ENVIRONMENTAL SUSTAINABILITY OF UNIVERSITY CAMPUSES: A PRACTICAL ASSESSMENT TOOL

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ABSTRACT

ENVIRONMENTAL SUSTAINABILITY OF UNIVERSITY CAMPUSES:
A PRACTICAL ASSESSMENT TOOL

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In this study the definition of environmental sustainability as a broad term in the university campuses which can be considered small scale cities, required environmental criteria to apply this and the assessment of the implementations to realize a sustainable campus were researched.

In this context inter institutional campus sustainability assessment tools are analyzed and among many indicators from these tools the concrete ones which assess environmental sustainability are selected. In the light of indicators which include the topics of EMS (Environmental Management System) implementation,

energy efficiency, water conservation, landscape sustainability, material conservation, transportation and green buildings; leading green campus practices from USA, Canada and Europe were assessed. These succeeding campuses are analyzed according to the aforementioned criteria and presented as a meta-analysis. Also by including METU campus in this analysis, a summary report was prepared which can form a starting point for the future sustainability implementations.

Based on this study, it can be said that campuses which use EMS have accomplished more successful results in terms of sustainability and applied more sustainability indicator in a broader area. Another outcome of this study is that using the indicators without the whole coverage of the campus area may not give the real environmental impact of the campus. At the same time it is seen that the indicators which are easy to implement and more feasible like waste recycling, landscape and transportation sustainability are commonly applied and the indicators which require investments and infrastructure costs like renewable energy production, waste water recycling and rainwater harvesting are applied rarely and covered a small percentage of the campus area. Moreover it was seen that green building policies were dependent to conventional certification tools like LEED and Green Star and the number of green buildings on campus were very low.

Keywords: sustainability, assessment of sustainability, campus ecology, sustainability in HEI

ÖZ

ENVIRONMENTAL SUSTAINABILITY OF UNIVERSITY CAMPUSES: A PRACTICAL ASSESSMENT TOOL

Koç, Havva Elif

Yüksek Lisans, Yapı Bilimleri, Mimarlık Bölümü

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Bu çalışmada çok geniş bir kavram olan çevresel sürdürebilirliğin küçük kent ölçeğindeki üniversite kampüslerindeki tanımlanışı, bunu gerçekleştirmek için gerekli çevresel kriterler ve sürdürülebilir bir kampüs adına yapılan uygulamaların değerlendirilmesi araştırılmıştır.

Bu bağlamda kurumlar arası kullanılan kampüs sürdürülebilirliği değerleme araçları da incelenmiş ve bu araçlardaki çok sayıdaki belirteç arasından sürdürebilirliğini ölçen somut kriterler seçilmiştir. EMS (Environmental Management System – çevre yönetim sistemleri) kullanımı, enerji etkinlik, su korunumu, peyzaj sürdürülebilirliği, atık geri dönüşümü, ulaşım ve yeşil bina konularından oluşan kriterler doğrultusunda

Amerika Birleşik Devletleri, Kanada ve Avrupa'da bulunan dünyanın önde gelen yeşil kampüs uygulamaları değerlendirilmiştir. Bu başarılı örnek kampüsler seçilen belirli kriterlerin ışığında analiz edilmiş ve bir meta analiz halinde sunulmuştur. ODTÜ kampüsü de bu analize dahil edilerek gelecek sürdürülebilirlik uygulamaları için başlangıç noktası teşkil edebilecek özet bir rapor oluşturulmuştur.

Bu çalışmaya dayanılarak denilebilir ki EMS kullanan kampüsler çevresel performans ve sürdürülebilirlik açısından daha başarılı sonuçlar elde etmişler ve daha fazla sürdürülebilirlik ölçütünü daha geniş kapsamda gerçekleştirmişlerdir. Bir diğer sonuç da bu çevresel kriterlerin kampüsü bir bütün olarak kapsamadan uygulanmasına rağmen değerlemede kullanılmasının kampüsün gerçek çevre etkisini vermediğidir. Aynı zamanda uygulaması daha kolay, daha ekonomik olan geri dönüşüm, peyzaj ve ulaşım gibi sürdürülebilirlik ölçütlerinin daha yaygın olarak bulunduğu, yenilenebilir enerji üretimi, atık su arıtma ve yağmur suyu dönüşümü gibi altyapı yatırımı ve maliyet gerektiren kriterlerin nadir olarak bulunduğu ve kampüsün çok küçük bir yüzdesini oluşturduğu görülmüştür. Yeşil bina politikalarının ise LEED ve Green Star gibi konvansiyonel sertifika sistemlerine endeksli olduğu ve özel şartların aranmadığı kampüslerdeki yeşil bina sayılarının düşük olduğu gözlenmiştir.

Anahtar sözcükler: Sürdürebilirlik, sürdürebilirliğin ölçülmesi, kampüs ekolojisi, kampüslerde sürdürebilirlik, kampüs sürdürebilirliği değerleme araçları, yeşil kampüs uygulamaları

To my beloved family

Abdulkadir Koç and Nurdan Koç
for their support, education and love

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ABBREVATIONS

AASHE	Association for the Advancement of Sustainability in Higher Education
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
BSP	Building Simulation Program
DOE	U.S. Department of Energy
EMCS	Building Energy Management and Control System
EMS	Environmental Management System
HE	Higher Education
HEI	Higher Education Institutions
HVAC	Heating Ventilation and Air-conditioning
LEED	Leadership in Energy and Environmental Design
STARS	Sustainability Tracking, Assessment and Rating System

CHAPTER 1

INTRODUCTION

This chapter presents the argument and objectives of the study and summarizes the way the study has been conducted. It concludes with a disposition of the subject matter, covered in each subsequent chapter.

1.1 Argument

Sustainability is the biggest challenge of the 21st century because civilization has reached at a point where natural resources are in a rapid decline. The environmental issues such as global warming, ozone depletion, natural resource decline, ecosystem destruction, carbon emissions have raised a concern for the causes of these problems. The conventional thoughts, principles, methods are in question now; while the challenge we are facing today requires radical changes and global leadership.

Universities are places where today's and tomorrow's leaders are groomed. Institutions of higher education can be considered as models for the society. They are expected to produce solutions to these global problems by conducting research, providing information, and raising qualified individuals. According to UNESCO, education means positive change of an individual.

Regarding these environmental concerns and mission of education, a sustainable university is important in this context in many ways. The most crucial one is educating students with better environmental consciousness. To reach this purpose the universities should be main drivers for change also for their students. Students can learn from everything around them, from the environment to the activities

happen in that environment. These activities form an outer world of experience and practice. Students should experience this paradigm shift in campus and gain a perspective through the environmental crisis. A campus that only has a few new buildings with unseen green measures, elderly ones having energy saving fixtures and sustainability center in the administrative office, is not an environmentally educative campus and not giving its message to the students. The life that is proposed should include its aim visually and functionally.

The other side of the issue, a sustainable campus can be included is its environmental impact. Universities resemble cities in many aspects; its scale, diversity of functions and inhabitants and its environmental damages. Ecologic development was considered for cities at first, since university campuses are considered as small cities eco city theme proposed for universities. Energy demand, water consumption, material usage, waste production and transportation are all parameters for sustainable cities as well as campuses. Since universities are places having central administration, which is a simpler mechanism to guide than a city, applying new regulations is easier. The measurements for energy efficiency, water efficiency and material recycle are manageable from a single focus. With these advantages a university campus can be a generator for social and environmental transformation.

Campuses are generally composed of large green areas, roads and pedestrian networks for transportation and buildings as physical structures. Being the main consumers of natural resources (60% of the energy and %30 of water) buildings are the main responsible for environmental problems. To establish environmental sustainability in a campus environment, both upper scale and subscale plans should be satisfying sustainability requirements. The buildings should be planned according to these indicators. Energy efficiency, water and material recycling are the most important qualities both for the larger environment and a single building. In a campus context a building is an educative tool for students to live in and around it.

With the raising concern of sustainability in university campuses, many assessment

tools are introduced to the context by commercial or non-commercial organizations. Since sustainability has measurable qualities these tools are aiming to define the sustainability degree of a campus and to measure the progress of the university by time and to make logical comparisons between universities. To reach these goals each assessment tool defines indicators related the subtitles of sustainability.

There are ambitious targets that universities have decided to reach in terms of environmental concerns such as decreasing carbon footprint of the campus, shift from nonrenewable sources to renewable, etc. as long term visions. And many concrete steps are taken in order to realize these targets. However sustainability is a comprehensive term and it takes enormous effort and time to change the status of a campus from a consumptive one to an environment friendly status. Without controlling mechanisms an Environmental Management System cycle which consists of 4 steps (plan-do-check-act) the results of the efforts can not be identified. The results of the actions are important to see if the initiative is working or not on the way through sustainability.

In this study leading examples throughout the world depicted and analyzed according the selected indicators from the commonly used assessment tools. The objective of this study is to research the potential of assessment of sustainability of a campus environment and to propose a guideline to assist the environmental management and future initiatives for the campus. Benefits of assessment are in the focus of this study because without evaluation of the taken steps it cannot be decided whether the aim is realized or not.

Recently there have been many attempts in Turkey to establish sustainability in campus projects, however these endeavors were in the concept project and not realized and very limited areas of the current campus settlements METU as a leading university in Turkey was assessed to take the picture of sustainability of the campus.

The aim of this research is to analyze an assessment for a sustainable environment in

the context of a sustainable campus. Sustainability has measurable qualities. How much a system consumes and how much it produces, its impact on environment can be assessed by objective tools. If there is guidance for this it can be the benefit of assessing sustainability is to be able to improve it, evaluate it and correct the misleading areas and propose new solutions. The selected indicators are showing the most focused items in campuses and the most disregarded ones. Moreover, an inter-institutional tool creates a baseline for universities to take lessons from other universities' experiences. The fulfilled or missing indicators demonstrated the weak and strong points of sustainability of a campus and also between pioneering examples. This fact points out the red spots to concentrate on the barriers and potentials which raise an issue in the campus sustainability argument.

1.2. Objectives

Sustainability is a general term that is being applied to many phenomena, for example in the built environment it is applied to transportation, water consumption, waste management, building construction etc. The aim of this study is to research the comprehensive definitions of these indicators which are related to sustainability and to analyze the university campuses which provide the best practices in terms of sustainability. To reach this aim this study has 4 objectives.

1. To transfer the principles of sustainability to a university campus in a broad sense.
2. To determine the types of assessment systems or tools that evaluate the level of sustainability in the campus environment
3. To use this information, both the contextual knowledge and assessment tools, to determine the leading sustainable campuses.
4. To evaluate METU campus according to the selected assessment system indicators and determine the degree of sustainability as a starting point to guide future attempts at developing a sustainable campus.

1.3. Procedure

In view of the objectives of the study the falling methodology was adapted in this study:

A thorough literature review was conducted to understand the concept and application of sustainability criteria to university campuses.

Then campus sustainability assessment tools which are commonly used throughout the world among universities were gathered together. These tools were analyzed from their development to their indicators in detail and presented in a table as a summary.

Thereafter leading sustainable campuses throughout the world were selected and reviewed according to the selected indicators of these assessment tolls. Each campus had been investigated as a case study and information thus collected was used for a meta-analysis.

METU campus was also evaluated according to the selected indicators of the assessment tool and used in the meta-analysis.

Finally a critical evaluation is done according to the table and the sustainability management and success of the campuses and the results of the indicators are analyzed.

1.4. Disposition

The information covered in this research study is presented in five chapters. This introduction chapter is the first.

The second chapter is a brief summary of literature on the subject matter. It covers the concept of sustainability in campus settlements and issues related assessment of sustainability in concrete terms. Sustainability assessment tools and development of the concept are also summarized in this chapter.

In the third chapter the input data referring to examined campuses and indicators, which are used for the analysis, are described. The method used to conduct the study is defined in detail.

The fourth chapter is the presentation of results. The data are displayed and the outcomes of campus sustainability and sustainability assessment according to the selected indicators are discussed in this chapter.

The fifth and the last chapter is the conclusion in which the study and results are summarized.

CHAPTER 2

LITERATURE REVIEW

2.1. Sustainability and Sustainable Development

Sustainability is a concern of contemporary discourse, influencing governmental, nongovernmental and higher education (HE) organizations' practices and attitudes. Today's public concern for sustainability started to arise in North America in the early seventies after the environmental crisis occurred. After realization of the danger of the effect of environmental degradation on economic development and social justice, sustainability appeared as a slogan to overcome these environmental challenges. Sustainability followed by environmentalist movement is influencing governmental and non governmental organizations to be more socially and economically responsible to environment. (Clougston and Calder, 1999)

In the seventies sustainability was discussed in the political circles to question the impacts of human activity and consumption of natural resources. Environmental problems such as habitat degradation, species extinction, ozone depletion, and global warming were the consequences of the industrial revolution since the mid eighteenth century. The United Nations Organization (UNO) used the term "sustainable development" to resolve the competition between economic growth and environmental conservation. Sustainable development mainly focused on current resource needs, but also the resource needs that would effect tomorrow. As a solution sustainability suggests that economic growth and industrial progress are not necessarily conflicting with environmental quality. (Porras, 2009). In sustainability the main argument is that to achieve the goals of environmental conservation and economic and social improvement, working in a way to promote each other is the

only solution. According to Porras (2009), “sustainability means pursuing economic activity while promoting sound environmental management.”

The most cited definition of sustainability after many declarations and worldwide conferences, came into existence in the U.N. appointed World Commission on Environment and Development in 1987. Known as the Brundtland Commission, this commission, published a milestone report Our Common Future. In this report, the Commission defined sustainable development as “…development that meets the needs of the present without compromising the ability of future generations to meet their own needs” which can be called as one of the first definitions in the literature.(World Commission on Environment and Development 1987).

John Elkington proposed a framework which is called as triple bottom line in his book Cannibals with Forks, in 1997. This triple bottom line framework based on three basic and equal categories of impact. These categories consists of social, environmental, and economic fields. The triple bottom line framework proposes that business sustainability depends on economic, environmental, and social resources. The origin of mainstream contemporary sustainability thinking relies on the co-existence of environmental, social and economic sustainability at the same time. (Figure 2.1).

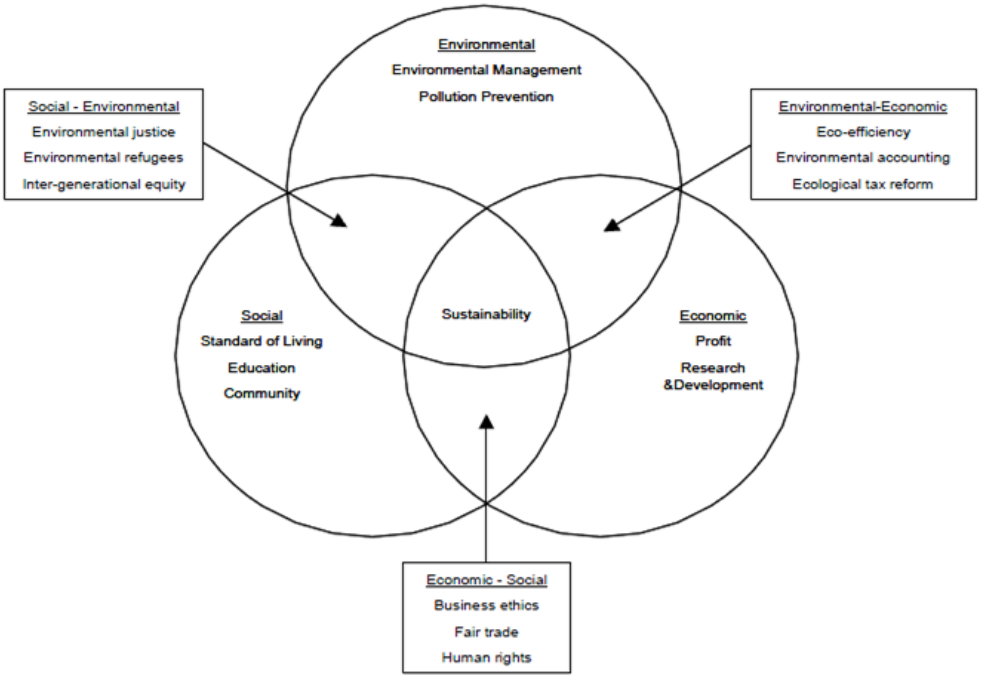

Figure 2.1 Triple bottom line framework of sustainability(Rodriguez, 2002)

In its 30 years of history many definitions were put forth to describe sustainability. After the publication of the Brundtland Report , more than 100 alternative definitions of the sustainable development and sustainability, which are more detailed and developed were proposed. (Elkington, 2002,: Murcott, 1997).

These definitions may differ according to the context depending to the formal, informal, governmental or nongovernmental organization they are derived for. However most of them are based on the same foundation. According to Gladwin (2001) this foundation has three principles:

"1. Continued development depends upon the availability of critical inputs directly or indirectly. There are four categories for these inputs that are given below

Ecological – renewable resources, such as food and timber, and services, such

as protection from ultraviolet solar radiation, water filtration by wetlands, and many other services which are provided by healthy natural ecosystems.

Material – non-renewable resources

Human – knowledge and the means, including income, health, human rights, freedom, and opportunity to apply that knowledge

Social – trust, reciprocity norms, equity, and other conditions that permit coordination

2. There are limits to the availability of finite material resources and to the regenerative capacity, or carrying capacity, of ecological resources

3. Ecological, social, and economic systems are interdependent complex systems. As such, they are heterogeneous, dynamic, non-linear, and adaptive groupings of agents whose actions have impacts within each of the three realms (Center for the Study of Complex Systems, 2002)."

Table 2.1 World summits and conferences about sustainability and environmental issues (International Institute for Sustainable Development-IISD, 2005)

Year	Summit, Conference, Research, Act
1962	Silent Spring by Rachel Carson brought together research on toxicology, ecology and epidemiology to suggest that agricultural pesticides were building to catastrophic levels.
1969	National Environmental Policy Act is passed in the U.S., creating the Council on Environmental Quality and establishing a national policy for the environment.
1970	First Earth Day held as a national teach in on the environment. An estimated 20 million people participated in peaceful demonstrations across the U.S.
1972	UN Conference on Human Environment/UNEP held in Stockholm is rooted in the regional pollution and acid rain problems of northern Europe.
1973	U.S. enacts Endangered Species Act to better safeguard, for the benefit of all citizens, the nation's heritage in fish, wildlife and plants.
1976	Habitat Summit is the First global meeting to link environment and human settlement.
1985	Climate change. Austria meeting of World Meteorological Society, UNEP and the International Council of Scientific Unions reports on the build-up of CO2 and other "greenhouse gases" in the atmosphere. They predicted global warming.
1987	Our Common Future Brundtland Report
1992	Earth Summit. UN Conference on Environment and Development (UNCED) held in Rio de Janeiro.
1997	Kyoto Protocol. This document sets goals for greenhouse gas emission reduction and establishes emissions trading in developed countries and the clean development mechanism for developing countries.
1999	The World Commission on Forests and Sustainable Development releases its report "Our Forests...Our Future". This independent Commission, after extensive hearings with stakeholders worldwide, concluded that the world's material needs from forests can be satisfied without jeopardizing them by changing the way we value and manage forests.
1999	Launch of the first global sustainability index tracking leading corporate sustainability practices worldwide. Called the Dow Jones Sustainability Group Indexes.
2000	The Second World Water Forum and Ministerial held in The Netherlands.
2001	The Marrakech Accords, agreed to at COP-7, finalize how the Kyoto Protocol should work, lay the groundwork for ratification by different countries and mark the conclusion of a process begun at COP-4 in Buenos Aires.
2002	World Summit on Sustainable Development held in Johannesburg, South Africa.
2003	G8 Summit in Evian, France. Marine Environment and Tanker Safety.
2004	G8 Summit took place in Sea Island, Georgia.
2005	G8 Summit took place at Gleneagles Hotel, Scotland. The main agreements reached covered development in Africa and tackling global climate change. Kyoto Protocol comes into effect. Most countries are now pledged to reduce the emission of gasses that contribute to global warming.

2.2 Sustainability in Higher Education Institutions

Sustainability is a major topic in academic discourse in the institutions of higher education HE. There are sustainability degree programs and courses teaching ecology and sustainability. Academic research has grown to a point that can integrate three pillar of sustainability; *i.e.* society, economics and environment in their interdisciplinary curricula. Although sustainability is a major issue in research and teaching in institutions of HE, the challenge for them is to revise their institutions' practices and physical environment according to sustainability. To achieve sustainability and its core principles in the university campus, activities and institute there have been many conferences and commitments directing the way through sustainability (Table 2.1). There are also nonprofit organizations (NGO) assessing the degree of the university's sustainability level with focus on environmental sustainability.

The interest for sustainability in institutions of HE arose in the 1970s when the environmental degradation became a global problem and entered into the political field. Academics realized that ongoing environmental crisis had influence on the economic and social facilities. (Clougston and Calder, 1999). To overcome this comprehensive issue and develop holistic policy academics facilitated many declarations and international conferences. More than 1000 academic institutions have signed international declarations to implement sustainability through academic curriculum, institutional organization and greening their physical activities. The number of universities signing declarations to indicate their commitments to sustainability, is increasing day by day. (Wright T., 2002) Most of these have been presented in Figure 2.2 below and elaborated upon in the following pages.

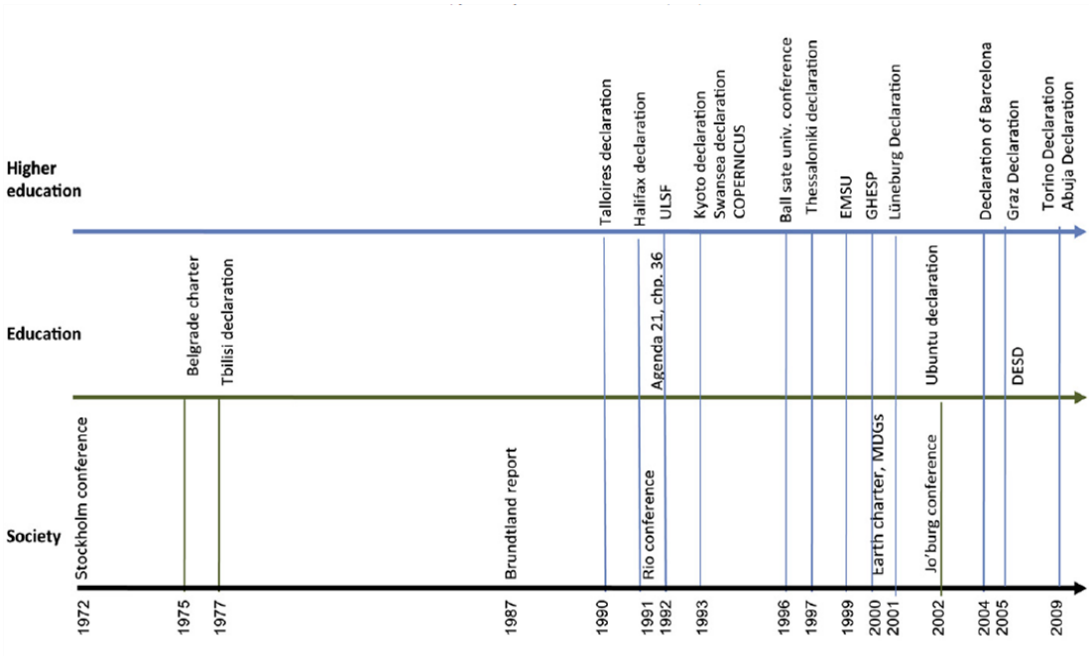

Figure 2.2 28 declarations for sustainability in HE (Lourdel, 2010)

The Stockholm Declaration can be named as the first one to make a connection between sustainability and higher education in 1972. And in the 1990s many international declarations and conferences made this link more explicit. Other declarations shared the foundation of Talloires Declaration and tried to establish an international understanding on Higher Education Sustainable Development (HESD). (Clugston, 2003)

The Stockholm Declaration 1972

This declaration was not specifically about HE. The main idea was interdependency between human beings and the environment. The declaration was basically focusing on human needs, proposing that "nations must improve the human environment for present and future generations. This is a goal to be reached together with the established and fundamental goals of peace, world-wide economic and social development." (UNESCO, 1972, p. 1). In this regard, the Stockholm Declaration

especially Principle 19 obligates environmental education in order to “broaden the basis for enlightened opinions and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension.”

Tbilisi Declaration (1977, Tbilisi, Canada)

Tbilisi Declaration was one of the most important acts in the evaluation of sustainable declarations in relation to education. United Nations Educational, Scientific and Cultural Organization (UNESCO) and the United Nations Environment Program (UNEP) were the sponsors of this conference which is the origin to initiate international environmental education in formal norms. (Wright T., 2002) This declaration was the first in the context of higher education to take a holistic and international viewpoint to the environment. The need for environmental education and the principles of this new approach to the environmental education were the main concerns of this declaration. It defined the basics of environmental education as being necessary for students in all fields, not only natural and technical sciences, but also social sciences and arts. Since there is a relationship between nature, technology and society, they determine the level of development of a society. (UNESCO-UNEP, 1977)

Talloires Declaration (1990, France)

The participants defined the role of the university in the Talloires Declaration as raising specialists in environmental management and related fields. Because lack of professional knowledge and practice have impacts on the environment and public health. (Clougsten, 2003)

It was the first declaration made by educational institutions to prove their commitment to sustainability in HE. Global issues that threatens human and biodiversity survival such as environmental degradation, pollution, depletion of natural resources were the main subjects that the declaration focused on. Talloires Declaration delegated universities by stating that “university heads must provide

leadership and support resources to respond this urgent challenge" (UNESCO, 1990, p. 2). The number of universities that signed increased from 20 in 1990 to 356 in 2007 (University Leaders for a Sustainable Future, 2000). This declaration consisted of a10-point action plan to direct HE institutions on the road to sustainability. The aim was to approach teaching, research, operations and outreach at colleges and universities by integrating sustainability and environmental literacy (UNESCO,1990). The Talloires Declaration addresses multidimensional subjects such as the curricula, research, campus operations, and public outreach. Moreover, the declaration emphasizes the implementation of sustainable development throughout all campus experiences. (Wright, 2002)

Halifax Declaration (1991, Canada)

University administrators in Halifax (Canada) gathered to voice their concerns on the continuing global problems such as degradation of environment, and the inevitable impact of economy on the issue. (UNESCO, 1991). The scope and principles of this declaration are similar to the Talloires Declaration.

Agenda 21 (1992, Rio de Janeiro)

Agenda 21 was mainly related to environmental sustainability and sustainability in education, this declaration addressed the directives of the previous declarations. Agenda 21 included initiatives for individuals, governments and nations and its premise was that they can develop their own programs according to their own needs, policies and future visions to ensure sustainable development by including education, public awareness and outreach. (Wright T., 2002)

Kyoto Declaration (1993, Kyoto, Japan)

The fundamental contribution of the Kyoto Declaration, adopted at the Ninth International Association of Universities Round Table, to the current discussion of sustainability was a clear base to achieve sustainable development within universities. Main argument of Kyoto Declaration to define the international

university community as a substructure maker to create sustainability plans of in while implementing university development plan. (Wright T., 2002)

It focused on the ethical responsibility of universities to reform the current systems and proposed to implement institutional plans of action. The principles adopted urged them to better utilize natural resources, to stop unsustainable practices, to emphasize the need for academicians to teach and to do research on the practice of sustainable development, to review their results to depict most efficient sustainable development practices. Universities adopting these policies are showing that sustainability started to be implemented in the campus environment. The Kyoto Declaration also calls attention to the curricula, research, operations, and public outreach and mentions the necessity of the collaboration of universities (Lambrechts, *et all*, 2000)

Swansea Declaration (1993, Swansea, Wales)

Swansea Declaration focused on the degradation of environment, the ecenomic impact to issue, and the vitality of the need for sustainable initiatives. (Lambrechts, W *et all*, 2000) Swansea declaration pointed out that societies have to develop an environmentally secure civilized world. Many of the points from past university sustainability declarations were emphasized. The need for universities to review the physical operations of the campus, the need for environmentally responsible students and academicians, and ethical responsibility of a university were the main points of the declaration. (Wright T., 2002)

The CRE-Copernicus Charter (Geneva, Switzerland, 1994)

This is an inter-university, co-operation program mainly dealing with the environment and sustainable development. Over 320 European universities have attended this program. The Copernicus charter emphasized the responsibility of universities to be leaders and decision makers in creating sustainable societies. Additionally, the Charter emphasized the necessity of networking amongst the universities. (Copernicus Secretariat, 2000).

The Thessaloniki Declaration (Thessaloniki, Greece, 1997)

Adapted at the International Conference on Environment and Society, this is a multidimensional and comprehensive declaration. This declaration claims that sustainability principles must be applied in all facets of the society. The declaration stated that the concept of environmental sustainability has a relation with poverty and social needs. "Population, food security, democracy, human rights, peace and health and a respect for traditional cultural and ecological knowledge are ingredients of the sustainable development." (Wright T., 2002)

Campus Earth Summit 1994,

In 1994 Yale University organized a major national conference and over 400 faculty, staff, and student participated from 22 countries around the world were included in the conference. This conference produced a report called the "Blueprint for a Green Campus", which clarifies the way to sustainability for HE. It suggests adding environmental learning into all relevant disciplines; making the campus a model of environmental sustainability through waste reduction, energy efficiency, and energy efficient design; implementing environmentally responsible purchasing policies; and promoting environmentally responsible career search among students. (Clougsten, 2003) It basically recommends to extent the scope of environmental learning and research at colleges and universities, to improve campus environmental operations, and to promote environmental activism for students. (Lourdel, 2008)

As a result of the pressure of the mentioned declarations on the universities, many of them have initiated projects and implemented policies to integrate sustainability into their systems. (Alshuwaikhat, 2008) University's environmental policy and university EMS for sustainability are directing these initiatives. (Lourdel, 2008)

2.3 Defining a Sustainable Campus

“A university is an undergraduate and postgraduate educational institution for higher learning that typically includes an undergraduate college and graduate schools in various disciplines. A college is an institution of higher education created to educate and grant degrees; often it is a part of a university” (Oxford English Dictionary, 2003).

The latin term campus “describes the distinctive physical character of American universities”. Today campus term refers the entire property, including buildings and it gradually became the synonym for all university components. By being located in nature and removed from the corrupting forces of the city, American college is the result of the romantic idea of isolation of campus from the city and civilization. (Turner 1990, p. 12).

A campus can be considered as an “intentional community” comprised of many different elements such as administrators, faculty, staff, and students that fosters discourse, debate, collaboration, and social interaction (Chapman 2006). Learning occurs in the whole system in this environment from the classroom to laboratory. These institutions have established patterns and policies for operations and maintenance in all fields as defined systems. As a result their physical presence projects an image as a whole system.(Kenney, Dumont, and Kenney 2005).

Campuses are also the places that reflect changes in values as well as in politics and ethics. After the realization of the impacts of universities on environment by their activities and operations, university policy makers and planners treated the campus sustainability issue as a global concern. The sustainability issue on university campuses has also been intensified by the pressure from many actors from governmental environment protection agencies and nongovernmental organizations. (Alshuwaikhat, 2008)

Through its 30 year of development history from Stockholm Declaration to many international declarations in 1990s, sustainability in HE evolved in many ways. These national and international conferences and declarations defined the sustainability in HE and the criteria to ensure sustainability in campus. The central focus of these declarations is the ethical responsibilities of universities to facilitate change and be a model for the society and to respond the need for environmental literacy. Except Halifax and Kyoto, these declarations focus on the development of sustainable practices and programs within universities. Halifax and Kyoto offer practical action plans and roadmaps to reach their targets.

After analyzing the national and international declarations, conferences and institutional policies Sarah Wright (2002) states that there are common principles and theories to define a sustainable university among these initiatives. These themes are the summaries of certain priorities for implementing sustainability in higher education:

Sustainable physical operations: Although this theme expressed in almost all declarations it was not the main task. The Kyoto Declaration encourages universities to review their physical operations to reflect best sustainable development practices. Universities should demonstrate environmental commitment by establishing institutional ecology policies and practices. These practices include resource conservation, recycling, waste reduction, and environmental friendly operations. (University Leaders for a Sustainable Future, 1990)

Sustainable research: It is mentioned as the academic research related to sustainability. It is an environmentally responsible research towards sustainability and it is a necessity because it has economic and social benefits.

Public outreach: Environmental change occurs only if all facets of society are involved. Universities as being places to seek knowledge, have to apply this knowledge to solve challenging problems.

Inter-university cooperation: the Halifax Declaration draws attention to the need to share information about the greening of the universities by establishing a network among universities.

Partnerships with government: NGOs and industry should incerporate with government to develop models and knowledge related to environmental management and sustainability.

Ecological literacy: In the Talloires Declaration it is said that universities must teach environmental literacy to all school students to develop the capability of university faculty by organizing programs. In the Halifax Declaration it states that universities are responsible to develop environmental literacy, and to promote the environmental understanding of ethics. The university is also responsible for developing the capacity of the university to teach and practice sustainable development principles.

Developing inter-disciplinary curriculum: This item is a part of environmental literature. Declaration directs universities to develop programs to educate students for a sustainable future.

Moral obligation: This is the common theme among the declarations. All the declarations are the results of this mission. To promote environmental knowledge and to propogate the practice of environmental ethics in society are defined as the main role of universities in CRE- Copernicus Declaration.

Association of **University Leaders for a Sustainable Future (ULSF),** another institutional endeavor to frame sustainability in HE, focuses on sustainability as a crucial dimension of teaching, research, operations and outreach at colleges. This institution puts sustainability in practice by developing seven criteria for a sustainable campus; these are: (Clougsten, R., 2003)

1. Curriculum: Principles of sustainability should be incorporated into all academic disciplines in the college or university. For a sustainable future a common platform should be provided in basic disciplines and critical thinking skills. Course offerings featuring certain topics are opened in the committed institutions to sustainability e.g., Globalization and Sustainable Development; Environmental Philosophy; and many others.

2. Research and Scholarship: Sustainability should be integrated into faculty and student research by using environmentally sound topics such as renewable energy, sustainable building design, ecological economics, indigenous knowledge and technologies and environmental management can be studied as research areas.

3. Operations: The university should gradually reduce its "ecological footprint." The institution should follow sustainable policies and practices. The “use of emission control devices; sustainable building construction and renovation; energy conservation practices; local food purchasing program; purchasing and investment in environmentally and socially responsible products; regularly conducted environmental audits” can be examples to CO2 reduction practices. Moreover these operational practices should be integrated into the educational program of the university.

4. Faculty & Staff Development and Rewards: Knowledge of sustainability should be the main concern in the promotion, reward and hiring systems. Since education and research are the fundamental purposes of academic institutions, an institution should:

a. Reward academic personnel’s contributions to field of sustainability in research, teaching, or campus and social activities.

b. Provide significant opportunities to staff and faculty to develop understanding, teaching and research in sustainability.

5. Outreach and Service: The college or university would support sustainable communities both locally and globally and develop partnerships with local economies that enhance sustainable practices. One would expect an institution to seek solutions to global environmental conservation and sustainability issues by international cooperation through conferences, declarations, etc.

6. Student Opportunities: The college or university should provide opportunities to students to reflect its commitment to sustainability such as:

a. New student orientation, scholarships, internships and job placement related to public outreach and sustainability issues;

b. For strong student representation; An Environmental or Sustainability Council or Task Force

c. Student groups on campus that actively dedicated to enhance sustainability in the local community.

7. Institutional Mission, Structure and Planning: To express commitment to environmental mission of the institution and engagement to sustainability, the university or college would use written statements of the mission and goals. To indicate this commitment the institution would provide paid positions like Energy Officer or Director of Sustainability Programs in the university. Public events such as lectures and conferences are important components of institutional concern for sustainable development. (ULSF, 2001)

In general sense, being sustainable for a city or organization or an institution requires conservation and enhancement of its natural resources, equal distribution of poverty of its inhabitants, broad understanding of the concept of development so that it covers not only economic growth but also social and cultural development.

(Quaddus, 2001) According to this definition, a sustainable university campus means conserving environment, promoting economic growth, and engagement to society.

Another definition for sustainable university was made by Velazquez et al. in 2006 as “a higher educational institution that addresses the minimization of negative environmental, economic, societal, and health effects generated through the use of the campus resources.”

Sustainable campus community is defined by Cole (2003) as the one that protects and improves the health of humanity and environment by directions of its local and global responsibilities. It has correlates with university community to consult its knowledge to deal with the ecological and social challenges of today and future. It can be generally said that sustainable university campus can only occurs through environmental management, a healthy campus environment which creates a balance between energy consumption and resource conservation and waste reduction. Moreover a sustainable campus should enhance equity and social justice inside itself and should transport all these principles to society. (Piper, 2002)

Alshuwaikhat, (2008) states that a sustainable university campus is a place which satisfies a better balance between economic, social and environmental goals in policy production while analyzing consequences of current campus operations. To achieve sustainability goals all stakeholders’ co-operation and participation is important. Based on these definitions for a city or an organization like a university campus to be sustainable, it requires conservation and enhancement of its resources, an elimination of poverty and deprivation of its inhabitants, exporting of the concept of sustainability to include social development. (Newman L, 2006)

After analyzing all the declarations about sustainability in HE and; current practices and regulations in the university campuses, Alshuwaikhat, H. (2008) makes a comprehensive and integrated chart which organizes all the themes required in sustainability concept for universities. In this model defining sustainability;

implementing university EMS, public participation and social responsibility and teaching and research in sustainability is interrelated together.

To integrate sustainability to a university campus requires a clear vision and policy; and the commitment to sustainability as a multidimensional issue.

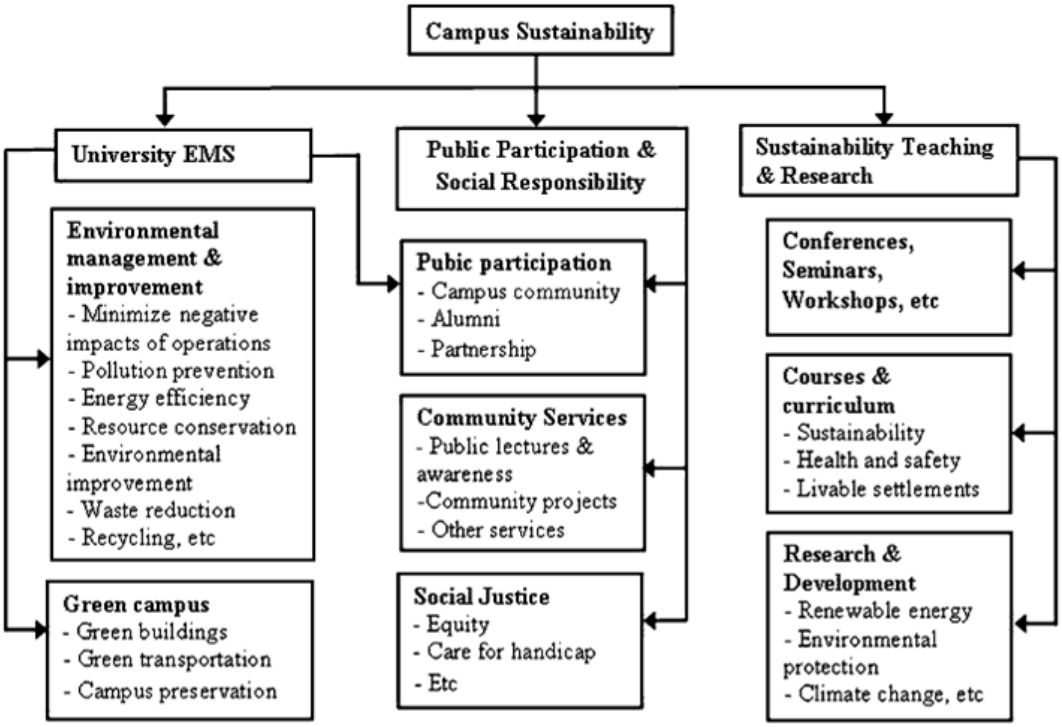

Figure 2.3. Campus Sustainability Model (Alshuwaikhat, 2008)

University EMS: EMS application is the initial point of environmental sustainability in campus. An EMS constitutes all the regulations, practices and procedures to achieve, review and maintain university policy for sustainability. It is a systematic approach to environmental problems to guide and monitor the solution process. EMS integrates all the environmental protection programs; and EMS application enables

the university to control its environmental impacts while enhancing its operating efficiency. Implementing EMS also promotes energy efficiency and conservation, resource conservation, recycling and management. The main purpose of university EMS is to initiate a green campus that is the combination of green buildings, green transportation and nature conservation. To develop a green campus, it requires promoting green building construction and environmental friendly transportation facilities such as footpaths, cycle-ways, greenways, etc. on the campus.

Public participation and social responsibility: This requires the incorporation and engagement with private sector, governmental and non-governmental organizations to promote environmental justice and equity. Public participation is necessary for the decisions about them. All the interests and common needs of all participants are communicated and they are provided with necessary information to participate in a meaningful way. Universities should promote ethics like human dignity, peace and justice, equality, human and civil rights, health and safety considerations in sustainability to achieve justice in every aspect of society.

Sustainability teaching and research: Universities provide the technical research, the qualified professionals, educates future leaders, decision makers and entrepreneurs and drives public attention. International organizations, industry and academia should be encouraged to discuss and work on environmental issues through conferences and seminars. Integrating sustainability into university program would provide qualified professionals and the technical knowledge for environmental management, built environment, science and technology.(Alshuwaikhat, 2008)

2.4 Eco Campus (Green Campus)

A green campus integrates sustainability into all relevant disciplines, develops environmental knowledge by course offerings. By providing opportunities for students to study local environmental problems a green campus conducts

environmental reports. Developing environmentally responsible purchasing policies, maximizing energy efficiency, reducing campus waste, promoting environmental friendly transportation, and green building are also components of a green campus. Furthermore student environmental center, and environmentally responsible careers opportunities makes environmental sustainability a priority in the campus. (Heinz Family Foundation, 1995)

Eco-campus is a concept that has been developed in an attempt to achieve environmental sustainability by the Universidad Autonoma de Madrid (UAM). This University, being a public institution devoted to knowledge through teaching and research, has also taken on a leading role in spreading environmental awareness. The UAM Senate has unanimously approved a Charter of Commitment to Agenda 21 and to the agreements reached at the "Earth Summit" (Johannesburg, 2002) - the so-called Eco-campus Project.

Finley J (2010) proposes Richard Register's ecocity model as a principal framework that can lead sustainability application in university campuses. To develop green campuses, similarity between a city and a university campus in terms of size, ecological footprint, intense consumption of resources and environmental damage enable to transfer ecocity principles to campuses.

Cities are the greatest human products which have the most destructive impact upon nature. Ecocity concept proposes a new approach to cities, the biggest human settlements so that they can be less destructive to nature. The eco city considers the city as an organic ecological society in harmony with nature. The main goal of an ecocity is to eliminate all carbon waste, to produce energy from renewable sources, and to integrate the environment to the city. Ecocities are realigning cities to the new circumstances due to the environmental degradation. They are the places that promote to apply new green technologies to solve the current problems. Urban planning, public transportation, district heating, building and design, reducing

resource consumption lifestyles and waste management are reconsidered while integrating new environmental approach. (Register, 2006).

Ecocity Builders(2010) defines an Ecocity as "a human settlement modeled on the self sustaining resilient structure and function of natural ecosystems. An ecocity provides healthy abundance to its inhabitants without consuming more (renewable) resources than it produces, without producing more waste than it can assimilate, and without being toxic to itself or neighboring ecosystems. Its inhabitants' ecological impact reflects planetary supportive lifestyles; and its social order reflects fundamental principles of fairness, justice and reasonable equity."

Since campuses resemble small scale cities there are similarities between campuses and cities including "an independent governing body, diverse-use infrastructure, a security force and legal system, a unique history and culture, and an independent communications network" (Masey, 2012). Beside the aesthetic quality through building planning and landscaping, green parks and garden plots, outdoor recreation facilities, tree lined streets are common features between a city and a campus. All these structured systems and features service huge populations in both cases. All these similarities in built environment, facilities and operation make the amount of environmental impact similar also. (Eagan *et all*, 2008) Campuses are smaller samples of broader complexities, therefore they experience all the environmental problems, concerns and challenges that a city goes through. Institutions of HE have significant environmental impacts like cities including air and water pollution, waste, the use of hazardous chemicals and habitat degradation. (Dahle and Neumayer, 2001)

Campuses can adopt the Ecocity concept to be environmentally sustainable and to green their practices, to diminish their environmental damage, to conserve natural resources and to fulfill social responsibilities as solution drivers. Most of the existing campus planning and building stock were done when energy was not expensive and the energy consumption for the operations like heating, cooling, lighting or ventilation was not a concern. The guiding principles of ecocities such as restoring

damaged urban environments, revising land-use priorities, increasing environmental ethics are appropriate to revise campus settlements as specific cities. (Finlay J., 2011). The ecocity principles can be used to guide retrofitting these consumer buildings and to revise the campus infrastructure and transportation system. The ecocity model represents a reference on how to redesign consumption, purchasing, transportation, design, construction and purchasing policies. By eco-campus model implementation of innovative environmental measures and green technology in areas such as public transport, building strategies, design and construction can be reconsidered and revised.

Universities and colleges are centers for transformation and social change by being world leaders in fields of research, innovation, and education. Therefore universities can be considered as key places to solve global problems and create progressive initiatives for current and future generations (Moore, 2005; Clarke and Kouri, 2009) An ecocity community is dedicated to the reducing energy consumption, water and food conservation, and minimizing waste generation, air pollution and water pollution. The community of HE has the ethical responsibilities to engaged in environmental measures in order to find a balance between human facilities and nature. These are listed below as ten principal strategies in building the ecocity: (Register, 2006, pp. 183-4)

> "1 Revise land-use priorities to create compact, diverse, green, safe, pleasant and vital mixed-use communities near transit nodes and other transportation facilities
> 2 Revise transportation priorities to favor foot, bicycle, cart, and transit over autos
> 3 Restore damaged urban environments, especially creeks, shore lines, ridgelines and wetlands
> 4 Create decent, affordable, safe, convenient, and racially and economically mixed housing
> 5 Nurture social justice and create improved opportunities for women, people of color and the disabled

6 Support local agriculture, urban greening projects and community gardening

7 Promote recycling, innovative appropriate technology, and resource conservation while reducing pollution and hazardous wastes

8 Work with businesses to support ecologically sound economic activity

9 Promote voluntary simplicity and discourage excessive consumption of material goods

10 Increase awareness of the local environment and bioregion through activist and educational projects that increase public awareness of ecological sustainability issues"

2.5. Environmental Policy

The concept of sustainable development was initiated in the United Nations Conference on Environment and Development (UNCED), in 1992 in Rio de Janeiro, Brazil. To address global problems such as poverty, war or the growing gap between industrialized and developing countries, government officials from 178 countries and individuals from governments, NGOs and the media participated in this event. The question of how to ensure the health of the global environmental system by implementing of sustainable development principles was the central theme. This conference stated that both economic and social progress depends on the positive stocks of the natural resources which is possible by effective measures to environmental conservation. (Johannesburg, 2002)

After that earth summit, several educational institutions, and communities, governmental Sectors and private sectors and organizations have become more concerned about their environmental sustainability and ecological impact in their own places. They started to implement that concept by the establishment of their own environmental policies. (Johannesburg, 2002)

Environmental policy is a result of an organization's commitment to the environmental concerns and sustainability. Air and water pollution, prevention of environmental degradation, solid waste management, maintenance of biodiversity, natural resource conservation and management of these ecosystems, wildlife and endangered species are the main concerns. Environmental policy focuses on the problems arising from human act which will have negative impact on human health , environment and vital sources. (McCormick, 2001)

2.6. Environmental Management System (EMS)

Universities are causing environmental damage in the form of energy, material and resource consumption and ecosystem pollution could be significantly reduced by the implementation of the environmental protection policies. Concrete environmental protection measures that can be seen at many universities are easy to initiate, but organizational and institutional systems are lacking. There has been a growing interest to implement Environmental Management System (EMS) to university campuses in order to facilitate change to prevent environmental degradation. An EMS is integrated to an organization's overall management system. A management system can be defined basically "as the combination of steps an organization takes to manage its processes and activities". Based on this definition an environmental management system can be identified "as a well-defined management structure designed to address the impacts of an organization" on the environment. (Kinsella and McCully, 1999). In the case of a university campus an EMS can be described as greening all the facilities of the campus, from the transportation to the lighting of a classroom while improving environmental quality. (Keniry, 2003)

An EMS controls all of the practices, procedures, processes and resources of an organization to develop, implement, achieve, review and maintain environmental policy. EMS is a guide to fulfill environmental responsibility for a university which

tries to ensure that environmental protection measurements are managed constantly and systematically throughout the campus. (Alshuwaikhat, 2008)

The implementation of an EMS depends on the sector; institutions of HE trying to implement EMS to their system uses either formal certified ones or informal uncertified ones. The consideration of environmental interactions ranging from operations risks to research and education benefits are directing the EMS implementation. Since generic formal EMS models are basically focusing on environmental risk management and not considering the positive effects and benefits that a university can manage, they are not covering a university's environmental interaction. (Keniry, J., 2003)

In practice, many campuses around the world, though not yet the majority, have integrated an EMS to their management systems. Although it is a voluntary act to implement an EMS in most parts of the world, in Sweden it is mandatory for all higher education institutions Canada and US universities and colleges have engaged themselves with a growing interest.
(Keniry, 2003)

Generally an EMS is a cycle of plan-do-check-act, leading to continual improvement. This cycle is the foundation of all management systems. (Kinsella and McCully ,1999). Clarke (2006) states that the campus EMS in practice is similar to a life cycle with the same process logic.

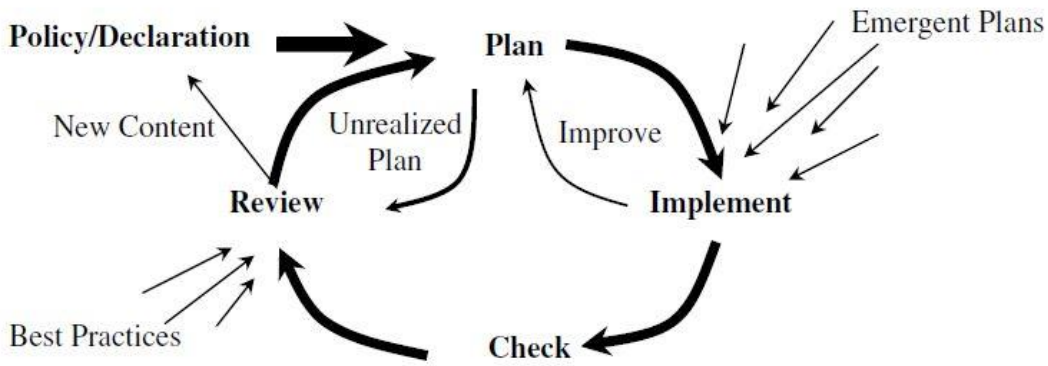

Figure 2.4 Environmental management system cycle with emergent content (Clarke, 2006)

Compared to a generic EMS cycle, this figure also includes Policy and declarations. The emergent plans feeding in the implementation step, the best practices feeding in the review step and feedback loops of unrealized plans and improvements are included.

The first step of the cycle is the environmental policy, which determines the overall objectives and basic principles of environmental protection. It represents the voluntary commitment to protection of the environment and includes an ‘‘environmental mission statement’’. To convert principles into action measurable objectives are required. (Keniry, 2003)

Reviewing the effect of the system on the environment is included in the implementation phase. Hazardous waste handling, energy usage, resource conservation etc. are managed according to the regulations made in the planning phase. Activities, products or operations that have impacts on the environment are determined. (ISO 14001, 1996)

The Checking step covers the environmental audit (life-cycle assessment). This step affects the following checking and review processes. Environmental audit is done to overview its environmental impacts. If all input and output materials and energy consumption at the university are listed, it can be determined where critical measures need to be implemented to increase resource efficiency. Beside taking measures for the ineffective parts, the lists form the basis to analyze the effects that items have on the environment. (Viebann, 2001)

The Review part is comprises the environmental report management review. The aim of environmental report is to inform the public and university members about environmental status of the campus. The measures that have already been implemented are declared to draw attention and raise awareness. Its purpose is to report the environmental situation of the university. (Viebann, P.,2001)

There is an ongoing debate about the utility of the EMS certification literature. Some authors claim that generic EMS formal models are not ideally suited to the universities and a unique university EMS model is required. Some authors argue that formal standard EMS models like ISO 14001 are suitable for any organization, even for universities. The existing EMS models used in university campuses may fall into two categories: the formal certified models and informal uncertified ones. Informal EMS's are based on certified models such as ISO 14001, EMAS and tailored to the university itself. (Clarke, 2008)

Although several guides are now available, there are only two EMS models that have been which were proposed specifically for colleges and universities. These are namely The Osnabruck model, and another model by the South Carolina Sustainable Universities Initiative. (Savely, 2006) There are other examples of university specific EMS models, such as the Netherlands based tool, the Auditing Instrument for Sustainability in Higher Education (AISHE) and Canada based tool the Campus Sustainability Assessment Framework (CSAF). However these tools are not linked to a formal EMS model. (Keniry, 2003)

To create a standard for environmental systems, International Standards Organization (ISO) has developed the 14000 series including, ISO 14001, that is increasingly used in business and industry directly or as a source to create their specific models. (Stapleton, Glover, and Davis 2000)

i. ISO 14001 EMS Model

The ISO 14001 model uses these titles to form a framework: policy, planning, implementation and operation, checking and corrective action, and management review. It offers a formal certification for a generic model and is not sector-specific; it is suitable for any organization. Starting with the University of Missouri-Rolla and The University of Texas in North America, this model is used by many universities throughout the world from Germany to UK.

The ISO 14001 includes two main parts: specification with guidance for use and general guidelines or principles, systems and supporting techniques. Simkins and Nolan (2007) indicate that this model has the objectives such as to:

- "Reduce waste, resource depletion and environmental pollution;
- Promote environmental awareness among employees and within the community;
- Provide a platform for companies to demonstrate their commitment to environmental protection;
- Help management pursue continual improvement in environmental performance;
- Provide a worldwide focus on environmental management;
- Promote a voluntary, consensus standard approach for environmental issues;
- Demonstrate a commitment to moving beyond regulatory compliance"

ii. Osnabrück Model:

The ‘‘Osnabruck Environmental Management Model for Universities’’ is developed in Germany in Osnabruck University. It is based on the Environmental Management and Auditing Scheme Directive of the European Union (EMAS) and is composed of ten building blocks.

“EM1: organizational structure,
EM2: environmental guidelines (internal),
EM3: external environmental regulations,
EM4: environmental audit (life cycle assessment),
EM5: environmental goals,
EM6: environmental program,
EM7: environmental report,
EM8: environmental information system,
EM9: environmental training and courses, and
EM10: staff involvement/ public relations work.”

These 10 building blocks correspond to the objectives of an EMS as in the ISO 14001. (Viebann, P.,2001)

2.7. Assessing Sustainability of a Campus

Organizations like the Association for the Advancement of Sustainability in Higher Education (AASHE) represent hundreds of educational institutions trying to put sustainable development principles into practice. AASHE projects range from energy retrofits to supplying local food in campus cafeterias, and organizations like this one offer a plethora of resources for moving towards greater change in the institution’s daily practices. Clearly, within the contemporary context of the environmental situations, institutions are struggling with how to create a sustainable campus.

Therefore Higher Education Institutions are in need of tools to create this change while they maintain their other priorities of education, research, and housing students (Creighton, 1998).

2.7.1 Benefits of Assessment

Assessment tools take a picture of the institution and establish a starting point with knowledge about the resources and constraints. Assessment of campuses with cross-institutional tools identifies sustainability leaders and best practices among universities. The assessment tools communicate common goals, experiences and methods and their efficiency under different conditions. Beside these benefits they create the opportunity to measure the progress toward the concept of a sustainable campus. An ideal assessment tool identifies the most important features of a sustainable campus through calculable and comparable indicators. They measure more than eco-efficiency, assess processes and motivations and are comprehensible to different stakeholders. (Shriberg, 2002)

Cross-institutional assessment tools identify support and resistance forces for sustainability initiatives. This quality helps stakeholders to lead more effective sustainability policies, objectives, and programs. Furthermore assessment tools can identify best practices across the world and deal with the problem by focusing campus efforts on continual improvement. Inter institutional communication which also facilitates progress can be considered as a key to success to achieve ambitious and determined goals of sustainable development in higher education. (Cole, 2003)

Using a common methodology and indicator set ensures the comparison of sustainability performance across individual campuses. This would help campuses to understand where they stand among their colleagues toward the way sustainability. This would also encourage other passive campuses to take action. The institutional assessment would help campuses to assess a wide range of different sustainability

issues. Some of them are not always paid attention in the design of individual assessment tool. (Cole, 2003)

Shriberg (2002) conducted a research and analysis of eleven different tools already in limited use in North America and Europe. Based on this research Shriberg offered some suggestions about an ideal campus sustainability assessment tool and its benefits. This "ideal tool" for cross-institutional sustainability assessments would:

"-identify important issues;
-be calculable and comparable;
-move beyond eco-efficiency;
-measure processes and motivations; and
-stress comprehensibility" (Shriberg, 2002).

2.7.2 Leading Assessment Frameworks

a. Campus Ecology (1993)

Campus Ecology was developed by Student Environmental Action Coalition (SEAC) in 1993. It is a baseline for current tools with its 20 year history. The cross-functional and comprehensive center was unique at that time and it was "state-of-the art" which students and others across the US and the world have used extensively to conduct environmental audits of their campuses. It was a starting point for student effort based environmental assessments and has become a main source, basis and reference point for cross-institutional sustainability assessments for campuses. (Schriberg, M., 2003)

Mainly the topics are addressed with a focus on eco-efficiency, then the necessity and integration of social and poverty topics enlarged the debate with the discussion of "environmental justice" and "investment policies". Being environmentally focused and having limited sustainability considerations are the weak points of this

assessment type. The major strength of this tool is providing practicality as a clear, coherent framework for assessment. Campus Ecology frames the problem, asks assessment questions, gathers data, identifies best practices, develops recommendations and strategies, and finds resources for implementation in a linear logical order. (Schriberg, M., 2003)

b. University Leaders for a Sustainable Future's Sustainability Assessment Questionnaire (SAQ) 1999

Sustainability Assessment Questionnaire (SAQ) is currently being utilized at selected campuses across the world. This tool complements National Wildlife Federation's endeavors. Unlike NWF which focuses on performance benchmarking, the SAQ is a largely qualitative tool that promotes discussion and detailed assessment (ULSF, 1999). Being in the form of a questionnaire, Sustainability Assessment Questionnaire has "22 questions requiring responses on a scale of 1 – 5, or open-ended paragraph answers" (ULSF, 1999). ULSF encourages institutions to benefit from SAQ as a group exercise for students since it was developed as a teaching tool. According to ULSF's advice this group survey should be led by a ULSF staff-member with 10–15 representatives from campus to be assessed.

Main objectives of the Sustainability Assessment Questionnaire are to develop "a comprehensive definition of sustainability in higher education and to take a realistic photograph of their institutions on the path to sustainability". The progress on sustainability and decision-making mechanisms are emphasized by the SAQ. (Schriberg, M., 2003)

Having a neat focus on sustainability and sustainable progress SAQ describes the term sustainability through explicit definitions at the beginning of the questionnaire. (Cole, 2003) The social dimension of sustainability and assessing sustainability as a campus and benefits of moving toward are emphasized through these definitions. The objective of providing these definitions is to establish the common ground and a starting point for participants to use while answering the questions. Being a

straightforward questionnaire, SAQ does not require intensive numerical data. This tool covers a range of sustainability issues without intensive data collection or analysis or a great deal of time. Promoting dialogue, capacity building and community consideration are the strength of this tool. Moreover for the improvement of the sustainability among unıversities, this tool helps to identify common objectives among universities. (Schriberg, M., 2003)

To test the weaknesses, strengths , goals and desires of the campus, SAQ directs probing questions to increase sustainability. This can be considered another major strength of SAQ which makes it a useful conversational and teaching tool. (Schriberg, 2003)

By including source reduction and integrating social responsibility into investing, and sustainable landscaping in institutional operations, ULSF focuses on sustainability, not eco-efficiency. As a requirement of focusing on sustainability, the organizational structures and progress such as integration of sustainability into policies, staffing and rewards are concerns of assessment.

On the other side the primary weakness of the tool is being subjective, qualitative, and impressionistic and so the responses cannot be used to rate or compare institutions (ULSF, 1999), or even to measure a single institutions' performance change over time. Many possible indicators of sustainability are lacking in the tool and is quite simple in scope,organization, and structure. In short, having no reliable mechanisms for comparisons or benchmarking among universities and the difficulty for large universities to complete can be reported as the weak points of this assessment tool.

On the other hand, the results are useful to manage and demonstrate the understanding of sustainability in university campuses. As a result, the SAQ will continue to be very successful as a discussion- generating and progress-reporting assessment tool for campus sustainability.

c. Penn State Indicators Report (2000)

This tool was developed by Penn State Green Destiny Council in 2001 for Pennsylvania State University. Rather than designed to be cross-institutional, this project was undertaken by an individual campus. This assessment tool was referred as their starting point by many campus sustainability assessment projects. The Campus Sustainability Assessment Review Project declared that Penn State's assessment was the most comprehensive sustainability assessment in the literature (Nixon and Glasser, 2002). This tool uses a 4-point system to measure 33 different indicators of campus sustainability issues. (Cole, 2003)

Penn State Indicators Report is well documented, and represents a diverse teamwork of campus stakeholders. Relevance of the indicators were discussed and performance levels are well defined and the reason of the situations and best practices from other campuses are analyzed. Short and long term recommendations to develop sustainability at Penn State are also discussed since this is planned to be a useful tool for decision makers in determining policies. (Penn State Green Destiny Council, 2000)

The weak point of the tool is its inadequate coverage of sustainability issues. The process of defining the indicators is not described efficiently. Lack of information about the performance levels for each indicator and their rating criteria are among its weak points. (Cole 2003)

d. Auditing Instrument for Sustainability in Higher Education (AISHE) 2001

Major goals of AISHE are to provide a structure and a framework for sustainability audits; to measure the level sustainability integration to campus; and to create a mechanism to transfer and share experiences and motivations among universities.(Roorda, 2000). Following an environmental management system process of plan, do, check and act this tool has 24 issues that are assessed. These

issues are evaluated on five developmental "stages" such as activity oriented, process oriented, system oriented, chain oriented and total quality.

By directly involving decision-makers and all stakeholders in assessing process, AISHE is a very interactive tool. This tool stresses on process rather than content, qualitative measures are preferred over quantitative measures. Therefore, beside being a policy instrument, AISHE is an auditing method also. (Schriberg, M., 2003) Its process-orientation quality ensures dynamic decisions involved in managing for sustainability. Furthermore, without quantitative measures progress measurement is possible for developmental stages. Overall, this tool can be used for cross-institutional comparison.

Focusing on educational performance of faculties to assess sustainability, many campus sustainability issues such as operations, research, finance, governance, etc. are lacking in this tool. In addition to the weak points this tool has a very limited scope in environmental sustainability and this prevents inter institutional usage of the tool to make comparisons among campuses. (Cole, 2003)

e. The National Wildlife Federation's "State of the Campus Environment" (US) 2001

State of the Campus Environment project is a comprehensive and effective assessment framework. The idea of providing a profile for each college or university in America for environmental performance was the starting point of National Wildlife Federation (NWF) which is a non-profit organization. After an extensive literature review, the first large-scale campus environmental performance survey was developed by NWF. (National Wildlife Federation, 2001)

By combining eco-efficiency measures such as "water conservation and recycling with more long-term, sustainable processes such as faculty training in sustainability, land stewardship practices, and use of life-cycle assessment" this is an effective survey. This survey also considers accountability and practicality for assessment of

environmental performance. Furthermore to lead change for a sustainable campus and to gain a perspective, it identifies barriers, incentives, drivers and motivations. (McIntosh et al., 2001)

Both measuring qualitative and quantitative indicators, this assessment tool provides the opportunity to compare and detect best practices and creates a contextual richness. As NWF states that the main goal of the survey is not to rank campus sustainability individually, but it is designed rather to provide nationwide roadmaps on institutional decisions. (McIntosh et al., 2001)

Little use of the term "sustainability" instead of using the terms "environment and management" and small sample within each college university can be seen as the weaknesses of this comprehensive tool. Moreover this tool is lacking to define the meaning of "sustainable campus" with performance benchmarks on a wide range of sustainability topics. Related to this the tool is also missing to guide decision makers through providing efficient discussion of how to describe the performance. This assessment tool is still under development. (Cole, 2003)

f. Campus Sustainability Assessment Review Project (CSARP) 2002

This project was initiated at Western Michigan University in 2002. To develop campus sustainability assessment guidelines the CSARP comprehensively described the process. This project derives from an intense literature review including over 225 assessment frameworks throughout the world. Among these frameworks 55 of them were high-quality which were reviewed in detail. The literature review used as a methodology to determine the most effective elements of sustainability assessment framework of campuses. (Nixon and Glasser, 2002).

This research reviews most of the existing assessment tools to determine the best principles in order to form a set of assessment guidelines as a major strength (Cole, 2003). Having been built on the campus sustainability assessment history, this

research takes it to the next level in its evolution. Covering sustainability comprehensively and addressing both humanity and ecosystem considerations, this tool is quite comprehensive and highly analytical (Nixon and Glasser, 2002).

A weakness of this work derives from its origin from existing resources and not being directly designed to fill the gaps in assessment tools. Since it covers sustainability issues from the existing assessment tools as the main source, there is the probability of missing an issue that have not been addressed or identified in any projects reviewed. Dynamic data such as interactive input that may come from auditing experts is lacking in the guideline of the tool and indicators are not discussed and defined efficiently as other weak points. For instance there is no information related with the performance benchmarks that can direct the stakeholders and decision makers. (Cole, 2003).

g. Sustainability Tracking, Assessment and Rating System (STARS) for Colleges and Universities Version 0.5 2007

This tool was developed in 2007 as a preliminary draft version and has been improving it ever since. Colleges and universities can assess their sustainability performance by STARS since it is a self-reporting and transparent framework. This voluntary, self-reporting framework is designed to reach the goals of enabling meaningful comparisons across institutions. Main goals of this tool are to establish a common ground of assessment for environmental sustainability in universities and to promote collaboration and cooperation by sharing experiences and knowledge about sustainability.Integrating sustainability into the campus community and establishing continual improvement toward sustainability are also important objectives of the initiative. (STARS 0.5).

In STARS, institutions are not competing against each other to earn a high score which makes this tool a rating system not a ranking. Evaluations are based on the institution's performance on its own context. Performance and strategy are two main categories that Stars comprised of. Quantitative measurements like the percentage of

new buildings that meet LEED standards are included in performance credits. Policies, approaches and processes such as adopting a green building policy and transportation system organization are included in the strategy credits. (STARS 0.5).

Performance indicators that give measurable, quantitative and comparable information about sustainability of a campus are not clearly identified in STARS. However, the institution's sustainability initiatives and valuable information about experiences and experiments that worth collecting and sharing are depicted by strategy indicators. (STARS 0.5).

STARS scorecard consists of "three categories namely Education and Research (ER), Operations (OP) and Administration and Finance (AF)". Buildings, energy and climate, dining services, materials, grounds, recycling, and waste minimization and sustainable transportation are subtitles of operation category. All the points that can be earned from each category are defined clearly. (STARS 0.5).

h. College Sustainability Report Card Sustainable Endowment Institute 2010

Sustainable Endowments Institute is the establisher of both The GreenReportCard.org website and the College Sustainability Report Card. This institute is dedicated to sustainability in research and education in universities and in campus operations and endowment practices.

By using the information conducted by the College Sustainability Report Card through an extensive research, GreenReportCard.org is established to provide colleges' sustainability profiles. Hundreds of colleges and universities in U.S. and Canada were included in this interactive online source.

The main idea of The Report Card is to provide accessible and transparent information for universities about integration sustainability to campus. The Report Card is identifying best practices and leading examples so that the universities committed to sustainability can learn from the existing initiatives, practices and experiences in order to develop more efficient policies. There are nine main

categories in the tool, which are assessed through 43 indicators.

Grading was designed to be simple by using only full grades such as A, B, C, D, and F not using plus and minus degrees. Accumulating over 70 percent of points in any category, a school can receive an "A" grade. There are 300 schools' sustainability profiles in the system database. This information is gathered through the consultancy of university administrators. (http://www.greenreportcard.org/about)

A general overview of these eight well-known and commonly used assessment tools are shown in the table 2.7.2. Basic categories are determined according to the Alshuwaikhat's Campus Sustainability Model. (2008).

2.8. Environmental Audit

Many colleges and universities have employed campus environmental audit as a common tool in recent years. By providing campus sustainability assessment, campus environmental audit identifies how the resources are being utilized. As being a report card, an environmental audit evaluates the current policies whether they are reaching their goals. Therefore it can be said that environmental audit is the first step of the sustainability planning process. A campus environmental audit identifies the impacts the campus on the environment and draws a roadmap to reduce them. (2008 Merrimack College Campus Environmental Audit)

Assessing an organization's activities and operations requires a systematic and objective well documented process. These activities and operations are evaluated in relation to environmental management which demands integrating with society, raising awareness among students, committing to environmental policies, providing opportunities and establishing a baseline for performance.

Table 2.2 Environmental assessment frameworks for universities

(Savannick, 2004)

Assessment Protocols Specifically for University Campuses			
Assessment	Origin	Description	University Examples
Blueprint for a Green Campus	Developed at a 1994 Campus Earth Summit at Yale University	Practical recommendations for greening campus operations, curricula and community relations	Offers recommendation, but does not collect data on implementation
Campus Ecology Research Station	National Wildlife Federation Campus Ecology Program	Offers practical recommendations about starting projects and details best management practices at colleges and universities	Numerous examples of best practices available on extensive website through the campus environmental yearbook
Clean Air Cool Planet	Based on Kyoto Protocol, international voluntary agreement to reduce carbon dioxide emissions.	Advocates greenhouse gas emission calculations (with a template available from Tufts University) as well as adopting the provision of the protocol.	Many, for example Tufts University, Massachusetts Institute of Technology
Ecological Footprint	(Wackernagel 1996)and Chambers, (2000)	Standardizes environmental impacts of institutions, cities and countries by converting raw data to acre feet required to produce products and assimilate waste.	University of Newcastle, Australia University of the Redlands Oxford Brookes University, UK Footprint calculator developed for UK student unions.

Table 2.2 Environmental assessment frameworks for universities (continued)

(Savannick, 2004)

ISO 14001 (University Version)	International Organization for Standardization (ISO) adapted for campuses by USEPA	Environmental management system that describes data needs and environmental management process	Tulane Humboldt State University of Missouri-Rolla
The Natural Step	Founded in Sweden	Conceptual framework for addressing environmental problems on different levels through meeting four system conditions	Georgia Institute of Technology University of Texas at Houston
Tallois Declaration	Policy commitment developed at conference of university presidents and chancellors.	10 campus-based actions to reduce environment degradation	265 signatories, no data on implementation
ULSF Sustainability Assessment	University Leaders for a Sustainable Future	Short questionnaire specifically asking questions about sustainability for campuses	Tool available on website. Best practices case studies available on website

Table 2.3 Assessment tools according to the main categories

	Environmental management		**Public participation & social responsibility**		**Sustainability teaching & research**		**Others**
	EMS management	Operations green campus	Public participation	social responsibility	curriculum	Research & development	
University leaders for a sustainable future (ULSF)	✓	✓	✓	✓	✓	✓	Faculty and Staff Development and Rewards Student opportunities
Penn State indicators report	✓	✓	X	✓	X	✓	
Auditing instrument for sustainability in HE (AISHE)	✓	✓	✓	✓	✓	✓	Financial resources and mechanisms Individual initiatives Staff development plan
State of the campus environment	✓	✓	✓	✓	✓	✓	
Campus sustainability assessment review project (CSARP)	✓	✓	✓	X	✓	✓	
STARS Version 2.00	✓	✓	✓	✓	✓	✓	Positive Sustainability Investments
College sustainability report card	✓	✓	✓	✓	✓	X	Investment priorities Endowment transparency Shareholder engagement

To conduct a campus environmental audit, these 3 priorities should be considered:

a. "Conduct an assessment of campus environmental impacts, including, but not limited to: solid waste, hazardous substances, wastewater and storm runoff, air quality, the workplace environment, water, energy, food, purchasing policies, transportation, campus design and growth, research activities, investment policies, business ties, environmental education and literacy, job placement and environmental careers.
b. Providing recommendations for improved performance in each area, ranking priorities for action, and setting goals to be completed by the next audit.
c. Distribute to all members of the campus community, including high-level campus officials, staff, faculty, students, alumni, foundation donors and the society at large." (www.campusactivism.org)

An environmental assessment consists of such measures as energy efficiency, water efficiency, sustainable landscape, material wastage/ conservation, transportation, and buildings; which are described in more detail in the following sections:

2.8.1 Energy Efficiency

Energy makes possible the existence of life, human civilizations and ecosystems formed by living beings. Energy is used in almost all facets of life throughout the world, with an increase parallel to the technological improvement, mass production and population growth. (Rosen, 2009). "The United Nations Conference on Environment and Development indicates that the largest impact to environment of human development comes from energy management including production, distribution, and use." (Earth Summit-Rio de Janeiro 1992)

Combustion of fossil fuels is the main source for the production of energy for human

use. Although they have negative impacts on environment through their collection and combustion; oil, coal and natural gas are the most commonly used resources. Several alternative renewable production methods exist, such as solar, wind, geothermal energy and bioenergy. (Concordia CSA, 2009) To be sustainable, energy use will clearly have to move toward renewable sources of energy rather than the current carbon based energy sources. Energy production affects land, air and water and its conservation is a means to reduce impacts, improve efficiency and lower costs and protect habitat. (Creighton, 1998)

Energy is among the most important inputs that makes a university campus operate. It is needed for lighting and heating in the buildings, computers, air conditioning, and all kinds of technical applications. This huge amount of energy need requires a huge conservation during this consumption to increase efficiency and to lead the way of sustainability. The next step on this way to sustainability is to shift to renewable sources to supply energy to diminish the environmental impacts. If it is not feasible to produce on-site renewable energy in a campus due to many constraints, it can be purchased from the grid. (Rappaport, 2008)

A campus wide energy policy is required to take action on the way to sustainability. This includes an overview of the current status of the campus energy system and energy saving initiatives would be based on the critical points of that snapshot. A campus wide monitoring and data collecting system will determine whether the precautions are working or not according to the results and provides the opportunity of improving them. (Concordia CSA, 2009)

A sustainable energy management model for a university would focus on 3 key areas:

i. Lifestyle Change and Reconstructing Values to Reduce Energy Consumption: The level of concern for environmental issues and awareness of the implications of energy use on environment have effects on personal habits. To draw attention to the need for energy conservation and provide opportunities for action is under the

institution's responsibility. Energy users would be more concerned about lifestyle choices after events like campus-wide competitions among dormitories which have direct effects on consumption.

ii. Greater Efficiency: The old technology and non-efficient appliances would be replaced. Highly efficient products and energy saving systems and devices could be implemented. Approximately a third of all the energy is used by space and water heating, cooling, lighting, ventilation and equipment in buildings and an upgrade of these systems is a requirement for energy efficiency. Since energy demand is increasing each year, efficiency improvements are inevitable to establish campus energy conservation.

Building design and infrastructure that minimizes energy use could be implemented. Whole-building approach which integrates passive solar design should be considered for the new construction which saves energy. Energy-efficiency design strategies would be implemented to decrease energy loads. For existing building buildings built in an era which had no consideration of environment would be upgraded. (Office of Energy Efficiency, 2001).This topic will be explained in a separate section "Green Building" later in detail.

iii. Shift in Sources of Fuels from fossil fuels to renewable:
Moving from non-renewable sources for power generation to renewable alternatives is the greatest challenge for campus energy supply and for sustainability in its basis. To develop alternatives to fossil fuels, research and innovative technologies are the missions of a Higher Education Institution. Several alternative renewable production methods can be activated such as solar, wind, geothermal energy and bioenergy. (Klein, K. 2002)

a. Solar Energy: Harvesting energy from solar radiation is another way to increase renewable energy production on campus. There are mainly two approaches for

utilizing solar energy including photovoltaic (PVs) and solar thermal heating systems.

PV systems use an array of solar panels and an inverter to convert solar energy into electricity. Those PVs can be placed both on ground called solar array, and also on a building shell, roof or façade. On the other hand, solar thermal heating systems pump water or antifreeze through collectors to absorb heat from the sun. Solar thermal heating system collectors mainly placed on the building roofs. (Klein, 2010)

b. Wind Energy: Wind energy is a proven, cost effective, renewable source of clean energy. If it is not possible to find an appropriate place in campus, wind turbines would be located off campus. Availability of land with a good wind resource is a potential barrier. (Keoleian, 2011)

c. Geotermal Energy: Geothermal energy is another source for clean energy and also it is "cost effective, reliable, sustainable, and environmentally friendly". It is the "thermal energy" generated and stored in the Earth. During summer, the heat pump transfers the building's heat into the fluid circulating through this geoexchange field which benefits from the thermal mass of the ground. This system works vice versa during winter times. (Keoleian, 2011)

d. Biomass: Since combustion of biomass releases carbon that was recently sequestered by vegetation, biomass is considered to be a zero-emission fuel. Thus, the use of biomass as a fuel source can greatly reduce the campus' greenhouse gas emissions. Moreover being a cost efficient source, biomass can provide cost savings compared to current energy sources. (Klein, 2010)

2.8.2 Water Efficiency

Fresh water is the source of all life forms such as agricultural, industrial, recreational, and human and animal. In the last century, water use has increased at more than

twice. In addition, only one percent of the world's water is available for human use which shows the importance of the fresh water management. A sustainable campus "should control and reduce water runoff from its site, consume fresh water as efficiently as possible, and recover and reuse gray water to the feasible extent." Since water delivery and treatment requires high amounts of energy, conserving water saves energy, beside protecting environment, (National Best Practices Manual, 2007).

A water audit can be broken down into three separate categories of water. These categories consist of blue, green, and grey water. Blue water is an indicator of consumptive use of fresh surface or groundwater. (Aldaya, 2011). Although water is a semi-renewable resource, one cannot consume more water than is available in a certain period. (Aldaya, 2011). In contrast to blue water, green water is an indicator of human use. Green water refers to precipitation on land that does not run off or recharge the groundwater, *i.e*. precipitation that does not become blue water. Instead, green water is stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, this type of water either evaporates or transpires through plants. (Aldaya, 2011).

Lastly, grey water measures the pollution associated with freshwater. Grey water is defined as, "the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards" in *The Water Footprint Assessment Manual* (2011, p. 30). In other words, grey water represents the volume of water needed to dilute pollutants so that they will become harmless (Aldaya, 2011).

a. water consumption reduction

To reduce water consumption enhancing the awareness of water conservation is the starting point. With the water management policies water conservation atmosphere may be established in the whole campus by positive publicity, guidance and water conservation activities. It is a must to reduce or eliminate use of potable water for

non-drinking uses since fresh water is a limited and valuable source for water consumption reduction. In order to improve the ability to monitor water use on campus, universities would install advanced water metering systems. (National Best Practices Manual, 2007)

Water use reductions can be achieved by high performance fixtures. “This can be reached with a combination of water-conserving fixtures and equipment such as low-flow or waterless toilets and urinals, automatic lavatory faucet shut-off controls, low-flow showerheads, and high-efficiency dishwashers and laundry appliances.” To reduce water use regular maintenance on this equipment is important because leakages are the biggest cause of waste water in buildings. (National Best Practices Manual, 2007)

b. waste water treatment

To provide water for irrigation or non-potable indoor purposes such as flushing toilets, streams, rivers, lakes, and groundwater resources should not be consumed. Their environmental and financial costs are considerably high. In these cases using reclaimed water is an effective alternative to the high-quality potable water,. (Chai, Y. 2011)

Recycled water is either reclaimed wastewater or untreated gray water. Reclaimed wastewater is treated water that can be used for non potable uses such as toilet flushing, landscape irrigation, cooling towers, industrial processes and fire protection.

The untreated wastewater generated from showers, bathroom sinks and laundry but not from toilets, kitchen sinks, urinals or dishwashers is called gray water. Gray water is diverted from the existing drain line to a surge tank in order to be filtered, sterilized, and recycled. Since it is used in irrigation and toilet flushing, gray water treatment reduce fresh water consumption and the load on treatment plants because it

is treated on-site. (Chai, 2011)

Although it is not used for above-ground irrigation, gray water can be used for use below-ground. Due to organic matter, gray water should be used right away and not stored. If gray water is stored too long, the oxygen will be used up and anaerobic conditions will result in unpleasant odors. (Aldaya, 2011).

The scenario of treating gray water for reuse purpose within a single building "involves collecting gray water from either campus dorms or buildings, treating the gray water and using it for toilet flushing" (Anglin, Maravilla, Miller, 2008)

2.8.3 Sustainable Landscape

Green space is a basic environmental character of campus settlements especially the ones which are out of the city. Green space has many environmental benefits including reduction of impermeable surface area that prevents water pollution from run-off and decreased heat absorption in the summer time that decreaes cooling costs. Moreover green space increase air moisture and decrease urban heat island effect which results in a cooler urban area. Improving air quality and providing habitat for birds and other animals, green areas keep the environment healthy. Green landscape provides an accessible, public space to relax and enjoy which is an important social feature on a university campus. (Concordia CSAF, 2009)

Considering the importance of the green space in campus sustainability, the strategies to achieve sustainable landscape becomes crucial. For a sustainable landscape in the campus several key elements of the landscape design are:

-Storm water management
-Using water outdoors
-Parking pavement
-Landscape vegetation (Klein, 2002)

a. Stormwater management

Stormwater is runoff water that flows along the surface of the ground. This is precipitation that does not evaporate or soak into the ground. Concentrating runoff water and carrying it off the site as quickly as possible through storm sewers is the conventional solution for storm water management. Many environmental problems occur due to this solution such as downstream flooding, erosion, surface water pollution, and groundwater recharge reduction. (National Best Practices Manual, 2007)

Managing the quantity of storm water runoff is based on drainage and flood control. Impervious surfaces such as rooftops, roadways and parking lots are main contributors to storm water runoff. A green (vegetated) roof can serve as a very effective storm water management system. This practice is working as a storm water controller and pollutant filtration systems. Such a roof will typically absorb the first half or more of a rain. Management of on-site sources of pollutants in storm water and treating the storm water to remove these pollutants are important stages of water quality control. (Nagy, 2002)

b. Using water outdoor

Water management requires prevent potable water from waste, overuse, and exploitation. Water efficiency is the management of water with efficient planning which accomplish “do more with less,” without any decrease in performance. For effective water management in outdoors run off control and the water quantity used for irrigation should be considered. Rainwater harvesting and water saving irrigation systems such as low-volume distribution devices should be used. Native, drought tolerant vegetation and effective irrigation reduces water consumption dramatically.

c. Rainwater Harvesting

Rainwater harvesting is the practice of collecting rainwater off roof surfaces and

plain grounds and storing that water for later use. While collected water can be filtered and treated for potable uses, such systems are fairly complex and costing. Thereby it is preferred to use collected rainwater for landscape irrigation. (Nagy, S, 2002)

d. Parking /pavements

For maintaining and restoring natural water cycles on developed sites, permeable paving is a powerful tool. By allowing water infiltration rather than concentrating rainwater into runoff they help storm water management. A permeable paving system is a pavement surface that contains voids, allowing water to infiltrate through. (Concordia CSAF, 2009)

e. Landscape vegetation

Landscaping is the key to the relationship of the building and the site. Functional aspects of landscaping should be incorporated into the site design. An important component of landscape design can be ecological restoration. Through ecological restoration and careful siting of buildings on a degraded site, it is possible for a post-development site to support greater biodiversity than prior to development. To accomplish ecological restoration preserve and promote native, drought tolerant vegetation that is naturally optimized for campus precipitation levels. If plants are desired that need water more than natural fauna, grouping them by similar watering and soil type needs is an effective strategy. (Nagy, S, 2002)

2.8.4 Material Conservation

Today cities are generating great amounts of waste that has reached unsustainable and environmentally threatening levels. University campuses as small cities are generators of great quantity of waste. Being sustainability leaders they have a responsibility to develop waste management strategies to minimize waste generation and to increase reusing or recycling the amount of waste they produce. For institutional waste management policies, the planning process should include all the

factors effecting material consumption from purchasing to awareness. (Klein, 2002). A sustainable waste management system consists of these policies:

"-Waste minimization policy
-Purchasing/guidelines policy
-Recycling and reuse policy
-Composting policy" (Klein, 2002).

a. Reduce

Preventing waste from existing in the first place is the most efficient waste management policy. The purchasing policies that obligate minimal packaging and the avoidance of disposable products in campus food services are main points of reduction programs for campus waste. In addition consumer habits and the awareness of the campus community are important indicators of waste reduction. (Klein, 2002).

b. Reuse:

Reused materials in a campus environment can prevent environmental and economic inefficiencies. Some simple examples from daily life can increase the life of the product. Using both sides of paper before it is recycled; using condiment containers in campus cafeterias increases efficiencies and decrease waste, which requires energy and additives. (Klein, 2002).

c. Composting

As a composted and reused material, food waste can be used as valuable landscaping material for the green space of the campus. To reduce disposal fees many universities throughout the world have employed campus-wide composting projects. This is a process that decreases the amount of waste sent to the landfill substantially. (UB Climate Action Plan, 2009)

d. Recycle

Recyclable material market has grown during the last decades. Implementing

effective recycling programs has created significant economic costs for universities. By implementing recycling policies universities organized sale of the recycled material and also by sending less waste to the landfill, saved disposal fees. (UB Climate Action Plan, 2009)

Recycling means collecting and reprocessing a resource so it can be used again. Paper, cardboard, batteries, plastics, beverage containers (plastic, cans ,glass), toner cartridges, yard waste, metal, wood, hazardous waste, tin, rubber, books, furniture, equipment, clothes are the items that are consistently recycling in universities. (Klein, 2002).

To develop a campus recycling policy a green procurement guidelines should be formed and implemented. So that purchasing of recycled products can be increased in the university which can reduce emissions associated with extracting and processing raw materials. (UB Climate Action Plan, 2009)

2.8.5 Transportation

Over the last century primary solution of transportation has become driving. Today, the car is considered as a convenient transportation solution, and used as a habit rather than necessity. Therefore the development of the modern cities and communities supporting the car dependency vehicular infrastructure has growing needs. This vehicle-dependent transportation system has substantial environmental, social and economic costs which are having been experienced throughout the last century. As high density communities mostly located out of the city, universities are facing the problem of transportation.(Klein,K. 2002)

Toxic gas emissions are the major environmental problem that vehicle dependent transportation causes. The local air quality of the campus is affected by the toxic gases such as Co2, nitrogen dioxide and particulates which vehicles release. Moreover, asphalt roads and parking lots which are the results of the vehicular

infrastructure contribute to runoff of precipitation and complicate stormwater management. Vehicular traffic products such as engine oil, antifreeze and rubber is transferred by this runoff water directly into local water bodies. (Klein,K. 2002)

Transportation needs of colleges and universities have unique character. To foster academic collaboration, educational institutions require a walkable, green and user friendly campus where buildings are in close proximity. Many institutions of higher education are aiming to develop alternative models to shift away from automobile dependent transportation. (Miller,2001).

Sustainable transportation system is defined by Canada's Centre for Sustainable Transportation as one that:

> **"-**allows the basic access needs of individuals and societies to be met safely and consistent with human and ecosystem health
> -is affordable, offers choice of transport mode, operates efficiently and supports a vibrant economy;
> -limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise." (The Centre for Sustainable Transportation, 2002)

The main strategy to reach sustainability in transportation to discourage single-use automobile transportation and encourage energy efficient transportation alternatives including walking, biking, shared vehicle transportation such as carpools, vanpools and more importantly mass transit. For sustainable transportation expanding transportation alternatives and access for all users and including transit service improvements are key strategies. (Miller,2001).Encouraging pedestrian activity through connected paths, green spaces and walkways by keeping roads on the perimeter and green space is a basic strategy to support walking. By providing safe bike and pedestrian ways and effective parking and storage for bicycles, skateboards, and scooters and regulating public transportation according to the needs of the

campus habitants, the transportation system can be independent from automobile culture. (The Collaborative for High Performance Schools, 2006)

2.8.6 Buildings

Building policies are an important part of the campus sustainability. They should be considered in the implementation of the Environmental Management Systems. In U.S. and Canada many universities have diligently adopted green building practices into their policies. Damages generated by the buildings should be reduced by making a shift to the green building design from conventional building design. Buildings are responsible for the significant amounts of total energy use, water consumption, total electricity consumption, and greenhouse gas emissions.(CaGBC, 2009).

"Green building is a term used to describe a building that is more energy and resource efficient, releases less pollution into the air, soil and water, and is healthier for occupants than standard buildings." (Orr, 2004). Green buildings are environmentally sensitive buildings in terms of design, construction and operation compromising a whole building design approach by considering energy management, water management, site planning, material use and indoor air quality (IAQ). Site selection involves choosing locations which are not environmentally sensitive. Proper site design is also crucial to minimizing the building's effect on the surrounding landscape. Materials and resources involve choosing building materials that are sustainable, such as recycled or locally-produced material. This technique also involves proper usage and disposal of excess materials. Indoor environmental quality is a measure of indoor air quality, as well as interior comfort. (USGBC, 2008).

The main objective of sustainable design is to prevent environmental degradation caused by buildings throughout their lifecycle (WBDG, 2008). "A green building is a

high-performance property that considers and reduces its impact on the environment and human health" (Yudelson, 2008, p. 13). Another definition for green building is done by The United States Environmental Protection Agency (EPA) "as the practice of creating structures and using processes that are environmentally responsible and resource-efficient." These qualities are considered throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction to ensure sustainability. (EPA, 2008).

CHAPTER 3

MATERIAL AND METHOD

This chapter gives the details of the materials and methodology that are used to conduct the study. The section on material describes the case study campuses which were used as inputs, and the evaluation indicators which were used for auditing environmental sustainability. The procedure of the study is presented in steps consisting of analysis of sustainability of selected campuses, determination of the critical indicators in acclaimed sustainable university campuses, and data processing and evaluation.

3.1. Material

The material of this research consisted of a thorough literature review based on --- sources; campuses selected from many different countries across America, Canada and Europe that are claimed as pioneers in sustainability and environmental awareness; and campus sustainability indicators and sustainability assessment tools from which the indicators are gathered.

The campus sustainability assessment tools are: Campus Ecology, University Leaders for a Sustainable Future's Sustainability Assessment Questionnaire (SAQ), Penn State Indicators Report, Auditing Instrument for Sustainability in Higher Education (AISHE), The National Wildlife Federation's "State of the Campus Environment" (US), Campus Sustainability Assessment Review Project (CSARP), Sustainability Tracking, Assessment and Rating System (STARS) and College Sustainability Report Card Sustainable Endowment Institute which were analyzed in the literature review section.

The indicators for environmental sustainability for campus assessment are adapted from these assessment tools. These tools are including many indicators for many categories such as administration, student involvement, investment management and public concern which are out of the scope of this study. The selected indicators are specific for the physical environment of the campus.

The indicators which are used to assess environmental sustainability are selected from the above mentioned assessment frameworks/tools, and are listed below:

1.Environmental Management Policy of campus (EMS)

2.Energy Efficiency

- i.energy use reduction
- ii. energy efficiency
- iii.renewable energy production

3.Water Efficiency

- i. water use reduction
- ii. waste water treatment

4.Sustainable Landscape

- i. stormwater management
- ii.rainwater management
- iii.vegetation

5. Material/ Waste Conservation

- i.pollution prevention
- ii.waste minimization
- iii.waste recycling

6. Transportation

- i.public transportation
- ii.pedestrian and cycling
- iii.reduce emissions

7. Buildings

i.green building policy
ii.green building applications in campus

Campuses that have accomplished an innovative way of problem solving about environmental sustainability in at least one field were selected. These campuses are: Oberlin College, Princeton University University of Berkeley(USA), Harvard University, University of Wisconsin Oskhosh, Leeds University(Europe), the University of Saskatchewan, Merrimack College, Mount Allison University, Chapman University, University of Waterloo, Tulane University, New York University. Additionally METU was also included in the assessment table to see where it stands in comparison with the selected campuses.

All these universities are also famous for their dedication to achieving sustainability as an institution; however, only the first five in this list and their initiatives are described in detail, according to the selected environmental assessment indicators. Information on these universities has been collected from their official websites and the assessment tools web pages; and is presented in the following sections.

1. Oberlin College (Ohio, USA)

Oberlin College is a pioneer university in sustainability. It proves its determination in the sustainability assessment rankings by receiving a grade of "A" in the College Sustainability Report Card framework. In 2007, it was featured as a "Campus Sustainability Leader". Oberlin College received a grade of Gold in AASHE's STARS assessment tool in early 2012.

Oberlin College is a private liberal arts college which was established near Cleveland, Ohio; in 1833. This college has a population of 8300 and a total campus area of 440-acre. Oberlin College is one of the first four higher education institutions in the USA to sign the American College and University President's Climate Commitment (ACUPCC). This charter is a "high-visibility effort to address global

warming by creating a network of colleges and universities that have committed to neutralizing their greenhouse gas emissions; and accelerating the research and educational efforts of higher education to equip society to re-stabilize the earth's climate. This college has set the target date for climate neutrality as 2025". (The Princeton Review)

By conducting a greenhouse gas inventory and offering courses about Campus Sustainability, the college is working actively to integrate sustainability to the campus. The college aims to engage students in green-related issues, by educating them in energy efficiency and environmental protection. Currently, Oberlin gathers 40 percent of energy demand from renewable resources. There are also robust composting and recycling programs. The college developed a unique recycling program which focuses not just on cans, glass, and plastic, but also clothing and even carpets. Oberlin has implemented a Campus Resource Monitoring System to monitor energy use in the dorms. This system allows students, faculty, and administration to see the results and to hold a yearly competition among dorms. The dorm that has achieves the most reduction in its energy consumption and thereby its carbon footprint wins the competition. (The Princeton Review)

The following steps have been taken in terms of promoting **resource efficiency**:

- Numerous energy efficiency technologies have been installed, including a campus resource monitoring system (CRMS) with real-time web-based feedback on electricity consumption. Real time and historic electricity and water use monitors were installed to each residence hall.
- Lighting was upgraded and in some dorms special lamps, which change color depending on how real time energy use compares to the average historic energy use were installed.
- Existing inefficient central cooling system was replaced with new high efficiency units; the two new 700 ton electric centrifugal chillers are expected to be nearly twice as efficient as the existing units in the long run.
- An energy management system was established

The following steps were taken to promote **renewable energy production** on the campus:

- about 50% of the college's annual electricity consumption is purchased from green energy sources
- 12% of the college's annual consumption is produced from solar array on the campus
- three buildings on the campus are heated with geothermal pump systems.

Following precautions are taken to promote **water efficiency** by installing:

- Water conservation technologies such as low-flow fixtures, showers and faucets.
- Waterless urinals and dual –flush toilets
- Gray water systems

To ensure a **sustainable campus landscape** the following steps were taken:

- Stormwater management was established by designing living and vegetated roofs; retention pond and vegetated swales.
- Vegetation was provided by integrating native ecosystems into the landscaping; restoring wetland that serves as a repository for native species diversity; implementing an organic landscape program to remove exotic invasive plants; and installing a butterfly garden on the campus.
- Weather-informed irrigation was programmed.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- To **reduce** waste amount of plastic going to the landfill Oberlin offers discounts for using mugs and reusable to-go containers and has eliminated the sale of bottled water on campus.
- There is a rough recycling policy even for carpets on the campus. Recycling items are; cans (tin, aluminum, etc.), glass bottles and jars, paper (colored,

glossy, office, newspaper), paperboard (like cereal boxes), plastics(labeled 1 through 7, however not DeCafe containers)

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- Partnership was achieved with a car-sharing program and subsidizes membership costs for students.
- There is Bike Co-op where bikes can be rented, repaired and sold from on campus.
- There is a free shuttle service at night and occasional bus service to shopping and entertainment destinations.
- To reduce carbon emissions alternative fuel vehicles are included in the fleet. two 100% electric vehicles and three gasoline-electric hybrid, vehicles are purchaised

  22 club cars are also included and newer, more efficient vehicles are being phased in to replace older, less efficient vehicles. Additionally a tractor was converted to run on waste vegetable oil used for lawn mowing and snow plowing.

As a **Green Building Initiative** the college adopted a **Green Building Policy** in June 2006, stipulating that all new construction and major renovations on campus have to be designed and built to meet the U.S. Green Building Council's (LEED) silver standard. By the adoption of this standard the use of resources on campus would significantly be reduced. The buildings will both be built more efficiently and operate more efficiently. There are currently five buildings on the campus that meets this criteria; Williams Field House is LEED Gold certified, and four other buildings meet minimum LEED criteria.

The Adam Joseph Lewis Center for Environmental Studies (AJLC) is the **greenest building** on campus, that has been labeled as one of the "milestone" buildings of the 20th century by the US Department of Energy. This building has the following

features:

- A passive solar design and solar electric (Photovoltaic) panels on the roof and over its parking lot use renewable energy
- To provide a comfortable working environment for its residents students, faculty and staff the building relies on both active and passive systems. Passive systems extract and move heat with a minimum of mechanical devices while active systems use mechanical equipment.
- 240 feet (72 m) deep 24 wells were buried under the organic vegetable garden on the north side of the building. The wells consist of a loop of tubing which brings water from the building and exchanges the heat from this water with the ground's heat.
- To visualize real-time energy flows and cycling over 150 environmental sensors are installed throughout the building and landscape. This data monitoring and display system provides an opportunity to control the built environment.
- The building was designed to mimic the natural world’s more internalized water cycling. The ecologically engineered system of The Living Machine combines conventional wastewater technology with the natural processes. Treatment of the wastewater and recycling it within the building is done by this combination of elements of conventional technology and wetland ecosystems’ purification process. Since they can damage human and environmental health if discharged, the organic wastes, nutrients, and pathogens are removed by this way. The Living Machine cleans this water so that it can be used in the building's toilet flushing and irrigation for landscape. Since this Living Machine can be considered as a valuable research laboratory, it is used as an educational tool for students and faculty. The maintainance of the system and the ecological performance tracking are done by a team of student operators.

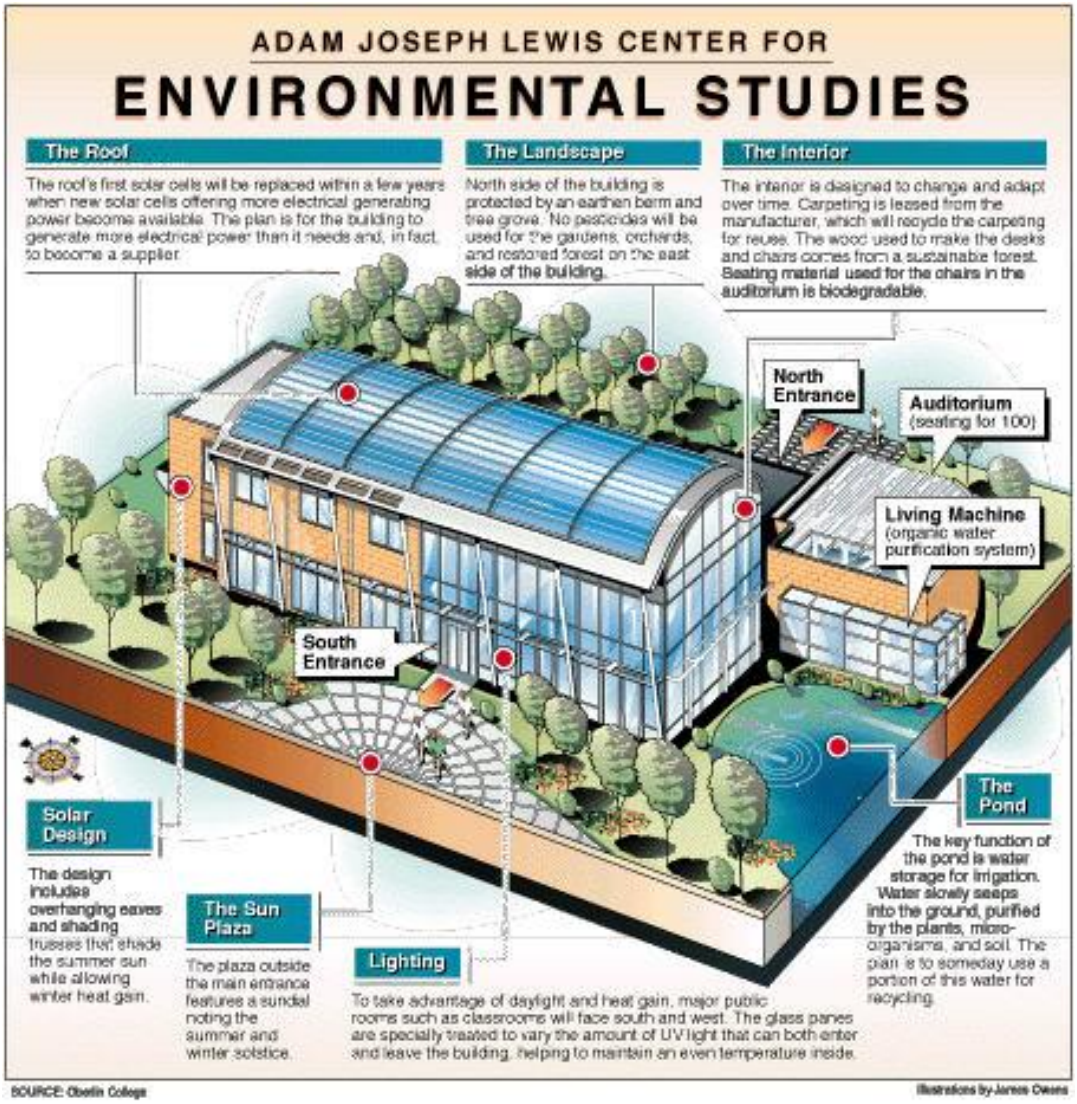

Figure 3.1 Diagram showing sustainability features of Oberlin College Adam Joseph Center (Source: http://www.oberlin.edu/alummag/oamcurrent/oam_fall98/envicenter.html retrieved on February, 2014)

2. Princeton University (USA)

Established in 174, Princeton University main campus consists of 180 buildings on 500 acres. It has a residential college system and approximately 10,000 people live on the campus.

Princeton proves its determination for developing an environmental friendly by receiving a grade of "A-" in the annual College Sustainability Report Card framework of Sustainable Endowments Institute. It has committed to reducing its carbon dioxide emissions to 1990 levels by 2020. Sustainability was declared as an institutional priority in the Campus Plan by the university administration. To develop an action plan for major sustainability challenges the university designed a comprehensive framework which is organized into three in operational and academic structure:

1) greenhouse gas emissions,
2) resource conservation, and
3) education, research, and civic engagement.

Princeton Sustainability Committee with student, faculty, and staff participation is managing each theme. This committee is also responsible for assessment the performance, defining metrics over time, and setting performance targets.

The following steps have been taken in terms of promoting **resource efficiency**:

- To reduce electricity consumption the campus has an energy management system installed in most buildings, is able to monitor individual building energy use, and has conducted building-specific energy audits.
- Student educational initiatives such as "Pull the Plug," as the energy reduction program was initiated
- Lighting retrofits including sensors and more efficient bulbs are done. Advanced technologies such as highly efficient LED lighting, tests of alternative lighting such as solar concentrator skylights are studied as research area.

- Steam and chilled water delivery infrastructure operates at maximum energy and economic efficiency was installed which is monitored by a real-time dispatch system.
- Window upgrades and replacement were done to reduce heating loads.

The items below are **renewable energy production** initiatives in the campus:

- The campus installed a 100-well geothermal system in 2003 to serve 207 units at Lawrence Apartments.
- There is a 400-kilowatt solar panel array on one of campus' Forrestal Campus warehouses.
- %6.8 energy of total energy consumption is produced from renewables.

Following precautions are taken to promote **water efficiency**:

- Campus low-flow fixture program and water conservation at the plant cooling towers results in 25% decrease in campus water usage. Low-flow fixture program includes the installation of low-flow showerheads and faucets, as well as water conservation technologies at cooling towers.
- New construction and renovations include installation of low-flow shower heads, toilets, and faucet fixtures, and upgraded metering as well as water-free and ultra-low-flow urinals.
- To reduce water usage on campus low-flow plumbing and athletic irrigation fixtures are installed and high-efficiency washing machines and dishwashers, and tray-free dining in all dining halls are used.

To ensure a **sustainable campus landscape** the following steps were taken:

- Instead of hard infrastructure that disturbs the landscape, bio-engineered techniques were adapted for stormwater management. Living roofs, porous pavements, retention ponds and vegetated swales are designed to manage stormwater.
- For rainwater harvesting new constructions in the college are installing rainwater capture and reuse systems. Rainwater capture and reuse system is

used for irrigation in Butler Building and for flushing toilets Chemistry Building.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- Recycling includes approximately 38 percent of all household items, including bottles, paper, cans, cardboard, scrap metal, and food scraps.
- To increase recycling rates more uniform and visible labeling for all containers were introduced, receptacle locations were expanded
- Energy Star appliances and paper made from 100 percent postconsumer recycled content are purchased by the university.

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- Public transportation has a 50 percent discount for faculty and staff and 25 percent for students.
- Existing pedestrian and cyclist circulation network is extended to new areas of campus and employee residential clusters near campus and improving the network is improved; existing pathways are enhanced in the Campus Plan
- For interested staff, Princeton helps facilitate ride-matching. Since 2007, the university has run a bike-sharing program that now includes 150 bikes.

As a **Green Building Initiative** Princeton University has established its own rigorous guidelines for sustainable building. **This Green Building Policy** ensures that every new construction and major renovation achieves campus sustainability goals including significant energy cost reduction versus comparable off-campus buildings. Princeton sustainable building guidelines are integrated into the overall university design standards. Life Cycle Cost Analysis guidelines specifically addresses energy performance guidelines. All new construction and major renovations must meet LEED Silver standards and be 50 percent more energy efficient than comparable off-campus buildings. A life-cycle cost assessment is done

by the university inform building decisions. However the university doesn't seek for certification for any LEED degree.

Green Buildings on campus consists of 701-Carnegie Building which is a Gold level certified building and Sherrerd Hall, Butler College, New Chemistry buildings which are LEED silver level but not certified buildings.

Figure 3.2 Butler College, Princeton University (Source: http://www.princeton.edu/pr/pictures/a-f/butler_college/20090812_Butler_021-2.jpg retrieved on January,2014)

Butler College has many green building design considerations such as having high efficiency window glazing and extensive shallow-soil" green" roof. This roof will be tested on 50% of roof area, with white ballasted roof on remaining roof area. Academic study with extensive instrumentation of green roof vs. conventional system will be applied to the project, with funding from the High Meadows

Foundation. High efficiency valence system will be used with individual room controls to prevent overheating in living areas. Rainwater will be captured and reused for irrigation of outdoor amphitheater.

3. University of California (UC) Berkeley:

The University of California occupies a 1,232 acre campus with a central campus having 178-acre central core, was established in 1868, in Berkeley. The university has a formal policy for sustainability. Two committees and the Office of Sustainability are responsible for sustainability initiatives. The university encourages green purchasing and Energy Star labeled products are used on campus. The university set a goal to reduce greenhouse gas emissions to 1990 levels by 2014.

UC Berkeley formalized its commitment to sustainability in 2007 by **"**Statement of Our Commitment to the Environment" which includes the institutional policies of the university. Significantly reducing campus greenhouse gas emissions and protecting the campus environment are priorities of this statement.

UC Berkeley shows its determination for developing an environmental friendly campus by receiving an overall grade of "B+" in the College Sustainability Report Card framework.

The following steps have been taken in terms of promoting **resource efficiency**:

- An Energy Management Initiative is implemented which is a comprehensive program that empowers faculty, staff, and students to take simple energy savings measures. About 60% of buildings are monitored as part of the centralized energy management system to track energy use. Real-time energy use data for 63 campus buildings can be viewed through myPower website by university community. The proven ways to save energy in offices, labs, and residence halls are presented in the website.
- To reduce energy consumption 275 bi-level LED lights in stairwells in

thirteen buildings, with occupancy sensors are installed, and also steam-line insulation, co-generation are installed

- Solar thermal water heating system is designed.

The items below are **renewable energy production** initiatives in the campus:

- The college generates renewable energy through a 59-kilowatt photovoltaic array
- 15 percent of the campus' electricity is fueled from renewable sources.

Following precautions are taken to promote **water efficiency**:

- Campus Plumbers reduce water use 17% by installing water efficient appliances; low-flow faucets, dual-flush toilets and low-flow showerheads and leak detection and reduction system
- Non-potable well water is being used for some applications.(irrigation, construction)

To ensure a **sustainable campus landscape** the following steps were taken:

- Vegetation consists of drought tolerant landscaping, the area planted with native vegetation is increased
- Runoff from nearby impermeable surfaces is captured by the new lawn and storm water retention basin. Also vegetated roofs, porous pavements, retention ponds and stone swales are elements of the stormwater management plan.
- Campus Services is using a smart irrigation system to reduce the amount of water used for irrigation. An electronic metering and a weather station are installed to provide real-time management of campus irrigation systems. Over 90% of irrigation systems area automated and connected to a weather station.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- To reduce waste production use of bottled water is rejected. The college is promoting drinking fountains and reusable bottles through signage and offering a variety of reusable bottles for purchase.
- By hosting Free Days in late October in Campbell Hall, ReUSE and their partners kept almost 35,000 pounds of office supplies and furniture out of the landfill by finding them new uses or owners.
- The campus currently recycles mixed paper, newspaper, magazines and books, toner and ink jet cartridges, cardboard, beverage containers, electronic waste, plastic film, plastic pipette containers, metal, motor oil, tires, and batteries. Also a portion of food waste, compostable kitchenware, green and wood waste, and pallets are the items currently composted in campus.
- There is a hazardous waste and waste minimization plan that includes e-waste.

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- Over 55 percent of the school community travels by walk
- Campus fleet decreased its carbon emission by increasing the number of alternative fuel vehicles such as 100% electric buses
- The university provides a campus shuttle system. There is discount for public transit and runs. For alternative transit Berkeley offers discounted daily parking permits and provides a ride-matching service to those who carpool.
- There is a bike-sharing program operated by a student group, and a car-sharing program organized by school.
- Public transportation: New Direction Program offers bus pass programs, discounted carpool parking pricing, transit subsidies, pre-tax purchases and regional ride matching services.

As a **Green Building Initiative** UC Berkeley has a formal green building policy for design and construction for new buildings and major renovations. A new Energy

Policy (currently under development) will also impact how buildings are constructed and renovated Minimum LEED Silver standard for new construction is obligated.

There are ten buildings in the campus meeting these criteria; two of them are certified as LEED Silver. The Boalt Law Building Infill Project, Early Childhood Education Center and Energy Biosciences Building are award winning projects in terms of sustainability.

The newly-opened Maximino Martinez Commons (MMC) Residence Hall won a Best Practice Award for Overall Sustainable Design at the California Higher Education Sustainability Conference. MMC is certified LEED Gold and is named in memory of a longtime staff member. The award was given for “demonstrating exemplary integration of design principles with the building’s purpose.” The building features include natural ventilation and daylighting, and this building performs at almost 50% better than code requirements.

By connecting to nearby People's Park and an active commercial district, the project contributes to its cultural context. To increase resource efficiency all public spaces and dorm rooms have operable windows for natural ventilation. Public area windows are motor operated and connected to the building management system. The exposed structure of the building and the lobby skylight which can be opened for cooling are allowing a nighttime cooling strategy. For hydronic heating rooms have wall radiators and public areas have radiant floors. 95 percent efficient condensing boilers are helping resource efficiency. The building used the wood from trees removed from the site and the low water landscape with capillary subsurface irrigation system are sustainability features of the building.

Figure 3.3 Maximino Martinez Commons (MMC) Residence Hall on UC Berkley campus (Source: http://greenbuildings.berkeley.edu/pdfs/bp2013-ucb-mmc.pdf retrieved on September,2013)

4. Harvard University

Established in 1636, Harvard's 209-acre (85 ha) main campus is centered in downtown Boston, USA. It has approximately 25.000 residents on campus. The University's revolving loan fund has invested over $15 million in energy efficiency and conservation projects. The sustainability office employs 21 staff, and 3 sustainability committees have worked on a number of initiatives, including the development of a university life-cycle analysis tool. The university purchases a variety of Energy Star- and EPEAT-certified products. Harvard has cut greenhouse gas emissions 7 percent since 2006 and aims to achieve a 30 percent reduction by 2016. To track GHG emissions University-wide in a consistent format a Greenhouse Gas Information Management System was developed. Extensive energy auditing,

implementation energy conservation measures and building commissioning projects, and incorporation of energy efficiency and greenhouse gas reduction planning into the University's five year capital planning process have increased the efficiency of buildings and reduced energy use campus-wide.

Harvard received an overall grade of "A-" in the College Sustainability Report Card framework which shows its determination for developing an environmental friendly campus.

The following steps have been taken in terms of promoting **resource efficiency**:

- Improvements in the Cambridge campus energy supply have been accomplished by: using more efficient chillers and free-cooling heat exchangers to produce chilled water; switching the fuel source which powers the steam plant to natural gas; replacing and upgrading boilers; and adding a 5 megawatt back pressure turbine to generate electricity.
- To reduce energy consumption the college has implemented temperature setbacks, and has retrofitted all buildings with steam line insulation, energy efficient interior and exterior LED lighting, lighting sensors, and metering for electricity and chilled water. Energy conservation is promoted with individual energy audits, energy monitoring displays, and a trade-in program for inefficient appliances.
- To promote user sensitivity energy reduction competitions among departments and/or offices are designed. Energy monitoring website displays for buildings are implemented.
- For some buildings solar hot water systems generating domestic hot water and ground source heat pumps for cooling are installed
- Building retrofitting includes: upgrading windows and skylights and installing extra insulation which is better than code insulation and installation of high efficiency condensing boilers

The items below are **renewable energy production** initiatives in the campus:

- A significant commitment to investing in renewable energy has been made, in part to meet Commonwealth of Massachusetts regulations requiring an increasing percentage of electricity from renewable sources. On-campus solar projects produce over 1 megawatt (MW) of electricity and in 2009 Harvard became the largest institutional buyer of wind power in New England.
- Photovoltaic panels, ground source heat pumps, and usage of biodiesel for 75 trucks and vans in the university fleet are renewable energy systems in the campus that Harvard has installed.
- 17.5% of campus electricity comes from renewable sources. Energy percentages are: 12% wind and 5.5% combined landfill gas, hydro facilities and other sources and 6% Combined Heat and Power (cogeneration at steam plant)

Following precautions are taken to promote **water efficiency**:

- The sustainable design guidelines for all new and major renovation capital projects reduce potable water consumption by 30-50% compared to current regulatory standards
- To reduce water consumption water metering is installed each building, water saving appliances are installed such as: low-flow faucets, low-flow showerheads, dual flush toilets and waterless urinals.
- A leak detection and reduction system is designed and laundry technology is improved.
- Non-potable water is used in several buildings for other purposes. In order to reduce water consumption rainwater is being collected and reused for in toilets and for irrigation.
- Campus fleet uses rainwater to wash campus vehicles.

To ensure a **sustainable campus landscape** the following steps were taken:

- The University also has a stormwater management policy
- For public sidewalks a system is installed to capture and filter reclaimed

water (storm water runoff), and then store it in cisterns. This water is then delivered underneath the trees for capillary action.

- The parking lots have porous paving produced from recycled asphalt.
- To decrease irrigation drought tolerant plants are preferred in landscape and being utilized where available
- Weather-informed irrigation system with soil sensors is installed
- Living and vegetated roofs, vegetated swales, dry wells, stormtech and cultech systems are designed to decrease stormwater runoff.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- Fifty-six percent of campus waste is recycled, and all landscaping waste is composted or mulched. Harvard Recycling also runs a surplus center for reuse of furniture and other items. An online reuse list, and move-out donation boxes encourage reuse of donated or unwanted materials.
- Reusable container programs are implemented in Dining Halls and discounts for patrons using reusable mugs are offered to encourage reuse by Harvard University Dining Services
- Aluminum, cardboard, glass, paper and all plastics are recycled items. Recycled napkins, mugs, bottles are used on campus. Electronic waste collection areas are designed for waste reduction.
- The campus composts food scraps, coffee grounds, landscape waste, and compostable products in order to gain valuable nutrients to plants and soils.
- By installing water refill stations to eliminate use of plastic bottles, the college has reduced use of disposable plastic water bottles on campus
- Construction and demolition waste diversion is done. 90% waste diverted from completed LEED NC projects.

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- There is a free shuttle on-campus service which operates during the academic

year

- Local public transportation is subsidized for the school community
- The school partners with a car-sharing program. Harvard offers incentives for carpooling
- The college created a cycling infrastructure, and supported improvement. And to reinforce the connections between the University campus and other parts of city, local and regional bike networks were improved.
- A free bike-share and repair program is available for employees.
- For low-emitting and fuel-efficient vehicles, the college offers a preferred parking program in many garages
- To reduce toxic gas emissions natural gas buses for campus shuttles and gasoline-electric hybrid vehicles are used as alternative fuel vehicles.

As a **Green Building Initiative** Harvard University has adopted the **Green Building Standards** from previous guidelines, in 2009. This new Standards promotes varying levels of Integrated Design, Energy Modeling, Life Cycle Costing and Greenhouse Gas Estimation, Project Close-Out and Operations & Maintenance Readiness and Metering and Sub-Metering as the main topics. Moreover specific environmental performance targets are required based on the project scope. To support decision makers while planning all present and future costs of new construction and renovation, the university designed The Harvard Life Cycle Costing policy and calculator.

All new construction and major renovations are now required to achieve LEED Gold certification (previously LEED Silver-minimum was required) and reduce energy costs compared to ASHRAE 90.1-2004 by 34% and 30% respectively. All projects are required to use at least 35% less water than EPAct 1992, have a lighting power density at least 25% lower than allowed by code, and pursue enhanced commissioning of the space. The campus includes 31 LEED-certified buildings and 49 LEED-registered buildings.

The **Peabody Terrace dormitory complex**, designed in 1963 by Sert, Jackson & Gourley, is an architectural landmark of the campus. The design team faced the challenge renovating this significant landmark while designing the spaces to update HVAC systems, maximize daylighting, reduce utility dependency, and incorporate sustainable materials, while maintaining the integrity of the original exterior design and the character of the interior aesthetic. In addition to these there is an envelope repair, abatement, and waterproofing program to preserve the exterior façade. The building received a LEED Platinum rating in LEED for Commercial Interiors.

Energy efficiency is promoted through upgrading heating and cooling systems by installing a Variable Air Volume Control (VAV), air-side economizing and occupancy sensors.
56% reduction in lighting power density (watts/square foot) compared to the baseline Standard is achieved through installation of Occupancy Sensors, Daylight Sensors and Energy Star Equipment which includes refrigerators, dishwashers, washing machines, and dryers. 36% reduction in water use compared to the EPAct 1992 baseline by installing system sensor faucets and low-flow sanitary appliances. As green qualities regional manufactured materials value 27% as a percentage of total materials cost and reused materials value 13% as a percentage of total materials. The design team took particular care in preserving and re-using acoustical wood paneling that is prevalent in the lobby.

Figure 3.4 Peabody Terrace dormitory complex terrace (Source http://green.harvard.edu/sites/green.harvard.edu/files/toolresource/field_file/peabody_terrace_graduate_commons_case_study.pdf retrieved on February,2014)

Figure 3.5 Peabody Terrace dormitory complex retrofitted interior (Source http://green.harvard.edu/sites/green.harvard.edu/files/toolresource/field_file/peabody_terrace_graduate_commons_case_study.pdf retrieved on February,2014)

5. University of Wisconsin Oshkosh

Established in 1871 UW Oshkosh's 171-acre campus is located along Wisconsin, near Lake Winnebago which is the largest body of water in the state. Beside receiving a recognition from leading organizations, UW Oshkosh University has been going green since 2002. UW Oshkosh has earned place in Princeton Review's "Guide to Green Colleges" for the third year in a row in 2012. This is a spotlight of colleges and universities in the U.S. and Canada that demonstrate a strong commitment to sustainability. The University earned "Gold" label in the STARS of the AASHE. By developing a truly sustainable campus the university aims to be a leader in the sustainability area. Having a net zero impact goal on the climate and environment, the university has an EMS to direct all the green initiatives.

The following steps have been taken in terms of promoting **resource efficiency**:

- Wisconsin Energy Initiative (WEI) program is developed which requires energy efficiency retrofits to existing facilities such as replacement of old, inefficient building chiller systems with a central chilled water plant in 2001 and 2006. This plant serves the major core of the campus.
- A centralized energy management system is in use that tracks energy consumption and performance in multiple buildings concurrently.
- To schedule the heating and cooling of facilities based on occupancy and use the college has implemented a computerized energy management system which is important on weekends, evenings and during summer school.
- 29% of total building space has undergone energy retrofits and renovations such as technical systems upgrade and building exteriors .
- In 2011, substantial outdoor lighting upgrades were about half LED fixtures and half induction lighting fixtures. LED fixtures were used predominantly in pole lighting along walkways. Motion sensors to control lighting are installed in all buildings.

The items below are **renewable energy production** initiatives in the campus:

- **Wind** is the largest source of renewable energy for the campus. The campus gets 23% of electricity from renewable sources: 13% through NatureWise and 10% wind power purchased from state.
- **Solar Power** was started to be used in 2010, by installing the first photovoltaic panels on campus grounds. There are many buildings that use solar energy for different purposes e.g. solar energy is used for producing electricity and heating water (Taylor Residence Hall); for dishwashing (Blackhawk Commons); for heating an indoor swimming pool (Albee Hall); and in a heating plant to pre-heat water for steam production.
- **Biomass** was started to be used in 2011with the first commercial-scale dry anaerobic biodigester in the USA. The organic waste from regional dining halls, yards, supermarkets and farms is used in the plant to produce methane gas. To generate electricity this waste is burned to power turbines. Waste heat is used for space heat by nearby buildings. Approximately 8% of the electricity used on campus is provided by this waste heat.

Following precautions are taken to promote **water efficiency**:

- By reducing water consumption and preventing pollution associated with stormwater, the university is engaged to sustainable water management.
- To reduce the use of water ,the college retrofitted the water-cooling systems with air-cooled equipment.
- To reduce water consumption the college replaced 1,005 older 4.18 gallon per flush (gpf) toilets with 1.6 gpf toilets and installed low-flow faucet restrictors on sinks throughout the campus. The college also installed 5 waterless urinals.
- The natural grass football field at Titans Stadium is replaced with artificial grass.

To ensure a **sustainable campus landscape** the following steps were taken:

- Developed a storm water management plan .

- Parking lots are cleaned in a semi – annual routine.
- Silt fences around construction sites became mandatory.
- For sustainable vegetation the natural grass football field at Titans Stadium was replaced with artificial grass which saves 850,000 gallons of water used for irrigation annually.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- Recycling and re-use donation programs are organized
- The college has been recycling since the 1980s and currently recycles paper, cardboard, cans and bottles, rechargeable batteries, printer cartridges, tires, oil, wood, metal, and electronics. UW Oshkosh recycles approximately 10% of its total solid waste.
- Recent construction projects have achieved recycling rates of 85-96%

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- All students and staff use city public bus system for free with a campus identification card since 2003.
- To make the campus more pedestrian and bicycle friendly, new bike racks have been purchased and installed throughout campus over the past several years.
- A comprehensive parking plan which offers reduction of parking spaces and leaving them as green spaces is applied.
- In 2006, the university began to convert the campus fleet to E-85 compliant vehicles which is an ethanol based fuel.

As a **Green Building Initiative** the **green building policy** adopted by the college mandates that all construction and renovations projects shall meet minimum "Silver" level of sustainability in LEED. Including the renovations to Taylor Hall, the construction of the Student Recreation and Wellness Center, and the South Campus

Parking Ramp, Student Success Center, Sage Hall and Horizon Village recent construction works is done according to LEED standards.

Figure 3.6 Sage Hall, University of Wisconsin Oshkosh (retrieved from http://www.uwosh.edu/lt/learning-spaces-support/directory-of-classrooms/sage-hall on January, 2014)

Sage Hall is a $40 million Project that symbolizes the University's commitment to sustainability and green building practices. and was honored as one of construction trade magazine 'The Daily Reporter's' "Top Green Projects of 2011." and Wisconsin Masonry Alliance (WMA) recognized Sage Hall as with an "Excellence in Masonry Award." received a Gold label in LEED. Solar photovoltaic panels such as roof-mounted thermal and parking-lot photovoltaic solar panels and solar thermal hot water installations generate 10 percent of the energy need for the 190,000-square-foot building.

To reduce the need for electricity, Sage Hall is equipped with features that improve

daylight use for lighting and in-floor radiant heating and cooling systems. Sage was built to be about 40% more efficient than a conventional building of equal size. The green roof of Sage contributes to stormwater management. This green roof with natural plantings and bioswales controls runoff and improves quality of following precipitation events. The sustainable features are expected to save $182,000 annually.

3.2 Method

A literature review, based on --- sources, was conducted to understand the concept and application of sustainability criteria to university campuses. This review includes the chronological background of sustainable campuses, such as development of the discussion from political to environmental arena. The international concern for environmental problems and their solutions and the ethical responsibility of universities as educational institutions and research centers are summarized.

Then, campus sustainability assessment tools, which are commonly used throughout the world by universities were gathered together. These tools were analyzed from their development to their indicators in detail and presented in a table as a summary. Among many indicators of these tools the focus was on the indicators which are assessing the quantitative features of the campus environmental sustainability.

Leading sustainable campuses throughout the world were selected and reviewed according to sustainability considerations. All these campuses are aiming to be a role model for sustainable campus development by their efforts and initiatives in this field. All these campuses have applied at least one assessment tool that are covered in the literature survey of this study. These are two main criteria for the selection of the campuses.

These campuses mostly have an EMS to report and document all their endeavors in accordance with their environmental policies. To identify the efficiency of the precautions taken to develop a green campus there has to be an evaluation to see

whether they are working or not and an EMS 4 step approach is a guidance. This approach also creates an opportunity to report the results of the sustainability plan in order to review the actions and decisions. If an institution employs an EMS for the checking phase the required information is obtainedwhich makes it possible to see the concrete numeric data in terms of efficiency and conservation; and to express how much of the campus is included in that measurement or initiative for sustainability. Consequently, campuses are selected from amongst the most dedicated ones in the world, to the practice of sustainability according to their documentation and reporting of the sustainability initiatives. Therefore EMS usage, whether it is a formal certified or an institution specific one, was a major selective quality to gather information about that campus for the study. All the selected campuses are subscribing to at least one assessment program.

Each campus had been investigated as a case study and information thus collected was used for a meta-analysis. The indicators used in the assessment procedure were: EMS, energy use reduction, energy efficiency, renewable energy production, water use reduction, waste water treatment, storm water management, rainwater harvesting, landscape vegetation, pollution prevention, waste minimization, waste recycling, public transportation, pedestrian and cycling, reduce emissions, green building policy and green buildings in the campus.

Finally METU campus was also evaluated according to the selected assessment tool, after a short summary that may be considered as a starting point for an environmental assessment report. The indicators which exist or are nonexistent were identified as a result of the campus sustainability evaluation.

A critical assessment which shows the relation between the indicators and their ability to demonstrate the real degree of sustainability of a campus is discussed for the selected campuses.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1. Indicators

In the assessment tools there are many aspects, such as facilities management, life cycle assessment, food used in the canteen, staff housing, building in the campus; included as sustainability indicators. However in this study only the physical environment was the main ground of the discussion and others were indicators were out of the scope of the discussion. These tools were analyzed from their development to their indicators in detail and presented in a table. The list of the indicators used in this study are selected according to this criteria; *i.e.* the built environment. The selected campuses are analyzed in view of these indicators which are listed below: 14 campuses were analyzed according to 17 indicators in 7 seven categories and are shown in Table 4.2 as a meta-analysis.

4.2. University Campuses

The universities analized according to the indicators listed above, in addition to the ones presented in detail in Chapter 3 section 3.1on research material, are Leeds, Merrimack College, Mount Allison University, Chapman University, University of Waterloo, Tulane University, and New York University. These university campuses are selected because of their efforts to develop a sustainable campus and document their study as environmental reports and thus demonstrating a sustainable campus state of art. These universities have also gained high rankings in the campus

sustainability assessments with some tools; e.g. the Green Card, which is an assessment tool that publishes the results for public knowledge.

Table 4.1 General Evaluation of the Selected Campuses

		EMS	energy efficie			water efficiency					waste			transportatic			green bui		grade
	university name	EMS	energy use reduction	energy efficiency	renewable energy	water use reduction	waste water treatment	stormwater management	rainwater harvesting	landscape vegetation	hazardous pollution prevention	waste minimization	waste recycling	public transportation	pedestrian and cycling	reduce emissions	green building policy	green building in campus	total number of indicators:17
1	Oberlin College	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	15
2	Princeton University	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	15
3	University of Berkeley	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	16
4	Harvard University	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	16
5	University of Wisconsin Osl	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	15
6	Leeds University	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	14
7	University of Saskatchewan	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1	0	0	1	12
8	Merrimack Colle1e	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	13
9	Mount Allison University	1	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	13
10	Chapman University	0	1	0	0	1	0	0	0	1	1	1	1	1	1	1	1	1	1	11
11	University of Waterloo	0	1	1	0	1	0	0	0	1	1	1	0	1	1	1	1	0	1	10
12	Tulane University	0	1	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	11
13	New York University	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	13
14	METU	0	1	1	1	1	0	0	1	1	0	0	1	1	1	1	0	0	1	10

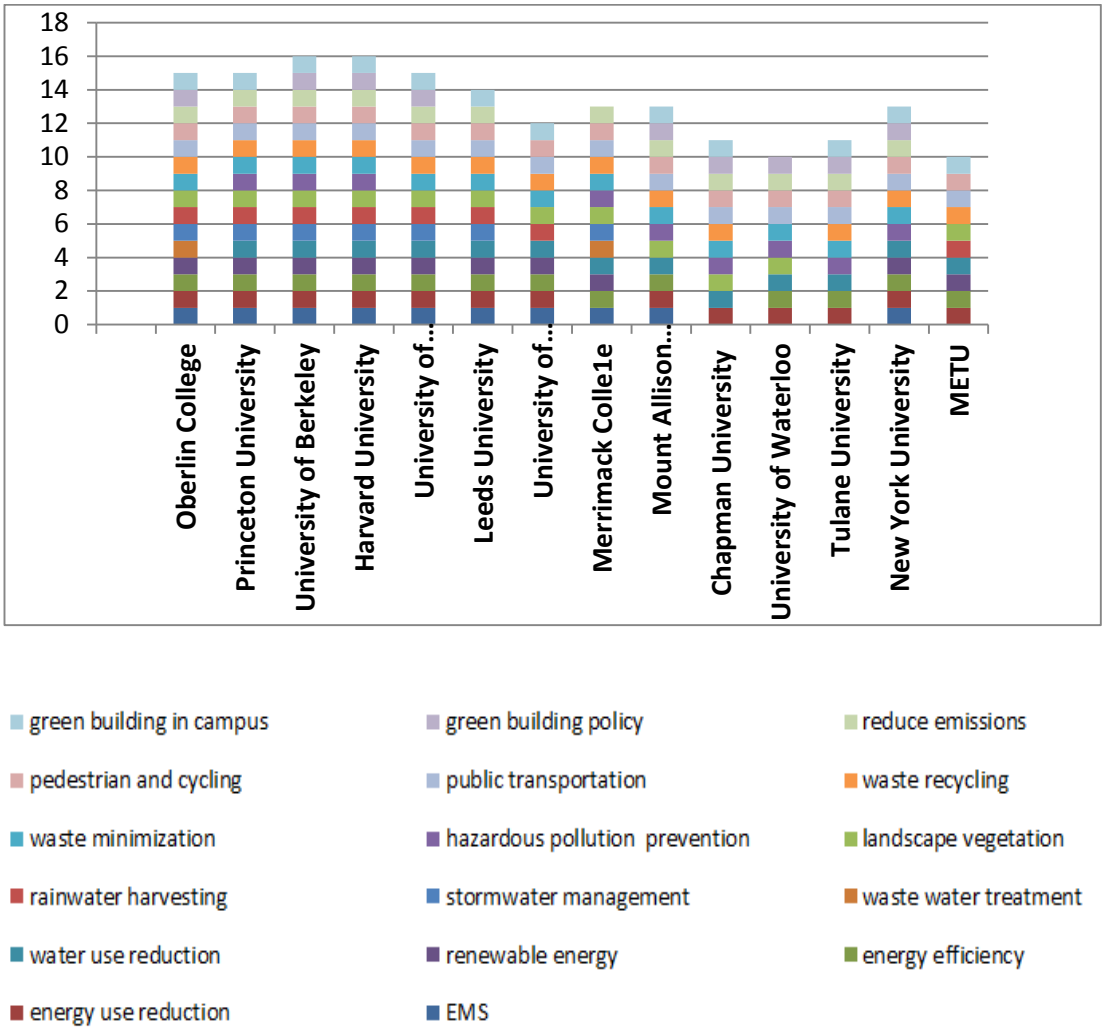

Figure 4.1 Graphical Presentation of Evaluation of the Selected Campuses

A detailed analysis was done after the general view to the campuses. The most developed 4 university campuses and METU campus were selected to make an elaborated analysis and to determine the sustainability degree in a concrete way. To define the degree of sustainability a five point scale, which is between zero and four point, was used for each indicator and the results presented in a table. With this detailed evaluation the indicators valued according to the coverage of the campus. By this way a more quantitative level was able to be identified.

For each indicator, the points represented as

0 : indicator was not implemented on the campus

1 : indicator implemented on the 25% of campus

2 : indicator implemented on the 50% of campus

3 : indicator implemented on the 75% of campus

4 : indicator implemented on the 100% of campus

Table 4.2 Detailed Evaluation of the five Selected Campuses

		EMS	energy efficienc			water efficiency					waste			transportation			green buil		grade
	university name	EMS	energy use reduction	energy efficiency	renewable energy	water use reduction	waste water treatment	stormwater management	rainwater harvesting	landscape vegetation	hazardous pollution prevention	waste minimization	waste recycling	public transportation	pedestrian and cycling	reduce emissions	green building policy	green building in campus	total points:17X4=68
1	Oberlin College	4	4	4	3	4	1	4	1	4	0	4	4	4	4	3	4	1	53
2	Princeton University	4	3	3	3	4	1	4	1	3	2	4	4	4	4	3	4	1	52
3	University of Berkeley	4	3	3	2	4	1	4	1	3	2	4	4	4	4	3	4	2	52
4	Harvard University	4	4	4	2	4	1	4	1	4	2	4	4	4	4	3	4	3	56
5	METU	0	1	1	1	1	0	0	1	1	0	0	3	4	3	0	0	1	17

4.3. Data and Information on the Case Study of METU

Middle East Technical University (METU) is a state university founded in 1956, currently has about **26,500** students. The campus area is 4500 hectares including 3043 hectare forest area and Lake Eymir**,** which is about 20 kilometers away from the city center of Ankara. General recreational activities such as rowing, fishing and picnicking are facilities available for METU students. There is a bus service from the METU main

campus to the locations in the city even to the lake. METU Cultural and Convention Center, a primary center for the city of Ankara,is hosting cultural, intellectual, arts activities throughout the year. METU rated as “Turkish University with Richest Social Life” by Newsweek-Turkey magazine in 2011. The creation of 30 km^2 of forest area on METU Ankara Campus, was an initiative that received the “The Aga Khan Award” in 1995. (http://www.metu.edu.tr/history)

Figure 4.2 General view of the METU campus (retrieved from http://tr.wikipedia.org/wiki/Dosya:MiddleEastTechnicalUniversityCampus800x470.jpg on March, 2014)

Although METU is an environmentally sensitive institution that has created lush green forests in the campus area, which was once arid and barren, it doesn’t employ an EMS to be used for campus development and operation. There is no environmental sustainability office in the campus and there is no documented evidence available regarding attempts at assessing the environmental performance of the campus.

The following steps have been taken in terms of promoting **resource efficiency**:

- Retrofitting work is done for the efficiency of the HVAC systems for the old buildings by replacing old boilers with the new energy conserving ones.
- To reduce heating load the dormitory buildings are coated with high efficient thermal insulation.

There is no **renewable energy production** initiative in the campus except PV panels placed on the roof and façade of one building on the campus.

Following precautions are taken to promote **water efficiency**:

- In the dormitories water saving fixtures are installed.

Although campus have broad green areas there is no specific steps taken to ensure a **sustainable campus landscape**. There is no stormwater management plan for the campus.

The following steps have been taken in terms of promoting **material/ waste conservation:**

- To reduce waste generation the waste is collected separately throughout the campus. Waste recycling is done for the items of paper, cardboard and glass.

The following steps have been taken in terms of promoting **sustainable transportation** on campus:

- Most of the students are reaching by public transportation. The campus free ring system is efficiently working. And a carpooling application started in the technocity of the campus
- Light rail system (monoray) was under construction before it is cancelled and its road is converted to a bicycle road.
- Solar car development for car races among universities.
- The campus has a pedestrian- bicycle road system.

Figure 4.3 METU main alle as pedestrian and bicycle ways (Source: retrieved from http://www.metu.edu.tr/tr/galeri/odtuden-fotograflar on February 2014 on February 2014)

Figure 4.4 METU bicycle tracks (Source: retrieved from http://www.metu.edu.tr/tr/galeri/odtuden-fotograflar on February 2014)

As far as a **Green Building Initiative** is concerned METU does not have a specific green building policy. Since the campus started to be built in the 1950s, most major buildings were built according to the brutalist architectural style of that time, which dictates brute concrete and no insulation on the building shell. The newer buildings that have been constructed in the new millenium have applied the new state regulations and therefore become more environmentally sensitive.

Specific attempts to design green buildings started with the **Solar house** (Güneş Evi**)** in 1980 which was to be an experimental building with a hybrid solar heating system consisting of roof mounted solar collectors and a greenhouse in front of it. (http://www.yenienerji.info/?pid=18697) Unfortunately, the solar collectors broke down but the green house still exists.

MATPUM building which is claimed to have a holistic design approach, is a linear block which is elongated through east-west direction. This orientation creates the opportunity for heat gain for Ankara. The long south façade is transparent and have climate control elements which were supposed to react to the weather conditions. The north façade is a more closed wall designed to contribute to the air circulation which was expected to exist in the roof two layer structure. (http://v2.arkiv.com.tr/p8601-matpum---odtu-mimarlik-fakultesi-arastirma-merkezi.html)

Lastly **Ayaşlı Center** was constructed as a high budget building including many green building features and applying sustainability criteria. This building has two types of **PV panels**, one is a flexible membrane PV system which is used for the first time in Turkey, and the other is roof integrated PV panels on the south side of the building for energy generation of approximately 60,000 KWH per year. The aim is to compare the performance of these systems by collecting and measuring data. There is a combined system to heat and cool the building which basically relies on passive design strategiessuch as facing south for the long facade. The cooling at the northern façade in winter and the heating at the southern façade in summer are optimized.

Greywater recycling is done by collecting rain water from roof surface and stored in the basement for treatment and is used for the toilet flushes and garden irrigation. (http://www.eee.metu.edu.tr/ayasli-research-center/)

Figure 4.5 Ayaşlı Research Center building's showing the north and west facades METU (retrieved from http://www.eee.metu.edu.tr/ayasli-research-center/on March, 2014)

Figure 4.6 Interior view of the Ayaşlı Research Center, METU (retrieved from http://www.eee.metu.edu.tr/ayasli-research-center/on March, 2014)

4.4. General Analysis of the Table

All the selected campuses assessed according to the environmental audit indicators are summarized in Table 4.2 for a meta-analysis. In this table it can be seen that most of the universities selected have EMS and they are the ones that have achieved high

scores in the indicator checklist. It can be seen that leading universities both as educational and sustainability pioneers like Harvard and Princeton ensure more indicators. These universities have reached that level through large funding and by establishing an environmental office to employ professionals in this field who have designed an action plan. EMS implementation is another mechanism that helps to organize and direct the initiatives and regularize them.

The objectives and sustainability goals of universities' and their long term vision and goals are determined by the sustainability office. These first steps determine the universty's overall environmental performance. EMS implementation orders the check and review processes by the long term sustainability decisions and their life cycle impacts. The results of the facilities are tracked and reported and in so doing the planned activities are reviewed according to the updated targets.

The campuses that are trying to reduce their carbon footprint by decreasing their levels to before the 1990s have also energy management policies beside an EMS. To promote water conservation and to make buildings more resource efficient universities make a specific effort by employing guidelines for their campus. Harvard is a successful example in this regard by trying to reach beyond the conventional environmental conservation levels.

EMS implementation is a systematic approach to reaching the desired levels since a campus transformation is a complex phenomenon and requires long term endeavours. Universities are using EMS both for their development strategy and campus transformation. Besides being a guide in the long run for campus sustainability, EMS dictates to report the results and document the vision of the campus which creates a database and source for the stakeholders such as students, instructors, campus residents, researchers and academicians.

4.5. Evaluation of the Indicators

According to the results of the assessment it is seen that certain indicators are not applied in many universities. These indicators are renewable energy production and waste water treatment which are considerably challenging facilities to implement. It can be said that the indicators which require infrastructure and incur economic costs are rarely implemented while other indicators such as recycling and efficient resource consumption are preferred. Recycling is an indicator that many universities are reflecting on the state recycling level. They are collecting the waste separately according to the items recycled in the city. Consequently the campus is taking into consideration to the national targets as well as its local recycling situation.

Challenging indicators namely renewable energy production, waste water recycling and stormwater management are not focused upon in the university development plans. These indicators are the main solutions for environmental degradation. If nonrenewable energy sources are continued to be used, the cities will be dependent on carbon based fuels and will contribute to the carbon footprint.

Another challenging point is the green building issue which is considered at the level of policy development. These policies are the results of the awareness that buildings are the main consumers of energy, material and water in their life from construction to their operation. Since most campuses were established a long time ago when energy was cheap and environmental pollution was not threatening, today the current building stock needs to be converted to a more efficient manner. Most universities are determining regulations for new constructions for being more resource efficient than the conventional standards. Their reference sources are commercial license systems such as LEED and GREEN STAR green building labels. Although universities are trying to raise the bar, they are relying on commercial tools while defining their building standards. As an exception Harvard and Princeton Universities have their own regulations and building codes in the context of green building design. Nevertheless universities include pioneer sustainable buildings in

their campuses which can be considered as role models for conventional buildings.

In green building issue existing building stock needs to be retrofitted. Also green retrofittings are obligated by the campus green building policy. However a small percentage of the campus had been retrofitted.

Another important point that should be discussed is that the indicators are not covering the whole campus. The campus is gaining sustainability points for the indicators however the indicator is not applied throughout the campus. It comprises a limited area as an initiative on the campus. This situation is valid for most of the indicators except recycling and transportation, which are campus wide applications.

Renewable energy production is a great effort area for campuses; yet they have a small share in meeting the total energy needs of the campus. Also energy retrofittings are done for a limited area of the campus, except lighting, since it is upgraded throughout the building interiors and the landscape. Water conservation initiative is also limited , since water conservative fixtures and installations are applied in a small part of the buildings especially dormitories.

Green building policies are activated for a small part of the campus. They are basically applied to new construction which is promising for future development, however old buildings are waiting for upgrades. There is a huge potential in this area because most of the energy consumption is due to these old buildings on the campus. This requires high investments to upgrade the building stock which is an financial problem for the university. Utilization requirement during construction process is another limiting factor while transforming the campus.

Transportation is generally successfully accomplished by the promotion of public transportation, alternative vehicles and improvement of campus bicycle facilities.

For water conservation all of the universities, are taking precautions to achieve water

use reduction. Waste water recycling is a neglected item while stormwater management and rainwater harvesting seems to be rare indicators that universities could not apply due to the lack of infrastructure to conserve water. Sustainable landscape is another improved quality in the universities. The broad green areas of the campus settlements make this important to create a livable environment without excessive use of irrigation.

In short, it can be said that this assessment has revealed which initiatives are easy to implement for campus sustainability and the areas where much more effort is required for campus transformation.

CHAPTER 5

CONCLUSION

University campuses can be considered small cities in terms of their physical infrastructure, facilities diversity, scale and population. Therefore they are facing the challenges of the cities in environmental issues like resource depletion, environmental pollution, global warming, etc.
Since they are small models of cities which have the main function of research conduction and knowledge generation, their role is significant. The solutions and roadmaps to transform the cities in an environmental friendly way are a major concern in universities today. Campuses have great potentials to produce solutions and exemplify their application to be a key for the cities which are main sources of global environmental problems.

Campus sustainability is a wide term that needs to be divided into subtopics such as education, research and environmental sustainability, the latter being the subject of this study. Although sustainability has many qualitative traits, environmental sustainability relies on quantitative criteria such as energy efficiency, water conservation, transportation and green building measurements.

To develop sustainability concept on an existing university campus is a matter of applying the steps over time which requires to be tested and evaluated routinely. All the efforts to develop an environmentally friendly campus by decreasing its environmental impact, reducing its carbon footprint and increasing resource efficiency are required to be assessed to analyze if they are working or how efficient they are. The results will guide the way to sustainability while making decisions to improve the situation. This fact makes the implementation of an EMS a prerequisite

to realize the ambitious objectives of the dedicated universities.

It can be seen from the meta-analysis table that the universities implementing EMS are gathering more environmental benefits and more checks in the indicator table. The universities implementing EMS have started the way through a green campus by providing funds and employing a sustainability office to gather a professional team. To make the university campus more environmental friendly, more resource efficient and consuming less means an economic campus in the long run which saves money. However in the beginning the sustainability revisions and interventions to a conventional campus require high investments.

Many universities have sustainability goals to reach in the future which can be seen in their targets like decreasing their carbon levels to1980 levels by 2020. In order to reach such goals quite organized guidelines and management plans should be applied. By analyzing the universities which are realizing their sustainability goals and greening their campus they are applying an EMS plan hence experiencing a step by step progress. Besides while documenting and recording their results, reviewing and analyzing them and constructing following steps they provide invaluable resource as a role model among their counterparts. The weak points or challenges that one university may experience are a guide for other one about to face the same problem.

To support the development of sustainability the assessment documents and presenting them for public knowledge highlights environmental consciousness in a very tangible and perceptible way. A general guideline needs to be applied to support sustainability. To make assessments, research and control and see the weak points and draw the direction for future efforts.

Although campus sustainability assessment tools are not depicting the true picture of campus sustainability level they are still giving directions for sustainability transformation in the long run and to manage future development. Easy indicators

which do not require investments and infrastructure costs are preferred for implementation in the short term action plans. The difficulty is to implement the indicators with infrastructure, technical background and comprehensive analysis of the campus. These initiatives have more potential to save energy and conserve natural resources and therefore be a guide to the city environment.

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