HCU HafenCity University Hamburg

University of the Built Environment and Metropolitan Development

Sustainable Campus Planning II

Aristotle University of Thessaloniki

RESOURCE
EFFICIENCY IN
ARCHITECTURE AND
PLANNING
wintersemester 2013/14

0.2 REAP&AUTH students (Osman, 2013)

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0.3 Campus of Aristotle University of Thessaloniki (Symvoli, 2012)

Introduction

The concept of Sustainable Campus Planning, Aristotle University of Thessaloniki (AUTH) was embarked on by students of Resource Efficiency in Architecture and Planning (REAP), HafenCity University, Hamburg right from the first generation of REAP Master Program in October 2010.

The present effort is the second round of interpolations executed by the fourth generation of the REAP Master Students. This has been done after careful study of proposals from the first generation and more importantly, the consequential success and failures of these proposals. Therefore, in a way this work is a result of the same project, in collaboration with the Faculty of Electrical Engineering in AUTH which is hopefully a continuous bilateral process. The project aims at proposing sustainable plans for AUTH Campus, regarding the key factors of resource efficiency revolving around aspects of water, energy and materials.

AUTH was founded in 1925. Being located in the center of the historical city of Thessaloniki, it expanded over the last century to become the largest university in Greece. Despite numerous challenges due to the recent economic crisis in Greece, AUTH has succeeded to keep academic ranking among the top 500 universities in the world. Moreover, various geographical and academic factors like the central location and advanced research programs respectively, account for a great potential in sustainable growth inside the campus (AUTH, 2014).

This project is conducted in different phases by seven groups of students in different research areas. The broad overview includes 'Research on fundamentals of a sustainable campus', as the first phase. It defines specific goals for sustainable campus development by reviewing different case studies around the world. Site analysis was done in the second phase, including a site visit to Thessaloniki for field research and surveys. The last phase contains proposals to enhance the sustainable growth in AUTH campus, with specific focuses. The focus areas generally include social engagements, sustainable Mensa and energy conservation policies such as re-commissioning and passive cooling. This document provides a general analysis of the project and indicates selected parts of every proposal, highlighting its' salient points and strategies.

Resource Efficiency in Architecture and Planning (REAP) is a Master of Science degree program offered by HafenCity University in Hamburg. REAP program was kicked off in October 2009, mainly focusing on efficient and sustainable management of resources in urban and architectural development encompassing different geographical and cultural contexts. International and interdisciplinary approach is a unique characteristic of REAP program being open to participants from all around the world with a variety of professional backgrounds. This feature plays an important role in the present project. This variety has contributed to harness opportunities and resources in AUTH to plan an integrative sustainability program for the campus.

„Education is the most effective means that society possesses for confronting the challenges of the future. Indeed, education will shape the world of tomorrow.“
UNESCO

0.4 Thessaloniki at sunset (Oviir, 2013)

Sustainable campus

University campus as paradigm for the city

“Universities have a responsibility to lead society towards a sustainable future.” (Bekessy et al, 2003).

Most managers and decision makers go or went to a university. Research and critical thinking prevalent in a university environment shape global economies and individual behaviour. There is a factual need for “more sustainable forms of human activity” (Bekessy et al, 2003), and universities are key actors in providing guidance and expertise on how to cope with the challenges that humanity is facing today. These are some of the reasons why campuses all over the world are compelled to include a sustainability plan or strategy at all levels of operation. Given their direct effect on society, universities have the responsibility to offer new and improved ways to cope with current difficulties.

More and more universities are generating scientific, empirical literature based on their own experiences and results. The Ca’Foscari University in Venice, for example, has a very successful sustainability program, where ecologically sound measures are analysed and their results are summarized in yearly Sustainability Reports.

UNEP’s Greening Universities Toolkit

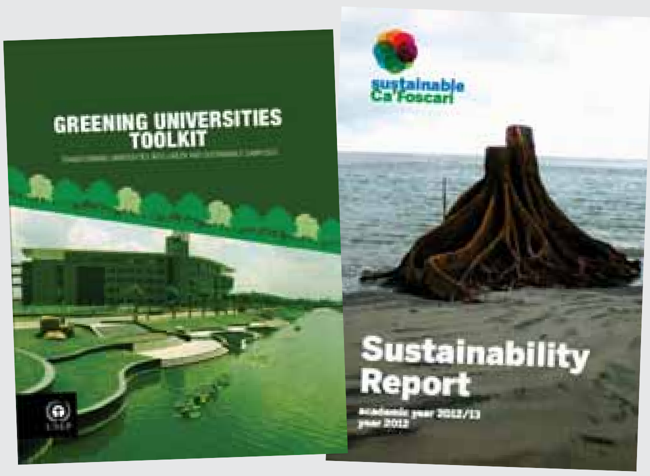
In 2013, the United Nations Environmental Programme published a general guide that provides examples of how universities can carry out activities that are “ecologically sound, socially and culturally just and economically viable” (UNEP, 2013). The “Greening Universities Toolkit” (UNEP, 2013), presents 8 sections that introduce sustainable planning in a university campus:

1. Defining Sustainability
2. Strategies of action
3. Tools for transformation
4. Awards and recognition of positive initiatives
5. Resources for change
6. Produce a “Greening your own Uni brochure”
7. Look at global exemplars
8. Technical appendix

The toolkit presents several case studies that give an idea of scope, budget, funding and time of implementation of specific measures carried out in universities all over the world. Throughout the evaluation of these measures, the common characteristic is the active participation of students, staff and the administration. Agreement and participation on behalf of the immediate users is the key to a successful implementation of ecologically friendly measures. The university as an institution must provide viable platforms where information is shared and promoted and where all members of the institution feel represented and are able to engage and be part of positive changes.

The challenge ahead

Aristotle University in Thessaloniki already began its transition towards becoming a sustainable campus with the creation of Eco-AUTh (Sustainability Department). The following pages provide an overview of seven proposals that aim to convert AUTH into a model of innovation, energy efficiency, and an inspiration for the city of Thessaloniki.



0.5 Covers from „Greening Universities Toolkit“ and „Sustainability Report“ (UNEP, 2013 and Ca’Foscari University, 2012).

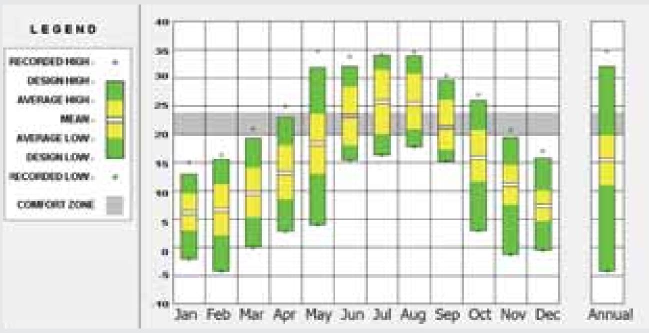
0.6 Location map of AUTH (GoogleEarth, 2014)

Thessaloniki: Climate and current situation

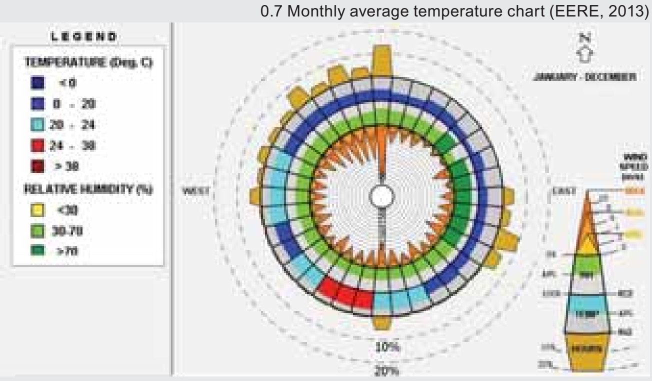
Various approaches to a sustainable campus are based on the climate conditions and set in the context of economic recession.

Climate in General

Thessaloniki is located on the eastern coast of Thermaic Gulf, in the north of Greece (40°30′N, 22°57′E). Its proximity to sea and imposing mountain ranges, directly affects the climate. According to Köppen climate classification, it is a humid subtropical climate (Cfa) (Canty and Associates, 2013). Over the course of a year, the temperature typically varies from 1°C to 32°C and is rarely below -4°C or above 35°C. The winters are relatively dry, with average temperature drops between 5-10°C during December to March; Summers are hot and humid, with average temperature from 20 to 27 °C from June to September. Thessaloniki experiences common frosts and sporadic snow falls in winter (EERE, 2013). Heating and cooling system are usually suggested for a comfort indoor environment.



0.7 Monthly average temperature chart (EERE, 2013)



0.8 Annual wind chart (EERE, 2013)

Wind

The average wind velocity is about 3m/s during the year. The wind is most often out of the north and north-west, least often from the north east. Due to its costal location, wind direction may change perpendicular to the coastal line during the day.

Precipitation

There are on average 94.0 days of precipitation during the year in Thessaloniki, with a total amount of 450 mm. The month with the most precipitation on average is December (55.9 mm) and August sees the least precipitation (20.3 mm) (Canty and Associates, 2013). There are sporadic snow falls in winter, but usually do not last for more than a few days.

Solar radiation

Global horizontal radiation is about 1500 kWh/m^2, it peaks in June and July (about 7 kWh/m^2 a day) and bottoms to 1.5 kWh/m^2 in December. Solar position ranges from 20° to 70° from winter to summer at mid-day in the south direction. Sky cover range is relatively low (45%), especially during summer (EERE, 2013). This gives a good condition for natural lighting.

Economic crisis

Greece was struck by an economic crisis in 2009 due to global recession in October 2008. It is believed that one of the crises source was structural weaknesses of Greek economy and worsened by adopting EU single currency (BBC,2012). The crisis itself brought drastic change into the political situation and raised the unemployment rate across the country. Aristotle University of Thessaloniki (AUTH) as a state university also suffered from the recession. Financial budget cuts forced several tough decisions to be taken. In the engineering faculty for finstance, out of 850 academic and service employees, 81 were re-allocated and 169 had to step down from their position (K. Katsampalos, personal communication, November 6, 2012). This condition brings many management problems and negligence in AUTH because of lacking on man power and financial support.

0.9 Thessaloniki, Greece (Skoog, 2009)

Urban context

Building of the city

Located in the centre of Greek Macedonia, Thessaloniki plays a unique architectural role reflecting its historical developments in Byzantine, Ottoman and Judaical periods.

The city was founded by King Cassander of Macedon around 315 BC. In Byzantine period, aside from its commercial importance, the city was for many centuries the military and administrative hub of the region, as well as the transportation link between Europe and the Levant (today known as Syria, Lebanon, Jordan, Isreal and Palestine) (Thessaloniki, 2014). Therefore numerous merchants, traders and refugees from all over Europe came and settled in this city. It then came up with the thirst for commercial and public buildings, which led to the construction of large edifices in the city center.

In 1870s, the city experienced a fortification demolishing process, except the white tower on the water front, to give more space for quay construction for a better economic development. As a result, the city layout changed with elimination of old walls and the urban area was expanded east and west along the coast. Since then, the working class moved to the western districts while the middle and upper classes moved to the eastern suburbs. In 1917, a devastating fire destroyed the city's historic center and a large part of its architectural heritages were then exterminated. The rehabilitation was based on Byzantine form including several survived outstanding buildings, like old town, and a great road network. Thessaloniki under the Ottoman occupation then obtained several marvels, like Aristotelous Square, and paved its way to a modern European city (Karadimou-Gerolympou, 1996).

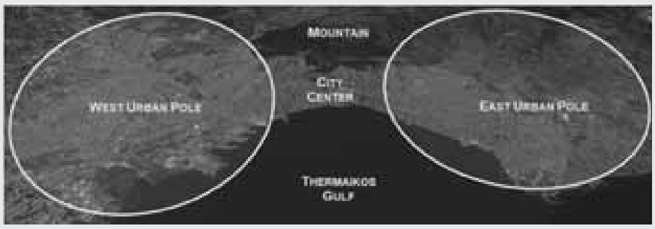
Today, Thessaloniki is a mixture of modern buildings and historical monuments several of which are declared as World Heritage Sites from UNESCO, like Agia Sofia church. It is regarded as an attractive tourist city to understand Balkan culture.

Transportation

Thessaloniki is a city with around one million inhabitants, which has expanded its size momentously within last a few years. The complete urbanized area of Thessaloniki is 5.5 hectares.

The existing housing development shows a city shaped with its centre being the virtual point where two traffic circles are joined, covering an area larger than the current limits of the urban agglomeration of Thessaloniki. So, the two urban poles (eastern and western) communicate through five basic road axes that pass through the centre of the city (Frangopoulos et al., 2009).

With the great expansion of economic activities, the demand for transportation is rising, causing severe pressure on the existing system. To solve this problem, government initiated gigantic redevelopment plans in 2011. The plans included total restructuring of the road A16 in the western side of the city, with new junctions and new emergency lanes throughout the whole length of the motorway. Besides, they also include adding one more lane in each direction on the existing A16 ring road and on the A25 passing through Thessaloniki's southeast suburbs (Tasioulas, 2011). The expansion of the outer ring road which circles around the entire Thessaloniki Metropolitan Area is also planned. The construction of the Thessaloniki Metropolitan Railway began in 2006 and is scheduled for completion in 2018, where it is set to become the city's most vital public transport service (Attiko Metro A.E. , 2011).



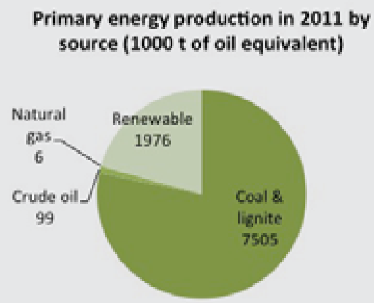
0.10 Thessaloniki's city center as the contactpoint of two urban poles (Frangopoulos et al, 2009)

0.11 Thessaloniki covered with the smog from the residential buildings (Top Story, 2013)

Energy

Energy production and consumption in Greece

An important side effect of Greece's crushing economic crisis has been a drastic reduction in the amount of energy being used (Eurostat, 2014). This has been largely due to rapid increase in energy prices. As Greece's energy sector relies on fossil fuel combustion, this effect has influenced positively GHG emission reduction (The World Bank, 2014). The production of solid fuels and oil products accounts for 78% of total production, while the contribution of renewables is 21% (see the figure below). Lignite is Greece's only significant fossil fuel resource, with reserves reaching 4.3 billion short tons (Reegle, 2013).



0.12 Energy production in 2011 (Eurostat, 2014)

The gross inland consumption in 2011 amounted to approximately 788 584 GJ (Eurostat, 2014).

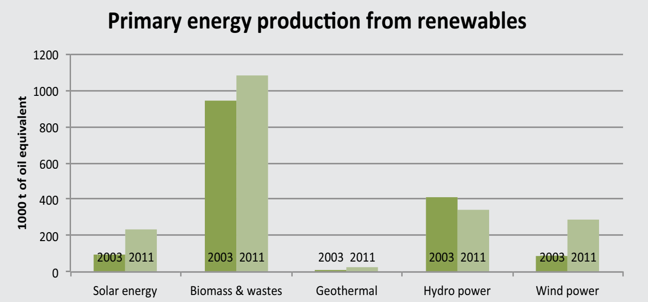
Energy in the Campus

Aristotle University of Thessaloniki is contributing greatly into research about the potential of using renewable energy sources in Greece and Thessaloniki. The Laboratory of Power systems is involved in several research and development projects funded by European Union, National Research Programs and private investors (PSL, 2009).

Next to the research, AUTH has started an intention of energy monitoring on campus. In 2009 the Supervisory Control and Data Acquisition System (SCADA) software was installed. The following two years, in 2010 and 2011 the SCADA system was run, measuring the electricity consumption of 10 buildings. The results, however, were not comprehensively presented to the wider public.

Renewables

The share of renewables accounts for 21 % of the total energy production in Greece, which comprises heat and electricity (Eurostat, 2014).



0.13 Energy production from renewables in Greece (Eurostat, 2014)

In terms of total primary energy supply (TPES), the percentage of renewables with 7.5 % is relatively low. Only 15 % of the total electricity generation in 2010 was produced by regenerative sources, while the IEA (International Energy Agency) average was 17.7 %. The declared target for 2020 is a share of at least 40 % for electricity generation.

Legal background

The energy sector, influencing direct or indirect all the other sectors, is seen as cornerstone in the economic development. The Ministry of Environment, Energy & Climate Change (MEECC), has developed a National Renewable Energy Action Plan, under the 20-20-20 targets, which role is to ensure energy security, reduce national GHG emissions, boost the competitiveness of the economy and attract investment capital.

The energy policy of Greece favours major private sector investment. Various feed-in-tariffs were introduced and amended by laws in the recent years. Especially the law for "Generation of electricity from renewable energy sources and through high-efficiency co-generation of electricity and heat and miscellaneous provisions" (MEECC, 2009), sets detailed pricing for different energy sources.

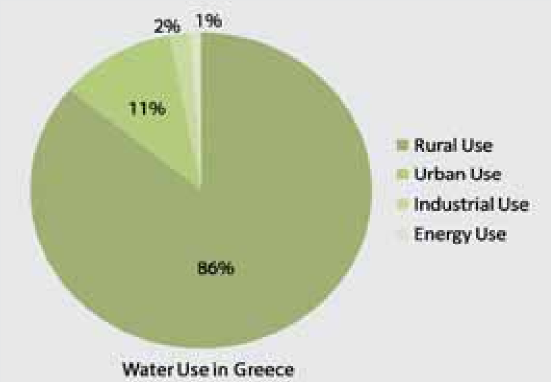
0.14 Waterfront of Thessaloniki (Own compilation, 2013)

Water

Greece national scale

Greece is characterized by a steep relief, restricted inland and a very long coastline. As for the natural characteristics and climate, Greece has an uneven distribution of spatial mean annual and seasonal rainfall. Thus, water resource availability is uneven both in time and space.

The annual drinkable water demand in Greece is about 1.046 106 m^3 (Chatzisavva, Arampatzis, & Tero Ltd, 2007, p.3). The demand is estimated by considering potable water consumption of 200 liters/person/day by permanent habitants and 300 liters/person/day by tourists (Chatzisavva, Arampatzis, & Tero Ltd, 2007, p.3). The water sources for the water supply are mainly surface water – rivers and natural and artificial lakes - and groundwater – spring and boreholes. With the exception of the large cities such as Athens and Thessaloniki where long distance water transport is present, water sources are local. The quality of the portable water meets the quality features required by regulations (Chatzisavva, Arampatzis, & Tero Ltd, 2007, p.3). The water usage in Greece is shown in chart below.



0.15 Water usage in Greece (Lazarou Anastasia, 2006)

Thessaloniki regional scale

The Thessaloniki Water Supply and Sewerage Company is responsible for the water supply and the sewerage of over one million customers within the area of Thessaloniki. It covers an area of approximately 270 km^2, the length of the water network is 1650 km and the length of the sewer/storm water network is 1550 km.

The city of Thessaloniki has an average monthly precipitation of 39 mm/month (El Dorado Weather, 2014). The water sources for the city water supply come from springs and rivers. Almost 70% of the city's total water demand is covered by springs and the rest from rivers (CC-Waters, 2012, p.135). The water network of Thessaloniki has approximately 120 drills and 25 pump stations providing water to 40 tanks within the entire water network (Ioannis & Michael, n.d. p.1). In addition to that, Thessaloniki has a daily average water supply of 250.000 m^3 and a daily average waste water treatment of 170.000 m^3 (Chatzisavva, Arampatzis, & Tero Ltd, 2007, pp.15-16).

Legal background

The main laws, ordinances and directives in the Greek legislation system are Law 1739/87 for potable water, Law 3199/2003 for water resources management, and EC Directive 2000/60 (23/10/2000) for Water protection & management. Law 3199/2003 was put forward in compliance with the EC Directive (Chatzisavva, Arampatzis, & Tero Ltd, 2007, p.35).

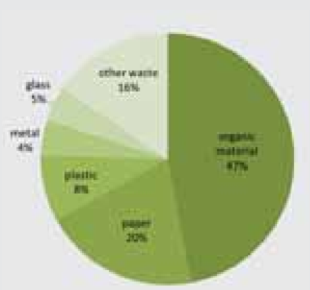
Law 3199/2003 divides the country into 14 river basin districts. It also establishes regional and national administrative bodies. According to this law, several agents are established for the protection and management of water. The National Water Commission is responsible for the water policy of the country and consists of several Ministries. The responsibility for the development of national water protection and management program is given by this law to the Central Division for Water, with in the Ministry of Energy. The Central Division for Water is also responsible for water pricing policy, control and support of regional Water Division (Prodes-Project, 2010, p.70).

0.16 Construction materials collage (Can Stock Photo Inc., 2014) 0.17 Materials used in Thessaloniki (Own compilation, 2014)

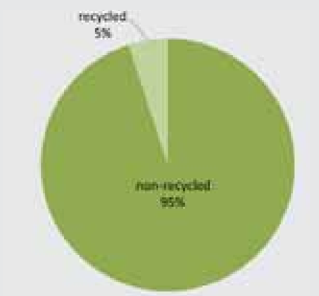
Materials

Definition

According to the Merriam-Webster dictionary, the term 'material' is defined as an element, constituent or substance of which something is composed or can be made. Under this definition, any element can be considered as material; including waste materials. Materials are the stuff of economic life in the industrial world. They include the resource inputs and the product outputs of industrial production. How it is handled is the major determinant of real economic efficiency, and also has an impact on health and natural environment (Milani, 2005).



0.18 MSW in Greece, 2000 (Limbachiya & Roberts, 2004)



0.19 C&D waste in Greece (Papachristou et al., 2009)

Situation in Greece

The common construction materials used in Greece are stone, bricks, wood, straw, marble, ceramics, lime, glass, reeds, sand, clay and terracotta that are a representative part of the Greek and Mediterranean architecture. Nowadays, techniques of material production have been combined to create new architectural styles in the country (Vavili & Karantaki, 2012). It is well known that the construction industry is one of the largest polluters worldwide, and Greece is not the exception. Construction and Demolition (C&D) waste are an important part of the waste management sector of most industrialized countries. In Greece, 3 million tons of C&D waste are estimated to be generated annually, less than 5% are recycled and reused; whereas in the EU countries almost 30% of the relevant annual production is recycled (Limbachiya & Roberts, 2004).

Nevertheless, the country has taken actions and nowadays tries to apply practices for reusing and recycling construction materials to adopt the traditional Mediterranean style by integrating it into the contemporary architecture. Although, reusing materials has been applied over the years, this practice is relatively low, and there are stockyards with demolition materials in many cities (Vavili & Karantaki, 2012).

Municipal solid waste (MSW) management in Greece is not yet as developed as in many EU countries. Land disposal is still the predominant method for managing MSW. Of the total amount of municipal solid waste, approximately 8% is recycled at the source and 92% is disposed without prior treatment (Papachristou et al., 2009).

Situation in Thessaloniki

In 2000, approximately 4.6 million tons of MSW were generated in Greece; the city of Thessaloniki contributed approximately 9% of the total amount of MSW generated in Greece (Papachristou et al., 2009).

Legal background

Environmental issues are of great concern in Greece; thus the Environmental Law 1650/86 was enacted in 1986 and designed to cover all aspects about environmental protection, which includes provisions regarding solid protection from the disposal of municipal and industrial waste. Greece has also developed the national strategy on sustainable development (NSSD) enacted in 2002, which focuses on the reduction and rational management of solid waste.

Furthermore, the Municipal Solid Waste Act in Greece developed the harmonization of the EU Directive 94/904/EC: Joint Ministerial Decision JMD 69728/824 (HOG 358B/17-5-1996) enacted in May 1996, and titled "Measures and terms for Solid Waste Management", promotes waste prevention and reduction, as well as recycling, reuse and recovery (NATO/CCMS, 2002). In addition, the municipal solid waste legal framework focuses on minimizing the use of uncontrolled dumpsites and remediation of major ones. For the last 25 years the entire area of Thessaloniki was served by one sanitary landfill, and the construction of new ones is in progress.

0.20 AUTH campus (AUTH, 2012)

AUTH map and location of the team areas

The AUTH campus

Seven teams of three to four students were commissioned to make Aristotle University a more sustainable campus. Every team developed different topics and targeted various buildings. The following map illustrates the intervention of the seven proposals on AUTH campus (the legend indicates which teams are working on which buildings or areas, sometimes more than one team focuses itself on the same building or area).

Team 1: Energy and funding

Closed loop for funding and energy efficiency that provides short term, mid-term and long-term strategies to improve campus sustainability development.

Team 2: Log in- Turn off

Grass roots network to generate awareness about energy efficiency measures. Monitoring of energy consumption and data visualization to implement a yearly sustainability report.

Team 3: PLUS Guidelines

Develop low cost, user friendly and passive cooling guidelines for the campus and Thessaloniki.

Team 4: Sustainable Waste Management

Tackling waste problems and developing solutions through integrating the 3R's into AUTH. Involving students and community towards its development to becoming a role model for its city.

Team 5: Recommissioning

Reorganizing the space use of the classrooms in order to enhance energy-efficiency and comfort.

Team 6: Sustainable library

Tackle social, environmental and economical aspects. Deal with energy water efficiency and comfort.

Team 7: Sustainable mensa

Enhance the AUTH restaurant towards a sustainable one, with respect to: architecture, food, energy and water.

0.21 AUTH green spaces (AUTH, 2013)

0.22 Location of the team areas (Own compilation, 2014)

0.23 Research (AUTH, 2013)

Objectives and time terms

After the initial analysis of searching, studying and analyzing, five themes were found out to be in common between most of the sustainable campuses' case studies worldwide. Which are: community, education, research, campus and finance.

Those themes were intersected with three main time frames: short, mid and longterm, in order to create a solid plan acting as a base and a starting point towards a sustainable AUTH.

Each crossing point between a theme and a time frame, forms a field of objectives and actions that will be covered by one or more teams of the 4th REAP generation. Through this process of experiencing and developing, varied approaches would achieve a sustainable campus for Thessaloniki.

As a main overview, all teams are tackling all themes on different levels, as the sustainability process is indivisible. However, each team has developed a focus area and the following table will showcase how the teams distributed themselves over these action fields with different objectives, to deliver a comprehensive plan that can act as a road map for a sustainable campus.

	Community
Short Term	*Bottom-up approach (students = faculty = staff=administration).
	*Fostering student engagement volunteering opportunities and rewards.
	*Online network.
	*Annual Photography contest.
	*Social media.
	*Raising student and staff awareness of sustainability.
	*Integration of AUTH with sustainable campus network.
	* Career platform for students.
Mid Term	*Workshops/summer schools involving the students in all ongoing activities on-site.
	*Small scales interventions to raise awareness and involve the city/ community.
	*Online sustainability survey to obtain on-going feedback from students, faculty and staff members.
Long Term	*Continuous city/campus cooperation towards a sustainable future.
	*Online platform: Sustainable AUTH website.

Legend

- Team 1: Energy and funding
- Team 2: Log in-Turn off
- Team 3: PLUS Guidelines
- Team 4: Sustainable waste management
- Team 5: Recommissioning
- Team 6: Sustainable library
- Team 7: Sustainable mensa
- Uncovered areas

0.24 Studies (AUTH, 2013)

Education	Research	Campus	Finance
* Integrating experimental courses related to sustainability in the faculties that have direct involvement with sustainability. * Providing basic information of sustainability into campus daily life. * Informing & educating. * Participation of students. * Provision of seminars, workshops and classes.	* Sustainable workshops practiced by professionals from different backgrounds and departments of the university. * esearching in simple and low budget technology in terms of agriculture (example: composting).	*Elaborating statistics of the energy consumption of each building on campus and informative totem to display recent achievements. *Publishing guidelines about how to conserve energy. *Providing an action framework to improve heating system management and re-organizing the schedules. *Low budget retrofitting. *Energy conservation measures for pilot buildings. *Re-design of space for better efficiency.	*Crowd funding promoted by the university to students. *Tuition fees. *Initiative fund. *Engaging closed funding with agricultural farm supply (sign agreement).
*Basic courses of sustainability in every department.	*Creating an interdisciplinary research platform. Ex: Research of bio-waste usage, to involve Agriculture, Engineering, Ecology and Economics departments. *More depth research in energy measure and technology (cooking oil into biodiesel, etc). *Energy monitoring teams give feedback about change in behavior.	*Campus wide schedule and intelligent facility management system. *Energy conservation measures. *Energy management system. *Energy monitoring. * KPI dashboards displaying recent achievements. *Passive cooling measures. * Enhancing accessibility of the campus. * Enhancing green area. *Improving building envelope.	*Alumni funding. *Funding from companies and the European Union. *Funding from agriculture production (mostly fertilizer).
*Pilot projects as references for educational purposes. *International workshops: knowledge exchange between universities. *Obligatory course for every student of every faculty (construction sites, waste separation, conservation tools, measuring).	*Joint process of learning, experiencing and developing sustainable technologies. *Annual sustainability report (online and printed).	*Measures guaranteeing the continuity of the EAP by combining the synergies of all categories, methods and results. *Intensive retrofitting. *Sustainable practice within University campus. *Step further to achieve energy efficient building by refurbishing and self power generation.	*Policies providing the possibility for the campus to pay for itself. *Schemes that provide monetary returns. *Restaurant supply and money cycles mostly from locals to locals, strengthening mensa and locals economy.

0.25 Team objectives (Own compilation, 2014)

1.1 Thessaloniki (Own compilation, 2014)

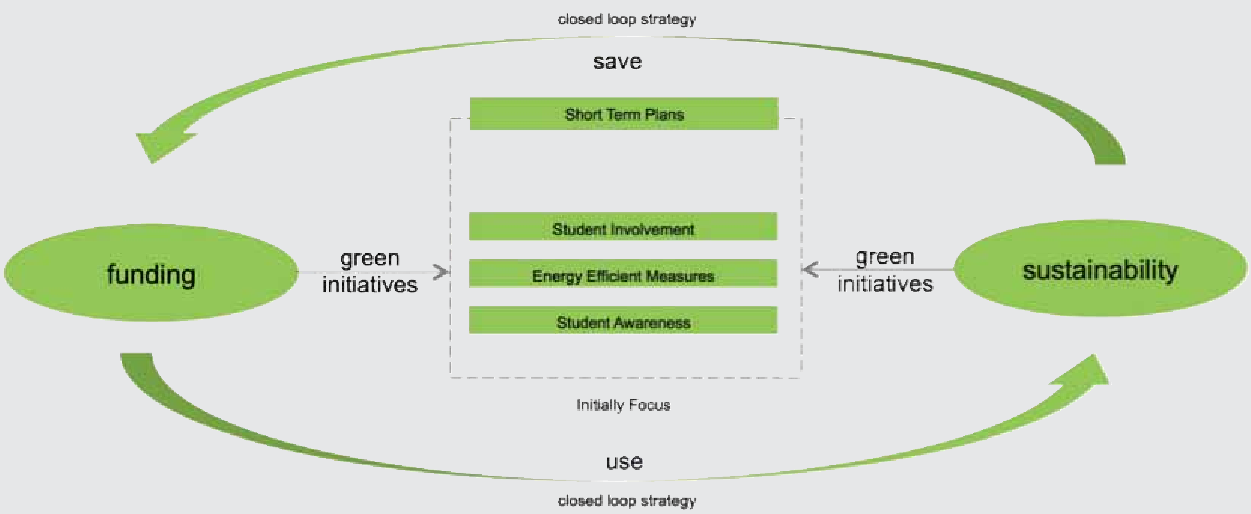
Team 1: Energy and funding

"It is essential that university campuses and students play a central role in the national transformation to the clean energy economy. As centers of intellectual power, campuses are on the forefront of cultural and technological change, campuses are where innovation is born and future engineers and scientists gain the skills to change the world." (Campus in Power, 2008)

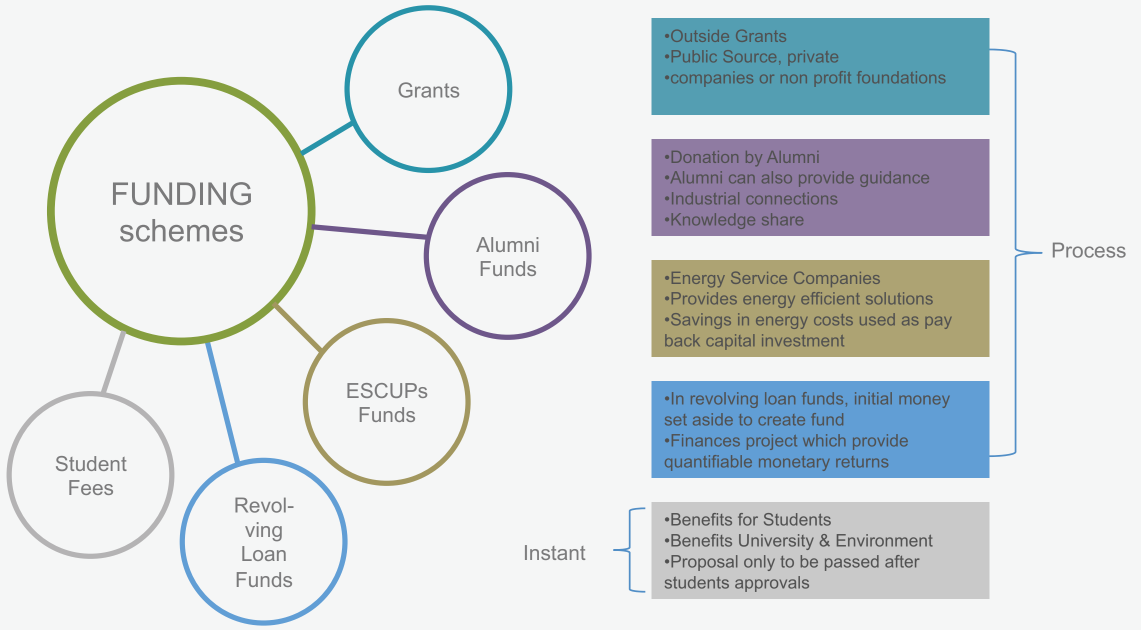
Green initiatives & short term plans

The Aristotle University (AUTH) should become a living laboratory model to its nation for a sustainable future. Along with inspirational ideas, funds are also required to make a campus sustainable. A Green Initiative is a closed loop strategy for short term goals. It begins with the funding schemes, where funds are generated and used for sustainable projects which provide sufficient savings or monetary returns. The savings are then again added to the funds thus creating the closed loop cycle. In the strategy of green initiatives funds, money would be invested for energy efficient measures along with student involvement and promoting environmental awareness.

1.2 Way towards green campus (Own compilation, 2014)



1.3 Short-term closed loop strategy (Own compilation, 2014)



1.4 Funding schemes (Own compilation, 2014)

Funding schemes

There are five suggested options for generating funds for sustainable campus projects. The first four options include grants, alumni funds, ESCUP's (Energy Service Companies and University Partnerships) funds and revolving loan funds, which would take some time for processing. Student fees are one of the possible ways to generate instantaneous financial support. This method will be further analyzed and applied in short-term strategies.

Methodology and development stages focused in student fees

Phase1 – preparation and campaigning

Supporters and students

Development of student groups with diverse skills to provide training to support the promotion of the campaign.

Research

Research has to be carried out to know what kind of fee structure can be applicable. An analysis of successful fund raising case studies for universities has to be done.

Outline for potential challenges

In order to get prepared for all the potential challenges, and to know the possible legal barriers, an outline must be done.

Student union / ballot process

A law can be passed for student fees by the Student Union or by carrying out a ballot process.

Campaigning

Campaigning through posters, flyers, social media, concerts, presentations, logos, slogans, websites, etc. can promote the campaign (Campus In Power, 2008).

Phase 2 - development

Management system

A system has to be designed and structured through a preparation of byelaws or guidelines. A core committee of students and staff that can regulate the money and its distribution has to be formed. A development of short term and long term plans for making the campus sustainable must also be carried out.

Finance through eco meal system

Approximately 8,500 students per day have meal at AUTH's dining hall (Y. Tsougrakis, personal communication, December 12, 2013). These meals are offered for free. If 5 Euro/month of payment is asked for an Eco-meal system, then every month, 42,000 Euros would be gathered. These funds would be used as follows:

For 1st and 2nd month, 20% of funds would be used for awareness, documentation, campaigning and other miscellaneous expenses. About 80% of funds would be used for installation and for development of an eco - card system.

From the 3rd month onwards, 20% of funds would be spent on student internships and for the operation and maintenance of the eco-meal system. 5% of funds can be used to encourage student awareness and involvement. 75% of funds would be used for the development of energy efficiency measures.

Further analysis of energy efficient measures like sensors and humidifiers are carried out to know the possible return periods.

Key advantages

Students

Student who would pay fees would have the opportunity to have internships from the devoted funds. Student would be able to participate in overall sustainable activities happening within the AUTH University.

University

The university would have a controlled and organized meal system. Funds would be used for student benefits and making the campus sustainable.

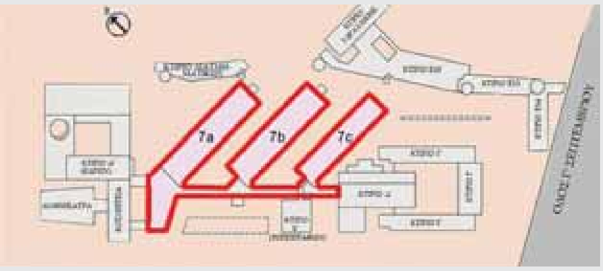
Key disadvantages

Students:	University:
Students have to pay fees.	Legal barriers.

Saving energy with a daylight sensor...


1.5 Lutron daylight sensor (Lutron, 2011)

Lighting and Heating


1.6 Chosen buildings for applying energy efficiency measures (AUTH, 2014)

As shown in Fig 1.6, the building 7a, 7b, 7c are chosen buildings for applying energy efficiency measures.

In order to decrease the electricity demand for artificial light, daylight sensors are applied in all classrooms, libraries and design rooms. The sensors can switch off the lights automatically when sufficient daylight is present.

Daylight Factor= E_{in}/E_{out}*100%

(E_{in}: Internal luminance E_{out}: External luminance)

Required inside luminance (Mardaljevic et al., 1998)

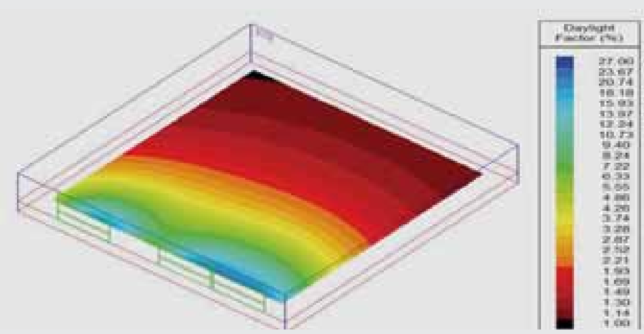
Classroom/ library: 300 lux , Design Room: 500 lux

Daylight factor: 1.3% (Considering the location of the switch, a daylight factor around the door area is chosen)

Required outside luminance

Classroom/ library: 300/0.013=23,000 lux

Design Room : 500/0.013=38,000 lux


1.7 Simulation of daylight factors of an ideal room(IES Consulting, 2007)

Annual frequency of an outdoor luminance level is exceeded in Thessaloniki (AA Environment and Energy Programme, 2011)

Classroom/ library: 20% Design room: 5%

Potential reduction of lighting operating hours

Classroom/ library: 6% Design room: 1.5%

NUMBER OF LIBRARAY & CLASSROOM	36
NUMBER OF DESIGN ROOM	24
SENSORS NEEDED	60
LAMPS IN EACH ROOM (TEMPORARILY AVERAGE)	20
LAMP WATTAGE	72W

1.8 Background information for energy efficiency calculation (own compilation, 2014)

MODEL NUMBER	LUTRON MS-OPS5M-WH
WEIGHT	22.7 G
PRODUCT DIMENSIONS	4.6*5.1*10.7 CM
COLOR	WHITE
VOLTAGE	120.00
BATTERIES REQUIRED?	NO
PRICE	20€

1.9 Technical data of chosen daylight sensor (Lutron, 2011)

Conclusion:

Annual energy saved

Classroom & Library:

36*20*72W*8h/d*6%*20d/m*12=5976kWh/m

Design rooms:

24*20*72W*8h/d*1.5%*20d/m*12=996kWh/m

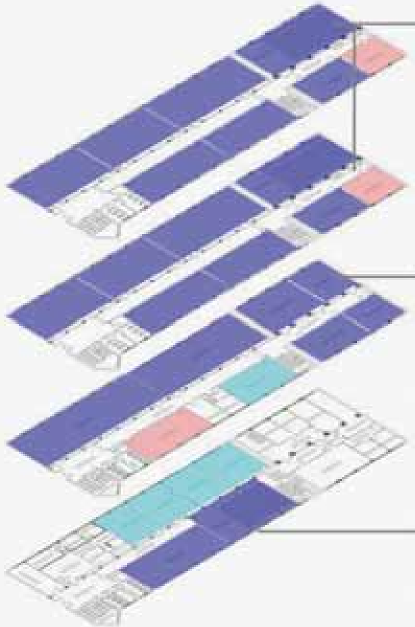
Every year

5976kWh+996kWh=6972kWh 0.144€/kWh*6972kWh= 1004€

Initial invest

20€*60=1200€ Installation fee: 120€

1200€+120€= 1320€



1st and 2nd floor

Lecture1:	4*190m²/169 occupants	3 pieces	total: 32 pieces
Lecture2:	4*150m²/169 occupants	2 pieces	
Lecture3:	2*130m²/80 occupants	2 pieces	
Lecture4:	2*110m²/80 occupants	2 pieces	
Lecture5:	2*80m²/80 occupants	1 pieces	
Design:	2*60m²/45 occupants	1 pieces	

Ground floor

Lecture1:	1*260m²/230 occupants	4 pieces	total: 14 pieces
Lecture2:	1*200m²/200 occupants	3 pieces	
Lecture3:	1*110m²/70 occupants	2 pieces	
Lecture4:	1*80m²/70 occupants	1 pieces	
Lecture5:	1*70m²/70 occupants	1 pieces	
Lecture6:	1*50m²/70 occupants	1 pieces	
Lab:	1*80m²/20 occupants	0 pieces for computer sake	
Design:	1*100m²/85 occupants	2 pieces	

Basement

Lecture1:	1*150m²/196 occupants	2 pieces	total: 4 pieces
Lecture2:	1*130m²/148 occupants	2 pieces	
Lab:	4*70m²/56 occupants	0 pieces for computer sake	

Price: €192 / piece

Function space: 60m²

Wattage: 160-480w

Aimed humidity: 55%

1.10 Classroom space analysis of Building 7b (Own compilation, 2014)

1.11 Humidifier produc sample(Air-O-Swiss, 2014)

Conclusion

Heating energy saving without comfort promise

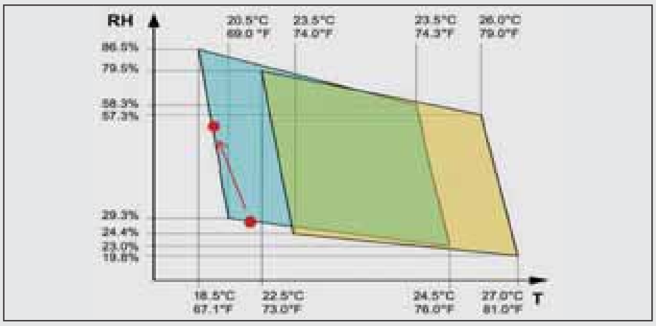
According to the ASHRAE standard, space heating energy saving without human comfort compromise can be achieved by dropping the interior temperature while raising relative humidity (RH) to a certain level, which is to stay in the comfort zone while reducing temperature.

The pre-set heating atmosphere temperature is proposed to be cut from 21°C to 19°C while lifting interior RH from 28% to 55%, so that in winter people seldom perceive the discomfort caused by the temperature drop.

Energy saving bill

Based on Figure 1.10, the required quantity of humidifiers regarding to student-use classrooms of Building 7b are roughly estimated. Through calculation, it can be seen from Figure 1.14 that deducted by humidifier energy consumption and maintenance cost, the annual energy saving bill can reach almost 1,3000 Euros (if the proposal is applied to three buildings 7a, 7b, 7c) which leads to a 3-year payback period (Building location refer to Figure 1.6)

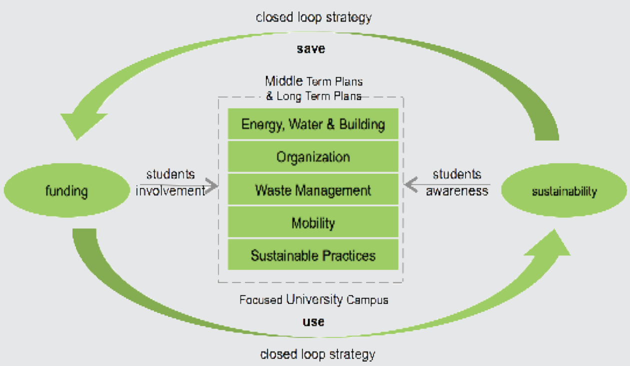
(Calculation based on hypothesis)



1.12 RH / T diagram based on comfort zone (Sensirion, 2010)

Temperature	Space heating energy demand (kWh / a)	Final end energy saved (kWh / a) (energy consumption by hu-
19 °C	254875	30009
21 °C	207444	
Energy saving	Building 7b	€ 4321.4 / a
	Building 7a+7b+7c	€ 12964.2 / a
Payback year	3.03 years	

1.14 Energy saving calculation from space heating (Own compilation, 2014)



1.13 Closed loop strategy for middle and long-term (Own compilation, 2014)

Conclusion

Closed loop strategy for middle and long-term

Through the application of short-term funding schemes and energy saving measures in lighting and heating in pilot buildings 7a, 7b and 7c (Building location refer to Figure 1.6), it can be seen that carrying out these activities campus wide is possible.

In the middle and long-term plan, the closed loop system will be formed by involving various funding schemes and organizations, application of energy saving measures, mobility, waste management, and other sustainable practices. Meanwhile, student awareness will be improved in all aspects in hopes to build a sustainable campus together.

2.1 Students of AUTH (Oviir, 2013)

Team 2: Turn off - Log in

Developing a sustainability concept

After defining the characteristics of Sustainable Campus, the site visit and analysis of the AUTH commenced the concept development of the 'Turn off – Log in". The origin of the concept is built on two main ideas: the necessity of visualizing the effects of a collective behaviour on energy consumption, and secondly, the thoughts and visions of current members of the university.

After interviewing students and professors, the collected answers defined the core problem, which is the lack of communication and possibilities for knowledge exchange between different institutions and individuals within the campus.

The concept consists of three scales of actions, which define the scope of impact and the time needed for the realization:

S scale - Easy and low/no-cost implementation, first stage initiatives that aim to arise awareness among the target group. M scale - Project influences entire campus, actions need social engagement and medium to long-term commitment. L scale - Influences entire campus or beyond, includes cumulative research, requires long-term commitment and regular maintenance.

The actions in different scales are divided into five main fields of actions:

- Research
- Promotion
- Knowledge Exchange
- Engagement
- Monitoring

The starting point

The first step was a comprehensive site analysis in order to understand the existing situation and define the weak points. The following step was to find and create the contacts with the institutions, which are working on the matters related to sustainability, and possibly can comprehend and realize the proposals of the project team.

The main strategic partners were necessary to realize the project:

The School of Electrical and Computer Engineering: provided necessary data to design the possibilities of data visualization of the energy consumption, to result collective behaviour change.

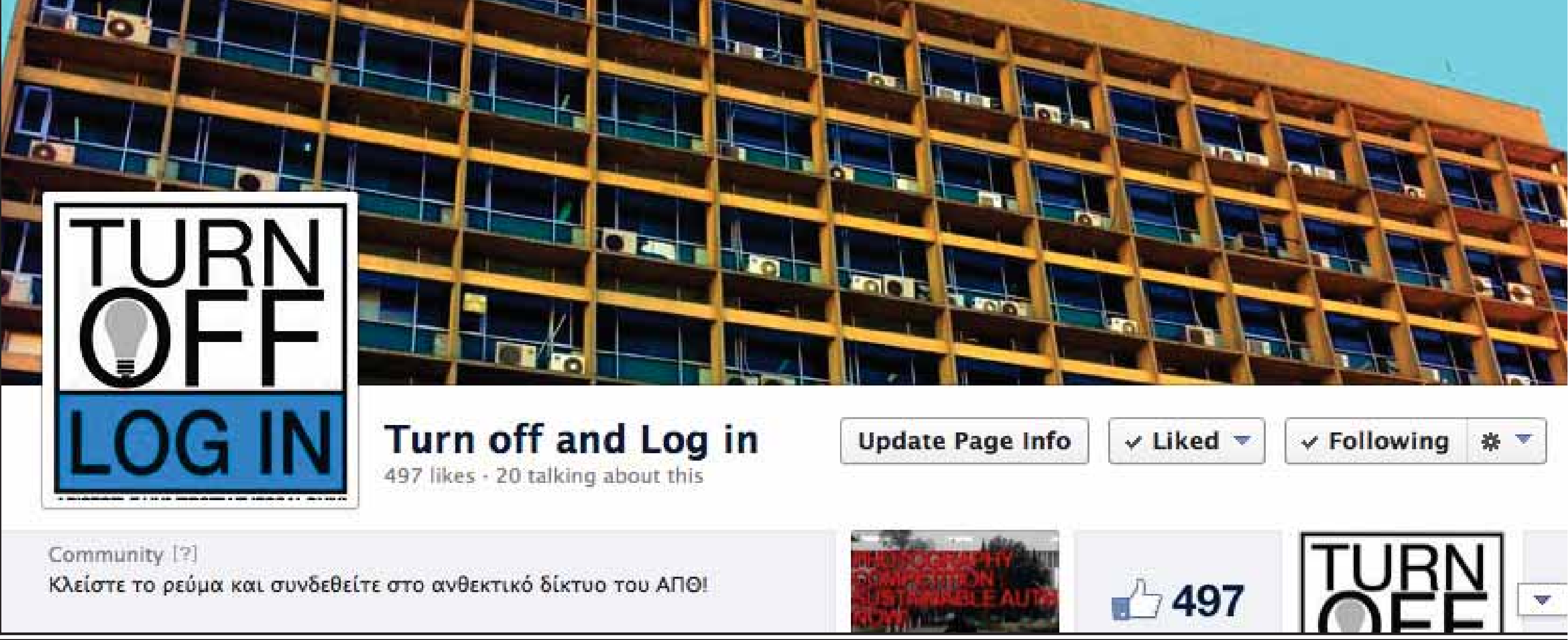
Sustainability office Eco-AUTH: supported promotion and engagement actions. Provided a working space, found further partners, promoted an engagement action I Annual Photo Contest, and spread the online-network site.

Ultimate goal

The main proposal of this project is to create a platform from where institutions and individuals of Aristotle University of Thessaloniki can join efforts and provide measures to become a sustainable campus, without further need of advise or support from outside.

Investigation of the best practice sustainable campuses, indicates two main factors that are necessary for irreversible process of becoming environmentally sound institution (UNEP, 2013). The elements are the establishment of an official sustainability online-platform for the university; and the Annual Sustainability Report, that indicates different environmental parameters and is available for a wider public.

To accomplish these goals, the Turn off – Log in is providing a Handbook for the existing partners at the University, with the guidelines and main steps to be taken in order to achieve those two main targets.



2.2 Printscreen of Turn off-Log in's Facebook page (Own compilation, 2014)

Small scale actions: Immediate impact

Site analysis

The proposal initiates with a thorough on-site analysis. Informal interviews are made in order to collect impressions, learn about the difficulties as well as the expectations/needs of the campus' occupants/users. These must be carried out in order to obtain a first hand understanding of the pressing issues and current conditions. Photographic documentation and video recordings are valuable tools that will help to analyse the evolution of the project at later stages.

Online network

The creation of an online network is a direct and fast method to introduce and promote the project within the university as well as outside. An online platform, such as a Facebook page or a Twitter account is a useful tool for connecting future stakeholders and gaining support for the realization of the project. The acceptance and interest of the public can be easily measured and a direct connection among strategic partners can be established very early on the implementation phase.

Annual photography contest

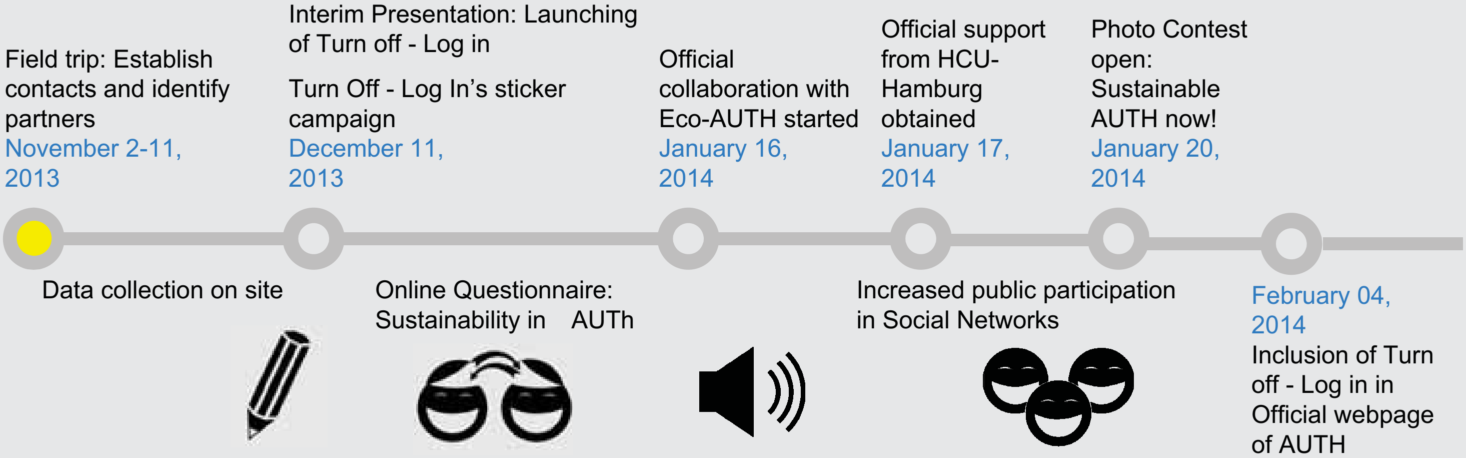
The establishment of a seasonal event such as the Annual Photo Contest is another means to obtain public support and attention. The recurring event generates expectation and eventually becomes part of the campus life making it a new tradition. The theme of the photo contest is in itself another tool to promote other ways of perceiving what sustainability means for each person.

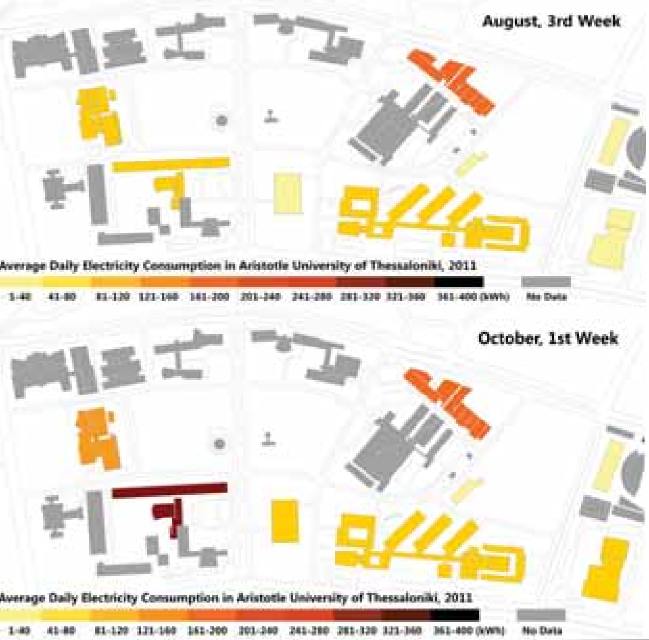
Social events, volunteering opportunities and certificates for volunteers

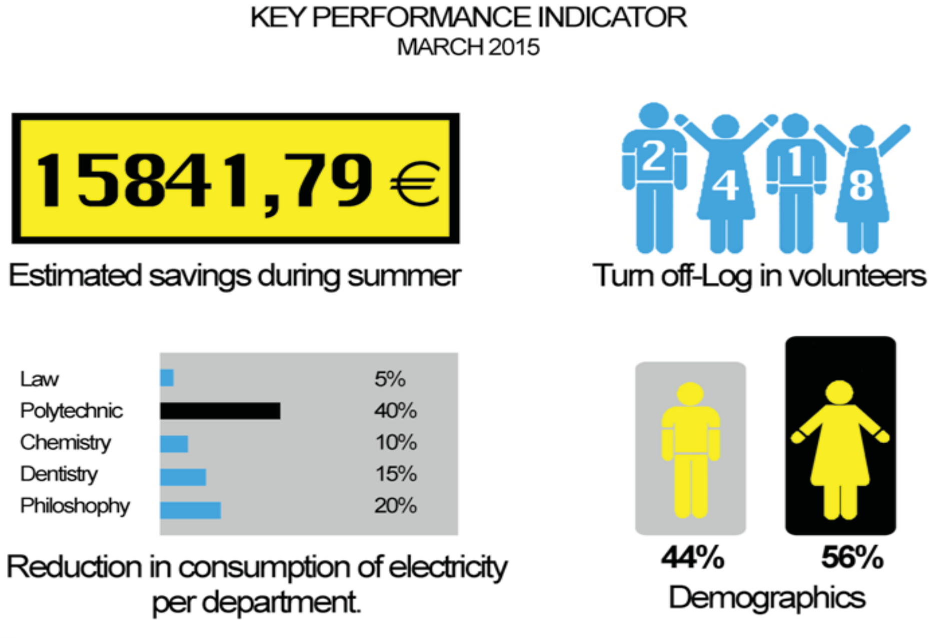
Other informal social events that can attract a wider interest are special "thematic days". While providing volunteering opportunities, "a day without plastic bags on campus", for example, could be launched via the existing social networks. These events can be organized in a participatory manner, sharing ideas and experiences: the campus starts to become an active community.

With the launching of the Turn off – Log in campaign and creation of the online network new volunteering opportunities arise. The implementation of the proposal is only possible with the help of an interdisciplinary team that will work in collaboration with Eco-AUTH, the existing sustainability office at Aristotle University. The team of volunteers are provided with a physical working-space inside the Eco-AUTH offices.

In order to maintain the interest in volunteering activities, certificates of participation or sustainability awards will be offered to observe the efforts and contribution of each person working to make the university a more ecologically sound and pleasant environment.







2.3 Fragments of the data visualization (Own compilation, 2014)

2.4 An example of KPI dash board (Saldaña, 2014)

Medium scale actions: On-going activities

Data gathering, visualization and monitoring teams

Observing the current situation and recording the consumption provides a process evaluation. In 2009 installed SCADA system (Energy Monitoring System) measured electricity and heating consumption of all the departments until 2012. The obtained data from SCADA is raw and not easily understandable, therefore, it is essential to simplify and visualize the values for the wider public. As figure 2.3 shows, picturing the records from SCADA and translating it into an image, draws a clear picture about the electricity consumption behaviour in individual buildings on the campus.

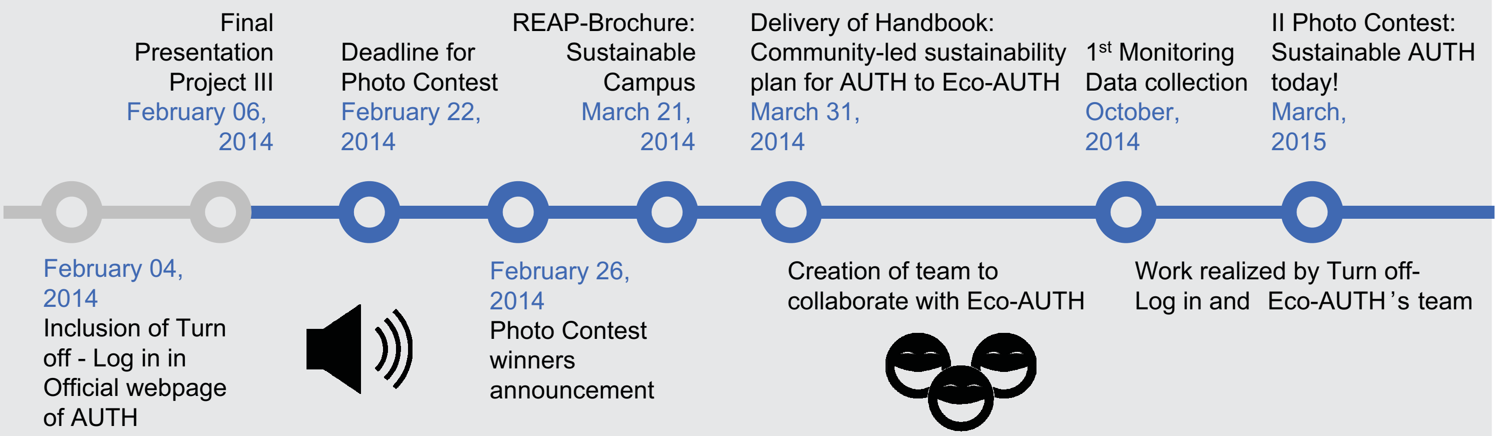
Organizing motivated students in voluntary groups to maintain the monitoring system and generate the visualizations, will ensure the process towards sustainable AUTH. Constant feedback for the wider public can influence the future behaviour (NHS, 2007). Providing behavioural feedback about the daily energy consumption of the members of the campus is the main aim of the monitoring team.

Online Sustainability Questionnaire

AUTH sustainable Questionnaire is a tool to gauge/raise the awareness regarding sustainability, creating an interactive discussion among AUTH students and asking provocative questions, in order to stimulate sustainable daily actions on the personal level. Still, the Questionnaire is an initial platform for different ideas and initiatives within the campus. It was published on the 16th of January using Google Docs. A total number of 406 Participants filled the Questionnaire until 19.02.2014: the majority (78%) were students, and as the figure 4.3 explains 49% of the participants agreed, that Turn off- Log in has increased their awareness of sustainability at AUTH.

Info boards

The proposal includes a series of Info boards where the university community will be periodically informed of the effects and findings that Turn off-Log in accomplishes over time. Key Performance Indicator (KPI) Dashboards are a combination of charts, data and conclusions that present in a simple and direct manner results of the measures initiated in the university. Allocating tangible visualization elements to the most visited locations in the campus (cafeteria, library) drives constant attention and enhances sustainable attitude, keeping AUTH members updated with an overview of the process. Informing the students about achieved efforts becomes an incentive to participate in the upcoming sustainable activities.



2.5 Volunteering opportunities at Turn off-Log in (Saldaña, 2014)

Large scale action: Long term commitment

Handbook: Community-led sustainability plan for AUTH

The purpose of the creation of the handbook is to collect the measures and guidelines developed within Turn off-Log in to one set. The instructions are divided into three different scales and five fields of actions to describe of how to proceed in becoming a sustainable campus. It is crucial to have a community-led plan, as it takes into account the needs of the public and the actual conditions of the site.

Annual Sustainability Report

The Annual Sustainability Report presents the development of the university, by demonstrating different sustainability indicators (e.g. environmental, social and economic) that have improved within one year. The purpose of the report is to inform all the members of the university and the stakeholders about the results. Turn off-Log in has scheduled the first Sustainability Report to be published in the beginning of 2016.

Online-platform for sustainable AUTH

The online-platform for Sustainable AUTH aims to connect all the information about the research, current actions and volunteering possibilities in sustainability purposes at one place. The site functions as a source of information and affects the community beyond the campus.

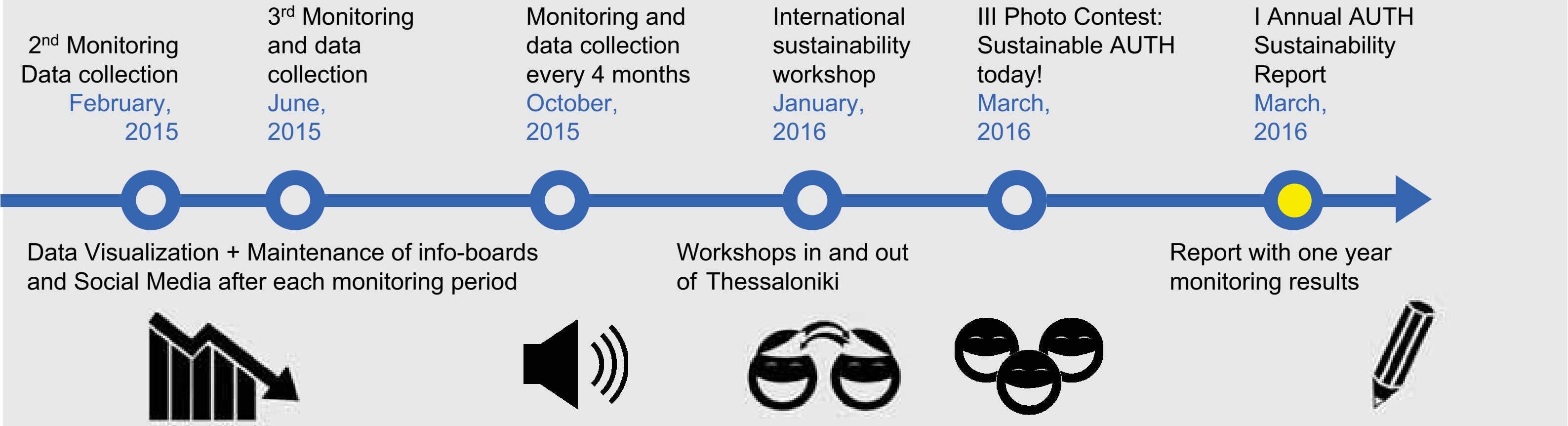
Re-activating the SCADA system

The decision of re-activating the SCADA system comes from the administration of the university. Therefore it is crucial to indicate the benefits of the data collection. Data collection of energy consumption is the first step when creating the awareness among the community. However, it needs regular maintenance and qualified operators. The results must be visualized and presented to a wider public in order to benefit in a large extent and achieve the behaviour change.

Demonstration projects, workshops and lectures

Large-scale demonstration projects rise public awareness about different sustainability measures. For instance, implementation of solar panels with a thorough explanation about the purposes, costs, and long-term effects may influence people to implement the panels in their own households.

Lectures and workshops, on the other hand, create an opportunity for knowledge exchange and possibility to learn from each other experiences and understandings. The events must be regular, to create a strong community who are motivated to bring the ideas into the actions.



3.1 City wind analysis (Map Stack, 2014) 3.2 Campus wind channelling proposal (stamen design 2014; Papadopoulos, 2013 & own compilation, 2014)

Team 3: PLUS Guidelines

Sustainable campus in a sustainable city

Universities are naturally a linchpin for innovation, research and of course education. Therefore, they can be seen as the intellectual heart of a city and serve as an ideal starting point for raising awareness and a change of thinking.

After the fieldtrip and the analysis it was discovered that the campus represents and reflects the inner city also in several physical aspects. For instance, unsustainable and inefficient building designs, such as unshaded windows and glass facades that make these buildings dependent on air conditioners which are omnipresent throughout the whole city.

These buildings were designed taking into account neither climate conditions nor vernacular building principles. This has resulted in a disproportional consumption of energy to cool them down. Thus, traditional passive cooling measures have been chosen as a focus of study to apply low cost and sustainable cooling solutions that take in consideration the shattered financial situation in Greece.

As the campus of Aristotle University is located in direct proximity of the city centre, the idea is to interconnect the campus and the city not only in an intellectual way but also on a physical layer by setting the campus as a sustainable hub where everybody can participate and learn, to act as a platform towards a sustainable city.

Creating a physical relationship between the city and the campus was set as a goal; the best way to achieve it with respect to passive cooling is by deriving the traditional passive cooling principles and methods which are going to be experimented, developed, revived and delivered back to the city. The methodology is by using the Architecture department building of the Civil Engineering Faculty to function as a case study and an experimental site where different techniques will be applied, and professors, students and community members can work collaboratively together.

Another aspect that needs to be considered is the creation of a beneficial micro-climate. Thessaloniki stresses the lack of interconnected green spaces. By exploiting wind channeling and creation of green cool spaces in order to reduce the ambient temperature, the cooling demand of buildings can also be lowered. The campus therefore represents a unique urban situation within the city. Many people come here to enjoy the green space and the associated pleasant climate. These conditions can be even more optimized and transferred back to the city.

The PLUS Guidelines

Besides the physical implementation in a demonstration project, the techniques are also going to be collected, evaluated and published in a handbook, the PLUS Guidelines. PLUS therefore stands for Passive, Low cost, User friendly and Simple which represents our basic principles. These guidelines serve as a collection of best practice examples and give a general overview of how the single methods perform in different categories. Over time, the guidelines can be extended, evaluated, adapted and revised.

Convert
Adapt
Apply

Passive
Low Cost
User friendly
Simple

PLUS Guidelines

3.3 External shading (Own compilation, 2014)

3.4 Vertical shading (Own compilation, 2014)

Applied technologies

Landscape ventilation

To tackle the microclimate, it is of great importance to pay attention to the larger scale as well. Based on research carried out in the same climate area, it is proven that vegetation can help reduce the ambient temperature by 1-3 °C (Chatzidimitriou & Yannas, 2004). The vegetation (mostly trees) planted on a certain alignment can channel wind direction towards the building to bring the fresh air to the interior and thus facilitate natural ventilation and passive cooling (Fig 3.2) (Santa Monica Office of Sustainability and the Environment, 2010).

Cross ventilation

When a building is ventilated with natural measures, maintenance and energy consumption is relatively reduced because of the lack of mechanical components or ducts.

As cross ventilation requires window operability to channel the wind based on the need, suitable windows size and a proper wind flow in-between openings (RIBA, 2014). The windows of the studied building were changed into operable ones, after lowering the corridors walls 30 cm to allow the wind flow. Those procedures based on a case study at Oregon University can reduce the total energy consumption of the building about 64% (Sophia Duluk,, Toshi Woudenberg, Wesley Thompson, & Alison G. Kwok, 2013).

Night cooling

"A building with sufficient thermal mass, which can be exposed to nighttime ventilation, can reduce peak daytime temperatures by 2° to 3°." Night cooling is used as a passive approach to ventilate architectural masses at night. This technique depends on the characteristics of the location where it's being applied; therefore, by taking advantage of the good wind speed and direction at night (north, east) of Thessaloniki, the studied building can channel wind flows to ventilate inner spaces. Night cooling is a measure that enforces the guidelines of resource efficiency, given the fact that it doesn't rely on mechanical ventilation systems but natural sources (Passivent Limited, n.d.).

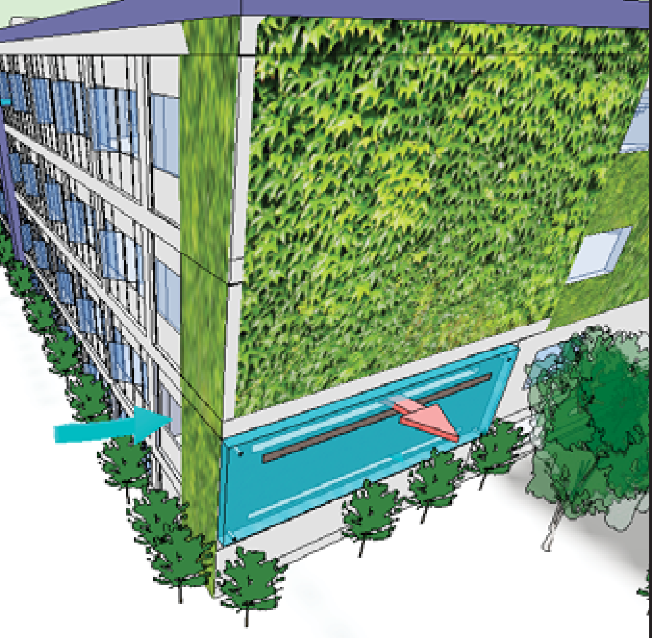
Shading system

External shading devices can reduce the annual cooling energy consumption about 36 % (Synnefa, Santamouris, & Kolokotsa, n.d.). They can be applied in various forms, materials or mountings. Considering the economical and ecological aspects, bright external translucent fabric shade screens were proposed (Fig 3.3; 3.4). These lightweight modules can be easily attached to existing buildings, without the need to additional supporting structures. They can also be manufactured out of 100 % recycled materials and by using light colors; the cooling factor can be even more amplified. They can also be applied between buildings as overhangs in order to create a beneficial microclimate, in addition, to the aesthetic appearance.

Albedo effect

Brightening building surfaces is a well known technique in the Mediterranean basin. Nowadays, a wide range of different materials and colors is available, for instance coatings, membranes tiles, shingles or metal roofing. Performance is determined by factors like: Solar Reflectance (SR or albedo) which represents the reflected fraction of sunlight and the value of Infrared Emittance (E) describes the ratio with which a surface emits thermal radiation (cf. European Cool Roofs Council, 2012). It enhances the life expectancy of the roof and reduces maintenance, also reduce the electricity demand as well as the Heat Island Effect by 1-2 °C (cf. Synnefa, Santamouris, & Kolokotsa, n.d.). Thus, a process of brightening the studied mass was applied, to experience those positive effects (Fig 3.5; 3.10).

3.5 Bright surfaces (Own compilation, 2014)



3.6 Trombe wall (Own compilation, 2014)

3.7 Pleasant micro climate (Own compilation, 2014)

PLUS Guidelines

Windcatcher

In recent years, this ancient technology experiences renewed popularity. These wind-catching towers exist in a diverse range of designs; they function within any wind speeds and directions (Saadatian, Haw, Sopian, & Sulaiman, 2012). Considering the local wind and building conditions, the Windcatcher was located at the end of the central corridor (on the eastern façade) to use the existing openings to ventilate each floor in combination with the cross ventilation (Fig 3.8). In order to achieve an optimum performance, the tower was oriented to the west, to capture most of the day time wind of the city.

3.8 Wind catcher (Own compilation, 2014)

Solar assisted ventilation roof

From a zero energy building in Singapore, the solar assisted roof is proved to reduce at least 1 °C and achieve natural ventilation (Nyuk Hien Wong & Alex Yong Kwang Tan, 2011). Considering the studied building, a dark color alumni layer 30 cm above the original roof was added to form an enclosure space, and the space is connected to the interior with two vertical ventilation ducts attached to the existing windows. When the dark surface absorbs sunlight and the air beneath heats up, the air expands. Due to buoyancy principle, when the air expands, it will rise and be driven out. Therefore the cold fresh air can be sucked in and replace the hot air, forming an air circulation (Fig 3.6).

Trombe wall

It is applied on the western façade of the Architecture building. A trombe wall functions as a thermal mass with a glass façade with a few centimeters away. A semi-enclosure space is thus formed to contain air. When the sunlight passes through the glass and is absorbed by the dark-colored wall, the air is heated up. This facilitates the air circulation movement to extract the hot air and draw in the cool air to the interior (Fig 3.6). It can also act as cooling method. A case study focused on the same climate range shows the air temperatures can be lowered down by 2- 7 °C (M.S.Ahmed & M. ATTALLA, 2012).

Performance evaluation

To ensure a better outline, the technologies are evaluated in a Performance Index (Fig 3.10). The parameters are as follows:

Low Budget: The costs needed to implement the chosen technique.

Efficiency: The level of effectiveness the technology performs in terms of temperature reduction.

Implementation: The level of complexity of the physical implementation of the technique. (For example, brightening the building envelope is simpler than the construction of a solar roof).

Maintenance: The degree of maintenance costs and frequency of serving the technical equipment.

Stand-alone: The independency of the technique performance .

Due to indivdual circumstances of each location, the table facilitates the selection of the most suitable technology. It functions like a construction kit, where everyone can tailor its own adapted solution concerning pivotal criteria such as price oder level of implementation.

Before/After

3.9 Livable environment (Own compilation, 2014)

Conclusion

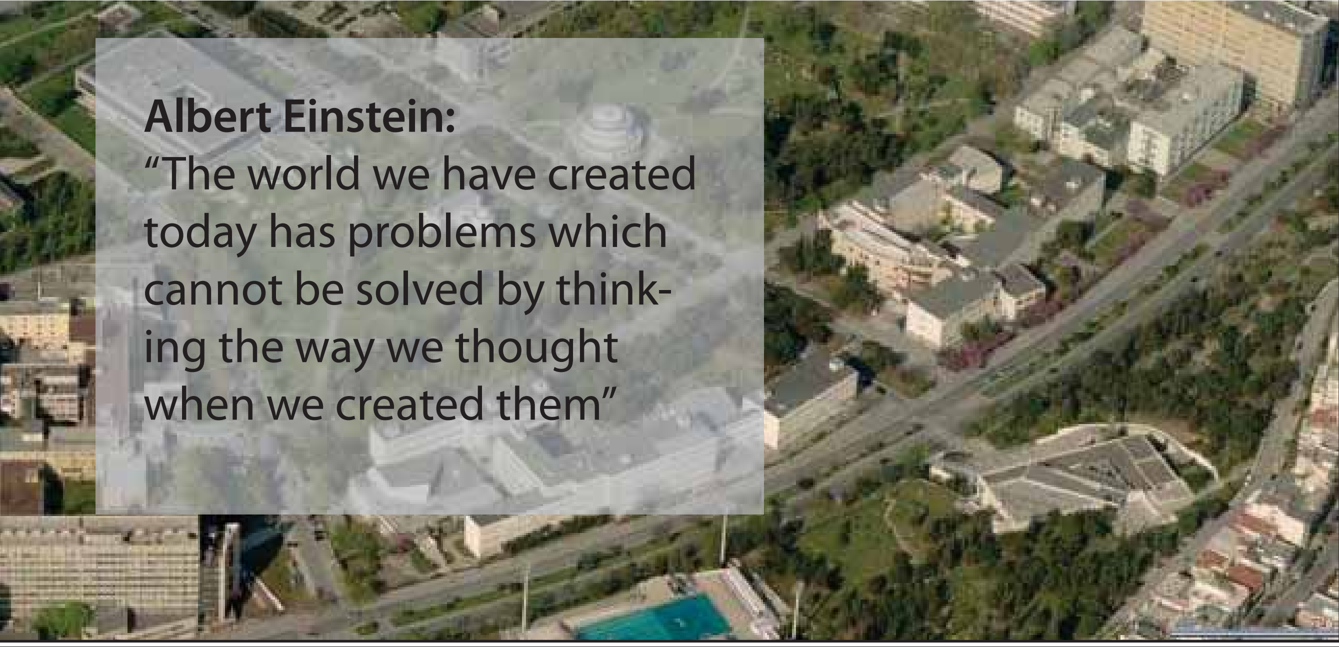
Passive cooling measures reduce consistently the energy use of buildings, turning it into a sustainable example to follow. Additional benefits are the low maintenance of passive techniques and therefore a reduction in costs as well as savings in energy expenses. A welcoming side effect is the valorized environment and the improved micro climate (Fig 3.7), which results in a more livable and pleasant environment (Fig 3.9).

Since the university is developing the idea of a sustainable campus, students' involvement is essential on every level. Hence, the awareness and multiplication of the measures throughout the city would be increased. This reproduction of techniques will enforce the relationship between the campus and the city to be strengthened and developed towards a sustainable future.

PERFORMANCE EVALUATION

Classification / Technique	Low Budget	Effeciency	Implementation	Maintenance	Stand-alone	Total
Landscape Ventilation	+			+	+	✚✚✚✙✙
Cross Ventilation		+		+		✚✚✙✙✙
Night Cooling	+	+	+	+		✚✚✚✚✙
Shading System		+		+	+	✚✚✚✙✙
Albedo Effect	+		+	+	+	✚✚✚✚✙
Wind-catcher		+		+		✚✚✙✙✙
Trombe Wall		+		+		✚✚✙✙✙
Solar Roof		+				✚✙✙✙✙

3.10 Performance evaluation, (Own compilation, 2014)



4.1 Aristotle University of Thessaloniki (AUTH, 2013)

Team 4: Sustainable waste management

Introduction

The city of Thessaloniki currently has a waste management problem. Although there are recycling bins throughout the city, piles of rubbish, mainly construction waste, are found throughout Ano Poli. The Aristotle University on the other hand, is experiencing inadequate waste management in the form of overfilled trash bins.

Waste analysis in Thessaloniki

In Thessaloniki, 616,000,000 kg of waste for the year 2006 was generated (Papachristou, 2009); to give this number tangibility, this is the equivalent of almost 12 Titanic’s (52,000,000 kg). The city contributed to 9% (414,000 tons) of the total amount of MSW (4.6 million tons) generated in the year 2000 for the country of Greece. Recyclable materials were estimated at 37.5% (155,250 tons).

Waste analysis in Aristotle University

From a total of 85,440 people, students and staff, 47,846,400 kg of waste was generated on campus; the equivalent of roughly 1 titanic. From a case study on school waste in Minnesota, waste streams are discovered for different uses such as classrooms, cafeteria, and hospital (Minnesota, 2010). Figure 4.2 shows the waste stream classifications, from which the total waste stream in AUTH has been generated. The top three categories of waste on campus are Paper, Bio-waste and Plastic. Topics for the sustainable waste management project will focus on paper and plastic, bio-waste is complemented by Team 7: Sustainable Mensa which is dealing with composting.

Vision

The vision towards a sustainable campus requires finding problems, a methodological approach and expected results. A main problem observed on campus was that there is no common goal towards sustainability. Additionally, there is no union between student organizations or communication between departments. The approach is to create awareness through seminars, workshops and classes. Expected results for the active participation in workshops and competitions are student unity as well as a greater sense of community and ownership. During the competitions, students will be expected to gather as much “waste” as they can such as plastic bottles or paper, to work towards ridding the campus of unneeded waste. Students will learn what sustainable waste management is and how they can play an active role in reducing, reusing and recycling.

Main objectives

The concept of Reduce, Reuse and Recycle started in the 80’s and is fundamental in sustainable waste management. Thessaloniki’s waste goes to one landfill (Papachristou, et al., 2009) and is not incinerated, enforcing the need to divert waste streams.

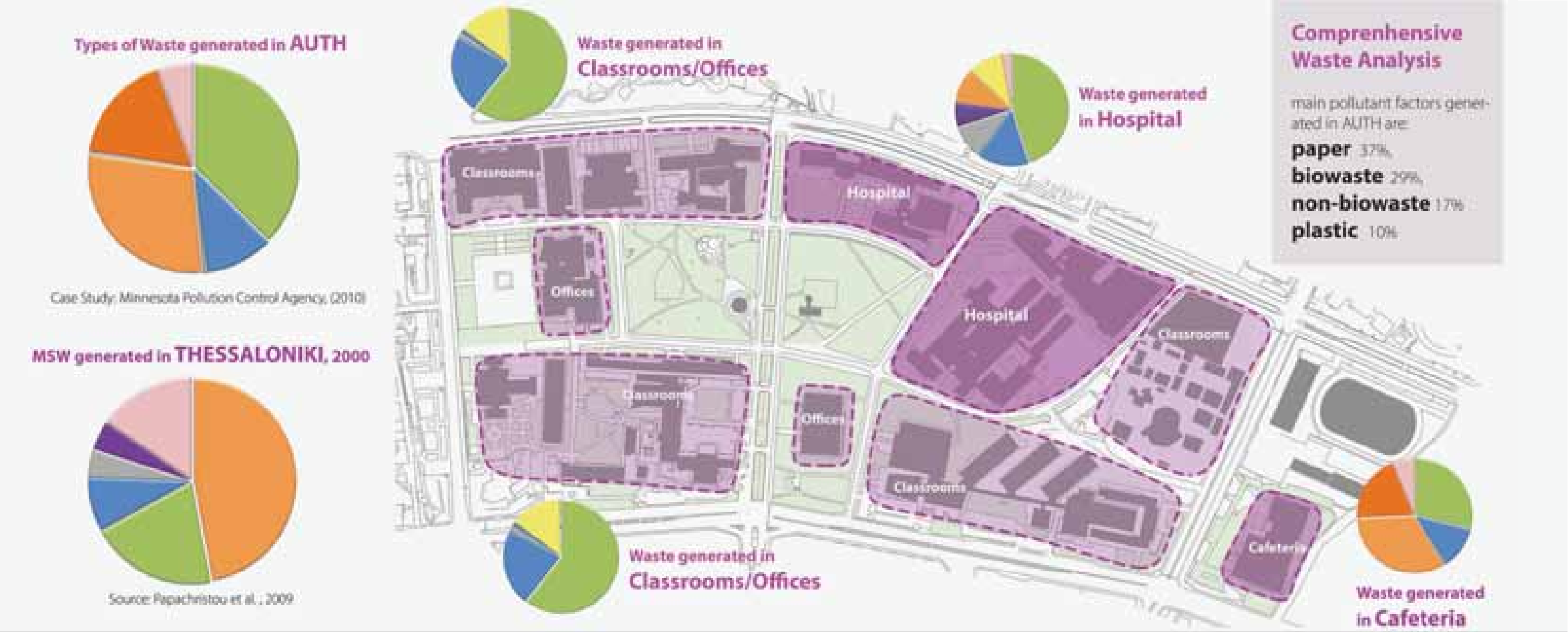
The main objective for reduction can be reached through diverting waste from landfills and turning it into useful products.

Reusing local items, such as bronze cans for plantation is a tradition in the city of Thessaloniki. The bronze cans provide an optimal base for the plants, and it is said among the locals, the bronze gives extra nutrients to the plants.

The goal of recycling can be achieved in a variety of ways, through selling the product to the local recycling plants or through up-cycling the products in the workshops. Up-cycling is an art that has been practiced for many decades. When an object is up-cycled, it is given a new purpose, for example an old juice carton can become a purse.

Approaches

Two approaches, each revolving around the 3 R’s, have been integrated within the project: Social and Educational actions. Social actions aim to reduce waste and implement sustainable practices while the Educational actions have a focus on bringing awareness through the seminars, workshops and classes. Each of these aspects has three phases integrated within them. Phase 1: Awareness which lasts around 1 year, Phase 2: Innovation which lasts around 2 years and Phase 3: Diffusion which is indefinite.



4.2 Comprehensive waste analysis in AUTH (Own compilation, 2014)

Stepping stones towards sustainability

Reduction goals

The goal for phase 1 is to have a 15% reduction, phase 2 a 30% reduction and phase 3 a 50% reduction. These reduction goals can be realized through a series of efforts based on case studies.

Stepping stones towards sustainabilty

The success of a sustainable waste management system in AUTH implies the inclusion of student participation and the community. For that reason the project proposal is administering the integration of social and educational actions as stepping stones towards sustainability. The development of these two actions includes the implementation of sustainable best practices in different scales and throughout different phases.

Social actions

Since the main goal of the project is to reduce waste on campus, best practices on sustainability will be applied throughout the entire university. In order to implement the social actions, the inclusion of the 3R's principle is fundamental in all phases.

Social Actions

Phases	Goals	Best Practices	Results
1 Awareness (1 year)	reducing paper waste	reusing cups	paper waste reduction by **1.5%** per year
		sustainable paper practices	paper waste reduction by **12.5%** per year
2 Innovation (2 years)	reducing paper and plastic waste	sustainable paper practices	paper waste reduction by **12.5%** per year
		plastic bottles competition	plastic waste reduction by **20%** per year
3 Diffusion (indefinite)	creating sustainable business	second hand market	waste reduction from landfill by **25%** per year
		online store	providing reusable goods

4.3 Social actions goals (Own compilation, 2014)

Phase 1: Awareness

This phase aims to teach sustainability and encourages students to take action and participate in the project. As a result of previous research, the main waste generator on the AUTH campus is paper. Therefore, practices to be applied will reduce paper waste by 15% during the first year. One of these practices is reusing cups at coffee shops on campus, which will reduce paper waste by 1.5% per year (Starbucks, 2012). Students will be compensated with a discount when they bring in personal tumblers or mugs. In addition, applying sustainable paper practices on campus will reduce waste by 12.5% per year (Minnesota Office of Environmental Assistance, n.d.). These practices are double sided printing, using recycled paper, using e-mails as a communication mean, creating flier friendly zones, and using social media to reduce the use of flyers.

Phase 2: Innovation

Second phase focuses on reducing paper and plastic waste on campus, which is estimated to reduce waste by 30% in approximately 2 years. At this stage, the sustainable paper practices will continue to ensure the paper reduction by another 12.5% yearly. As plastic is another main pollutant factor on campus, the practice to be applied is the reduction of plastic bottles by 20% per year (Clean Air Champions, 2011). To realize this practice, competitions for collecting plastic bottles will be implemented between faculties. By creating fun activities, students are encouraged to participate and can also be rewarded with awards.

Phase 3: Diffusion

Third phase aims to transform waste into a valuable resource by creating a sustainable business that will generate educational, environmental and economic benefits. Implementing this action will divert waste from the landfill by 25% annually. Second hand and upcycling markets will be created on campus, which can also be advertised in an online store. Students will have the opportunity to start a program that diverts reusable goods away from landfills by collecting, upcycling when necessary and selling them (Post-Landfill Action Network, 2013).

4.4 Interdisciplinary courses for sustainability (Own compilation, 2014)

4.5 Future student participation towards sustainability (Yi Lu, n.d.)

Stepping stones towards sustainability

Educational actions

Understanding sustainability is necessary to achieve the main goal of the project, which is waste reduction on campus. Educational actions focus on integrating student participation and the community throughout different phases.

Educational Actions

Phases	Goals	Best Practices	Results
1 Awareness (1 year)	understanding sustainability	learning 3R's principle in seminars	getting aware
		collaborations	engaging university community
2 Innovation (2 years)	learning and practicing sustainability	creating workshops	sustainability practices
		waste collection competition	encouraging student participation
3 Diffusion (indefinite)	creating sustainability	mandatory classes	integrating the community
		upcycling market	creating a new life style

4.6 Educational actions goals (Own compilation, 2014)

Phase 1: Awareness

First phase aims to teach sustainability by implementing seminars and integrating collaborations at the first year. The seminars focus on understanding the 3R's principle, and applying practices into waste separation. Collaborations between AUTH and other educational institutions are fundamental. The ECO-AUTh program and faculties can include professional staff as guest speakers by teaching the university how to handle sustainability issues. Furthermore, the use of social media is also vital because it can create a junction between ECO-AUTh and the students, as well as encourage participation.

Phase 2: Innovation

Second phase focuses on the inclusion of innovative programs to encourage the university community to participate. This phase lasts 2 years. At this stage, the seminars will become workshops and waste collection competitions will be implemented. Workshops focus on reusing and upcycling materials to be used on campus, such as recycled plastic bottles to improve the irrigation system, or upcycled tyres for greeneries. In addition, student participation will be possible through competitions between departments to design trash bins and collect waste on campus.

Phase 3: Diffusion

Third phase aims to create mandatory classes which focus on sustainability issues and provide ideas for increasing the economy on campus by making an upcycling market. At this stage, workshops will become mandatory classes, which aim to ensure the behavioral changes on campus by encouraging community service. Through integrating students into the community, the university will have the opportunity to engage citizens and ultimately become a role model for the city. Moreover, students may create upcycled products that can be exhibited on campus or also sell them in the upcycling market. This activity will create a sustainable business by providing funding for the development of the university.

Merging actions for sustainability

To ensure project success, interdisciplinary courses based on sustainability fundamentals (water, material and energy) will be covered, see Figure 4.4. Participants will get certifications as an incentive which can be useful for their professional careers. AUTH has implemented the successful project "Use Efficiency" to motivate students on environmental issues through attending summer courses focus on sustainable energy issues (Papadopoulos, n.d.). Social and educational actions will engage students to be an active part in the university, as well as in the city.

Sustainability is a process to be learned and integrated within the city. Research on student participation programs in developing countries such as Ecuador has shown that students are the key factor to help the community. They must attend mandatory courses focus on environmental issues, health, literacy, citizen security and community service, taught in 200 hours in 2 years in order to graduate from high school (Ministerio de Educación del Ecuador, 2012). No doubt, student participation is the solution towards sustainability.

4.7 Aristotle University of Thessaloniki (AUTH, 2013)

Sustainable management

Potential partners

In order to realize this project, it is important to have a structure that will lead users. This section will deal with the potential partners that can play a fundamental part in this project in the long term. Any project needs aid from professionals, experts and also the integration of the community, most of these potential partners exist in Thessaloniki and some are located outside but are currently in collaboration with AUTH.

ECO-AUTh (n.d): The office for the AUTH Sustainability, will integrate within seminars, classes, workshops, actions such as waste separation and collection. Its web portal will help introduce the project. Additionally, it will handle the supervision of sustainable campus initiative fund. Generally, the management of the whole project will be done by ECO-AUTh.

The following three partners will help integrate the community with the project through collaboration with the workshops, seminars and exhibitions. Their online portals will also work as an information sharing platform and introduce the program goals.

Parallaxi (2013) is a free-press magazine in Thessaloniki.

Thessalonitas (2013) are a group of individuals working towards creating a sustainable environment.

Turn off and log in (2013) is a network of students, professors, staff members and citizens with the common goal of turning the Aristotle University into a more environmentally friendly and sustainable campus.

International sustainable organizations such as:

The Oldenburg **Centre for Sustainability Economics and Management** (CENTOS), (2013) is dedicated to work on social change towards sustainability. Currently, this university is engaged with the HCU University and has invited students to participate on a workshop which focuses on sustainability issues.

EUA (European University Association, n.d.), has key priorities towards the internationalization of higher education and research.

These collaborations will help AUTH reach its goal of being sustainable, through learning from others. Also, knowledge sharing helps the current professionals on site to expertise.

Student funding initiative

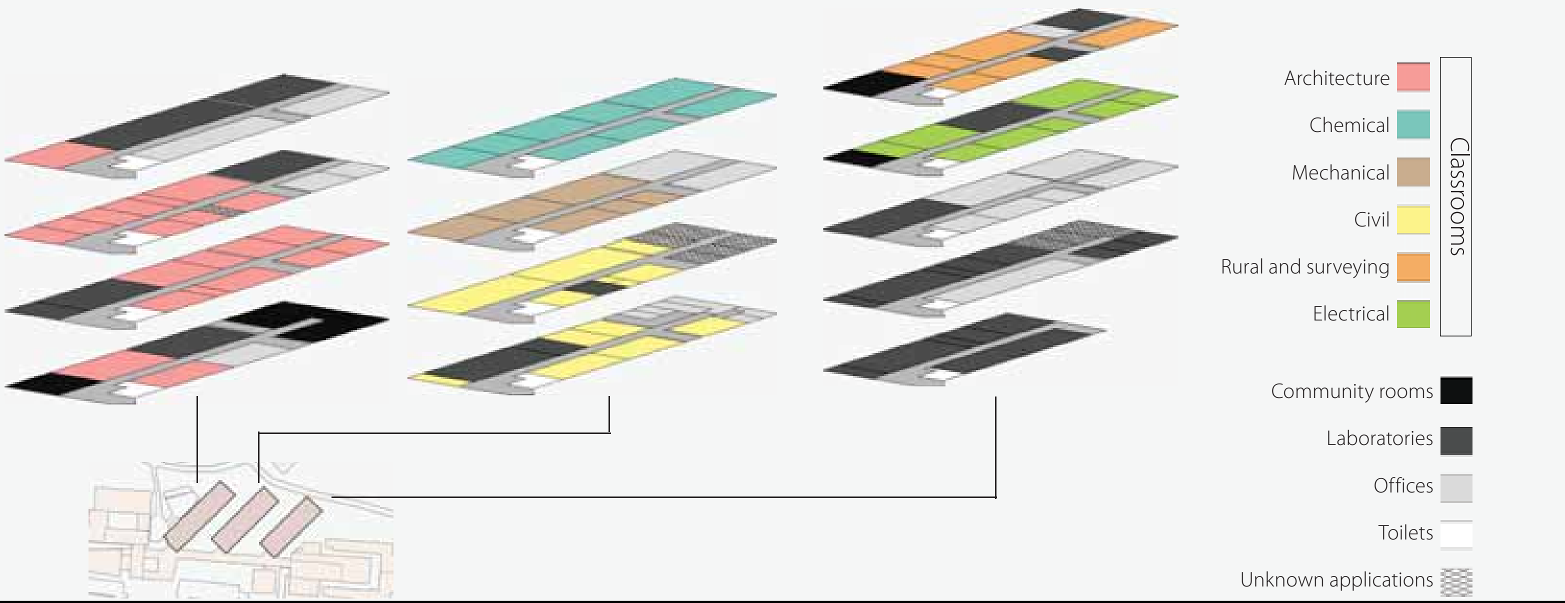
Utah University has created the Sustainable Campus Initiative Fund, which makes students pay $2.50 per semester to develop sustainable projects on campus. This system is managed by the sustainable resource center (sustainable office of the campus).

The university has more than 3000 students and the income from this funding system is more than $7000 per semester, which can be used for the university development (The University of Utah, 2014).

This concept can be adapted to AUTH due to its limited budget. This funding system guarantees that projects will not have an economical obstacle. This system will start during the first phase of the project, with a contribution of €2 per student per semester. In this case, at the beginning of the second phase, AUTH will have more than €300,000. The needs at the second phase such as awards and workshop equipment, as well as the third phase needs, employees and market management, can be covered with this funding system.

Conclusion

Aristotle University of Thessaloniki has a great potential in becoming a sustainable campus. Even if the current situation towards sustainability is not adequate, integrating the students and the community in AUTH will help attain its goal of becoming a role model to its city. Waste is a valuable resource if treated properly, it has a potential to produce income. This project aims to change the perception towards waste. The sustainable movement starting in AUTH will create a sustainable waste management system on campus through integration of reduce, reuse and recycle practices. Moreover the educational progress of AUTH will create a new sustainable standard for future generations.



5.1 Space use in faculty of engineering (Own compilation, 2014)

Team 5: Recommissioning - resource optimization

Analysis of the current situation

Europe is immersed in a financial crisis and public institutions in Greece suffer from this situation in particular. The Engineering faculty in AUTH, the focus area of the project, is affected by these circumstances. Layoffs amounting to around 30% of the staff, professors, administration and maintenance were made (K. Katsampalos, personal communication, November 06, 2013). The current situation at the university shows a lack of cleanliness, operability of installations and overburdened courses.

The Engineering faculty is hosted in three wings shown in figure 5.1. Different schools make use of a particular floor or floors within the building. The organization and schedules are made by each school individually, without communication.

The analysis of the usage of classrooms revealed that during peak times, generally in the mornings, the occupancy of the classrooms never reaches 80%. Considering the class hours (Monday to Friday from 8 am to 9 pm) the percentage of occupancy of a single classroom is on average 30%.

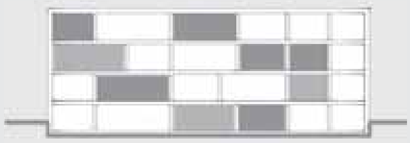
Concept : Recommissioning

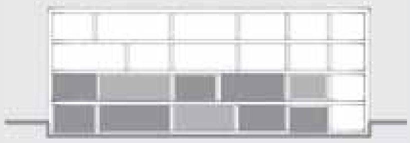
Currently rooms are not occupied continuously, thus in winter, the heat in a room is wasted during breaks.

The approach consists of optimizing the schedules so that the number of breaks in the classrooms is reduced. As a result, less heat would be wasted and less heated space would be needed in total. Therefore, it is proposed to remove the existing physical division between the different engineering schools within the three wings. The procedure assigns different classrooms to the existing courses, taking advantage of the resulted flexible designation of classrooms when the boundaries between departments are discarded. The project focuses on the winter semester. This sort of resolution is called recommissioning.

Recommissioning is defined as a re-optimization process for existing buildings that improve a building's overall performance by optimizing energy efficient design features and assessing equipment performance (Government of Canada, 2012).

The distribution and use of the heat is improved when the continuous and constant use of rooms aretaken into consideration. As a result, less space is needed and better maintenance for the frequently used spaces is achieved, as an extra benefit, an interdisciplinary learning atmosphere is created.


5.2 Actual use of classrooms (Own compilation, 2014)


5.3 Proposed use of classrooms(Own compilation, 2014)

Working process

During the excursion in Thessaloniki, the project team collected the floor plans and schedules of all the schools from the engineering faculty. Further, these data were digitalized and the current situation was analyzed. The first black and white graph on the head of the following page (5.4) shows the current occupancy of the classrooms in an abstract manner. The rows refer to the 46 classrooms and the columns to the timeslots from Monday 8 am to Friday 9 pm. A black pixel represents that a course is taking place in a classroom, while the white pixel depicts a vacant classroom.

Afterwards, the new schedules were created with the aim to use classrooms more continuously. The location of the classes was changed, while the time remained the same. This was done considering the sizes of the classrooms, which previously were classified as S, M and L. Priorities were defined for the use of rooms. Favor is given to the south oriented rooms in order to make use of solar heat gains. Due to the poor daylight situation, basements were less preferred. Top floors are chosen last, since they have the highest share of the building envelope. In this initial re-commissioning step, 9 rooms become fully unoccupied and available. It is proposed to offer 4 out of 8 sanitary rooms, which could then be maintained in a sufficient way.

5.4 Current schedule matrix and reorganized schedule matrix (Own compilation, 2014)

Recommissioning - resource optimization

Potential use for spared spaces

The available rooms resulting from reorganizing the schedules in the first stage can be attributed towards other usage. However, as a public entity, it is not possible for the university to rent the rooms. Therefore, applications are proposed according to their heating requirements:

1. Physical activities adapted to lower room temperature –decrease in heating demand (5.7). Dynamic activities like drama workshops or yoga courses, either held by university or related institutions. Other proposals such as second hand markets and bike repair shops can enhance the sustainable culture in the AUTH community. However, it is important to choose quiet activities in order to respect the lectures held in the building.

2. Activities with normal comfort temperature – win-win situation. For example, by offering free rooms to private language schools, affordable classes can be provided to the students. In addition, newly graduates can make use of the rooms to start up their professional activities. In return, they do not only offer valuable services, but also the commitment to enhance the conditions of these spaces.

In order to optimize the usage, not only the available rooms, but also the breaks in between the courses are supposed to be utilized. Thus, an online system is suggested to monitor all the schedules. This system allows users to know which room at which period of time is available. Users can book a room via the internet for group works, conferences and meetings (5.5).

Potential energy saving

Current situation

The basic heating load during the class period of the winter semester is first simulated. It is calculated that the heat demand of an average classrooms (113.5m^2) is 3.63 kWh (effective energy) per 1 hour of class use, which includes transmission loss and ventilation loss through the building envelope. The lower comfort level temperature of 20°C indoor against outdoor average 9.78°C (EERE, 2013) is used in this study.

As visualized in 5.6 - current situation, the classrooms are heated from 8am to 8pm (Kastrinakis, 2008). Considering the heat demand in order to preheat the rooms in the morning, the current energy demand was calculated to be 379 MWh which equals 72kWh/m^{2}a. This number is based on the assumption that out of 100% net energy, 40% of the net energy is lost within the heating system (Dockrill & Friedrich, 2001). The remaining 60% is defined as effective energy.

The information that is stated for the costs and CO_2 emissions are based on a gas price of 0.077 €/kWh (Eurostat, 2013) and a CO_2-factor of 0.237 kg per kWh of gas (Garg, Kazunari & Pulles, 2006).

Scenario 1

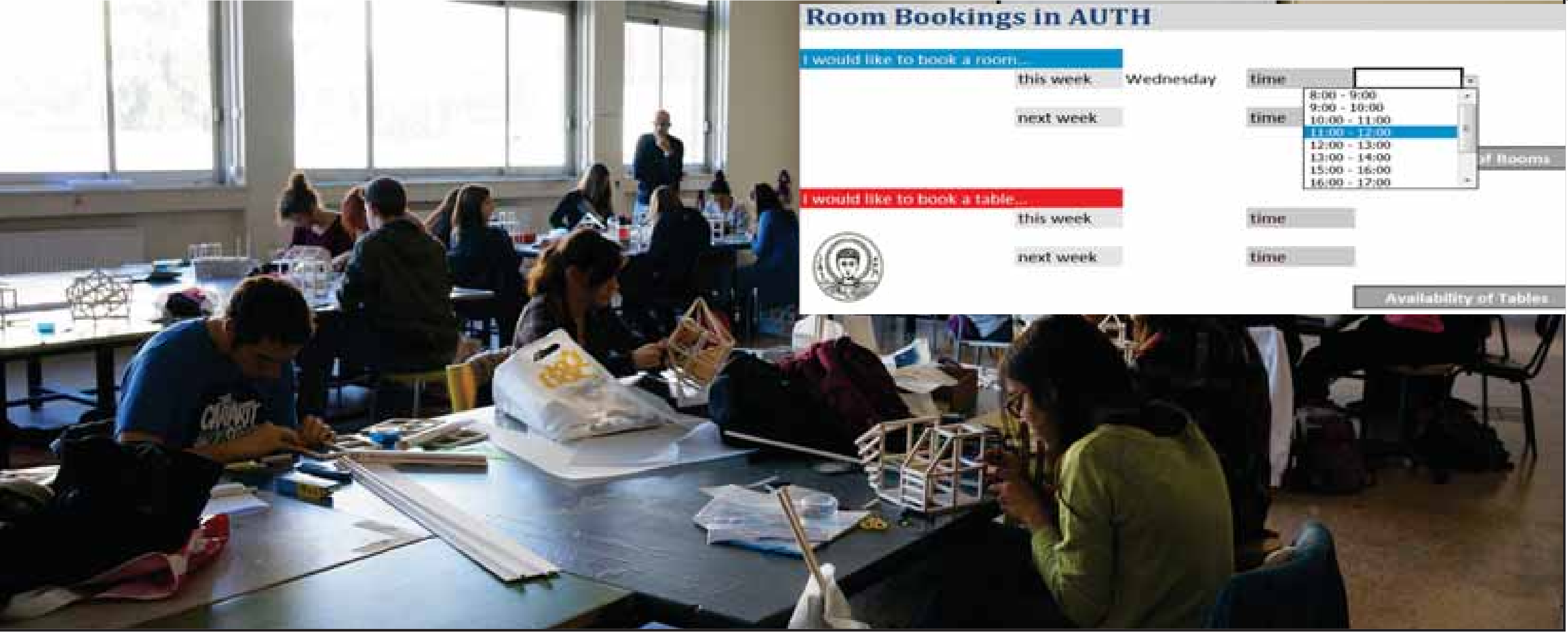
The operation of radiators is adjusted to the actual lecture hours of each individual classroom, with the help of programmable thermostats. This leads to savings upon the time discrepancy, at the beginning and end of the day, as well as savings during the breaks. Savings during the breaks are subtracted with the preheating demand, which are determined by the lower temperature after certain time intervals. Because the power of heat loss is proportional to the temperature difference between indoor and outdoor, the indoor temperature decreases slower over time. As a result, it is notable that the savings during the breaks are drastically increased at longer periods. For example, an hour break saves 0.05 kWh in an average room, while 0.19 kWh and 0.43 kWh are saved during a 2 and 3 hour breaks respectively.

Scenario 2

This scenario shows the saving due to the new created schedules. Fewer breaks and the fact that 9 rooms do not need to be heated lead to 17% more savings than in the first scenario which equals around 2 000 €.

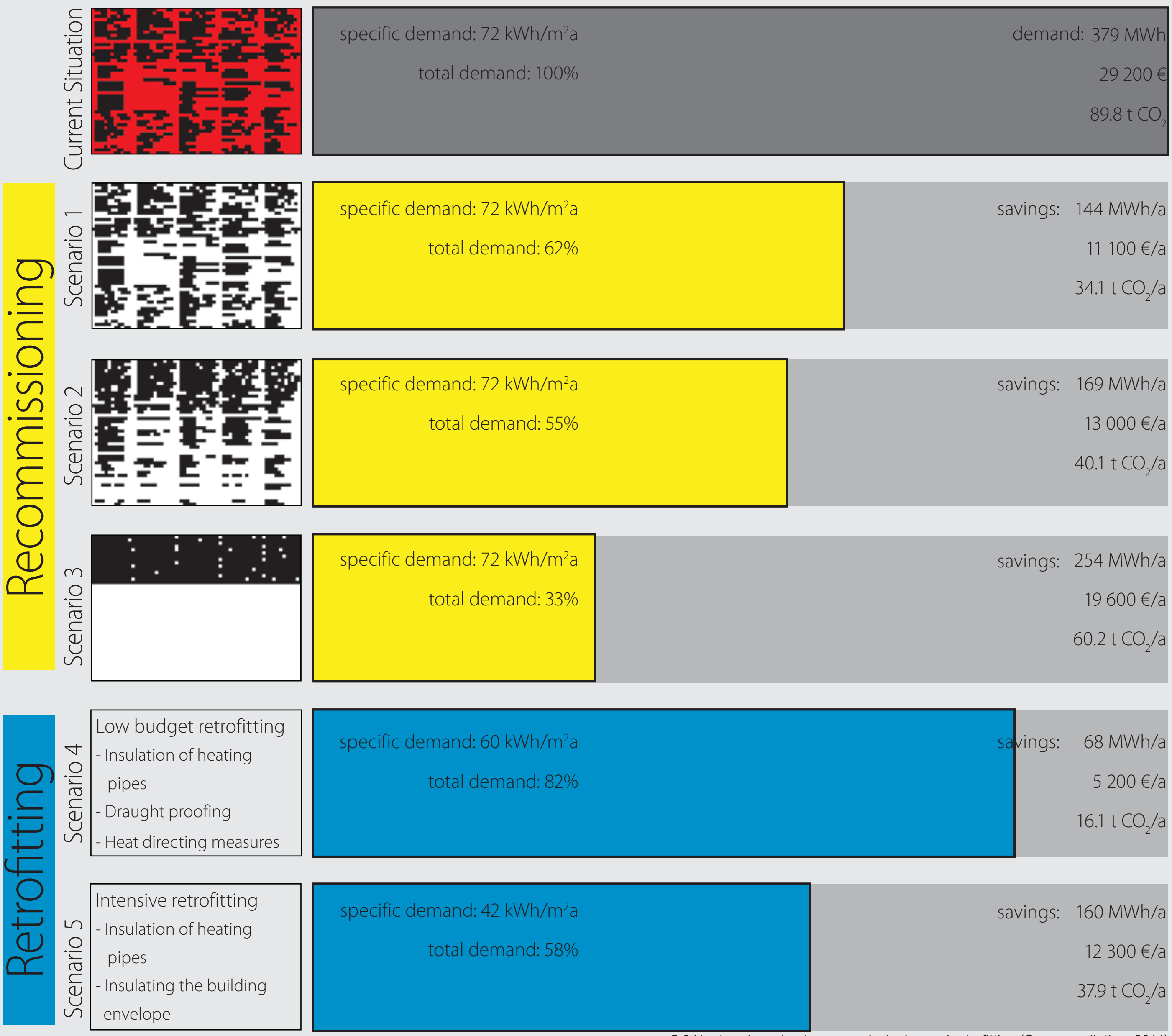
Scenario 3

The optimized schedules from Scenario 2 are created with some limitations: Courses are just moved within their timeslots and classrooms with the same sizes. In an ideal scenario, class times are changed, so that classes take place evenly throughout the day. Further, the number of participants is known so that rooms could be chosen accordingly. The potential of this vision if carried out campus-wide is presented in this scenario. Given to the fact that



5.5 Interface to control and monitor the occupancy state of the roooms (Own compilation, 2014)

Recommissioning - resource optimization



5.6 Heat savings due to recommissioning and retrofitting (Own compilation, 2014)

5.7 Potential Uses for spared spaces (Yoga with Mischa, n.d; Sukses-Kerja-Usaha, 2013; Mapolis, 2012; University of Brighton, 2014; Accademia Leonardo, 2009; swords, 2014)

the first three scenarios do not rely on embodied energy or big investments, the results are remarkable.

Scenario 4

In order to compare the effectiveness of the recomissioning and retrofitting measures, the following two scenarios show the potential heating saving if applied on the current situation, meaning without changing the operation time of the heating system.

Savings due to a low budget retrofitting are shown in this scenario. The measures applied consist of insulating heating pipes which reduces 9% of the net energy losses (Armacell, n.d.). In addition, draught proofing of the openings and heat directing measures, (installation of a metal foil behind the radiators and a shelf above) are proposed, reducing by 14.7% of the effective energy demand. These actions bring an annual savings of 5 200 €.

Scenario 5

The last hypothesis determines the savings achieved through intensive retrofitting. This action consists of improving the building envelope. The U-values to achieve are taken from KENAK, which stands for regulation of building energy efficiency in Greece and sets the minimal requirements (5.9). This scenario implies savings of 12 300 € per year.

U –value (W/m²K)	Actual situation [1]	KENAK [2]
Windows	5.05	2.80
Walls	2.40	0.45
Roof	0.38	0.40
Ground Floor	2.40	0.75

[1] Theofilos Papadopoulos, personal communication, Evaluation of energy efficiency & improvement proposals for the Hydraulics building, November 2, 2013)

[2] (Greek State Journal, 2010)

5.8 Current and required U-values (Own compilation, 2014)

Action Plan

Given the current economic context in Greece, a practical action plan is made based on the different scenarios. Comparing the potential of the retrofitting with the recommissioning, due to the low expense and capital investment of the recommissioning, these measures are to be carried out with priority. The savings from the initial actions are used for further commissioning action, so as to achieve long-term financial sustainability.

Regarding the current heating system operation, implementing thermostats and reorganizing the schedules across the departments are proposed as immediate actions. In a further step savings are invested in a low budget retrofitting. For the mid-term, an intelligent facility management system, which operates a compact, campus-wide schedule, will reduce the energy consumption and cut down the maintenance cost.

Conclusion

This project dealt with optimizing the use of the existing resources without further investment in order to conserve energy and enhance the comfort situation regarding cleanness and maintenance. In other words; making the best of the current situation. It is prominent that simple measures for enhancing the heating system operation have great effect on energy conservation, especially in poor insulated buildings. Reorganizing the schedules across departments reduces heating cost significantly, meanwhile it enhances the maintenance. In this sense, a campus-wide intelligent facility management system is proposed for the near future. Finally, the project suggests building recommissioning to be carried out periodically, in order to optimize limited resources.

Action Plan

1. Step: Scenario 2 — Immediatly

2. Step: Scenario 2 + 4 — Short Term
194 MWh
14 900 €
46 t CO_2/a

3. Step: Scenario 3 + 4 — Mid Term
277 MWh
21 200 €
65.7 t CO_2/a

4. Step: Scenario 3 + 5 — Long Term
322 MWh
24 800 €
76.3 t CO_2/a

Switch to renewables — Long Term

5.9 Energy action plan (Own compilation, 2014)

6.1 Current library building (Own compilation, 2013)

Team 6: The green library, towards a sustainable pilot project

Introduction

The library building was chosen out of various buildings found on campus as it is one of the most commonly frequented buildings by students from multiple disciplines. This fact that this building is common for everyone will inspire students from disciplines other than the built environment, not only learn from the proposal but also to participate actively in developing it further.

SWOT analysis

A SWOT analysis was conducted in order to determine the strengths, weaknesses, opportunities as well as threats on the campus and to evaluate the interventions to make positive changes.

Strengths

- The people are welcoming and open-minded
- Social will and contribution is extensive from the public and students which provides a large room for interventions within the campus
- The climatic conditions of Thessaloniki allow for complete utilization of various forms of renewable energy

Weaknesses

- Unawareness about sustainability and disrespect towards environment
- Stagnancy in the development due to economic crisis as well as lack of administrative resources in main office departments
- Inadequate provision of garbage bins and no separation of garbage except segregation of batteries
- Wastage of fresh-water due to lack of maintenance
- Utilization of air conditioning devices consuming large amounts of energy
- Under-utilized areas and large distances and no means of internal public transportation within the campus i.e. buses
- Disregard to the disabled

Opportunities

- The existing condition of the university provides tremendous scope for future improvements and energy interventions
- Old dilapidated buildings can be repaired and renovated extensively.
- Opportunity for public participation and for innovation in the campus post financial crisis
- The crisis may act as a stepping stone to prevent excessive energy usage and become sustainable

Threats

- Economic crisis in the country and insecurity within the campus
- Lack of maintenance of green areas as well as unhygienic sanitary conditions
- Large energy losses due to buildings being in a state of disrepair and also due to inadequate and inefficient shading devices
- Lack of maintenance of new interventions to improve the condition on the campus e.g. the bicycles
- Inadequate knowledge of the universities condition by the government

Strategy and vision of the project

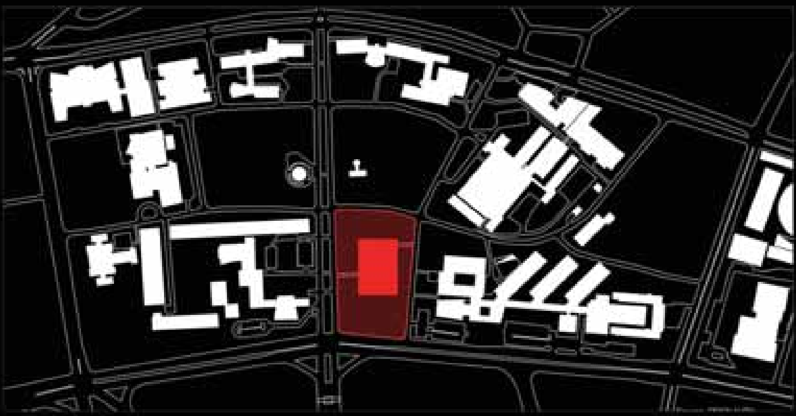
The whole project has been envisioned in three stages pertaining to the present economic condition as well as the social constraints accompanying it. The methodology is a "Whole-to-Part" process which will encompass all aspects of urban as well as architectural scale. The primary reason for consideration of this approach was the unaware and demotivated participants which in this case is the student and staff population. We realise the need for holistic integration of the society to make this project a success at an overall level.

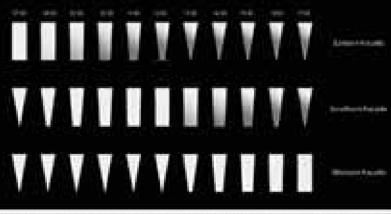
Three steps toward a sustainable campus

The project will be divided into three phases anticipating the timeline from the current situation till the point in time when Greece is out of financial crisis. The timeline is not rigid to certain number of years, it rather can be executed independently based on the financial situation.

Phase 1

A first phase is planned for the present situation and can be executed





6.2 Top, Library location (AUTH,2013) 6.3 Down Left, Facades projection; Down Right, Facade shading system (Own compilation, 2014) 6.4 Project strategy (Own compilation, 2014)

with zero financial support. These are the social interventions that will create awareness and act as the first step towards a sustainable campus. This step includes interventions of promoting awareness and reducing energy consumption under the broad topic of sustainability. These have been divided into voluntary work and university initiated work.

For voluntary work, proposals include educating students through self-organized discussions, moot courts and street plays about sustainability to induce a positive change in the existing lifestyle for a better future; create an organization to accomplish tasks like cleaning classrooms, toilets and common spaces and maintenance of green areas; switching off lights, computers and appliances consuming energy; proper separation and disposal of garbage.

The university initiated interventions include proposals like establishing mandatory seminars, classes and workshops for students and staff to promote energy saving measures; incentives to students like awarding credit points; integrate the university at an international scale within a network of sustainable campuses to strengthen the whole project and encourage participation; addressing user occupancy -time v/s use as an energy saving measure; reduce or compress or change the time of use of the buildings.

Phase 2

The second phase is a macro-scale development involving the whole campus of AUTH. The major areas of consideration are transportation which involves making the campus accessible by green transportation measures such as pedestrian and bikes, as well as for the disabled; maintenance of green areas; flood mitigation measures; rain water harvesting and water management at a whole campus level; biogas energy production for the cafeteria; energy efficiency by management of building occupancy and insulation of building; increasing comfort by reducing solar gains through installation of overhangs and solar shading devices.

Phase 3

The third phase is the primary focus in this project. This is a micro scale development just focussing on one building as an attempt to make it into a pilot project for the university. The main concept behind the intervention is to make the existing building into a completely sustainable one. The target principles for a sustainable library are zero CO2 emissions, 100% on-site renewable energy, wastewater management, optimum comfort level through heating and cooling, provision of natural ventilation and natural light. After the culmination of phase 3, there will be room for interventions around the library for landscaping and other efforts.

The library as a pilot project

The library building is used not only as a tool for information but also provides a peaceful, quiet place with a friendly environment that allows students to focus on their work. It will act as a pilot project where different energy interventions take place in order to minimize the energy demand and consequently the bills associated with the energy consumption. It will act as a reference building from which other buildings in the future may take and apply the principles in order to become more energy efficient.

The current library building

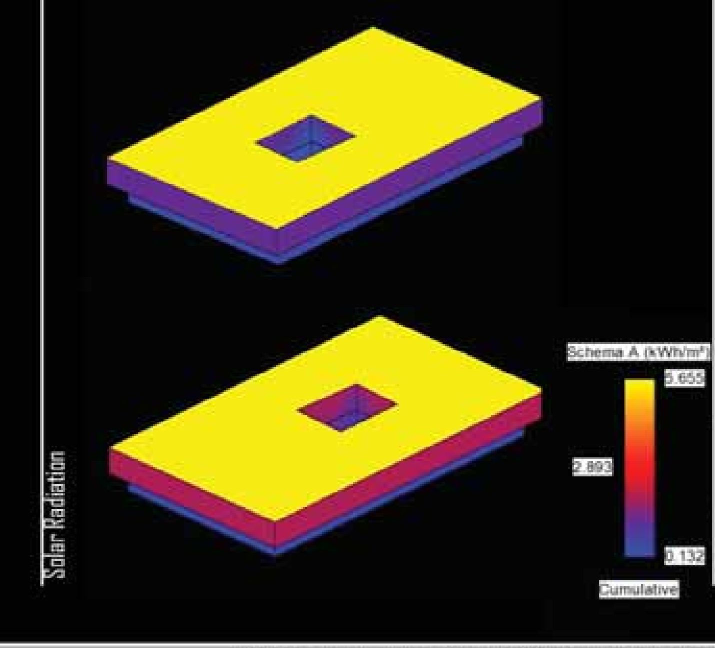
The existing library is situated with its long axis running along Northeast and Southwest. It features a strong influence from the French architect Le Corbusier. Its use of unplastered concrete is evident throughout the entire building; it has large window surfaces (curtain wall system) and protective slats (vertical shading system) on the exterior façade. Also, a very small void/courtyard is found in the interior. The library consists of spaces for reading, as well as a computer pool.

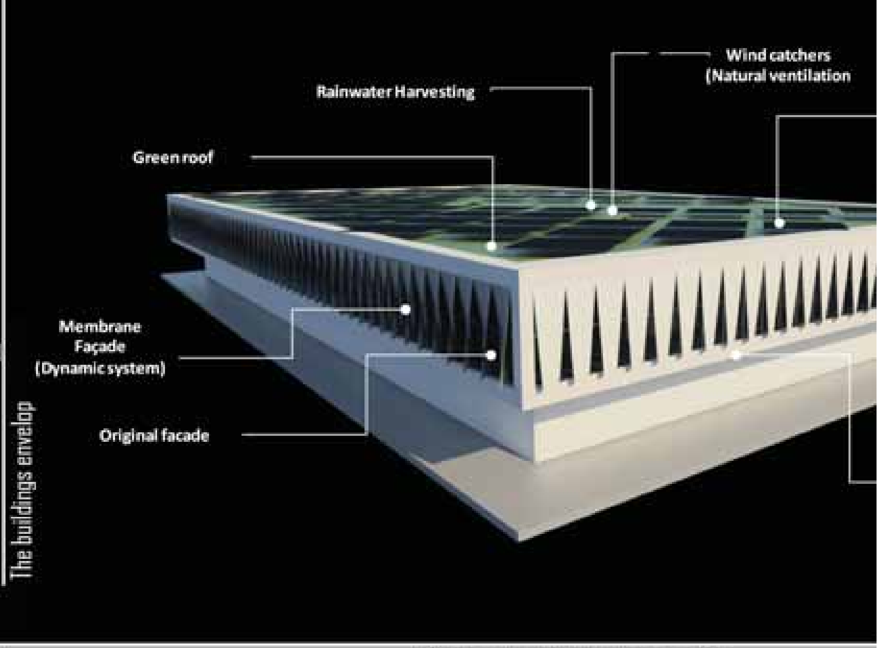
The facades are not adequately shaded, therefore during summer, the heat gains are enormous resulting in an uncomfortably hot environment. The courtyard is not situated in the centre but rather more towards one side in the building and is very small hence, not optimal for cross-ventilation in proportion to the dimensions of the whole building. The windows are of single glazing with inadequate insulation.

Analyzing the urban context

Wind analysis

According to a local weather station in Thessaloniki, the yearly





6.5 Solar radiation analysis, (Autodesk & Own compilation, 2014)

6.6 The proposal (Own compilation,2014)

The green library, towards a sustainable pilot project

average prevailing wind direction is Northwest. However, a detailed analysis of wind shows that the wind direction is changing according to the season as well as to the time of the day. This is due to the local conditions of Thessaloniki, where the Mediterranean Sea plays an important role in terms of pressure and temperature difference between day and night.

During winter, the prevailing wind comes mainly from East and Northwest; in spring, from Northwest, Southwest to Southeast whereas in summer time, the wind flows from Northwest and West direction; and finally in autumn, from the Northwest direction. In addition to these differing seasonal winds, for efficient natural ventilation; the influence of the sea breeze and land breeze on the local wind has to be taken into consideration. For instance, during summer, the prevailing wind direction is mainly NNW at night, NW in the morning, WSW in the afternoon and NW-SSE in the evening.

For the calculations, the optimal consideration for the wind direction therefore has been the peak time of use for the library building i.e. morning to noon and noon to evening.

Solar radiation

The Mediterranean climate of Thessaloniki is very warm in summer with the solar radiation reaching its peak at 1580 kWh/m²a. This increases the heat gains in the building, thus, resulting in high cooling demand. An analysis of the existing facades indicates massive heat gains during summer leading to an uncomfortable environment (figure 6.5). Therefore, the solar shading system in the facades has to be redesigned to enhance the energy performance of the library.

The green library, concept

The proposal of the Green Library is based on the concepts of user comfort, energy consumption and water efficiency. The refurbished library aims to be a pilot project in the AUTH campus. The proposed design will enhance the energy performance of the building by providing a comfortable environment through moderation of aspects of temperature, lighting, ventilation and protection from glare by re-modelling the building's envelope. This is being accomplished by taking into consideration two main elements - the roof and the facades based on the fact that the maximum solar gains are from the flat roof and the glazing on the facade as seen in (figure 6.5).

The facades

Shading system and day-lighting

The building requires adequate daylight to increase user comfort. However, increasing the glazed area will affect the energy demand of the building as the existing shading system is insufficient.

Therefore, the proposed shading system is an envelope consisting of panels made of a light membrane, which is a dynamic rotating system tracking the sun-path at an hourly basis. This is the first system designed to provide optimum shading in synchronization with the movement of the sun throughout the day (figure 6.6).

The roof

Rainwater harvesting and natural ventilation

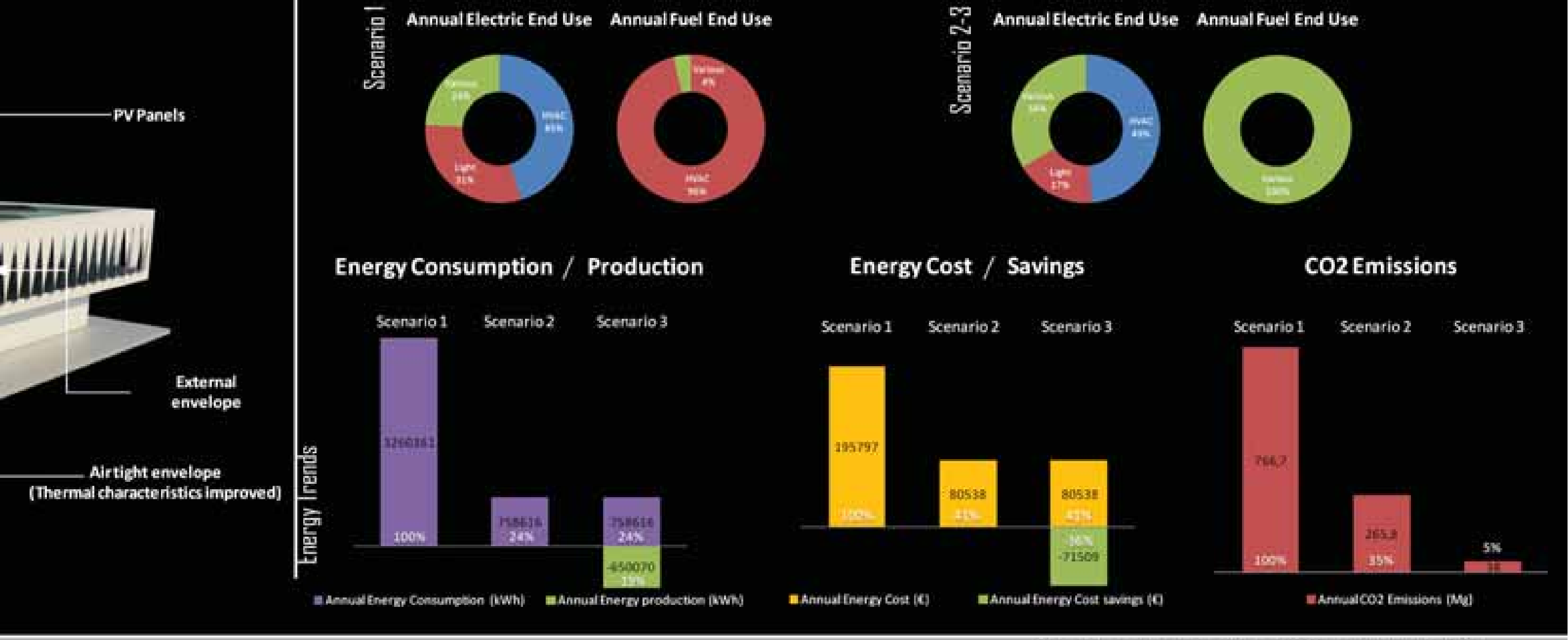
The second element enhancing the optimization of the building is the roof. The proposed roof is a combination of wind catcher and green roof to reduce the heat gains, promote wind penetration, enhance rain-water and energy harvesting through Photovoltaic panels.

The large surface area of the roof will be designed as a green roof considering the high precipitation in Thessaloniki during winter. This water can be recycled to be used as grey water and in landscaping thus, completely eliminating the demand for external water sources (except potable) for this building.

Natural ventilation is being promoted so that the building can benefit from the strong winds on site thereby substantially reducing the cooling demand of the building in the summer season.

Considering the width to depth ratio of the existing building, cross-ventilation is not possible. Therefore, the concept of stack ventilation (Baker, 2014) is proposed which takes the advantage of pressure difference. The wind is captured and channelled from the roof, which then penetrates through the building, finally escaping through the windows.

As the wind direction fluctuates, the wind catchers will be of a



6.7 End use energy flow (Autodesk & Own compilation, 2014)

cube form situated on top of the roof. This shape allows for optimal capturing of wind throughout the year. As a library building, the air change rate considered for the energy calculation is 4/h (The Engineering Toolbox, 2014).

Energy trends

The rationality of the refurbishments can be validated by measuring the difference in the energy consumption, comparisons between emissions of greenhouse gases of the existing building and the proposed as well as the resultant financial savings. The process of energy calculation follows three stages or scenarios to document the difference between each as discussed further.

Since there was no data available for the existing building, assumptions were made by developing a virtual model in 3d, by using the BIM technology (Autodesk, 2014). This model contains all the parameters that allow the energy simulation such as thermal properties of materials, building orientation, local weather data, building use and occupancy. These aspects provide a realistic energy flow, which is close to the existing building.

Scenario 1: The current library

The virtual model of the current library was developed by considering the construction period and then cross-referencing the construction type with similar buildings from that decade (Dascalaki, Balaras, Droutsa, & Kontoyannidis, 2012). The details were further developed based on site visit, plans and pictures. The parameters taken into consideration were onsite weather data, standard material properties of the envelope as well as a standard HVAC system.

Scenario 2: The GREEN library

The model of the proposed building was developed by implementing the concepts and principles discussed previously. This model improves the envelope's thermal properties in addition to a more effective HVAC, dynamic shading system, efficient lighting devices, and an optimal cross ventilation system.

Scenario 3: The SUSTAINABLE library

Scenario 3 is similar to Scenario 2, (the GREEN library), but it also takes into consideration the onsite energy production by PV systems. It provides an assessment about the energy demand of the proposed library.

The results

In terms of energy consumption, the GREEN Library uses around 75% less energy than the original building. This leads to monetary savings amounting 60% and a CO_2 reduction of 65%.

For the SUSTAINABLE Library, taking into account the production of approximately 650,000 kWh/a from PV panels, this covers around 85% of the total energy consumption of the GREEN library (building in Scenario 2), leading to a yearly monetary savings of around 90% and a reduction in CO_2 emission of around 85% compared to Scenario 2 (Figure 6.7).

Green education

Apart from its function as an information centre, the library will act as a catalyst for sustainability. This will be achieved by showcasing the principles and strategies that converted the existing library into the SUSTAINABLE reference building. The courtyard is going to be used as the exhibition space to monitor as well as display the energy demands and generation in and around the building. Additionally, the external membranes will be used as advertisement panels where beams will project the sustainability awareness measures and campaigns at night (Figure 6.2).

Conclusion

The project was taken up as a case study to analyse the techniques for reduction in building energy consumption in an existing building. The library serves as a pilot project for future reference and acts as a tool for educational purposes where people may be informed about the various principles and their importance in the reduction of energy demand as well as for a more sustainable environment. The principles that were taken into account throughout the process may be realized independently or together in other buildings depending on the availability of resources and the creativity of the designers.

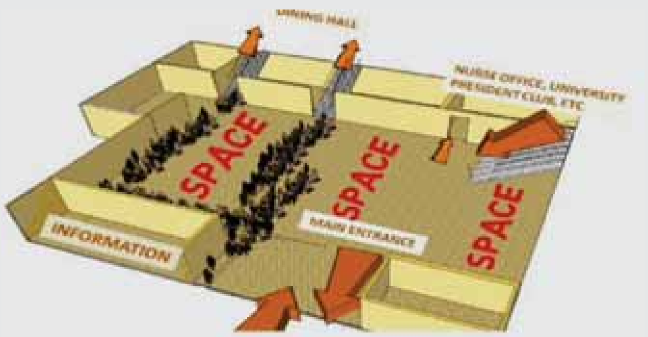
7.1 AUTH Cafeteria building entrance (Own compilation,2013)

Team 7: Sustainable mensa

The cafeteria is a vital part of the Aristotle University, considering that it is the sole cafeteria in the university. Amvrosia S.A is the private company whose task is taking care of the cafeteria management such as outcome of electricity, total energy, worker payment and everything about the building. The current situation in AUTH shows a lack of communication between university and the private companies, whom manage different sectors in the university. Due to this reason, it is hard to regulate and keep track of the sustainability level of the cafeteria, regarding the catering company mostly focuses on the food distribution rather than building management. Therefore, the focus of this group is to give a better proposal in managing and enhancing the level of sustainability of the cafeteria. The proposal will also take the economical budgets limitation into account. The later part of the proposal will be divided into four categories: Architecture, Food, Water and Energy, each will be proposed in staging goals.

Architectural aspect

The cafeteria is a two story building with basement as its kitchen. The first floor is practically used for nothing except waiting lines which extend to the second floor where the sitting table is located. The cafeteria is serving more than 8000 meals every day. (Alexandrostsioros _ Food science department).



7.2 first floor circulation (Own compilation, 2014)

The current situation of building functions leads to an inefficient use in waiting time and space of the first floor. There is sufficient area in the first floor to open a new dining area by just opening a wall which is connecting the vertical conveyor belt to the kitchen. This proposal could be done anytime and requires a minimum budget and effort.

7.3 Vertical conveyor belt (Brinkmann technologie, n.d)

The new opened area could be used as a vegetarian food section. This section will introduce the delicacy of vegetarianism itself and promote a low carbon footprint menu. By using a six person cafeteria table (1m x 2.5m), in an area of 90 m^2 (15m x 6m) this area can accommodate 64 people at time. In the future, this arrangement could be improved easily to make the service more efficient and cut the waiting lines in half.

7.4 Vegetarian section proposal (Own compilation, 2014)

The intermediate goals will be a continuation of the new vegetarian section. To increase the number of seats in the first floor, opening a new entrance is proposed. The new entrance will avoid a mass crowd of people in waiting lines in front of the stairs and cut the waiting time as well. The last stage of the design goal is to decrease energy consumption and transmission losses. Some renovation will be added, such as retrofitting and opening skylights on the roof.

7.5 AUTH agriculture (Own compilation,2013)

Sustainable mensa

Food aspect

AUTH's cafeteria serves meals three times per day, including breakfast, lunch and dinner. The meal is served as a set on a tray, which consists of a main dish, salad, and soup. Every student gets exactly the same portion from the cafeteria attendant and may take fruit from the basket provided at the end of the line. For a huge cafeteria that provides more than 8000 meals per day, this type of distribution may look the most suitable. However, it wastes a huge amount of food since many students just eat their preferable plate (either meal or salad, rarely soup), and the rest is thrown into the garbage bin.

Estimated total food waste

Due to a lack of food waste concern in AUTH, there is no solid number to identify how big the food waste is produced by the AUTH cafeteria per day. However, conducting a rough calculation is still possible. Based on the Journal of the Academy of Nutrition and Dietetics of Indiana University, students produced about 124.45 grams of solid food waste per person when they ate with a tray system. The amount will decreased about 18% once the tray system was removed (Reuters, 2012). The total Cafetaria food waste for 8000 meals would be about 995 kilograms of food wasted per day. Therefore, it can be assumed that approximately, a ton of food is wasted per day at AUTH.

Reducing and composting the waste

This number should be decreased through the introduction of a new system. However the financial crisis brought money limitations and several restrictions which cannot be trespassed. Eliminating tray system and introducing a new buffet system would be a perfect solution in many cafeterias, but not in AUTH. A possible solution would be to keep the tray system (time efficiency) but give an option for taking side dishes (salad and soup). Salad could be served in a small portion in the end of the line, ready to be picked up by anyone that is interested. Soup could be ready in a big pot by the side of the attendants, ready to be poured into the students bowl. This strategy will reduce unnecessary waste regarding side dishes.

For the rest of the food waste, there is the possibility to turn the organic waste into fertilizer without a big investment for example with starting a corporation with the mechanical department to set up compost machine. If all of the food waste is turned into fertilizer, roughly one ton per day, it will bring a new prospect in marketing or even cultivating own products. John Jeavons in his book ‚How to Grow More vegetables', wrote that for vegetable gardening, the maximum composting requirement for each harvest season is 0,25 inch/feet2 (Jeavons, 2012). It is equal to 0.25 hectare of an agriculture plot just from our daily composting (about 0.9 ton) or 7.5 hectare from monthly composting (roughly 27 to 30 tons).

Food supply

In case of supply, the cafeteria supplies its kitchen with imported products, except for fruits and vegetables. This is due the crisis in Greece, which made the cost of local production inflate. The action of importing is not very sustainable, but finance also plays a crucial part in this sector. There is a bright prospect that emerges from AUTH itself in the case of food supply. The university has an agriculture farm, which is part of the Agriculture and Forestry faculty. The farm has several barns, vegetable and fruit fields whose products are already sold in the market. The most important product is milk, which is approximately produced in the quantity of 2 tons per day. The agriculture faculty members already show their interest in supplying the cafeteria kitchen, and are willing to expand their farm to cope to the cafeteria scale. If this plan is accepted by the university board members, milk from the farm can be supplied to the cafeteria on the very same day as the contract commences. The number can increase with time, and hopefully local products can dominate the food supply for the cafeteria. The proposal for the food section proposes a closed loop cycle when waste, fertilizer and the agriculture farm are integrated together.

7.6 Proposed food flow(Own compilation, 2014)

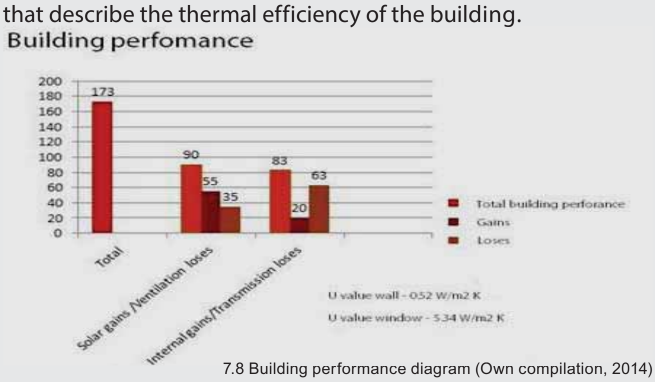
7.7 AUTH cafeteria dining room (Own compilation,2013)

Sustainable mensa

Energy and climate

A resource efficient energy management of the cafeteria can be achieved through partnership with the power systems laboratory of the Electrical Engineering department of the Aristotle University which aims to promote efficient and intelligent use of electricity and stimulate behavioral change concerning the use of electricity and promotion of innovative practices through retrofitting and replacement of appliances which consumes electricity (AUTH ManagEnergy).

The methodology is based on an energy balance electricity consumption analysis of the building, it specifically incorporates the calculation of the electricity consumption of the kitchen equipments, heating and cooling as well as the artificial lighting and the contribution of solar and internal heat gains to the energy balance of the Mensa building. The U values of walls and windows are 0.52 and 5.34 W/ (m^2 K) being some of the factors that describe the thermal efficiency of the building.



7.8 Building performance diagram (Own compilation, 2014)

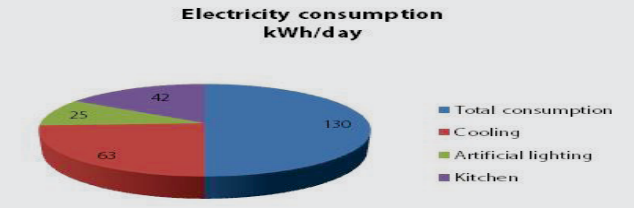
Building description

The thermal efficiency of the building performance as shown on figure 7.8 indicated 38% ventilation loses and 61% solar gains, the ventilation loses most times are as a result of occupant behavior of opening the windows hence having the losses, another factor is the window type which is single glazing and elasticity of argon sealants used for the edges of the windows.

The efficiency ratio of the Mensa is ineffective regarding to its overall performance(Powers, 2014),resulting to lost of 75% out of 24% from the building facade, this can be atributed to the building being designed under a contemporary building code as most of the developments in 1954 (Dumitrache, 2009).

Electricity, heating and cooling

In the Mensa,19 % of electricity is consumed on artificial lighting because of the lighting systems that were always in use during the daytime, 48 % on the cooling demand and 32 % on the kitchen appliances due to old cooking equipment, furthermore are the total heat energy demand 12,792kWh/(m^2 a) and the annual losses of 5628 kWh/(m^2) roof and 4349 kWh/(m^2) wall representing 44 and 34 % respectively from the heat energy demand.

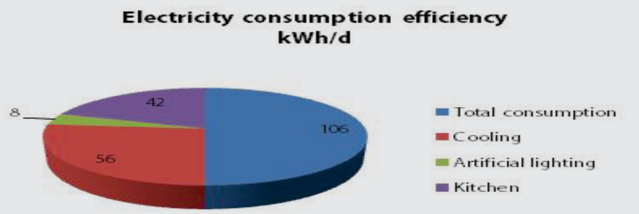


7.9 Energy Consumption,present situation(Own compilation, 2014)

Strategies

Short, intermediate and long term goals are the strategies instituted to achieve the goals considering the economic crisis of Thessaloniki to optimize the efficiency in the building and electricity consumption ,to achieve this, insulation,retrofitting and change of equipments and roof sky light were proposed, the chart below illustrates the efficiencies in electricity consumption.

24kWh/day of electricity is saved from impementing the strategies and annually, 5040 kWh/a from electrical consumption,2268kg of CO_2 reduction on the environment and 5756kg of CO_2 reduction from insulation and retrofiting.



7.10 Electricity Consumption Efficiency,after implementation(Own compilation,

0.7 Rain water harvesting (YALE, 2010)

Sustainable mensa

Water aspect

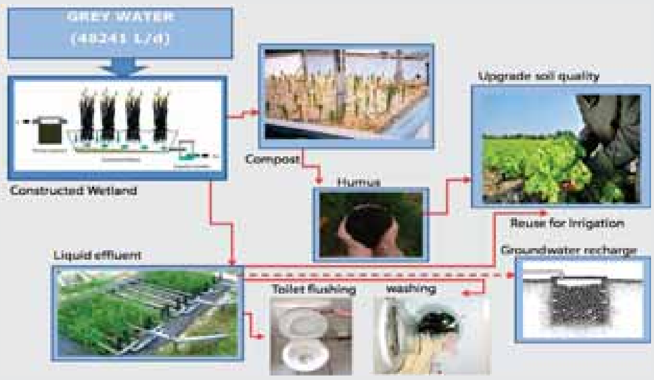
For a sustainable campus, sustainable water management is one of the key aspects. One of the largest water users on campus is the campus cafeteria. This makes the campus cafeteria ideal for the implementation of sustainable water management practices.

In the cafeteria, the water used for food preparation, cleaning and other purposes generates a lot of wastewater. The actual annual water consumption is about 17,608 m^3/year (P. Zoi& T. Alexandros, Personal communication, November 6, 2013). Managing water sustainably does not only reduce the monthly water bill, but it also helps to conserve the water resources.

Considering the economical situation, three sustainable water management practices are proposed for AUTH cafeteria that would be implemented in different timeframes; decreasing water wastage through awareness, grey water reuse and roof-top rain water harvesting.

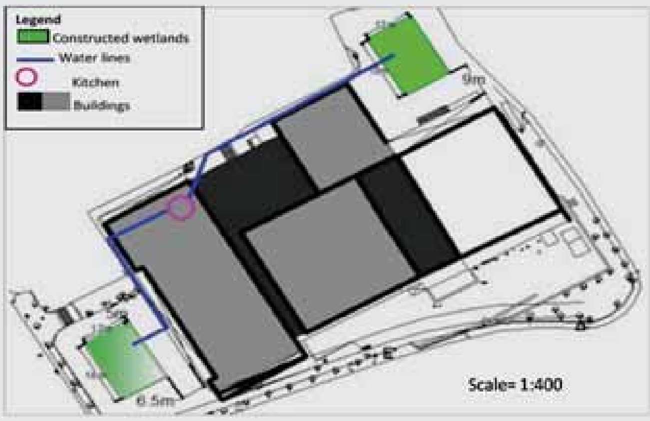
Given that the AUTH cafeteria serves food for free, it is likely that students who use the cafeteria use plates, forks, spoons and etc that they actually do not need. However, this can be minimized through awareness, for example, using pamphlets that show how much water would be consumed to wash spoiled dishes. The awareness method is very important, especially for a large campus that serves around 8000 meals per day.

To treat grey water, a constructed wetland technique is proposed. The treated water can be used for different purposes, for instance, for gardening, irrigation, toilet flushing, washing machine, cleaning, ground water recharging and other purposes (Queensland Government, 2010; Carleton University, 2013).



7.11 Treated grey water reuse possibility (Own compilation, 2014)

The dimensions of the wetland needed for the treatment of the grey water of the Cafteria is dimensioned based on standard area of $1m^2$ per population equivalent (PE). 1 PE corresponds to waste water generation of 120 liter per capita per day. So, waste generation of 17608 m^3/year gives 402 PE. Using these, the required area of the wetland will be 402 m^2. And the area is proportioned using length width ratios 3:1.



7.12 Locations of constructed wetland (Own compilation, 2014)

Roof top rainwater harvesting is another water management practice that can be proposed for the AUTH cafeteria in a long term. It can be installed at low cost investment and can help reduce the amount of fresh water needed in the cafeteria. The technology is particularly attractive since Thessaloniki has enough rain water.

0.26 Aristotle University of Thessaloniki (Wikipedia & Own compilation, 2014)

Summary and outlook

The 4th generation REAP teams have proposed seven feasible approaches aiming to accomplish the developed Energy Action Plan EAP with their various strategies and time frames. EAP's ambition is to guarantee the achievement of continuous innovations and to set a new benchmark towards a sustainable AUTH. The roadmap also takes into consideration the city's as well as the and campus's different situations, especially the financial one. The REAP teams have cultivated collaboration principles for the AUTH community including the staff and students, to act as the present and future hub of sustainability. As previously introduced, the teams have developed fields of actions within five main themes: community, education, research, campus and finance, intersecting with three time frames: short, mid and long-term. To sum up what has been achieved over this process, community will be the starting point.

Community

As people are the core aspect of sustainability, their right attitude is vital for a healthy and environmentally friendly way of living. The community of AUTH and Thessaloniki has already taken its first steps towards the road of sustainability. However, with the proposed projects, a higher awareness can be realized from the use of social media, online platforms and grass root campaigns. Participation in the on-site refurbishment workshops and volunteer actions,delivers tangible knowledges regarding sustainable living, and therefore creates a sense of responsibility.

Education

The second step transmits knowledge to more students , as well as other groups of the society and to the new generations. The delivery of basic information concerning sustainable ways of daily living can help in changing the behaviors of the users. The introduced courses with more professional contents such as architecturally-sound techniques and waste management, intended for people with different interests. The enforcement of obligatory courses involved in all academic departments further facilitates the spread of knowledge.

Research

AUTH is a university with a diverse range of academic realms. Therefore an interdisciplinary research platform was established aiming in enhancing the sustainability goals with the aid of the other four main themes. Feedbacks needs to be gathered and a sustainability report has to be published at a certain period of time.

Campus

A campus-wide masterplan indicating space use on different levels, from single buildings to the landscape, helps in visualizing the reduction of the environmental footprints. Not only is space taken into consideration, but also the time dimension is included in order to achieve a better distribution of resources. Architectural refurbishments and the management of heating systems is carried out to improve the energy efficiency and reduce energy consumption. Energy monitoring and informative board displays acted as a reminder and to keep people aware while keeping track of their energy behaviors. The waste generated on campus and its potential to be reduced or converted to energy are also taken into account.

Finance

Finance is currently an important issue in Greece with its harsh economic situation. For short term, pilot projects and initiatives are made to encourage the first moves from the economically-plagued crowd. In the long run a stable cooperation with governmental or non-governmental organizations and enterprises can bring in funding and financial-aid.

The proposals have brought remarkable outcomes. Nevertheless, to accomplish far-reaching influences, exchange with other universities may bring further fresh ideas and establish an ideal long-term cooperation platform, together with the uncovered fields of the EAP that leave an open space for future approaches in order to achieve the term „Sustainable Campus in a Sustainable City".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