technical transactions

No. 2024/008

architecture and urban planning

sciendo

Public Facilities in the Context of Sustainable Development: A Multiple-Study of Academic Libraries

Marcin Gierbienis

marcin.gierbienis@pk.edu.pl | https://orcid.org/0000-0003-2822-2695

Faculty of Architecture, Cracow University of Technology

Scientific Editor: Mateusz Gyurkovich, Cracow University of Technology
Technical Editor: Aleksandra Urzędowska, Cracow University of Technology Press
Typesetting: Anna Pawlik, Cracow University of Technology Press

Received: April 3, 2024
Accepted: October 7, 2024

Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing interests: The authors have declared that no competing interests exist.

Citation: Gierbienis, M. (2024). Public Facilities in the Context of Sustainable Development: A Multiple-Study of Academic Libraries. *Technical Transactions, e2024008*. https://doi.org/10.37705/TechTrans/e2024008

Abstract

We live in a time when thinking about the environment today means thinking about the future of a generation. In an increasingly urbanised space, not only are we gradually losing contact with nature, but we can also see that the impact of development on it is often negative and irreversible. A sustainable approach to design, which places greater emphasis on building design, use, and good practices, seems essential. Libraries, whose existence is strongly tied to their educational mission, play a very important role. By remaining repositories of knowledge and places of activity, but also by their pro-environmental orientation, they can become a model of contemporary architecture. The aim of this paper is to present academic libraries that play a special role as the focal point of a campus plan, offering both a rich programme of cultural events and a place to study.

Keywords: library; sustainable development; green architecture; energy efficiency

1. Introduction

Libraries can be a model of sustainable public facilities. Over the years, they have evolved from closed, quiet institutions to open activity centres. Library buildings have an additional role to play, not only as high-quality green buildings, but also as an opportunity to educate and promote the principles of sustainable design. Library buildings have an even stronger role in the context of campus development, where its pedagogical role can synergise with education about healthy and environmentally friendly construction.

Sustainability and green architecture are contemporary global architectural trends. Regardless of geographic location, ecology remains essential, with conversations about it accompanying scholarly discussions and published in mass media outlets, and it is present in the everyday reality of many people. Although pro-environmental thinking has been around as a buzzword since the 1960s, it has only relatively recently gained sufficient traction to enter other disciplines, such as architecture or civil engineering. At present, sustainability elements are part of informed consumer choice and legal determinants in specific countries, international directives or many other documents and strategies proposed by organisations that promote attitudes consistent with sustainable development.

We can discuss the success of sustainable architecture by pointing to its benefits. They are visible in the improvement of the quality of both the natural and the urban environment, their positive impact on the human psycho--physical condition or in achieving cost-effectiveness associated with the use of energy-efficient building solutions. Considering the costs of construction and occupancy, as well as the impact of traditional energy generation methods on the environment and, indirectly, on human health and physical condition, alternative solutions should be considered much more often when planning a new building. Pursuing lower energy consumption brings extensive benefits and is indisputably the most quantifiable goal that should be prioritised in development project planning. However, we should also try to convince the consumer that design and construction should be performed in a well-thought--out and informed manner, and consider both people and the environment.

1.1. The library as a model in the promotion of green building

According to its encyclopaedic definition, sustainable development is a form of stable socio-economic development of contemporary societies; it is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs (Waas, 2010: 640).

Sustainable development, as a term, was first used in 1987 in the G. Brundtland Report entitled *Our Common Future*, which was drafted for The World Commission on Environment and Development. This document features a list of threats to the future development of humankind and points to the rationale behind implementing a cohesive and sustainable economy by all states in such a manner as to satisfy current needs while also considering those of future generations (Borowy, 2014: 3–12).

In 1992, the United Nations Conference on Environment and Development, abbreviated as UNCED, took place in Rio de Janeiro. Governments and NGOs met at this summit. The motto of the conference was 'Environment and Development'. The Rio Declaration on Environment and Development includes precepts that define the rights and obligations of states in the pursuit of implementing sustainable development. Human life in harmony with nature is stressed there, as is the role of states in the application of their own sovereign practices in environmental policy, so that environmental damage can be avoided and that the borders of surrounding countries will not be infringed (Conference of the United Nations, Rio de Janeiro, 1992).

https://doi.org/10.37705/TechTrans/e2024008

Agenda 21 discusses, among other things, social and economic issues that pertain to changing human lifestyles, demographic dynamics and combating poverty. Separate chapters discussed protecting and managing development resources; biodiversity; biotechnology; integrated land planning and governance; strengthening the role of various major social groups; financial mechanisms; conducting research and the mechanisms of implementing and transferring technology (Sjöström, 2010: 347–353).

The sustainable approach to building is associated with green architecture, which places a greater emphasis on pursuing energy efficiency and cost--effective occupancy. The beginnings of green building can be traced to the US construction sector and the oil crisis. Limiting construction costs and using environmentally friendly materials was a concept intended to address the country's difficult economic situation and had a direct carryover to its economy and ecology. Apart from limiting negative environmental impact, it was the lowering of building energy demand that made it popular in the American construction sector, providing an example to other, smaller countries. When we look at legal regulations or directives that are introduced on the global and regional scale, we can clearly see that the use of alternative energy sources has become all but mandatory for real estate developers (Runkiewicz, Błaszczyński, 2016: 3–4).

In addition to reducing CO_2 emissions and conventional energy consumption, education has also become the goal set for eco-friendly construction. At the time, public awareness of the construction sector's environmental impacts was negligible. The construction process, production and transport of building materials, exploitation, noise, and poor waste management contribute to imbalances in nature. In recent years, reducing energy consumption in buildings by using renewable energy sources (RES) can be seen as increasingly key in architecture. Solar, wind, water and geothermal power and biomass energy have become an alternative to fossil fuels. While conventional fuels are not endless, and obtaining them is becoming increasingly difficult and costly, the use of RES is an advantage as it helps protect the environment and enhances comfort (Cierpisz, Pilip, 2010: 93–94).

The significance of libraries in the promotion of green buildings was first acknowledged in the United States, where in 1992 the non-profit organisation US Green Building Council highlighted that library buildings, in light of their pedagogical mission, can constitute an excellent example for future generations, underscoring how important the environment is to humans while also giving energy-efficient and pro-environmental solutions greater exposure. The US Green Building Council is a part of the World Green Building Council (WGBC), a global organisation that promotes an informed and eco-friendly approach to design. According to the WGBC, a 'green' building is a building which reduces or eliminates negative impact and can positively affect the climate and the natural environment through its construction and occupancy. Green buildings are a means of protecting natural resources and improving quality of life (PLGBC, 2024).

The Green Library Movement is an initiative that has focused primarily on librarianship, the manner of conducting library operations, striving to preserve cultural heritage and disseminating knowledge on sustainable development. Gradually, it moved to the construction of new, green buildings and making existing buildings green as well, in addition to supporting environmentally friendly and sustainable practices. The movement's creators wanted to demonstrate how negative environmental impact can be minimised and how to build contemporary, attractive and energy-efficient buildings.

Insight into the relationship between library buildings, environmental protection and sustainability has been constantly growing over the course of recent decades. In a review paper, M. Antonelli (Antonelli, 2018) identified major publications that formed the foundation for establishing the green library as a concept. Here, she listed the 1991 issue of *The Wilson Library*

Bulletin, devoted to the library and the external environment. S. LeRue (LeRue, 1991) pointed out how environmental protection should be supported in the home and in the library. T. Watson (Watson, 1991) compiled a catalogue of groups, organisations and publications that formed the state of the art on the environment. A. Eagan (Eagan,1991) pointed to the problem of noise and the role of acoustics in the functioning of libraries. S. Smith (Smith,1991) discusses matters of protecting both the natural environment and the valuable role of the library function. These studies have made a significant impact on the academic community and fell on the fertile ground of building ecological awareness in the United States. Among other things, a periodical dedicated to the notion has been founded, established by the non-profit organisation called Green Library in Berkeley, California, together with librarians from the University of Idaho in Moscow, intended on raising awareness on environmental policy. The 1993 paper by C. Atton explained what green librarianship meant in the USA and identified it as a form of opposition to commercialisation and consumerism, which would later appear in librarianship models in other countries. The *Library Journal*, a review periodical founded in 1876, which discusses various aspects of a librarian's work, has also started to publish information concerning library buildings as green architecture. The 2003 study by B. Brown pointed to green libraries being a trend in American architecture. The greenlibraries.org website, which collects information on green library architecture, was established soon after. The appearance of numerous conferences, workshops and new websites with lists of libraries, in addition to many different articles that delve deeper into this subject can be observed (Antonelli, 2008: 2–5).

In order to aid the process of sustainable design and construction, special verification systems have been established for all stages of a building's life cycle: from the conceptual proposal to occupancy. These are multi-criteria assessment systems that are also called ecological certification, as buildings are given scores and ratings during the process. Apart from purely technical significance, they also signify a project's prestige. The multi-criteria character of these methods refers to categories that need to be considered during certification. Interdisciplinary work is recommended, such as the close cooperation between the architect and landscape architects, botanists, ecologists, acoustical engineers, innovative companies, etc. Rating systems differ depending on the approach to the use and goal, and can be used during the planning, design, construction, maintenance, occupancy, conservation, renovation and the various stages of the demolition of a green building. The most popular and widely used systems are the British BREEAM (Building Research Establishment Environmental Assessment Method) and the American LEED (Leadership in Energy and Environmental Design) (Kamionka, 2012: 33–34).

The year 1990 saw the first round of BREEAM certification, introduced by BRE Global in Great Britain. The appearance of certification tools in Great Britain was inspired by concern for the environment and desire to exert a greater deal of control over the site and process of construction. The system is based on 8 fields: management; health and wellbeing; energy; transport; water; materials; land use and ecology; pollution and waste, and innovation. The building's environmental impact is assessed both for the phases of its construction and occupancy. Apart from the building itself, transport, the traffic and deliveries layout, or waste management are also assessed. Many criteria pertain to technical and formal solutions concerning human health and wellbeing, such as ensuring appropriate access to sunlight, indoor air quality, acoustics, etc. Attention is also given to energy sources, lowering CO_2 emissions, as well as the energy efficiency and performance of the applied technology. Certification encourages the use of materials that have been produced using eco-friendly means, or that have been locally sourced or reclaimed. The points a building scores carry over to its rating level (Kamionka, 2012: 43–45).

LEED was established in the United States in 1993. Originally, it was a project developed by activists belonging to the US Green Building Council and was

https://doi.org/10.37705/TechTrans/e2024008

intended to introduce a standard aimed at minimising the negative impact of buildings on the environment, in addition to fostering building energy efficiency. The method is based on issuing a building rating according to criteria that are focused on: sustainable location and integration with the environment; effective water management; energy and atmosphere; resources and materials; eco--friendliness and comfort of use; innovation and the quality of design solutions or regional priorities. Points are awarded in each category and are then summed into a score. The final point score is used to determine the certification level achieved by the building. The rating levels include: certified, silver, gold and platinum, which is the highest (Kamionka, 2012: 38–42).

Sustainable buildings should also be subjected to life cycle assessment. This term should be understood as an informed approach to design and construction which works to the benefit of the building's future site and its impact on climatic and environmental conditions (12 pp. 95–96). The stage of planning and determining the needs of the developer is essential to ensure that the new use will meet both current and future needs. The stage that follows is design, which is the preparation of an appropriate, comprehensive documentation and the application of the adopted design strategy. This strategy should consider ecological, economic and social factors. The construction stage encompasses the building's construction and handover, while also including its occupancy and any changes and potential transformation of its form or use. The cycle should also feature the demolition stage and the site's later revitalisation (Kamionka, 2012: 30).

The scope and nature of ecological criteria in technical and spatial solution selection is relatively the most changed in the light of building cyclicality. An appropriate approach to a building's life cycle is based on thinking outside the box. It also includes the analysis of applied materials, technologies and the character of the building's use, so that their downsides and benefits can be assessed with a future-oriented outlook. The minimisation of a project's impact on the environment is therefore assessed not only from the point of view of construction alone, but also the building's operation, repair and its potential demolition. The current popular state-of-the-art multi-criteria life--cycle assessment systems encompass qualitative analysis of embodied energy, which is assigned to an element, material or product used in the building. In line with the increase in the amount of energy generated from renewable sources, such as solar, wind, geothermal, or biomass-derived energy, the assessment has also come to include a quantitative calculation of this energy in the form of embodied life-cycle emissions, including CO, SO or NO. Multifunctionality, adaptive reuse potential and transport systems are also important (Baranowski, 1998: 100–105).

1.2. The library as a third place

The choice of the library as an example of the application of sustainability principles is due to its educational character, the role it plays in the human consciousness and in the structure of the city. Along with institutions such as theatres, opera houses or museums, libraries form the cultural centres of a city. They also have an advantage over the other uses mentioned above in that they are largely open, accessible and inviting buildings, and are generally less formal.

Similar to the beginnings of green architecture, the US have also contributed to the social and educational perception of the library, having acknowledged their potential. In 1989, the American sociologist Ray Oldenburg first introduced the notion of 'the third place'. Oldenburg used this term in his book *The great good place*, where he discussed the role of the third place in the life of city residents. Oldenburg observed that Americans largely remained inside their homes, where they spent the greatest amount of time, which led to a type of stagnation, preventing their cultural development. He argued that people, apart from requiring a place to live, a place to call home, and a place to work in, e.g.,

an office, also need a third place in which they could socialise. This place is meant to be something in-between a space in which we feel comfortable, where we can rest and spend our time unproductively, and a space for social life, which people require. In the US, clubs, pubs, bowling alleys and libraries have naturally become such places over the years (Jędrych, 2015).

The third place has a much wider dimension when we refer it to the space of a library located on a university campus, where the aspect of a place that acts as a home and a place for learning has a much greater significance. The university library is often the most important working and relaxation space for students. Social and leisure activities can also develop at weekends. Here, the university library plays a significant centre-forming, social and integrating role. It is particularly important in the context of improving the quality of space in poor and neglected areas (Williams, Hipp, 2019: 75–78).

2. Materials and methods

This study's methodology was based on the use of the current state of knowledge on sustainable development, the literature, design documentation and the author's previous research and professional experience in analysing specific projects as case studies. Information on specific buildings and graphical materials were obtained from trade journals and websites of architectural design firms or professional platforms.

Considering the changes that have taken place around the world in the fields of technology, lifestyle and the manner in which libraries are used, research should first focus attention on the current period: the initial years of the 21st century, as it provides the most reliable picture of the subject matter.

The main objectives for a sustainable library that were considered was coordinated with the assumptions of sustainable development, as well as with guidelines by H. Faulkner-Brown and A. McDonald. Their lectures combine a practical approach to the construction of library facilities with in-depth research.

Faulkner-Brown derived his principles from practice. He had been developing them since the 1970s, which means that today some of his postulates need to be re-examined because their meaning or emphasis may have changed. The Faulkner-Brown manifesto came at a time when librarians were moving away from the popular idea of tripartition in library design, finding it outdated and too limiting to the functioning of libraries. The growing demand for books and a greater access to them was already noticeable. Faulkner-Brown emphasised that the most important thing in a building is the person. The guest should easily orientate themselves in the building, whether they are first--time visitors or regulars, and have comfortable access to both the staff and the books. The interiors, through their organisation and aesthetics, should stimulate creativity, which is the role of architecture. The architect pays attention to the way the books are stored and to the economy in the construction and subsequent operation of the building (Faulkner-Brown, 1994).

A few years later, at the 2006 LIBER seminar in Utrecht, Andrew McDonald, librarian and Chair of IFLA's Academic and Research Libraries Section, presented a proposal to systematise practice in relation to his own experience, along the lines of the Faulkner-Browne principles. McDonald pays more attention to aspects of functionality and user comfort. He acknowledges that an attractive library space should be creatively designed. The features he identifies are not intended to be manuals for making a building, thereby limiting the influence of its designers. Premade solutions should not be present; the designs are not meant to be the same. McDonald noted that today's libraries are hybrid in nature, offering a balance between traditional and digital collections, and enhance the social role of the institution and provide entertainment. They are, in effect, centres of learning, education, research villages and meeting places.

https://doi.org/10.37705/TechTrans/e2024008

McDonald noted the technological advances that have made the use of facilities more convenient over space and the operation of facilities more modern, extending their character beyond the aran. When computers arrived, providing access to them at some of the reader's desks needed to be considered. However, today's infrastructure is different, geared towards mobile devices, which may change over the years. McDonald presented his article when wireless networks were present, but not as prevalent as they are now, demonstrating that while functionality and aesthetics may serve over the long term, technological adaptation is a requirement that inevitably leads to modernisation. While the prospect of desks equipped with desktop computers seemed close to ideal at the time, it is now a thing of the past. Collection management and control systems are also more advanced than in the past. McDonald devotes a space to green, energy-saving architecture – an idea that fits perfectly with the assumptions about how libraries work.He adds a further point – 'Oomph', which is the expression of delight, as a set of building features that cause the user to feel excitement. In the case of architecture, for example, these can be photogenic aspect of the buildings (McDonald, 2006: 162).

During the analysis, the author searched for common denominators for sustainable construction, as well as individual solutions that can be beneft both humans and the environment. Multi-criteria assessment method manuals such as BREEAM and LEED were helpful in the analysis. It is also noted that the use of rating systems in public facilities is not a popular choice in Europe due to the additional costs of doing so incurred by project owners.

3. Libraries

Based on analysis of the literature, professional awards and programmes that promote eco-friendly projects, the author used the principles of sustainable design to analyse library buildings from an ecological and architectural perspective. The author elected to present projects completed in the 21st century and located in various parts of the world as a representative sample. This made it possible to present a broad spectrum of cases and the differences resulting from their construction in specific cultural contexts and landscapes, often featuring different climate conditions and geography.

Table 1. A selection of sustainable design principles that constitute the criteria for the analysis of selected library buildings (own elaboration)

The most important principles of sustainable design	
Taking into account individual natural and cultural circumstances of the location	Efficiency of materials and raw materials
Reducing negative environmental impact	Energy efficiency
Environmentally friendly use of land	Comfort and quality of use and user satisfaction
Multi-criteria assessment	Eco-friendly innovation of solutions

3.1. The Leo and Dottie Kolligian library in UC Merced (USA)

The Leo and Dottie Kolligian Library in Merced, designed by Skidmore, Owings & Merril LLP, was completed in 2005 as part of the University of California at Merced campus complex and is among the first major projects to promote sustainable development through library construction in the US. The project has been a success not only architecturally, offering elegant and high quality architecture, but also in terms of promoting pro-environmental attitudes. The project received a LEED Gold certificate, the Energy Efficiency Integration Merit Award, and the Chicago Athenaeum Green Good Design Award.

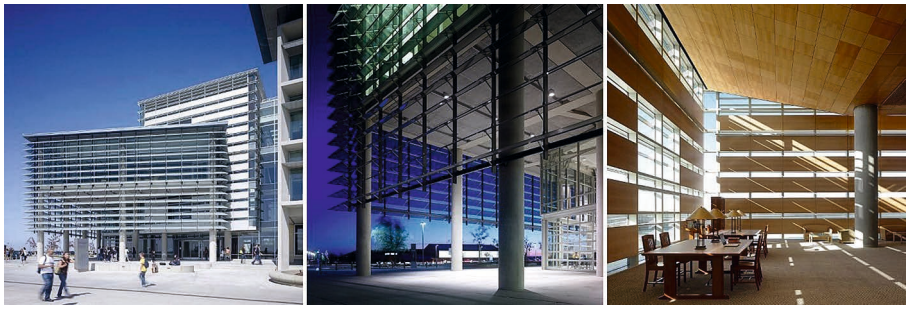

Fig. 1. The Leo and Dottie Kolligian Library – exterior and interior views, showing entrance zone and blinds controlling the light at different times of day (source: https://www.som.com/projects/university_of_california_merced__kolligian_library)

According to the architects' proposal, the building should act as a gateway to the campus. Its form is made up of three elements: a traditional library based on the 'stacks and carrels' concept; a multifunctional space; and an organisational and social space, called the Lantern, to emphasise the building's importance as a reference point on the campus map. The project incorporates future-oriented thinking, which is one of the principles of sustainable development – it directly recommends the preparation of conceptual proposals that assume further individual development. Flexibility in the space's design and its capacity for change and extension was therefore an essential criterion. The 17,000 m^2 building uses 42% less water and 50% less energy than similar buildings. Most of the finishes, particularly the floors and ceilings, are made from reclaimed or recycled materials. Up to 30% of the materials used to construct the building were locally produced or sourced, resulting in significant reductions in transport and energy costs.

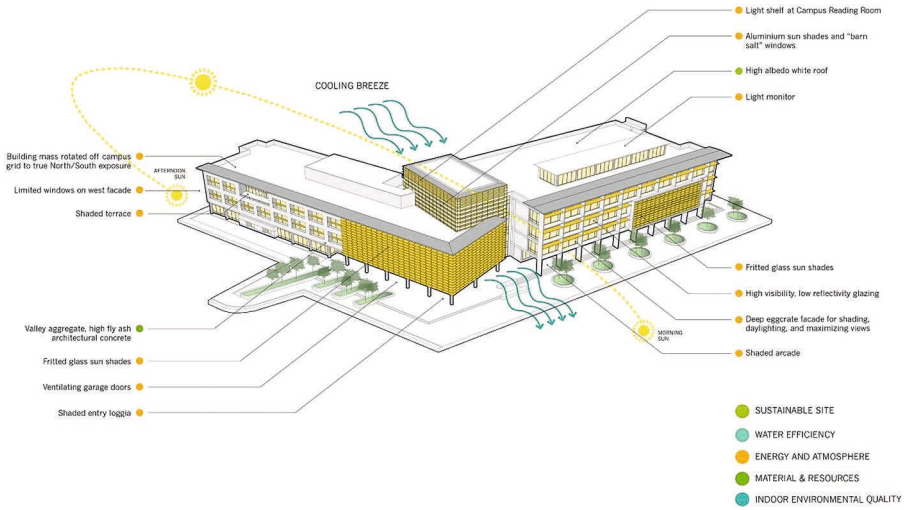

Fig. 2. The Leo and Dottie Kolligian Library – sustainability diagram (source: https://aeworldmap.com/2009/08/29/university-of-california-merced-library-and-information-technology-center-merced-california/)

The biggest challenge the architects faced was designing for a site with very high temperatures. Located in the San Joaquin Valley, temperatures can reach 100 °F. A number of strategies were implemented to address solar heat gain while still providing views of the surrounding landscape. The building is oriented along the north-south direction and the façades are set back into the massing to provide plenty of shade. The louvres, loggias, cantilevers and arcades fulfil their basic function and at the same time define the aesthetics of the building, which is an interesting urban solution that creates a space at the point of contact between the inside and the outside. The building therefore confirms the statement that geographical and climatic conditions often influence both the form and function of buildings, and it is thanks to them that an interesting end result can be achieved (Greenbuildings, UC Merced).

https://doi.org/10.37705/TechTrans/e2024008

3.2. The Palomar College library (USA)

The Palomar College library building, which was delivered in 2019, similarly to the UC Merced Library, is a part of a broader plan to transform its university campus, which was drafted in 2005 by LPA. It is also an example of a contemporary outlook on library use, which is a centre of culture and social integration of any university campus. The Palomar College Learning Resource, as its name suggests, extends its main library programme, spread across a floor area of 8,000 m^2, by adding an array of accompanying office and staff spaces. The building has received a LEED Gold rating.

The building has been incorporated into existing development in the vicinity of previously constructed educational and humanities buildings and has been linked with the remaining part of the campus through a new circulation system. The front of the building houses its entrance section, designed as a green square with an amphitheatre. The back side is a world of nature, with a garden and pool meant to facilitate bio-retention. All of the elements of site development highlight the significance of the context, utilising both local greenery and using the earthen elements of the landscape, sand, aggregate and rock, creating an attractive layout that blends well with the landscape and is a compositional foreground for the contemporary form of the building.

Fig. 3. The Palomar College library – exterior and interior views, showing main façade and high hall (source: https://lpadesignstudios.com/projects/palomar-college-learning-resource-center)

According to the building's design assumptions, its functional programme has been divided into three sections: a library (called the earth level), an academic section (called the technology level) and a didactic section (the tutoring level), each placed on separate floors that are visually linked by a hall with a high ceiling. The library, as an essential zone, has been placed on the ground floor, but the reading room has also been placed on the uppermost, fourth storey (the sky level). This was motivated by practical considerations and comfort of use. The uppermost storey with the reading room offers attractive views of the surrounding landscape, which makes it peaceful and provides appropriate conditions for reading and study. It is also well-designed in social terms, which stimulates both interaction and relaxation. The two middle levels house organisations and institutions associated with the university's operations. The architects wanted the programme's internal division to be reflected in the visual reception of the building from outside. The ground floor is a visually solid foundation covered with grey aluminium panels. The middle storeys are highlighted by their cladding, which have the colour of red ceramics, providing a reference to the aesthetic of the surrounding buildings. The concept behind the fourth storey, considered exceptional from a functional point of view, is also expressed through architectural form. While the three lower levels have a repetitive character, the uppermost one is strongly accentuated thanks to its extension beyond the building line (Archdaily, The Palomar College Learning Resource).

In terms of green solutions, the designers focused on energy efficiency, which was discussed during every stage of the project. The construction phase was given a particular focus, as the structural system used in the building led to a lowering of fossil fuel consumption by 70%, therefore meeting the guidelines

of the AIA's 2030 Commitment. In 2006, the non-profit architecture 2030 issued a call to action meant to raise awareness of how we construct buildings, and proposed goals which, when reached, will ensure appropriate energy efficiency and limit CO_2 emissions. The initiative could be joined by accepting the manifesto. The American Institute of Architects (AIA) adopted the idea and drafted its own document and formulated specific tools meant to implement the process. The 2030 Commitment, through its specifically formulated obligations and recommendations, aids companies by providing a methodology for progressive, responsible architecture. The commitment posits electing a leader, implementing operations and an action plan towards sustainable development and reporting progress. (2030 commitment)

Energy efficiency has been improved through a high-performance HVAC installation, an integrated system that handles heating, ventilation and air conditioning, providing the sensation of thermal comfort in the building. Photovoltaic systems have also been used, converting solar energy to electric power and satisfying 20% of the building's energy demand. The high-ceiling lobby is also used to aid sustainability, as it has been made into an air exchange space, based on a system that controls the opening of windows and utilises the natural breeze.

The designers analysed the path of the sun throughout the seasons of the year and designed the overhang formed by the fourth storey to provide shade during the summer and prevent overheating without any dedicated louvre system, while during winter, the cooler light reaches the interiors of the lower levels. The frontal façade features the largest glazed surfaces, highlighting the ground floor that is open towards the square, and the three levels of the building's extensive hall. The uppermost storey is equipped with additional circumferential glazed surfaces, which are also meant to refer to the massing's openness to the landscape. A light control system relying on louvre-based solutions was installed on the uppermost storey. In addition, the stairwells in the lobby are illuminated by skylights.

The architects paid particular attention to using eco-certified, sound--absorbing materials in the building's interiors. User comfort has been provided by intentionally dividing the massing into three sections, an active zone that is open to the frontal square, a transitory zone – a lobby that integrates all the levels, and a quiet zone, focused on the garden. The aforementioned garden at the back of the building is a visually attractive place, in addition to being a bio-retention site because of its wetlands-like character, as it collects surface runoff from the building's roof and can act as a storm drain (Archdaily, The Palomar College Learning Resource).

3.3. Langara College library (Canada)

Teeple Architects made it their goal to formulate a strategy of implementing an eco-friendly vision of the university's future, which involved drafting a master plan and applying for LEED certification and received a Gold certificate.

Langara College is a public degree-granting college in Vancouver, British Columbia, Canada. The institution was established in 1965 as part of the Vancouver Community College and opened a campus on West 49th Avenue in 1970.

The functional programme has been enclosed in a cuboid massing, whose floors have been shifted in relation to each other, as in a sculpture. The elements that have been extended from the main body of the building include the entrance area and the emergency staircases. Of particular note is the top floor, part of which are classrooms that have been placed in a dynamically suspended fragment of the building, while another part has the terraced levels of the reading room. The library is located on all three levels of the building and occupies spaces of different shapes, filled with bookshelves and workstations. Meeting rooms and classrooms are adjacent to these spaces. On the ground

https://doi.org/10.37705/TechTrans/e2024008

floor, along the longer façade, there is a corridor open along the entire length of the building, whose role is to distribute fresh air from the wind towers.

Fig. 4. Langara College library – exterior and interior views, showing biodiversity development with façade of the building and high, concrete atrium (source: http://www.teeplearch.com/portfolio/langara-library-classroom-building/)

The architects wanted to highlight the building's eco-friendly properties through its appearance. For instance, the roof surface has been designed to directly reflect wind flow, which is directed and guided to so-called wind towers, which redistribute the air into indoor spaces. This form of wind management, intended to provide indoor air circulation, is a solution that has been custom--designed for the project. Ecological certification promotes innovative solutions, encouraging designers to search for models that are not widely used and which also make use of natural phenomena. It is important to monitor weather conditions for the system to work as intended. Therefore, a weather monitoring station has been installed on the roof, detecting wind speed, direction and humidity. The station automatically activates windows in the ventilation towers. The air, prior to reaching the designated spaces, is tempered as it is directed through an underground carpark. According to the architects, the use of air is not the only instance of replacing conventional heating and air conditioning, but is also an element of experiencing architecture. The use of air can be felt by the building's users and can positively affect the perception of its spaces.

The popular HVAC system has been replaced by heating and cooling using geothermal sources and displacement ventilation, which has significantly reduced energy consumption. The indoor climate in the building is controlled by a system that is supported by ground heating and cooling, which adapts the temperature of the building's concrete thermal mass. Energy consumption is constantly monitored and the internal air quality sensors monitor and regulate its movement, temperature, humidity and CO_2 levels.

Another matter associated with the roof is the collection of surface runoff, which is stored in cisterns and tanks located underneath the building. This water is then used to irrigate the greenery of the campus grounds. Surface runoff is processed along the western façade using custom-shaped elements, which are planted with greenery and compost that helps to filter it. The sanitary installations inside are fitted with low-flow toilets and waterless urinals.

The green elements of site development are present both outside and inside the building, admitting greenery and daylight into its spaces. The aforementioned garden is composed of greenery and water, which, through its concrete pools, forms a harmonious, geometric whole with the rest of the building. The designers focused on using glazed surfaces in an optimal manner so that the attractiveness of the building could be highlighted and the view offering from inside the building would be enriched. They also used it to limit the risk of internal spaces becoming overheated and ensured that their surface area ratio relative to solid walls is compliant with LEED certification requirements.

The building has been built using concrete technology. However, the concrete mixture used to build it contains recycled components, such as fly ash. The architects decided to leave the concrete raw, so as to limit problems with its conservation. The concrete's thermal mass stores heat and significantly lowers the need for active heating and cooling systems. On the other hand, the exposed texture of the concrete gives the building's interiors an industrial

character, which blends well with its function. Other materials used in the project were selected so as to meet pro-environmental criteria and to ensure that no pollutants were generated during their production and that they contain no harmful substances. Recycled and reclaimed materials were also used, in addition to locally-sourced products (Archdaily, Langara College Library).

3.4. Bio University library in Constitución (Chile)

The library built in the Chilean city of Constitución is a remarkable project because of the circumstances of its construction. In 2010, the Maule region was affected by a powerful natural disaster. The earthquake, with a magnitude of 8.8 on the Richter scale, was one of the most powerful to date and covered large areas of southern and central Chile, destroying buildings, roads, bridges and railway lines. Around a quarter of an hour after the earthquake, a tsunami made landfall, with waves as high as six metres going up the Maule river and hitting La Poza, Constitución's coastal district. New housing, public and cultural development projects were a part of a public-private initiative intended to rebuild the small city – a former fishing village that has become a centre of forestry. It was the availability of timber and developed craftsmanship associated with it that provided the stimulus for the city's reconstruction (Long, 2015).

Fig. 5. Bio University library – exterior and interior views, showing external passage with timber platform and reading room open to the courtyard (source: https://www.archdaily.com/403018/bio-bio-university-library-ruben-munoz)

The library, along with the information technology building, were the first stage of the construction of Bio University's information centre. The architects from the Rubén Muñoz studio wanted to link the building with the layout of the campus. They did so by dividing the ground floor plan into two sections, an external roofed square adjoining the entrance zone, and the open plan of the interior. The square was built on a timber platform elevated above floodwater level. Due to the geographic and climate conditions, it is important to consider not only flooding, but also sudden heavy rains and strong winds when building in Chile. Due to poor soil quality, the building was designed to feature a steel and concrete structural system with exposed walls. This form of Brutalism is encountered in Chilean architecture quite often. The designers were convinced that the steel structure would perform better during potential earthquakes and would highlight the link between the building and a nearby sculpture, as they have been expressively highlighted in this case –underneath the ground floor's deck we can see beams, while the columns that support the deck in this part of the square are supported by braces. The steel structure is also visible in the interior, but the walls and ceilings are plastered. The staircases and furniture are made of wood and introduce a warm atmosphere into the reading zone.

The architects focused on access to natural sunlight while trying to avoid the risk of overheating. Large glazed surfaces were designed along the shorter façades, while in the longer façades windows take on the form of narrow, vertical slits, which produce a visual rhythm. Additional insolation is provided by three vertically-oriented, empty spaces, which are an interpretation of courtyards – they facilitate the insolation of the interiors while also being a reference to the previous library building. The main space of the reading room has been placed on the first floor, which is accessible both through a staircase located on the ground

https://doi.org/10.37705/TechTrans/e2024008

floor and through an external staircase and a gallery in one of the courtyards. The designers intended to create a form of internal landscape that would offer different, changing spaces to the reader. From the technological side, particular emphasis has been placed on energy efficiency. A high-performance floor heating system was designed, in addition to passive ventilation which regulates air flow. Timber from radiata pine trees has been used as façade cladding.

The Constitución case demonstrates that the role of architecture is currently changing and that we should consider climatic and geographic factors when designing in difficult environmental conditions. We can also use landscape architecture in other ways than simply attractive elements, as it can be used to minimise threats associated with climate disasters. The reconstruction has demonstrated that public participation and establishing successful cooperation at the local level, with the involvement of local business and resources, is the correct course of action, being not only an eco-friendly, but also a cost-effective solution (Archdaily, Bio Bio University Library).

3.5. The Hive – University of Worcester library (United Kingdom, England)

The Hive is an innovative hybrid building opened in 2012, in which the library is the leading use, and which includes University of Worcester facilities, the county archives, a local history centre and a council customer service facility. The architects from Feilden Clegg Bradley Studios placed a considerable emphasis on the educational aspect that could be used in the design. The client also wanted the building to offer access to public services and promote a balance between social needs and environmental aspects.

The building received more than a dozen distinctions and awards. It was acknowledged by the RIBA in 2013 with two prizes: the National Award and the Regional Sustainability award. It also received awards associated with sustainable development, including the BCI Award: Sustainability, the Building Awards: Sustainability Project of the Year 2013 award and those associated with the library function: the SCONUL Library Design Award in 2016, the public Guardian University Award and the 2013 Civic Trust Award. (Bregroup, 2020).

The project applied for BREEAM certification and was awarded an Outstanding rating, the highest available. The buildings that have been awarded this certification rating remain a most elite group. The project has further confirmed its eco-friendly status by receiving an A-level Energy Performance Certificate. The building's certification requires constant energy consumption monitoring. As its architects have reported, the energy consumption level after 7 years of occupancy was at around 50 kWh/m^2 per year, which is around half of what had been assumed during the design stage. The building's energy efficiency can therefore be considered outstanding. Its educational value has also proved to be a success – 18,000 people registered with it and book rentals increased by 10%.

Fig. 6. The Hive – exterior views, showing aerial view, views from the river and from recreational space (source: https://fcbstudios.com/projects/the-hive-worcester-library)

As in many other cases of sustainable building, the designers wanted to not only meet the requirements as specified in the building code, but also to refer

to the climate change agenda drafted by UK-CIP. UK-CIP has been encouraging and supporting developers and designers in an active debate on the adaptation of buildings to climate change, as it is happening right now and which will only become more severe in the future. This support is predominantly based on providing specialist information, sharing experience and knowledge, as well as offering tools and strategies that can make the real estate development process more efficient. The design of The Hive includes such a strategy, having already met the conditions slated for 2050 (UKCIP, 2024).

Sustainable development has been expressed in many of its elements, solutions and aesthetic concepts. Both the client and the designer expressed interest not only in popular solutions, but also in innovation. The building's form and cladding – gleaming, gold-coloured metal sheets made from a copper alloy – are its most eye-catching element. The distinctive massing of the building was the product of expectations concerning the integration of various needs, hence the reference to the form of a lantern as a symbol of an orientation point within the city. The building has been placed in the so-called new part of the city, near the River Severn, becoming a link between the historic centre and the Castle Street University campus. In contrast to other university-related projects, in this case the building is also accessible to all. The sculptural form, shaped akin to dynamically protruding flat-topped pyramidal shapes, is an expression of a more elaborate concept. Symbolically, they refer to the nearby undulating Malverns hills, as well as to the historic ceramic Royal Worcester furnaces. From the technical side, they are responsible for the building's natural ventilation and, thanks to skylights in their topmost areas, they insolate the space. Local biomass is an alternative source of energy for the building's heating system. The proximity of the river makes it possible to use it to supplement the air conditioning system by facilitating cooling. As a result, optimal temperature is provided during winter and on hot days it is lowered due to the use of water from the river.

The building's ground floor, in its section that is open to the square and the adjacent garden, have been designed as a library, open for the youth. Closed spaces are occupied by the archaeology sector, while the central part of the floor plan houses a storage area. The first floor is largely open and resembles a piano nobile, designed as a formal level with a multi-functional zone at its entrance, featuring a reception desk, seminar hall and children's reading room. This level, thanks to its staircases, lamps and a well-defined, square-like space, forms the main public section of the building. The second level was assigned for the historical section, with a division into an open space and separate study subsections. The main reading room is located on the third floor and, as a part of a fully open space, is an example of a contemporary, freeform arrangement with a diverse bookshelf, reading station, workstation and meeting space layout. This uppermost storey does not have a traditional ceiling and has been topped with a distinctive roof, whose surface has been shaped into the aforementioned flat-topped pyramids – which feature ventilation and insolation towers. The sectioned-off quiet zone has been built in an interesting manner – it is cut off from the main level and is located in a mass suspended underneath the roof, using one of the flat-topped towers for insolation.

The structure and location of the building have been selected and designed so as to make maximum use of the available land. The structure of the roof, with its flat-topped elements, has been built out of solid, layer-glued laminated timber, generating over 2,000 tons of CO_2 savings when compared to popular concrete structures. The *façade* cladding is made of a copper alloy. Simple and effective solutions were also used, such as keeping the concrete decks exposed so as to utilise the building's thermal mass. Many materials and internal installations are exposed. The interiors have been made warmer through *local* colour accents. The architects wanted all of the spaces meant for human occupancy to have both access to daylight and an attractive view. The space adjacent to the building was assigned for a public square and a spacious garden, whose plants were selected with the intent to provide biodiversity and utilise local species. It was

https://doi.org/10.37705/TechTrans/e2024008

intended to resemble a wildlife habitat enclosed in contemporary, geometric forms (FCBSTUDIOS, 2020).

4. Discussion

A contemporary library can be seen as a model example of the implementation of sustainable, green and energy-saving solutions in a modern public facility.

The university library is often referred to as 'The heart of the campus' and seen as a central object that determines all development. The building plays a special role in the entire campus's plan, remaining not only a treasury of books, but above all a place where users will spend a lot of time. It is a place for reading and studying, but not exclusively. The 'heart' is a term associated with activity and life, which directly translates into understanding the meaning of this function. Libraries today are multi-functional spaces, offering not only a rich programme of events, meetings and workshops, but are also recreational and social places. Contemporary libraries are often hybrid structures that combine library use with culture and art. This importance of the library is visible regardless of geographical and cultural location, also also taking into account a pro-environmental approach.

One of the most popular ideas associated with building libraries is the renovation or extension of existing buildings. It seems that such a process is definitely simpler from a technical point of view, but also economical and practical. Unfortunately, in many cases the structure to be remodelled does not meet many requirements resulting from current construction codes and at the same time its functional and spatial solutions do not meet modern use standards. Remodelling is therefore possible, but extremely difficult, especially when attention should be paid to ecological aspects.

One chief motto of sustainability is that a building should remain flexible and be built with the future in mind, and therefore that it should remain – in its design, form, function – adaptable, and that its potential demolition or adaptive reuse should not leave negative trace on the environment. This study of library buildings constructed over the past 24 years found a gradual abandonment of adaptive reuse or remodelling in favour of erecting a completely new building as the most popular form of implementation, guaranteeing the emergence of qualitative and energy-saving architecture that meets modern human needs.

Table 2 presents a brief summary of the most important aspects related to sustainable building construction in relation to the presented cases. As we can see in each example, it is important to refer not only to architecture, such as mass, but also to site development, seen not only as a location, but also a broader view of the landscape and geographical conditions. Depending on the site conditions, when starting work, the architects had to individually solve problems related to siting, and these included both atmospheric and land-related conditions, or – as in the case of Chile – past and potential natural disasters.

Many public buildings participate in multi-criteria rating systems such as BREEAM or LEED. This is very popular in the US and the UK, but not in other countries. Joining the system, and in particular adopting appropriate practices and solutions at the design stage, means increased project costs. Public project owners are therefore unwilling to take this risk. In the US and neighbouring Canada, library certification is the result of national policy and widespread acceptance of the phenomenon of acting for the benefit of the environment, as illustrated by the Green Library Movement initiative. The situation is different in Europe, where the use of rating systems is not yet widespread and is only visible in private project.s This is mainly due to economic reasons, as public institutions do not derive any measurable financial benefits from certification.

The situation is different in the private sector, e.g., in the office building sector, where having a certificate can benefit to the the project owner by attracting brands and companies that are their target customers/tenants. Even

if a project does not apply for certificiation for economic reasons, the institution does not always have sufficient budget to go through the process, good practices are still implemented during construction, and it should be noted that not all solutions mean higher construction costs. In recent years, this situation has begun to change slowly, as many public institutions understand the need for savings that result directly from properly implemented, healthy buildings that are – most importantly – cost-effective in operation, but also see the potential in promoting their eco-friendliness. Library buildings in many respects are subject to similar assumptions as the green architecture of public buildings, focusing on the three principles of sustainable architecture: ecological, economic and social factors. The case study of the buildings mentioned in the article draws attention to several recurring issues that should be prioritised in the implementation of a modern library: integration with nature, the use of alternative energy sources, the use of daylight, water management, or the policy of using local and recycled materials.

Multi-criteria assessment also draws attention to the innovation, and here also the case studies show that architectural firms are trying to look for this type of solutions, often supported by site-specific conditions analysis. Being situated in specific geographical and natural conditions is often an opportunity to apply non-standard ecological solutions. The conceptual phase in sustainable architecture processes is of particular importance as it should not only concern the work of architects and the client, but also broader consultations and meetings with the recipient or specialists. Working methods are recommended, that refer to the idea of workshops and social participation, establishing cooperation with regional craftsmen or artists, so that the activities have an interdisciplinary character.

In the first place sustainable buidling is the pursuit of energy efficiency, i.e. the search for alternative energy sources and in particular the use of opportunities arising from the geographical and climatic conditions of the location. The overall design of a case study buildings is based on the correct positioning of the volume in relation to the points of the compass and the correct positioning of the glazing, taking into account the movement of the sun. The compact form and compromise between glass and solid partitions is evident in all examples. Examples show that designers most often use HVAC systems, but alternative energy sources, the use of biomass or water, are also chosen. The Hive, where water from a nearby river is used in the air-conditioning system, is an inspiring example. It obtained an A-level energy performance certificate.

There are other aspects to reducing energy consumption that relate to the use of air and light. In the case of air, this means taking advantage of natural ventilation, and in the case of light, limiting the use of artificial light. Daylight is an issue in itself. Library buildings, whose centre is always the space open to the user, are almost always built behind large glazing, so that the rooms are bright and comfortable. Problems related to the overheating of the façade, too much light in certain places or during certain seasons are solved with classic blinds and various types of other barriers, diffusers, to prevent obscuring the outside view. Each project approaches wind and solar individually. In two cases, Langara College and The Hive, the use of wind for ventilation and air conditioning, using wind towers, deserves a mention. UC Merced proposes several different solutions to avoid overheating, but each project also provides comfort through glazing that opens to the landscape, while at the same time covering the windows to protect the spaces from excessive light. For reading rooms, diffuse light is appropriate, which is specific to this use.

The low carbon footprint is primarily a construction that remains the biggest challenge for designers who are accustomed to both design and technological simplicity in using concrete as the main building material. Over the years, wood has gained in popularity, which through modern processing methods, using, e.g., layer gluing methods, allows obtaining comparable parameters to concrete and steel, while having a low carbon footprint. However, the use of wood as a structural

https://doi.org/10.37705/TechTrans/e2024008

material is still uncommon. Among the examples described, The Hive uses this technology. However, it is worth noting that fly ash is also used in concrete mixes as a form of recycling. Negative aspects related to concrete and steel can be limited by recycling these materials, which has already appeared in several cases. The technology for the separation and recovery of construction waste is widespread in the US and Canada, and is also often used for BREEAM high criteria assessment, which draws attention to segregation and appropriate waste management. Elements made with the use of recycled materials are also used, often they are interior design products. Here, too, this solution enjoys the greatest popularity in the US, which definitely stands out from other countries in the processing and reuse of materials.

Contact with nature is another important aspect of a green library. In an already attractive environment, the situation is easier, but even in an urban environment the view from a window is often one of the key elements of a proposal. Attractive green development is increasingly associated with buildings and is also used in sustainability, e.g., introducing local plant species, looking for biodiversity, creating an oasis for insects. Green roofs have become such a popular solution over the years that they seem an obvious choice when implementing greenery. Greenery itself is also connected with water use and bio-retention. Each case refers both to greening and to the use of rainwater harvesting and use; some buildings have an accompanying water reservoir.

Finally, it is worth noting the increasing importance of the users' well-being and comfort. Appropriate architecture can significantly improve the quality and impact of work, and this is also important in the case of libraries, places of study and active leisure. Here it is worth mentioning again the importance of access to natural light, climatic conditions, and contact with nature, both directly and indirectly, for example by using natural materials. Many companies already manufacture products with the appropriate certificates and attestations, which enables the incorporation of materials that do not deteriorate the health of users, and products with limited negative impact on the environment. Another criterion is natural material use, limiting processed material use, as well as the use of local resources, which is also associated with shorter transport routes, i.e., CO_2 emissions. The issue of materials is thus related to acoustics. The spaces of modern libraries are open space surfaces, so it is important to prepare an appropriate acoustic design, taking into account the problems arising from open space solutions. Convenience and comfort of use is, after all, one of the most important goals of a good library.

Table 2. Comparison of university libraries in relation to sustainable development principles (own elaboration)

UC Merced	*Palomar College*	*Langara College*	*Bio Bio University*	*The Hive*
Environment – friendly use of land				
Connecting and creating spatial relationships between the building and the landscape	Creation of a green space, pool conceptualised as a wildlife habitat, biodiversity, bioretention.	Development takes into account water management. Elements of the site plan, with greenery and compost, help filter water.	By raising the main mass above the ground, a significant part of the green development was preserved	Public square and garden, using local species in the spirit of biodiversity – creating a wildlife habitat enclosed in modern forms.
Individual, natural and cultural circumstances of the location				
Located in a hot climate due to existing conditions. Design with louvres, loggias, cantilevers, arcades, screens to reduce overheating.	Make use of the existing context, both local greenery and earthen features, sand, aggregates and rocks. Response to seasons and changes in weather conditions specific to the region.	Harnessing the potential of the wind by creating wind towers at the same time as skylights. A weather station was installed on the roof to monitor wind speed, direction and humidity.	The design takes into account the experience of the cataclysm that befell the city. The facility was built on a platform elevated above the flood level with a wind--resistant construction.	Water from a nearby river was used as part of the building's cooling system. The idea of wind towers, through the use of conical shapes on the roof, providing indoor air circulation.

Reducing negative environmental impact				
Reduce transport and energy costs by using locally produced or sourced materials.	Reduce transport and energy costs by using locally produced or sourced materials.	Reduce transport and energy costs by using locally produced or sourced materials.	Analysing the location and poor soil quality, the building was constructed taking into account potential disasters.	The building was located in an urban area with a view to introducing greenery.
Multi-criteria assessment				
LEED Gold	LEED Gold	LEED Gold	None	BREEAM Outstanding
Efficiency of materials and raw materials				
Reclaimed or recycled materials were used.	Eco-certified, sound--absorbing materials were used.	The concrete mix used for construction contains recycled components such as fly ash. Raw concrete reduces maintenance needs. The finishing materials take into account ecological criteria in terms of pollution levels and harmful substances.	Timber from radiata pine (local wood) has been used as in the façade. A mix with recycled ash was used for the concrete. The exposed raw materials reduces maintenance needs.	The structure incorporates solid laminated timber technology, which saved circa 2,000 tons of CO_2 compared to common concrete structures. The façade cladding was made of copper alloy. Finishing materials incorporate recycled products or can be recycled.
Energy efficiency				
Appropriate orientation of the volume in relation to the world and the movement of the sun. Limiting the introduction of glazing and use shading solutions. Use of natural ventilation. Control of artificial lighting. Advanced HVAC solutions.	Optimization of the building structure. Reducing fossil fuel consumption by 70%. Highly efficient HVAC installation, an integrated system supporting heating, ventilation and air conditioning, ensuring a sense of thermal comfort in the building. Photovoltaic systems that convert solar energy into electricity and meet 20% of a building's energy need. The high lobby is used as an air exchange space, based on a system that controls the opening of windows.	Idea of open corridor to distribute fresh air from the wind towers. The HVAC system was replaced with geothermal heating and cooling and displacement ventilation, significantly reducing energy consumption. Energy consumption is monitored, and internal air quality sensors regulate air movement, temperature and humidity. Collecting rainwater from the roof in cisterns. The indoor plumbing is equipped with low-flow toilets and waterless urinals.	Strategic use of glazing, with access to natural light. Additional sunlight is provided by vertically oriented, empty courtyards – they facilitate illumination of the interiors, improving building's thermal insulation. Highly efficient underfloor heating system and passive ventilation regulating air flow.	Obtained an energy performance certificate of level A with an energy consumption level of 50 kWh/m^2 per year, which is half of what was assumed at the design stage. The form of the conical roof as the wind towers responsible for the natural ventilation of the building, and thanks to the skylights in their top, they insulate the space inside. Local biomass as an alternative energy source for the building's heating system. The nearby river water is used in air conditioning, facilitating cooling and optimizing temperature, especially in the summer.
Comfort and quality of use and user satisfaction				
Student spaces offer attractive views of the surrounding landscape, which ensures silence and provides appropriate conditions for reading and studying. The spaces have varied and comfortable access to natural light, as well as appropriate thermal conditions.	Interior spaces are in constant contact with the surrounding landscape. Large glazing guarantees access to natural light. In terms of acoustic and thermal properties, they meet the needs of user comfort.	Optimal use of glazing to emphasize attractiveness of the building and enrich the view from and into the interior. Through the conscious use of glazing, the risk of overheating is eliminated. The interiors use natural light and healthy materials.	Green landscaping elements are present not only outside but also inside the building, introducing both greenery and daylight into its space. The furniture and stairs are made of wood and introduce a warm atmosphere into the reading zone.	Many materials and internal installations are exposed in the industrial aesthetics, well received by students The interiors are warm through the use of natural materials and also colour accents. All spaces intended for human occupancy have both access to daylight and an attractive view.

https://doi.org/10.37705/TechTrans/e2024008

Eco-friendly innovations				
The building presents many different solutions to counteract overheating and provide various access to natural light.	The garden at the back of the building is a visually attractive place, in addition to being a bio-retention site because of its wetlands-like character, as it collects surface runoff from the building's roof and can act as a storm drain.	Monitoring weather conditions and air control by station on the roof with a use of wind towers, also to replace conventional heating and overall air conditioning.	The overall design, it's structure and characteristic of the form takes into account climatic and geographical factors and use natural landscape as an element to minimise the risks associated with climatic disasters.	The concept idea is distinguished by the use of innovative massive wood technology in the structure and the introduction of the idea of wind towers and skylights at the same time, influencing both energy savings and the quality of the internal space.

5. Conclusions

In its simplest definition, sustainable development is the design, construction and use of buildings with the future in mind. In the case of university libraries, it also means educating the generation that will shape them. The library is of particular importance in a campus's urban layout and its academic character clearly fits with the social aspect of the institution's operation. This paper shows, through a multiple-case study, the possibilities of implementing specific pro-environmental design solutions that are useful for librarians, researchers and architects.

Based on a multiple-case study of university libraries from around the world, their functio-spatial structure, form and the technological solutions used in them, a clear trend towards the promotion of green architecture can be identified. Sustainable development is not seen as an obligation resulting from legal requirements or regulations, but as part of the design phase and ultimately as an element of support for universities. This educational aspect, so closely linked to the academic origin of the projects, is becoming an increasingly important criterion in the promotion of environmentally friendly values. The future fate of our planet will depend on how we educate young people and raise their awareness of ecology. One measurable effect will be a reduction in energy consumption, which will translate into lower running costs.

References

Antonelli, M. (2008). The Green Library Movement: An Overview and Beyond, *Electronic Green Journal*, *27*, 2–5. Retrieved from https://escholarship.org/uc/item/39d3v236 (access: 11.03.2024).

Baranowski, A. (1998). *Projektowanie zrównoważone w architekturze.* Gdańsk: Wydawnictwo Politechniki Gdańskiej, Seria Monografie.

Bio, bio univeristy library (2008). Retrieved from https://www.archdaily.com/403018/bio-bio-university-library-ruben-munoz (access: 11.03.2024).

Borowy I., (2014) *Defining Sustainable Development for Our Common Future.* London: Routledge, 3–12. https://doi.org/10.4324/9780203383797

Cierpisz, A., Pilip, A. (2010). Budownictwo enrgooszczędne w imię rozwoju zrównoważonego. In: R. Masztalski (Eds.) *Homo Naturalis – Człowiek, przyroda, przestrzeń w myśl zrównoważonego rozwoju* (pp. 93–94). Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej.

Faulkner-Brown H. (1994). Factors affecting the planning and design of academic libraries. In: *Library planning and design, Newcastle upon Tyne*, 1994.

Final documents of the Conference of the United Nations – Declaration on Environment and Development, Rio De Janeiro (1992). Retrieved from https://www.cbd.int/doc/ref/rio-declaration.shtml (access: 11.03.2024).

How a Growing Campus Reached Carbon Neutrality in Record Time (2021). Retrieved from https://www.som.com/story/how-a-growing-campus-reached-carbon-neutrality-in-record-time/ (access: 11.03.2024).

Jędrych, J. (2015). Ray Oldenburg i jego teoria trzeciego miejsca. *Warsztaty Bibliotekarskie, 45.* Retrieved from http://warsztatybibliotekarskie.pedagogiczna.edu.pl/nr-12015-45/ray-oldenburg-i-jego-teoria-trzeciego-miejsca/ (access: 11.03.2024).

Kamionka, L. (2012) *Architektura zrównoważona i jej standardy na przykładzie wybranych metod oceny*. Kielce: Wydawnictwo Politechniki Świętokrzyskiej.

LeRue J., LeRue S. (1991). The green librarian. *Wilson Library Bulletin*, *65*, 27–33.

Library and Classroom Building, Langara College (2008). Retrieved from https://www.archdaily.com/116405/library-and-classroom-building-langara-college-teeple-architects (access: 11.03.2024).

Long, G. (2015) The rebuilding of Chile's Constitución: how a 'dead city' was brought back to life. *The Guardian*. Retrieved from https://www.theguardian.com/cities/2015/feb/23/rebuilding-chile-constitucion-earthquake-tsunami (access: 11.03.2024).

McDonald, A. (2006). The Ten Commandments revisited: the Qualities of Good Library Space. *LIBER Quarterly: The Journal of the Association of European Research Libraries, 16(2).* DOI: https://doi.org/10.18352/lq.7840

Palomar College Learning Resource Center (2020). Retrieved from https://www.archdaily.com/924741/palomar-college-learning-resource-center-lpa (access: 11.03.2024).

People and places: The Hive, Worcester. (2020). Retrieved from https://www.bregroup.com/buzz/people-and-places-the-hive-worcester/ (access: 11.03.2024).

Runkiewicz, L., Błaszczyński, T. (2016). Przedmowa. In: L. Runkiewicz, T. Błaszczyński (Eds.), *Ekologia a budownictwo* (pp. 3–5). Wrocław: Dolnośląskie Wydawnictwo Edukacyjne.

Sjöström, C., Bakens, W., (2010). CIB Agenda 21 for sustainable construction: why, how and what. *Building Research & Information, 27*(6), 347–353. https://doi.org/10.1080/096132199369174

Smith, S. (1991). The library as an environmental alternative (among other things). *Wilson Library Bulletin*, *65*, 85 and 156.

The 2030 commitment. AIA (2020). Retrieved from https://www.aia.org/resources/202041-the-2030-commitment (access: 11.03.2024).

The Hive – sustainability, accessibility and books for all (2020). Retrieved from https://fcbstudios.com/projects/the-hive-worcester-library (access: 11.03.2024).

UC Merced, Science and Engineering Building (2009) Retrieved from https://greenbuildings.berkeley.edu/pdfs/bp2009_merced_science.pdf (access: 11.03.2024).

UKCIP (2024). https://www.ukcip.org.uk/ (access: 11.03.2024).

Waas, T., Verbruggen, A., Wright, T. (2010) University research for sustainable development: definition andcharacteristics explored. *Journal of Cleaner Production*, *18*(7), 640. https://doi.org/10.1016/j.jclepro.2009.09.017

Watson, T. (1991). Finding the trees in the forest: Environmental sources. *Wilson Library Bulletin*, *65*, 34–39.

Williams, S.A., Hipp, J.R. (2019). How great and how good?: Third places, neighbor interaction, and cohesion in the neighborhood context, *Social Science Research*, *77*, 75–78. https://doi.org/10.1016/j.ssresearch.2018.10.008

Zielone budownictwo. Definicja. PLGBC. Retrieved from https://plgbc.org.pl/zrownowazone-budownictwo/definicja/ (access: 11.03.2024).