anchored, within the possibilities of the General Administrative Order (AmvB). Third parties wishing to settle on the campus in the future must also comply with the conditions set out in the window plan. Furthermore, one of the researches of the Institute of the Royal Netherlands Academy of Arts and Sciences (KNAW), studies the effect of nature in all its many forms. By adapting only those ecological processes and the dynamics of nature themselves, they influenced the design and construction of the new spaces. Since 2011, NIOO researchers have been working in the new building with laboratories and offices surrounded by greenhouses, experimental ponds and a range of other facilities. It is a testing ground for the latest eco-technology: for example, the experimental green roof, the innovative application of solar energy or the unconventional approach to wastewater treatment. The Cradle to Cradle approach has been an important source of inspiration. The ambition is to close as many cycles (energy, water, nutrients) as possible. This can be done through new techniques (not yet fully developed) in the areas of energy generation, sustainable energy use, water treatment technology, material selection and CO2 emissions. Maximising biodiversity within the land is another important consideration. These things together constitute what can be called 'integrated sustainability', going far beyond the focus on one or two individual aspects. The building has quickly become an architectural eye-catcher that showcases the ecological research within its grounds. One of the most sustainable buildings in the Netherlands, it is often held up as an example.

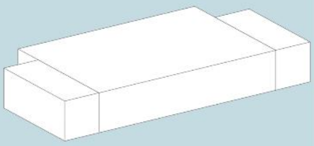
Wur - Lumen

Il Lumen Building si trova a nord della città universitaria di Wageningen, vicino ad altri istituti agricoli esistenti. Progettato dall'architetto Stefan Behnisch il brief di progettazione era per una struttura di ricerca funzionale e di facile utilizzo che lavorasse in armonia con la natura; versatile ed ecologicamente valido.

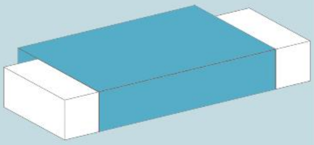
L'edificio è stato progettato non per dominare il suo ambiente rurale, ma per abbracciare il paesaggio, con tutti i luoghi di lavoro a diretto contatto con giardini interni ed esterni. Due giardini al coperto forniscono l'attenzione per le attività quotidiane e fungono da aree di incontro informali. Oltre a ciò, sono parte integrante del concetto energetico dell'edificio, migliorando le prestazioni dell'involucro esterno.

Type of Building

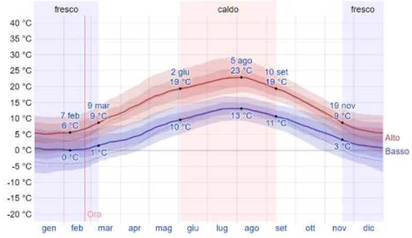
-Grouped block



Intervation Area

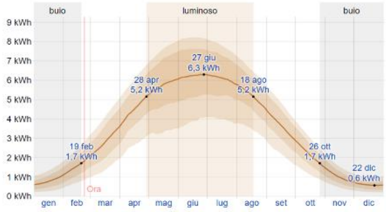


Temperatura massima e minima



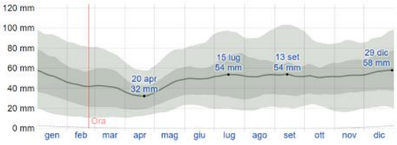
La temperatura massima (riga rossa) e minima (riga blu) giornaliere medie, con fasce del 25° - 75° e 10° - 90° percentile. Le righe sottili tratteggiate rappresentano le temperature medie percepite.

Energia solare a onde corte incidente giornaliera media



L'energia solare a onde corte incidente media che raggiunge il suolo per medio quadrato (riga arancione), con fasce di percentili dal 25° al 75° e dal 10° al 90°.

Precipitazioni mensile medie



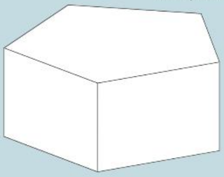
La pioggia media (riga continua) accumulata durante un periodo mobile di 31 giorni centrato sul giorno in questione con fasce del 25° - 75° e 10° - 90° percentile. La riga tratteggiata sottile indica le nevicate medie in misure equivalenti in acqua.

Wur - ORION

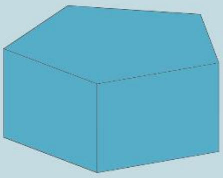
Questo straordinario edificio pentagonale, con le sue facciate in vetro rivestito di metallo,è in grado di creare un ambiente dedicato all'abbondanza di luce del giorno. Il progetto di Orion è stato interpretato con un consumo minimo di energia, il design della facciata, l'orientamento dell'edificio e il posizionamento degli spazi sono finalizzati a sfruttare al massimo la luce del giorno e l'esclusione del calore indesiderato. Sotto l'ampio auditorium è stato costruito un atrio che funge da cuscinetto climatico per gli spazi circostanti, sopra l'auditorium c'è un patio a cinque piani con un tetto a doghe che mantiene le sale di pratica circostanti lontano dalla luce diretta del sole. Tutte le tubazioni, il riscaldamento a pavimento e il materiale acustico sono stati integrati in un innovativo sistema di pavimentazione sufficientemente sottile da consentire la creazione di una grande altezza di spazio aperto con un numero limitato di piani.

Type of Building

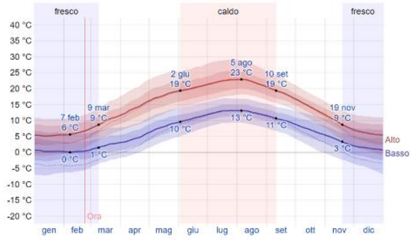
-Grouped block



Intervation Area



Temperatura massima e minima



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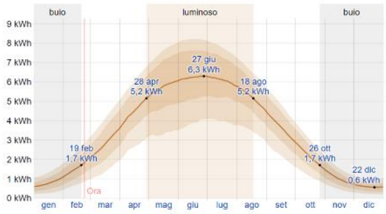
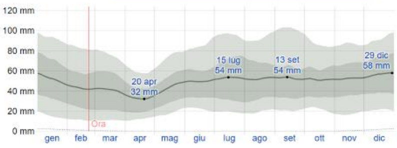
Energia solare a onde corte incidente giornaliera media



L'energia solare a onde corte incidente media che raggiunge il suolo per medio quadrato (riga arancione), con fasce di percentili dal 25° al 75° e dal 10° al 90°.

Precipitazioni mensile medie



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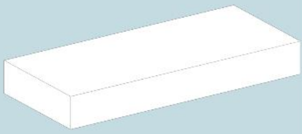
Wur - NIOO KNAW

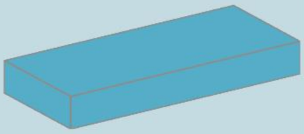
Il NIOO KNAW studia l'effetto della natura in tutte le sue molteplici forme. È, quindi, solo adattando quei processi ecologici e le dinamiche della natura essi stessi hanno influenzato la progettazione e la costruzione dei loro NIOO – KNAW. Gli sforzi verso l'efficienza energetica coprono due aree: riduzione dei consumi e sostenibilità che portano entrambi a una riduzione delle emissioni di CO_2. È stato installato un sistema di ventilazione ibrido e il design incoraggia la ventilazione naturale e la migrazione termica attraverso le pareti. La ventilazione meccanica è abilitata solo in base al rilevamento di CO_2. Inoltre è in corso una sperimentazione con la società Suncycle per sviluppare una nuova generazione di celle solari che producono energia. Il collettore solare sotto forma di una sfera è più economico e più efficiente rispetto alle soluzioni tradizionali e fornisce anche calore. A una profondità di 300 metri, si consente di immagazzinare il calore in eccesso prodotto durante l'estate per l'uso nell'inverno successivo.

Type of Building

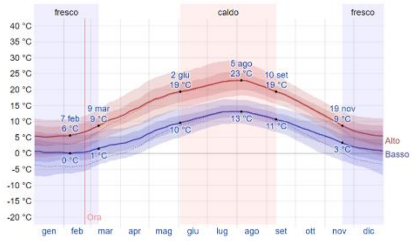
-Grouped block



Intervation Area

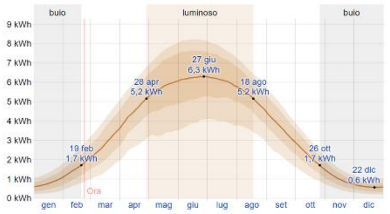


Temperatura massima e minima



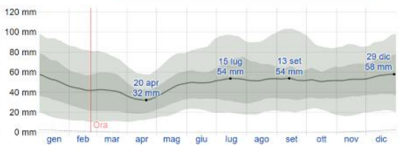
La temperatura massima (riga rossa) e minima (riga blu) giornaliere medie, con fasce del 25° - 75° e 10° - 90° percentile. Le righe sottili tratteggiate rappresentano le temperature medie percepite.

Energia solare a onde corte incidente giornaliera media



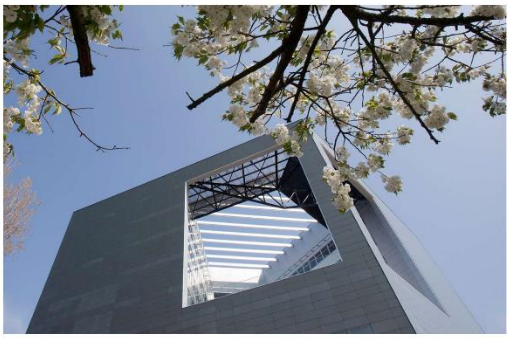
L'energia solare a onde corte incidente media che raggiunge il suolo per medio quadrato (riga arancione), con fasce di percentili dal 25° al 75° e dal 10° al 90°.

Precipatazioni mensile medie

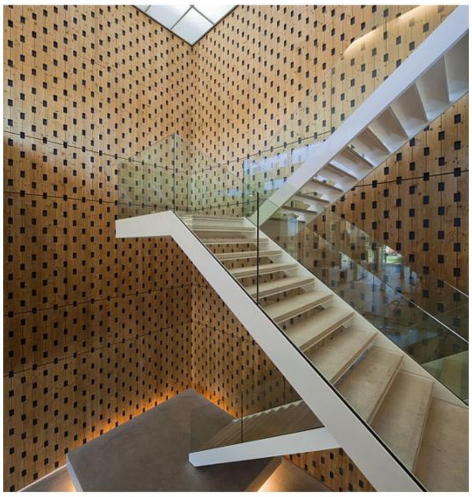
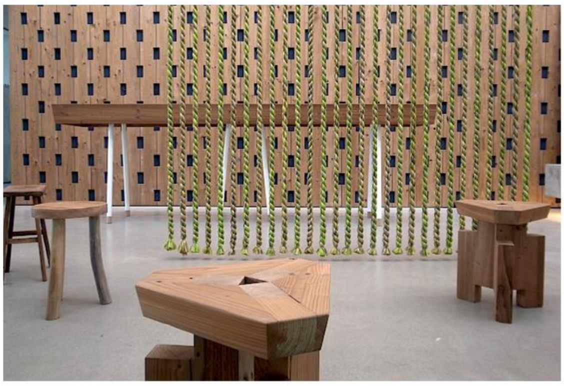
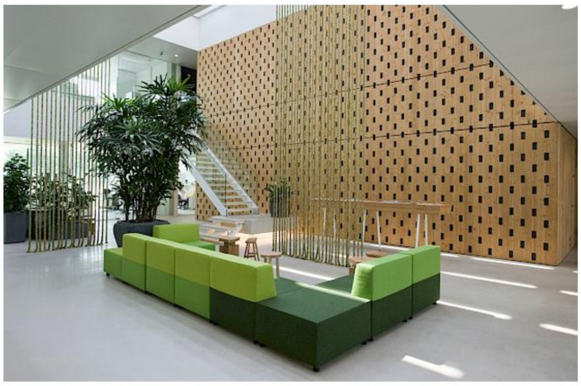


La pioggia media (riga continua) accumulata durante un periodo mobile di 31 giorni centrato sul giorno in questione con fasce del 25° - 75° e 10° - 90° percentile. La riga tratteggiata sottile indica le nevicate medie in misure equivalenti in acqua.

Wur - Orion



Wur - NIOO KNAW

University of Bologna in Italy

On the basis of an in-depth survey of energy-efficient university buildings, the focus was placed on Italian universities that have succeeded in implementing sustainability measures.

One of the first universities to feature in the Green Metric is the Ateneo Alma Mater Studiorum in Bologna, which has implemented measures aimed at sustainability.

One major initiative was the creation of a total of 1,000 square metres of green roofs on the roofs of several university buildings. In addition, part of the roofs were made available for research both for the study of alternative plant species to traditional roofing and for the analysis of drainage water. Green roofs and micro hanging gardens were installed on the horizontal roofs of the university buildings in order to achieve good thermal insulation, as vegetative roofs contribute to the reduction of heat loss between indoors and outdoors with a consequent reduction in energy consumption.

The thermal insulation consists in a bioclimatic improvement as the evaporation process contributes to the cooling of the temperature in the surrounding area and also rebuilds that biological mass that has disappeared due to cementification, which, through photosynthesis, allows the transformation of carbon dioxide into oxygen, also reducing the emissions caused by the use of air conditioning systems, thanks to the evapotranspiration processes (reduction of the temperature range of 15°-20°).

In addition, these green roofs are designed for high water retention, i.e. the elements that make up the package and the substrates are able to return up to 80% of rainwater to the environment through evapotranspiration, thus reducing the flow of waste water to the sewers.

This process reduces water dispersion by contributing to the regimentation of rainwater: it reduces water dispersion, mitigates peak inputs to the drainage system, avoids water stagnation and reduces the heat island phenomenon as the vegetation allows the retention of dust.

In addition, the 'Sun Addicted' Project was also introduced, which provides for the installation of photovoltaic systems in university facilities to enable the production of electricity through the use of renewable sources. The energy produced by the systems is mainly used for on-site consumption, i.e. for the operation of the heating/cooling systems and the energy needs of the facilities.

"The plants installed in the first phase exceed 1 MW in power and are distributed over the various University campuses: Lazzaretto, CAAB, Ozzano, Cadriano and the former Morassutti. The projects of the new settlements implement AUTC's intention to provide for the production of energy from renewable sources in a significant manner."

The most important development is the one installed at the new Cesena Campus, which houses the activities of the School of Engineering and Architecture. The total power output is 150 kW. The first photovoltaic shelter for pedal-assisted bicycles was also built at this location. The new installations at the Cesena Technopole were connected for 50 kW. At the Forlì Campus, the 12 kW Tecnopolo and Teaching Hub plants are active, at the Leon Battista Alberti complex in Rimini for 20 kW and in Fano for 3 kW.

The G.E.CO (energy management and remote control) project is aimed at seeking maximum energy savings in buildings, through the control of energy flows and environmental parameters, so as to allow the containment of consumption related to technological systems.

This project is aimed at seeking maximum energy savings in buildings, through the control of energy flows and environmental parameters, so as to allow the containment of consumption related to technological systems. In addition, it envisages the provision in the various buildings of control and data acquisition systems (meters) and the implementation of a web-based platform for data management, collection and processing and the possibility of setting parameters and operating times. The system is able to read data from the various proprietary information systems, thus allowing the management of all the systems in a building to be integrated into a single platform.

The University of Bologna ensures the constant upgrading of internal and external lighting, with the aim of reducing electricity consumption. To this end, it has begun experimenting with innovative systems for the remote management and remote control of lighting fixtures and the gradual upgrading of obsolete, energy-intensive lighting fixtures with innovative systems (DALI and LED) with energy savings of more than 50% compared to the current situation.

In addition, the University of Bologna has also addressed the problem of the current thermal power plants running on diesel oil, in fact it has replaced these plants with heat exchangers connected to the city's district heating networks. The objectives are: to reduce polluting emissions into the atmosphere and fuel; to save on energy consumption; and to reduce any risks of smoke poisoning and explosion.

To date, the facilities already served by district heating are 15 in Bologna and 6 on the Forlì Campus for a total thermal energy production of about 25,000,000 kWh/year.

Further attention has been paid by the university to the development of green areas in order to aim for bioclimatic and aesthetic improvement of spaces and to reduce the 'heat island' phenomenon. Green areas are therefore emphasised as a necessary element to increase the quality of life in university spaces. As a first step, the area outside the Forlì Campus was made usable with outdoor boxes to allow studying outdoors. The library of the Cesena campus also has seating types that extend it towards the outdoor space.

Another significant project is 'AlmaAlberi', which aims at the knowledge and monitoring of the university tree heritage.

Alma Mater Studiorum - Università di Bologna - Italia

L'Alma Mater Studiorum di Bologna, è stata certificata l'ateneo più sostenibile d'Italia. A certificarlo è stato GreenMetric, nella classifica internazionale che valuta le iniziative green delle università. Tale Ateneo adotta modelli di gestione e funzionamento basati sui principi dello sviluppo sostenibile, come strategia che combina sviluppo economico, inclusione sociale e sostenibilità ambientale.

Identity Information

Nazione: Italia

Città: Bologna

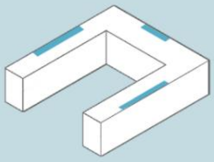
Anno d'intervento: 2013-2016

Tipo d'intervento: Tetti Verdi
Pannelli Fotovoltaici

Orientamento: NW - SE

Tipo di clima: Semi-continentale

Intervation Area



Focus Interventi

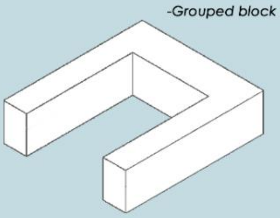
Un'iniziativa di rilievo, orientata verso la sostenibilità, è stata la realizzazione di 1000 i metri quadri complessivi di tetti verdi e micro giardini pensili sui piani di copertura orizzontali degli edifici universitari per avere un buon isolamento termico, in quanto le coperture vegetative contribuiscono alla riduzione delle dispersioni termiche tra interno ed esterno con una conseguente riduzione dei consumi energetici.

È stato introdotto il Progetto "Sun Addicted" che prevede l'installazione di impianti fotovoltaici nelle strutture universitarie per permettere la produzione di energia elettrica mediante utilizzo di fonti rinnovabili.

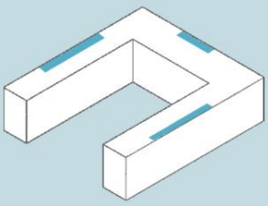
È stata resa fruibile l'area esterna del Campus di Forlì denominata EXtra con box che consentono di studiare comodamente all'aperto nelle giornate più miti che sono stati molto apprezzati dalla comunità studentesca.

Type of Building

-Grouped block



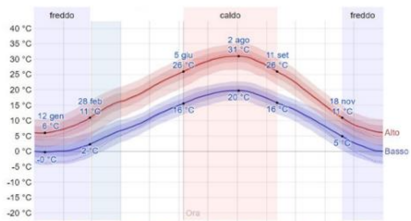
Intervation Area



ALMA - Bologna

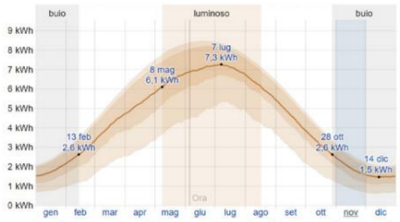
Un'iniziativa di rilievo, orientata verso la sostenibilità, è stata la realizzazione di 1000 i metri quadri complessivi di verde pensile realizzato sulla copertura di alcuni edifici universitari, inoltre parte delle coperture sono state messe a disposizione della ricerca sia per lo studio di specie vegetali alternative alle tradizionali coperture, sia per l'analisi delle acque di drenaggio. Quindi si è proceduto con l'installazione di tetti verdi e micro giardini pensili sui piani di copertura orizzontali degli edifici universitari per avere un buon isolamento termico in quanto le coperture vegetative contribuiscono alla riduzione delle dispersioni termiche tra interno ed esterno con una conseguente riduzione dei consumi energetici.

Temperatura massima e minima



La temperatura massima (riga rossa) e minima (riga blu) giornaliere medie, con fasce del 25° - 75° e 10° - 90° percentile. Le righe sottili tratteggiate rappresentano le temperature medie percepite.

Energia solare a onde corte incidente giornaliera media



L'energia solare a onde corte incidente media che raggiunge il suolo per metro quadrato (riga arancione), con fasce di percentili dal 25° al 75° e dal 10° al 90°.

Precipitazioni mensile medie

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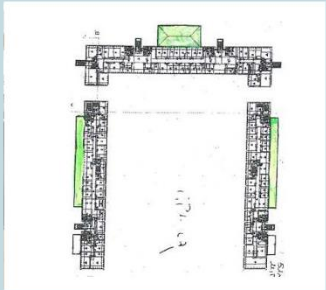
IL Campus

L'Alma Mater Studiorum di Bologna, è stata certificata l'ateneo più sostenibile d'Italia. A certificarlo è stato GreenMetric, nella classifica internazionale che valuta le iniziative green delle università. L'Università di Bologna adotta modelli di gestione e funzionamento basati sui principi dello sviluppo sostenibile, come strategia che combina sviluppo economico, inclusione sociale e sostenibilità ambientale. In questo contesto l'impegno dell'Alma Mater verso uno sviluppo sostenibile si declina nel progetto Multicampus Sostenibile che riporta l'attenzione sui bisogni e abitudini della comunità universitaria, su l'ambiente e sul loro reciproco rapporto attraverso nuovi modelli gestionali capaci di ridurre l'impatto ambientale delle politiche di Ateneo e incentivare una comunità sempre più green e attenta alla tutela dell'ambiente con comportamenti più attivi e responsabili.



University of Kolding in Denmark

The University of Kolding, Denmark, can be considered one of the most sustainable in Europe thanks to its dynamic façade composed of 1600 mobile modules made of perforated steel. Technology and bioclimatic principles make the building designed by Henning Larsen Architects an architectural gem.

The building is the result of a careful period of research into both technology and design, and represents an excellent combination of innovation and architecture, characterised by a modern design and special attention and reflections on life inside the University that have led the Danish firm to generate a vibrant and dynamic interior space.

The floors are accessed by a triangular-shaped atrium that changes at each level in both shape and position, generating an evocative, living space. This space generates an interplay of offsets to create visual connections between the access landings to the different floors, which not only creates a dynamic architectural environment, but also emphasises the fundamental aspects of the university environment:

- communication
- knowledge
- research
- experimentation.

A fundamental role is played by light and natural lighting.

"Daylight is an important parameter," says Henning Larsen Architects, "to ensure an optimal indoor microclimate and the well-being of the users.

Large windows allow a lot of light to enter the interior, but they also require shading to prevent the rooms from overheating. Light varies over the course of the day and year, hence the idea of a dynamic envelope, perfectly integrated into the building, which allows light and heat to be controlled and managed, guaranteeing an optimal climate and giving a unique and variable architectural significance.

The solar screens are mounted on movable frames that allow movement in order to regulate the desired amount of light within the rooms. The system is equipped with sensors that continuously measure the level of light and heat by mechanically adjusting and moving the brises-soleils via a small motor. When the modules are closed they adhere perfectly to the façade, creating a continuous surface, while when they are open they create a dynamic façade, protruding with their tips and transforming the building into a true monument. Even the circular holes in the panels are the result of research and calculations by engineers and architects who established 30 per cent as the optimum opening angle for both shading and for the view from the inside to the outside. During the day, natural light filters through the holes, creating ever-changing plays of light inside, while in the evening the game is reversed, when the sun has set, artificial light from inside passes through the holes, making the façade more transparent by projecting shadows towards the outdoor spaces in front of the faculty, bringing the internal world of the University outside and reinforcing the concept behind the project: creating a strong interaction and dialogue between university life and the city. The triangular shape of the modules is due to a design choice linked to its inclusion in the urban context, the shape of the building and the desire to create a true monument for the city rather than a simple university building, becoming a symbol and actively interacting with its surroundings.

IL Campus

Il campus di kolding è un nuovo punto di attrazione situato vicino al fiume kolding e ha come obiettivo l'interazione con altre istituzioni educative della città. La forma e le facciate dell'edificio mostrano un dialogo tra il le persone dentro e l'osservatore esterno, creando un'espressione unica e variabile. Grandi vetrate permettono di far entrare molta luce all'interno, ma richiedono anche una schermatura per evitare un eccessivo surriscaldamento degli ambienti. La luce varia nel corso della giornata e dell'anno, è da qui che nasce l'idea di un involucro dinamico, perfettamente integrato nell'edificio, che permette di controllare e gestire luce e calore garantendo un clima ottimale e conferendo un'immagine architettonica significativa unica e variabile.

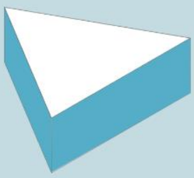
University of sourthen - Danimarca

Le facciate dell' edificio sono costituite da grandi vetrate che permettono di far entrare molta luce all'interno, ma richiedono anche una schermatura, costituita da 1600 moduli di forma triangolare in acciaio perforato, per evitare un eccessivo surriscaldamento degli ambienti. La luce varia nel corso della giornata e dell'anno, è da qui che nasce l'idea di un involucro dinamico, perfettamente integrato nell'edificio.
Gli schermi solari sono montanti su telai mobili che permettono il movimento al fine di regolare la quantità di luce desiderata all'interno degli ambienti. Quando i moduli sono chiusi aderiscono perfettamente alla facciata creando una superficie continua.

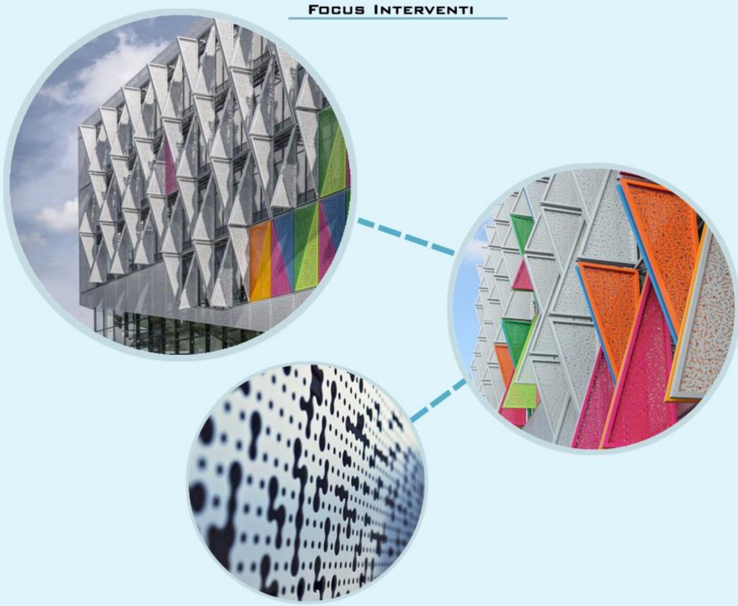
Identity Information

- **Nazione:** Danimarca
- **Città:** Kolding
- **Anno d'intervento:** 2008-2014
- **Tipo d'intervento:** Schermatura
- **Orientamento:** NE - SW
- **Tipo di clima:** Marino - Oceanico

Intervation Area

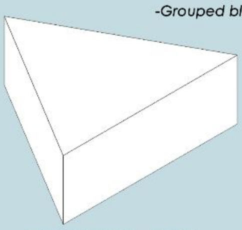


Focus Interventi

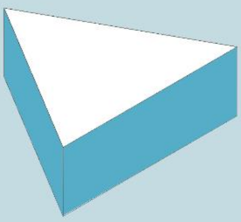


TYPE OF BUILDING

-Grouped block



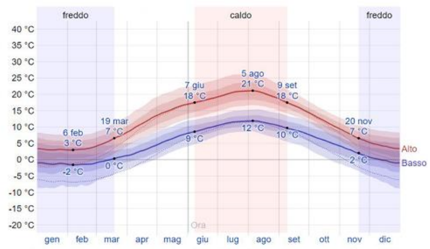
INTERVATION AREA



DESCRIPTION

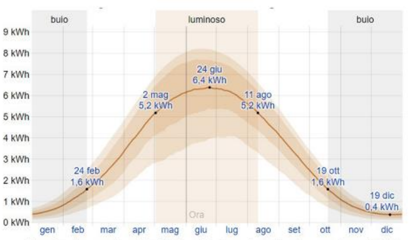
L'Università della Danimarca meridionale si tratta di un istituto di ricerca ed educazione con profonde radici regionali e una prospettiva internazionale. L'obiettivo principale dell'università è ingegneria,salute e scienza. L'edificio si trova a Kolding, con una popolazione di 58.021, lo è la settima città più grande della Danimarca. È un porto marittimo danese con numerose compagnie industriali in generale orientate alla costruzione Il clima della Danimarca è caratterizzato da inverni miti ed estati fresche; l'autunno è la stagione più piovosa.

Temperatura massima e minima



La temperatura massima (riga rossa) e minima (riga blu) giornaliere medie, con fasce del 25° - 75° e 10° - 90° percentile. Le righe sottili tratteggiate rappresentano le temperature medie percepite.

Energia solare a onde corte incidente giornaliera media



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The Aulario of Valladolid in Spain

The University of Valladolid has recently completed a building in the name of sustainability: the Aulario IndUVa, a building that replaces the old stepped Aulario demolished due to its inefficiency. The Aulario is located in a university area with a great city tradition, consisting of teaching centres, laboratories and student residences, which includes important green areas and car parks. The image of the building reflects this complete coordination of the traditional elements of the environment (the location, the garden, the connection to other buildings) with techniques adapted to the new ways of learning and previous experience in environmental architecture. It is a monolithic volumetric building, with its own distinctive and personal language, in which elements such as modulation and colour (strong and notable as the building's identity element) are integrated, supported by an absolute and radical technical functionality that seeks the comfort of students and teachers. The construction of this building represents a great opportunity for research and improvement of the techniques already applied on the net zero energy buildings on campus, in fact the IndUVA Aularium aims at GREEN GBCe, LEED and Well certifications.

Accommodating up to 2,500 students in 34 classrooms, with a total built surface area of 5,845 square metres, it is almost zero energy, given the presence of systems that exploit renewable energy sources as well as passive systems. In fact, to achieve their zero energy goal, the design team was guided by two strong passive principles: compactness in a simple volume and optimisation of natural lighting. In addition, there are coordinated renewable energy production systems: biomass district heating network, geothermal and photovoltaics.

The IndUVA Aulario is also a field of experimentation: on natural lighting using optical fibre, on phase change materials implemented at strategic points in the building, and on the circular economy using recycled building materials. Finally, the project pays real attention to local biodiversity to preserve the gardens and facilitate the development of local species.

The formal configuration of the building responds to the need to reduce energy demand through a near-zero energy envelope with high internal thermal loads of variable and discontinuous pattern, which gives it a great uniqueness, earning a non-renewable primary energy saving compared to the requirements of the Technical Building Code of 98 % in heating 84 % in refrigeration and 75 % in lighting, with the addition of the use of renewable energy (connection to the biomass district heating network of the University of Valladolid, Structured in three longitudinal bands, the two lateral ones (north-east and south-west façades) group the classroom spaces (and the ground floor facilities), while the central band corresponds to the delivery space. A glazed corridor ensures the interconnection between all floors of the building.

The façade orientations are optimal in terms of sun protection and capturing natural light, with reflective sunshades towards the inner roof. The classrooms open almost completely onto the north-east and south-west façades seeking maximum interior lighting, protected from direct sunlight by a structure of vertical and horizontal sunshades. The north-west and south-east façades, on the other hand, are almost completely closed off, protecting the classroom spaces to minimise heat loss in winter and solar heat gain in spring and summer.

On the façades of the classrooms (north-east and south-west), over 1,900 m² of the TP 52 and TPV 52 CORTIZO curtain walling was installed, a traditional façade or stick system consisting of aluminium mullions and transoms with a 52 mm line of sight forming a load-bearing structure. This allows natural light to enter the interior spaces by assembling a glazed surface from floor to ceiling in the six heights of the building. In the case of TP 52, the glass is fixed on all four sides by a continuous press profile screwed from the outside to the screw doors embedded in the mullions and transoms. At the same time, the façades are protected from direct radiation by a structure of perpendicular ribs supporting the trusses, made of CORTIZO die-cut composite panel, which provide optimal shading. It is an efficient, aesthetic and sustainable construction solution for cladding building envelopes consisting of two aluminium sheets, lacquered on the outer face in orange with PVDF 70/30 paint, and a protective primer on the inside, with a 3 mm thick core of mineral composite and polyethylene. In this case, the composite panel was used both for the configuration of the pylons and for the cladding of the façades in their opaque parts. As the north-west and south-east sides of the building are almost completely closed off, protecting the classroom spaces, they only open up in the central corridor areas to provide the user not only with lighting, but also with the possibility of external views.

The green roof and vegetation have an important function in that they reduce the heat island effect but above all help to create a favourable microclimate.

The two innovative solutions in passive systems in combination with the use of renewable energies and careful control of ventilation, air conditioning and lighting have endowed an energy-efficient building that has been recognised with prestigious awards, such as Construction 21's Green Solutions Award or the first Sustainable Building Award in Castilla y León.

Aulario IndUVa - Universidad de Valladolid - Spagna

L'Università di Valladolid ha da pochi anni realizzato un edificio all'insegna della sostenibilità: l'aulario IndUVa. Si tratta di un edificio volumetrico monolitico che va a sostituire il vecchio aulario a gradoni demolito per la sua inefficenza. L'edificio è quasi a consumo zero, data la presenza di sistemi che sfruttano fonti di energia rinnovabile ma anche sistemi passivi. Questo progetto è stato realizzato con materiali a bassa tossicità soprattutto per ridurre al minimo l'inquinamento indoor ed evitare impatti negativi sulla salute.

Identity Information

Nazione: Spagna

Città: Valladolid

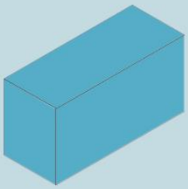
Anno d'intervento: 2017-2019

Tipo d'intervento: Aulario a consumo zero

Orientamento: SW - NE

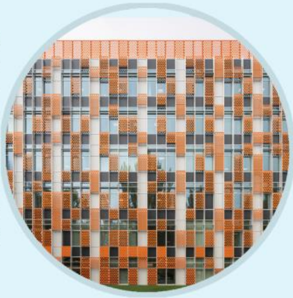
Tipo di clima: Mediterraneo

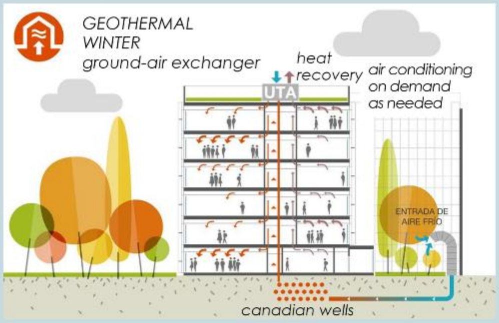
Intervation Area

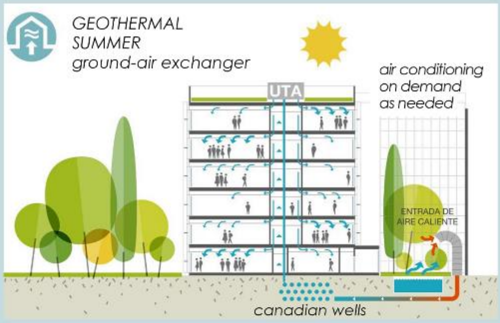


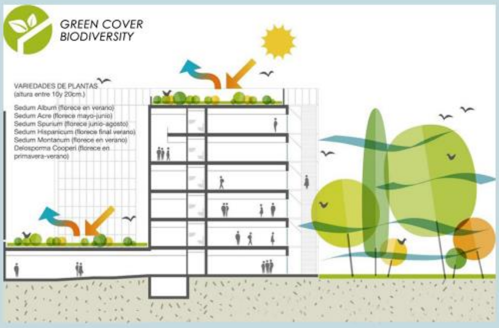
Focus Interventi

L'innovatività di quest'edificio è frutto di uno studio particolare, il team di progettazione, infatti, ha lavorato seguendo due forti principi passivi: compattezza in un volume semplice e ottimizzazione dell'illuminazione naturale. Si aggiungono sistemi di produzione coordinata di energia rinnovabile: rete di riscaldamento urbano a biomasse, energia geotermica e fotovoltaica. Aulario IndUVA è anche campo di sperimentazione: sull'illuminazione naturale tramite fibra ottica, sui materiali a cambiamento di fase implementati in punti strategici dell'edificio, e sull'economia circolare utilizzando materiali da costruzione riciclati. Infine, il progetto presta una reale attenzione alla biodiversità locale per preservare i giardini e facilitare lo sviluppo delle specie locali.







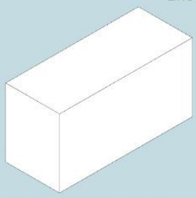


IndUVa - Valladolid

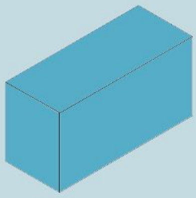
iL'innovatività di quest'edificio è frutto di uno studio particolare, il team di progettazione, infatti, ha lavorato seguendo due forti principi passivi: compattezza in un volume semplice e ottimizzazione dell'illuminazione naturale. Si aggiungono sistemi di produzione coordinata di energia rinnovabile: rete di riscaldamento urbano a biomasse, energia geotermica e fotovoltaica. Aulario IndUVA è anche campo di sperimentazione: sull'illuminazione naturale tramite fibra ottica, sui materiali a cambiamento di fase implementati in punti strategici dell'edificio, e sull'economia circolare utilizzando materiali da costruzione riciclati. Infine, il progetto presta una reale attenzione alla biodiversità locale per preservare i giardini e facilitare lo sviluppo delle specie locali.

Type of Building

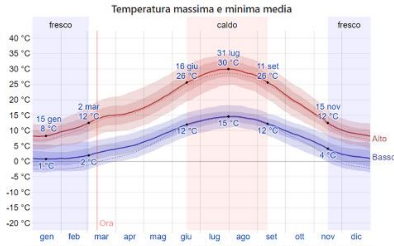
-Linear block



Intervation Area

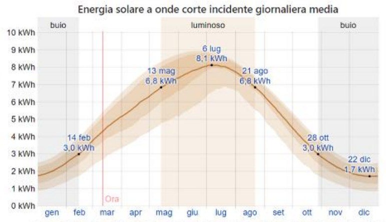


Temperatura massima e minima



La temperatura massima (riga rossa) e minima (riga blu) giornaliere medie, con fasce del 25° - 75° e 10° - 90° percentile. Le righe sottili tratteggiate rappresentano le temperature medie percepite.

Energia solare a onde corte incidente giornaliera media



L'energia solare a onde corte incidente media che raggiunge il suolo per medio quadrato (riga arancione), con fasce di percentili dal 25° al 75° e dal 10° al 90°.

La pioggia media (riga continua) accumulata durante un periodo mobile di 31 giorni centrato sul giorno in questione con fasce del 25° - 75° e 10° - 90° percentile. La riga tratteggiata sottile indica le nevicate medie in misure equivalenti in acqua.

IL Campus

L'Aulario si trova in una zona universitaria di grande tradizione cittadina, fatta di centri didattici, laboratori e residenze studentesche, che comprende importanti aree verdi e parcheggi. L'immagine dell'edificio riflette questo completo coordinamento tra gli elementi tradizionali dell'ambiente (l'ubicazione, il giardino, il collegamento con altri edifici), con tecniche adattate ai nuovi modi di apprendimento e alla precedente esperienza acquisita nell'architettura ambientale. Si tratta di un edificio volumetrico monolitico, con un proprio linguaggio distintivo e personale, in cui si integrano elementi come la modulazione e il colore (forte e notevole come elemento identitario dell'edificio) supportati da una funzionalità tecnica assoluta e radicale che ricerca il comfort di studenti e docenti . Il team di progettazione ha già abbastanza esperienza per risolvere le sfide di questa nuova architettura che utilizza la massima conoscenza sui temi della sostenibilità.

Case study: Aularium of the Department of Humanities and Cultural Heritage (DiLBEC) of the University of Campania Luigi Vanvitelli

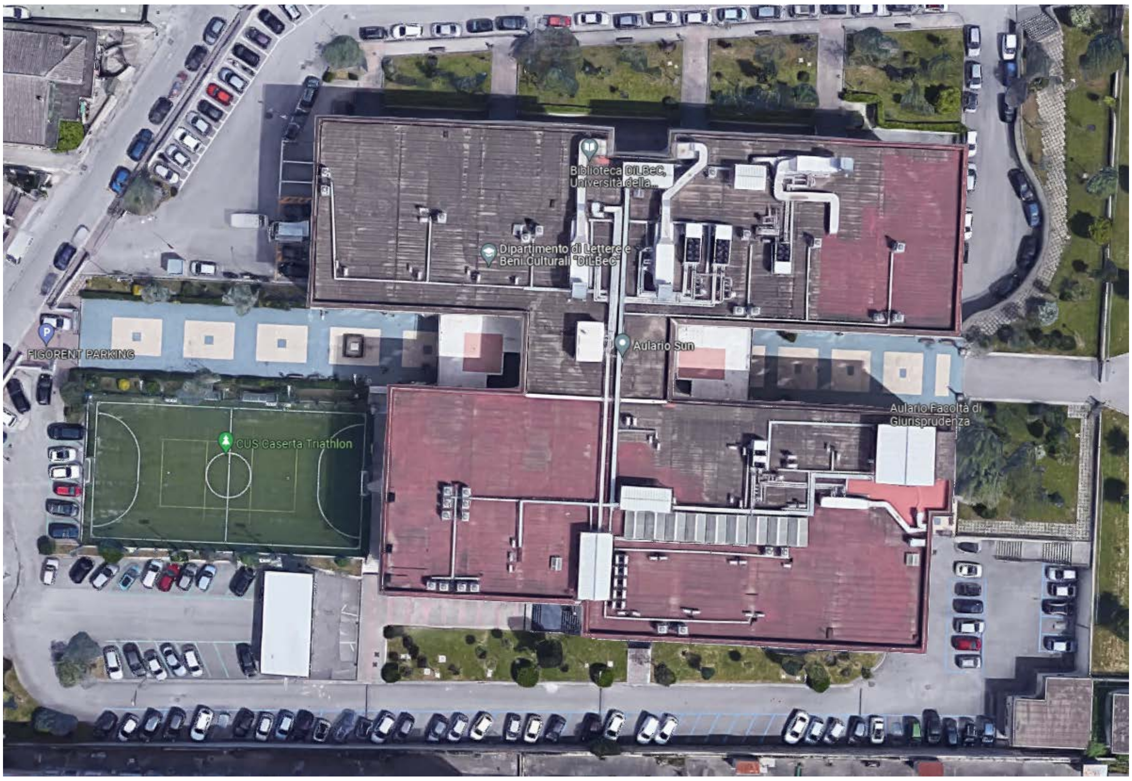
A building-installation energy diagnosis is a systematic procedure aimed at the knowledge of energy end-uses and the identification and analysis of any inefficiencies and energy criticalities of the building and the systems present. The energy diagnosis involves a series of operations consisting of the survey and analysis of the building-plant system under standard operating conditions and the analysis and economic evaluation of the building's energy consumption. The purpose of an energy diagnosis is to identify ways in which energy requirements can be reduced and to evaluate possible interventions from a cost-benefit point of view, ranging from retrofit actions to optimised operating/management models of energy resources.

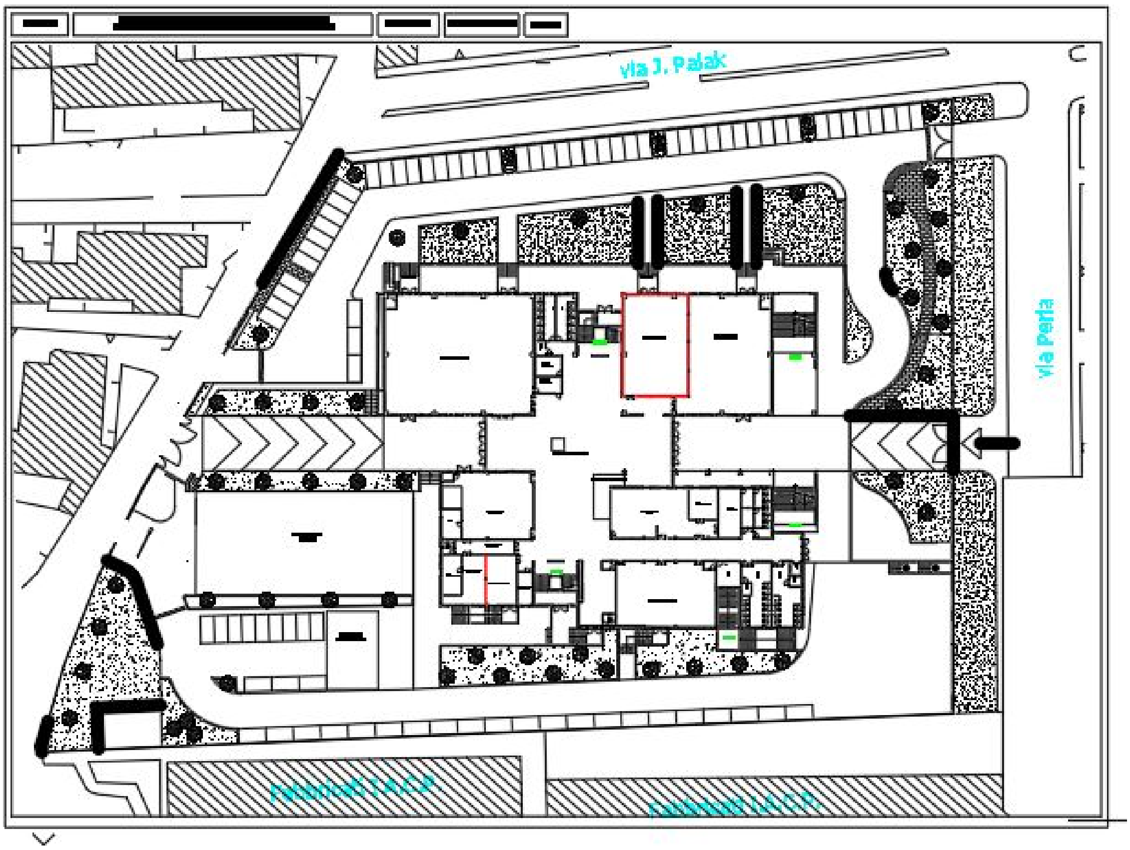
The energy diagnosis of the analysed case study is the Department of Humanities and Cultural Heritage (DiLBEC) of the University of Campania Luigi Vanvitelli, located in S. Maria Capua Vetere (Caserta) at via Raffaele Perla 21, in a recently built structure, equipped with numerous and spacious classrooms, teachers' studios, laboratories and various multifunctional spaces available to students (study rooms, rooms for cultural and recreational activities).

The activity was carried out by processing the data found, surveyed during the inspection and monitored for the construction of a real and reliable energy simulation model. This model was subsequently validated by the TmtUS programme set up by the University of Seville by comparing theoretical energy requirements with real consumption. The recalibrated model thus made it possible to investigate with greater precision any criticalities in the building-plant-operator-user system and to define with greater reliability the payback times of the hypothesised energy requalification measures.

From the results of the energy diagnosis, it emerged that the multifunctional building presents various possibilities for efficiency upgrading. This could be achieved through the implementation of energy efficiency measures with simple and rather short payback times.

Territorial context


Biblioteca DILBeC Università della
Dipartimento di Lettere e Beni Culturali "DILBeC"
Aulario Sun
CUS Caserta Triathlon
Aulario Facoltà di Giurisprudenza


via J. Palak
via Perla

Planimetry

Building description

The building consists of an almost square building made of prefabricated blocks on three levels.

GENERAL DATA

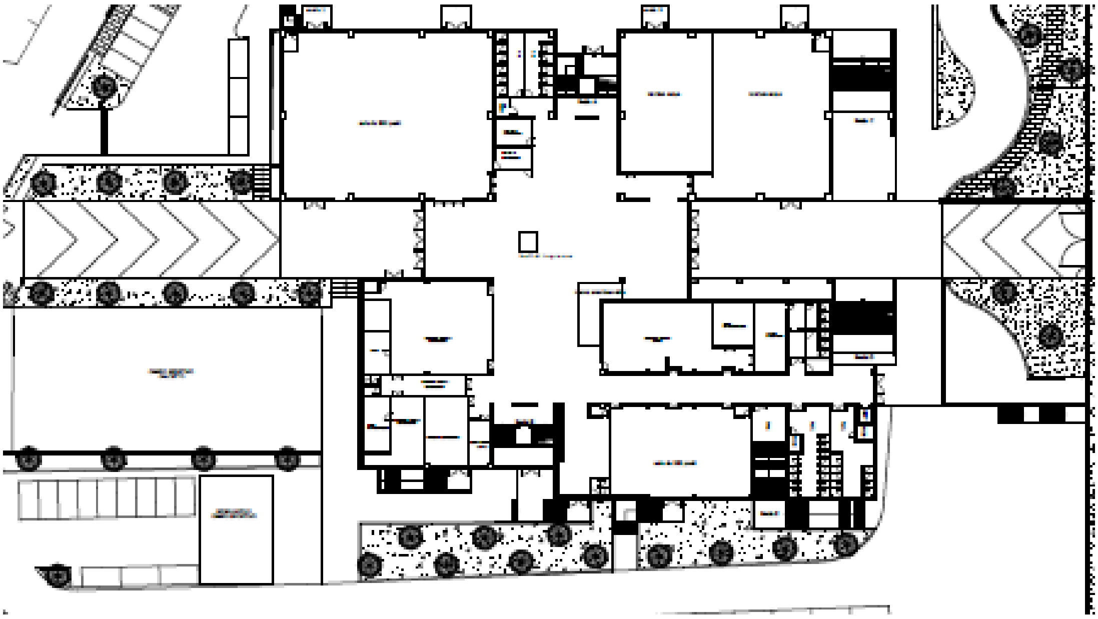
(Presidential Decree No. 412/93 - Legislative Decree 311/06 UNI 10349 - UNI 10339):


East and west entrance

Tipologia	*E.7.*
Zona climatica:	*C*
Gradi giorno della località :	*1113*
Longitudine:	*14° 15'*
Latitudine:	*41° 04'*
Temperatura esterna di progetto:	*0 °C*
Periodo di riscaldamento (g.g.)	*137*
Temperatura esterna di progetto :	*32,1 °C*
Periodo di condizionamento (g.g.)	*100÷110*

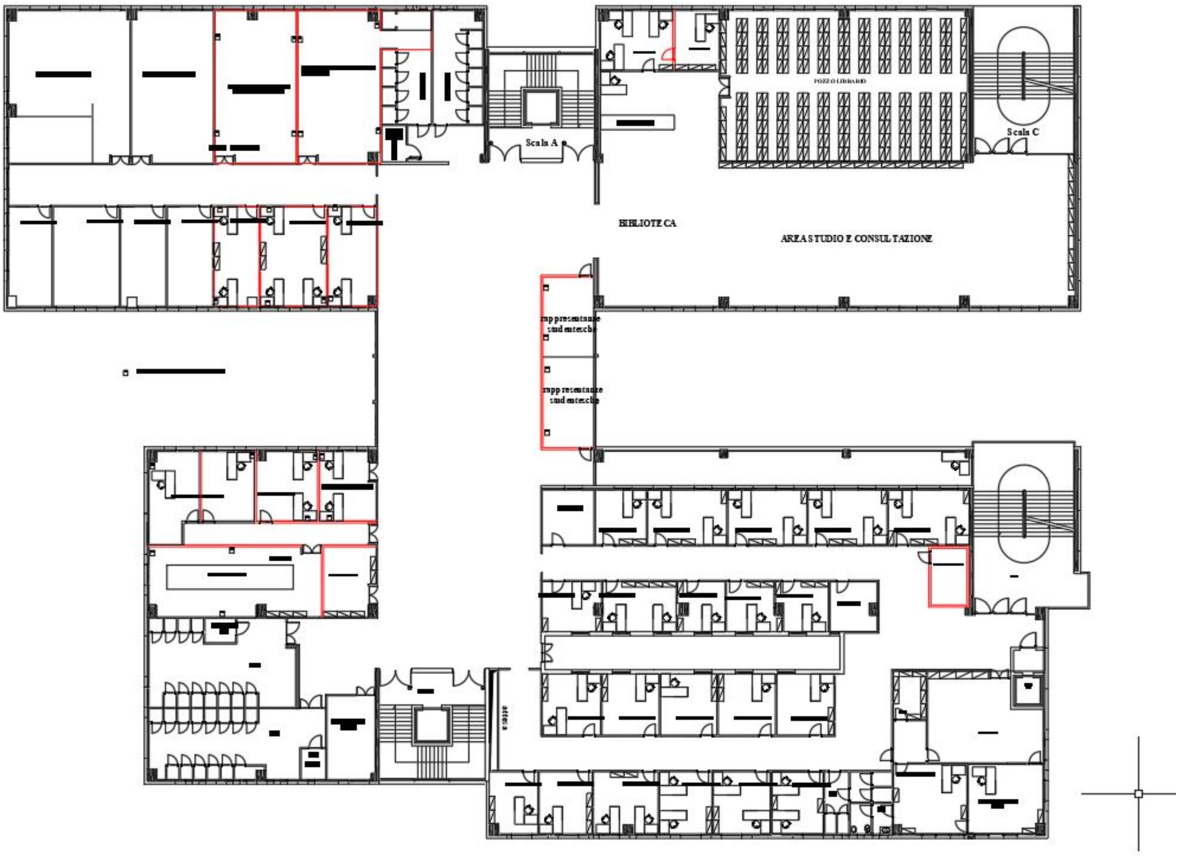
Below are the main geometric data of the building:

Floor area:	3'733 mq
Total volume:	44'796 mc
Dispersing surface	46'788 mq
S/V:	1,150



ground floor plan

Pianta piano primo



Pianta piano secondo

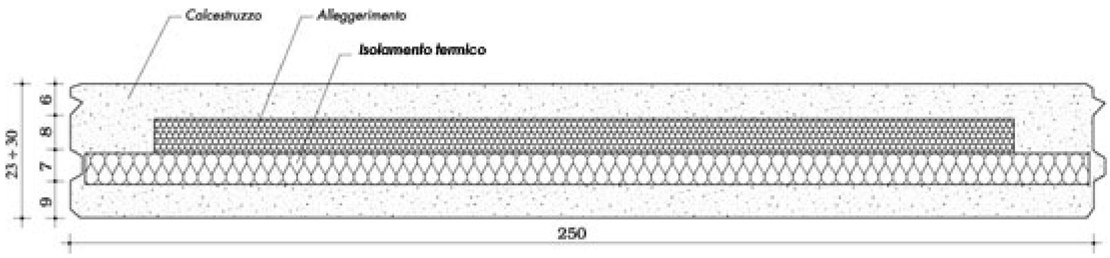
External wall

Opaque envelope features

The vertical opaque envelope consists of prefabricated infill panels with a total thickness of 33 cm, positioned externally to the pillars of the structure and fixed by means of metal elements.

The wall structure is made of GRC (vibrated reinforced concrete) with insulating material (polystyrene) in between to provide thermal and acoustic insulation.

The thermal transmittance is 0.30 W/m2K.



Parete verticale esterna lato sud

Opaque dispersing surface for each façade

EAST façade total surface= 287.3 sqm

WEST façade total surface= 298,45 sqm

SOUTH façade total surface= 630,94 sqm

NORTH façade total surface= 609,44 sqm


Parete verticale esterna lato nord

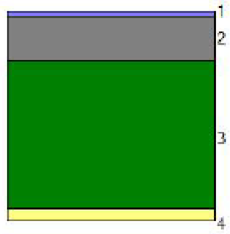
ROOF

The roof of the building is flat and practicable. All the building systems are installed on it, and there is also a photovoltaic system. It consists of a self-supporting sheet of reinforced concrete lightened by PSE blocks, and with a concrete slab and waterproofing membrane. The overall thickness is 33 cm.

Below is the calculation of the roof's energy performance:


Foto copertura

Descrizione struttura



1	IMP	Membrana impermeabilizzante bituminosa
2	CLS	Calcestruzzo - 1800 kg/m³
3	SOL	Solaio tipo predalles con blocchi in PSE rif 2.4.05 - sp.solaio 23cm
4	INT	Malta di cemento

	s [m]	ρ [kg/m³]	λ [W/mK]	c [J/kgK]	μ [-]	Ms [kg/m²]	R [m²K/W]	SD [m]	a [m²/Ms]
							0,04		
1	0,008	1200,0	0,170	1000,0	50000,0	9,6	0,05	400,00	0,142
2	0,070	1800,0	1,150	1000,0	60,0	126,0	0,06	4,20	0,639
3	0,230	970,0	0,348	1000,0	20,0	223,1	0,66	4,60	0,359
4	0,020	2000,0	1,400	1000,0	38,0	40,0	0,01	0,76	0,700
							0,10		

Elenco simboli

s	Spessore
ρ	Densità
λ	Conduttività
c	Calore specifico
μ	Fattore di resistenza al vapore
Ms	Massa superficiale
R	Resistenza termica
SD	Spessore equivalente d'aria
a	Diffusività

Parametri stazionari

Spessore totale	0,328	m
Massa superficiale	398,7	kg/m²
Massa superficiale esclusi intonaci	358,7	kg/m²
Resistenza	0,92	m²K/W
Trasmittanza U	1,084	W/m²K

Parametri dinamici	**Valori invernali**	**Valori estivi**
Trasmittanza periodica Y	0,289 W/m²K	0,194 W/m²K
Fattore di attenuazione	0,266	0,197
Sfasamento	11h 14'	12h 7'

Verifica trasmittanza

Provincia	CASERTA
Comune	Santa Maria Capua Vetere
Gradi giorno	1113
Zona	C

Verifica invernale

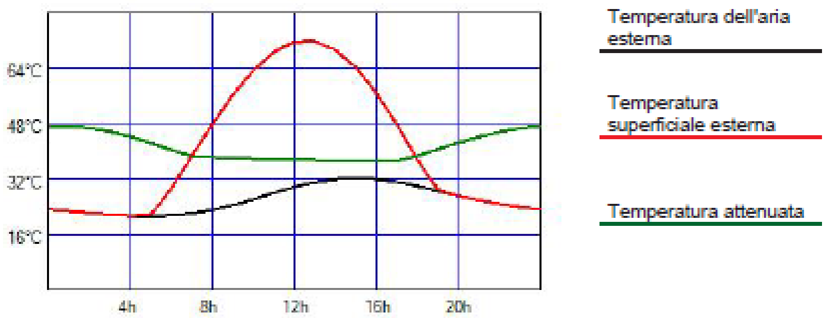
Trasmittanza	1,084 W/m²K
Trasmittanza di riferimento	0,33 W/m²K

Verifica estiva

Irradianza media del mese di massima insolazione	322,0 W/m² > 290 W/m²	***Verifica inerziale richiesta***
Trasmittanza periodica	0,194 W/m²K	
Trasmittanza periodica limite	0,18 W/m²K	**Verifica non superata**

Verifica inerziale

Attenuazione	0,20
Sfasamento	12h 7'
Orientamento	Orizzontale
Fattore di assorbimento solare	0,6



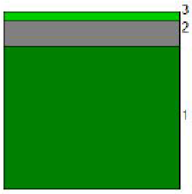
GROUND FLOOR

The ground floor ceiling, which has the same structure as the roof ceiling, is placed on unheated rooms.


Foto solaio piano terra

Struttura: Ground floor

Descrizione struttura



1	SOL	Solaio tipo predalles con blocchi in PSE rif 2.4.05 - sp.solaio 23cm
2	CLS	Massetto in calcestruzzo alleggerito densità 1200 kg/m^3
3	PAV	Pavimentazione interna - gres

	s [m]	ρ [kg/m³]	λ [W/mK]	c [J/kgK]	μ [-]	M_s [kg/m²]	R [m²K/W]	S_D [m]	a [m²/Ms]
							0,17		
1	0,230	970,0	0,348	1000,0	20,0	223,1	0,66	4,60	0,359
2	0,040	1200,0	0,330	1000,0	60,0	48,0	0,12	2,40	0,275
3	0,015	1700,0	1,470	711,3	2000000,0	25,5	0,01	30000,00	1,216
							0,17		

Elenco simboli

s	Spessore
ρ	Densità
λ	Conduttività
c	Calore specifico
μ	Fattore di resistenza al vapore
M_s	Massa superficiale
R	Resistenza termica
S_D	Spessore equivalente d'aria
a	Diffusività

Parametri stazionari

Spessore totale	0,285	m
Massa superficiale	296,6	kg/m²
Massa superficiale esclusi intonaci	296,6	kg/m²
Resistenza	1,13	m²K/W
Trasmittanza U	0,884	W/m²K

Parametri dinamici	**Valori invernali**	**Valori estivi**
Trasmittanza periodica Y	0,198 W/m²K	0,314 W/m²K
Fattore di attenuazione	0,224	0,308
Sfasamento	10h 52'	9h 54'
Capacità termica periodica		

Verifica invernale

Trasmittanza	0,884 W/m²K
Trasmittanza di riferimento	0,38 W/m²K

Features Transparent envelope:

The transparent envelope consists of aluminium frames with double-glazing with the following characteristics

- average thermal transmittance of Uw=2.8 W/m2K

- glass thermal transmittance equal to Ug=2.6 W/m2K

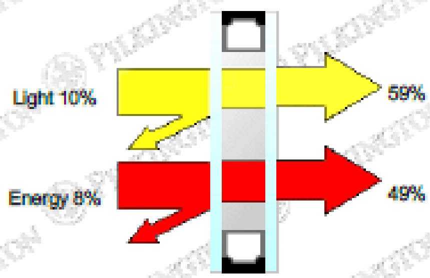
- Solar factor of glazing 0.5

The windows are without external shading systems

Finestra lato sud

Finestra parete lato sud

Di seguito le prestazioni del vetro:



DESCRIPTION

Position	Product	Process	Thickness (nominal) mm	Weight kg/m²
Pilkington **Insulight**™ Sun				
Glass 1	Pilkington **Arctic Blue**™	Annealed	4.0	
Cavity 1	Argon (90%)		16.0	
Glass 2	Pilkington **Optifloat**™ Clear	Annealed	4.0	
Product Code	4ab-16Ar-4		24.0	20.00

PERFORMANCE

Light		
Transmittance	LT	59%
	UV %	23%
Reflectance Out	LR out	10%
Reflectance In	LR in	13%
Performance Code		
U_g-value/Light/Energy		2.6 / 59 / 49
Ra		85
The values of some of characteristics are displayed as NPD. This stands for No Performance Determined.		

Energy		
Direct Transmittance	ET	43%
Reflectance	ER	8%
Absorptance	EA	49%
Total Transmittance	g	49%
Shading Coefficient Total		0.56
Shading Coefficient Shortwave		0.49
Sound Reduction	R_w (C;C_{tr}) dB	31 (-2; -5)
Thermal Transmittance	W/m²K	2.6

Pilkington Spectrum allows you to combine a wide range of products available from Pilkington and determine their key properties such as light transmittance, g value and U value. The program includes restrictions that prevent some combinations being selected that may be considered unwise or impractical. Even with these restrictions, it is still possible to create product combinations that may not be available from your supplier. Please check with your supplier that your chosen product combination is possible, available in the sizes required and in a timescale appropriate to your project. Furthermore, it is essential that you check that your product combination is appropriate for satisfying local, regional, national and other project-specific requirements.

Calculations are made according to EN standards 410 and 673/12898

Transparent dispersion surface for each façade (m2)

EAST façade total surface= 96,28 sqm

WEST façade total surface= 82,51 sqm

SOUTH façade total surface= 239,72 sqm

NORTH façade total surface= 284,85 m2

Below are the summary data of the building envelope as entered in the software in the "Geometry and Construction" section:

Intended Use and Mode of Occupation of the Premises

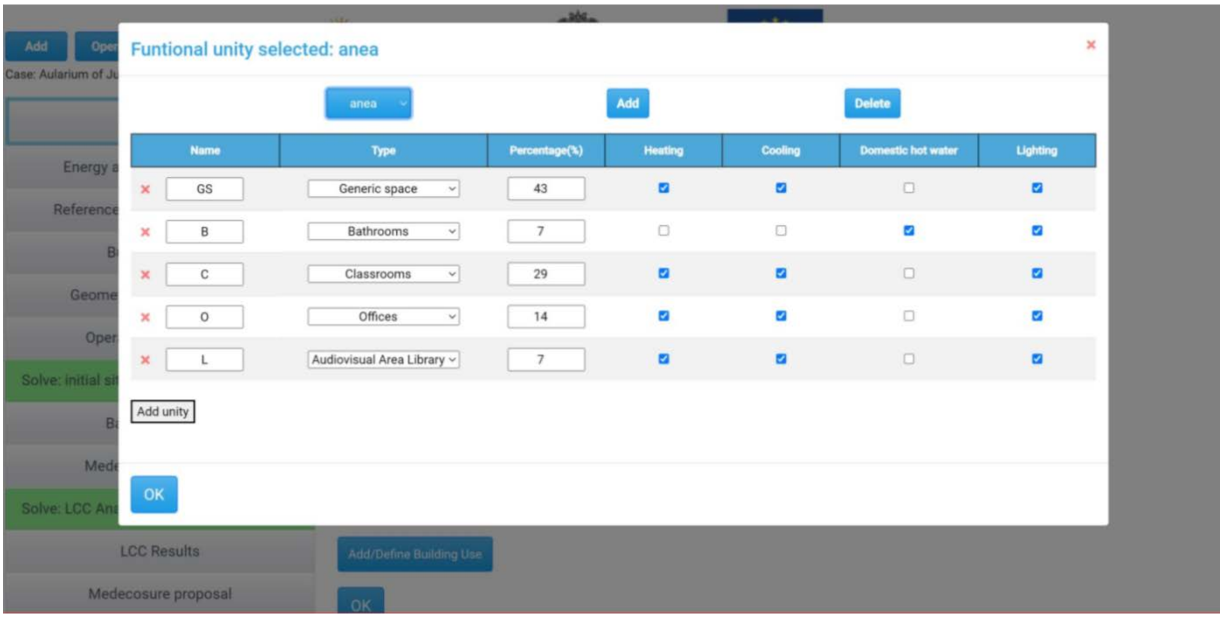
In particular, Dilbec has 9 fully equipped classrooms, with a capacity suitable for the regular and functional conduct of teaching activities in all its various articulations.

The classrooms are distributed over three floors. Dilbec has a Library (second floor) and a large study room (128 seats) adjacent to it, which is also used by Law students.

There are also workstations on the second floor, in the spacious atrium, which are available to students, as well as laboratories and multifunctional spaces. Several offices are also located in the Aularium, including those of the Student Secretariat.

Compared to the overall surface area of the building, approximately 29 % is occupied by classrooms, about 1l 14 % by offices, 7 % by toilets, 7 % by the Library, and the remaining 43 % by general spaces, such as lobbies, and open study stations.

As far as energy use is concerned, with the exception of the toilets, where only lighting and hot water are provided, both winter heating and summer cooling are provided for all other rooms.



Characteristics of Thermal Installations:

The building is equipped with a centralised primary air conditioning system and fancoils for offices and classrooms with all-air AHUs, powered by 4 heat pumps, in the roof. One area of the building is air-conditioned by individual independent splits.

The central heating and cooling plant is on the roof with an external thermal flywheel. There are 4 RHOSS heat pumps (1 out of use) with refrigerant gas R 407 and 2+2 primary and secondary circulation pumps, with fixed flow rate, in addition to the circuit of the 4

AHUS.

The 4 AHUs are :

- 2 x 14,000 mc/h with 3 batteries + fixed capacity mixing plenum

- 1 x 10,000 mc/h with 3 batteries + fixed flow mixture plenum

- 1 x 3,600 mc/h with 2 batteries, fixed flow rate

TIPOLOGIA	Quantità	Caratteristiche
Condizionatori autonomi SPLIT	78	
C.T.F. e sottocentrali	1	
Pompe di calore RHOSS mod. THAES	4	2 x 196 KW 1 x 142 KW 1 x 128 KW
Gruppi frigo		
Ventilconvettori a 2 tubi	33	Sabiana
UTA - NOVAIR	4	2 x 14.000 mc/h 1 x 10.000 mc/h 1 x 3.600mc/h
Elettropompe		Singole p. fissa
Generatori di calore a basamento		
Generatori autonomi murali		
Torrini estrazione	3	
Addolcitori		

HYDRONIC CIRCUIT

Circulation is provided by fixed capacity pump units located in the roof.

All pumps are not protected by a galvanised sheet metal roof.

THERMOREGULATION

Present on board the AHU coils and fan coils

Photos of the building to follow

Area occupancy index

Being a university building, the occupancy of areas (classrooms-laboratories-offices) is well scanned over the whole year.

In particular, four different occupancy bands can be defined:

1. Regular (8:00 a.m. to 7:00 p.m.): related to those months of the year dedicated to the performance of teaching and research activities

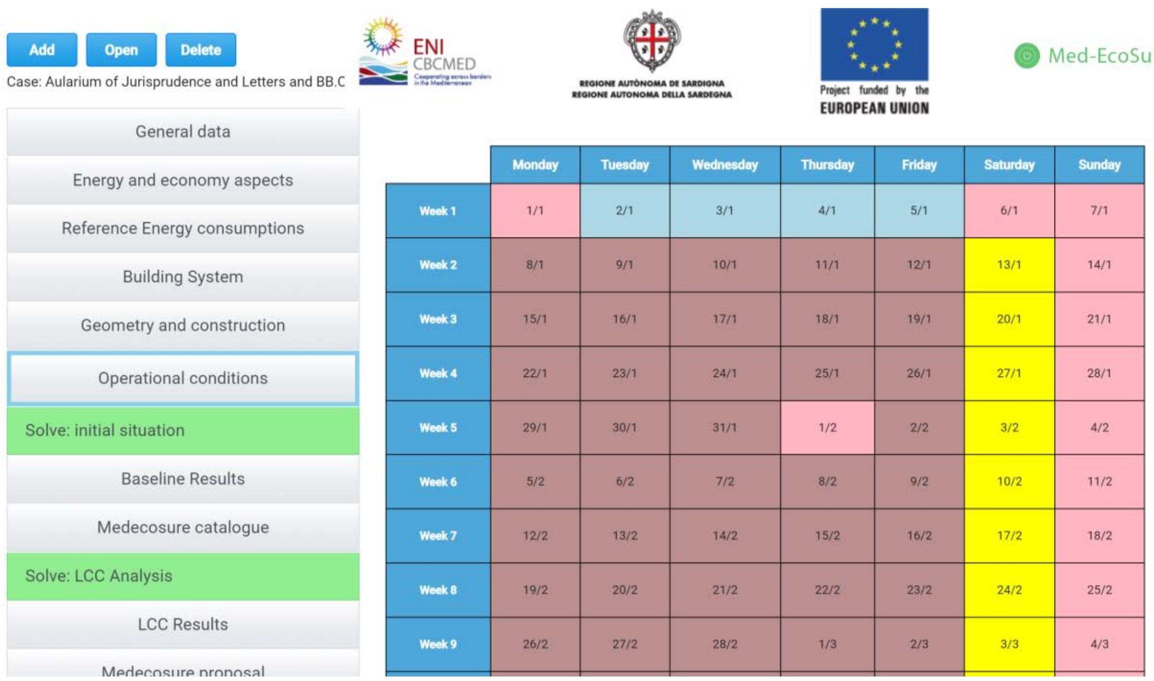
2. Intensive (8:00 a.m. - 2:00 p.m.): relating to specific times of the week when the facility is used exclusively during the first part of the day

3. Regular with 50% reduced occupancy: relating to those months of the year destined for the conduct of examinations and therefore characterised by a lower frequency and use of the premises

4. Closed: relating to those periods of the year when the facility is closed to activities and therefore the building is not actually used.

The image below shows an example of the calendar management of the building's operating conditions, developed within the software, in which the following are identified:

1. Regular band: dark pink colour
2. Intensive band: yellow colour
3. Reduced to 50% band: light pink colour
4. Closure: yellow colour



CONCLUSION

The energy analysis of the building envelope revealed that the vertical walls have good performance in terms of thermal insulation, and are in excellent condition for maintenance.

With regard to the roof, on the other hand, thermal insulation work could be useful to reduce transmittance. It would also be advisable to redo the covering to improve reflectance and reduce the summer heat load.

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