Examining Sustainability on University Campuses: Case Study of EMU

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Architecture

Eastern Mediterranean University
February 2022
Gazimağusa, North Cyprus

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ABSTRACT

In this study, campuses are considered as the small-scale form of cities in terms of environmental impact. For this reason, a general 'sustainable campus design' analysis has been made by examining sustainable campus criteria, sustainable campus performance indicators and selected sample campuses.

Within the scope of the studies, it is stated that the campuses that adopt the sustainable campus evaluation criteria achieve more stable results in terms of sustainability, but this is not yet clear and sufficient.

The conclusion reached in this study is that the sustainability indicators in universities and the international green building certification criteria that evaluate these indicators are weak in the implementation phase, the local problems of the campus settlements are not addressed, and the sustainable areas on the campus are insufficient both quantitatively and qualitatively. The failure of campuses to achieve their sustainability goals in terms of physical and system relations results in the architect's inability to fully design sustainable campus design indicators and build the whole.

For this reason, it is understood that in the sustainable design of campuses, architects should clearly determine the campus indicators and the entire design should be created on local indicators.

Keywords: Sustainability, Campus Sustainability Criteria, Sustainability Indicators, Sustainable Campus Design, Architecture Sustainability.

ÖZ

Bu çalışmada kampüslerin, çevresel etki açısından şehirlerin küçük ölçekli şekli olarak kabul edilmektedir. Bu sebeple, sürdürülebilir kampüs kriterleri, sürdürülebilir kampüs performans göstergeleri ve seçilen örnek kampüsler incelenerek genel bir 'sürdürülebilir kampüs tasarım'ının analizi yapılmıştır.

Yapılan çalışmalar kapsamında, sürdürülebilir kampüs değerlendirme kriterlerini benimseyen kampüslerin sürdürülebilirlik açısından daha istikrarlı sonuçlar elde ettikleri, fakat bunun henüz yeteri kadar açık ve yeterli düzeyde olmadığı yönündedir.

Bu çalışmada varılan kanı, üniversitelerdeki sürdürülebilir göstergelerinin ve bu göstergeleri değerlendiren uluslararası yeşil bina sertifika kriterlerinin uygulama aşamasındaki zayıflığı, kampüs yerleşim alanlarının yerelindeki sorunların ele alınmaması ve kampüsteki sürdürülebilir alanların hem nicelik hem de niteliksel olarak yetersiz olduğudur. Kampüslerin fiziksel ve sistem ilişkileri açısından sürdürülebilirlik hedeflerine ulaşamaması, mimarın sürdürülebilir kampüs tasarım göstergelerini tam olarak tasarlayamaması ve bütünü inşa edememesi sonucunu doğurmaktadır.

Bu nedenle kampüslerin sürdürülebilir tasarımında mimarların kampüs göstergelerini net bir şekilde belirlemesi ve tüm tasarımın yerel göstergeler üzerinden oluşturulması gerektiği anlaşılmaktadır.

Anahtar Kelimeler: Sürdürülebilirlik, Kampüs Sürdürülebilirlik Kriterleri, Sürdürülebilirlik Göstergeleri, Sürdürülebilir Kampüs Tasarımı, Mimari Sürdürülebilirlik.

ACKNOWLEDGMENT

Everything started with believing in myself. In a small city with limited opportunities and despite the problems I experienced, I researched, learned, and wondered for more; I started to transform myself and my environment. And I know that whoever becomes aware of self-awareness will become one of the touchstones of change in himself and the universe.

I would like to thank my unsung heroes who took part backstage in this thesis and supported me, and my esteemed thesis client who always listened to me.

I hope that this work of mine will lead to many good beginnings.

My endless thanks to the universe and all it has to offer...

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LIST OF ABBREVIATIONS

AET	Advanced Energy Threshold
CPSL	University of Cambridge Program of Sustainable Leadership
DOE	Department of Energy
EBOM	Existing Buildings- Operations and Managements
FSC	Forest Stewardship Council
FTE	Full-time Equivalent
HE	Higher Education
IARU	International Association of Research Universities
INDC	Intended Nationally Determined Contributions
IPaC	Information, Planning and Conservation
IPM	Integrated Pest Management
IEQ	Indoor Environmental Quality
IT	Information Technology
IWP	Institute of Water Policy
KPI	Key Performance Indicators
LCC	Life Cycle Cost
LEED	Leadership in Energy and Environmental Design
MWdc	MegaWatts Defined Conditions
OM	Operations and Managements
PI	Performance Indicators
PUB	Singapore's National Water Agency
RYR	Revise Your Ride
TDM	Transportation Demand Management

TZE	Total Zone Exclusion
USGBC	United State Green Building Council
VCS	Verified Carbon Standard

Chapter 1

INTRODUCTION

1.1 Problem Statement

In recent years, there are several university initiatives that plan to turn their campuses into 'sustainable buildings' and take many actions in this context. Researches on various examples of this issue is developing day by day. In addition, due to the greater emphasis on communication, regulations and partnerships for a sustainable campus in higher education, universities have begun to set their own targets of sustainability especially since 1990. The researches on academic studies and motivations prove that in almost every university there are some similarities and differences in constructions for the creation of sustainable campuses.

With the aim of creating a sustainable lifestyle and a more livable future, all important strategic elements must be taken into account; fatalism and indifference must be eliminated. Accordingly, in many countries the dissemination of the information, publicity and education for sustainable green campus construction has primarily been focused on. From 1972 to the present, awareness has been created for the movement for environmental protection actions and sustainability in many different academic events held at universities such as conferences, seminars, congresses etc.

Recently, universities have been focusing more on target 11 (one of the United Nations sustainable development goals) in this regard. The concerns about environment and sustainable oriented mission for educational constructions have a

great importance for both the renovations of existing buildings and new constructions. Environmentally, socially and economically sustainable university, by minimizing the negative effects of all its activities; It should provide both university users and society with an instructive and stimulating basis for sustainable living. (Velaquez et al., 2006)

Based on this definition, it would be right to say that a sustainable university campus should focus on various observations, practical applications and sustainable technology. The administrators of the campus with environmental responsibility should work with their stakeholders on potential environmental problems and solutions of them. This will lead university administrators and other staff to an environmentalist approach in education and will provide the formation of sustainable campuses.

Universities in many countries conduct researches to create sustainable campuses. Due to their common concerns about the future, they also make cooperation.

By carrying the central campus of the EMU to a more sustainable design and adopting sustainable usage habits, an advantage will be provided both for today and for the future. For this reason, it is necessary to determine and implement the steps that need to be solved on the way to becoming a sustainable campus as soon as possible.

For finding sustainability solutions, many factors are investigated and latest studies are examined in the universities that meet their needs in their own cycles with sustainable campuses. Considering the important role of educational constructions in universities, the EMU campus is not yet at the desired level for being a sustainable university.

The questions sought to be answered in the study are as follows:

- What indicators do the sustainable campus design criteria include?

- Which factors and indicators are more effective for universities in the process of sustainable campus design and sustainability?
- What are the duties of architects in the process of sustainable campus formation?
- What are the indicators of the EMU campus for sustainable campus design and sustainability?
- What should be done for the sustainability of the EMU campus?

1.2 Aim and Objectives

Sustainable solutions and actions are increasing day by day in the buildings of the university campuses. Sustainability has measurable qualities and indicators. Accordingly, the evaluation tools and sustainability indicators of campuses are determined and sustainable campus performance of universities is evaluated in the light of them.

Sustainability has many indicators such as recycling, energy consumption, accessibility, water consumption, waste management, building construction, transportation, etc. This study covers campus sustainability comprehensively and evaluates the whole process from a more architectural perspective. For this reason, the case studies related to sustainability will be examined and a meta-analysis will be done for the aim of making the study more concrete.

The aim of this study is to classify the indicators in the design and integration process of university campuses; examining successful case studies against sustainable campus criteria and indicators; to identify the influence areas of architects in sustainable campus concepts with building designs and others. In addition to these, it is targeted to make evaluations for the sustainability of the EMU campus and suggest solutions.

The objectives of the study are as follows:

- to determine the priority sustainability indicators of each university in the process of ensuring sustainability in universities,
- to define the sustainability assessment systems and tools for university campuses,
- to determine the architectural boundaries and scopes of sustainable campus design,
- to evaluate the sustainability indicators in the case studies according the sustainable campus evaluation criteria used and determine the performance indicator for each criterion,
- to create a meta-analysis for guiding sustainable campus actions,
- to determine the architectural boundaries in the formation of a sustainable campus and determining the roles of architects in this process,
- to evaluate the sustainability performance indicators on the EMU campus and present suggestions for a more sustainable campus.

1.3 Research Methodology

In the study, qualitative method will be used for literature review, comparison of case studies. In addition, the quantitative method will be applied with the meta-analysis table that will be created from the evaluation criteria used in the evaluation of the sustainability indicators in the campuses. As can be seen, the study will be carried out according to a mixed method in which both qualitative and quantitative methods are used together.

The study methodology will be carried out within the scope of the stages presented below:

- A comprehensive literature review will be conducted to determine the

performance indicators of universities and to set sustainability criteria.

- A sample meta-analysis table, which is aimed to be a guide in achieving high sustainability performance in universities, will be created by evaluating the campus sustainability indicators of the universities in different parts of the world as sustainable campus evaluation criteria.
- Indicators with the same meaning will be determined in the meta-analysis table and all indicators will be gathered under a single 'sustainable campus criterion'.
- Architectural scopes will be determined in the formation of sustainable campuses and it will be determined which indicators they meet in the ‘sustainable campus criterion'.
- Performance indicators (PI) of EMU will be determined and suggestions for achieving sustainable architectural performance will be.

1.4 Limitation of the Study

In this study, sample campuses will be examined in order to determine which sustainable campus indicators cover the international sustainability criteria. Using the data obtained, campus sustainability indicators, which include more understandable and comprehensive sustainable campus management and design policies that are acceptable to all, will be determined. It will be determined which of the which of the indicators are included in the architectural scope. Finally, the sustainability potential of the EMU campus will be examined, the indicators that need to be addressed in terms of architecture will be evaluated and suggestions will be offered.

1.5 Structure of the Study

In the beginning, a detailed literature review will be carried out in order to determine the sustainability indicators of the campuses, to set the campus’s United Nations Sustainable Development Goals, to scrutinize their sample building, and to

evaluate the campus sustainability performances according to these criteria. Within the scope of the sustainability criteria handled in the study, case studies will be examined and evaluated with performance indicators. Thereafter, which of the determined campus sustainability indicators are included in the architectural scope will be determined.

At the final stage of the study, EMU campus performance indicators will be determined and evaluated according to the sustainable campus indicator criteria in order to embody the results. All evaluation results in the meta-analysis table created within the scope of the study will be analyzed according to the criteria handled by the sustainability management of the universities.

Chapter 2

LITERATURE REVIEW

2.1 Emergence, Scope and Development of Sustainability

Sustainability, which influences the practices, attitudes and identities of governments, non-governmental organizations and higher education institutions, is a matter of contemporary discourse today. Sustainability is the main reference of the environmental movement. By influencing the government and non-governmental organizations, it enables them to be more socially and economically responsible towards the environment (Clougston et al., 1999)

This concept was first discussed in political circles with the aim of questioning the effects of human activities and natural resource consumption. It was based on environmental problems such as habitat degradation, extinction of some species, depletion of the ozone layer and global warming as a result of the industrial revolution in the 18th century. In this process, it was revealed that sustainability, which was put forward as a solution, did not conflict with economic growth, industrial progress and environmental quality. (Porras, 2009)

The main argument in sustainability has been that working in a way that encourages each other is the only solution to protect the environment and achieve the goals of economic and social development.

Sustainability was defined in many declarations and conferences around the world, the most general definition was made in the World Commission on Environment and Development appointed by the UN in 1987. In this commission,

known as the Brundtland Commission, sustainability was defined as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs” in the report “Sustainable Development, Our Common Future” (World Commission on Environment and Development).

In 1997, John Elkington, in his book Cannibals with Forks 'The Triple Bottom Line of 21th Century Business', proposed a framework called the triple bottom line. This framework was based on three basic and equal impact categories: social, environmental and economic.

Although many definitions have been made on sustainability from its first emergence to the present, the most comprehensive ones have been proposed after the publication of the Brundtland Report. According to all these definitions, sustainability is based on common basic features (Gladwin, Thomas, 2001)

These features are as follows:

1. Various inputs and the direct and indirect ecological, material, human and social effects of them.
2. Limited material resources, limited replenishment and carrying capacity of ecological resources.

The Role of Universities in Sustainability

Due to the rapid decline of natural resources, sustainability has become the biggest challenge of the 21st century. The difficult situation we face today requires some radical changes and global leadership. Traditional thoughts, principles and methods are insufficient for the solution of this situation. Universities, as the institutions where the people of today and the future are raised, form a model for the society in many aspects. These institutions are expected to raise individuals who can find solutions to global problems and produce solutions through the studies conducted

in these situations. For this reason, each proposed information should include its purpose as a visual and functional whole and provide the necessary infrastructure.

On the other hand, a sustainable campus also has environmental, social, and economic impacts. Since the ecological campus theme proposed in the new generation campus understanding is seen as a sustainable action, ecological development actions are primarily discussed. For this reason, all parameters such as energy demand, water consumption, material use, waste generation and transportation should be handled together to ensure the sustainability of campuses.

Every building on campus should be an educational tool for students to live in and around. Therefore, with the increasing concern of sustainability on university campuses, many commercial and non-commercial assessment tools should be used. Because of the measurable qualities of sustainability, these tools aim to define the degree of sustainability of a campus, measure the progress of the university and make sensible comparisons between universities. To achieve these important targets, each assessment tool also defines indicators related to the subtitles of sustainability. Universities have important sustainability targets in the long term, such as reducing the carbon footprint on campuses and switching from non-renewable sources to renewable sources. Many concrete steps are also being taken to achieve them.

The Talloires Declaration, announced at an international conference in France in 1990, was the first official statement of university administrators on a commitment to sustainability in higher education. (The UNESCO, 1990) The declaration consisted of a ten-point action plan for incorporating sustainability and environmental literacy into teaching, researches, activities and outreaches at colleges and universities. More than 300 university rectors from more than 40 countries signed the declaration and started projects and initiatives to incorporate sustainability into their systems.

Sustainable campus has the meaning of "a university that contributes to the building of a sustainable society through education, research, community collaboration and campus development". Therefore, the policies of universities should be designed to support campus development in harmony with its environment and nature by expanding education and research based on social challenges. It should also aim to promote the well-being of society in practice and multilaterally.

With the implementation of sustainability criteria in university campuses, rain water and wastewater is reused, energy efficiency is increased, economic gains are achieved with water and energy efficient designs. With green buildings and renewable energy-oriented designs, physical gains are achieved by increasing air quality and comfort characteristics. Social gains are also achieved with healthy society-oriented designs in which environmental pollution is prevented and the negative effects of climate change are reduced.

A successful campus development is only possible with integrated approaches. (Güllü et al., 2012) In this process, education and training is seen as the most important tool to implement effective practices of sustainable development. It should be ensured that universities define sustainable development in the best way and be the best example for it.

For the purpose of ensuring the continuation of the 'sustainability' in the campuses and carrying out teaching, research, publication and partnership functions resources are directed to relevant organizations. it helps society by minimizing negative environmental, economic, social and health effects. In addition, the campus offers its users the opportunity to conduct research with sustainability parameters with in-class and outdoor facilities. (Kapitulčinová et al. 2018)

Atmospheric and ecosystem pollution will also be significantly reduced by the implementation of sustainability criteria on campuses. However, institutional strategies and systems are also needed. For this purpose, the key indicators of sustainable campus should be identified and sustainable campus management systems should be implemented to prevent human-induced degradation in the ecosystem and to make sustainable change universal and more applicable.

These practices should be planned as guiding systems that provide a campus-based axiom of global responsibility, aiming to protect the natural environment in a systematic and integrated manner in campuses. (Alshuwaikhat, 2008).

Sustainability Development on Campus

Universities have direct or indirect effects on the environment because of their size, population and extensive activities. Higher education institutions have been involved in sustainability studies, which first started with the Stockholm Declaration in 1972, by 1990. (Alshuwaikhat and Abubakar, 2008; Lozano et al., 2013)

Since 1990, universities have made various initiatives related to sustainability. In this context, they formed various unions and societies, signed declarations and conditions (Tab. 1). Today, more than 1400 universities have signed these declarations.

Table 1: Declarations and Conditions Signed by Universities to have Sustainable Campuses. (Alshuwaikhat et al., 2008; Lozano et al., 2013; Grindsted, 2011)

NO	YEAR	DECLARATION-CONDITION
1	1990	TALLOIRES DECLARATION, FRANCE
2	1991	HALIFAX DECLERATION, CANADIAN
3	1993	KYOTO DECLERATION, JAPAN
4	1993	SWANSEA DECLERATION, GALLER
5	1993	COPERNICUS CONDITION
6	2000	Global Higher Education for Sustainability Partnership (GHESP)
7	2001	LUNEBURG DECLERATION, GERMANY
8	2004	BARSELONA DECLERATION, SPAIN
9	2005	GRAZ DECLERATION, AUSTRIA
10	2009	ABUJA DECLERATION, NIGERIA
11	2009	TORINO DECLERATION, ITALY

2.2 Evaluation of Sustainability on Campuses

The measurable feature of sustainability provides the formation of different evaluation systems. As a result of this, numerous evaluation criteria have been developed to determine the effects of sustainability in campus environments.

In this study, sustainable campus evaluation criteria and sustainable campus performance indicators, which are used at international scales, will be analyzed and the campuses where these are used will be presented as concrete examples. The universities in question and related criteria were chosen from among the most well-known examples.

Developing an evaluation guide in accordance with the common sustainable campus performance indicators and criteria, which will be determined in line with the campus values accepted by everyone, is considered important in terms of both evaluating the sustainability of the campuses according to standard parameters and helping future initiatives to be made on the campuses.

Today, most planners use physical planning as the primary tool to achieve their vision of sustainability. Although sustainability is an important issue for both our present and future, there is limited consensus on how to plan the indicators of sustainability on campus and how to evaluate their results. Baer's (Baer, 1997),

In one of his articles, Baer stated that such an assessment is possible at many stages and can be driven by different ideas to desired outcomes. According to him, the implementation (the extent to which results and plan content are reflected “on the ground”) of a plan can be evaluated through a performance approach that focuses on the planning processes (Berke et al., 2006)

According to the results of the practices in the latest studies, there is a limited relationship between the characteristics of the plans and the criteria adopted. (Berke and Conroy, 2000; Brody and Highfield, 2005; Laurian et al., 2004a)

In other words, these practices are often unsustainable initiatives. Laurian et al. (Laurian, et al., 2004b) listed the key factors that are important for the sustainability of an application as the quality of planning, developer capacity-determination, the capacity and commitment of the institution staff, and institution-developer interactions.

On the other hand, Burby (Burby, 2003), stated that the success of the practices is higher when there is more stakeholder participation in the implementation process.

More information is needed on sustainability indicators and criteria before deciding on appropriate evaluation parameters for evaluating campus sustainability practices. After understanding the elements that make up such applications, it can be discussed which elements contribute to a successful campus plan.

Both the standard plan evaluation criteria and the criteria specific to higher education are factors that will be beneficial in this study. What should be the indicators of sustainable campus performance and according to which criteria should campuses be evaluated? Studies on sustainability campus practices are increasing day by day. Determining the effectiveness of the sustainable campus efforts is important for the evaluation of campus structures.

In this context, at first, it would be useful to adopt a different performance approach (Laurian et al., 2004) for analyzing the performance indicators and evaluation criteria in the practices suggested by the past researches.

As a result, it is important that the criteria are clear and the indicators are understandable in order to ensure full success. (Baer, 1997) A comprehensive sustainability planning, that includes campus indicators on environmental, economic and social equality, should be done for the purpose of determining the criteria for accessible campus (Berke and Conroy, 2000; Field and Paterson, 2008) by Calhoun. (Calhoun, 2011)

It is still not clear which performance indicators the campuses should have and according to which criteria sustainability practices can be evaluated. However, according to the results of the researches, the explanation of the planning process; scaling implementation phases; measurability of the process; specifying implementation details; being accessible to all and linked to other campus plans are

requirements. Some of these are general planning criteria, while others may be specific to the campus layout.

The use of criteria that can be made more specific by adding evaluation criteria and performance indicators will contribute to the quality and successful performance of campus sustainability plans. Efforts to determine the possibilities of success are beneficial in terms of providing information for new applications to be made as well as existing applications.

The perception of campuses as "living laboratories" or "micro-cities" indicates that the results to be drawn from the development and implementation of these practices will be very useful in their contribution to sustainability efforts at other scales. It also appears that there is no standard practice or criterion in the evaluation of many early campus sustainability. This is because of the diversity of motivations for developing these applications. Those adopting criteria such as AASHE STARS, GREENMETRIC are also inspired by the concerns expressed by different stakeholders.

The "rational model" elements should also be evaluated in the goals and targets of the plans (Baer, 1997). Thus, involving students in developing practices and determining strategies will contribute to campuses. For this reason, campuses should try to create and facilitate participatory practice opportunities. Students should be included in these processes and other evaluation criteria should be taken into account, which will make their applications more successful.

2.3 Environmental, Social and Economic Indicators in Sustainable Campus Design

A comprehensive and long-term process management is a requirement in integrating sustainability into university campuses. In this process, the determination

of performance indicators for sustainable university campuses and the creation of evaluation criteria are important components that require infrastructural, managerial and operational thinking. In this framework, many guidelines have been published with the aim of supporting universities in the development of their own transformation strategies for creating a sustainable, resource-efficient and low-carbon campus. The focus of these guidelines is the design, creation, development and management of university campuses according to a sustainability plan. Moreover, all guidelines aim to increase the sustainability performance indicators of universities on the global platform. Sustainability of universities in general; is defined as "the ecological sensitivity, social and cultural fairness and economic vitality of the activities," (UNEP, 2013)

First of all, sustainability indicators in campuses should be categorized and the design should be based on this classification. Hence, sustainable campus designs should be categorized under three main indicators: environmental, socio-cultural and economic.

Environmental Indicators for Sustainable Campus Design:

Within the university, social, economic and environmental problems are encountered at every level caused by community habits, from greenhouse gas emissions to noise pollution, from social inequality to accessibility. Therefore, a university is connected with the settlement where it is located at the point of ensuring all urban planning, management, growth and development; social and economic needs. Finance, production, purchasing and human resources are sub-performance indicators of social and economic sustainability. Accordingly, although the main target of universities is to provide education, research and access to society, they must also

fulfill important responsibilities towards resource consumption, carbon emissions, waste and pollution of the settlement they are connected to.

While the universities are carry out these activities, it causes a problem no to determine the negative effects and the activity causing this effect. In other words, planning according to sustainable performance indicators such as energy; carbon; climate change; water consumption and administrative performance indicators such as campus design and development, offices, laboratories, information technology and access should form key areas of intervention. (UNEP, 2013)

Economic Indicators in Sustainable Campus Design:

Universities are the primary employer, investor and consumer for their immediate environment. Direct or indirect support for local job opportunities, sustainable investments and sustainable production strategies make significant contributions to extending sustainability to the entire supply chain.

However, the depletion of resources and their limitedness are among the economic difficulties in the process. Therefore, the management of key resources and materials such as energy and water that can protect investments in sustainable partnerships and future capital gains importance. Each university has a unique life cycle and local characteristics differ. Thus, universities also need to create a framework suitable for their own conditions (UNEP, 2013)

Socio-Cultural Indicators in Sustainable Campus Design:

In the social evaluation of the sustainability of universities, both the formal or informal relations within the campus itself and their relations with people outside the campus should be considered. The most important purpose in the relations within itself is to ensure that all relations, from academicians to students, from high-level managers to operators, progress in a common direction.

The adequacy of practical resources; its activeness in finance, human resources, management and external links; accessibility and effective teaching priority are issues that should be evaluated primarily by universities. Evaluation results will be an important guide for the sustainable process on campus. (UNEP, 2013)

Chapter 3

MATERIALS AND METHODS OF SUSTAINABLE CAMPUS DESIGN

In this part of the study, details of the material and methodology are presented. In the materials, within the scope of exemplary campus structures, the United Nations sustainable development goals, internationally accepted campus sustainable evaluation criteria, and sustainable campus performance indicators to ensure campus sustainability; interpreted together with its exemplary architectural structure.

In the procedure of the study, the campus sustainability criteria adopted by each campus are summarized separately as a diagram. The results of the analyzes made according to these parameters of the universities where the sustainability criteria and campus performance indicators determined in the last stage were successfully applied are presented.

3.1 Materials of Sustainable Campus Design

The material of this study consists of a comprehensive literature review, analysis of campus sustainable performance indicators, campus sustainability evaluation criteria and the results of the university campuses where these parameters have been successfully applied.

Tools used to assess the sustainability of campuses are as follows: Universitas Indonesia (UI) GreenMetric World University Ranking, International Alliance of Research Universities (IARU), Greening Universities Toolkit V2.0, Sustainability in

Higher Education (AASHE) and STARS a Program of AASHE, The International Sustainable Campus Network - ISCN, LEED V4 for Educations.

These tools should be used to determine the key performance indicators (KPI) used in the evaluation of the sustainability of campuses. One of the most frequently used indicators for sustainable campus evaluation is included in the Guidelines of UI GreenMetric World University Ranking, which consists of six categories and a total of 33 indicators. Universitas Indonesia is a reference world university to evaluate and compare campus sustainability efforts. (UI GreenMetric World University Ranking, 2014)

The UI Greenmetric World University Rankings is the first attempt to rank the sustainable behavior of universities globally. (Grinsted, 2011) UI Greenmetric proposes a set of KPI to evaluate the sustainable campus. These indicators are presented below:

1. ***Setting and Infrastructure:*** open space area/total area**,** open space area/total people**,** area on campus covered in forested vegetation**,** non-retentive surfaces/total area**,** sustainability budget/total university budget.
2. ***Energy and Climate Change:*** energy efficient appliances usage, renewable energy usage policy, total electricity use/total people, energy conservation program, green building, climate change adaptation and mitigation program, greenhouse gas emission reduction policy, smoking area policy on campus, sustainable food program campus.
3. ***Waste:*** recycling program for university waste, toxic waste recycling, organic waste treatment (garbage), inorganic waste treatment (rubbish), sewerage disposal, policy to reduce the use of paper and plastic on campus.
4. ***Water:*** water conservation program**,** piped water.

5. Transportation: total cars entering/total people, total bicycles/total people, transportation policy on limiting vehicles on campus, transportation policy on limiting parking space, campus buses, bicycle and pedestrian policy.

6. Education: sustainability courses/total courses, sustainability research funding/total research funding, sustainability publications, sustainability events, sustainability student organizations, sustainability website.

Analytical Hierarchy Process (AHP) methodology is applied to evaluate key performance indicators more concretely. In this way, it is thought that the proposed KPIs may be more effective in improving the sustainable campus performance of universities.

Analytical Hierarchy Process (AHP) methodology;

Level 1- Sustainable Campus Performance Indicators with Sub-Indicators

Level 2- Campus Sustainability Criteria

Level 3- Sustainable Campus Action Plan

In our study, we will create our sustainable campus criteria by determining our own campus performance indicators to be used in the evaluation of sustainable campus designs in the light of this information. In the next stage, we will determine under which indicators architects are involved in this process. Finally, we will determine the sustainable campus indicators of the EMU campus, examine its sustainability potential and present suggestions.

3.2 Methods of Sustainable Campus

In the study, a detailed literature review has been carried out to understand the university sustainability criteria and campus sustainability practices in a better way. This review includes the backgrounds of sustainable campuses in terms of the development of sustainable policies in educational constructions. (Hamon et al., 2016)

The ethical responsibilities of universities, which have the duty of being both educational institutions and research centers, for the international interest in environmental problems reaching universal dimensions and the institutional solutions taken for these problems are summarized.

In the following parts of the study, campus sustainability assessment tools, which are effective in sustainable campus practices and are widely used by universities in the world, have been brought together. These tools have been analyzed in detail from the development stage until the indicators were formed.

The universities included in the study have been selected according to their achievements in campus sustainability indicators; and the sustainability criteria of these universities have been reviewed. These universities aim to be models for the development of sustainable campuses with their efforts of sustainability. After each evaluation criterion is explained in light of the data obtained in the literature review, the sustainable indicators of the universities that have adopted the relevant criteria have been explained.

All the studies of the selected campuses must be reported in accordance with the sustainability policies and they must have a KPI to document their sustainability processes. Evaluations should be made to determine the effectiveness of the measures taken for a sustainable campus. In this context, the 3-stage approach of KPI consisting of 6 sub-categories should be used as an example, but should not be used in the same way. With this approach, the action decisions are reviewed and the opportunity to report the results of the sustainability plan is provided. If an institution uses a KPI for the control phase, necessary information is obtained in this way. Additionally, it becomes possible to predict the sustainability performances of campuses and evaluate their outputs in the light of concrete data.

As a result, the criteria are chosen from among the most widely used throughout the world in the documentation and reporting of sustainability initiatives. Each of the selected campuses is among the members of the evaluation criteria programs considered in the evaluation of them. Each criterion has been examined together with the studies of the universities and the collected information has been evaluated by meta-analysis. The indicators used in the evaluation procedure are:

KPI; *Setting and Infrastructure, Energy and Climate Change, Waste, Water, Transportation, Education.*

The last stage of the study is considered as the starting point for sustainable campuses. At this stage, the indicators have been summarized and the campuses has been evaluated based on the selected evaluation criteria. Within the scope of sustainability criteria and sustainability indicators of a university, a critical evaluation has been made regarding the real sustainability success.

Chapter 4

SUSTAINABLE CAMPUS INDICATORS ASSESSMENT TOOLS, COLLABORATIONS, AND RANKING SYSTEMS

With the broadest definition, an indicator can be defined as a parameter that provides information about the state of a phenomenon, explains and measures the situation. (Sahely et al., 2005; Delzeit et al., 2009)

According to the analysis of sustainability assessment and definitions of sustainability indicators, it can be concluded that sustainability assessment is related to the assessment process, while measurements of sustainability indicators are concerned with the "technical" aspects. These features enable evaluation and indicators to complement and reinforce each other.

These parameters have significant benefits for the process, as they contribute to the solution of problems related to interpretation and influencing, as well as problems related to the difficulty of constructing information. Despite that, from a methodological perspective, these two concepts share a number of concerns. Although there are several international efforts to measure sustainability, only a few of them have a holistic approach that takes into account the environmental, economic and social aspects of it. In most cases, the focus is on one of the three directions. While it is said that they can complement each other, the issue of sustainability is more than simply bringing together important issues. Sustainability is also about the

interconnections of these subjects and the dynamics developed within the system. A clear formulation and implementation of indicators allows them to become more understandable and acceptable. Indicators are used to control the sustainability process by creating sustainability criteria and to make concrete evaluations. In addition to this, indicators can provide quantitative measurement and qualitative evaluation of the impact of people's habits and behaviors on nature. (National Research Council of the National Academies, 2010)

It should be noted here that organizations use sustainability limits and sustainability standards as two different concepts as "*sustainability criteria*" and "*sustainability indicators*". While some sustainability criteria consist of measurable indicators, some criteria may not include indicators. (Biomass Technology Group (BTG), 2008) Indicators that make the criteria more understandable and applicable should not contradict the sustainability goals and targets. They should also ensure that the criteria are more interactive and sustainable. At the stage of determining the criteria, a lot of information should be collected and the actions should be monitored repeatedly. Indicators should have a peripheral view. Also, they also should both have a basis and environmental problems reaching global dimensions (such as global warming, water scarcity, extinct generations) should be taken into account.

For the purpose of making a comparative sustainability assessment for higher education institutions, first of all, a theoretical model should be created by analyzing the existing campus sustainability indicators.

In general, indicators are expected to have the following features: (National Research Council of the National Academies, 2010)

- Having a realistic approach for the process and its functions,
- Being sensitive about the evaluation of the changes that are experienced or

likely to be experienced during the changing process,

- Measurable in terms of process (i.e. time) and economic (i.e. financial viability),
- In practice, being understandable by everyone involved in the process and being relevant to sustainability.

All of the key indicators are based on common measures and practices determined for sustainability. (Veleva et al., 2001) In general, the key indicator parameters in sustainability should cover the following features:

- Compliance with the purpose of energy and materials,
- Use of environmentally friendly materials and techniques,
- Being oriented to long-term economic performance,
- Designing the entire process so that its life cycles are ecological

(Veleva and Ellenbecker, 2013)

All of these features should be fully incorporated in the creation and implementation of campus indicator criteria. Following the introduction of simple and practical strategies for compliance and resource efficiency, more complex indicators are also being studied that address the environmental, social and economic impacts of these strategies as well as their impact on the supply chain and life cycle. (Veleva and Ellenbecker, 2001) Different approaches and methods are used in the development and application of indicators. Ultimately, it is necessary to determine how multifaceted indicators reflecting various sustainability goals and targets will address the partial and relative sustainability of different systems as a holistic assessment tool.

According to an alternative view, it is argued that systems should be created within a synergy for an award-oriented competition without relying on a single criterion of performance and the evaluation should be made not only in terms of

quantity but also in terms of quality. One of the key issues in the process is how to implement a single system for the continuous review and evaluation of sustainability targets with criteria and indicators in a legal dimension or within a sustainability standard. The source of concern here is that examinations and evaluations made with different methods may lead to different results and interpretations. (National Research Council of the National Academies, 2010)

However, in the evaluations with a long process, indicators should be more effective and functional. Moreover, according to some researchers, a continuous improvement will be achieved in the system by observing and revising the indicators and applications within the system in a regular way. (Veleva and Ellenbecker 2001) Developing the link between indicators, sustainability criteria and sustainability goals and presenting possible alternatives will guide future studies. (National Research Council of the National Academies, 2010)

For example, criteria for many sustainable campus indicators have been developed, including Universitas Indonesia (UI) GreenMetric World University Ranking, STARS, Greening Universities Toolkit, LEED for Education. Collaborative attempts have been made between different campuses to reach a common denominator in the basic indicators used for measuring campus sustainability. Sustainability in Higher Education (SHE) and International Alliance of Research Universities (IARU) initiatives can be given as examples for these attempts.

United Nations Sustainable Development Goals (UN SDGs)

The concept of sustainable development in education was first brought to the agenda at the United Nations (UN) conference in 1992. (Anderberg et al., 2009). After all international attention focused on this issue at the World Sustainable Development Summit in 2002, the UN declared the years 2005-2014 as the “Decade of Education

for Sustainable Development”. (Sherren, 2008). Higher education institutions play an important role in the international arena at the point of integrating sustainability into business and education. (Djordjevic and Cotton, 2011).

'Sustainability' is understood as minimizing the pressure on the ecosystem (Moore, 2005). The concept of 'sustainability' in current usage covers social and economic conditions in addition to issues related to the 'environment'. (Axelsson et al., 2008; Moore, 2005).

Many definitions of the concepts of sustainability and sustainable development have been made. According to Moore (2005-A), 'sustainable development' is defined as 'meeting the needs of today's people without compromising the needs of future generations'.

According to UNESCO (2002), 'sustainable development' is related to the values and perceptions of individuals and the natural world; It includes the culture of sustainability and how social systems are affected by political, economic and biophysical environments. (Hammond and Churchman, 2008). For this reason, universities are seen as very effective institutions in transforming into a sustainable future (Orr, 2002).

Cortese (1992) states that universities should have great responsibilities in developing knowledge and technology in order to raise awareness for an environmentally sustainable future. Because universities are the most effective institutions in these matters, both with their structural formations and their experiences. (Cortese, 1992).

The United Nations Development Program (UNDP) makes adjustments in areas including poverty reduction, democratic governance, and peace building, climate

change and disaster risk, and economic inequality through its strategic plans to the 'Sustainable Development Goals' that guide its policy and financing.

For this reason, it is aimed to reach the goals determined by the partnership of governments, private sector, civil society, and citizens in order to realize the Sustainable Development Goals in order to leave a better planet for future generations.

Sustainable Development Goals (Transforming our world, 2015)

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security, improved nutrition, and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages.

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

Goal 5. Achieve gender equality and empower all women and girls.

Goal 6. Ensure availability and sustainable management of water and sanitation for all.

Goal 7. Ensure access to affordable, reliable, sustainable, and modern energy for all.

Goal 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.

Goal 10. Reduce inequality within and among countries.

Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable.

Goal 12. Ensure sustainable consumption and production patterns.

Goal 13. Take urgent action to combat climate change and its impacts[1].

Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

4.1 Universitas Indonesia (UI) GreenMetric World University Ranking System

Green Metric, a global assessment system, has been started to be used as a ranking system in 2010 to evaluate the sustainability studies carried out at the University of Indonesia (UI). This ranking system is based on the statements of the participating universities through an online survey for the purpose of evaluating the sustainability programs and policies of the universities according to their statements. After the data submission is completed, the verifiable ones of the sent data are examined and when necessary, proofs of the information are requested from the institutions.

The Green Metric evaluation criteria have been gathered under six main headings and expressed as a percentage according to their importance. These titles and their

[1] Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

percentages are as follows; *Structure and infrastructure (15%), Energy and climate change (21%), Waste (18%), Water (10%), Transportation (18%) and Education (18%).* Six main categories are divided into 51 parameters in total.[2]

Scoring is made according to the fulfillment of the conditions determined in the parameters. Each parameter is scored numerically and these scores are evaluated statistically.

With the Green Measurement system, knowledge and experience are shared among the universities participating in the evaluation. Moreover, the universities are given the opportunity to see their weaknesses and strengths in terms of sustainability.

The important points emphasized in the system can be summarized as follows:

- Unsustainable production and consumption patterns,
- Environmental degradation,
- Promotion of research on sustainability,
- The necessity to include sustainability in the curriculum in all disciplines
- Importance of collaborations (public, governments, non-governmental organizations, private sector, other universities)
- The necessity of doing interdisciplinary studies.

Some of the universities that have adopted the Green Measurement system are: Massachusetts Institute of Technology (MIT), Harvard University, University of Winconsin Oskhosh, Princeton University.

4.1.1 Massachusetts Institute of Technology (MIT)

Massachusetts Institute of Technology is one of the world's best universities on technology and engineering. The university is known for its innovative perspective and academic achievements in the development of modern science, engineering,

[2] https://greenmetric.ui.ac.id/publications/guidelines/2021/english

mathematics, and technology. ("World's 10 most prestigious universities, 2016"; Smith, 2016; Denham, 2013)

Sustainable MIT

MIT has created the Sustainability Office (MITOS) by focusing on the fundamentals of 'climate, buildings, energy and mobility' to carry out its studies to find scalable permanent solutions and to realize its low carbon laboratory campus goals.

The main vision of MIT is to use the campus as a laboratory environment by making use of different fields of expertise, to implement innovative practices in fair and accessible ways and to reduce greenhouse gas emissions.

The main topics that the MIT Sustainability Office (MITOS) is working on Zero Carbon Campus, Climate Resiliency, Material Lifecycles, Healthy People, Thriving Networks. Thus, by using the campus as a laboratory and pilot place, MIT aims to transform it into a powerful model with solutions that produce new and proven ways to global challenges.[3]

Table 2: MIT Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Zero Carbon Campus Climate Resiliency Material Lifecycles Healthy People Thriving Networks	Environmental Economical Social	Goal 5,6,7,9,10,11,13,17	Green Metric	MIT.nano, Building 12

[3] https://sustainability.mit.edu/about

MIT.nano, Building 12

Electron microscopes, sensitive imaging and measurement tools are located in the basement floor of the building, which is fixed with a concrete slab. Wide glass facades connect the two levels with air exchange systems.

The transparently designed building allows researchers working inside to benefit from natural daylight, while allowing campus users outside to monitor the work inside. With its transparent usage features, the building has obtained the LEED Platinum certificate.

Figure 1: The transparent designed building accepts natural daylight throughout the day.

4.1.2 Harvard University

Harvard University, founded in 1636[4] in Cambridge, is a private higher education institution that is one of the world's leading institutions in its field.

Sustainable Harvard University

[4] https://www.harvard.edu/about-harvard/harvard-history/

Emphasis is placed on excellence and interdisciplinary collaboration in researches. The university's main aim is to address global issues such as climate change and sustainability through researches and teaching. Harvard University uses its campus as a laboratory to contribute to finding global solutions by raising a society conscious of sustainability.

The university carries out community-oriented studies by establishing consensus on sustainability and sustainable development with government institutions, private companies and other organizations. Focusing on sustainable development to increase the welfare of society, it has achieved success in five different areas: (Harvard University, 2015)

- In 'Natural Capital' by using natural energy as a primary resource,
- In 'Manufactured Capital' by improving the production performance and infrastructure,
- In 'Human Capital' by balancing the demographic structure and systems,
- In 'Social Capital' by ensuring that the rules are followed by everyone,
- In the 'Knowledge Capital', by conducting all studies with scientific data.

Emissions and energy; campus operations; nature and ecosystems; welfare and culture; health and healthy pleaces; culture and learning are studied as five main topics. A Harvard Sustainability Plan has been prepared, in which each topic is evaluated in three sub-categories as target, standard and commitment. This plan is reviewed every five years. With this study, the development and change over time is evaluated in order to set new targets. (Harvard University Sustainability Plan Fiscal Year 2015 – 2020)

Table 3: Harvard University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Emission and Energy Health and Well being Campus Operations Nature and Ecosystems Culture and Learning	Environmental Economical Social	Goal 3,4,6,7,11,12,13 ,15,17	Green Metric	Esteves Hall Executive Education Residence

Esteves Hall Executive Education Residence – HBS

Esteves Hall Executive Education Residence facility located on the Harvard Business School (HBS) campus has undergone a renovation process to make it a more sustainable, economical and healthy building. Systems such as solar thermal systems, GHG emission strategies, recycling and ASHRAE standards are integrated into the building sustainable design process. For example: landscape areas have been reconsidered in order to reduce stormwater runoff and create a comfortable outdoor area. Upgrades have been made in the building envelope in order to both reduce the energy use and comfort of the building occupants and to meet the high-performance target. With the strategy of daylight and occupancy sensors, energy efficient lighting systems are used to reduce energy consumption. Energy saving fixtures are used in the building. Indoor air quality is met with high efficiency HVAC systems.

The building received LEED Platinum certification for its indoor air quality, user controls, and drinking water protected by an energy-efficient sanitary system design strategy.

Figure 2: Upgrades have been made to the building envelope to meet the high-performance target.

4.1.3 University of Wisconsin Oshkosh

It is the third largest university in Wisconsin founded in 1871[5] in Wisconsin-Oshkosh.

Sustainability University Wisconsin Oshkosh

At Oshkosh University of Wisconsin, the World Charter signed in 2002, which is the first step towards sustainability, is taken into account in all kinds of actions, including research activities, services to stakeholders, social aids, facility operations and management practices.

UW Oshkosh also pledged to consider climate neutrality in all its actions for sustainability by signing the American College and University Presidents Climate Commitment (ACUPCC) in 2007. For this purpose, the first sustainability plan, which was updated in 2014, was prepared. Accordingly, the university is committed to being carbon neutral by 2030.[6]

[5] https://uwosh.edu/about-uw-oshkosh/history10/
[6] https://uwosh.edu/sirt/mission/

On Campus Renewable Energy Generations:

- *Wind Power at the University of Wisconsin Oshkosh*
- *Solar Power at the University of Wisconsin Oshkosh*
- *Biomass at the University of Wisconsin Oshkosh:*
    - *Dry Fermentation Anaerobic Digester (BD1)*
    - *Small Farm Digester (Allen Farms)*
    - *Big Farm Wet Digester (Rosendale Digester)*
- *Geothermal Energy at the University of Wisconsin Oshkosh:*
- *Renewable Energy Purchases at the University of Wisconsin Oshkosh*

Green Buildings at the University of Wisconsin Oshkosh

UW Oshkosh University tries to reduce the ecological impact of the university by constructing LEED Certified green buildings so that the buildings and activities inside them do not affect the environment and people.

Green Purchases at the University of Wisconsin Oshkosh

With LEED certified systems locally produced products and materials that have a minimum negative impact on the environment are selected in building purchase agreements.

Recyclable papers; UWO standard computers with EPEAT Silver or EPEAT Gold certificates at least Bronze level according to Electronic Products Environmental Assessment Tool (EPEAT) and energy star approved devices are used throughout the campus. Mostly, Compact Fluorescent Lamp (CFL) or LED lights are used instead of incandescent bulbs on campus. The green cleaning products used by Reeve Union are preferred for cleaning materials.[7]

Sustainable Transportation at the University of Wisconsin Oshkosh

[7] https://uwosh.edu/sirt/green-purchasing/

UWO aims to minimize the carbon impact of vehicles and achieve financial savings by providing alternative transportation options in and around the Campus. For this purpose, E-85 compatible vehicles have been used instead of old-style campus transportation vehicles since 2006. With the fuel change in all vehicle and equipment fuels working with diesel, a 10% biodiesel fuel mixture system has been adopted.[8]

Table 4. Wisconsin Oshkosh University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Food&Dining Energy Green Building Grounds Green Purchasing Milestones and Awards Transportation Waste Reduction Water	Environmental Economical Social	Goal 3,4,5,9,11,12,13,17	Green Metric	Sage Hall

Sage Hall

The project achieves 10% savings with the use of on-site renewable resources, and 30% savings thanks to the use of low-tech light shelves that reflect light to provide soft light, automatic blinds that regulate the intensity of the light, and natural lighting. A total of 47.1 kW of electrical energy is provided by 188 fixed-mounted photovoltaic cell panels located on the roof of the building. In addition, 70% of the building's hot water needs are met with the 60 roof solar energy panel system on the roof of the building. The greenroof of the building, which can hold 6192 gallons of water with its 5,203 square feet area, filters the rain water and reduces the flow volume and speed of

[8] https://uwosh.edu/sirt/transportation/

the water. With this system, it also provides insulation in winter and evaporative cooling in summer. The water quality is improved by reducing the flow volume and speed with the bioswales ground systems that hold the rain water in the building landscape. Building materials with low volatile organic compounds (VOCs) are used in the building.

Figure 3: Bioswales floor systems that retain rainwater.

4.1.4 Princeton University

It is a private Ivy League[9] research university founded in 1746[10] in New Jersey, USA.

Campus Sustainability Plan

Princeton University first prepared its Campus Sustainability Plan in 2008 with the aim of bringing together campus stakeholders and practicing within the scope of sustainability. At the same time, it accepted the campus as a living laboratory and

[9] Includes universities with social elitism, aiming for excellence in academia and adopting a selective application approach. It is the largest university in the world, allowing universities to provide resources for their academic programs, financial aid, and research efforts.
[10] https://www.princeton.edu/meet-princeton/history

aimed to develop it with pilot applications, social assistance, creative solutions, and communication initiatives.

Energy Field at Princeton University

16,500 photovoltaic solar panels of 4.5 megawatts each were installed at the 27-acre Princeton University in 2012. With the energy provided here, approximately 6% of the total annual electrical energy need of the university is met. Electricity production stages and data are open to everyone throughout the academic year.

• *Net Zero Target for Greenhouse Gas Emissions:* "Greenhouse Gas Reduction Decision Making Criteria" was developed at the university. The carbon emission reduction targets for 2020 was achieved with active CO2 duty elements, efficient central installation, ground source heat pump (geo-exchange) system, a $45 million investment in existing building improvements by the 4.5-megawatt on-campus photovoltaic array. (Sustainability Action Plan: Toward 2026, 2019)

• *Geo-exchange Resources at Princeton University:* It is aimed to increase energy efficiency with the system established with several ground source heat pump (geo-exchange) wells created on the campus.

The roadmap drawn in order to reach the targets set in university carbon emissions until 2046 is as follows: (Sustainability Action Plan: Toward 2026, 2019)

- To implement the greenhouse gas emission budget of approximately 1,750,000 tons of CO2 determined for the operations within the campus.
- To reduce greenhouse gas emissions until 2046, considering the negative effects of greenhouse gases on the climate.
- To achieve GHG emissions neutrality through the adoption of both technical and behavioral solutions.
- To incorporate innovative technology, approaches and initiatives that provide

savings across the campus.

- *Lighting Improvement at Princeton University*
- *Reducing Water Use at Princeton University*

Princeton University Building Planning Practices:[11]

- With Lakeside Apartments meeting high sustainability standards; LEED Silver certificate, 701 Carnegie Center and High-Performance Computing Research Center LEED Gold certificates were obtained from the US Green Building Council.

- Princeton University has been using the Life Cycle Cost Assessment (LCCA) application since 2008 to make decisions during the building planning process and measure its internal carbon pricing strategy.

- The Lakeside Graduate Housing complex has the LEED Silver Certificate, Bicycle and public transport, walking, roads connecting to the campus, bicycle storage are encouraged with TigerTransit service stops. In addition, applications such as selected sustainable materials, energy efficient lighting and controls, storm water management, Energy STAR devices, geothermal heating and cooling, low flow plumbing fixtures are also included in this complex.

- Indoor bicycle parking spaces and routes for alternative public transportation options such as bus and train stations. The project has many sustainable features such as green roof, rainwater management, use of sustainable materials, daylight saving, geothermal heating and cooling systems.

The Princeton Index for Land Use and Ecological Assessment:

A habitat quality assessment tool, the Princeton Land Use and Ecological Assessment Index (PILEA), has been developed to conduct land use planning, inform on ongoing management practices and monitor progress. Perennial natural plants are

[11] https://sustain.princeton.edu/sustainability-action-plan/design-develop

used, water-saving green cover is designed, and the infiltration of rain water into the landscape is encouraged by reducing the use of synthetic chemicals with the administrative staff, students and academic staff. Efforts to eliminate invasive species contribute to the improvement of the ecological balance. With the studies carried out, pesticides used in landscape management have been reduced by 39% and water quality and human health have been improved.

Construction and Demolition Recycling Program: With the study carried out by William Bausmith, 95% savings from construction waste are achieved by recycling the construction and demolition debris of new and renovated buildings. In order to promote social and environmental sustainability in the procurement of goods and services and the supply chain in 2008, Princeton University does the following; Purchasing 92% of electronics from EPEAT® Gold registered products, increasing the purchase rate of paper from the 100% recyclable category to 88%, providing approximately 44% of all food in cafeterias from local producers, purchasing 66% of cleaning equipment from the products certified with Green Seal®. (Sustainability Action Plan: Toward 2026, 2019)

Table 5: Princeton University sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
GHG Emissions Water Usage Stormwater Management Design& Develop Healthy Habitats Alternative Communing Purchasing& Waste	Environmental Economical Social	Goal 3,6,7,12,13,15,16,17	Green Metric	Arts and Transit Project

Arts and Transit Project Building

The Arts and Transportation Project is a project that supports academic programs in buildings, theatre, dance, visual arts and music with new teaching, rehearsal and administrative spaces.

Among the most striking features of the building are the rainwater management system made using green infrastructure, the sustainable use of most of the materials used, the active use of daylight, the use of the Geo exchange system in heating and cooling, the active green roof system, the use of high-performance exterior installation.

Figure 4: High performance exterior design.

4.2 International Alliance of Research Universities (IARU)

IARU is a campus sustainability program created with the aim of reducing the environmental impact of campuses. The member universities serve as a part of sustainability with their sustainable solutions and basic initiatives for climate change.

The program works on the development of a series of global education initiatives aimed at fostering feelings of global citizenship and leadership among students. In addition, the global summer program, sustainability scholarships and internships are intended to provide opportunities for students to interact critically as global citizens.

IARU connects universities with various tools and methods such as project organization, equal opportunity, technology transfer, technology enhanced learning, research management, and open access libraries. Furthermore, institutional partnerships between member universities are encouraged by supporting institutional learning and staff development. Criteria: (IARU Green Guide for Universities, 2014) *Sustainable Campus Organization, Campus-Wide Operations, Buildings, Laboratories, Green Procurement, Transportation, Communication, Participation of Employee and Students, Universities as Catalysts for Sustainable Society.*

4.2.1 Australian National University

ANU, founded in 1944[12] in Australia, is among the world's leading higher education institutions.

The issues such as research, experience, national and international policy are at the center of every work done at ANU. Over time, with these studies, ANU has become a resource that explores the most important questions facing society, and today it is among the top 100 universities in the world.

Examples for Sustainable Enterprise:

• *Organic Waste Recycling:* Thanks to the ANU organic waste recycling program established in 2007, approximately 136 tons of food and biological waste are removed from landfills every year. These wastes turn into a high-quality compost used in vegetable gardens and campus landscaping. Although it is called an activity, the collection of a significant portion of food waste in cafeterias; It is the cooperation between the services unit and the student dormitories. A small part of the unusable organic matter is collected from the research areas and turned into a rich compost. For this purpose, a large onboard composting unit is used for an aerobic process. Thus, a

[12] https://www.anu.edu.au/about/our-history

sustainable method is used, which ensures the complete elimination of large amounts of methane and other greenhouse gases produced during the decay phase of materials. (ANU Green Precinct Project Final Report)

• *Six-Star Green Rating Design:* Fenner School for Environment and Society, located in the Frank Fenner Building at the Australian National University, was built to achieve a six-star green rating beyond its design purpose. To achieve zero net kg CO production, energy and water saving initiatives have been incorporated into the design. In this context, approximately 80% of building demolition and construction waste has been recycled; a 40kw solar photovoltaic array capable of producing more than 65000 kWh per year and a system where the surplus is fed back to the grid has been installed; hybrid air conditioning units have started to be used. In addition, passive ventilation supported by the traffic light system and operable windows has been preferred, high quality insulation materials, including double-glazed windows, have been preferred; external shading has been made, rainwater collection tank systems have been installed; efficient plumbing systems have been used.

Table 6: ANU Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Research& Innovation Education& Experience Achieving Equity Engagements Buildings	Environmental Social	Goal 4,5,6,16,17	IARU	The Frank Fenner Building

Frank Fenner Building

The Frank Fenner Building opened in 2011 as an integrated environmental research and education center, built to high sustainability and energy efficiency standards.

The main features of the building are:

Roof photovoltaic solar panels: A large part of the electricity of the building is met by the photovoltaic system consisting of 142x240W solar panels placed on the roof.

Water recycling: All waste water is recycled with systems that recycle water in water tanks placed on the roofs of buildings and are used in landscape irrigation and in areas such as toilets.

Sun orientation: Most of the occupant's lighting needs are provided by natural daylight, which is naturally taken into the building.

Low carbon emissions: The building meets its low carbon emissions by using equipment that complies with Green Star standards.

Efficient thermal façade: Building insulation techniques are used to ensure building efficiency.

Air flow and ventilation: A savings of 150% above the current Australian standard is achieved with the amount of outside air supplied to the building through the ventilation provided with the outside air.

Interiors with minimal gas emission: The use of materials with low 'volatile organic compounds' reduces gas emissions from materials and pollutants.

Figure 5: Carbon Neutral Building.

4.2.2 ETH Zurich

ETH Zurich University was founded in 1854 by the Swiss Confederation under the Swiss Federal Ministry of the Interior. In 1855[13], it started to provide education with 6 departments.

According to IARU reports, some of the successful works of ETH Zurich University on becoming a sustainable campus are as follows:

Energy Network of ETH Zurich: With the aim of reducing fossil fuel consumption in a significant way, a new energy concept has been developed that reduces the specific energy intensity in the region and accordingly the CO emissions.

For this purpose, the energy flows in the buildings; for example, (technical and structural reduction scale) is configured to efficient heat recovery systems. At ETH Zurich's Hönggerberg campus, it is aimed to minimize fossil-based energy consumption and put an end to fossil fuel consumption with a dynamic underground storage system by 2025. Underground storage areas have been established on the campus to ensure the most appropriate energy storage and use. In addition, 100 to 200

[13] https://ethz.ch/en/the-eth-zurich/portrait/history.html

geothermal systems per site have been laid on a 5x5 meter grid at 200 meters depth. The energy needs of buildings are provided through main centers connected to the ring network. During peak periods (winter/summer), heat pumps used to generate and process heat in conventional energy production are operated in this center.

Life Cycle Cost Analysis at ETH Zurich: In ETH Zurich's Building and Construction Infrastructure Department, during the planning, construction and operation of buildings, the 'Triple Outcome Line', which includes all the variables of environment, society and economy and deals with the sustainability of its buildings holistically, is used.

Table 7: ETH Zurich Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Wide Operations Buildings Communication	Environmental Social	Goal 3,4,7,8,9,11, 12,13,14,16, 17	IARU	HIF Building

HIF Building

The HIF building complex, the home of the civil, environmental and geomatics engineering department, is available with the aim of obtaining various Swiss energy labels, such as the minergie-eco label, the GI Approval of Approval (good indoor climate) and an SGNI certificate (Swiss sustainable building council) by redevelopment. The building frame was removed and a transparent shell was created in its place. The renovated façade, with rear-ventilated wood panels, serves as a shell for laboratories and offices. The façade, supported by glass panels, also functions as photovoltaic. A comprehensive preliminary planning and cost analysis was created using the BIM system and working methodology during this entire design phase. Thus,

the architectural project of the building was structured in a virtual environment with BIM management and coordination, thus creating a commercial basis for pre-planning.

Figure 6: The concrete cylinder that encloses the centrifuge was already placed in August 2020.

The HIF renovation and expansion will be planned using building information modeling (BIM) and is considered a pilot project in this respect at ETH Zurich.

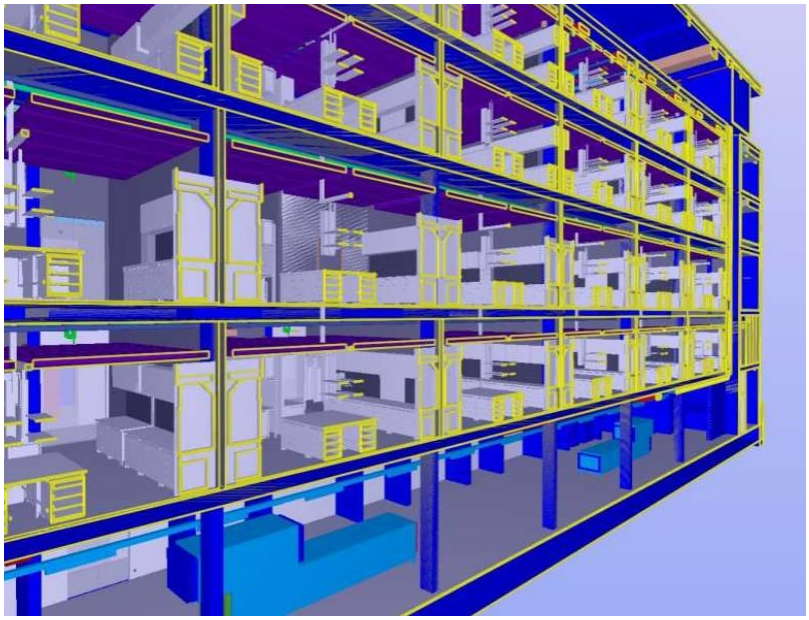

Figure 7: As a pilot project at ETH Zurich, the HIF renovation and extension will be planned using information modelling. (BIM).

4.2.3 National University of Singapore

National University of Singapore, founded in 1905 [14]in Singapore, is the country's oldest and largest research university.

• *Built Environment at NUS*

The university where the building construction authority is used and the green sign plan is implemented, has been certified with 18 buildings/regions, 7 of which are platinum-level.

It is aimed to upgrade the Green Mark certificate to the GoldPlus standard by using air conditioners with higher standards in all large buildings (GFA > 10,000 m2). Thus, it is aimed to reduce the carbon emissions of the university by ensuring the energy resource efficiency, which is an obligation for the certificate.

• *Energy at NUS*

For the purpose of reducing energy consumption on campus and increase energy efficiency, an Energy Task Force consisting of University Campus Infrastructure, Site and Development, Security, Health and Environment, Housing Services and Environmental Sustainability Office representatives has been formed. These people are informed about energy efficient and efficient buildings. Studies and initiatives are carried out to raise awareness about the use of new technologies and energy.

Within the scope of other energy efficiency initiatives, studies are carried out to convert cooling vehicles, elevators and street lighting in faculties to more efficient LED types.

[14] https://www.nus.edu.sg/about/founded-by-the-community

• *Water at NUS*

All new buildings have been brought into compliance with Water Efficient Building standards set by PUB, the institution where water related studies are carried out in Singapore.

• *Buildings at NUS*

Buildings built in 2010 and before on campus are certified according to WELL standards.[15]

• *Recycling at NUS*

The campus financial recycling rate for 2020 was recorded as 30%. This rate is targeted to be 90% by 2030. For this reason, studies about alternatives for recycling waste, including used posters and electronic waste continue.

• *Sustainable Learning / Education at NUS:*

In 2013, 30 NUS students from four different faculties participated in the Solar Decathlon Competition held in Datong, China, and designed a solar-powered prototype house. The house, which is suitable for urban and tropical living space, provides an example of innovative and sustainable design solutions on an international learning platform. It presents information on the system that will enable the permanent deployment of sustainable design and innovative technologies in the tropics.

[15] The WELL Building Standard is a system for measuring, validating and monitoring the properties of the built environment that affect human health and well-being through seven key areas: air, water, nutrition, light, wellness, comfort and mind. https://www.gbrionline.org/what-is-well

Table 8: NUS Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Carbon Emissions Energy Management Water Management Waste Minimisation and Recycling Built Environment Green Spaces(in buildings) Engagement and Outreach	Environmental Economical Social	Goal 4,5,6,7,12,13	ISCN	School of Design and Environment SDE4

School of Design and Environment

This addition to the School of Design and Environment building at the National University of Singapore is a successful example of net zero energy buildings (NZEB) in the tropics. During the construction phase of the five-storey building, optimization was made to the building in order to facilitate lateral ventilation and benefit from natural light. An innovative hybrid cooling system has been designed to replace traditional approaches to air-conditioning, ensuring that rooms are not over-cooled.

Most of the annual energy demand of the building is met by 1225 solar panels located on the roof of the building. The system is based on feedback and unused energy is stored.

Figure 8: Lateral ventilation and natural light used during the construction phase of the building.

4.2.4 University of California, Berkeley

The University of California, was founded in 1868[16] as the state's first land-grant university. The university's first campus is in Berkeley. As a founding member of the Association of American Universities, Berkeley has several leading research institutes, including the Mathematical Sciences Research Institute and the Space Sciences Laboratory.

Sustainable Campus Leadership at UC Berkeley

Comprehensive and successful studies on sustainability are achieved through efforts on zero waste curriculum, environmental justice, toxin reduction and climate action.

The UC Berkeley Campus works to develop its Silver-level WELL-certified areas. For this purpose, single-use or reusable materials are evaluated gradually, since there are no recycling bins in the buildings. In addition, efforts are being made to ensure that all food vendors throughout the building adhere to zero waste practices. (Annual Report on Sustainable Practices, 2019)

[16] https://150.universityofcalifornia.edu/#timeline

UC Berkeley Energy Management Initiative (EMI)

With the aim of promoting energy conservation efforts across campus, UC Berkeley focuses on programs that drive financial savings, such as the New Energy Management Initiative and Incentive Program.

It became a part of the daily operations of the university and a social norm. (Energy Management Initiative (EMI) Annual Report, 2013)

The Campus Energy Management Initiative does not just save energy. This initiative, which has caused a reduction of 1,500 tons in greenhouse gases, is a tool that succeeds in restoring the funds obtained to teaching and research.[17]

Table 9: California University Sustainability Berkeley Campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Wide Operations Communications Climate Resources and Recycling Employee and Student Engagements	Environmental Social	Goal 2,3,4,6,7,10, 11,12,13,14, 15,17	IARU	Jacobs Institute for Design Innovation

Jacobs Institute for Design Innovation

Aiming to accommodate up to 2,000 students each term, the program includes flexible design studios, project rooms, support areas and manufacturing equipment rooms with a variety of rapid prototyping tools and equipment.

Design & Innovation

[17] www.mypower.berkeley.edu

Modeling high-density/low-carbon living and learning in areas that support architecture, project-based learning, rapid prototyping, and manufacturing, the Jacobs Institute's mission is to encourage the role of design in engineering education to create innovative solutions to society's biggest problems with its users. A holistic design approach has been adopted, including integrated energy systems, high performance coatings and assisted photovoltaic array systems.

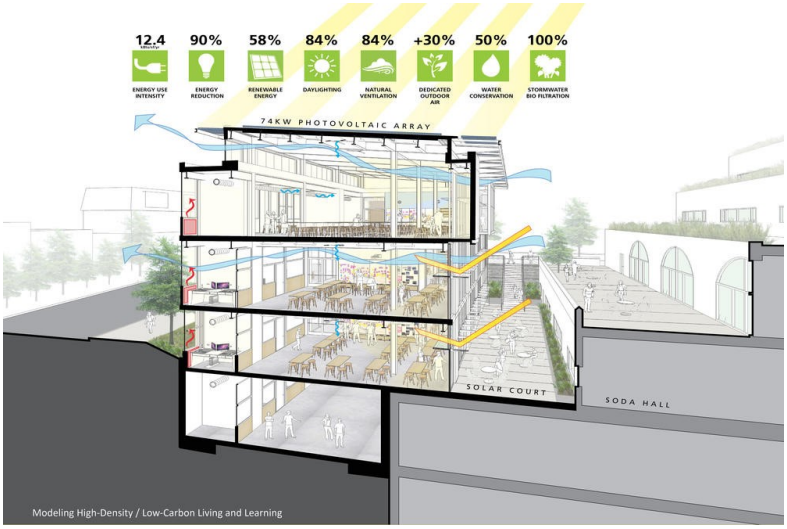

Figure 9: The project models highdensity / low-carbon living and learning.

Bioclimatic Design

The building is oriented on an east-west axis to provide optimum solar energy. Thus, a wind-protected and sunny courtyard is created in the south, while passive solar heating, daylight, natural ventilation and continuous indoor/outdoor building access are increased on the first floor. By creating a building mass with efficient compact features in the ratio of surface-to-floor area, thermal transfer is provided by ceilings, natural ventilation and daylight. External factors are managed with a highly insulated

high performance building envelope system with external insulation, rain screen cladding and integrated sunshade on three facades.

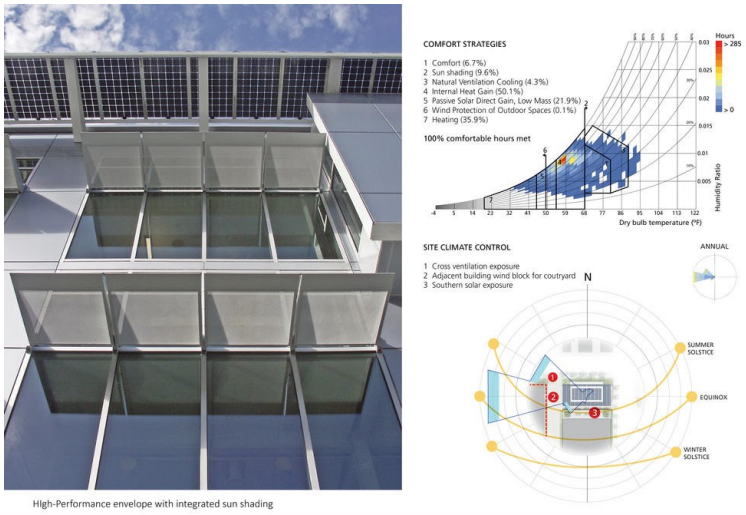

Figure 10: The building is oriented for maximum solar and natural ventilation benefit.

Light&Air

Although the building is located on a narrow ground, it uses daylight at optimum levels with its shaded facade systems towards the south. Biophilic benefits of daylight are used in building designs to keep public spaces alive all day long. All areas above the basement of the building, which are open to the prevailing winds, are naturally ventilated. When the windows are closed, fresh air is provided to the building by mechanical ventilation (30% more outdoor air than ASHRAE standards). With VOC-free paint, adhesives and sealing materials to ensure indoor air quality. Formaldehyde-free materials are used.

Energy Flows & Energy Future

In places where extra lighting is required, the need for extra interior lighting is met with efficient fixtures. With the specially designed cantilevered photovoltaic array, most of the building's energy needs are provided by renewable energy.

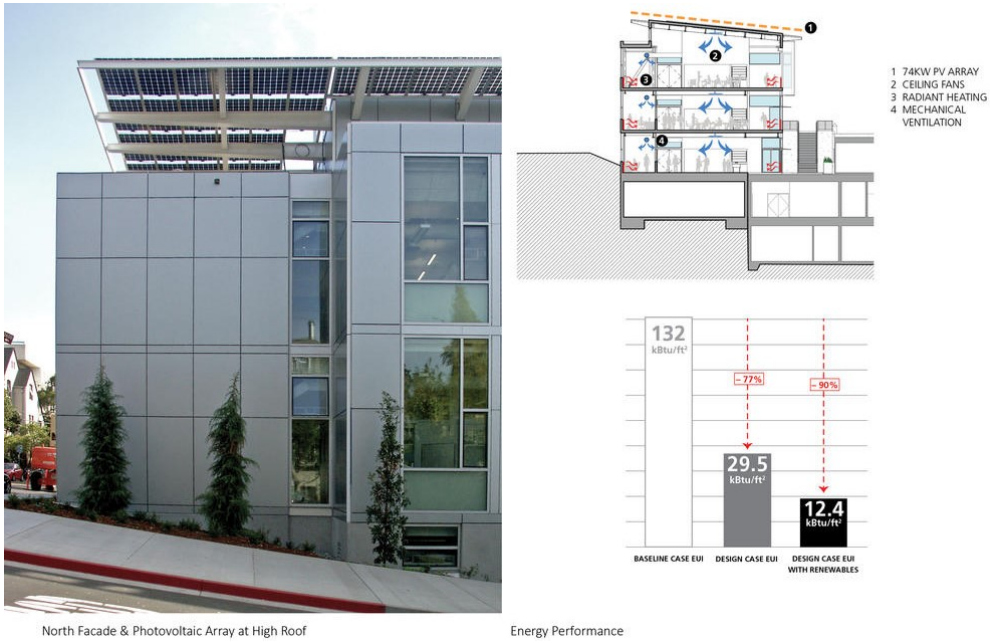

Figure 11: The project exceeds the AIA 2030 Commitment target, using 90% less energy than the national median for university buildings per EPA Target Finder.

4.2.5 University of Cambridge

The university, which provides undergraduate education, consists of 31 autonomous colleges and 150 departments. Founded in 1209[18], Cambridge University collaborates with its researchers and colleagues from around the world to establish large-scale partnerships.

[18] https://www.cam.ac.uk/about-the-university/cambridge-at-a-glance

Ranking of Importance at the University of Cambridge

Since 2014, the university has been giving priority to environmental sustainability.

Nine environmental sustainability impact areas are identified as the focus of Environmental Sustainability Policies and Strategies. Progress is also reported on these areas:

1. *Energy and carbon:* Reducing carbon emissions while supporting the university's development plans

2. *Water:* Conserving water through efficient use and management.

3. *Biodiversity and ecosystems:* Being a global leader in limiting adverse impacts and, where possible, in biodiversity and natural ecosystems conservation and food safety research

4. *Waste:* Minimizing and actively managing waste through disposal, reduction, reuse and recycling.

5. *Sustainable procurement*: Affecting the sustainability performance of suppliers and the sustainability references of purchased goods and services in a positive way.

6. *Sustainable construction and renovation:* Reducing the environmental sustainability impacts of the construction and renovation projects.

7. *Travel and transport:* Contributing to the reduction of carbon emissions by providing viable and accessible sustainable travel options for staff and students for travel to work and business travel.

8. *Environmental sustainability in teaching and research:* Undertaking sustainability-related researches, using the data of these studies in applications,

ensuring that all staff and students have access to formal or informal opportunities that enhance their knowledge, skills and understanding of sustainability.

9. *Partnership and participation:* Ensuring that staff and students effectively contribute to the achievement of the University's sustainability targets, creating opportunities where they can develop and share their knowledge and experience and to developing formal and informal cooperation partnerships with regional, national and international stakeholders.

The mission of the program is to deepen sustainability in social, environmental and economic contexts and to carry out sustainability studies in a way that will benefit society. Thus, the university's mission to provide teaching at the highest international level is supported by a lifelong learning vision and strategy. This system, which works with senior managers to provide information to the decision-making processes of other organizations, also contributes to the development of more economical and more politically sustainable systems.

Table 10: Cambridge University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Wide Operations Laboratories Sustainable Society Climate Resources and Recycling	Environmental Social	Goal 2.3.4,5,6,7,9,11, 12,13,14,15,17	IARU	University Library

University Library

One of the original Pilot Buildings for the Energy and Carbon Reduction Project (ECRP), the University Library (UL) has one of the largest carbon footprints of any

University building and is also one of the largest single buildings in terms of floor area. On university grounds. As one of the world's most important repository of records, most archives require close proximity control, which consumes a significant amount of energy.

In the University Library (UL), which has the largest carbon footprint among university buildings, seven different chillers were created with the support of the Employee Expense Reduction Program (ECRP). System operation is controlled by the Building Management System (BMS).

Figure 12: Carbon Neutral Cambridge University Library.

4.2.6 University of Cape Town

Founded in 1829, the University of Cape Town (UCT) is among Africa's leading universities (QS, THE, Shanghai-JT rankings) with a 'tradition of academic excellence'.

A great deal of work is being carried out at the university to expand its contribution to the indigenous knowledge base for tackling Africa's development challenges. With these studies focusing on critical challenges such as climate,

Development, Poverty and Inequality, UCT has become a center for astronomy and astrophysics research in Africa.

Sustainability at UCT

The University of Cape Town (UCT) has the world's leading research centers as well as the various faculties and departments that make up these centers. The University is among the universities that have adopted national and global sustainability targets and the UN Sustainable Development Goals (SDGs).

Sustainability Activities at UCT:

- Benefiting from natural daylight in all indoor and outdoor environments, ensuring everyone's access to natural air flow; limiting the use of toxic and harmful products in these environments.

Reducing UCT energy consumption; supporting the net zero policy for carbon emissions, water consumption and waste by 2050 with long-term practices and stakeholder partnerships. (UN goals-Paris Agreement)

- Conducting green campus actions through initiatives such as walkability and fossil-free mobility, biodiversity, digital and data connectivity, sustainable food and sustainable supply.

- Making investments that provide a stable decrease in fossil fuels by giving priority to participation and social sensitivity.

Participation and Social Awareness:

- UCT aims to increase the number of campus users who take an active role in sustainability on and off campus and participation in the green movement. In this sense, it continues to be involved, formally or informally, in organizational strategic partnerships across societal dimensions. (IARU, ISCN, WWF, Green Council SA, Greenpop and acuho-i etc.

Green Buildings

UCT uses the Green Star Standard in the buildings constructed in recent years. It also has a 4 Star Green Building Policy approved by the Green Building Council South Africa (GBCSA):

'UCT buildings certified as green buildings by GBCSA; New Classroom, Upper Campus (2017); GSB Conference Center, Avenue Road Student Dormitory, the Middle Campus (2020).'

Table 11: Cape Town University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Wide Operations Laboratories Sustainable Society Climate Buildings Resources and Recycling Participation and Social Awareness	Environmental Social	Goal 2.3.4,5,6,7,8,9,10,11,12,13,14,15,17	IARU	**Graduate School of Business (GSB) Conference Center**

<u>The University of Cape Town's Graduate School of Business (GSB) Conference Center</u>

In line with UCT's energy and water efficiency strategies, the building has a building management system, LED lighting, energy efficient fixtures, waterless urinals, gray water treatment system, waste management and recycling facility, motion sensor lighting and ventilation in order to actively control the effectiveness of its services. have systems.

With all these features, the building has obtained the 4-Star Design and 4-Star Public and Education Building v1 Design certificates issued by the South African Green Building Council, which are required for all new UCT building projects for the site.

Figure 13: 4-Star Design and 4-Star Public and Education Building v1 Design certificates

4.2.7 University of Copenhagen

Founded in 1479[19] in Copenhagen, Denmark; University of Copenhagen is the country's second oldest university. Considered as the best university in Scandinavian countries and Europe, the university has focused on resource consumption, climate and climate responsibility in research and education in the field of sustainability since 2008.

Themes and Approaches to Sustainability

New solutions, initiatives and actions on sustainability issues are developed by incorporating up-to-date information and technology into research. Climate and environmental impact are evaluated in the product and consumption lifecycle

[19] https://about.ku.dk/profile-history/history/

perspectives. These concepts are handled from a holistic perspective where behavior, participation and co-creation are accepted, and students and academics are included in the process. (Knowledge and Responsibility, Sustainable Institution 2030, 2021)

General Campus Targets of UCPH

UCPH aims to achieve its targets by 2030 through different initiatives and actions. It has national and global targets regarding sustainability including issues such as climate, resources, chemistry and biodiversity. In the process of global information sharing, problems with special importance can be added to the process.

'UCPH's main target is to reduce the overall climate footprint by 50% by 2030.'

Other UCPH sustainability actions focus on chemistry, biodiversity, participation and behavior. (Knowledge and Responsibility, Sustainable Institution 2030, 2021)

Collaboration and Global Knowledge Sharing at UCPH

Climate: UCPH's climate target covers CO2-eq2 emissions on a global scale. It focuses on the most critical areas by taking responsibility for the real impact of climate, with a life-cycle-based and holistic perspective.

The University aims to achieve success by continuously evaluating the development and solution methods in CO2-eq emissions until 2030.

Table 12: Copenhagen University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Resources and Recycling Chemistry Biodiversity Involvement, Participation and Behaviour Collaboration and Global Knowledge Sharing	Environmental Social	Goal 2.3.4,5,6,9,11,12,13,15	IARU	Maersk Tower

Maerks Tower

Maersk Tower is a research center with technological equipment. The building offers a campus environment open to everyone with its relationship with its surroundings, its architectural design and the wide landscape it covers within the urban fabric. With its large transparent building envelope systems, it provides a relationship between the user and the landscape, as well as between the city and the building.

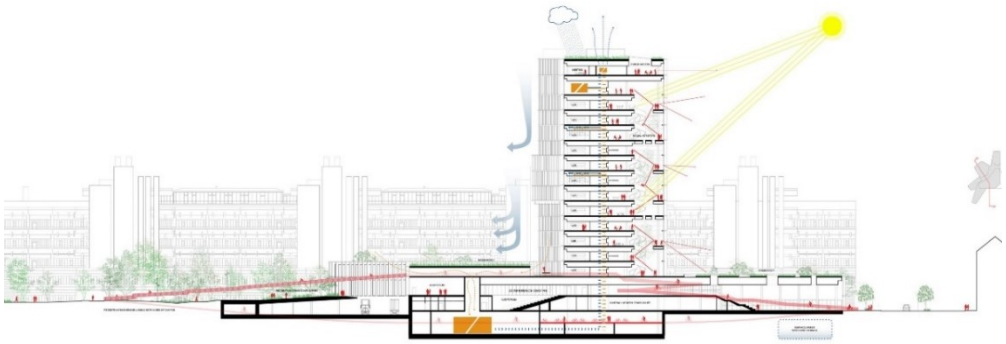

Figure 14: The relationship of the building with its surroundings.

The mobile air conditioning system, which can be opened and closed automatically depending on the weather conditions, of the copper-clad elements located at the floor heights on the facade of the building, provides both the indoor climate and the energy-efficient building conditions.

Figure 15: Copper façade at floor heights.

4.2.8 University of Oxford

University of Oxford is the oldest English-speaking university in the world, with a history of nearly nine centuries. Although there is no exact date of foundation, teaching at Oxford began in 1096[20]. The university, which has developed rapidly since 1167, is a large research university. It is a member of the Russell Group, which consists of 24 leading universities in the UK.

The University has obtained the following outputs by preparing a guide in line with its basic principles and goals:

- Ensures the delivery of sustainable buildings that complement and support the University's educational and research goals.
- Increases energy efficiency by reducing carbon emissions.
- Increases comfort, experience and productivity of campus users.
- Finds long-lasting, flexible and recyclable solutions that have low

[20] https://www.ox.ac.uk/about/organisation/history#:~:text=As%20the%20oldest%20university%20in,attending%20the%20University%20of%20Paris.

environmental impact and require low maintenance.

- Increases user awareness by installing systems that make the energy consumed in buildings visible to building users.
- Reduces water consumption.
- Increases biodiversity.
- Promotes and supports sustainable travel alternatives.

The Compliance Checklist is updated by using this guide during the project process. The system is controlled by the Environmental Sustainability Team and a result report is prepared.

Some of the studies carried out in these areas are as follows: (Heel, 2017)

- By continuing to invest in technologies that will increase energy, efficiency-based low-carbon or zero-carbon technologies are used, including the use of renewable energy. -> A series of solar PV installations completed with funding from the Carbon Management Fund to support the programs=> 100% success,
- The Carbon Management Plan and Program continued to be implemented to support the Carbon Management Strategy -> Carbon Management Program Managers role was determined. Significant number of projects implemented and additional projects developed=> 100% success,
- The implementation of the Soft-Landing initiative was supported and their operational capacity was increased. Positive developments were achieved for energy efficiency. -> Soft Landing became a core part of Capital Projects. The close working relationship of the Environmental Sustainability, Capital Projects and Building Services teams was developed. => 100% success.
- As an extension of the Midnight Oil Project, it was aimed to raise awareness with staff and students to use energy efficiently. -> Student Closure and Green

Impact schemes continue to work. Many projects carried out within the scope of the Carbon Management Program, such as the Building Management System (BMS) optimization, are built on this. => 100% success.

- Commission Display Energy Certificates (DECs) were implemented. -> A total of 133 buildings were included in the annual December assessment until October 2015. => result 95% success.

It is aimed to increase the biodiversity of the campus with the sustainable-oriented activities and strategies of the university, which will continue until 2035.

Strategies focus on: (Environmental Sustainability Strategy, 2021)

- *Research:* To increase researches and participation in environmental sustainability.
- *Curriculum:* To offer all students the opportunity to study environmental sustainability within or outside of the curriculum.
- *Buildings:* carbon emissions of the university buildings: To minimize carbon emissions related to energy consumption.
- *Biodiversity:* To improve biodiversity on university grounds by identifying major biodiversity impacts from the university's operations and supply chain.
- *Sustainable food:* To reduce the carbon emissions of food and its impact on biodiversity.
- *Sustainable sourcing*: To reduce the environmental impact of consumption and supply chain.
- *International travel:* To reduce and balance aviation emissions from university staff and student travel.
- *Local travel:* To promote walking, cycling and public transport by reducing the need for travel; to limit transport emissions by managing the demand to travel by

car.

- *Investments:* To ensure the University as an investor is part of the solution to climate change and biodiversity loss.
- *Learning from the pandemic:* To make the transition to more sustainable working practices by taking advantage of the experiences gained from the pandemic.

All these strategic plans and practices are supported by four main enablers: *management, reporting, financing* and *balancing.* (Environmental Sustainability Strategy, 2021)

Table 13: Oxford University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Resources and Recycling Sustainable Campus Organization Buildings Transportation Green Purchasing	Environmental Social Economical	Goal 3.4,5,11,12,13, 16	IARU	Blavatnik School of Government

Blavatnik School of Government

Located in the Radcliffe Observatory District at the University of Oxford, Blavatnik Public School features 4,000 square feet of Taylor Maxwell European Oak flooring.

Combining modern control systems and the latest technological solutions to limit the environmental impact of the building, the project meets the 'BREEAM Excellent' standards with the materials used. In the project, Europe's largest double-glazed single

glass was used to connect the university with the outside. While natural light and fresh air are ensured to be effective in the entire building in the design, sunlight energy is actively used with 107 photovoltaic panels and 500 square meters of greenroof systems. The wooden flooring, which is used as a large atrium flooring that starts in the basement of the building, connects all the units of the project as a spiral staircase. In the project, automatic natural ventilation and ground source heat pumps were used to ensure environmental sustainability and to maintain the operating temperature all year round. Less energy consumption is achieved with solar panels, low-energy lighting and rainwater harvesting.

Figure 16: Spiral staircase connecting all units of the project.

4.2.9 Yale University

Yale University was founded[21] as a college in 1701, and after 1718 it gained the status of a university. As of this date, the university made progress in scientific researches and trained many leaders.

[21] https://www.yale.edu/about-yale/traditions-history

Yale Sustainability Strategy

Yale University aspires to be a leader in higher education sustainability and seeks excellence in carbon neutrality actions. Professionals, practitioners, voters, community members, focus groups, students, faculty, staff, alumni and other stakeholders are reached through information, researches and experimental studies, interviews and subject-specific workshops at the university.

By 2025, Yale University aims to reach the 9 main items in the sustainable development vision with the hierarchical plan are presented below.

Yale University Hierarchy Plan: (Yale Sustainability Plan 2025. 2020)

- Steps and Targets - key tactical milestones for achieving Goals
- 38 Goals - measureable and time-bound methods for achieving Objectives
- 20 Objectives - priorities that support the Ambitions
- 9 Ambitions - top-level commitments;

  • *Leadership* – to be both a local and global leader in teaching, research, services and operations about sustainability.

  • *Empowerment* – to promote the sustainability movement in a diverse and comprehensive way.

  • *Health & Well-being* – to ensure the vitality in the ecosystem and the development of health.

  • *Climate Action* – to reduce climate change through active participation in urgent measures and actions.

  • *Stewardship* - to protect and plan landscape areas, to create flexible and sustainable infrastructure.

  • *Built Environment* - to use sustainable products in construction and repairs, to carry out their maintenance.

• *Mobility* – to support human and ecosystem health by providing sustainable transportation.

• *Materials* - to ensure the sustainability conditions in the materials used.

• *Technology* - to use innovative technology in sustainable actions.

The 9 main items in the sustainability strategy are presented below:

Table 14: Yale University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Resources and Recycling Sustainable Campus Organization Green Purchasing Employee and Student Engagement	Environmental Social Economical	Goal 3.4,5,8,9,10,11, 16,17	IARU	Brady Memorial Laboratory

Brady Memorial Laboratory (Brady 3)

Thanks to high-performance building envelope upgrades and new energy-efficient windows in the Brady 3, potential heating loads by infiltration are reduced.

The window glasses are used to reduce the demand for artificial lighting and provide benefit from visible daylight while minimizing unwanted sun rays and glare from the east and west. The efficient lighting fixtures used in the project keep the lighting levels at the most economical levels and reduce the energy loads by 25% compared to the standards that comply with the building regulations. With automatic daylight and occupancy controls, energy costs are reduced and new technologies such

as active chilled beams provide low air volume radiant heating and cooling, and effective clean space ventilation.

Ventilation strategies modulate demand-controlled distribution rates as needed. The clean air that comes with energy recovery systems is indirectly used by recirculating the discharge energy in preheating or precooling. In the renovated building, the fresh air supply is provided by using ventilation strategies such as monitoring and measuring the CO2 intake. System efficiency is increased with the air filtration systems used.

Materials with low VOC emissions are used in building interior materials (painting, coating, etc.). The materials used in the flooring have solid FloorScore® and Green Label Plus emissions. Urea-formaldehyde resins or binders are not used in the production of the wood used in the construction. Thermal comfort is achieved based on EPA standards in indoor ventilation. The majority of the materials in the construction of the project have been obtained from recyclable materials and have nature-friendly ingredients. In addition, all materials used are sourced from local products and local suppliers. By using energy-saving fixtures and strategies throughout the building in accordance with EPA standards, 30% savings were achieved in drinking water use.

Figure 17: Use of FSC certified, low-emission wood.

4.3 Greening Universities Toolkit V2.0

It was created in 2011 by the Environmental Education and Training Unit (EETU) of the United Nations Environment Program (UNEP) as part of the Green Universities Initiative, within the Partnership for Environment and Sustainability (GUPES) program. UNEP sustainable campus criteria include:

- Sustainability / develop sustainable methods for campuses in infrastructural, managerial and operational issues;
- Ensuring the development and implementation of university sustainability / sustainable campus strategies;
- Supporting sustainable campus meetings and promotional activities;
- Developing and launching a global awards program for Sustainable Universities.

The car kit indicators are also: *Defining sustainability, Initiating transformations, Indicators, Technologies for transformation, Policy governance and administration, Resources for change, Greening your uni brochure, Global Exemplars.*

The Toolkit supports Universities to determine the strategies of low-carbon and efficient resource campuses in reducing sustainability to campus, to develop campuses and to transform existing systems accordingly. While the system supports the integration of all systems of universities, it supports the problems encountered in the process by sharing it with other stakeholders. In fact, the process does not focus solely on what happens on a campus basis, encouraging universities to contribute to the overall sustainability of the planet. As M'Gonigle et al. stated, "Universities do not have a sustainable world in which they promote sustainability, on the contrary, sustainable universities help to build a more sustainable world. (M'Gonigle and Starke, 2006)

4.3.1 University of Nairobi, Kenya

The University of Nairobi, established in 1956 in the province of Nairobi, is the largest university research center in Kenya. It is the only institution of higher education in Kenya. The University of Nairobi presents education in about 326 different academic programs with ten campuses. [22]

Sustainability at UON

Strategic planning and implementation; education and awareness; safety and health; monitoring and reporting; communication; purchasing policy and environmental management system principles are adopted to reduce the negative effects of environmental origin and to increase the positive effects. (Green Universities Toolkit V2.0, 2014)

It is committed to implement an Environmental Management System (EMS) based on the International Standard ISO 14001. Environmental Policy of the University is carried out by taking into consideration the EMS, ISO 9001-2008 Standard, as well as the legal regulations.

Waste management; energy management; water management and economy of use; noise assessment and control; indoor air quality; emergency prevention and preparedness; staff/student environmental awareness and education; environmental management system and University Environmental Policy are among the audited areas. Furthermore, the University cooperates with all stakeholders in Nairobi to ensure that the environmental impacts of its studies are minimized and the necessary support is provided to the stakeholders.

[22] https://uonbi.ac.ke/fact-file

Climate change; environmental governance; harmful substances and hazardous wastes and resource efficiency (sustainable consumption and production) have been identified as priority intervention areas. (Waithaka and Edwin, 2012)

For this reason, the greening of university infrastructure/facilities/operations, community collaborations, university management and student participation are primarily addressed. However, there are problems such as the lack of an environmental policy and a guide, failure to make measurements, the lack of intervention in waste production resulting from unconscious resource use.

Sustainable Campus Principles and Principles of UON

The University of Nairobi has introduced some principles for its work: *Legal Obligations, Sustainable Development, Strategic Planning and Implementation, Education and Awareness, Safety and Health, Monitoring and Reporting, Communication, Purchasing Policy, Environmental Management System.*

Table 15: Nairobi University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Change Environmental Governance Harmful Substances and Hazardous Waste Resource Efficiency	Environmental Economical	Goal 1,2,3.4,5,7,9, 13	Greening University Toolkit V2.0	Nairobi of University Towers

Nairobi of University Towers

The University of Nairobi towers are planned as 21 floors in pursuit of meeting the growing demand for university education versus the limited surface area of overcrowded university buildings in the University's main campus area.

In the development of this iconic building of the university, the idea of having an ecologically sustainable building with world-class aesthetic and environmental design considerations is involved. It proves this idea by meeting the strict carbon footprint criteria that provides almost 100 percent carbon neutrality.

The University of Nairobi towers support their stated spatial requirements through their leadership in the development of a holistic green environment and striving to achieve the highest green rating standards globally. With its transparency in its design, it provides the flexible transition between exterior and interior spaces with its modern green architecture.

The North-South oriented towers and the podium on which it sits are planned and put into use as a green building that includes natural ventilation, daylight, room acoustic design, rainwater collection and gray water recycling, passive ventilation design for good indoor air quality.

Figure 18: Towers with a North-South orientation.

4.3.2 Macquarie University, Australia

It was established in 1964[23] in the Australian state of New South Wales. Macquarie University; Located in North Ryde's rapidly expanding business and technology line.

Sustainability at Macquarie University

Sustainability strategies are supported by the corporate values, ethics, equality, diversity and social core components. Sustainability-focused external networks and memberships have been adopted with the Australasian Campuses Towards Sustainability (ACTS), Association for the Advancement of Sustainability in Higher Education (AASHE), Environmental Association for Universities and Colleges (EAUC).

Significant expenses are incurred in items such as scholarships, grants and awards, general supplies, contractors and consultants, construction and renovation costs, rental and rental fees, travel expenses, audit fees, bank fees and tax expenses, vehicles, maintenance contracts, advertising and promotions with the aim of enabling environmental and social impacts. Purchasing policies, purchasing procedures and procurement manuals have been prepared for procurement practices in purchasing processes throughout the campus.

Priority Areas of the University

Climate change; disasters and conflicts; environmental governance; harmful substances and hazardous wastes; ecosystem management. research and development, greening of university infrastructure/facilities/operations, community cooperation,

[23] https://www.mq.edu.au/about/about-the-university/mq-story/history

university administration, student participation have been identified as priority intervention areas of Macquarie University.

Table 16: Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
demonstrating best practice shared responsibility global social and community awareness participation leadership openness and transparency precautionary principle innovation and creativity self-sufficiency whole systems approach	Environmental Economical Social	Goal 5,7,10,11	Greening University Toolkit V2.0	Macquarie University Library

Macquarie University Library

Centrally located on campus, the library is a learning and research environment designed to facilitate interaction between people and knowledge. The design of the library, which was completed in 2011, was inspired by the natural park areas of the campus, emphasizing environmental sustainability, light, and circulation.

Sustainable Features of the Building:

ARC consists of an environmentally controlled cash register containing metal boxes that store items, and robotic cranes that pick up an item on request and deliver the item to the service desk for collection.

With this system used, space-saving is achieved by reducing the physical footprint. Since less water and electricity will be used in the library structure, which is reduced in size, the carbon footprint is also reduced.

Figure 19: Library's ARC System.

Thanks to the green roof feature of the building, the water is collected in the underground storage tank and used in library toilets and garden irrigation. With the drought-resistant native plants and drip irrigation technology used in the green roof, the water passing under the green roof causes less evaporation and provides more efficient use.

Recyclable local materials were used throughout the entire construction process of the library. Recycled concrete and other building materials obtained from industrial wastes were used instead of ready mixed concrete contributing to greenhouse gasses. The same strategy was used for crude steel containing heavy metals. Most of the furniture used in the library has been approved by 'Good Environmental Choice Australia'.

With the anti-glare glass facades used in the design of the library, the building makes more use of natural daylight. Lighting is provided up to the lower floors of the building with two Bahçeli light wells designed in the building. Photosensitive automatic and manual blinds and light-sensitive artificial lighting are used throughout the building.

Figure 20: Sustainable Construction Systems.

4.3.3 Tongji University, China

Tongji University, established in Shanghai in 1907[24], consists of 420 buildings on an area of 1,501,281 square meters. It is a comprehensive university with approximately 39,000 students studying across four campuses and 29 faculties.

It manages its activities in a way that reduces negative environmental impacts and promotes sustainability. Tongji University has established a steering committee, an expert committee and an executive office to share the responsibilities of sustainable campus construction. energy conservation in research, management and education has been identified as three priority areas for the sustainable campus.

[24] https://en.tongji.edu.cn/About/Introduction.htm

Tongji University is the first university to establish and chair the China Green Universities Network (CGUN), which consists of 8 core universities and 2 research institutes.[25]

Research and development, greening of university infrastructure/facilities/operations, community collaboration, university management, student engagement, research, management and conservation in education have been identified as innovation areas in university projects.

In this context, the Campus Energy Management System (CEMS) with online monitoring has been established to monitor and report energy use. (Tan, H., et al., 2013) With the support of the Chinese government, national technical guidelines have been established for the construction and operation of CEMS.

In 2010 and 2011, a bamboo solar house and a container solar house were designed in Solar Decathlon at the university, where sustainable designs of students were encouraged.[26]

Since 2009, energy and water efficiency, use of sewage source heat pumps, water recycling projects, vertical and roof greening etc. Building reinforcement works continue in an area of 296,647 m2 with various studies. Building reinforcement works have been continuing since 2009 on an area of 296,647 m2, with various studies such as energy and water efficiency, the use of sewage-sourced heat pumps, water recycling projects, vertical and roof greening.[27]

One of these studies is the reinforcement study carried out on behalf of the Architectural Design and Research Institute (ADRI). With this study, a 68.000 m2 five-storey demonstration building with 630KWp BIPV system was transformed into

[25] http://www.cgun.org.cn/en/content.aspx?info_lb=107&flag=1
[26] https://inhabitat.com/east-meets-west-in-tongji-universitys-para-eco-house-design-for-the-european-solar-decathlon/20120423155837320-copia-copia/
[27] https://www.solardecathlon.gov/past/2011/team_china.html

an energy saving and renewable energy technologies training center. (Lyu, Y., et al., 2017) With the BIPV system covering 6600 m2 roof area in the ADRI building, the university produces 535 MWh of electricity every year, resulting in a reduction of approximately 566 tons of CO2 emissions.[28]

Table 17: Tongji University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Change Environmental Governance Resource Efficiency	Environmental Economical	Goal 4,5,9,12,13,16	Greening University Toolkit V2.0	Para Eco House

Money Eco House

"Para Eco-House" has both parametric and ecological strategic features. The low-carbon feature achieved by both 'Passive' and 'Active' energy systems used in the project design brings functional and environmental benefits to the building.

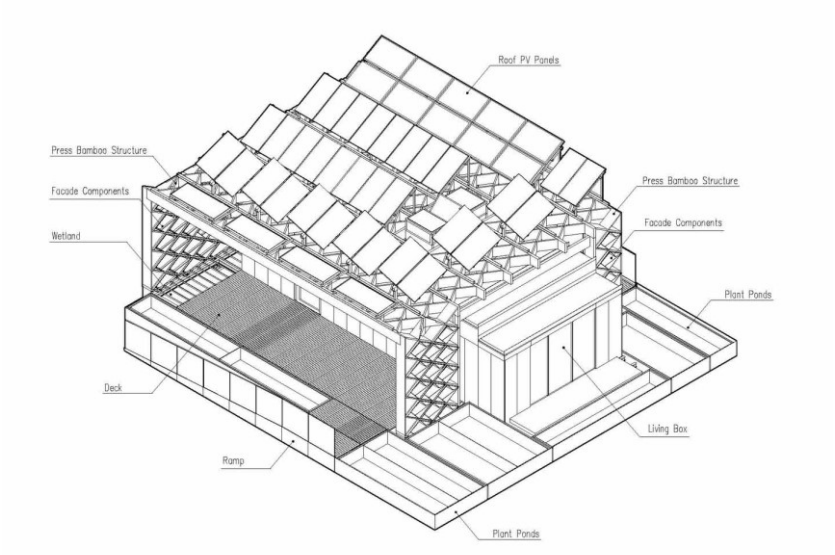

Figure 21: Building Passive and Active Energy Systems.

[28] https://www.tongji.edu.cn/eng/info/1020/1064.htm

Active ecosystems:

Highly efficient integrated solar energy, gray water treatment and ventilation systems are the active eco systems of the building. Multi-layer insulation used on the exterior, triple-glazed window systems, ecological greenroof, an environmentally sensitive veranda that uses reed water to help ventilate the building and for gray water treatment, are the passive eco systems of the building.

Photovoltaic Panels are placed on the roof of the building and directed towards the optimum solar energy that produces electrical energy by using solar cells to convert the energy from the sun into electron flow. The thermal solar collector system used in the project and the heat collected by the collectors provide heating of the houses with the solar energy array. In addition, the efficiency of the system has been increased by adding solar tracking systems to the solar panels. With gray water filtration, both the reuse of water is ensured and the continuity of the system is ensured by pumping back into the stagnant water systems when necessary. Unused waste from gray water filtration is considered as fertilizer.

The temperature of the building is regulated by heat pumps located in the pre-heating and pre-cooling water tanks located under the floor of the building. Excess energy produced by solar panels acting as a thermal cell is stored. Collected and filtered rain water is used for cooling purposes in the building. During seasonal changes, fresh outdoor air passes through the shafts under the building, making the air conditioning system more efficient and increasing the thermal comfort of the building. The outer wooden energy coating, which extends over the inner lining, protects the building from temperature fluctuations. With the inner courtyard ventilation system, which creates a chimney effect by heating the upper part, additional ventilation is provided to the building. With the landscape designs applied along the facade, the flow

of rain water is slowed down and the cooling of the solar panels is supported. The cooling of the panels is provided by oriented solar panels, vertical vegetation and air flow composite skin system. Press bamboo material was used in the project design due to its low carbon effect. The architectural features of the building are highlighted by using light-emitting LED diodes on the façade.

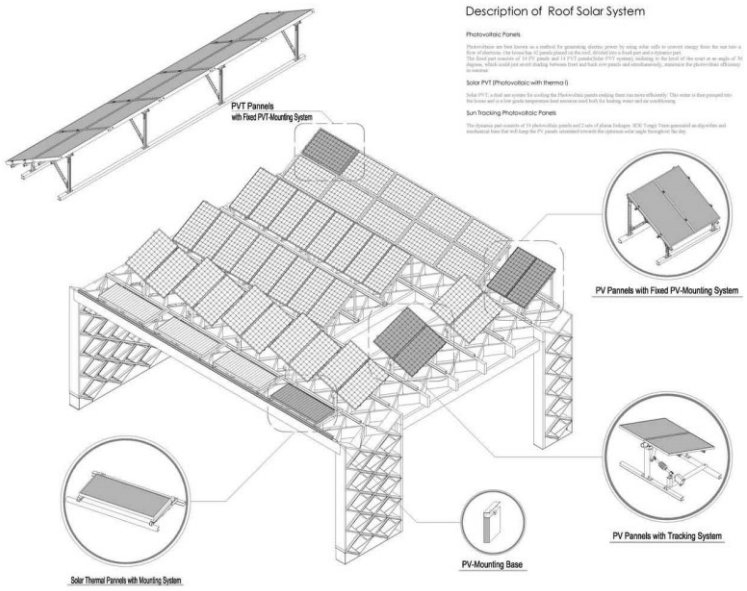

Figure 22:Roof Solar System description.

4.3.4 Middle East Technical University, Turkey

Middle East Technical University (METU), which was established in Ankara on an area of 4500 hectares in 1956. [29]In total, the university has more than 24,500 students, and there are more than 1,700 foreign students from 85 different countries in about 206 programs

Since the 1960s, efforts have been made to expand both research and education capacity. Evaluation of environmental performance and implementation of new strategies in line with sustainable environmental principles are considered very

[29] https://www.metu.edu.tr/history

important. Sustainability has become the focal point of all units with sustainable/green Campus practices that have adopted the principles of resource efficiency and sustainability; academic programs and research that include ecological sustainability principles. The use of renewable energy, the availability of recycling, the demand for local nutrients, water saving practices, alternative public transportation systems, sustainable stormwater management and reduced resource use are among the physical operations in the sustainability process at METU.

Green campus practices at METU are divided into three main components: *Stormwater Management, Solid Waste Management, Water Management.*

Hydrological analyzes are carried out using the Stormwater Management Model (SWMM) related to the amount of runoff water generated on the METU campus. (Kiraz, 2018)

It is aimed to reduce pollution, prevent floods and reuse rainwater with Low Impact Urbanization practices, which are part of *storm water management*. For this purpose, researches are carried out on green roofs, rain barrels (rain water harvesting), rain gardens, permeable concrete (road, parking lot, etc.). Accordingly, a software integrated with ArcGIS has been developed and suggestions are made for suitable places in the campus area.

Within the scope of *Water Management*, it is aimed to manage rainwater with energy-saving systems in pumping, treatment and heating in an efficient way and to reduce the amount of network water used for irrigation and similar needs.

In order to protect the water source in the region where METU campus is located, to reduce water consumption in the campus, to eliminate negative water-related factors, strengthening, reduction and renewal strategies have been established.

In this context, the Asset Management System, which includes various investments for water and wastewater infrastructure systems, has been developed.[30]

Within the scope of *Solid Waste Management*, the garbage collected by two garbage trucks belonging to the university is delivered to the solid waste storage area located near the campus.

In general, METU sustainability conducts studies related to stormwater, water and solid waste management. Within this scope, the current situation of METU is evaluated and suggestions are developed. In order to implement the recommendations, primarily; Establishment of the Sustainable Campus office; It is recommended that the performance evaluation be carried out in parallel with the Environmental Performance Evaluations.

Table 18: METU Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Climate Change Ecosystem Management Environmental Governance Resource Efficiency	Environmental Economical	Goal 1,3,4,5,8,12, 13,16	Greening University Toolkit V2.0	Co-working&Cafeteria

Middle East Technical University Coworking & Cafeteria

The building is designed as a cafeteria and co-working space designed within the Middle East Technical University campus. It is aimed to integrate with nature by using passive and active architectural systems in its design.

[30] https://kgpo.metu.edu.tr/tr/bilgi-yonetim-sistemi

Figure 23: Wide glass facades study areas.

While designing the building, it is possible to use flexible alternatives. Integration with nature is achieved through the greenhouses and courtyards created around the building and the building envelope designed as glass. All work areas are illuminated with natural daylight through the glass shells created. In addition, units with separate physical uses are combined by means of transparent shells.

One of the most important aspects of the project, these transparent boxes allow natural light to enter as much as possible, aiming to illuminate all work areas instead of illuminating the windowsills and leaving the rest to artificial lighting. In addition, the use of green provides pleasant dining and working environments, while at the same time allowing leaking sunlight to reach. Transparency in the horizontal direction allows for a continuous visual relationship, somehow uniting the masses despite their physical separation. The volumes created rhythmically offer the opportunity to use different numbers of work groups.

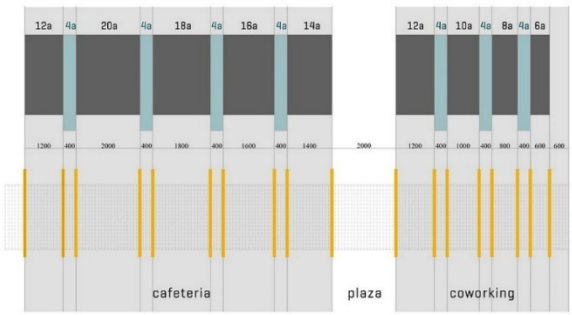

Figure 24: Rhythmically created to use for different numbers of work groups.

A pedestrian path that differentiates the greenhouses and courtyards and runs diagonally between the volumes by taking references from the surrounding streets, develops a physical relationship with the site and offers use for joint work and cafeteria. These service areas are designed as linear compact masses and are connected to the northern façade of the buildings and do not prevent the main mass from benefiting from daylight.

In the project, it is aimed to achieve Zero Energy Buildings as long-term strategies by using various sustainable building systems such as geothermal heat pumps used for heating and cooling, energy efficient lighting and solar panels.

4.4 The Sustainability Tracking, Assessment & Rating System™ (STARS)

In 2004, the first North American Conference on Sustainability in Higher Education was held by EFS West in Portland, Oregon. With the success of the system and increased demand for EFS West's resources, university partnerships have evolved from a regional network to an independent higher education association serving all of North America – the Association for the Advancement of Sustainability in Higher Education.

AASHE serves a wide range of higher education institutions, administrators, staff and students for the advancement of sustainability in higher education. AASHE is growing every day with more than 900 members in 48 US states, 1 US Territory, 9 Canadian provinces and 20 countries.[31]

Within the scope of activities, it is aimed to create a sustainability model that includes human health and ecological health, racial equality and social justice, secure livelihoods and a better world for all generations. This goal is sought to be achieved

[31] https://www.aashe.org/

through sustainable practices that address environmental, social and economic impacts. Sustainable practices are carried out in the fields of air and climate, buildings, energy, food and food, procurement, transportation, waste, water, coordination and planning, diversity and affordability, investment, public participation, welfare and work. These practices are organized consistently with the Sustainability Tracking, Assessment & Rating System™ (STARS).

Table 19: STARS Indicators and Sub-indicators (by Autor)

Academics (AC)	**Engagement (EN)**	**Operations (OP)**	**Planning & Administration (PA)**
Curriculum Research	Campus Engagement Public Engagement	Air & Climate Buildings Energy Food & Dining Grounds Purchasing Transportation Waste Water	Coordination & Planning Diversity & Affordability Investment & Finance Wellbeing & Work

4.4.1 Arizona State University

The Arizona State University was founded in 1886[32] by the 13th Arizona Territorial Legislature. The university is administered by the Arizona Board of Trustees and ranks among the largest public universities in the United States by enrollment.

The University works as part of the School for Sustainability, established in 2006, and the Julie Ann Wrigley Institute for Global Sustainability, a center for sustainability initiatives. ASU focuses on finding real-world solutions to environmental, economic and social challenges. (Sustainability Impact, 2019)

[32] https://www.asu.edu/about/university-history-and-milestones

More sustainable alternatives are being worked on, emphasizing the importance of experiential learning, faculty-based research, K-12 studies, community service, and leadership development. Initiatives are made and researches are focused on the subject of sustainability, which is also prominent in the academic program of the university. (New American University, Toward 2026 and Beyond, 2021)

The University is responsible for generating more than 50 MWdc[33] of equivalent capacity solar, including off-site components. It also has an extensive solar program with on-site and off-site components.

ASU is among the leading institutions thanks to the diversity, affordability and impact of this program in the fields of weather, climate and energy. Consistent with Second Nature's Climate Commitment, ASU offers GHG Inventories, the basis for sustainability metrics, to various organizations, including AASHE STARS.

The Operational Control methodology, created according to The Climate Registry's guidelines, is used to obtain the most accurate, flexible data that will provide a strong foundation for growth and progress. Many parallel factors and situations are taken into account in the implementation of the Climate Record guidelines. ASU, in this regard:

- implements the guidelines consistently and clearly reports its rationale along with its alternative approaches.

- Independent of the methodology, if the lessee is ASU, includes the facilities in the financial/capital leasing contracts.

The protocols of the Climate Record and World Resources Institute do not specifically consider park constructions. Park constructions do not provide Second Nature guidance; they provide STARS guidance. For this reason, they are considered

[33] MWDC is an acronym for MegaWatts defined conditions – power output is given a specific set of circumstances

within the scope of AASHE's STARS guidelines. ASU separates data in various ways to understand emissions (e.g. laboratory buildings, residences, third party, etc.) in a better way. (AASHE Report, 2020, PRE-3)

VCS Project ID 1497- Adopting the VCS Grouped Project for Renewable Power Generation, ASU has started purchases from Schneider Electric to replace the Verified Carbon Standard (VCS) for FY19.

Efforts to design and construct in accordance with green building codes, policies and/or rating systems have 1,259,309 square meters of building floor area. The percentage of newly constructed or renovated building areas approved under the green building rating system is 99.83%. (AASHE Report, 2020, OP-3)

As part of building energy efficiency, about 75% of the buildings on the Tempe campus are planned with the Johnson Controls Metasys system used to turn it on and off-air handling units and pumps, etc. according to their programming needs. With this system, building occupancy needs are determined by the academic and administrative staff. Equipment programs are optimized and unnecessary working times are avoided. In the polytechnic campus, the Alerton system, called Direct Digital Control (DDC), is used to control and protect temperature ranges and remotely monitor energy usage. In this system, less energy consumption is aimed to condition the outside air. ASHRAE design conditions are adopted at a rate of 99% for heating and 2% for cooling of non-critical program areas. The system also has the feature of generating reports about the process progress. The institution adopts Light Emitting Diode (LED) lighting and other energy efficient lighting strategies in both new constructions and building renovations. Due to the rapid return on investment of the projects, the Sustainability Initiatives Revolving Fund (SIRF) is utilized as a financial resource.

Throughout ASU's four campuses and the Research Park, there are approximately 90 24.2 MWdc capacity PV solar systems mounted on the roof, ground, parasols and above parking lots.[34]

The U.S. Information, Planning and Conservation (IPaC) online map tool is used to protect sensitive species that are endangered and at risk of extinction on owned or managed lands. Within the scope of sustainable supply, Life Cycle Cost Analysis (LCCA) is used in the evaluation of products and systems that use energy and water. (Sun Devil Dining, Sustainability Report 2019-2020)

Table 20: Arizona State University Sustainability campus main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Air&Climate Buildings Energy Investment& Finance Purchasing Doctoral Institutions	Environmental Economical	Goal 3,4,5,7,9,10, 11,12,16	STARS	ASU Polytechnic Building

ASU Polytechnic Building

Located in the Arizona desert, the ASU Polytechnic Building Complex consists of three buildings: the School of Agribusiness, the School of Science and Technology, and the School of Education and Humanities.

All structures are designed as an innovative learning environment beyond the classroom. And each building integrates many strategies to reduce the energy, water and waste load on campus.

[34] https://cfo.asu.edu/solar

Figure 25: Building's high performance reflective roof system.

With the Green Building Training Program developed in buildings, an environment of transparent participation of users in strategies is created. Within the scope of the strategies taken, Indoor Environmental Quality is ensured by the use of materials that emit low VOCs in the indoor environments of the buildings. High performance reflective roof systems are used on the roofs in order to reduce the 'Urban Heat Island' effect. In order to reduce water usage, low flow armatures are used. Building elements with recyclable properties supplied from local vendors were used in the construction of the building. Recycling Programs are implemented in order to minimize environmental impacts.

The project has achieved LEED New Construction Gold level with all these operations. The building met the ASHRAE 90.1-2004 energy standard with 33% energy cost savings. With the water saving strategies used, 43% reduction in domestic water has been achieved. With the gray water system, a 51% reduction in water use in landscape irrigation was achieved. With the use of recyclable construction materials, a 79% reduction in construction waste has been achieved.

4.4.2 Stanford University

Stanford University is one of the nation's top private higher education institutions in the US state of California. Established on 1885[35], the university is currently the 3rd University with the largest budget in the world. ("The 100 Richest Universities in the World", 2021)

Sustainability Efforts

Since 2007, leading initiatives have been taken in the fields of energy and climate, water, transportation, green buildings and sustainable information technology, which have been carried out in the campus infrastructure.

Stanford University invests in renewable energy systems for water conservation for the aim of reducing greenhouse gas emissions and meeting energy demand in natural energy sources.

Within the framework of the Energy and Climate Plan, the "Stanford Energy System Innovations" (SESI) program has been implemented to reduce campus GHG emissions by 68% and drinking water use by 15%. With this program, efficiency standards that demand less energy and water are offered for existing structures. Designs with mandatory standards are recommended for new buildings. (Wang, J., et al., 2017)

With the increasing energy demand, campus energy systems and the construction of new high-performance structures that will minimize the increase in greenhouse gas emissions have been a very important issue.

The regulations implemented by the university in the existing structures are as follows:

[35] https://www.stanford.edu/about/history/

- With the Energy Strengthening Program, approximately 300 billion British Thermal Units (BTUs) have been saved annually since 1993.

- With the Whole Building Reinforcement Program, which concerns the most inefficient buildings on campuses, approximately four million dollars are saved annually.

- The Energy Saving Incentive Program, which aims to reduce energy use by focusing on building user behaviors, is used.

- A Plug Load Energy Consumption Reduction program is implemented throughout the campus to replace all IT equipment with economical alternatives in order to reduce the plug load caused by various laboratory and electronic equipment.

These programs implemented by Stanford University and their positive results prove that the University's Energy and Climate Plan is effective. (Guidelines for Sustainable Buildings, 2002)

Stanford Energy System Innovations (SESI): It is a program established to produce sustainable and economical solutions to meet the increasing energy demands at the university, and to offer cost-effective options that cause less greenhouse gas impact. It works in line with the Brundtland Commission's goal of a sustainable university to adapt to new technologies. (Wang et al., 2017)

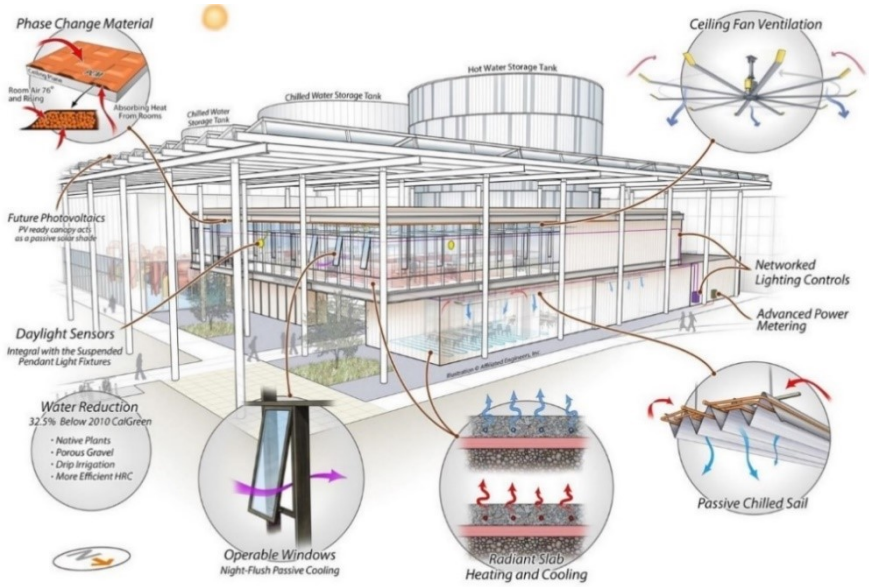

Figure 26: SESI Building Sustainable Diagrams.

Sustainability and Energy Management (SEM): Sustainability and Energy Management (SEM) conducts the campus' current energy use and GHG emissions inventory studies. (Sustainability at Stanford, 2020-2021 Year in Review)

A high-performing Stanford University requires low energy in its policies for energy efficiency and water conservation; pays attention to the use of energy efficient equipment and system design.

Sustainability Measures for Existing Structures

Presentations that serve both the market sector and the decision-making process are carried out with the efforts to ensure and protect energy efficiency on campus.

A comprehensive program has been implemented since 2008 with applications such as desktop power management, smart power strips, the use of Energy Star and EPEAT certified equipment, and HVAC system improvements. (Stanford University Energy and Climate Plan, 2015)

Energy and Climate Plan

Stanford University determines its comprehensive energy and climate plan based on three key components:

1. New efficient construction management programs,
2. Efficiency and management programs for existing structure demands,
3. Pragmatic solutions for sustainability supply-demand balance.

(Kabre, 2021).

Table 21: Stanford University Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Engagement Curriculum Diversity& Affordability Energy Public Engagement Water Wellbeing& Work Doctoral Institutions	Environmental Social	Goal 1,4,5.9,8,11,16	STARS	Shriam Center for Bioengineering and Chemical Engineering

Shriam Center For Bioengeneering And Chemical Engineering

Designed for intensive research, the Shriram building consists of both wet and dry laboratory areas and joint specialty laboratory units available to faculty members. Heating and cooling loads are reduced with the high-performance envelope system designed with roof, walls, windows, sunshades and facade projections. With the grid-connected PV solar system, electricity demand is reduced. Savings are achieved with double sanitary systems that use recycled water in toilets and throughout the building. Recycled materials and sustainable products are used throughout the building.

Additional costs are eliminated by designing the floors as open concrete. Variable air volume systems are preferred in the ventilation system. Energy savings are achieved with innovative heating and cooling systems.

Figure 27: Floors designed as open concrete.

4.4.3 Colorado State University

Originally established as the Colorado Agricultural College in 1870, Colorado State University is a university known for its ever-expanding green spaces. (Hansen et al, 2017)

Colorado State University Sustainability Initiatives

Colorado State University has a balanced teaching, researches, publications, public service and engagement programs that provide the foundation for the Agricultural Experiment Station and Extension and the Colorado State Forest Service. The University investigate the rapidly changing global environment with its emissions.

The first Platinum STARS rating was received in 2015. More than 335,000 square feet of new LEED Platinum or Gold certified classrooms, research spaces and offices have been added since 2017. (Koehn and Uitto, 2017).

Within the scope of the STARS program, over 10 million kWh/year of electricity is currently produced (according to the year 2021 data) with 18 solar PV facilities across the campus. At the university, 80% of academic departments and approximately 50% of faculty members actively participate in sustainability researches. Accordingly, between 2019 and 2021, campus electricity usage increased to 13.5% by balancing 20% in Facility Management and 100% in Accommodation and Food Services. (AASHE Report, 2021, OP-6)

Sustainability activities are integrated across the university, including student activism, classroom learning outcomes, cutting-edge research in laboratories, community service learning and outreach across the state of Colorado, according to STARS reports. The School of Global Environmental Sustainability supports campus-wide interdisciplinary research teams in environmental sustainability. In this school, trainings on innovative solutions to global energy problems and ecosystem sustainability are provided with interdisciplinary approaches.

Table 22: Colorado University Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Campus Engagement Curriculum Public Engagement Research Wellbeing& Work Doctoral Institutions	Environmental Social	Goal 1,2,3,13,15	STARS	CSU Center for the Arts Forth Collins

CSU Center for the Arts Fort Collins, CO

CSU Art Center, in sustainable design; It is a successful example of the integration of design and construction professionals in the developing process. In

particular, it provides long-term benefits to the tenant as well as many of the sustainability impacts of design decisions and their impact on the day-to-day operations of the facility. Low noise ballasts and drivers and ANSI S12.60 compliant luminaires are used in the building. Green criteria are adopted for Building Indoor Environment Quality. In terms of the sustainability and performance of the project, evaluations are made according to the Continuous Improvement of Existing Buildings (CIEB) standards. (Gotthelf, et al., 2016)

Figure 28: Improved existing building.

4.5 The International Sustainable Campus Network – ISCN

For the purpose of realizing sustainable campus practices, universities establish a global forum to support the exchange of knowledge, ideas and experiences between joint campuses and colleges. This forum, called the International Sustainable Campus Network (ISCN), aims to ensure continuity in the development of all components of sustainability through learning and innovation.

In 2010, ISCN and the Global University Leaders Forum (GULF) provided a general framework for universities to set their own priorities and goals in the design

process of sustainable campuses. In this context, a sustainable campus charter has been prepared to complement the existing, local or subject-oriented initiatives for sustainability in higher education. In this charter, instead of changing institutions, the principles of strengthening inter-institutional relations and being open to global organizations for the sustainability of campuses are adopted. This strong network increases the role of the charter in sustainable campus design. It cooperates with many universities and regional centers affiliated with the charter, the 1990 Talloires Declaration and the United Nations "Decade of Higher Education in Sustainable Development" on issues such as research, scholarship, teaching, reporting and setting goals. It also leads many local networks and partnerships. (ISCN Best Practice in Campus Sustainability, 2014; ISCN Implementation Guidelines, 2010)

Three hierarchical basic principles have been defined within the scope of the charter to address sustainability in accordance with its integrative feature in a comprehensive way. These are; *structures and their sustainability impacts; research with a holistic campus plan and objectives; integration of teaching and other services.*

The purpose of this report: (ISCN Implementation Guidelines, 2010)

- To observe the development of management approaches of each institution within the scope of sustainable campus, especially in line with the principles of the charter,
- To guide the institution in selecting its own priority issues under each principle and determine its quantitative and/or qualitative criteria, performance information and strategic targets for material issues,
- To report specific partnerships that will enable the institution to implement sustainable campus activities and converge to the targets for the selected priorities.

The holistic and comprehensive structure of the organization and its activities ensures that the principles defined by the charter are accepted on a global scale. Each organization that has signed the ISCN-GULF Sustainable Campus Charter is responsible for conducting its operations, researches and teaching activities within the framework of three basic principles. The charter is open to participation by all organizations providing research and higher education. Their commitment continues as long as participation continues. (ISCN Implementation Guidelines, 2010) The principles that institutions are responsible for are as follows:

- *Sustainability performance of structures on campus:* According to this principle; “To respect the environment and society, sustainability considerations must be an integral part of the planning, construction, renovation and implementation of structures on campus”. (ISCN Implementation Guidelines, 2010)
- *Master planning and setting goals throughout the campus:* Accordingly; "In order to ensure sustainable campus development in the long term, a campus-wide master planning and goal setting process should be carried out. Environmental and social goals should be included accordingly".

On a sustainable campus, the built environment, operational systems, research, science and education for sustainability are like a living laboratory that is interconnected. All campus users have the right to access researches, teaching and learning opportunities on the links between environmental, social and economic issues. Institutional commitment and efficient use of resources play an important role in raising this partnership to success.

4.5.1 McGill University

McGill University was founded in 1821 [36] in Montreal, Canada. Forty thousand students from different cultures and countries study at the 21 faculties of the university.

Sustainable University Coverage

Sustainability studies at the university are carried out according to the definition of sustainability made in the Brundtland Report (1987) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Accordingly, sustainability is handled with a holistic understanding in environmental, social and economic dimensions.

The Sustainability Board Committee consists of members of the board of directors, senate, student associations, staff and faculty, as well as members of the public. The committee began its activities in September 2020 and initially approved the McGill University Climate and Sustainability Strategy. (Report of the Committee on Sustainability, 2020)

McGill University's Climate and Sustainability Strategy covers a five-year period (2020-2025). The strategy has been structured in eight categories: (McGill University Climate & Sustainability Strategy 2020-2025, 2020)

- *Research and Education:* Research activities carried out on and off campus
- *Buildings and Facilities:* Activities in all physical areas, including heating and cooling
- *Waste Management:* Waste collection, separation, reduction and routing activities on campus, including recycling and composting
- *Travel & Commuting:* Ways for university members to travel around, including business travel

[36] https://www.mcgill.ca/about/history/features/founding

- *Food Systems:* The full cycle from production to consumption of food
- *Landscapes and Ecosystems:* Management and responsibility of the university's open spaces
- *Procurement*: Environmental, social and economic impacts on the selection and purchase of goods, resources and services
- *Community Building:* Ways of connecting people at the university with the aim of integrating social sustainability

• *Campus Energy Strategy:* Although electricity needs are fully renewable at McGill University's Quebec campus, natural gas continues to be used for heating. Converting energy systems to electricity and investing in energy efficiency improvements is central to the strategy to reduce greenhouse gas emissions. Improving the environmental performance of buildings and reducing their carbon footprint by 2025 is the main goal of McGill University.

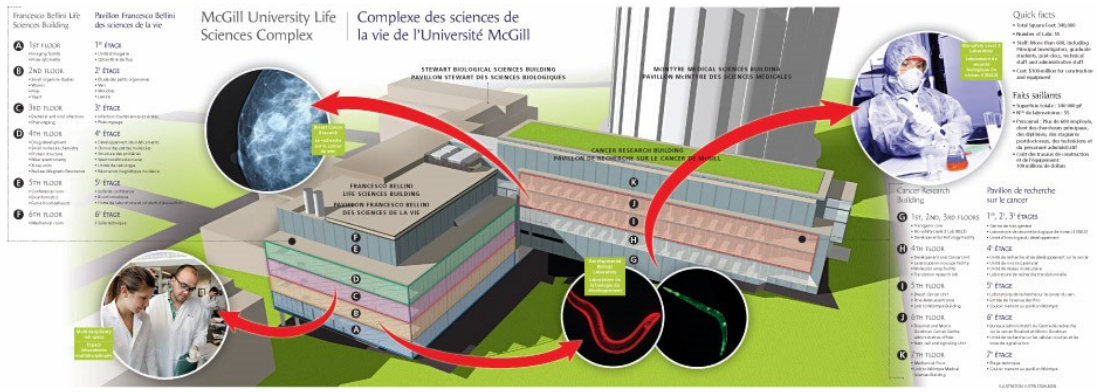

Figure 29: McGill University Life Sciences Complex.

Table 23: McGill University Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Resource& Education Buildings& Utilities Waste Management Travel& Commuting Food Systems Procurement Landscapes& Ecosystems Community Building	Environmental Economical Social	Goal 2,3,4,5,6,7,8, 14,15,17	ISCN	Life Sciences Complex

Life Sciences Complex

Completed in 2008, the building is the only university-owned laboratory building in Quebec to achieve the LEED gold rating. The main features of the building include heat recovery system, air exchange hood systems, artificial lighting with sensors, variable speed driven ventilation and air conditioning systems. All building systems used are 38 percent more energy efficient than the Canadian National Model Energy Code. Rainwater collected with the system designed on the roof is stored in a cistern and used for toilet, urinal and garden irrigation. With the Greenroof, both the urban heat island effect and energy consumption are reduced. Most of the materials used in construction contain post-consumer or post-industrial recycled ingredients and are sourced from local suppliers.

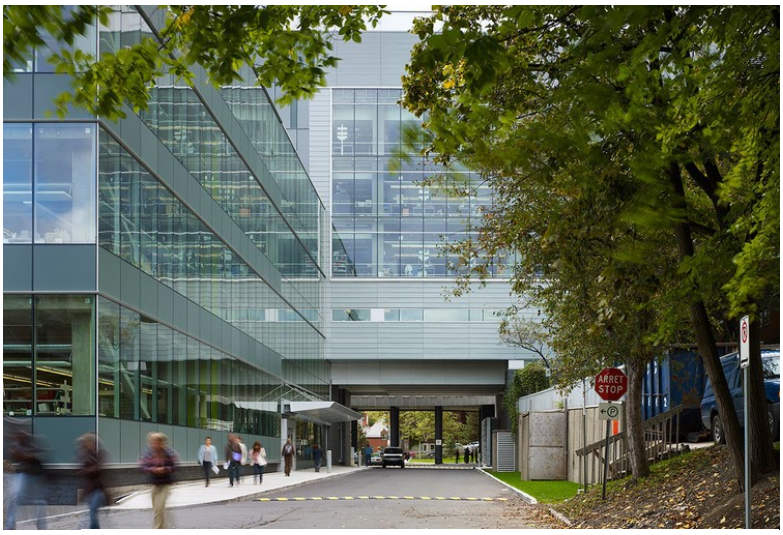

Figure 30: Energy Efficiency campus building.

4.5.2 National University of Singapore

National University of Singapore (NUS) was established in 1905[37] as the Straits Settlements and Federal Malay States Public School of Medicine. NUS' main campus spans 150 hectares (370 acres) in the southwestern part of Singapore.

NUS Sustainability Vision

NUS aims to make a positive impact on the environment through academic studies, researches and participation activities on sustainability. In this context, studies are carried out on carbon emission, energy, criminal, waste, built environment, green areas (buildings).

Sustainability Steering Committee: (NUS Sustainability Strategic Plan 2017 – 2020, 2017)

- *Energy Task Force*: Ensures energy efficiency and savings in operations; oversees building retrofitting, campus energy reduction and efficiency measures according to sustainability principles.
- *Water Management Task force:* Works to optimize the use of water on campus

[37] https://www.nus.edu.sg/about

and reduce dependence on drinking water.

• *Waste Reduction and Recycling Task Force:* Works to reduce waste generation and increase recycling rates on campus.

• *Built Environment Task Force*: Works on the design, planning and construction of new infrastructure and buildings on campus within the framework of sustainability principles.

• *Green Space Task Force:* Works to increase green spaces in buildings; plans and manages the landscape greenery on campus.

NUS Sustainability Actions

- *Campus Carbon Actions* (Choy et al., 2015)
- *Campus Energy Policies*
- *Campus Energy Management*

In terms of energy management, efforts are made to encourage changes in energy consumption behavior by ensuring efficiency in the energy portfolio and primarily to reduce energy use intensity by 20%. (NUS Sustainability Strategic Plan 2017 – 2020, 2017)

Table 24: NUS Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Carbon Emissions Energy Management Water Management Waste Minimisation and Recycling Built Environment Green Spaces(in buildings) Engagement and Outreach	Environmental Economical Social	Goal 4,5,6,7,12,13	ISCN	School of Design and Environment SDE4

School of Design and Environment

This addition to the School of Design and Environment building at the National University of Singapore is a successful example of net zero energy buildings (NZEB) in the tropics. During the construction phase of the five-storey building, optimization was made to the building in order to facilitate lateral ventilation and benefit from natural light. An innovative hybrid cooling system has been designed to replace traditional approaches to air-conditioning, ensuring that rooms are not over-cooled.

Most of the annual energy demand of the building is met by 1225 solar panels located on the roof of the building. The system is based on feedback and unused energy is stored.

Figure 31: Building with innovative hybrid cooling system.

4.5.3 Anglia Ruskin University

Anglia Ruskin University is a public university established in the South East region of the United Kingdom to provide undergraduate, graduate and doctoral education and conduct academic researches. The University, which gained the status

of being a polytechnic in 1991[38], continues to work with and international students and academicians from various fields.

Global Sustainable Anglia Ruskin

The Institute for Global Sustainability (GSI) was established at Anglia Ruskin University. Studies that address both the system and the individual are carried out at the Institute to develop practical solutions to global sustainability problems.

Researches are carried out on climate science, policy and climate finance communication at the university. In addition, a global collaboration is being established with project partnerships funded by non-profit organizations, the UK Government, the EU Commission, the United Nations and the UK Research Council. (Sustainability Strategy 2020-2026. 2020)

The Institute conducts research on four main topics: *Consumption & change, Global Risk and Resilience, Ecosystems and Human Welfare, Education for Sustainability.*

Table 25: ARU Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Resource& Education Buildings& Utilities Waste Management Food Systems Procurement Partnerships for the Goals	Environmental Economical Social	Goal 2,3,5,10,11,13	ISCN	Marconi Building

[38] https://aru.ac.uk/about-us/our-history

The Marconi Building

In the structure, which is designed as two cores, interior walls with lining and dry construction and a flat concrete floor construction in place are used. Thus, the internal layout of the building can be changed to create new spaces. This provides flexibility in use to the building owner. In addition, a movable wall system is used in the ground floor areas in order to provide a flexible use in room dimensions. Ceilings are designed as flat suspended ceilings in order to provide flexibility in use. VRF unit systems are used because it provides significant energy savings under partial load conditions and is more economical than HVAC systems in the use of cooling and heating. With the VRF technology used, the heat recovered within the compressor load is utilized while providing the heating and cooling of the independent indoor units. Aluminum curtain wall elements including Velfac composite windows and automatic opening doors are used; thus, savings in indoor air temperature have been achieved. In order to save water consumption in buildings, water is collected in tanks placed under the facade with the gray water method. (Khan, I., 2013)

Figure 32: Building with Velfac composite window system.

4.6 LEED V4 For Schools

The Leadership in Energy and Environmental Design (LEED) program was initiated by the US Green Building Council (USGBC) in 1998. (LEED 2009 for New Construction and Major Renovations, 2012) This program focuses mainly on green buildings and makes evaluations based on innovation and design, indoor air quality, use of materials and resources, sustainable floor plan, efficient use of water, energy efficiency, material and resource use. Generally, clean energy sources are used for building heating and cooling systems and renewable energy sources such as solar panels are used for heating. With the gray water techniques used, the rain water is filtered and the water is recovered.

In the LEED program, the rating systems are divided into 6 categories as *sustainability of the land, water efficiency, energy and atmosphere, materials and resources, indoor air quality and innovation and design process*. In general, the priority order of the criteria is (from the most important to the least important); *energy, water, material.*

4.6.1 Florida Atlantic University

Florida Atlantic University (FAU), with a main campus and six satellite campuses, is a public research university founded in Florida in 1964[39]. Since 2004, the budget allocated to researches at the university has been increased. With the new facilities and large research institutions built, academic and research status is tried to be increased.

Being an Environmental Leader at FAU

It is aimed to increase environmental sustainability awareness by giving priority to environmental and sustainability projects at FAU. According to the university,

[39] https://www.fau.edu/about/history/

Leadership in Energy and Environmental Design (LEED) is a tool to identify solutions for practical and measurable green building design, construction, operation and maintenance, thereby reshaping the way of thinking about everyday living spaces. For this reason, various sustainable LEED operations are carried out on the university campus. To save energy, a project with a $500,000 grant from the Florida Clean Energy Grant, which replaced the 2 largest chillers, was implemented. With this project, approximately $ 300,000 is saved in energy costs per year.

The number of solar-powered garbage compactors and recycling bins in buildings has been increased throughout the campus. In this way, wastes going to landfills are reduced and progress is made in recycling on campus.

The Pine Jog Environmental Education Center, completed in 2008, in West Palm Beach is used as an outdoor classroom. Apart from the fact that this center meets all the requirements of the buildings, it has become the first public primary school to be certified as a "green" building with its works in the categories of water efficiency; energy and atmosphere; sustainable space; indoor environmental quality, materials and resources; innovation and design and the standards adopted during the construction stages.

Figure 33: Florida Atlantic University Pine Jog Environmental Education Center.

The College of Engineering and Computer Science building is the first LEED platinum-certified building in the state. This building serves as a living teaching and research laboratory for environmental and alternative energy systems, thanks to the energy conservation and sustainable infrastructure design efforts carried out. (Dunbar et al., 2008) Various activities are carried out on photovoltaics, hydrogen fuel cells, renewable energy from the ocean, environmental engineering and sustainable infrastructure design/construction. In addition to these activities, applied education and information is provided to the public and students at all levels on environmental and energy issues, with ongoing teaching and research efforts related to environmental and alternative energy systems.

Figure 34: FAU College of Engineering and Computer Science LEED Platinum Certified Building Construction to Completion.

Some of the data provided by LEED standards, which offer solutions for measurable and applicable sustainable green building design, construction, operation and maintenance to building owners and users, are as follows:[40]

- 50% reduction in water demand in toilet fixtures,
- Recycling 75% of the waste generated by the project construction,
- Ensuring 75% reduction in landscape irrigation water,
- Providing 50% reduction in the rate of waste water produced in the toilet flush fixture,
- Achieving 50% more energy efficiency than a conventionally designed facility,
- Using 75% natural daylight for lighting,
- Planning 90% of the filled areas to have a window opening.

Florida Atlantic University's new College of Engineering and Computer Science Building in Boca Raton; which consists of the university's electrical instrumentation labs, computer construction/circuit labs and 5G technologies and private research labs; has received platinum LEED certification from the US Green Building Council. Photovoltaic systems, heat exchangers and other additional strategies, which caused an average of 35% less energy consumption compared to ASHRAE, were used in the project, along with cold ceiling technology.

With the geothermal wells, the clean air is reheated in the special outdoor air unit and kept at a constant temperature of 78 degrees throughout the year. Heat exchangers that capture heat from groundwater, data center computer servers and temperature control systems that provide heat recovery from UPS are used for this.

Daylight acquisition is used as a light source in 90% of the rooms in the campus buildings. To control glare, lighting controls that provide shading and wind direction

[40] https://www.upressonline.com/2015/05/engineering-east-is-leed-certified-but-what-does-that-mean/

of the exterior of the building are used. In addition, the heat required for hot water is obtained from the energy of the sun. Other sustainability actions:

- High efficiency toilet fixtures with passenger sensors are used, which reduces water consumption by 40% compared to typical fixtures,

- To protect natural plant and animal habitats, local vegetation with high adaptability is preferred,

- More than %80 of construction waste is removed from landfills and local products are used.

- A cloud computing infrastructure service that enables the use of information technology resources is provided through the high-tech classrooms and laboratories with LEED certification standards.

- LEED studies in architecture, planning, engineering and interior design programs carried out to include high-performance green buildings at the university are also supported by Leo A Daly.[41]

Table 26: FAU Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Waste Management Construction Transportation Buildings Energy Saving Recyclings	Environmental Economical	Goal 1,2,4,5,8,10, 13	LEED	College of Computer Science and Engineering Building

[41] **Leo A Daly**: Founded in 1915 by Leo A. Daly, LEO A DALY is an American architecture, planning, engineering, interior design and program management firm. The portfolio of the firm includes projects of 91 countries, 50 US states and Columbia. (https://en.wikipedia.org/wiki/Leo_A_Daly)

FAU College of Computer Science and Engineering Building

The five-story building houses the diverse laboratory of the Computer Science and Engineering Programs within a building that leads Florida's academic buildings in technology and sustainability.

Temperature is regulated in the FAU Computer Science and Engineering Building using cold beam technology. The system reduces energy costs by maintaining the standard temperature value.

Figure 35: Building that regulates temperature using cold beam technology.

4.6.2 University of Miami

It is a private research university established in Florida, USA in 1925[42]. At the University of Miami (UM), which consists of three campuses, intensive work is carried out to become a sustainable university in more than 6,000,000 square feet of building area.

[42] https://welcome.miami.edu/about-um/history/index.html#:~:text=The%20University%20of%20Miami%20was,flowed%2C%20and%20expectations%20were%20high.

Green Commitment Studies at the University of Miami

The UM was included in the American College and University Presidents Climate Commitment in 2007. The following studies are being conducted to reduce greenhouse gases as part of the climate commitment: (Sustainability Report 2020, 2021)

- A policy is sought to ensure that, at a minimum, the US Green Building Council's LEED Silver standard or an equivalent criterion is taken into account in all campus constructions.
- The purchase of ENERGY STAR certified energy efficient products is required in areas where the rating is available.
- Efforts are made to encourage all campus users to use public transportation.
- The National Recycling Frenzy competition is trying to be adopted by participating in the Waste Reduction component.

Sustainability studies are carried out at the university by adhering to these items.

Sustainable Building Operations

Under the policy of the Department of design and construction the University of Miami, facilities are planned, designed, constructed, managed, renovated and maintained in a sustainable way to support the University's commitment to environmental management and social values. This policy applies to all new construction and all major renovations.

The Miami Herbert School of Business Project, which is located on the campus of Miami Coral Cables University, has been certificated for its environmental performance and sustainable operations. The school is the first LEED v4.1 OM higher education building to receive a LEED Gold Certificate for Existing Building

Operations and Maintenance (EBOM) designated by the US Green Building Council (USGBC).

Patricia Louise Frost Music Studios (Coral Gables Campus) received LEED Platinum certification with its photovoltaic roof panels and system that converts sunlight into electricity. Rain water in and around the building is collected and used for toilet and landscape irrigation. Titanium dioxide mixed with concrete and electro-chromic windows automatically adapt to the bright weather outside and cloudy conditions, thus the amount of air pollutants is reduced.

With a 75 KW Photovoltaic solar panel system, 20% to 30% of the Patricia Louise Frost Music School's energy needs can be met.

Another 20 KW photovoltaic system has been installed on the roof of the Food Court building on the Coral Gables Campus of the UM, which has an educational mission to provide information about solar energy.

Campus Solar Thermal Systems: The energy demand required for scientific research and the hot water demand used in homes have been reduced by 30% in total with the use of solar thermal system, which was established as a part of the Silver LEED Neuroscience Center hot water system. In addition, with the solar charging umbrellas installed throughout the university, phones can be charged without the need for an additional source.

Campus Water Saving: All new buildings at the university are built in accordance with the minimum values of LEED Silver, resulting in at least 40% better performance in water consumption.

Green Roofs at Campuses: Sustainability initiatives are supported at Lakeside Village Student Housing, with innovative design features such as rooftop green spaces and a rain garden. Features of the LEED Gold Certified structures:

Sustainable Campus Uses

A reusable bottle is provided by Green U and the ECO Board to all new students during the orientation week. Students are searched for fountains on the online map of hydration stations and are encouraged to sign the "Take Back the Tap" pledge.

Miami University allocates its resources to sustainability coordination; develops plans to advance sustainability efforts; includes its users and stakeholders at the maximum level in the regulation and implementation of the institution's sustainability initiatives with the aim of becoming a sustainable university. (Bauer, 2005).

Table 27: Miami University Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Curriculum Climate Energy Food and Well-being Green Buildings Ecosystem Transportation Waste Diversion Water	Environmental Economical	Goal 3,4,6,7,12,13 ,15,17	LEED	Miami Herbert Business School- LEED OM Gold Certificate

Miami Herbert Business School

Located on the campus of Miami Coral Cables University, Miami Herbert School of Business is the first in the state to receive LEED Gold Certification for Existing Building Operations and Maintenance (EBOM) designated by the US Green Building Council (USGBC) for its environmental performance and sustainable operations, and the first in the state to hold LEED v4.1 OM certification. It is a learning building.

Figure 36: LEED certified higher education building.

The building's sustainable design efforts include:

- With the LED lighting used throughout the building, indoor air quality sensors, auditory/visual and automatic window shading efficiency are provided.
- Most of the waste consumed in the building is recycled and recovered and reused.
- To meet the comfort, health and safety requirements of the building occupants; The Operation and Maintenance process (MBS) is effectively managed in order to improve water and energy conservation efforts and ensure efficient use of resources.
- The carbon footprint of the campus has been reduced by encouraging the use of multimodal public transport such as the subway, bus, Brightline and bicycle.
- For the healthy indoor air conditions of the building, the use of materials containing formaldehyde, carbon monoxide and other harmful chemicals is avoided in the building.

4.6.3 University of Oregon

It was established in 1876[43] on 295 acres of land in the U.S. state of Oregon. It is a comprehensive university with 19 research centers and institutes.

[43] https://www.uoregon.edu/our-history

Sustainable design principles are taken into account in all repair, development and maintenance operations; in development and remodeling that has a decisive impact on the local environment and the future; in land uses and environmental regulations.

University of Oregon has created a Sustainable Development Model that deals with campus buildings and landscapes and focuses on energy, water and people. The University of Oregon has made some commitments to achieve LEED Gold under this model.[44] In the Oregon Sustainable Development Model, it is aimed to reach the general sustainability goals of the university by focusing on capital projects. Principles under Sustainable Development are evaluated at every Oregon Energy Code revision, every new LEED release and every 5 years.

Energy Efficiency Campus: Within the scope of university energy targets, it is aimed to optimize the energy efficiency of all new buildings and to minimize the increase in total campus energy use resulting from all capital projects.

Campus Water Conversations: The university aims to process an equivalent amount of stormwater runoff as required by city law. However, campus areas with relatively poor water quality, streets and parking lots are excluded from the treated areas. The focus is placed on campus areas, campus streets and parking lots that contribute the most to water quality deterioration and efforts are being made to improve the quality of campus rainwater, which spreads to the waterways of these regions.

Education for Social Equality Campus: A plan is developed for all capital projects to maintain campus habits and promote social equality. Building and/or

44 https://cpfm.uoregon.edu/sites/cpfm2.uoregon.edu/files/principle_10_sustainable_development_2021.pdf

landscape-related education/training opportunities are funded at the university to support all capital projects, energy use and other objectives

The goals for achieving equality in all social categories of the university and to promoting social equality and human health in all capital projects are as follows: (Sustainable Development Principle 10. Campus Plan 2021, 2021)

- Ensuring high quality levels of indoor environmental quality (IEQ) for the health and comfort of building occupants,
- Application of universal design principles to ensure equality in building uses and accessibility,
- Ensuring universal equality in building use and accessibility,
- Recording, documenting and sharing the techniques and materials used in the buildings during and after the construction phases,
- Enhancing choices for all individuals in accessing all toilet facilities (including gender).

Sustainable Design Strategies

In the university's projects with LEED Gold Certificate, new buildings constitute more than 60% of the total floor area. These buildings have heated or cooled floor space and mechanical equipment upgrades that serve the entire building. Documented and proven sustainable design strategies are utilized in all capital projects implementations. It is confirmed that Leadership in Energy and Environmental Design (LEED) has been achieved in buildings that have a certificate and it is shown that the university is committed to sustainable designs.

Table 28: Oregon University Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY POLICY PRIORITY	REFERENCE	ARCHITECTURAL FRAMEWORK RESPONSIBLE FOR PRIORITY
Curriculum& Courses Air&Climate Energy Buildings Ground& Stormwater Transportation Waste Water Purchasing Food&Dining Planning& Administration	Environmental Economical Social	Goal 2,4,6,7,9,11,12, 13	LEED	ERB Memorial Union

Erb Memorial Union

In the project design, hydronic radiant heating and cooling was preferred in order to reduce the fan power of the air handling unit. Heating/cooling amounts are reduced with the demand-controlled ventilation system used. More efficient serpentine heat transfer is achieved with the fan walls used in the air handling unit. Rainwater collected in tanks is used for landscape irrigation and toilets. All electrical systems of the building are integrated with photovoltaic systems. The heat obtained from the waste steam in the systems is used in the pre-heating of the domestic water.

Oregon Sustainable Development Model (OMSD) has been used on campus since 2011. The Oregon Model for Sustainable Development (OMSD) focuses on energy, water, and people.

Figure 37: Building with hydronic radiant heating and cooling system.

4.6.4 Florida International University

Founded in 1965[45], Florida International University is a multi-campus public research university with many local and global collaborations.

Campus Master Plan

The Campus Master Plan, which has sustainable design principles, is sensitive to geography, energy, resource consumption and the environment. It has been created in such a way as to support regional resources and strong local relations.

Campus Buildings

The criteria set by the USGBC for the minimum level of LEED Silver certification are used in all buildings on FIU campuses. In addition, the basic Energy Star criteria and all FIU building standards related to Master plan infrastructure strategies are complied with. Each stage of the process is examined and interpreted by the FIU sustainable office. (Building Standards, 2018)

Stormwater Management

[45] https://www.fiu.edu/about/history/index.html

Regulations are made to meet the FIU building standard in sustainable building criteria such as building systems, building insulations, rainwater management, general water collection systems, day lighting for new constructions.

Sustainable Campus Engagements

All buildings financed and constructed (except parking garages) are brought to meet these criteria. By 2021, the FIU has one LEED Silver and one LEED Gold certified building. (AASHE Report, 2016, OP-4)

Energy and Resource Efficiency Campus

The FIU Master Plan 2010-2020 guideline was created to build an environmentally sensitive campus that is sensitive to energy and resource consumption, supports regional resources and strong local relations. The plan, which aims to determine the direction for all new and existing buildings, includes the following:

- Interventions should be made to all buildings on FIU campuses according to the USGBC guidelines to achieve the minimum level of LEED Silver certification. The criteria outlined by the USGBC scorecard should be taken into account at every stage of the project.
- Energy Star criteria should be met in all buildings, even at a basic level. These buildings must comply with all FIU building standards related to master plan infrastructure strategies and general sustainable campus practices.
- Campus-wide best practices should be reviewed and commented on by the FIU sustainable office at all stages of the project.

Table 29: FIU Sustainability main work titles. (by autor)

UNIVERSITY TARGET	UNIVERSITY FOCUS	UNIVERSITY	REFERENCE	ARCHITECTURAL FRAMEWORK

		POLICY PRIORITY		RESPONSIBLE FOR PRIORITY
Nature& Ecosystem Air&Climate Energy Recycling Transportation Waste Water	Environmental Economical	Goal 5,6,7,11,14,15, 17	LEED	FIU Steven J. Green School of International&Public Affairs (SIPA)

The Florida International University Steven J. Green School of International & Public Affairs (SIPA)

The Florida International University Steven J. Green School of International & Public Affairs (SIPA) aims to achieve LEED Gold certification with its double-height auditorium with approximately 480 seats, the 5-storey office/classroom building located nearby and the green roof, which was completed in 2011. Miami is a sub-tropical climate and all green roofs in tropical and sub-tropical climates could be considered experimental since few or no sedums survive with such high humidity. To eliminate irrigation, a hybrid system with an average 6″ soil depth and drip irrigation was built with the FIU-SIPA green roof project. It is the second green roof at FIU after the FIU Nicole Wertheim College of Nursing and Health Sciences, which was built experimentally in 2010.

Figure 38: Green roof at Florida International University's Steven J. Green School of International and Public Affairs (SIPA).

4.7 Results and Discussions

As a result of the literature review, all campus practices, from the energy used in the buildings to the food consumed in the cafeterias, were included in the sustainability indicators. Considering only physical indicators within the scope of sustainability would prevent the study from giving complete and accurate results. For this reason, to understand the concept of 'sustainability' correctly and examine it from a holistic perspective, this concept was discussed in the social, environmental and economic context.

The tools used in this study, together with their corresponding indicators, were analyzed in detail and tabulated. In order to use a common language, international criteria were taken as reference while making the analysis. Accordingly, in the first stage, a general analysis was made using a total of 6 criteria, 29 campus representing successfully and 36 main indicators. In the second stage, the data obtained within the scope of the meta-analysis study were presented in tabular form.

Table 30: General Evaluation of the Criteria and Indicators Used by the Considered Campuses. (by autor)

CRITERIAS	UI GREEN METRIC						IARU									GREENING UNIVERSITY TOOLKIT V2.0								STARS				ISCN			LEED V4					
INDICATORS	Setting and Infrastructure (SI)	Energy and Climate Change (EC)	Waste (WS)	Water (WR)	Transportation (TR)	Education (ED)	Sustainable campus organization	Campus wide operations	Buildings	Laboratories	Green purchasing	Transport	Communication	Employee and student engagement	Universities as the catalyst for a sustainable	Defining Sustainability	Initiating Transformation	Indicators	Technologies for Transformation	Policy Governance and Administration	Resources for Change	Growing Your Own Brochures	Global Examples	Institutional Characteristics (IC)	Academics (AC)	Engagement (EN)	Operations (OP)	Sustainable performance of buildings on campus	Campus-wide master planning and goal setting	Integrating facilities, education, research and outreach as a living laboratory for sustainability	Sustainable Sites	Water Efficiency	Energy & Atmosphere	Materials & Resources	Indoor Environmental Quality	Innovation & Design Process
UNIVERSITIES																																				
Massachusetts Institute of Technology	1	1	0	0	1	1																														
Harvard University	1	1	1	1	1	1																														
University of Wisconsin Oskhosh	1	1	1	0	1	0																														
Princeton University	1	1	1	1	1	1																														
Australian National University							1	1	1	1	1	1	1	1	1																					
ETH Zurich							0	1	0	0	1	0	1	1	1																					
National University of Singapore							1	1	1	0	1	0	1	0	1																					
University of California, Berkeley							1	0	1	1	1	1	1	1	1																					
University of Cambridge							0	0	1	1	0	1	1	0	1																					
University of Cape Town							1	1	1	1	1	1	1	1	1																					
University of Copenhagen							1	1	0	1	0	0	1	1	1																					
University of Oxford							1	1	1	1	1	1	1	1	1																					
Yale University							1	1	1	1	1	1	1	1	1																					
University of Nairobi, Kenya																1	1	1	0	0	1	1	0													
Macquarie University, Australia																1	1	1	1	1	1	1	1													
Tongji University, Shanghai, China																1	1	1	1	1	1	1	1													
Middle East Technical University, Turkey																1	1	1	1	0	1	0	0													
Arizona State University																								1	1	1	1									
Stanford University																								1	1	1	1									
Colorado State University																								1	1	1	1									
McGill University																												1	1	1						
National University of Singapore																												1	1	1						
Anglia Ruskin University																												0	1	1						
Florida Atlantic University																															1	1	1	1	1	1
University of Miami																															1	1	1	1	1	1
University of Oregon																															1	1	1	1	1	1
Florida International University																															1	1	1	1	1	1
	4	4	3	2	4	3	7	7	7	7	7	6	9	7	9	4	4	4	3	2	4	3	2	3	3	3	3	2	3	3	4	4	4	4	4	4
	1	1	0.75	0.5	1	0.75	0.77	0.77	0.77	0.77	0.77	0.66	1	0.77	1	1	1	1	0.75	0.5	1	0.75	0.5	1	1	1	1	0.66	1	1	1	1	1	1	1	1

	0.83	Campus Physical Operations
	0.84	Sustainability Engagements for a Sustainable Society
	0.93	Institutional Characteristics and aims
	0.93	Innovation & Design Process for Green Transformations
	0.5	Policy Governance and Administration

4.8 Summary of the Chapter

Sustainability is a concept that should be supported by education. Due to the requirements reaching national dimensions, it should cover every socio-economic and socio-cultural group from the individual to the society. Taking advantage of the technological opportunities of the age, it is necessary to address it at a simpler level but in a more inclusive way in terms of the success and sustainability of the system.

Sustainable campus criteria discussed in the study were examined with campus indicators. In order to make the subject more concrete, the effectiveness of sustainable campus indicators on campuses was evaluated. In addition, the criteria were evaluated according to the general sustainability categories and presented in tables. In the light of the data obtained, it was determined which sustainable campus indicators should be included in the accessible, applicable and sustainable criteria that everyone can accept.

In addition, it was studied on how the sustainability process should be designed by architects.

It is aimed to reduce global problems by raising awareness of society with education and ensuring that this awareness is sustainable. However, this process should include cultural and economic main categories, intersections and sub-categories besides environmental problems. Also, it should be designed with a holistic approach. In the study, a table for the solution was created by considering the indicators. The EMU campus were evaluated to give a concrete example of how a global sustainability model can be utilized in solving global problems.

Since the subject is deep and comprehensive, it is suggested that the process of becoming a sustainable campus should be handled from different aspects. Because it is not possible to achieve sustainability only with environmental studies or partial initiatives. Addressing the sustainability process with a holistic perspective is important for the functioning, success and sustainability of the system.

Some of the problems identified in this study are as follows;

- Addressing the sustainability process only with its environmental aspect,
- Trying to apply the interventions performed in different places in the same way without changing them due to the fact that the place to be applied is not well known,
- Failure to reflect existing potentials in designs and raise awareness,
- Deficiencies in campus designs and uses; failure to fully explain the process to campus users and/or inability to understand the process by users,
- Strong belief that sustainability can only be achieved by replacing existing systems with more technological ones,
- The need for the support of external sources mostly in the process to meet the

economic criteria,

- Lack of cooperation or insufficient level,
- Inadequate development of joint projects by the public and private sectors.

It is possible to contribute to sustainability even with the small interventions and some changes in daily habits. In order to ensure that the education to be given on campuses is more effective, it must be experiential. At this stage, primarily architects have great responsibilities. Campus users and regional management are also included in this responsibility in sustainable management processes. All of the actions that need to be taken to turn existing campuses into sustainable ones include the improvement of existing systems and the transformation of these systems. As for sustainable campus designs include the formation of campuses with new designs. At this point, traditional construction methods are not sufficient and remain incomplete; new alternatives and different perspectives are needed.

The inability of a built campus to achieve its goals in terms of physical and system relationship leads to the conclusion that sustainable campus design indicators cannot be fully designed by architects and the whole cannot be created. For this reason, campus indicators should be clearly determined in the sustainable design of campuses and the entire design should be based on these indicators.

This process requires collective work. In other words, a domino effect should be created. Architects should guide the process with their designs in this process. It is necessary to act with a sense of responsibility towards the world in designs and even in individual decisions. Universities should be pioneers of change for the reasons stated. Environmentally friendly environments should be provided; new habits and perspectives based on environmental awareness should be gained both with the campuses and with the management styles and designs of university users.

Chapter 5

THE ROLE OF ARCHITECTURE IN SUSTAINABLE CAMPUS DESIGN

5.1 Sustainable Campus Indicators

In order to increase the technical and operational capacity of energy efficiency in environmentally friendly universities, campus should be evaluated by architects. These evaluations should be made in the perspective of the indicators that make up the energy use and sustainability characteristics of the campuses and the campus achievements should be defined by the architects. Architecturally, campuses are handled within the scope of two action groups: existing campuses and new campuses. Both categories have the goal of creating a sustainable campus. For this reason, architects have significant responsibilities in both categories. The failure of a built campus to achieve its goals in terms of physical and system relations shows that sustainable campus design indicators could not be fully designed. This situation also leads to the conclusion that the architect could not construct the whole. For this reason, architects for both categories should clearly define campus indicators and create their entire design based on these indicators.

Table 31: Sustainable Campus Indicators (by Autor)

CAMPUS PHYSICAL OPERATIONS
INSTITUTIONAL CHARACTERISTICS AND AIMS
INNOVATION&DESIGN PROCESS FOR GREEN TRANSFORMATIONS
SUSTAINABILITY ENGAGEMENTS FOR A SUSTAINABLE SOCIETY
POLICY GOVERNANCE AND ADMINISTRATION

5.1.1 Campus Physical Operations

- **Setting and Infrastructure**

This category forms the basis of sustainability policies applicable to all venues and infrastructure on campus so that institutions have a more sustainable future. It contains information about what basic features a sustainable campus should have. Although it contains more environmental items related to sustainability, it also gives social messages that will enable the development of energy by working for a sustainable environment. It provides the operational incentive for sustainability. It helps to interpret the sustainability infrastructure and system on a local basis; understand the current potential, advantages and disadvantages of the campus for making an evaluation. Subjects such as campus open-closed area ratio, cultivated vegetation, population, accessibility, facility features, forest vegetation are included in these indicators.

- **Air & Climate**

This category includes determining the sources of greenhouse gas and air pollutant emissions, measuring these values and conducting institution-based reduction studies. Universities, which greatly affect public and environmental health, prepare inventories for this problem. Within the scope of these inventories, all

working steps should be determined and more concrete steps should be taken to reduce air pollutant emissions.

- **Energy**

This category is consisted of conservation and more efficient use of limited natural resources; protection measures such as switching to cleaner and renewable energy sources such as solar, wind, geothermal and low-impact hydropower. In addition, it is aimed to provide resource economy with the local use of producible and renewable energy sources.

- **Transportation**

This category covers transportation systems and usage alternatives, which are the main source of greenhouse gas, which is one of the biggest causes of environmental pollution. Practices such as reducing or even ending vehicles using petroleum-based fuels; dissemination of environmentally friendly transport systems; increasing the use of asphalt with high capillarity on transportation routes, etc. are supported. Sustainable transportation systems and models should be planned to cover the entire campus and its immediate surroundings.

- **Waste**

Within the scope of this category, it is aimed to reduce the wastes that pollute the air and water and produce greenhouse gas emissions. In addition, the necessary measures, actions and regulations to ensure the recycling of the wastes are included in this category.

- **Water**

This category includes reducing the demand for water on campus, water recovery and gray water management. Energy is consumed from the source of the water until it reaches the end user and even in the phase of mixing with nature after consumption.

Therefore, by conserving water, a reduction in energy demand will be achieved. Thus, greenhouse gas emissions associated with energy production will be reduced. In addition, limited underground water resources will be protected by the protection and recycling of water. (STARS Technical Manual 2.1.,2017)

- **Education**

This category includes learning and sharing experiences within and outside the curriculum. With the purpose of adopting sustainability as a campus culture, the studies carried out must be carried out in accordance with the curriculum. Therefore, activities related to the curriculum should be developed and students should be involved in the process to deepen their understanding of sustainability. As the daily habits of individuals will shape the campus and this will affect the campus sustainability performance, the sustainable campus behavior of all campus users should be encouraged with information and activities. It should be ensured that campus users reflect their sustainability habits outside the campus as well, so that a public green awareness about sustainable daily living habits will be gained.

- **Purchasing**

This category covers subjects such as campus sustainable purchasing policies, purchases of all kinds of sustainable products and equipment, life cycle cost analyzes arising from purchases, sustainable suppliers and collaborations that should be followed in purchases.

- **Indoor Environmental Quality**

Within the scope of this category, unhealthy and inefficient indoor air conditions resulting from building construction systems, building designs and materials used in buildings are discussed. To improve these conditions, measures such as using materials with low VOC values, controlling pollutant and chemical sources used in buildings,

providing thermal comfort, using efficient lighting designs, disseminating traceable ventilation control systems, taking acoustic precautions, controlling ambient PM (particulate matter) values are being worked on.

- **Food & Dining**

In this category supply, consumption and disposal methods within the sustainable food system are handled on an institutional basis. Practices such as ensuring food supply from local producers, raising awareness in food habits, obtaining energy from food waste (biofuel, fertilizer, etc.) are being worked on.

- **Buildings**

In this category, efforts are made to provide healthy living spaces for campus users and to create designs that protect the environment. In this context, approaches that take environmental characteristics into account are used in sustainable designs and operations. The work done also contributes to increasing social welfare. Accordingly, natural resources such as water are protected; source energy efficiency is ensured by reducing the demand for energy; air quality is increased and efficiency in waste management is achieved. Building design and construction, building operations and maintenance-repair of buildings are also being worked on.

5.1.2 Institutional Characteristics and Aims

While preparing the report for campuses with institutional characteristics, the institutional boundaries of the campus should be defined first. All features related to the operational characteristics, demographic structure and academic framework of the campus should be clearly explained. The boundaries of the institution, the operational features it deals with, the demographic structure of the academicians and students that make up the institution, the distinctive features of the institution and the management infrastructure constitute the main indicators of the campus characteristics.

The sub-indicators of the institutions are as follows:

- *Institution Boundary*
- *Operational characteristics*
- *Demographic Structure*
- *Institution characteristics*
- *Management Infrastructure*

5.1.3 Innovation & Design Process for Green Transformations

Following the innovation processes in the design processes allows to see the quantitative performance improvements between the existing structures and the designed structures. This process, which includes comprehensive strategies involving multiple products and processes, is important for the continuity of sustainable design practices. For this reason, within the scope of performance improvements, all project equipment should be measured electronically, covering the entire campus. Measuring devices should have a daily automatic reading feature. All equipment and cleaning products should be included in the sustainable purchasing policy. A credit booklet should be created that will include strategies for the implementation and performance of the process.

The sub-indicators of the institutions are as follows:

- *Innovative Design Technologies*
- *Effective Equipment Policy*

5.1.4 Sustainability Engagements for a Sustainable Society

In this category, efforts to create a growing environmentally friendly audience and raise awareness of sustainability are discussed in line with increasing sustainability commitments. Accordingly, it includes studies, organizations and activities for the exchange of information established by university communities that want to be

pioneers to maintain their commitment to sustainability and to further expand their sustainability. With such interactions, experiences related to sustainability are shared and inter-institutional support is provided to become a sustainable campus. In addition, it is tried to increase individual and institutional awareness by creating social partnerships. For this purpose, online tools, international commitments, written and unwritten resources and award programs are used.

The sub-indicators of the institutions are as follows:

- *Continuing Education Center*
- *Orientation Programs*
- *Public Collaborations*

5.1.5 Policy Governance and Administration

In order for campuses to achieve their sustainability goals, they need to define their institutional commitments and visions. The use of international formats in defining campus sustainability ensures the continuity of the whole process from planning to implementation. The Plan-Do-Check-Act "Deming Cycle" developed by the International Organization for Standardization (ISO) is the most used formula. (Deming, 1986)

Campuses, which are defined as microcosms of many environmental problems that concern the whole society. (Dahle and Neumayer 2001) should give detailed coverage to sustainable policies and strategies. Understanding that the scope of anthropogenic environmental impacts is global (Vitousek et al., 1997; Palumbi, 2001) campuses have begun to act as an effective bridge on the road to sustainability. Setting long-term inclusive goals will be a guide to the limits and scope of sustainability actions.

Qualitative arrangements on issues such as sustainability policies, environmental management plans and systems, environmental audit, recruitment and personnel development, ethical investment, local economic development, student access and equality will provide quantitative advantages in the long term. In the study, the architects are limited to the physical aspects of this issue. (UNEP Greening Universities Toolkit, 2013)

The sub-indicators of the institutions are as follows:

- Sustainability Policy
- Sustainability Action Plans
- Administration

Table 32: Sustainable Campus Indicators with Sub-indicators (by autor)

CAMPUS PHYSICAL OPERATIONS	INSTITUTIONAL CHARACTERISTICS AND AIMS	INNOVATION&DESIGN PROCESS FOR GREEN TRANSFORMATIONS	SUSTAINABILITY ENGAGEMENTS FOR A SUSTAINABLE SOCIETY	POLICY GOVERNANCE AND ADMINISTRATION
Setting and Infrastructure Air & Climate Energy Transportation Waste Water Buildings Purchasing Food & Dining Indoor Environmental Quality Education	Institution Boundary Operational Characteristics Demographic Structure Institution Characteristics Management Infrastructure	Innovative Design Technologies Effective Equipment Policy	Continuing Education Center Orientation Programs Public Collaborations	Sustainability Policy Sustainability Action Plans Administration

5.2 Sustainable Campus Design

Making campuses sustainable makes their potentials visible, increases participation, provides campus-based solutions to global problems in the fields of social-economic-environmental sustainability and encourages cooperation. (Leal Filho, 2015) Incentives for sustainability should be based on educational strategies. (Huyuan and Yang, 2012) For this reason, sustainable campuses should have innovative steps in every application. (Yeh, 2006)

In order to ensure that the applications made for sustainable campuses are stable and obvious, general sustainability targets should be determined first. Accordingly;

- Structures should be designed where all campus users can benefit from natural daylight in the most effective way; the sunbathing effect should be taken into account in the positioning and planning of each structure.
- Demands for natural resources and energy use should be reduced.
- Alternatives (wind energy, bioenergy, etc.) should be preferred instead of traditional (oil, natural gas, etc.) resources.
- Passive and active energy systems integrated into the campus should be used.
- Greenhouse gas released to nature should be taken into account in all activities such as purchasing, planning and transportation. Both institutional and individual awareness should be created to reduce greenhouse gasses.
- The use of local and natural materials should be encouraged.
- Construction strategies that minimize all kinds of waste in the construction, use, maintenance and even demolition of structures should be developed.
- The natural energy resources of the region should be collected within the campus boundaries; these energy resources should be converted and energy demand should be met from here.

- The use of chlorofluorocarbon-derived materials, which have harmful effects on the atmosphere, especially on the ozone layer, should be avoided.
- Care should be taken to use recyclable materials in the campus environment.
- Energy efficient equipment should be used.
- As much as possible, larger green areas should be created on the campus.
- Everyone should have equal access to the campus and a safe campus environment should be created.
- The indoor air quality should be created in a way that does not affect the users. Measures should be taken to minimize the volatile organic compound rates originating from construction materials.
- Nature-friendly solutions that appeal to users should be offered to campus green areas.

All these items will be discussed in detail under the headings of indicators created for campuses that concern architects.

When all the indicators in sustainable campus design are examined, it is seen that the interventions of the architects are mostly in the physical scope. Environments with healthier physical conditions and atmosphere are created with indicators, the use of environmentally sensitive and nature-friendly materials is supported. In addition, the use of devices with high energy performance is encouraged and efforts are made to ensure low usage costs.

5.2.1 Architecturally Sustainable Campus Design

The use and efficiency of energy are the most important issues in sustainable campuses. The demand for energy can be reduced by conducting various preliminary studies on campuses. For this, equipment with advanced systems that consume less energy and have less energy demand should be used in the architectural designs of the

campuses. Furthermore, innovative holistic design approaches should be utilized. Because each component is included in the project as determined by the designer in holistic designs and thus it is possible to monitor the system operation. This situation provides benefits in terms of both time and economy in possible revisions, maintenance and renewal works.

Electrical energy constitutes about one third of the world's energy consumption. (EUAŞ, 2018) Considering the limitedness of natural resources, the protection of existing systems becomes more important every day. In sustainable structures, designs that require the least intervention should be made for the existing potentials. For example, trees, recreation areas, landscaping equipment and public areas that provide microclimate effect and temperature control should be provided for green areas on campus. Social equality and diversity should be ensured in the recycling with an effective waste management program. Waste collection areas should be designed at appropriate locations.

Campus policies and implementation criteria should be determined. These criteria and campus policy should be taken into account in renovations or constructions. If this whole process progresses in terms of architects, campus policies should be implemented in order to raise awareness in practice. Architects should act as a lever in this process and realize their designs with this philosophy. At this point, the main concern for everyone should be the sustainability of resources and awareness of sustainability.

5.2.2 Architecturally Sustainable Campus Building Design

The main goal of building design and renovation is to ensure that all spaces, especially busy places, have natural ventilation and natural lighting conditions. In line those goals:

- For work areas and rooms designed independently from each other, greened air and light paths (areas, courtyards, etc.) should be designed to bring daylight into the building from different angles.
- Care should be taken to ensure that fresh air reaches all areas by providing cross ventilation with the microclimate created by the landscape design. It is also possible to use landscape designs as noise canceling in facade designs. A double-walled facade application can be considered as another soundproofing system.
- Natural lighting analyzes should be made throughout the building and the openings should be optimized. For this reason, sunshade systems can be designed according to the locations and dimensions of the openings on the south facade.
- Building envelope systems with high insulation and non-condensation should be used on the facades.
- The energy consumption of all buildings should be evaluated according to the sustainable campus criteria and improvement studies should be determined.
- An effective campus sustainability management should be established that integrates all structures with the units they are associated with.
- To make the most of daylight, the working areas should be positioned on the north side of the building.
- Sunshades integrated into the buildings should be used on the south facade; passive pre-coating and pre-heating systems should be used; cooling and heating systems provided from the floors should be used.
- Systems that collect rain water and recover gray water should be preferred.
- Rainwater control should be provided with green roof applications.
- High efficiency lighting elements sensitive to motion should be used on campus.

- PV panels integrated into campus structures should be used.

5.3 Sustainable Campus Indicators That Are Related to Architecture

The architectural scope of the sustainable campus includes the indicators of setting and infrastructure, air & climate, energy, transportation, waste, water, purchasing, IEQ and buildings. Each indicator contains its own specific information and application stages. In order for universities to have sustainable campuses, architectural designs should be supported by vision, mission and regulations; and some strict rules should be set in practice.

Architects should use energy efficient, renewable technologies in their designs and thus contribute to the reduction of greenhouse gas emissions. In summary, environmentally friendly sustainable equipment should be preferred instead of fossil fuel consuming equipment in designs. In this way, carbon-based emissions resulting from the materials used will be reduced and a carbon neutral campus environment will be created.

Table 33: Sustainable Campus Indicators That Are Related to Architecture (by Autor)

SETTING AND INFRASTRUCTURE	AIR &CLIMATE	ENERGY	TRANSPORTATION	WASTE	WATER	PURCHASING	IEQ	BUILDINGS

Chapter 6

THE ROLE OF ARCHITECTURE IN SUSTAINABLE CAMPUS: EMU CASE

EMU is a public university founded in 1979 in Famagusta, Turkish Republic of Northern Cyprus. The university, which is a full member of the European Universities Association and the International Universities Association, offers various graduate and undergraduate programs in addition to undergraduate programs. (Wikipedia)

Universities are one of the stakeholders that make an important contribution to the achievement of sustainable development goals. With this aspect, universities contribute to environmental, social and economic problems with their more innovative and sustainable mechanisms. (Diesendorf, 2000) Campuses with different uses stand out as places where sustainable development can be applied. In this study, EMU campus has been interpreted according to the sustainable campus indicators. According to the evaluation results, suggestions for solutions have been presented.

6.1 General Analysis Sustainable Campus Indicators At EMU

For the purpose of being an institutional model as a sustainable campus, EMU campus studies should be developed in line with sustainable campus goals. Accordingly, EMU campus studies should be based on six concepts: sustainability, accessibility, energy efficiency, innovation, social responsibility and public interaction.

Campus infrastructure, climate, energy, waste, water, transportation, education, social responsibility and indoor air quality have been determined as priority study

subjects. These studies should be carried out after the evaluation of the EMU Institutional Strategy and the work of national and international institutions (STARS, LEED, GREEN METRIC, etc.). Also, studies should be carried out on themes that are handled with an inclusive perspective and a holistic approach. First of all, determining the method-scope-process stages of the system is important in terms of evaluating the process from a wider perspective.

Universities should aim to combine sustainability subcommittees with low sustainable design guidelines for construction programs. As the main objective of the Sustainable Design Guidelines, the university's commitment to the protection of its natural resources should be met.

Sustainable design guidelines should be addressed in three parts:

Part I – *Objectives of the Sustainable Design Guidelines*: The vision of the university, the principles necessary for this vision and the role that future development can play in the implementation of these principles should be explained.

Part II – *Technical Guidelines*: Funding should be provided for future development projects.

Part III – *Process Guidelines*: Recommendations for the implementation of sustainable strategies should be presented within the university's design and construction processes and procedures.

In order to protect the limited natural resources such as water, forest, soil and human health in the sustainable design guidelines, social responsibility should be taken from an architectural point of view and a sustainable approach should be adopted.

In this direction, EMU Sustainable design guidelines should propose future strategies that can minimize environmental impact in 5 main categories. These categories are:

- *Planning of Sustainable Sites*
- *Conservation of Water*
- *Conservation of Materials and Resources*
- *Increasing Energy Efficiency*
- *Increasing Indoor Environmental Quality*

6.2 Sustainable Campus Scope, Process and Method

It is expected that university campuses will be environmentally sensitive, have healthier buildings and bring their users to a higher level of welfare. The sustainable campus principles and indicators such as GREEN METRIC, STARS, GREEN UNITY TOOLKIT, ISCN, LEED should be examined in the sustainable campus studies carried out for this purpose.

- *Identification of Main Systems:* Identification and classification of sustainable campuses and structures of different scales; determining the main conceptual approaches and institutional boundaries according to the evaluation criteria; measuring the potential of existing values at this boundary and defining participation.
- *Identification of EMU Campus Potentials:* Establishing strategic goals and roadmaps as a result of evaluating EMU and its campuses in terms of sustainability.
- *Establishing the EMU Sustainable Campus Plan*: Establishing university-specific goals and principles by designing the evaluation and roadmap.

6.3 Institutional Values of EMU

The words 'director, guide' are used to draw attention to the fact that universities are not only educational institutions but also social guides. However, to achieve this goal, the term 'sustainability' should also be used in the current mission definitions.

When the current EMU 2017-2022 strategic plan is examined, it is seen that the basic campus values are listed as follows: (Doğu Akdeniz Üniversitesi Stratejik Plan 2017-2022, 2017)

- Free thought
- Creativity,
- Innovation
- Having ethical values
- Academic freedom
- Scientific productivity
- Environmental awareness
- Being against all kinds of discrimination
- Being sensitive to social problems
- Transparency and accountability
- People-oriented management
- Participation, was determined as.

As a public research university, EMU fulfills its mission to protect natural resources for a sustainable future. Within the scope of this mission, it is expected that the following study areas and related practices will be realized.

Controlled growth and management: Sustainability should be considered at every stage in university buildings and infrastructure; the environment should be protected in the plans and construction methods.

Campus Sustainable Management Plan: The targets for sustainability should be determined clearly and a management plan should be prepared.

Performance: Practices that have achieved successful results should be institutionalized; sustainability performance should be continuously monitored and reported.

Access: Sustainability should be supported by on-campus and off-campus studies.

Academic Staff: The sustainability ethics program should be implemented in curricula, researches and all practices taken on and off campus.

Protection: Natural resources must be protected; the use of all environmentally friendly sustainable products, materials and services, including renewable resources, should be increased; measures should be taken to prevent and reduce pollution and recycling should be encouraged.

Collaborations: Groups and individuals should be guided to achieve common sustainability goals; teamwork should be encouraged.

6.4 University Sustainability Guidelines

At this stage, the goals and strategies of the university and the goals and strategies sustainability should be evaluated together. Technical resources that need to be taken into account in the improvement works, including construction, renovation and strengthening works, should be identified.

In general, the EMU Sustainability Guidelines should be addressed in six categories. These categories are:

- *Campus Mega Plan with Sustainable Areas*
- *Protecting Water Resources*
- *Protecting Resources and Materials*
- *Ensuring Energy Efficiency*
- *Improving Indoor Air Quality*

- *Increasing Innovative Sustainable Enterprises*

6.5 EMU Campus Indicators

Campus Design Criteria derived from EMU Sustainable Campus Indicators should be established for both future constructions and existing constructions. For this purpose, campus indicators should be determined primarily.

The main indicators that should be focused on for EMU Sustainable Campus goals are' Setting and Infrastructure, Air & Climate, Energy, Transportation, Waste, Water, Purchasing, IEQ, Buildings.

6.5.1 Setting and Infrastructure

Goal 1- *Establishing a Campus Plan Including Sustainable Area Designs*

The existing campus open space and natural resources have environmental impacts. For this reason, environmental destruction should be prevented by a controlled campus growth and settlement planning.

EMU's strategies in this area should be:

- To preserve and develop the existing campus master plan in accordance with the guides published by the TRNC Ministry of Tourism and Environment, it should be consistent with local plans on both a district and island basis.

- Natural and direct feeding areas (such as reservoir, diversion areas) and aquifer[46] areas within the protection criteria of the ministry existing in the current campus plan should be protected. Interventions in these areas should be avoided.

- Protection and management plans should be developed by the Eastern Mediterranean University Urban Research and Development Center (EMU KENT-AG) to protect the university forest areas. These plans should be

[46] They are permeable geological units that can store a significant amount of water economically (high permeability) and transport it fast enough (conductor). (https://en.wikipedia.org/wiki/Akifer)

enforceable by everyone.

- Water and wetlands should be protected by creating plant buffers in existing wetlands and nearby areas where deterioration may occur.

- Threatened and endangered habitats should be protected.

Goal 2- *Preventing the negative effects of new plans on the natural landscape*

For this purpose, the following strategies should be implemented:

- A natural landscape plan covering the campus and surrounding areas should be created.

- The development of deteriorated or deteriorating areas according to the footprint should be determined; protection or prevention plans should be established.

- University tree protection directive should be established. Vegetation protection guidelines should be established with a protection committee.

- Local or adapted landscape elements that require less maintenance, provide water efficiency and have pest tolerance characteristics should be used in landscape arrangements.

6.5.2 Transportation

Goal 1- *Encouraging the use of alternative methods and energy vehicles in transportation*

For this purpose, the following strategies should be implemented:

- Plans for potential transportation needs should be created for future campus designs. Shared car use should be encouraged to reduce individual travel.

- Campus travel design and guidelines that provide easy, understandable, accessible and attractive connections should be created.

- Encouraging ideas and measurable practices should be developed for pedestrian

and bicycle use.

- As few vehicles as possible should be allowed to enter the campus area. For this purpose, an area for long-term parking should be created at the entrance of the campus. Access to the campus should be provided by alternative vehicles (bicycle, public transportation etc.) after this point and alternative plans should be developed and implemented with this purpose.

- The main points and transportation lines that provide collective service within the campus should be protected.

- New buses and/or maintenance vehicles using alternative fuels such as natural gas, electricity or biodiesel should be purchased for public transportation within the campus.

6.5.3 Air & Climate

Goal 1- *Minimizing the negative effects on the microclimate of the campus and its surroundings*

For this purpose, the following strategies should be implemented:

- Light colored materials with a minimum reflection coefficient of 0.3 should be used in paved areas such as pedestrian walkways, bike paths and roads

- Since campus structures have flat roofs, existing renovations or new planning must comply with the Environmental Protection Agency's (EPA) ENERGY STAR® Roofing Guidelines.[47]

- To alleviate the harsh conditions experienced in the summer months in large asphalt areas, shading should be provided with landscape islands and trees,

[47] EPA's ENERGY STAR® program allows voluntary partnerships between the US Department of Energy, the US Environmental Protection Agency, product manufacturers, local services, and retailers. The ENERGY STAR® program identifies roofing products that reduce the amount of air conditioning and can cut energy bills by up to 50 percent (source: EPA). Roofing products with the ENERGY STAR® logo meet EPA criteria for reflectivity and reliability. http://www.energystar.gov

preferably without sidewalks, covered with vegetation.

- Large paved areas should be planned for the northern facades of the buildings; landscape elements that provide shade should be used in these areas.

Goal 2- *Choosing field lighting that is sensitive to light pollution and requires less light at night*

For this purpose, the following strategies should be implemented:

- Materials with light levels and homogeneity ratios recommended by the TRNC Chamber of Electrical Engineers IEE 16. Installation Regulation should be used.
- Full-cut outdoor fixtures with an output above 3500 lumens, cutoff and full cutoff outdoor fixtures with an output below 3500 lumens, or display fixtures that prevent light scattering in the night sky should be used for outdoor lighting.

TRNC Chamber of Electrical Engineers provides general exterior lighting design guidance. It provides additional information on the lighting of different environments. The chamber also works on environmentally and socially conscious designs, lighting regulations, luminaire alternatives, indoor and outdoor hard and soft floor lighting.

According to the information provided by the TRNC Chamber of Electrical Engineers, LEED 2.1 light levels demand less energy. For that reason, at least the criteria of the TRNC Chamber of Electrical Engineers must be met while determining EMU and Sustainable Design Standards. More consistent efforts should be made to meet LEED 2.1 standards.[48]

6.5.4 Water

Water problem is an important issue in TRNC. In the last 50 years, the use of irrigation water has increased as the amount of precipitation has decreased, evaporation has increased and the population has increased. Institutional targets for

[48] https://www.ktemo.org/Sayfalar?LINK=IEE_16__Tesisat_Yonetmeligi_Ek_Bilgi

alternative water resources and water use on campus are not clearly stated and savings on water are left to individual preferences. It is expected that this issue will be taken into account in architectural designs. There is a need for designs that will change the daily habits of users and direct them to alternative resources.

Goal 1- *Reducing the runoff of rain water on the quantity and quality of water resources*

For this purpose, the following strategies should be implemented:

- Flow direction and speed of rain water should be adjusted. The collected water should be used in gray water systems such as garden irrigation.
- Water permeable asphalt systems should be worked on in the design of parking lots and driver areas. Thus, maintenance costs will be reduced in the long term.
- Systems that collect the water accumulated on the roofs and reuse it by transferring it to the gray line should be designed.
- Local plants that require less water and maintenance should be used in landscape designs.
- Plants on the roofs should be considered on flat roofs and roofs with low slopes.
- Bio-retention areas, rain gardens and vegetation that trap rainwater should be included in the campus design. On-site mechanical filtration systems should be included to purify the water; untreated water should not be allowed to mix directly into surface or groundwater.

Goal 2- *Reducing the effects of rainwater and use more gray water systems for waste transport*

For this purpose, the following strategies should be implemented:

- The water needs of places such as landscape irrigation and toilets should be met from gray water obtained from wastewater.

- In the design of the gray water system, the required filtration of the collected gray water should be ensured by working with the local water works units.

- System life cycle cost analysis should be developed with the aim of providing environmental and long-term economic advantages.

Goal 3- *Reducing overall water consumption*

For this purpose, the following strategies should be implemented:

- Energy saving standards should be determined in installation fixtures and all installation renewals should be made accordingly.

- Existing urinals should be replaced with waterless urinals and feedback should be given to the university's maintenance staff to identify maintenance needs.

- Two flush toilets should only be used in women's restrooms.

- Electrically assisted systems with low flow fixtures should be used in toilets.

- Infrared sensor luminaires should be used.

- A standard should be set to ensure the performance of fixtures for flow-limited showers and faucets; all campus fixtures should be renewed in accordance with this standard.

- Washing machines in campus dormitories must comply with the EPA's ENERGY STAR program.[49]

6.5.5 Waste

Goal 1- *Establishing waste sorting units and recycling stations throughout the campus and in accessible areas*

For this purpose, the following strategies should be implemented:

- Conversion stations should be designed in a more informative, attention-grabbing and stimulating way.

[49] ENERGY STAR® products save both energy and water.

- Informative trainings should be planned about the intended use.

Goal 2- *Minimizing construction and renovation waste*

For this purpose, the following strategies should be implemented:

- Procedures that prefer reuse as much as possible rather than demolition should be implemented.

- Materials with flexible, which ensure that the project is more durable and long-lasting, should be used during construction and renovation.

- Projects, in which disassembled products with the feature of recycling are used, should be designed.

- The products that have completed their service life (ceiling tiles, carpets, etc.) should be determined before being sent to waste recycling companies and an agreement should be made with these companies.

- Sustainable and saving methods should be adopted instead of classical methods in all kinds of construction, demolitions and renovations.

- A construction waste management plan should be established for the removal of construction waste from landfills.

6.5.6 Innovation & Design Process for Green Transformations

Goal 1- *Selection of durable, locally produced, recyclable, biologically safe building and site materials*

For this purpose, the following strategies should be implemented:

- The first investment cost, service life and annual maintenance costs should be covered with products using durable materials with a long service life.

- To minimize fossil fuel consumption and transportation impacts, it should be mandatory to select at least 10% of the materials to be used in the project from local products (products extracted within a radius of 1000 km from the project

area). This will indirectly contribute to the local industry.

- In material recycling, waste streams should be directed and recyclable materials should be used as in the LEED criteria.
- Composite systems that permanently combine different materials should not be used since they cannot be separated and recycled.
- Materials such as natural linoleum, bamboo and wood, which can be renewed within a maximum of 10 years, should be used.
- Biologically degradable materials should be preferred.
- The use of materials containing toxic components should be avoided.

Thermostats containing mercury and sanitary fitting products containing chrome should not be used.[50] (The latest studies of EPA do not recommend the use of chromium-based materials, since they cause serious long-term damage to the liver, kidneys, circulatory system and nervous tissue.)

Wood used outdoors must be pressure treated free of chromated copper arsenate (CCA). Wood products that are resistant to deterioration should be used, such as cedar wood or ammonium copper quat (ACQ).

In the process from production to destruction of a material, environmental problems such as acidification, changing weather conditions, ecological toxicity, eutrophication, global warming, and global footprint should be considered. The environmental performance of the materials to be selected should be considered. For this reason, EPA basic material criteria developed with the support of the National Institute of Standards and Technology should be taken into account and the life cycle environmental performance of the materials used should be examined.

[50] https://www.epa.gov/stationary-sources-air-pollution/chromium-electroplating-national-emission-standards-hazardous-air

Goal 2- *Using wood products obtained from sources approved by the Forestry Department*

For this purpose, the following strategies should be implemented:

- The use of products approved by the Forestry Department[51] in all woodwork such as architecture, molding and joinery should be stipulated.

6.5.7 Energy

Goal 1- *Reducing energy consumption from structures*

For this purpose, the following strategies should be implemented:

A strategic organizational chart should be created primarily to save energy throughout the campus. The demands of buildings on mechanical heating and cooling should be reduced. The operational systems that increase efficiency should be determined and the potential energy in the region should be utilized. By implementing these applications, the energy demand will be reduced. For this purpose, the following should be done:

- The interactions of similar strategies among themselves should be evaluated. As a result of the evaluation, energy performance should be optimized by creating an energy model.

- R values[52], which are the surface thermal conduction resistance on the inner and outer walls of the building, should be planned to meet the international values.

[51] It is the state agency for the realization of environmentally friendly, economically viable jobs in forestry practices. According to this institution, the standards of institutions that adopt and implement international forest management standards should be preferred. (https://www.ogm.gov.tr/tr/kurulusumuz/genel-bilgiler)

[52] The R value should be a minimum of 0.08 m2 K / W for interior walls and a minimum of 0.13 m2 K / W for exterior walls. (TS 825, ICS 91.120.10. Thermal Insulation Requirements for Buildings. Turkish Standard. RG.27291-Temmuz 2009-TS 825)

6.5.8 Buildings

Goal 1- *Investigation of all materials and techniques that may cause energy consumption and environmental pollution in buildings*

Considering the factors that increase the comfort of users and passive building design methods at the design stage.

For this purpose, the following strategies should be implemented:

- All window glass in buildings should be replaced with argon-filled, low-E coated double insulated glass units with a U factor of ≤0.27. Glass with this feature should be used in new buildings.

- New buildings should be directed to the southern facade as much as possible. Larger aperture thermal materials and passive design strategies should be used on this facade to store heat from the winter sun. Deciduous trees, front porches, blinds and roof overhangs should be used to prevent excessive sun on the southern facade in summer.

- Windows facing the western facade should be used with as little surface coating as possible; glass with a high shading coefficient, such as ceramic frit coated[53] or colored glass, should be used.

- To alleviate the cooling loads of the buildings, a suitable planning should be made to create stable heat waves that store the heat during the day and release it in the evening.

- To increase operational efficiency, all hot and cold water needs of the buildings should be supplied from the main central structure of the campus.

- The minimum energy efficiency level specified in ASHRAE Standard 90.1-

[53] Frit is a ceramic composition that has been melted, quenched and granulated. Frits form an important part of the batches used for combining enamel and ceramic glazes. The purpose of this pre-fusion is to render any soluble and/or toxic components insoluble by causing them to combine with silica and other added oxides. (https://en.wikipedia.org/wiki/Frit)

2001 should be mandatory for all new and renovation projects on campus.

- ENERGY STAR® certification must be required for all campus equipment.

- Equipment with high efficiency electronic ballast[54] should be used in lighting.

- Occupancy sensor systems that control the lighting in common areas should be used.

- Alternative energy supply systems and waste heat utilization strategies should be used.

- Ventilation strategies that can be used in cases where circulation fluctuations are intense and ventilation needs to be done by measuring the CO2 levels of the area should be determined. To reduce energy demands for heating and cooling, recovery systems that detect heat leaking from the system and restore it to the system should be used. Prior to these applications, it should be decided whether it is economically viable within the scope of life cycle analysis.

- Studies should be carried out for natural ventilation in heating and cooling of buildings. For this purpose, passive alternatives can be considered. Especially for classrooms and offices, systems with micro-sensors that detect movement during use and switch to operation can be used.

- The use of economizer[55] should be mandatory in ventilation systems of all kinds of new buildings.

- The energy required for hot water should be obtained from the sun. In this direction, life cycle cost analysis should be reviewed and a planning should be

[54] An electrical ballast is a device placed in series with a load to limit the amount of current in an electrical circuit. (https://en.wikipedia.org/wiki/Electrical_ballast)

[55] It is a heat exchanger device with a sufficient heating surface. It provides energy recover and used for heating the feed water or any liquid that receives heat from the heat of the hot smoke gases formed by the combustion of solid, liquid and gaseous fuels. (https://tsbenergy.com/tr/pdetay.asp?TID=45&Ekonomizer)(https://www.vat.com.tr/tr/ekonomizer-atik-isinin-geri-kazanilmasi/)

made according to the economic advantages of this strategy.

- Adequate lighting levels in indoor lighting should be determined in accordance with reference measurements taken from natural daylight. Interior lighting sensor systems should be used according to the natural light levels in the rooms.

- Lighting modules with multiple switches or restricted ballasts should be used for areas where lighting is not desired.

Goal 2- *Increasing the alternatives to meet the energy demand of the campus from renewable energy sources*

For this purpose, the following strategies should be implemented:

- Photovoltaic and wind turbines should be used as an important part of planning in new and renovation projects.

- By examining the potential energy resources of the region, alternatives for the project site should be developed as much as possible. For example, photovoltaic arrays should be designed in accordance with the direction and angle of the sun's arrival on the site and photovoltaics should be sized according to the need.

- Power purchases from green energy companies[56] close to the campus area should be considered. Every resource that is considered to be purchased must meet certification standards such as LEED, which makes international evaluations.

6.5.9 Purchasings

Goal 1- *Avoiding the use of all kinds of materials that damage the ozone layer*

For this purpose, the following strategies should be implemented:

- In all technical devices, it should be paid attention that especially building

[56] Each country has its own green energy certification systems. e.g.: YES-TR in Turkey, Green-E in America. (by autor)

coolers do not contain CFC and HCFC.[57] Existing systems should be replaced with new systems in campus renovation works.

- Care should be taken to use systems that do not contain halon[58] in fire extinguishing.

Goal 2- *Monitoring the operating performance and effectiveness of the systems for maximum efficiency*

For this purpose, the following strategies should be implemented:

- A third part control mechanism for system equipment like HVAC, building control, lighting, renewable and alternative energy etc. used within the scope of all renovation works should be included in the circuit. The control mechanism should be included in the system at an early stage as part of the design team. Operation and Maintenance Manual containing information about the system and its operation, control drawings and diagrams should be created.[59]

6.5.10 Indoor Environmental Quality

Goal 1- *Avoiding the use of materials with indoor air pollutant potential*

For this purpose, the following strategies should be implemented:

- An action plan should be prepared to improve indoor air quality.

- Space entrance mats should be used for pollutants entering spaces from the outside, and entrance covers should be used for exhaust gases leaking from

[57] Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are fully or partly halogenated paraffin hydrocarbons that contain only carbon (C), hydrogen (H), chlorine (Cl), and fluorine (F), produced as volatile derivatives of methane, ethane, and propane. (https://en.wikipedia.org/wiki/Chlorofluorocarbon)

[58] Halon is a chemical compound used in fire extinguishing. Halogenated aliphatic hydrocarbons, which are usually obtained by donating some or all of the hydrogen atoms in aliphatic hydrocarbons prepared from methane or ethane with halogens such as fluorine, bromine, chlorine, and iodine, are called halons. (https://en.wikipedia.org/wiki/Halon)

[59] The LEED TM 2.1 Reference Manual has also addressed Energy and Atmosphere Prerequisites as training issues that must be addressed by the appointing authority. Building Operations & Maintenance (LEED v4 O+M), (2013). LEED v4. updated August 2019. ISBN: 978-1-932444-20-9

building air intakes. Strategies such as placing smoking areas away from structures should be considered.

- All new structures and renovations must comply with ASHRAE 62-199919 (Ventilation for Acceptable Indoor Air Quality) standards.

- To prevent mold growth in the building, external wall insulation systems with ventilation gaps that prevent water infiltration and provide drainage should be applied.

- Potential polluting sources such as asbestos, radon, silica, mold existing in buildings should be identified and improvement plans should be developed.

- Long Term Strategies to prevent air pollution should be developed for constructions.

- The product catalog containing the behavioral characteristics of the materials planned to be used in the construction phase should be requested from the company authorities and the suitability of these materials for construction should be evaluated.

- A maintenance program should be prepared and implemented in accordance with the material behavior of the completed buildings.

- Ventilation of new constructions should be ensured and ventilation filters should be replaced with new ones before use.

- Against mold that may form inside the building, methods for arranging the outer wall layer and using absorbent building materials should be applied during the construction phase.

- Building materials with low emissions, non-volatile or extremely low volatile organic compounds (VOC) and meeting the values specified in LEED TM Credit

[60]EQ 4 should be used indoors.

- All weaving products, including carpets that are planned to be used on campus, should be selected from internationally recognized green label[61] products.

- In all interior design and applications, materials with VOC values that meet the limits specified in LEED TM Credit EQ4 should be used. Only products that do not contain urea formaldehyde resins should be used indoors in composite wood products.

- Adequate ventilation of the environment should be provided to prevent an increase in CO2 levels that may occur in intensive use areas.

- Systems that monitor the environment for carbon monoxide and VOC should be installed to predict unhealthy air conditions caused by the intensity of use inside the buildings.

Goal 2- *Transforming buildings into wellness areas that increase user performance*

For this purpose, the following strategies should be implemented:

- ASHRAE 55-1992: Thermal Environmental Conditions standards for Human Occupancy should be met indoors according to the characteristics, needs and use of the building.

- Natural light should be used as much as possible in every area. The main goal should be to provide and not exceed 2% of the daylight factor in each room. Internal strategies to prevent glare should be planned in accordance with user

[60] This standard, which specifies indoor air quality (IAQ) levels, is used as a guide for minimum ventilation standards that reduce the potential for adverse health. It provides up-to-date information on filtering options that will enable measures to be taken against the polluting effects of mechanical or natural ventilation systems, and minimize the development and spread of all kinds of harmful particles.
[61] Green label is given by authorized institutions to products with low emissions for consumers.

performance.[62]

A technical guide should be prepared to ensure that the techniques and practices used in the strategies are understandable by everyone. A holistic design should be created with the active participation of all users in campus construction and repair works. At this stage, it should be ensured that sustainable strategies are interactive with the project program.

In order for the system to be sustainable, the strategies and operating program must be predetermined and included in the early stages of the system. Thus, possible problems that may arise in the process will be determined in advance. In this way, the design and construction process will be collaborative. It will also require an integrated thinking and ensure that the whole process is compatible with the expectations and policy of the university. A University Environmental Sustainability Office should be established for the purpose of determining and monitoring the system and requirements. Office board members should be appointed from among authorized campus members with knowledge of the social, economic and environmental aspects of sustainability, including construction, design, and political affairs.

[62] To determine adequate daylight factors LEEDTM – NC v. 2.1 Reference Guide, Credit EQ 8 may be referenced.
Credit 8.1: Daylight & Views, Daylight 75% of Spaces
Credit 8.2: Daylight & Views, Daylight 90% of Spaces

Chapter 7

CONCLUSION

As a conclusion, it can be said that one of the ways to achieve success in sustainability is to integrate sustainability into universities. It is expected that universities will plan for all future risks by creating sustainable campuses in an environment where resources are limited and conditions are variable. In addition, universities are being prepared for the adoption of innovative approaches to management.

Universities, which are public institutions, should produce solutions to global problems; they must be leaders. In all sustainability studies of universities, due to the lack of social responsibility from an architectural point of view and the lack of a clear understanding of sustainability, more attention is paid to environmental impacts, and social impacts are defined more superficially.

In this context, a 'sustainable approach in terms of social responsibility and architecture' should be included in the sustainable concept planning of universities with clearer, more systematic, more user-environment-oriented designs. For this, a more user-conscious and environmentally responsible perspective is needed by architects. This will ensure that all units of the universities adopt sustainability in sustainable campus management systems.

Preparing sustainable campus concepts by architects is important for the implementation of campus sustainability sustainable campus building design, and the integration of all systems. At this stage, supporting the entire process in an institutional

framework also requires users to take an active part in the application. Sustainable campus success will only be possible with the work of the systems together and the design that directs the user habits. Here, the task of the architects should be to analyze the indicators of sustainable campus in their designs and to ensure that the users are guiding and active participants in line with the sustainable goals of this institution. Sustainable campus success will only be possible with the collaboration of design and systems that give users new habits. For this reason, all architectural elements, from materials used in campus design to design strategies, can lead to change and enable universities to be more effective in the sustainability process.

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APPENDIX

General Evaluation of the Criteria and Indicators Used by the Considered Campuses. (by autor)

CRITERIAS	UI GREEN METRIC						IARU									GREENING UNIVERSITY TOOLKIT V2.0									STARS				ISCN			LEED V4					
INDICATORS	Setting and Infrastructure (SI)	Energy and Climate Change (EC)	Waste (WS)	Water (WR)	Transportation (TR)	Education (ED)	Sustainable campus organization	Campus wide operations	Buildings	Laboratories	Green purchasing	Transport	Communication	Employee and student engagement	Universities as the catalyst for a sustainable	Defining Sustainability	Initiating Transformation	Indicators	Technologies for Transformation	Policy Governance and Administration	Resources for Change	Growing Your Own Brochures	Global Exemplars	Institutional Characteristics (IC)	Academics (AC)	Engagement (EN)	Operations (OP)	Sustainability performance of buildings on campus	Campus-wide master planning and goal setting	Integrating facilities, education, research and outreach as a living laboratory for sustainability	Sustainable Sites	Water Efficiency	Energy & Atmosphere	Materials & Resources	Indoor Environmental Quality	Innovation & Design Process
UNIVERSITIES																																				
Massachusetts Institute of Technology	1	1	0	0	1	1																														
Harvard University	1	1	1	1	1	1																														
University of Winconsin Oskhosh	1	1	1	0	1	0																														
Princeton University	1	1	1	1	1	1																														
Australian National Universitiy							1	1	1	1	1	1	1	1	1																					
ETH Zurich							0	1	0	0	1	0	1	1	1																					
National University of Singapore							1	1	1	0	1	0	1	0	1																					
University of California, Berkeley							1	0	1	1	1	1	1	1	1																					
University of Cambridge							0	0	1	1	0	1	1	0	1																					
University of Cape Town							1	1	1	1	1	1	1	1	1																					
University of Copenhagen							1	1	0	1	0	0	1	1	1																					
University of Oxford							1	1	1	1	1	1	1	1	1																					
Yale University							1	1	1	1	1	1	1	1	1																					
University of Nairobi, Kenya																1	1	1	0	0	1	1	0													
Macquarie University, Australia																1	1	1	1	1	1	1	1													
Tongji University, Shanghai, China																1	1	1	1	1	1	1	1													
Middle East Technical University, Turkey																1	1	1	1	0	1	0	0													
Arizona State University																								1	1	1	1									
Stanford University																								1	1	1	1									
Colorado State University																								1	1	1	1									
McGill University																												1	1	1						
National University of Singapore																												1	1	1						
Anglia Ruskin University																												0	1	1						
Florida Atlantic University																															1	1	1	1	1	1
University of Miami																															1	1	1	1	1	1
University of Oregon																															1	1	1	1	1	1
Florida International University																															1	1	1	1	1	1
	4	4	3	2	4	3	7	7	7	7	7	6	9	7	9	4	4	4	3	2	4	3	2	3	3	3	3	2	3	3	4	4	4	4	4	4
	1	*1*	*0.75*	*0.5*	*1*	*0.75*	*0.77*	*0.77*	*0.77*	*0.77*	*0.77*	*0.66*	*1*	*0.77*	*1*	*1*	*1*	*1*	*0.75*	*0.5*	*1*	*0.75*	*0.5*	*1*	*1*	*1*	*1*	*0.66*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
	0.83	Campus Physical Operations																																		
	0.84	Sustainability Engagements for a Sustainable Society																																		
	0.93	Institutional Characteristics and aims																																		
	0.93	Innovation & Design Process for Green Transformations																																		
	0.5	Policy Governance and Administration																																		