POLITECNICO DI MILANO

DEPARTMENT OF MANAGEMENT, ECONOMICS AND INDUSTRIAL ENGINEERING

Assessment of Users' Attitude towards Energy Utilization:

A case of Como campus-Politecnico di Milano

Supervisor: Prof. Marco TAISCH

Assistant Supervisor: Endris Temam KERGA

Master Graduation Thesis by: Mohammad FIROOZMAND

Student Id. Number: 749913

Academic Year 2011/2012

ACKNOWLEDGMENT

It would not have been possible to write this dissertation without support and kind help of several individuals who contributed with their supportive guidance and useful assistance in completion of this study.

I am heartily thankful to my supervisors, Professor Marco Taisch and Endris Temam Kerga whose guidance and assistance helped me to develop an understanding of the subject.

I deeply appreciate the kind support of general services office of Politecnico di Milano especially Emanuela Levi who helped me in a number of ways.

At last but not at least, I would like to thank my kind family who have supported and encouraged me through all the stages of my life.

Table of Contents

List of Figures

Abstract

Energy is one of the most crucial and at the same time costly resources on which sustainability of most processes and value streams is depended. Nowadays there are many organizations which are still consuming a lot of fossil fuels and other types of non-recyclable energy. Spreading the idea of using renewable energy to plants, companies, buildings and individuals and in general moving toward sustainability, still needs more time for culture change and technology development. Hence given these circumstances from one hand, and on the other hand environmental problems such as global warming and climate change, Energy Efficiency Improvement is dramatically important to be considered by any organization in the globe. Universities are organizations with large number of people including staff and students, as the number of occupants in the buildings increases human factor becomes very critical to energy conservation. The objective of this thesis is to assess users' attitude toward energy consumption. A case of energy consumption trend analysis and evaluation of user behavior at Politecnico di Milano, Como campus has been investigated and accordingly potential solutions for improving energy efficiency in the campus and moving towards sustainability have been suggested.

Keywords: Energy management, Energy usage awareness, Energy conservation motivation, Energy consumption support

1. Introduction

Nowadays given that most energy production relies on burning fossil fuels, form one hand due to depreciation of these resources, energy prices are increasing and on the other hand environmental problems caused by toxic emissions of fossil fuels is compromising future generations' health on our planet. Here it comes the definition of sustainability. World Commission on Environment and Development (1987) has defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs. Stivers (1976), describes sustainability as an economy which is in equilibrium with basic ecological support system. Daly challenges environmental concerns and proposes the alternative of a steady state economy. But critics to the idea of limits to growth define two major arguments. The first one which is technological optimism which believes technological advancement and efficiency improvement can overcome growth limits. The second one is decoupling arguments talking about dematerialized economy which can move forward without using more resources. However even with considering these issues still more resources are being used by economies in a ways that since 1970, carbon dioxide emissions from fossil fuels have increased by 80%.

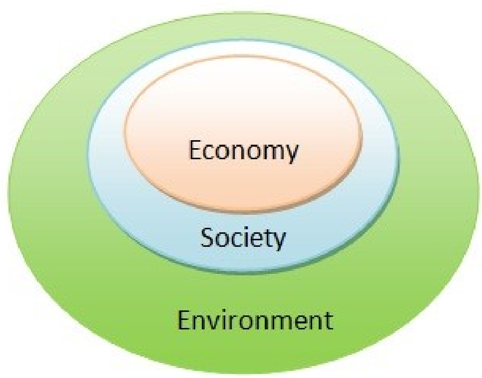


Figure 1: Scheme of sustainability representing that economy and society are both constrained by environmental limits (Ott, 2003)

The United Nations 2005 world summit outcome document further develops the standard definition of sustainable development with using three main pillars of sustainable development as: economic development, social development and environmental protection. It has been represented by using following scheme which shows interdependency and mutual reinforcement of the three pillars.

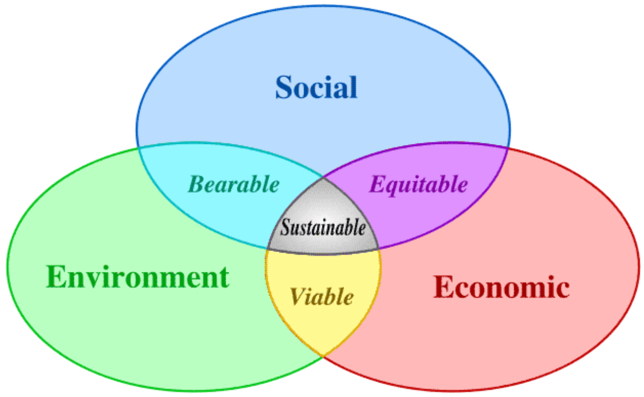


Figure 2: Scheme of sustainable development: at the confluence of three constituent parts (Adams, 2006)

National Academy of Engineering, (2008) considered environmental sustainability as an impressive issue both in magnitude and complexity and mentioned it as greatest challenges faced by modern society. Goldemberg et al. (2000) relates the definition of sustainable development to energy with two main issues. Firstly to provide sufficient energy services aiming at achieving economic growth and accordingly improving social welfare. Secondly to produce and use energy in a way that will not cause environmental problems hence doesn't disrupt the ecosystems. One simple way to sustain energy improvement is to reduce energy consumption and reduce energy losses. These practices are part of energy management. Capehart et al. (2006), describes energy management as the careful and effective way of energy consumption thus to minimize costs or maximize profit and improve competitiveness. Harrold, (1993) discusses about practical energy conservation methods including switching off lights, use of sunlight during the day, workplace de-lamping, reducing night time outdoor lighting or illumination of sings or advertising.

World Energy Consumption:

According to the statistics of International Energy Agency Report (2010), world energy consumption in 2010 is increased by 5%. Despite a slight decrease in energy consumption in 2009 which was due to economic recession, it is reaching its historical trend again. Oil, coal, gas, electricity markets are following the same trend. Statistics show that from 2004 to 2008 the world population increased by 5% and annual CO_2 emissions soared by 10% resulting from 10%

increase in world gross energy production. United States Energy Information Administration estimates total world consumption of marketed energy will increases by 49% from 2007 to 2035 which means 1.4 percent per year (International Energy Outlook, 2010).

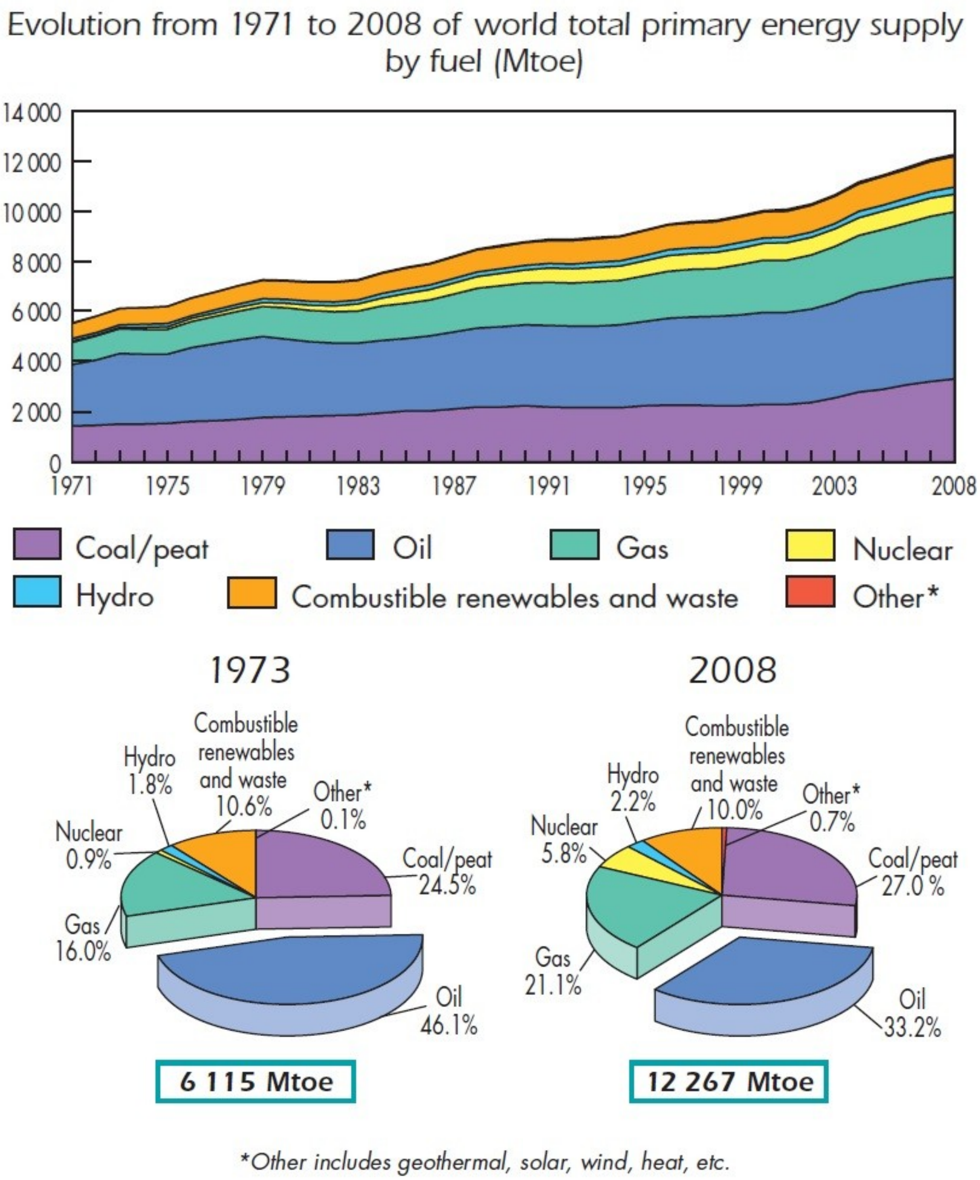


Figure 3: Fuel share of world total final energy supply, Source: IEA

The fastest growing end-use of energy consumption in the world is electricity. The main sources for generating electricity are coal, gas, oil, hydro and nuclear. Other sources including geothermal, solar, wind, combustible renewable like biomass stand for only 2.8% of the total share of electricity producing sources.

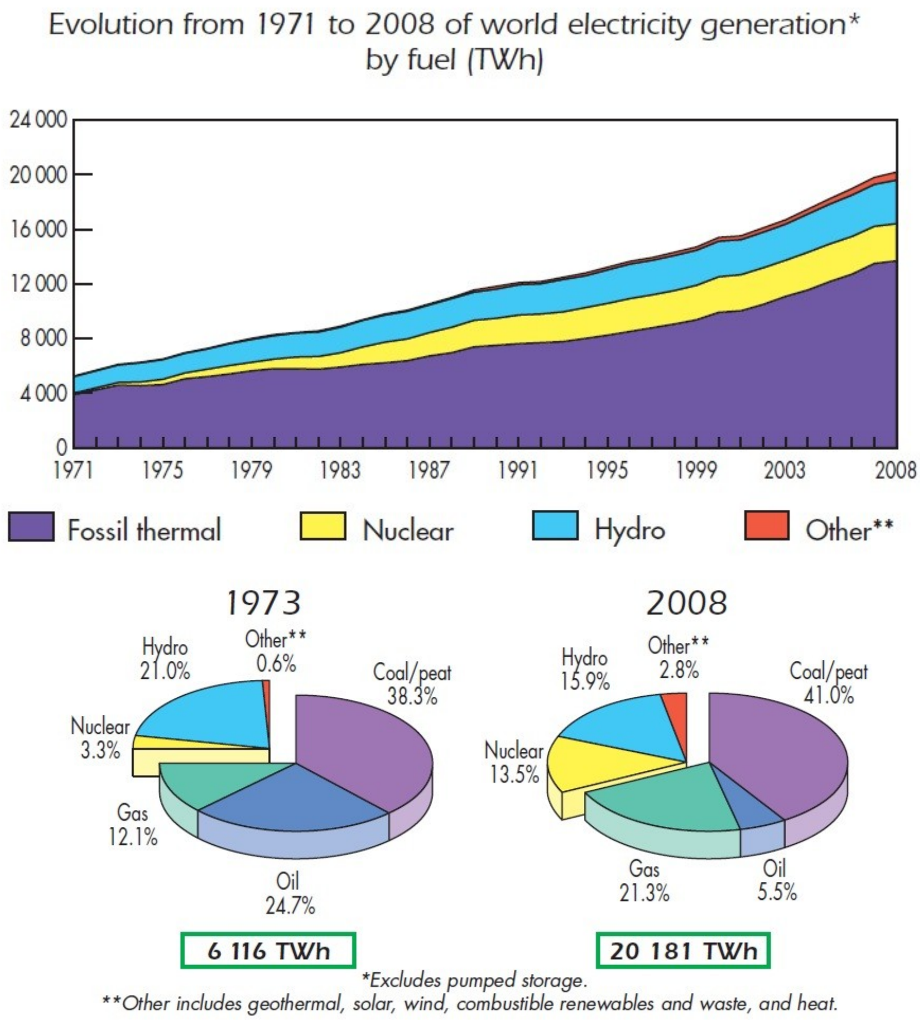


Figure 4: World electricity production trend by source, data source: IEA

In 2008 world electricity production has been 20261 TWh of which 16816 TWh (83%) was consumed by final users. The difference of 3464TWh (17%) was consumed in the process of generating power and consumed as transmission loss.

2. Literature Review

2.1. Energy Management in Organizations

For having a powerful energy management system, some organizations link energy management objectives with Lean targets. There are at least three reasons for reaching the synergy between Lean and Energy efficiency efforts:

Economic Factors

Energy conservation and therefore cutting energy costs has a significant effect on improving profitability. As energy cost has always been considered as a necessity of performing business, it is difficult to persuade senior managers to drives energy efficiency improvement plans. Focusing only on core operational needs will decrease organizational attention to objectives like energy performances and environmental goals. By linking environmental performance goals to Lean Six Sigma objectives, managers perceive it crucial for success of continuous improvement efforts (EPA, 2007). There are many companies who have uncovered this hidden cost and tried to reduce it by adopting Lean Six Sigma practices and have gained significant financial returns. For instance General Electric in Ohio State achieved over $1 million of savings at only one facility by implementing Lean method reducing fuel consumption. Conducting Kaizen events, New York Kodak Company could gain $15 million of savings reducing energy use between 1999 and 2006.

Environmental Impacts

Energy efficiency improvement efforts are closely related to environmental issues as well. Excess of carbon dioxide emission and green house gases will cause the problem of global warming or climate change. One of the important actions to be taken to prevent this harmful effect could be saving use of fossil fuels. There are many international organizations working on environmental issues regarding the assessment of global warming and climate change. One leading international body is Intergovernmental Panel on Climate Change (IPCC). It is established in November 1988 by the United Nations Environmental Program (UNEP) to aware the world about the current state of scientific activities and knowledge on climate change and its upcoming environmental and socio-economic impacts. There is also the Kyoto Protocol which is an international agreement related to the United Nations Framework Convention on Climate Change. Kyoto Protocol sets commitments for 37 industrialized countries and the European community to reduce green house gas emissions.

Since developed countries are mainly responsible for a higher portion of present GHG emissions resulting from their industrial activities for more than 150 years, the protocol gives them higher responsibility under the principle of “common but differentiated responsibilities.” Commission of European Communities, (2008) has planned to reduce its overall emissions by 20% by 2020 compared to its level in 1990. In addition to climate change, excess of energy consumption by companies can endanger employees' health. Combustion of fuels by boilers, transportation systems and other equipment can produce emissions which are dangerous for workers. Pollutants like Carbon monoxide (CO), sulfur dioxide (SO), nitrogen oxide (NO) and other toxic particles produced by industrial plants can also affect public health in cities and cause the need for emission monitoring and control activities set by environmental protection agencies which are highly expensive and can limit production as well.

Competitive Advantage

Eliminating waste using lean practices will provide lower recurring operating costs thus increase bottom line and accordingly competitiveness. Using Six Sigma methodology enables us to reduce variation and satisfying customer's expectation and accordingly increases profitability and satisfying shareholders. Reducing energy use and commitment to the energy standards and responding to the expectations of environmental protection organizations will provide organizations with public recognition for their low energy consumption and it can improve customer morale and loyalty, employee retention and cause an increase in competitive advantage.

It is appreciable to mention that leading companies in lean and Six Sigma implementation like Toyota, 3M or Kodak, have received energy-efficient certifications and awards form organizations like EPA and Energy Star program. These certificates are of influential criteria to customer decision for choosing a company to purchase from. Considering performance of these companies, the link between energy efficiency and Lean Six Sigma implementation will be more sensible.

2.1.1. Energy as a Strategic Business Concern

Nowadays regarding to inflation in energy market, organizations today are more concerned about energy management than any time in the past. Energy is becoming a key strategic decision in:

- Assuring a continuous supply to support company's key processes including manufacturing operations and guaranteeing data integrity in the organization;
- Optimizing energy consumption and accordingly cutting costs and reducing environmental problems;
- Designing new products or developing new services to gain competitiveness by adding value to the customers in fluctuating energy market.

However there are still many companies who are not aware of business opportunities in energy efficiency improvement efforts and have not still planned any energy management activities or are doing it in a disorganized way.

2.2. Lean Energy Management

Considering energy leakage as another lean waste and unnecessary energy use as a non value added activity form Six Sigma point of view, implementing lean Six Sigma methodology can help achieving dramatic cost reduction, competitive advantage and environmental efficiencies.

As a guide to companies in finding sources of energy related cost reduction opportunities Bennet et al. (2005), have developed a "roadmap" for energy management approaches. The roadmap has four general phases:

Phase 1: Initial Assessment

This phase starts with changing old paradigms toward energy. Instead of considering energy simply as a cost of operation, organizations should discover hidden business opportunities related to energy. The first phase of strategic approach to energy includes detailed assessment of energy through entire organization considering overall demand, costs, supply, risks, competitiveness, reputation and culture of the organization. The output of this phase is a decision whether to move forward with a more strategic focus on energy management or not.

Phase 2: Design the Process

The process design phase aim at benchmarking actual energy demand of the company to the one of the normal need in the business and finding the best ways of meeting that. Answering to the principal question of "how much energy does the organization need?" enables the company to allocate appropriate scale resources and equipments to different divisions of the organization. In this phase the scope of the energy management efforts should be identified whether it is one specific function or it is company-wide. The answer to this question is driven by an assessment of the availability of technical and financial resources. If the company has already run a Lean Six Sigma program, in this phase the objectives of energy management should be integrated with those of Lean Six Sigma.

Phase 3: Evaluate Opportunities

The third phase of energy management roadmap is the most important and pragmatic phase because in this step real opportunities can be realized. Considering complexity and broadness of this phase especially in energy intensive businesses, for maximizing the achievements in strategic energy goals this step should be mapped with detail and in a systematic way otherwise, potential opportunities could be lost. Fundamental to this phase is identifying the type, amount and cost of energy in any function of the company and by reducing the amount of energy used both cost and environmental impact will be reduced. Typically these functions are production, logistics and transportation. However leading companies in energy efficiency also consider the amount of energy which is embedded inside their products and services. The other action to be taken in this phase is to manage supply of energy in order to reduce costs and guarantee reliability.

Phase 4: Implementation

The final process phase use a dynamic management system aiming at integrating energy management program with organization management culture. At corporate level this management system should lead the organization with clear commitment to results. It sets measurable and achievable goals in appropriate functions of the company and defines responsibilities to those objectives. In implementation phase sufficient resources should be provided helping the system achieve its objectives. The system periodically reviews the planned objectives and sets new goals and increases commitments by putting in place incentives and rewards for the achieved results.

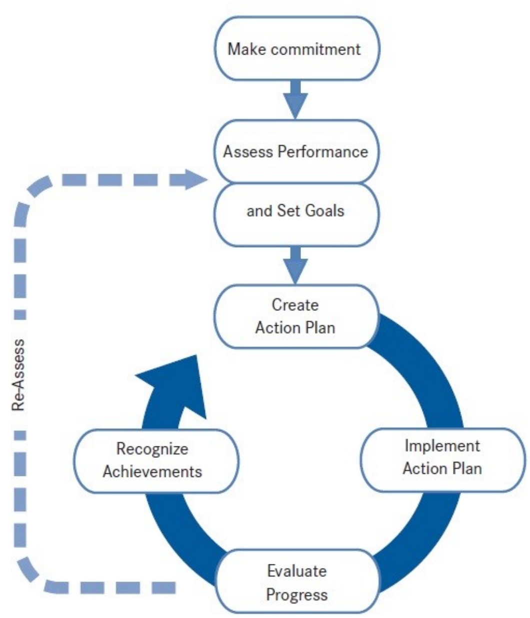


Figure 5: ENERGY STAR model for energy management

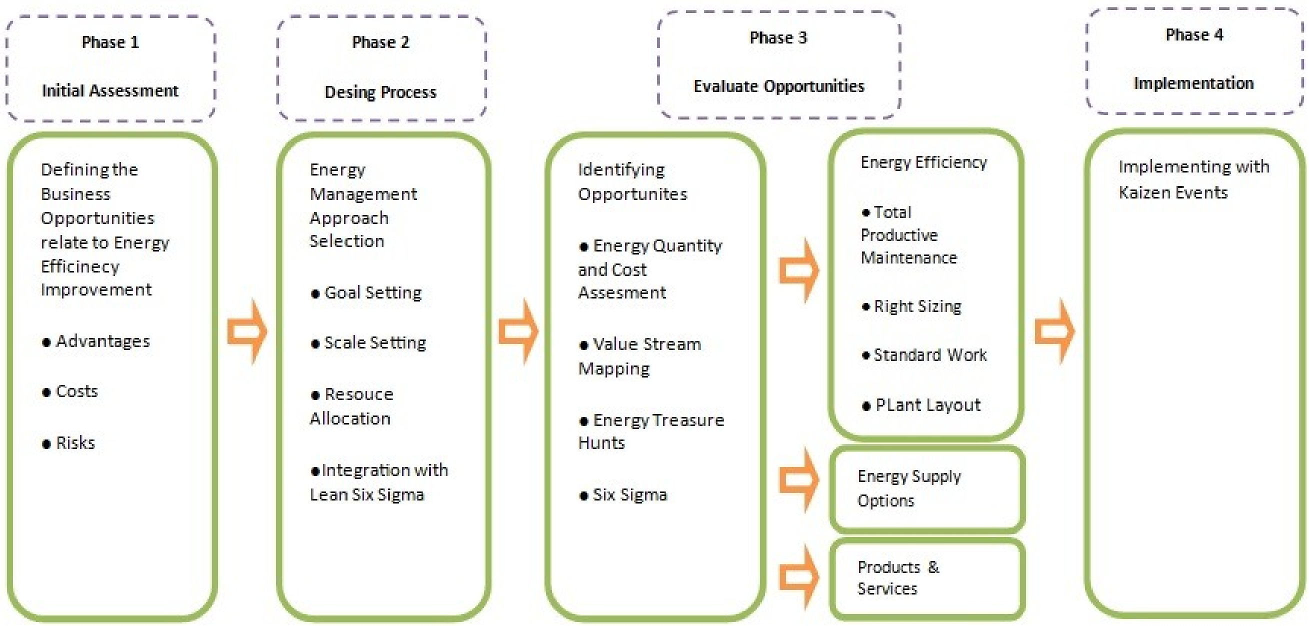


Figure 6: Lean Energy management roadmap, source: Adopted from Benet et al. (2005), Navigating Energy Management

2.2.1 Sources of Energy

Two main sources of energy in manufacturing sector are natural gas and electricity. In some industries other sources of energy including fuel oil and coal are also used for generating power and heat. Implementing Lean methodology in the context of energy efficiency, information about purposes of using energy helps understanding opportunities for consumption regulation and reducing costs. In office facilities energy end uses are mostly heating, ventilation and air conditioning (HVAC), lighting and equipment usage. In manufacturing in general, heating and cooling of processes and also transportation are of other targets of energy consumption.

However for integrating lean concepts with energy management, assessing energy consumption in equipment level in detail may help identifying more opportunities for lowering energy use.

2.2.2. Energy Costs

Making costs of energy visible to workers and managers encourages controlling demand and supply of energy. Energy costs are usually faded in the overhead accounts. This way of accounting has two main shortcomings. Firstly it is difficult to find those costs for setting energy saving targets and secondly if by doing so the result of energy efficiency activities get lost in those accounts this could demotivate managers of doing such activities (Environmental Protection Agency, 2007).

2.2.3. Causes of Variation in Energy Use

Before starting the assessment of energy costs and trying to reduce them by energy management efforts it is very important to understand the root causes of variation in energy consumption. The amount of energy consumed in each facility often varies during time. These changes are usually caused by following factors:

- Weather Changes: changing in temperature, humidity and solar flux, cause variation in energy used for heating, cooling, ventilation and lighting purposes. Seasonal changes force organizations to consume more energy for heating in winters and increases use of electricity for cooling purposes in summer. However only a part of facilities' total energy is dependent to weather. Typically energy consumed for heating and cooling intentions (boilers, heat exchangers, fans) is weather dependent, but lighting systems, ventilation and electrical equipment energy is not.
- Change in building area: Expanding or decreasing the size of the building has a strong impact on its energy consumption.
- Changes in operation and schedule: Changes in number of shifts, occupancy, and equipment operation will cause change in energy consumption. More lighting, heating and air conditioning will be needed if the facilities are open for a longer period of time.
- Changes in equipments: Purchasing and adding new equipments, eliminating, replacing or maintenance of already available consuming devices or systems including lighting systems, heating, cooling and ventilation equipments will cause variation in energy use.

However it is not possible to control all of these variables, it prevents managers to underestimate or overestimate the results of their energy efficiency improvement activities. Although there are energy accounting systems which can track and document changes in energy consumption and savings gained out of energy management efforts.

2.2.4. Utility Bills

Energy costs in each facility can be found in utility bills. These monthly bills information is input data for energy accounting. The two mostly used energies in any organizations are typically Gas and electricity. However in some organizations other alternative fuels including fuel oil, Propane and coal can be used. Fuels like gasoline and diesel are mainly used in logistics and transportation.

In most organizations utility bills are routinely paid without any further analysis of cost, consumption or their relationship. Understanding gas and electricity bills are often difficult. For other fuels like fuel oil or gasoline this analysis could be more difficult especially when there is no information about consumption date and the only available data are the delivery dates so the tracking of consumption is more difficult. Utility bills for different energy sources generally include following information:

Electricity: There are variety of data presented in electricity bills. Kilowatt-hour (kWh) represent amount of electricity consumed which is charged with a constant fee which means it is not related to the amount of consumption. Another parameter is kilowatt (KW) which is highest electricity used each month.

There are some different pricing policies depending on the time energy is being used. For instance prices per kWh are higher in the afternoons during summer as a consequence of high demand this period and are lower on weekends and at night as well. For high electricity consuming buildings another component of costs comes in to action which is a charge for reactive power. It is a penalty for facilities with too many electric equipment which are charged because of increasing electric transmission capacity. This component is presented on bills as “kvar” or a fine based on “power factor”.

Understanding factors affecting electricity costs is very important in managing energy consumption and planning energy efficiency efforts. Using computerized energy and price tracking can help real-time-pricing in which consumers will be informed in advance about the prices which they will be charged and thus they can proactively manage and control their consumption.

Natural gas: unit of measure for natural gas use is cubic meters. Charges per cubic meters may vary by season and by amount consumed. In some organizations natural gas is bought from an independent supplier in that case the cost of transportation and distribution (per cubic meters) should be considered as well.

Alternative fuels: fuels like fuel oil, coal and propane could be used for heating targets when natural gas is not accessible. Accurate consumption tracking of these fuels is complex because consumption is not often measured. The only estimation is usually monthly consumption according to fuel delivery dates but it’s not a good proxy for actual consumption.

2.3. Energy Accounting:

Energy Accounting is one of the main activities of an energy management program. It’s a system to record, analyze and report energy usage and its expenditures at regular intervals. This simple and effective tool helps providing feedback on organizations’ energy consumption and communicating the information to the organization energy administrative and technical people, managers and all the other occupants. In organizations with many different facilities monitoring energy consumption using energy accounts enables comparison between different sites and find out those who have spent highest cost and consequently be targeted for energy management investments.

Tracking energy consumption using computerized energy accounting systems provides identifying problems. There are many companies which have found errors in their energy bills and been mischarged and by comparing results of their energy accounts and those of energy bills have recovered thousands of dollars. Most of the time it is difficult to keep all the people in a company taking responsibility to work on energy efficiency issues because there is often little or no incentive considered for such activities.

If savings related to energy use reduction turn back to the general budget or just cause reduction in next year's budget, maintenance people or site managers may not see benefit in cutting energy related costs. This gap between responsibility and benefits can be reduced by sharing savings and setting other incentives by strategic decisions of energy conservation managers. Energy accounting systems enable making savings visible to all and sets energy cost savings objectives.

2.3.1. Energy accounting methods

Depending on the size and other characteristics of organizations, energy accounting systems can be manual, computer aided using spreadsheets or using a dedicated commercial software. For small size organizations, use of manual or computer spreadsheets could be sufficient. Large companies however, often purchase energy accounting software. Use of software provides flexible and fast analysis over consumption and it reveals hidden control problems, leaks and inefficiencies. It is possible to use its features for considering other factors which affect variability of energy use. They can also be connected to gas or electric meters and read the consumption data in real time. It provides real time pricing and can be used as a poka yoke tool to alert users for the price of the energy which they are using. Some companies outsource energy accounting as a service provided by energy consultant companies.

One of the energy accounting computer programs is energyCAP which is consisted of modules including utility bill tracking, cost avoidance, meter readings, rating, accounts payable link and report writer. These modules provide system problem troubleshooting, finding errors in utility bills, budget allocation and considering impact of different variables on energy consumption. Using electronic data interchange format this software can import utility data. Other software such as Metrix provides users to manually choose weather correction parameters. Utility Manager could be used for tracking many utilities in addition to energy such as water or sewer and recycling activates. This software provides report for different levels in the organizations such as organization, department, site or any other user defined level. (Knox et al. 2000)

2.4. Energy in Buildings

2.4.1. European Union Directive on the Energy Performance of Buildings

EU Directive on Energy Performance of Buildings (EPBD) came into force in 2003. This Directive is inspired by the Kyoto Protocol which commits the EU to decrease CO_2 by 8% by 2010. Since 2003 that it was the center point of references for future research. EPBD goal is to increase energy efficiency of the buildings considering local climate and internal condition as well. Article 1 of EPBD refers to requirements such as:

- Calculation of the integrated energy performance of buildings,
- Minimum requirements on the energy performance of new buildings,
- Minimum requirements on the energy performance of large existing buildings that are subject to major renovation,
- Energy certification of buildings,
- Regular inspection of boilers and air-conditioning systems in houses.

The importance of EPBD is that it covers energy performance evaluation of both new and existing buildings. Energy performance assessment for existing building is done in case of renovation which is followed by inspection of HVAC equipment and accordingly certificate is issued.

2.4.2. Energy Performance Evaluation in Buildings

Energy performance assessment of buildings can be classified as follows:

- Energy consumption measurement,
- Energy consumption estimation using software,
- Comparison of measurements and simulation results,
- Economic feasibility of building renovations,
- Statistical studies based on the static specification of the building envelope, including overall heat transfer coefficient (U), window/wall and area/volume ratio.

In order to improve energy consumption in office equipment and the possibilities to save energy, Mungwititikul & Mohanty (1996), run an energy audit. Considering the result, managing idle times of the office equipment had an important role in saving up to 25% in electricity consumption. As discussed earlier, energy consumption simulation has an important role in building energy performance evaluation. Crawley et al. (2008), compared the capabilities and features of twenty simulation programs which are used such as EnergyPlus, BLAST, DOE, Ecotect , IES, and TRNSYS. modeling features, building envelope improvement, renewable energy systems, day lighting, multi-zone airflow infiltration-ventilation and, HVAC system and equipment, environmental emissions, weather data availability, result reporting capability and such issues are all investigated in detail. ESP-r software is used for simulation energy requirement and indoor climate in a well-insulated house in Sweden. In order to show the air flow in selected room, CFD (computational fluid dynamic model) is used. Simulation cases are selected as rotation of the building, changing indoor temperature, changing U value, applying load management and using different climatic conditions. In conclusion, it is understood that when the temperature is increased from 23° C to 24° C, energy demand raised 21%. There was no major improvement on indoor comfort (PPD index). Another important point which concluded is that although high level of insulation causes overheating problem in mild or hot climate, it is not a problem for cooling in cold climate (Karlsson and Moshfegh 2005).

Becker et al. (2006), in their investigation, studied on development from a national research program to establish Building Energy Code for all building occupancy. In this research school building is chosen as a case study because of high internal gains which prevent to obtain thermal comfort in summer. Simulations are performed regarding occupancy period, indoor climate control, ventilation provision, lighting control, location of the building, construction features and internal gains. The result of investigation obviously shows that good design of ventilation can improve energy saving in northern and southern classrooms by 30% and 18% respectively.

In order to estimate economic feasibility of building renovation, Florides et al., (2002), used TRNSYS software. Typical meteorological year and a typical house model for Cyprus is selected for simulations. Insulation, Solar shading, natural and mechanical ventilation, different glazing types, orientation and shape of the building are variables which are investigated. They concluded that hot climates roof insulation and solar shadings pay back in 3-5 years while wall insulation pays back up to 10 years. Methodology to find optimum building form was proposed by Oral and Yılmaz (2003). This methodology depends on the U-value of opaque elements and window frames. It is applicable for cold areas which need the long period for heating. It can minimize heating energy demand of building. Energy efficiency improvement research in university buildings is mainly focused on running energy audit and surveys with objective of increasing energy performance, cutting costs and reduce carbon footprint. Barelli and Bidini (2004), worked on energy performance of Perugia University. They measured electricity consumption for different places in the university. Each building is defined according the function of the area and population of that. Annual amount of gas and electricity use were analyzed. Finally they proposed improvement efforts such as better insulation and using more efficient boilers and increasing quality of air heating systems. Di Stefano (2000), worked on energy efficeincy assessemet focusing on electricity consumption at Melbourne University. Reduction in electricity and costs by replacing 1.2 meter fluorescent lightning with different fixtures is calculated. The result of this experiment was compared to find the better cost effectiveness solution. Results illustrate that there is 64.9% saving on energy and also 10% decreasing on carbon dioxide emission. Although, there was no reduction in cost, because of the low operation time of lighting, high cost of replacement and low cost of electricity.

2.4.3. Low Energy Buildings in Europe

Directive on the energy performance of buildings (EPBD) promotes all EU members and supports national targets to apply for very low and close to zero energy buildings. 80% of the energy costs can be saved through design solutions in low energy buildings. Till now about 20,000 low energy buildings have been constructed in Europe mainly in Germany and Austria that are of highly supporters of EPBD.

There is no specific international definition for low-energy buildings. Buildings with better energy efficiency respect to standard energy performance requirements are generally called low energy buildings. These buildings normally have high level of insulations, energy efficient window thus use lower energy for cooling and heating purposes. Active or passive solar design techniques, hot water heat recycling technologies are also embedded in low energy buildings. Across Europe these buildings are known with different names. Eco-building or green building, high performance house, energy saving house, energy positive house, zero carbon or zero energy house are such names which are used in different countries for describing such buildings. There are also different standards and systems for calculating energy consumption. The performance requirements should consider all types of energy use that is used for heating and cooling, domestic hot water, electricity consumption and air conditioning. In low energy buildings normally the decrease in energy consumption will range from 30 to 50% of the one of typical new buildings. Given the fact that the climate is varying across Europe, it is difficult to define exactly how much energy is used by low energy building for entire EU because standards are different among different countries. But as a rough estimation the annual energy consumed in low energy buildings is around 40-60% kWh/m^2 in central European countries.

2.4.4. Zero Energy Houses and Energy Positive Houses:

In zero energy houses or zero carbon houses energy needs are entirely covered with carbon free energy sources. A building with zero net energy consumption can be independent from energy supply grid. But as renewable energy sources are often seasonal practically these houses gain energy from the grid in some periods and in other periods the power is sent back to grid (National renewable energy laboratory, 2006). Energy positive houses are buildings in which average annual energy production from its renewable sources is more than external sources.

These houses use a combination of solar design and small power generators. Careful site selection and placement and perfect insulation are very important in this type of buildings. (Energy performance of buildings directive, 2009)

2.4.5. Introduction to LEED

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System accelerates global adoption of sustainable green building and development practices through the creation and accomplishment of universally accepted tools and performance criteria.

LEED is a third-party certification program and an internationally accepted benchmark for the design, construction and operation of high performance green buildings. It provides necessary tools to building owners and operators, to have an immediate impact on the performance of their buildings.

There are five key areas that LEED promotes a building approach to sustainability:

- Sustainable site development
- Water efficiency
- Energy efficiency
- Materials selection
- Indoor environmental quality

Credits and Prerequisites are organized into these five categories; however certain rating systems include additional relevant categories. An additional category, focusing on innovation, addresses sustainable building expertise, exemplary performance, and design (or operational) measures not covered under these five environmental categories.

Certification is based on the total point score achieved, following an independent review. LEED is flexible enough to accommodate a wide range of green building strategies that best fit the constraints and goals of particular projects, owing to presence of four possible levels of certification (certified, silver, gold and platinum).

2.4.6. Why being certified is needed?

A rapidly-growing number of private sector organizations and governments are adopting LEED certification in their policies, programming and operations, with the goal of achieving and demonstrating sustainability. Mueller (2011) mentions the reasons for achieving LEED as:

- Gain recognition for green building efforts
- Validate achievement through third party review
- Qualify for a growing array of government incentives
- Contribute to a growing green building knowledge base

2.4.7. Benefits of LEED Standard

The benefits of green building and LEED certification can be summarized under several headings:

- Economics
- Education
- Public Relations
- Contribution to Facilities Planning
- Improved Quality of Work Life and Learning

2.4.8. Unsuspected Dangers and Difficulties

As with any innovation, there are potential pitfalls in the LEED certification process, Schendler and Udall (2005), mention that to be aware of these pitfalls, and the knowledge of their solutions is important. Two most common pitfalls are:

- The expense of LEED certification:

  The LEED certification process can be expensive. Since Commissioning, energy modeling, and completion of the necessary paperwork are complex, increase the costs of building projects.

- The risk of an "obsession" with accumulating LEED points:

  Because of the prestige associated with high LEED ratings, those involved in projects can become obsessed with obtaining LEED credits even when they are not particularly valuable from an environmental standpoint.

2.4.9. The Process of Achieving LEED Certification

Achieving LEED certification for a new building is a two-step process:

- Registration

  Upon registration, LEED applicants receive a 400 page Reference Guide, containing detailed strategies, benefits, calculations, and resources for each credit. Applicants are also supplied with LEED letter templates, which is a guide for calculations and credit declarations. At this stage, the project team prepares documentation and performs calculations required for LEED certification.

- Certification

  The applicant submits project application materials and supporting documents.

Each project must satisfy all prerequisites and provide enough credits for certification. Projects are awarded Certified, Silver, Gold or Platinum levels of certification based on the number of credits achieved. (Mueller 2011)

2.4.10. EU Members Strategies and targets for Low Energy Buildings

According to European Commission report, several countries in EU have set long-term goals for obtaining low energy standards for new buildings. For instance, UK has planned to have zero carbon houses by 2016. New buildings in France should comply with low consumption standards by 2012. And their long-term goal is to have energy positive houses by 2020. In Italy in several regions are moving toward low energy buildings. There are organizations such as CasaClima in the province of Bolzano that they are doing labeling and issuing certificates for low energy buildings and products. Training technical architects and traders for being ready to apply new standards in the houses they build, is other part of their mission. CENED (Certificazione ENergetica degli EDifici) is one this certificates which evaluates the energy performance of the buildings in Lombardy region. They have a certification committee with more than 14,300 engineers, architects, surveyor, and assessor of energy.

Table 1: Examples of definitions for low energy building standards.

Country	Official definition
Austria	• Low energy building = annual heating energy consumption below 60-40 KWh/m² gross area 30 % above standard performance) • Passive building = Feist passive house standard (15 kWh/m² per useful area (Styria) and per heated area (Tyrol)
Belgium (Flanders)	• Low Energy Class 1 for houses: 40 % lower than standard levels, 30 % lower for office and school buildings • Very low Energy class: 60 % reduction for houses, 45 % for schools and office buildings
France	• New dwellings: the average annual requirement for heating, cooling, ventilation, hot water and lighting must be lower than 50 kWh/m² (in primary energy). This ranges from 40 kWh/m² to 65 kWh/m² depending on the climatic area and altitude. • Other buildings: the average annual requirement for heating, cooling, ventilation, hot water and lighting must be 50% lower than current Building Regulation requirements for new buildings • For renovation: 80 kWh/m² as of 2009
Germany	• Residential Low Energy Building requirements = kfW60 (60kWh/(m²•a) or KfW40 (40 kWh/(m²•a)) maximum energy consumption • Passive House = KfW-40 buildings with an annual heat demand lower than 15 kWh/m² and total consumption lower than 120 kWh/m²

(Source: SBI (Danish Building Institute), European Strategies to move towards very low energy buildings, 2008)

2.5. Energy Conservation Behaviors

2.5.1. Using Technology and behavioral approaches to Energy Conservation

Energy management approaches are divided in two main categories. Firstly managing demand side which is related to user behaviors and secondly energy supply side which refers to technological approaches. Shinskey (1982) considers human factor of energy saving as a very important issue. Focusing on energy consumption in transportation Owens (1987) notes that indeed it is people who consume energy therefore it is very important to consider an educational system to encourage a culture change to conserve energy.

The technological approach is related to use of technological instrument aiming at introducing automation, designing new processes or installation of energy saving devices such as solar pre-heaters, occupancy sensors, building enclosure climate control, and new building designs. While implementing technological approach, return on investment is a significant issue to be considered. However this approach is effective, the initial cost of implementation is high therefore it is not recommended for organizations with limited capital. Given that technological approach doesn't persuade users to change their behavior toward energy, users still could waste energy in the same manner. Therefore we are just preventing users from making mistakes, not remedying the problem of excessive energy consumption that we are facing with. (Kempton and Schipper, 1994)

Respect to the technological approach, behavioral approach could be effective and can lead to an impressive decrease in energy consumption (Wedge, 2003). Energy use in buildings depends on the decisions and attitudes of occupants and owners. Socolow, (1978), researches at Princeton University represents that energy consumption in identical houses but with different occupants varies by more than a factor of two. Hansen (2002), shows that users are the main factor in energy efficiency. Levermore, (1985), by evaluating energy consumption in nine identical residents in London showed that there is a variation of 54% in electricity consumption and 40% in gas usage of those places. Monitoring users' behavior, Loozen, A and Moosdijk (2001), proved that 5-10% of the domestic energy use can be conserved by proper attitude toward energy consumption. Ueno et al (2006), showed that users' attitude towards energy consumption in non-residential buildings as well has a significant impact on total energy consumed mostly when the energy control systems are manually. However, in most cases managers have limited understanding about behavioral approaches and they don't believe the potential for energy efficiency improvement in changing workers attitude hence they usually don't focus on this aspect (Geller et al, 1982).

2.5.2. Socio-Psychological Model of behavior

Research has shown that a combination of factors such as knowledge, values, personal characteristics or attitudes influence individual behavior in society. Costanzo et al (1896) have developed a socio-psychological model to present people behavior towards energy conservation. The model combines individual, group and societal actions. This model supports overcoming barriers including lack of knowledge to help behavioral change in the context of energy savings. Researches about the socio-psychological model have demonstrated that people are more persuaded to change their behavior permanently when the new paradigms and attitudes were quite easy to be done, when they had enough knowledge and skills needed to adopt new attitudes, where they could see their colleagues and friends are acting in the same ways, and when they feel committed to change in society (Harrigan 1991).

Other researchers have demonstrated that people are more motivated to take action toward saving energy in the following conditions:

- They have possibility to see the amount of energy consumed and the savings achieved and therefore being promoted by goals and incentives.
- Information is provided in an active way and personal format. For example using intelligent and innovative ways of demonstrating particular actions to be taken using graphical symbols with different colors.
- Social comparison and running competition with others which raises their motivation to obtain a positive value. As shown by social identity theory people membership in groups is a part of their identity and they strive for a achieving a better self image (Tajfel and Turner, 1979). Festinger (1954), refering to social comparison theory mentions that comparison with others enables setting standards of individual behavior.

Accoding to these theoris underlining a common group indentity helps members to work collectively and effectively to reach an objective.

Refering to Maslow's hierarchy of needs (Maslow 1971) Geller believes that individuals need first to reach an adequate state of personal control and awareness before they start taking environemtally resoponsible actions to benefit others. Maslow mentions that satisfactoin of self needs helps individuals to be promoted for develping society and helping others. McMakin et al (2002), adopted socio-psyclogical model for evaluating motivation of the people in Yuma Marine Corps station in Arizona, for energy efficeinty efforts. Interviewing with people, residents believed that the last thing a soldier is concerned with is wheter his house is energy efficient. They believed when they are treated well then they would care about energy efficiency matters. These bahaviors are approved by Maslow's model.

2.5.3. Awareness and Knowledge the Power to Change

The first step to promote behavioral change is to raise awareness. Wong (1997) considers awareness as the seed for tomorrow's changes. There are profound potentials in behavioral approach to energy saving by empowering users with right attitudes, skills and knowledge (Vesma, 2002). Without providing users with enough knowledge, no one would be aware of advantages in energy savings and thus no realistic energy efforts would be done. There are several factors that are considered as barriers to move towards environmental sustainability including financial, cultural and urbanization (Dahle and Neumayer, 2001). They considered cultural and behavioral change as the second most important impediment on the way of greening process. In this study awareness has been considered as the starting point for cultural change with the goal of modifying behaviors.

3. Research Objectives and Methodology

Most of the universities in the world are following energy management programs aiming at decreasing their environmental footprints and air pollutant emissions produced by their operations. Reaching these targets they monitor and evaluate their environmental performance and each year they are setting new targets to reduce their footprint compared to previous years. To do so they are promoting awareness and responsibility among university staff and students to manage demand and control energy wastes. The objective of this study is to provide a continuous framework for changing awareness, attitudes and behavior of staff and students of of Politecnico di Milano, Como campus Valleggio Street building towards saving energy.

3.1. Research Significance

Most of the times staff and students in universities are taking energy use for granted. Energy bills at universities and other educational institutes are routinely paid without any concern. Simpson (1994), has considered energy awareness at universities of significant importance in energy conservation plans on campus. The reasons for the importance of raising energy awareness at universities are numerous. There are many people including staff and students using the facilities and consuming energy. As number of occupants in the buildings increases, human factor becomes very critical to energy conservation. Spreading and raising energy awareness among students will help them to become more responsible toward energy saving in their future life. These students in the coming future will become employees and managers of companies with different size from small companies to huge ones where they will be working and dealing with high energy consuming machines and devices and the decisions they take will have profound impact on energy consumption and sustainability of those organizations. Thus providing them sufficient information about energy concept and reasons for which they should care about consumption would be of great importance.

The other reason is that there are many facilities in universities including offices, classrooms, labs, computer rooms, restaurants, halls, university residences, libraries and other kind of facilities. The energy systems in these facilities are usually controlled manually therefore it is very important to educate students to use these systems effectively. University is paying annually for its energy consumption, by bringing energy efficiency efforts to the mission of the university and making it to be considered as a culture for its student and staff it can dramatically decrease its yearly energy expenditure.

A mobile population like students needs to be educated when they first arrive in the university. Especially at universities with many international students coming from all over the world it is very important to evaluate and improve their understanding of energy conservation attitude. Energy awareness programs not only cut costs but also bring good reputation for the university perceived by public.

3.2. Research Methodology

In this study firstly by analyzing energy bills, energy consumption of the university from 2008 to 2010 will be assessed and reported. An energy cost analysis will also be done for the same period. In the second part the objective of this study is to evaluate staff and students behavior toward energy conservation. To do so two questionnaire surveys are prepared which are targeting staff and students of the university. The level of their awareness, motivation and activeness towards energy conservation efforts will be evaluated and an overall assessment of the satisfaction level of staff and students about heating, cooling, ventilation and lighting system of the campus will be reported. At the end this research aims at providing university practical suggestions helping Politecnico di Milano to become a leader in sustainable practices.

4. Case Study: Como Campus Valleggio Street Building Energy Consumption

4.1. Description of the Building

General Information about Como campus Valleggio street building

The building is owned by two universities which are Politecnico di Milano and University of Insubria. The Valleggio street building is constructed in 1997. It is a 6+1 store building with 10,012 square meters floor area which is owned by both Politecnico di Milano and University of Insubria. The building is utilized by academic, administrative and technical staff for various purposes.

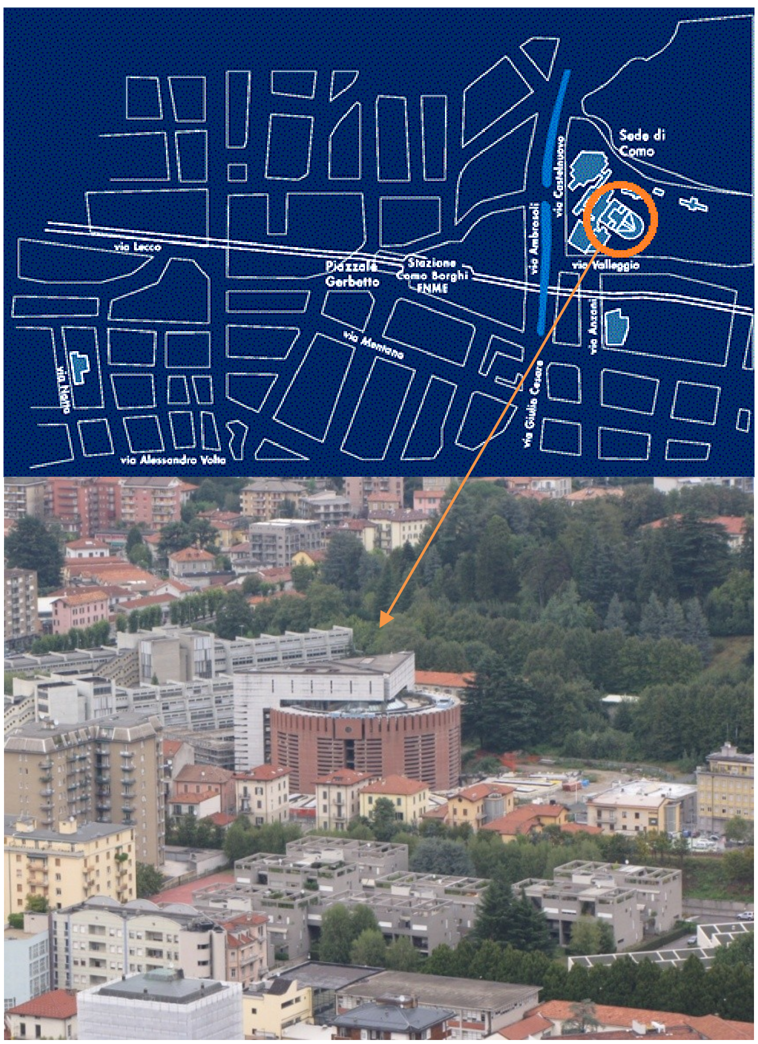


Figure 7: Location of Como campus Valleggio street building-Politecnico di Milano

Table 2: Distribution of spaces at Como campus, Valleggio street building (Share of Politecnico di Milano)

Space description	Total Area (m^2)
Classrooms	1,470
Hallway and stairs	958
Offices	547
Libraries	442
Service rooms	72
Laboratories	470
WC	64
Total	4,023

Currently the building is under modifications. There is a project of making a new passage between the building and Como campus Castelnuovo street office. A new small building will be constructed in front of the main building as well. The campus has not undergone an energy audit by now.

4.1.1. Heating, Cooling and Air Conditioning Systems of the Building

The building is using fire tube-steam heating system which works with natural gas energy. Cooling system is a mix of different types of chillers and compressors working with 400 voltage electricity. The cooling system starts working from June to September. The maintenance code for heating and cooling systems is mentioned fair. There are 10 units of domestic hot water heated by electricity with the temperature of 50 degrees centigrade.

Combination of natural and mechanical ventilation is used in the building serving 8,500 m^2 of the floor area. Different systems including single zone, multi zone, dual duct, fan coils, unit ventilators, and unit heaters are used in the ventilation system.

4.1.2. Campus Lighting System

Having a walk through the building it is observed that for the lighting system in the building mostly compact florescent fixtures are used. There is no photocell, motion or acoustic sensor for controlling the lighting of the building, it is controlled manually. It is often observed that there are empty classes with all lights on. The same situation is happening for the toilets. It is also observed that most of the times in the classes, windows shutters are closed and the lights are all on while there is the possibility of using sunlight. In the following pictures which are all taken in the morning the situation is clear.

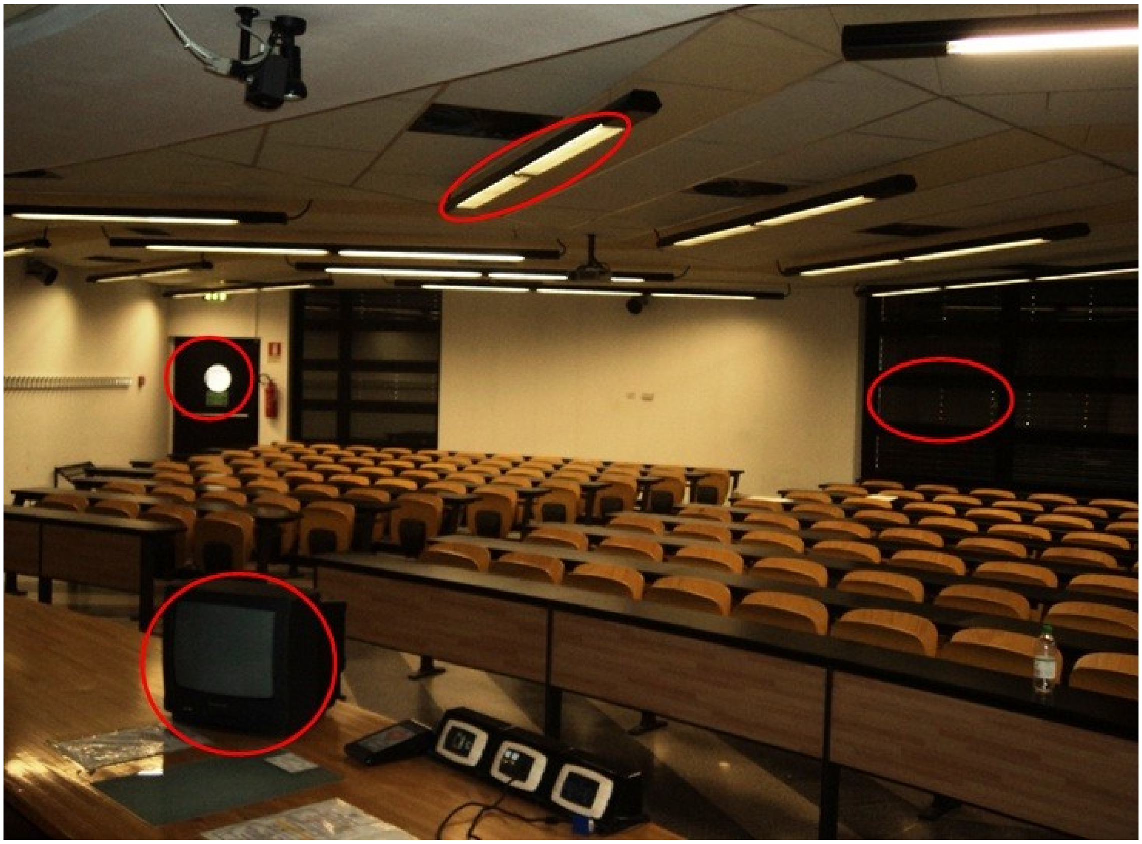


Figure 8: Class VS9 at Como valleggio building, Politecnico di Milano

In the picture above it is shown that although it is in the morning and there sunlight outside the class, window shutters are closed and all the lights are on while nobody is in the class. Some old and oversized electrical equipment are still being used in the classes like the television.

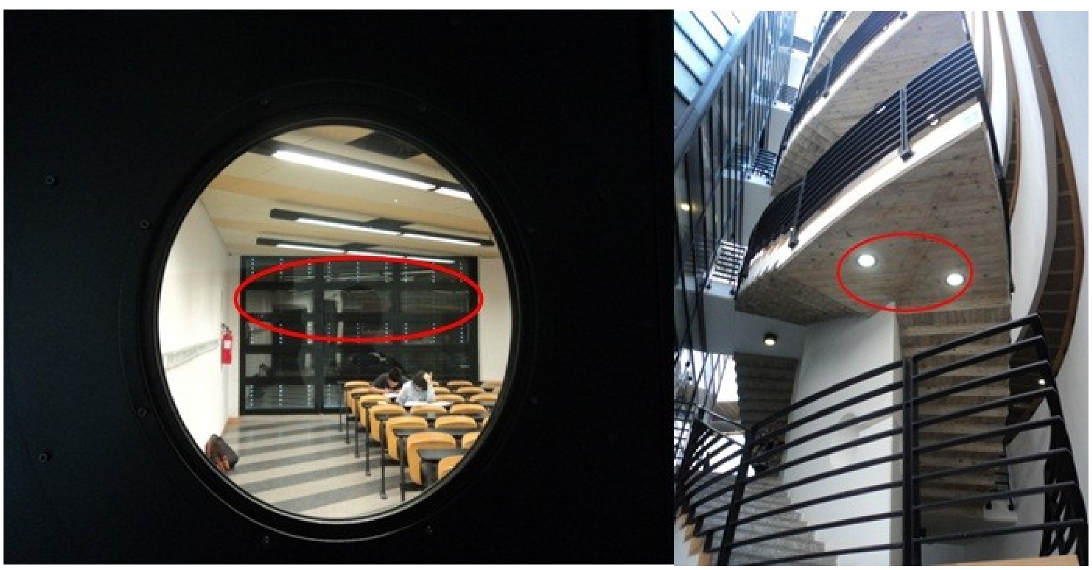


Figure 9: Campus natural illumination and electric lighting

4.2. Energy Consumption and Costs of the Building

The following graphs give an overview of electricity and gas consumption data of the Campus between 2008 and 2010.

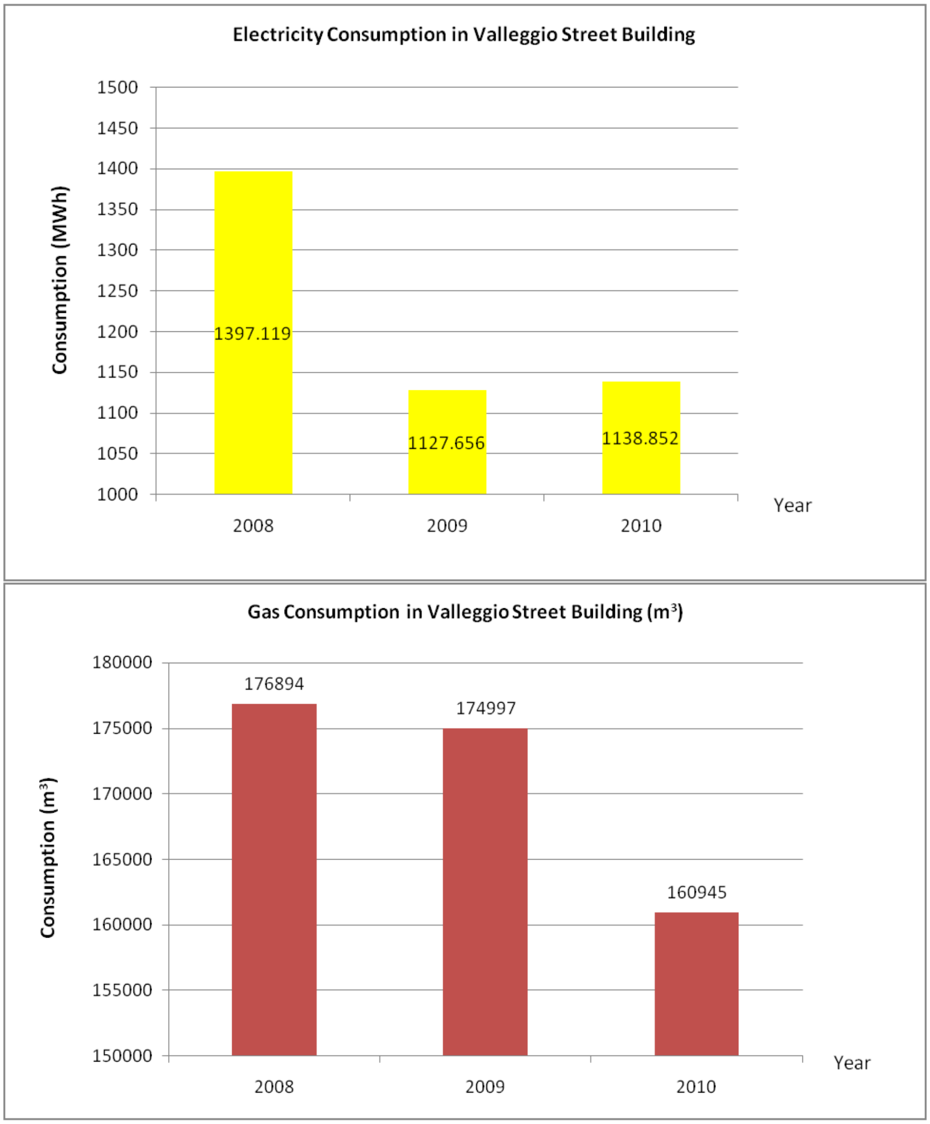


Figure 10: Electricity and Gas consumption in Valleggio street building of Como Campus. Source: Enel, Enerxenia

Considering each cubic meter of gas generates 10.35 KWh of energy the total energy consumption of the campus form 2008 till 2010 are as follows:

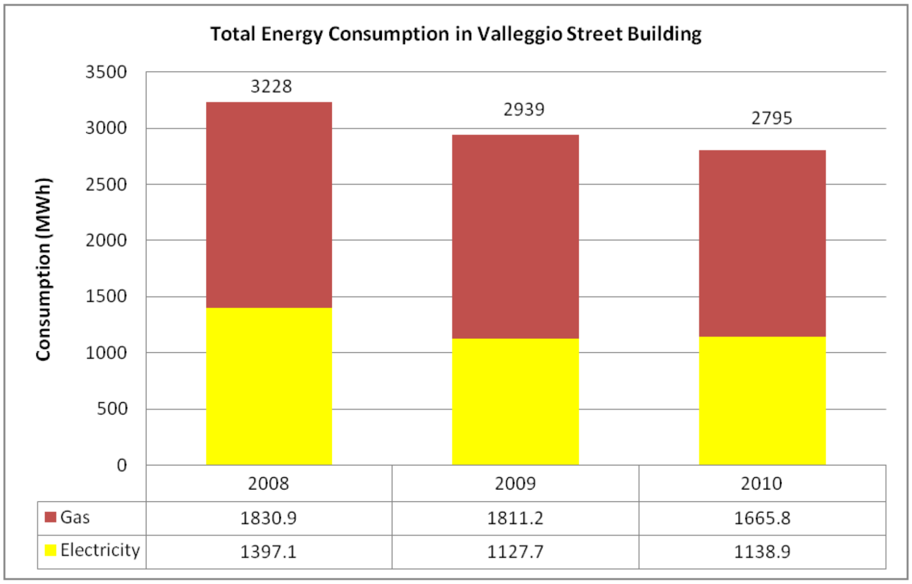


Figure 11: Total energy consumption in Valleggio street building of Como Campus. Source: Enel, Enerxenia

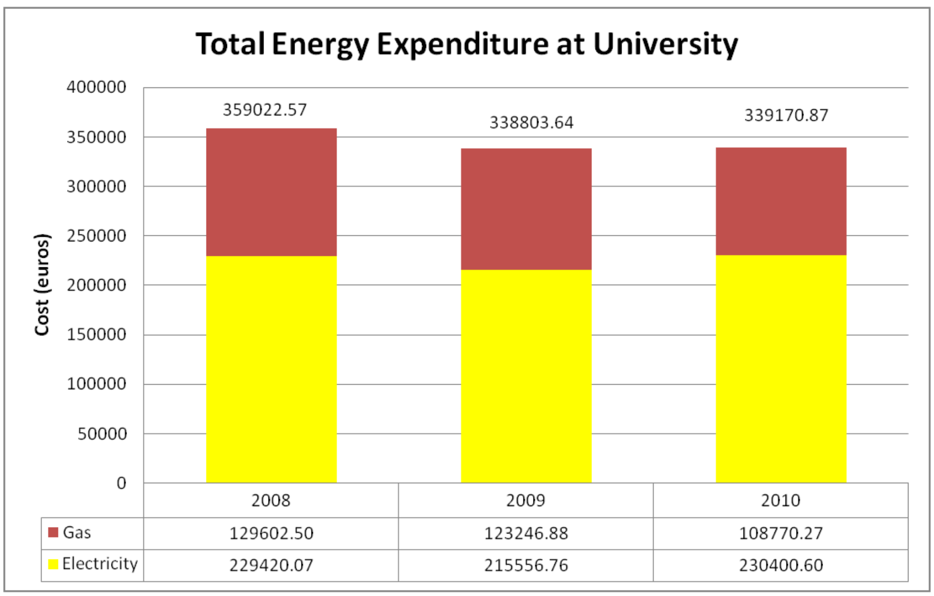


Figure 12: Como campus, Valleggio street building total annual energy expenditure. Source: (Chamber of Commerce of Como)

According to the above graphs, the university is annually consuming on average 2987.33 MWh of energy only in Valleggio building in Como campus and the average annual energy expenditure is about € 345,665.70 per year. Yearly cost paid for electricity is almost two times the cost of gas consumption. Total energy consumption is decreased from 2008 to 2010 by 13%, however, the cost of energy is decreased by only 5.5%.

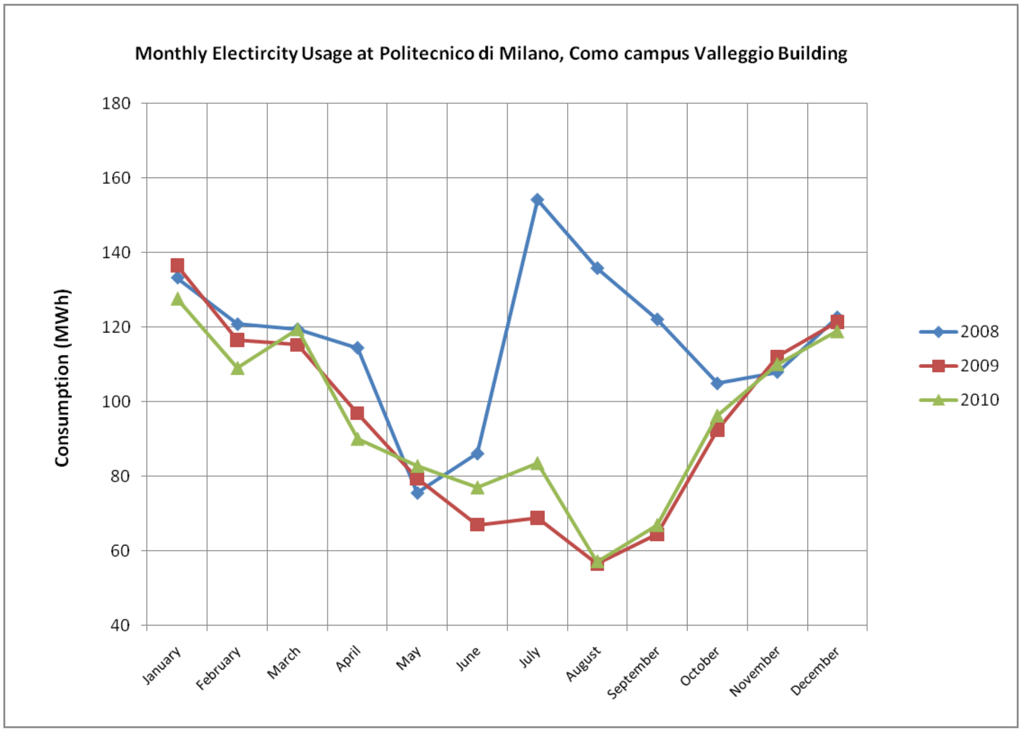


Figure 13: Monthly electricity consumption at Politecnico di Milano, Como campus Valleggio street building. Source: Enel, Enerxenia

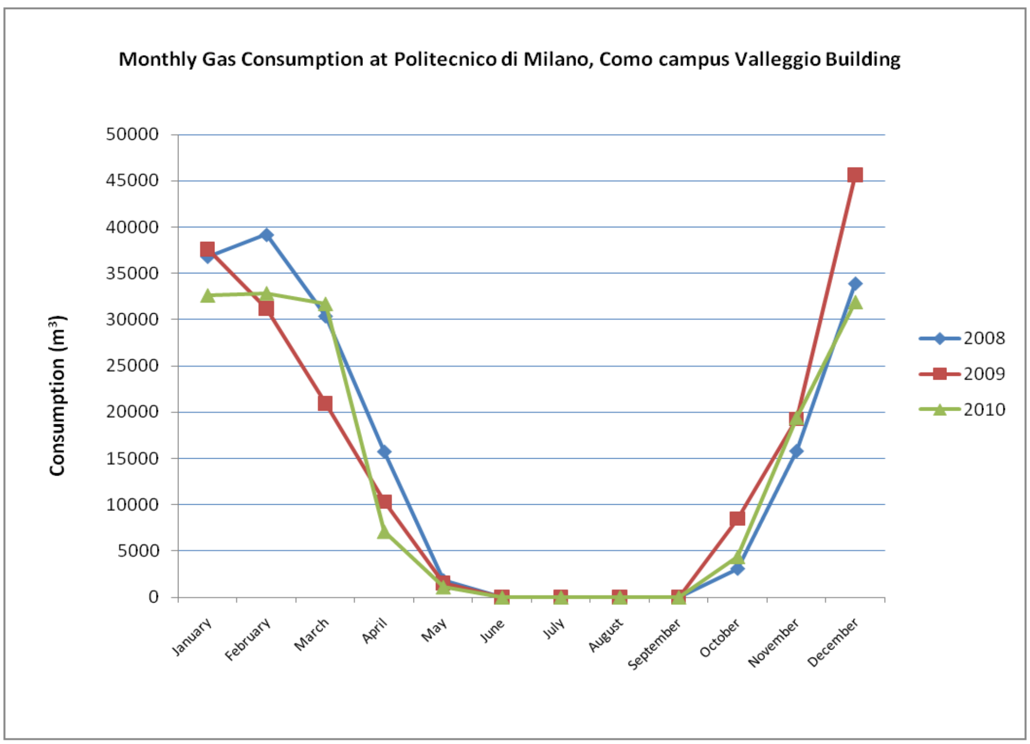


Figure 14: Monthly gas consumption at Politecnico di Milano, Como campus Valleggio street building. Source: Enel, Enerxenia

According to the above graphs during a year, energy is mainly used in cold season. Having an interview with energy manager of the main campus of Politecnico di Milano about the anomaly in energy use in summer of 2008 he mentioned that sometimes there are mistakes in energy bills and for preventing such mistakes they are planning to use electric and gas meters for having a better control over energy cost and consumption.

4.3. Energy Awareness and Energy Efficiency Assessment Survey

4.3.1. Questionnaire Information

To evaluate current energy awareness and energy efficiency among occupants of Valleggio street building a questionnaire survey was conducted. The survey has covered different aspects, such as energy consumption trend in university, average yearly cost of energy at university, staff and students awareness in concept of energy, their motivation for conserving energy, their activeness level for improving energy efficiency and level of satisfaction of the heating, cooling, ventilation and lighting systems of the university.

To evaluate users' attitude toward energy saving two different questionnaires were designed, one of the questionnaires is targeting students of Politecnico di Milano and university of Insubria and the other one is designed for staff of these two universities. Besides interviews with campus maintenance office were carried as a supplementary source of information for the study.

4.3.2. Student Energy Awareness Questionnaire

In total 110 paper questionnaires were distributed randomly among students of both Politecnico di Milano and University of Insubria and 100 students completed the questionnaire thus the survey has a response rate of 90.9 %.

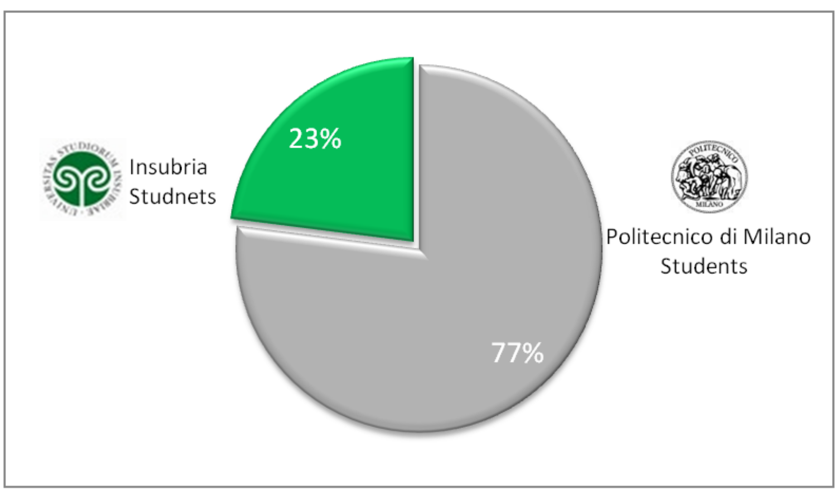


Figure 15: Students distribution according to their universities

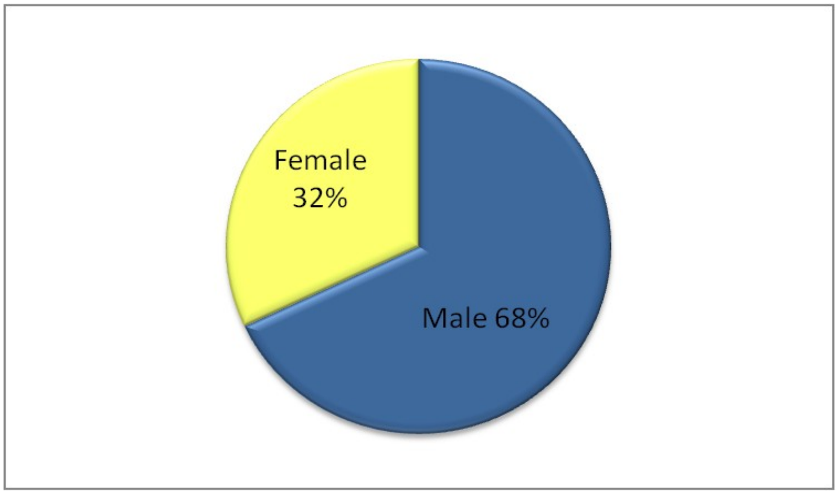


Figure 16 sample distribution by gender

Sample students are from 13 different countries: Italy, Turkey, Iran, Colombia, China, Russia, India, Egypt, Sweden, Switzerland, France, Bulgaria, and Ethiopia. The students who did not mention their nationality are considered as international students.

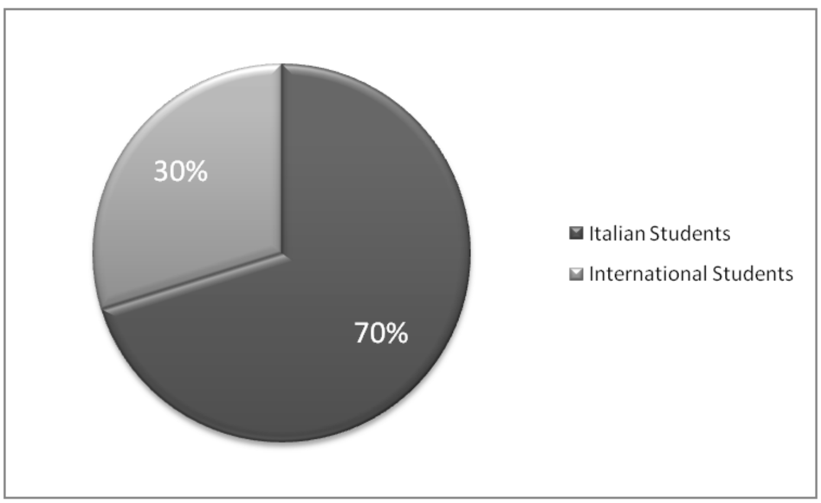


Figure 17: Student distribution by their nationalities

The questions of this questionnaire are categorized in four main groups: Awareness, Motivation, Activeness and Satisfaction.

Students Awareness

In the first assessment which is about student awareness the answers are in four different categories: Totally aware, aware, partially aware ad not aware. Details about the formula and weighting for the questions related to those three main groups are included in appendix B. The comparison is made between Italian and international students.
There are seven questions related to awareness evaluation. The table below shows the number of questions and the topics covered by them.

Table 3: Student Awareness Questions

Question Number	Topic
1	Concept of Energy
2	Types of Energy
3	Cost of Energy and Causes of Energy Loss
4	Estimation of The Cost of Energy at University
5	Energy Saving Attitude
6	Practical Ways of Energy Saving at University
7	Energy Saving Methods
10	Environmental Impacts

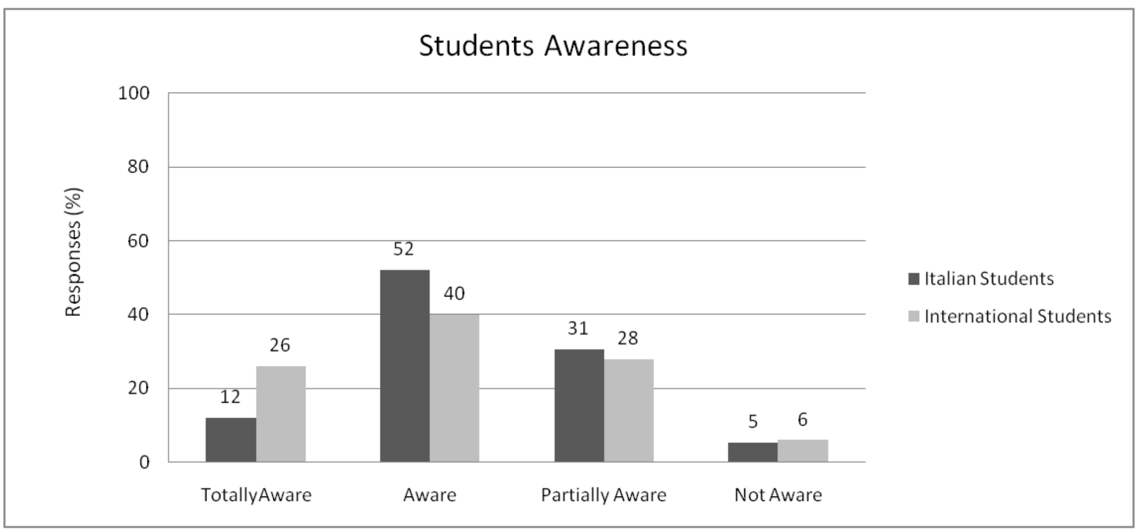


Figure 18: Student awareness figure

The above graph shows that Italian and international students are nearly at the same level of awareness. Almost 65% of the sample students are totally aware or aware of concept of energy, environmental impacts and energy conservation. For increasing student awareness level they were requested to mention their preferred ways for receiving information with the university.

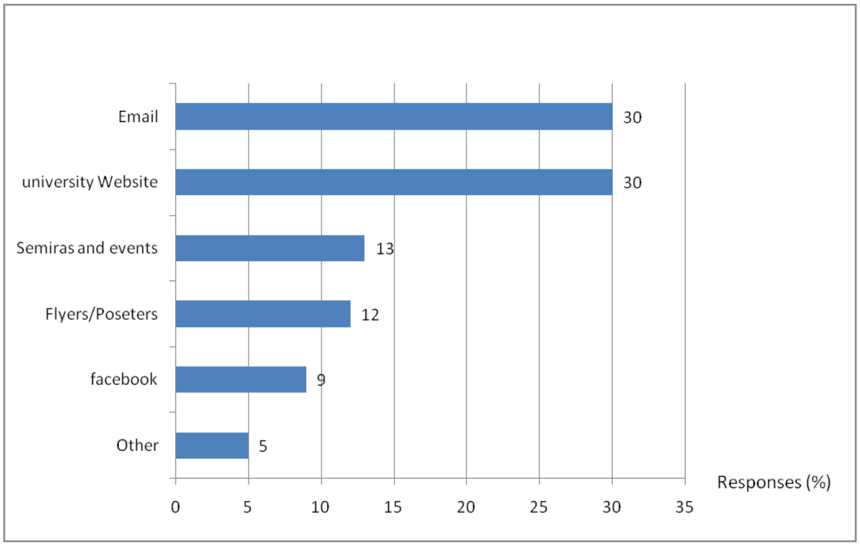


Figure 19: University communication channels with students

Como valleggio street campus student sample preferred to receive information about energy saving methods and energy conservation events mainly from Email, university websites, seminars and flyers and posters.

Students Motivation

There are three questions dealing with the level of motivation of students toward energy efficiency improvement. Firstly students are asked to mention how motivated they are to save energy. The answers to this question are as follow:

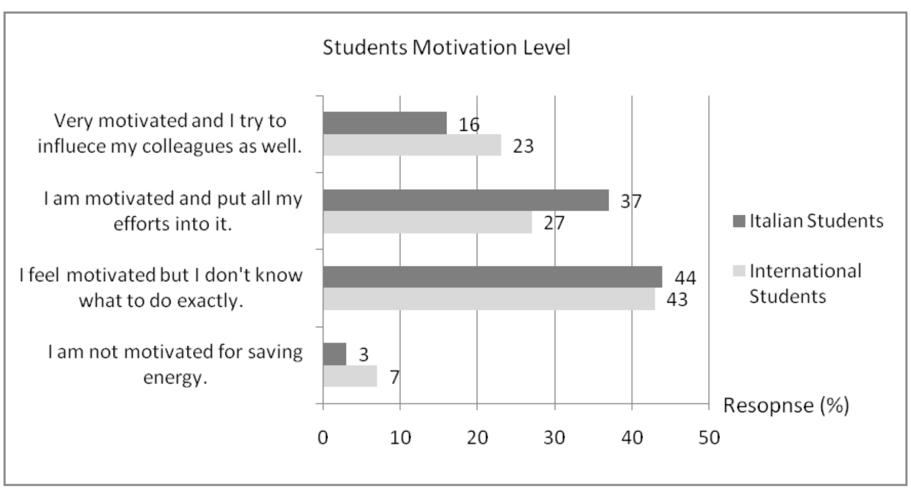


Figure 20: Student motivation level

There are many students who are motivated for saving energy but they don't have the insight to start. The university should support them with the right know-how of the saving opportunities. There are only about 20% of the students who try to spread the idea of improving energy efficiency of the campus. To build energy saving teams of students could be a way for increasing awareness and motivation for participation of a larger group of them in conservation events.

Accordingly they are asked to describe the primary reason for which they are trying to improve energy efficiency. The answers are as follow:

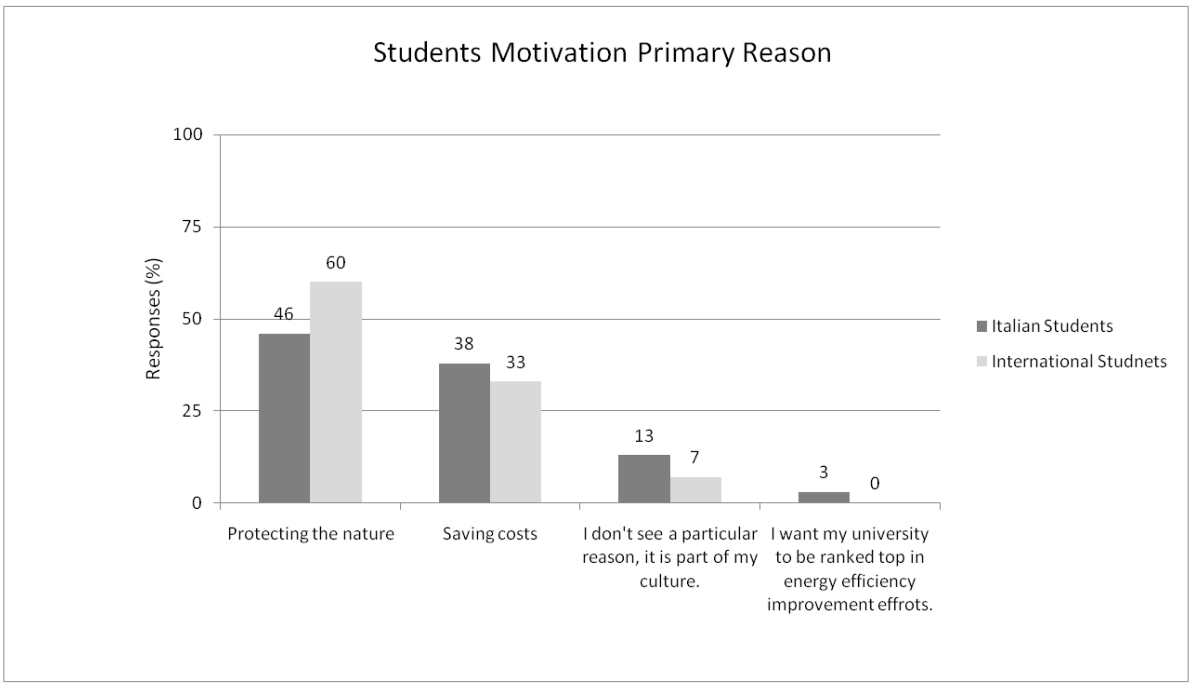


Figure 21: Students primary reason for motivation

It is observable that almost half of the students have selected "protecting the nature" as their main motivation reason to save energy the second main objective for saving energy among students is to save costs.

At the end they are asked for further participation for sharing their ideas about energy saving and the following results have been achieved:

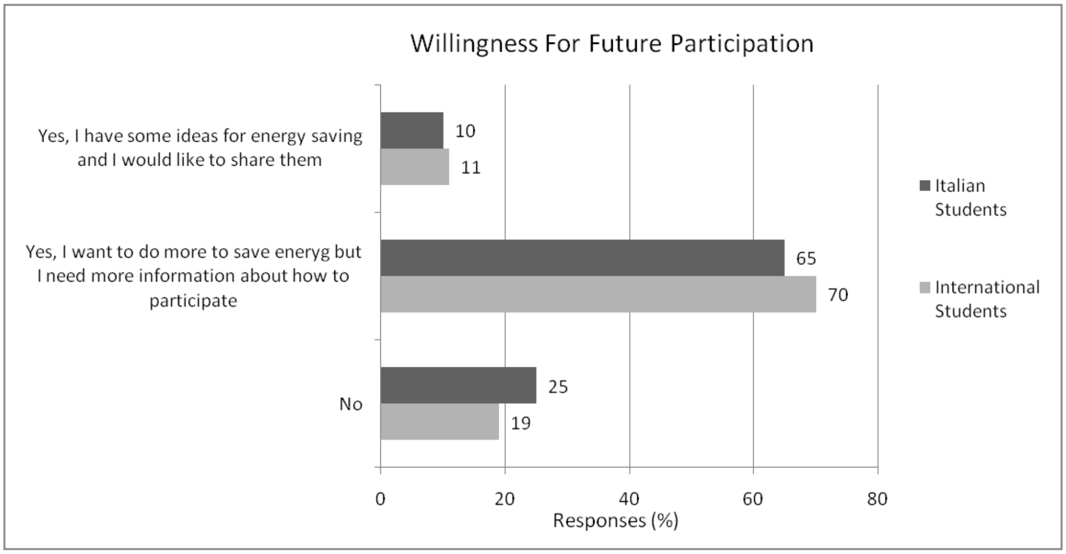


Figure 22: Student Willingness for Future participation

It can be seen that almost 65% of student sample are quite motivated for future participation for improving energy efficiency of the campus.

Students Activeness

For assessing activeness of students in increasing energy efficiency in the campus, they are asked to mention if it is important for them to save energy at their home and/or university and other public places. Following are the results of the responses to this question:

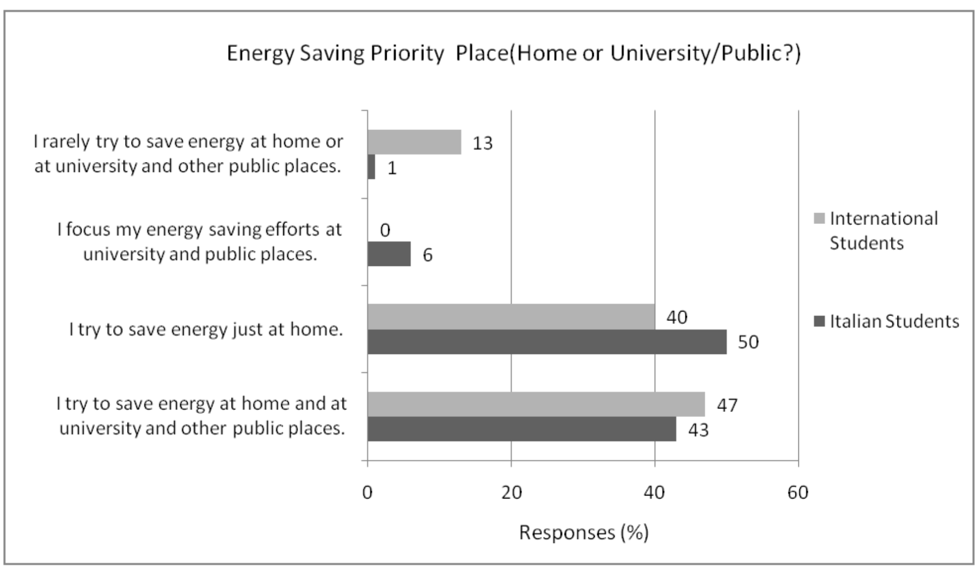
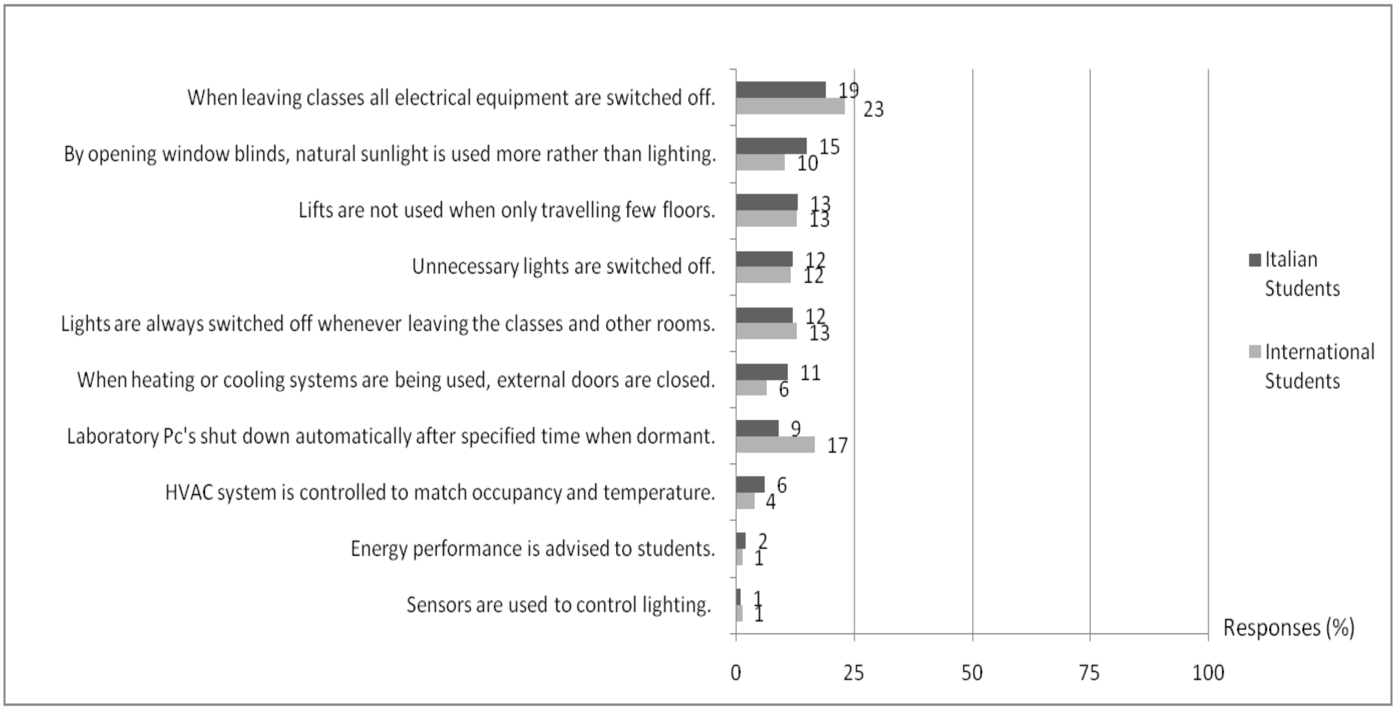


Figure 23: Students energy saving priority place

From the graph it is understood that almost 90% of the students are trying to save energy at their home. The reason may be because of alerts from mass media or the culture of their families. However, only less than 50% of the students are saving energy at university. According to figure 23, almost 70% of students want to participate in energy saving efforts so it can be concluded that they are motivated enough to improve energy efficiency in the campus as well but they don't have the know-how about how to start.

As a final assessment of the activeness of students and the campus in energy saving efforts students are asked to mark the actions which are routinely done in the Valleggio street building. The results are as follow:

Figure 24: Level of activeness in energy saving at university (Students responses)



The questions are not asked directly from the student as if they are doing that action or not. In this way they can answer them freely without having the sense of being blamed. As it is seen from the graph above, energy saving activities are seldom done in the campus.

Student Satisfaction

The final part of the questionnaire is dedicated to evaluation of overall satisfaction level of the students of heating, cooling, ventilation, and lighting systems of the campus.

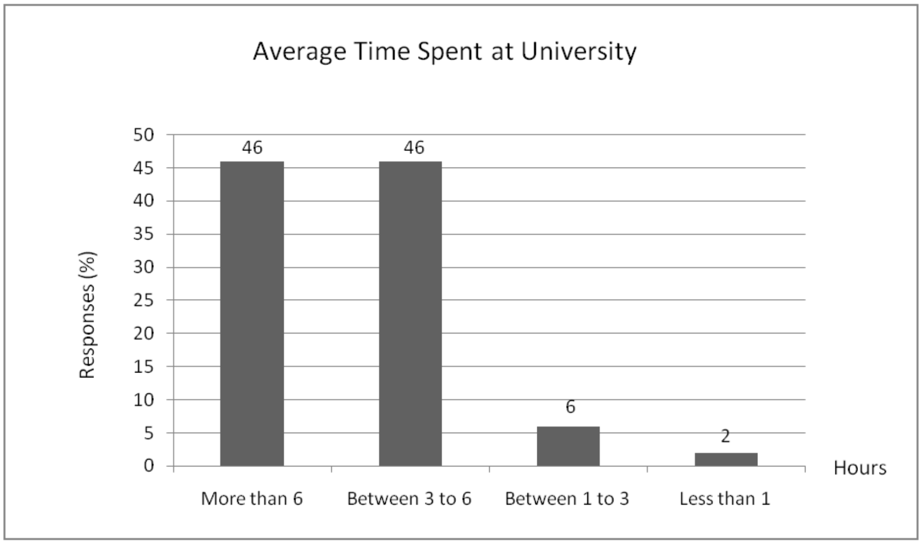


Figure 25: Average time spent by students every day at university

More than 90% of the students are spending more than three hours each day being on the Valleggio street campus. Fifty percent of the students reported that they spent most of their time in the libraries while 48 percent of them mentioned they are mostly using classes and the remaining two percent reported computer sites.

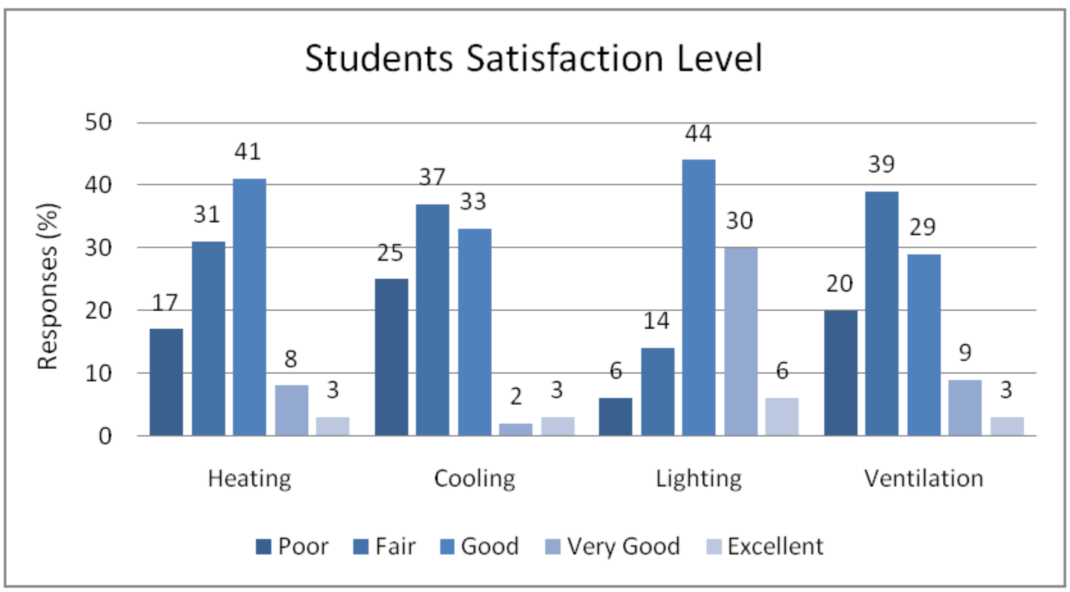


Figure 26: Student satisfaction level

According to the above chart, the level of student dissatisfaction in cooling and ventilation systems is notable. In heating and lighting systems almost half of the students have rated those systems as good but the other half were not satisfied.

4.3.3. Staff energy awareness questionnaire

Introduction

This report presents the results form a staff energy awareness survey carried out at Politecnico di Milano, Valleggio Street building of the Como campus. The questionnaire conducted from 13 June 2001 for one week. The objective of the survey is to assess awareness of the staff toward energy consumption and accordingly to encourage conservation attitudes and to improve energy efficiency of the campus.

Methodology

As the native language of the staff was Italian the questionnaire was prepared in Italian. In total 45 questionnaires in paper format were distributed randomly among staff of both Politecnico di Milano and University of Insubria. Since the building is owned by two different universities, due to lack of management integrity most of the Insubria staff didn't show willingness to respond to the questionnaires. Thus only 35 staff completed the questionnaires and therefore a response rate of 77.7 % was achieved.

This questionnaire comprises five main categories of questions: staff responsibility toward saving energy, staff awareness, staff motivation, staff activeness and staff satisfaction. Staff are categorized in four groups according to their positions in the university: academic and research, administration, maintenance and cleaning staff.

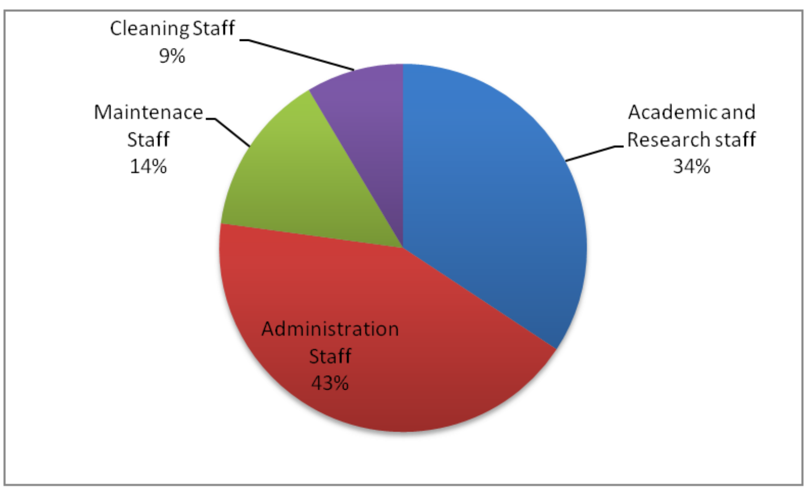


Figure 27: Staff distribution by their position

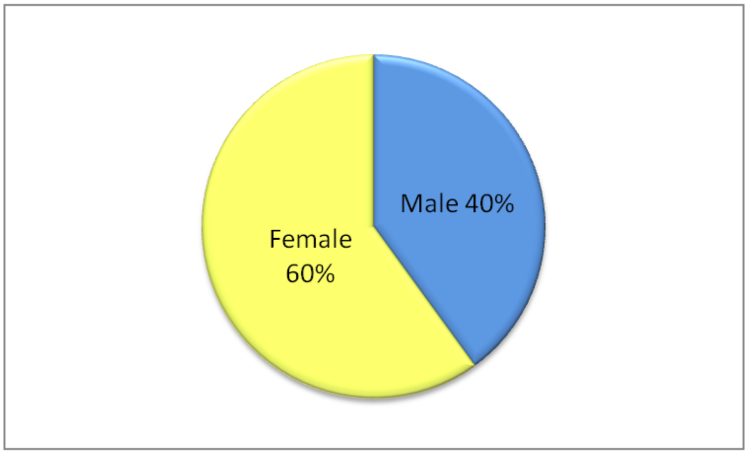


Figure 28: Staff distribution by gender

Staff Responsibility

85% of the staff strongly agreed or agreed that it is their responsibility to save energy while working. It is quite encouraging that almost 90% of the respondents strongly agreed or agreed that they should put more effort for improving energy efficiency at work. 90% of the staff strongly agreed or agreed that the university should become less reliant on non-renewable energies.

Staff awareness

Staff were asked whether they know if university has an energy policy or not. Their responses to this question show that almost 70% of them did not know if the university has some policies toward energy consumption and conservation. The answer of other 30% was negative to this question. 83% of the staff didn't know that if there is an energy manager in the campus while 14% answered there is no energy manager in Como campus. It can be concluded that either there is no energy policy in the university or it exist but it is not well communicated to the staff.

Analysis of the answer to the questions related to energy awareness shows that 60% of the staff are totally aware or aware of energy concept, its costs and the ways in which energy could be wasted and remaining 40% are partially aware or not aware of that.

For increasing staff awareness they were asked to mention the means with which they prefer to receive notification about energy efficiency from university.

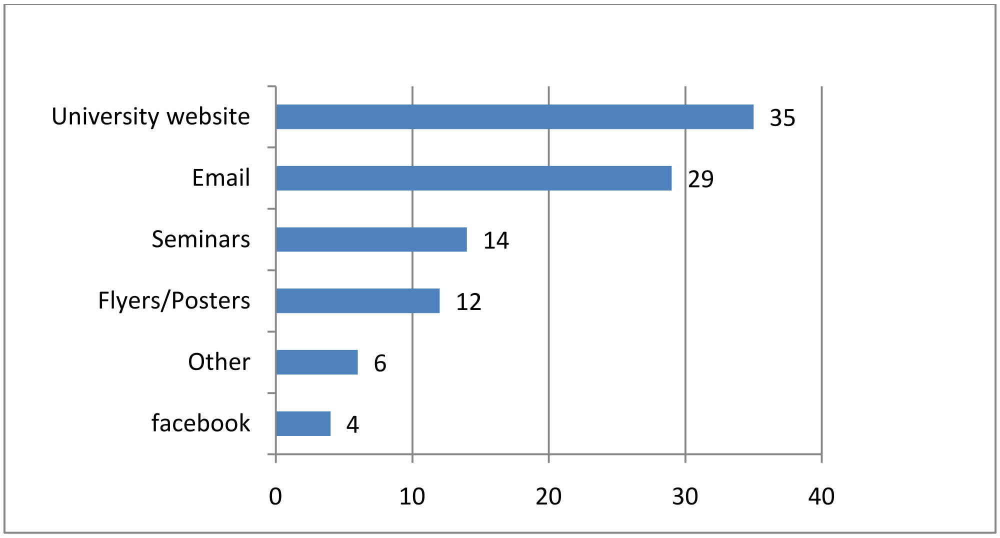


Figure 29: University communication channels with the staff

It shows that staff prefer receiving information about energy efficiency from university mainly by referring to university website and receiving email and attending seminars held by the university.

Staff Motivation

The staff showed a high level of motivation toward energy conservation. 85% of them are very motivated or motivated for saving energy.

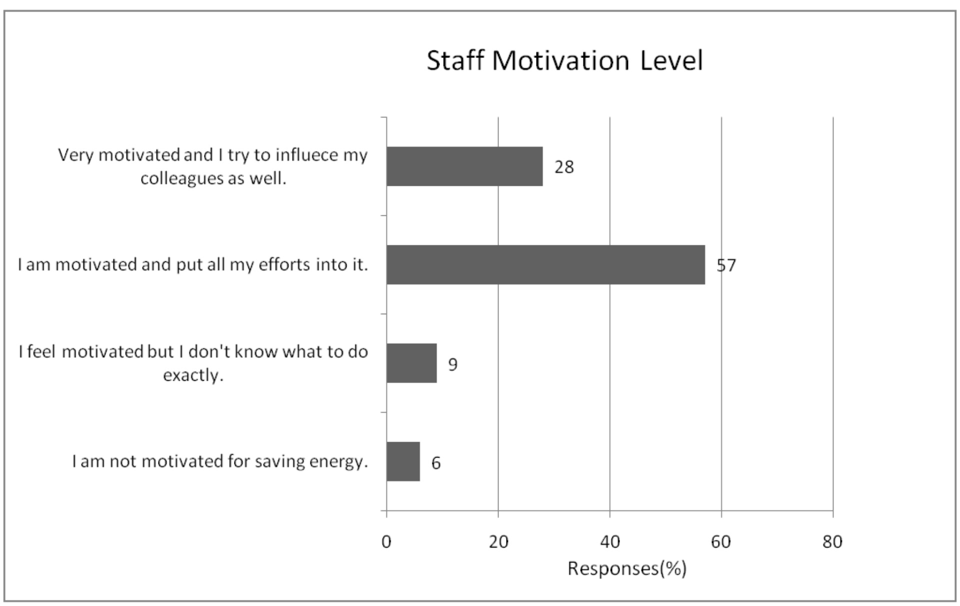


Figure 30: Staff motivation level for energy conservation

The primary reason for which they are this much motivated has been reported as protecting the nature, saving costs and increasing university reputation in energy saving efforts respectively.

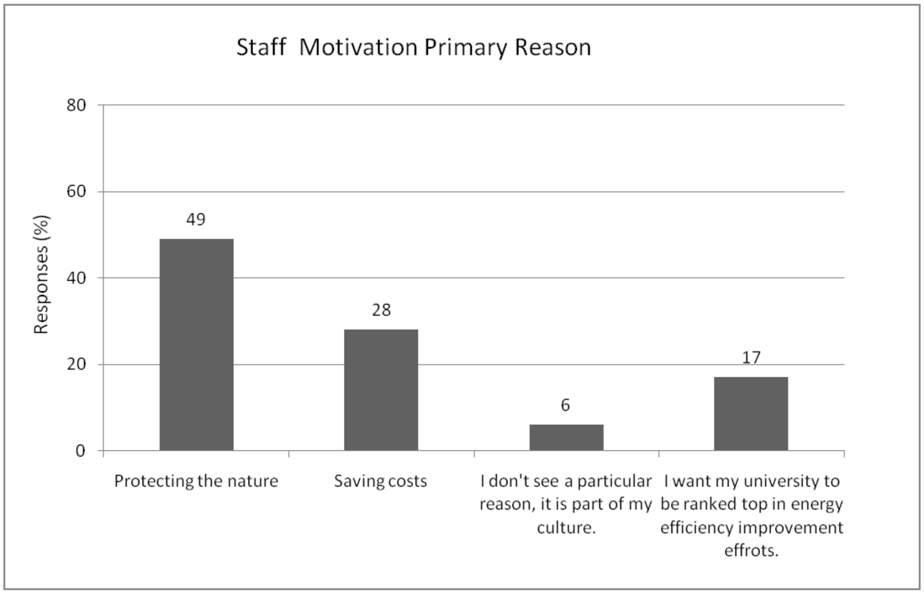


Figure 31: Staff motivation primary reason

Staff Activeness:

In this part staff firstly were requested to answer The same question which was asked from the students. “Where do you feel more committed to save energy?”. The result of staff answer to this question is as follow:

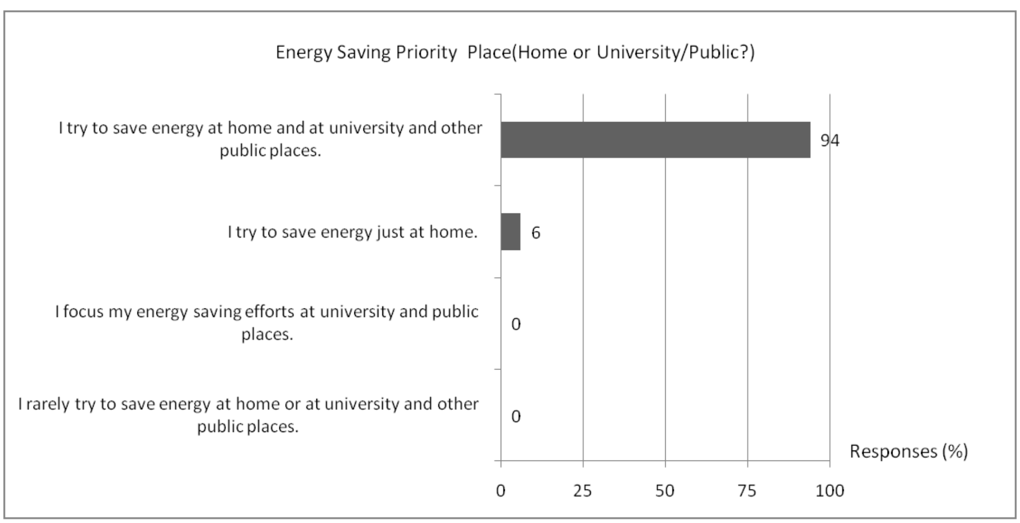


Figure 32: Staff energy conservation priority place

It shows that it is important for almost all the staff to take into account energy saving efforts both at home and at work. Then for finding out more carefully and thoroughly the level of activeness of the staff they are requested to mark the actions which are most of the time happening at university aiming for consuming energy more efficiently.

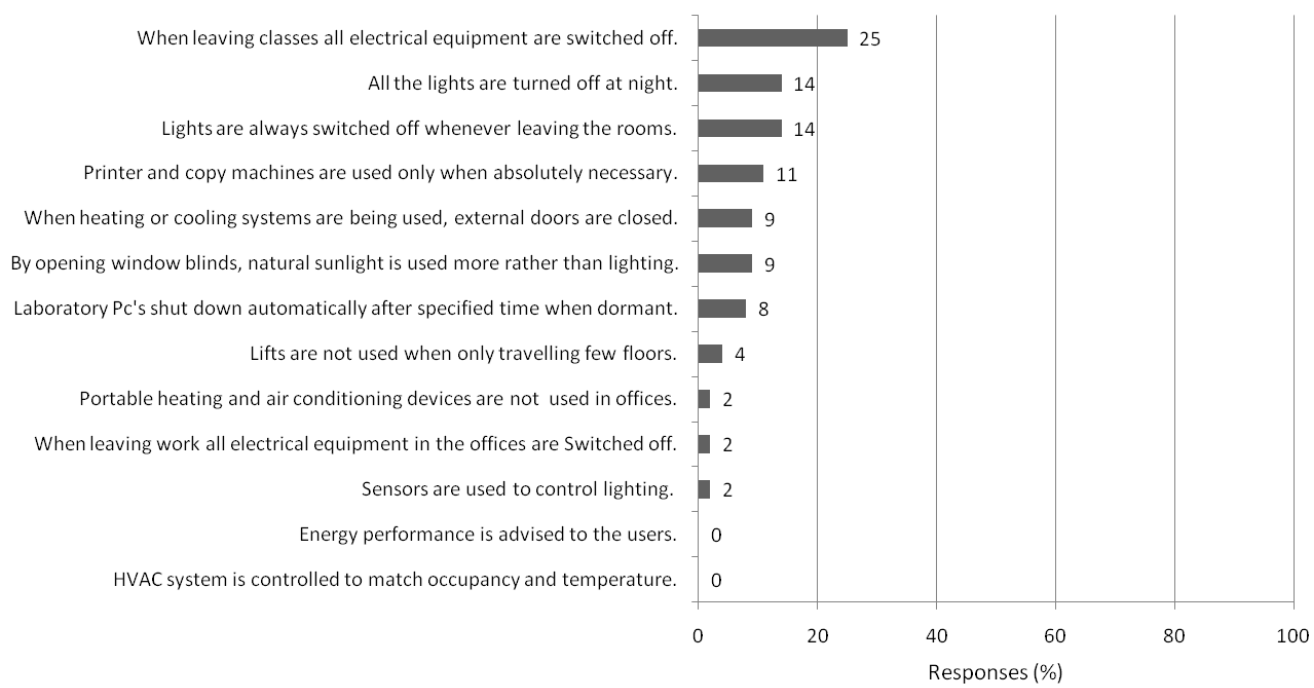


Figure 33 level of activeness in energy conservation at university (Staff responses)

Here according to the above graph it is obvious that these actions are rarely happening at the university. It seems that even if it was important for them to consider energy savings both at work and at home, staff are not taking actions seriously to improve energy efficiency. None of the staff has confirmed that if energy performance is advised to the users by university. It could be concluded that university doesn't persuade the staff to think more about this important issue of energy conservation. Visiting different offices of the campus, it has been observed that there are many portable heating, cooling and air conditioning devices in the rooms. Some of these devices are significantly oversized while are used by only one or two people in a very small room. Poka-yoke systems such as sensors or other controlling devices for preventing user's mistake which lead to waste energy are not used in the campus.

Staff Satisfaction

In this part staff were requested to evaluate the overall quality of heating, cooling, ventilation, and lighting systems available in the university. Almost 90% of the personnel spend more than six hours each day at university.

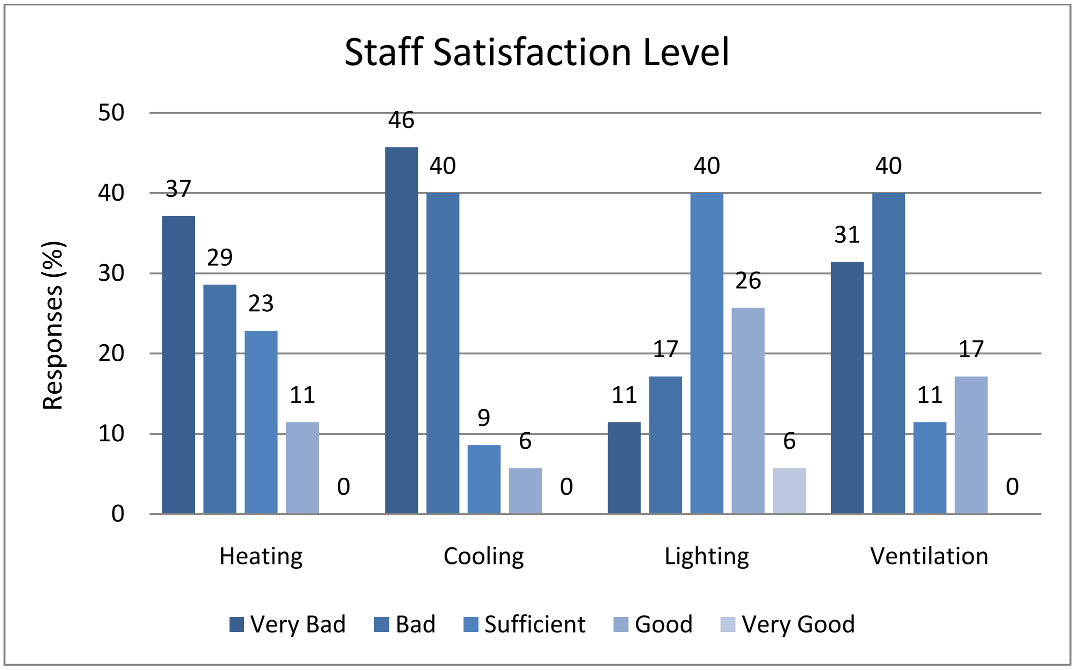


Figure 34: Staff satisfaction level

According to the chart in figure 10, the effectiveness of the heating, cooling and ventilation systems are not satisfying for the personnel. Almost 90% of the staff are not satisfied with the cooling system. For ventilation system the level of dissatisfaction is about 70% and for heating system 66% of the personnel rate it as very bad or bad.

The last question asks staff for assessing the overall level of energy efficiency of the Valleggio street building. The results are as follow:

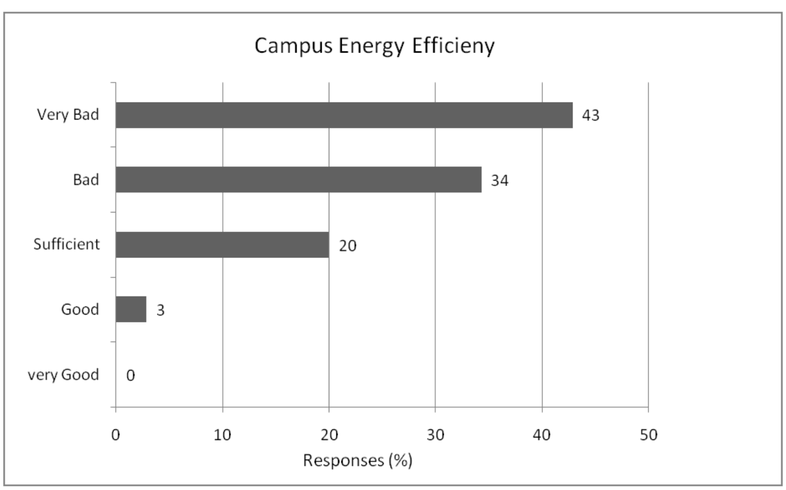


Figure 35: Staff view about campus energy efficiency

Results show that almost 80% of the staff sample believe that the energy performance of the building is very bad or bad.

4.4. Energy Saving Suggestions for Politecnico di Milano

Most of the universities in the world are following energy management programs aiming at decreasing their environmental footprints and air pollutant emissions produced by their operations. In order to reach this objective they monitor and evaluate their environmental performance and each year they are setting new targets to reduce their footprint compared to previous years. To do so they are promoting awareness and responsibility among university staff and students to manage demand and control energy wastes.

Energy consumption per gross floor area of Como campus Valleggio street building is 298KWh per square meters. The cost of energy per square meter is about 35.5 euros. Unfortunately there is limited data available for making a comparison between energy consumption among different Italian universities. According to table 1 which defines low energy building standards in Europe, total energy demand of a passive building in Germany should be less than 120 KWh per square meters. The energy consumption of Valleggio building is about 2.5 times of the standards of a passive building in Germany. According to Tertiary Educational Facilities Management Association (TEFMA), (2007) report which identifies the standard energy consumption in Australian universities, in 2007 benchmark report the annual energy consumption per square meter of gross floor area (GFA) is 0.72 gigajoule. This number for energy consumption in valleggio street building reaches 1.07 gigajoule, however, this comparison may not be accurate.

For becoming a leader in energy and environmental performances, Politecnico di Milano should develop an action plan addressing the student and staff of the university to increase their level of awareness, motivation and activeness toward energy conservation. It is very important to believe that students and staff of the university can significantly impact the success of the action plan. Key step for the success in the implementing phase of the action plan is to gain support and cooperation of the students and the staff. Furthermore providing information and increase the level of awareness and motivation and commitment of the people in the university will help university to reach its energy management targets.

4.4.1. Proposed Suggestions for Improving Energy and Environmental Performance at University

The university can start its movement toward promoting energy conservation, efficiency and renewable energies with following two steps:

Step one: To use energy more efficiently

- Standard Energy Consumption Methods
  Running energy conservation events in which students and staff can better understand standard energy performances. By attending these kind of energy efficiency improvement Kaizen events student can participate in team works and brainstorm ideas for eliminating waste in consuming energy. This part includes providing energy reduction best practices for maintenance and technical staff of the university in form of training material and standard equipment operation and maintenance as well. Monthly meetings for the energy and environmental performance improvement teams helps them identifying achieved targets and setting new objectives.

- Visual Control
  Visual control techniques can be used for encouraging staff and students to carry out standardized tasks toward saving energy and to make them visible the current energy consumption of the university. Since electricity dominates the university energy budget, for cutting electricity costs these simple techniques including drawing signs over the electricity switches can remind staff and students not to forget turning off the lights when not in use.

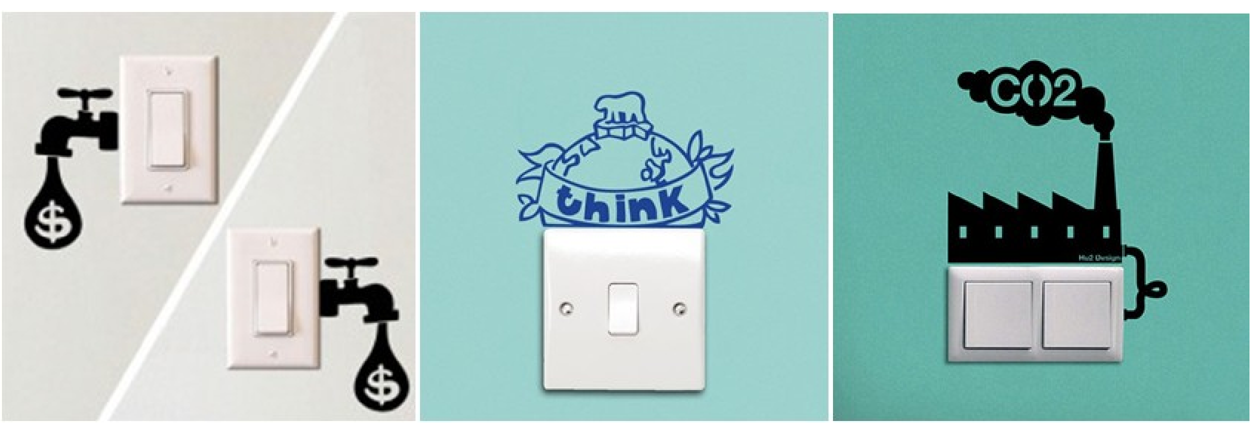


Figure 36: Visual control signs targeting costs and environmental impacts for encouraging users to take action. Source: www.recyclereminders.com

Figure 37: Visual control signs aiming at reminding users to take proper action to save energy, Source: www.recyclereminders.com

Using these signs would be more effective if energy efficiency efforts are part of university energy plan and energy saving routines. If the students observe that standard actions toward saving energy are not done by university, they would lose motivation to conserve energy.

Visual control techniques are also used for tracking actual results against objectives and targets to encourage further improvement. Using electricity and gas meters and connecting them to the consumption and cost dashboards for making visible actual state of energy consumption, CO_2 emissions, costs and other indicators would make staff and students to take proper actions.

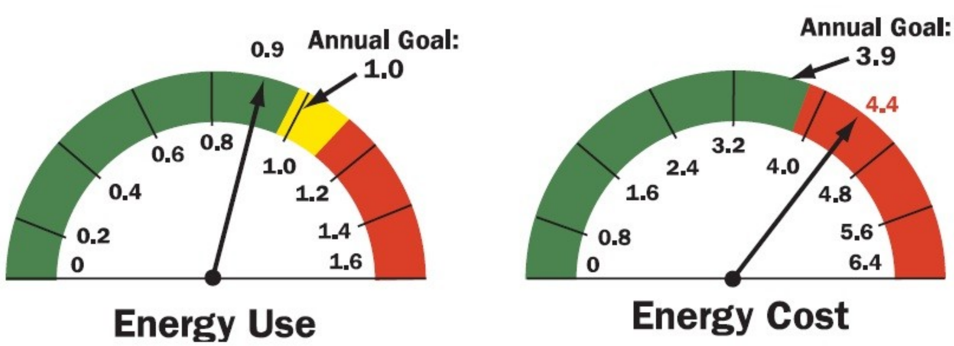


Figure 38: Energy consumption and costs dashboards, Source: EPA

- Mistake Proofing
  These techniques are also known as poka-yoke which are procedures to prevent defects and errors done by employees. One of the mistake proofing techniques which can be used at university could be light sensors. Photocells, acoustic, movement or occupancy sensors which can be installed in places at university at which there is no permanent need for lighting including classrooms, toilets, stairs and such places.

- Upgrading old equipment
  Changing old and aged HVAC system components like compressors, and pumps, fan coils and other equipment with new and energy efficient qualified ones (ENERGY STAR products) would significantly decrease energy consumption and environmental impact accordingly. Using efficient lighting for example LED light bulbs in exit signs is also of upgrading actions which helps reduction electricity energy consumption.

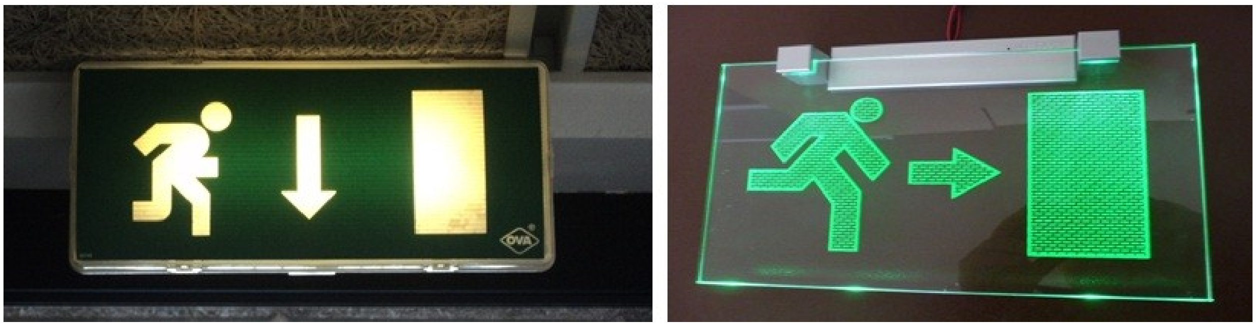


Figure 39: The left picture shows florescent exit signs used at Como campus - Right picture a modern LED exit sign

To complete the first step toward energy efficiency needs good level of communication between the staff and students of the university. The following model shows the cooperation between staff and students with commitment as one of the most important driving forces at the center of energy performance improvement cycle. The cycle starts with providing information to the building users for increasing their awareness toward energy conservation and environmental impacts of energy consumption. They should become aware of:

- Why and how energy is consumed in the university,
- How their behavior affects energy consumption,
- What are the environmental impacts of energy consumption,
- What are the advantages in saving energy for them.

Next step is to motivated staff and students. When motivating staff and students following points are important to notice:

- There are different incentives for which staff and students could be motivated for saving energy including environmental concerns, recognition and reputation, financial gains,
- Increasing decision power of staff and students can increase their motivation,
- Building energy efficiency improvement teams and giving responsibility to the staff and students will result in increasing their motivation.

According to the student survey, there were many students who were motivated for saving energy but they didn't know how to start. The university should support them with the right know-how of the saving opportunities. This could be done through different ways such as energy saving workshops and seminars, providing the staff and students enough practical knowledge about energy efficiency.

Figure 40: Energy efficiency improvement cycle

Studies have shown that although in some cases energy users have shown strong saving views and have claimed to have taken variety of conservation actions but measurement showed these statements to be exaggerated (McDougall et al. 1981). Therefore there is a need to run an energy audit to understand if there are improvements in energy consumption. Also there is a need for having an assessment over the results of the taken actions to make sure if the objectives are achieved. However, to provide continuous framework for improving energy efficiency at the university there is a need for setting new targets and goals and communicate the previous achievements to the staff and students. By changing the awareness and attitudes of the people toward preventable energy waste the energy efficiency improvement cycle would spontaneously continue its path through an energy efficient university without any need to an external force.

Step two: To Use Green Energies

After making sure that the inside of the building is energy efficient now it is the time for moving toward using renewable energies.

Reducing water consumption at Politecnico di Milano

Since it rains a lot in Como city, Politecnico di Milano can take advantage of collecting, storing and using rain water for the purposes such as toilet flushing, irrigation, cleaning and constructions. This simple system is consisted of a storage tank, a pump and filter connected to the guttering system of the building.

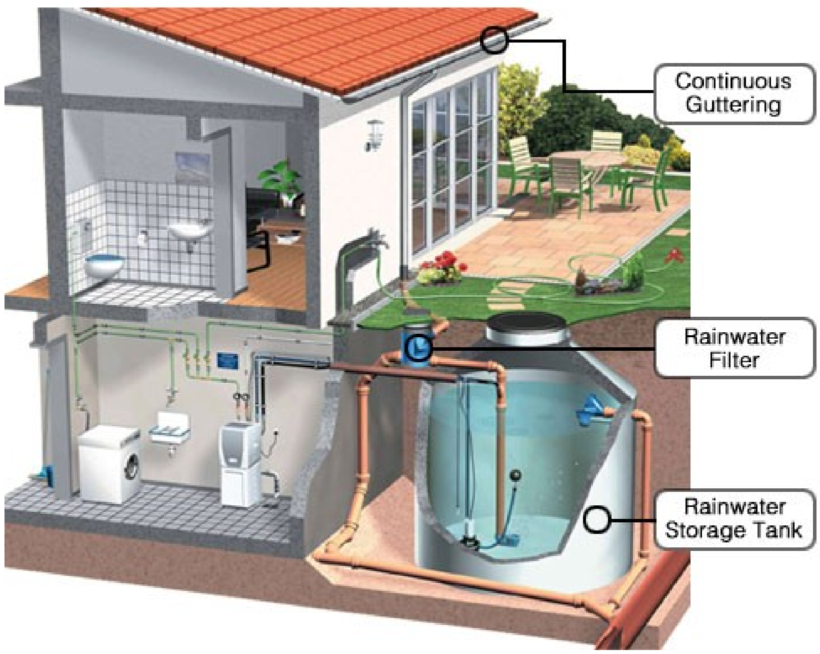


Figure 41: Rainwater collector system, source: www.allthingsrainwater.com

Using green energies

Today there are many universities who are using renewable clean energies and educate their students about sustainable practices. These environmentally-conscious universities are seeking sustainability by focusing on reducing their CO_2 emissions by using solar energy. One example is Butte College in California which is the first college in the United States that has gone 'grid positive'. It means that using solar panels they are producing more electricity than they consumes so they deliver the power back to the electric grid. This college operates a total number of 25000 solar panels which generate more than 6.5 million kilowatt hours of electricity per year. They have estimated that they will save between $50 and $75 million over 15 years excluding the cost of the project and the amount which they were paid for excess of electricity production. Butte College has been awarded many times for being a leader in sustainability efforts including 2009 Environmental Protection Agency (EPA) Green Power Partnership Award, 2009 Campus Leadership Award from Advancement of Sustainability in Higher Education (AASHE), and several LEED building certifications from United States Green Building Council, 2010 (Butte College Public Information Office, 2011). Politecnico di Milano could be one of the leaders in sustainability efforts as well.

5. Conclusion

Most of the universities in the world are following energy management programs aiming at decreasing their environmental footprints and air pollutant emissions produced by their operations. In order to reach these targets, they monitor and evaluate their environmental performance and each year they are setting new targets to reduce their footprint compared to previous years. To do so they are promoting awareness and responsibility among university staff and students to manage demand and control energy wastes. The objective of this study is to provide a continuous framework for changing awareness, attitudes and behavior of staff and students of Politecnico di Milano, Como campus Valleggio street building towards saving energy. By conducting a questionnaire survey, most of the staff and students showed a high level of motivation towards saving energy on the campus. But probably because of not having proper practical knowledge to start, energy saving activities were rarely done at the university. The survey showed that 90% of the staff spend more than 6 hours each day on the campus so university can be considered as their second home. Therefore it is very important to develop an energy saving culture. Most of the staff and students did not know if university has an energy policy or if there is an energy manager at the university. It shows that university doesn’t communicate well with the building users about sustainable practices.

As it is mentioned before, the first step to promote behavioral change toward energy conservation is to increase the level of awareness. Without providing users with enough knowledge, no one would be aware of advantages in energy savings and thus no realistic energy efforts would be done. Therefore firstly university should provide the students and staff with sufficient information about energy saving ways and secondly to support them and give them proper level of delegation and autonomy to act toward conserving energy on campus and contributing to this globally important issue. It was proposed to the university to get advantage of using different tools including energy saving Kaizen events, visual controls, mistake proofing tools and to upgrade old energy consuming equipment. After making sure that inside of the building is energy efficient, for moving further towards sustainable development university can use clean and green energies.

For further development of this study aiming at improving energy and environmental performance of Como campus of Politecnico di Milano, it is recommended to run an energy audit using technical tools to find opportunities to eliminate energy loss and to measure the level of CO_2 emissions from the university operation.

References

Antony, J., A. Kumar, and R. Banuelas. *World class applications of Six Sigma.* Oxford, 2006.

Bennet, C.J, and M. Armstrong Whiting. "Navigating Energy Managment: A roadmap for Business." *The Conference Board*, 2005.

Caphart, Barney L., Wayne C. Turner, and William J. Kennedy. *Guide to Energy Management.* Fairmont Press, 2006.

Costanzo, M, D Archer, M Aronson, and T Pettigrew. "Energy conservation behavior: the difficult path from information to action." *American Psychologit*, 1986: 521-528.

Environmental Protection Agency, United States Environmental Protection Agency. *The Lean and energy toolkit, Achieving process excellence using less energy.* EPA, 2007.

Geller, E. S., Richard, W. and Peter, E. (1982). Preserving the Environment. New York: Pergammon Press.

Goldemberg, J. *World Energy Assessment: Energy and the Challenge of Sustainability* . New York: United Nations Development Programme, United Nations, Department of Economic and Social Affairs and World Energy Council, 2000.

Hansen, S. J. (2002). Manual for Intelligent Energy Services. Lilburn, Ga: Fairmont Press.

Harrigan, M. "Moving consumers to choose energy efficiency." *The Alliance to Save Energy, Washington, D.C.*, 1991.

Harrold, R.M. (1993). Lighting. In: Turner, W. C. (Ed). Energy Management Handbook. (2nd ed.).

Karlsson, J.F, and B Moshfegh. "Energy demand and indoor climate in a low energy building—changed control strategies and boundary conditions." *Energy and Buildings 38*, 2005: 315-326.

"Kempton, W. and Schipper, L. (1994). Expanding the Human Dimensions Research Agenda. Proceedings of the ACEE 1944 Summer Study on Energy Efficiency in Buildings. American."

Knox, B., V. Lew, D. Mills, and M. Sloss. *Energy Accounting:A Key Tool in Managing Energy Costs.* California: California Energy Commission, January 2000.

Levermore, G.J. "Monitoring and targeting; motivation and training." *Energy Management Experience Conference.* Cambridge, UK, 1985. 21-30.

Loozen, A and Moosdijk, C.V.D. (2001). A Consumer Advise on Energy Efficient Use and Purchase of Household Appliances and Lighting. In: Bertoldi, P., Ricci, A. and Almeida, A.D. Energy Efficiency in Household Appliances and Lighting (pp. 468-474). Berlin.

Maslow, A.H. *The father reaches of human nature.* New York: Viking, 1971.

McDougall, G.H.G, J.D. Claxton, J.R.B. Ritchie, and C.D. Anderson. "Consumer energy reseach: A review." *Journal of Consumer Research*, 1981: 343-354.

McMakin, A, E Malone, and R Lundgren. "Motivating residents to conserve energy without financial incentives." *Environment and Behavrio Journal*, 2002.

Mueller, T. *LEED certification Report.* Canada Green Building Council, 2011.

Owens, S. (1987). The Urban Future: Does Energy Really Matter? In Hawkes, D (Ed.) Energy and Urban Built Form (pp.169-186). London: Butterworths.

Schendler, A., and R. Udall. "LEED Is Broken, Let's Fix It ." 2005.

Shinskey, F.G. (1982). Controls Systems. In: Turner, W.C. (Ed.) Energy Management Handbook.(pp. 356-398). New York: John Wiley.

Socolow, R.H. "Saving energy in the home." *Princeton's experiments at Twin Rivers, Ballinger Press, Cambridge, MA.*, 1978.

Stivers, R. "The Sustainable Society." In *Ethics and Economic Growth. Philadelphia*. Westminster Press, 1976.

Tajfel, H, and J.C. Turner. "An integrative theory of intergroup conflict." In *The social psychology of intergroup relations*, 33-47. Brooks/Cole Publishing Company, 1979.

Ueno, T, F. Sano, O Saeki, and K Tsuji. "Effectiveness of an energy-consumption information system on energy savings in residential houses based on monitored data." *Applied Energy*, 2006: 166-183.

"United Nations General Assembly, World Summit Outcome. Resolution A/60/1, adopted by the General Assembly on 15 September 2005." 2005.

United Nations Report of the World Commission on Environment and Development General Assembly Resolution,. United Nations, 11 December 1987,Retrieved: 2007-04-12.

"Wedge, R. (2003). Energy Efficiency: Key to Managing Costs. NZ Forest Industries."

Appendix A – **University Students Energy Awareness Questionnaire**

This survey is designed to help the university to improve its energy efficiency in Valleggio street building. Your responses to these questions will help Politecnico to better understand your needs and provide accordingly a comfortable and environment-friendly place.

Please indicate your gender:	Male ☐	Female ☐
Nationality:	....	
I am student of:	Politecnico di Milano ☐	Insubria ☐
I study:	Management Engineering ☐	Computer Engineering ☐
	Environmental Engineering ☐	Other ☐

1) How much are you aware of the concept of energy? (Energy definition, energy sources, energy cycle, energy loss, etc.)

Totally aware ☐ Aware ☐ Partially aware ☐ Not aware ☐

2) What types of energy do you think are currently being used in our campus in Como? (Check the relevant items)

Electricity ☐ Gas ☐ Solar ☐

Other fuels ☐ I don't know ☐

3) What is the degree of your awareness about costs of energy and causes of energy loss?

☐ I know what energy costs are and I know where energy is mostly wasted.

☐ I'm aware of energy costs but I don't know where energy is wasted.

☐ I'm not aware about energy costs but I know where it is wasted.

☐ I'm not aware of costs of energy, nor about where it is wasted.

4) How much do you think is the average cost of annual energy consumption of our campus in Vallegio Street? (the sum of gas and electricity consumption costs)

☐ 50,000 to 100,000 Euros per year

☐ 100,000 to 200,000 Euros per year

☐ 200,000 to 300,000 Euros per year

☐ More than 300,000 Euros per year

5) My general opinion about energy saving:

☐ Strongly Active and aware: I'm completely aware of energy saving issues and I always put this knowledge to action.

☐ Positive and aware: I am aware of the ways that I can use energy efficiently but I'm not taking particular actions.

☐ Partially energy aware: I occasionally think about this issue and talk with my friends about it but I don't know how to take action.

☐ I am generally indifferent toward energy saving activities.

6) Please write down three routine actions which you do at university to save energy.

………………………………………………………………………………………..
………………………………………………………………………………………..
………………………………………………………………………………………..

7) How much is the level of your awareness about ways in which you can save energy?

☐ I know many ways of reducing energy consumption.

☐ I know some ways of reducing energy consumption.

☐ I am aware of basic ways of energy savings.

☐ I don't know any way for saving energy.

8) What are the means that you prefer to receive notification about energy savings from university? (mark all that apply)

Email ☐	University website ☐	facebook ☐
Seminars and events ☐	Flyers/Posters☐	Other ☐

9) Where do you feel more committed to energy saving efforts?

☐ I try to save energy at home and at university and other public places.

☐ I try to save energy just at home.

☐ I focus my energy saving efforts at university and public places.

☐ I rarely try to save energy at home or at university and other public places.

10) My awareness toward the environmental impact of energy use:

☐ I'm strongly aware of environmental impacts of energy consumption and I always do research about it.

☐ I'm aware of environmental impacts of energy consumption by public attention (while reading newspaper, watching TV, etc,).

☐ I'm aware of environmental impacts of energy consumption by receiving notifications from the university.

☐ I'm aware of such impacts but I'm not persuaded.

☐ I'm not aware of environmental impacts.

11) How motivated are you to improve energy efficiency?

☐ Very motivated and try to influence my colleagues as well.

☐ I am motivated and put all my efforts into it.

☐ I feel motivated but I don't know what to do exactly.

☐ I am not motivated for saving energy.

12) What is the primary reason for which you are trying to improve energy efficiency? (just pick one of them)

☐ To protect the nature

☐ To save costs.

☐ I want my university to be ranked as top in energy efficiency improvement efforts.

☐ I don't see a particular reason, it is a part of my culture.

13) How many hours on average do you spend in university each day?

More than 6 ☐ Between 3 to 6 ☐ between 1 to 3 ☐ Less than 1

14) Where is the place in the university at which you spend most of your time?

Library ☐ Classes ☐ Computer site ☐ Other offices ☐

15) How satisfied are you with following systems of Valleggio building?

	Poor	Fair	Good	Very good	Excellent
Heating	☐	☐	☐	☐	☐
Cooling	☐	☐	☐	☐	☐
Lighting	☐	☐	☐	☐	☐
Ventilation	☐	☐	☐	☐	☐

16) Which of the following actions are happening in our university? (mark all that apply)

Lights are always switched off whenever leaving the classes and other rooms.	☐
When leaving classes all electrical equipment (projectors, camcorders and other electronic teaching equipments, copy machine, etc.) are Switched off.	☐
When heating or cooling systems are being used, external doors are closed.	☐
Unnecessary lights are switched off.	☐
Laboratory Pc's shut down automatically after specified time when dormant.	☐
During the day by opening window blinds, natural sunlight is used more rather than lighting.	☐
Lifts are not used when only travelling few floors.	☐
Energy performance is advised to students.	☐
Heating and ventilation is controlled to match occupancy patterns and/or temperature?	☐
Photocell, acoustic or movement sensors are used to control lighting.	☐

17) Are you willing to help to further increase the energy efficiency of our campus?

☐ Yes, I have some ideas for energy saving, and I would like to share them.
☐ Yes, I want to do more to save energy but I need more information about how to participate.
☐ No but it is important for me.

THANK YOU!

Appendix B – University Staff Energy Awareness Questionnaire

Politecnico di Milano

Sondaggio per il personale sulla consapevolezza energetica

Questo sondaggio è stato progettato per migliorare l'efficienza energetica dell'università. I risultati di questo sondaggio aiuteranno il Politecnico di Milano a soddisfare le esigenze di comfort rispettando l'ambiente.

Indica con una croce:	M ☐	F ☐
Dipendente di	Politecnico di Milano ☐	Insubria ☐

In quale ambito lavora:

Insegnamento☐ Ricerca ☐ Amministrazione ☐ Manutenzione ☐ Pulizia ☐

Esprima il suo parere in merito alle seguenti affermazioni:

1) "dipende da me risparmiare energia sul posto di lavoro ":

Completamente d'accordo ☐ Parzialmente d'accordo ☐ Incerto☐ In parziale disaccordo ☐ In completo disaccordo ☐

2) "Il personale deve sforzarsi maggiormente per ridurre il consumo di energia dell'Università"

Completamente d'accordo ☐ Parzialmente d'accordo ☐ Incerto☐ In parziale disaccordo ☐ In completo disaccordo ☐

3) Indichi tre esempi di azioni messe in pratica per risparmiare energia sul posto di lavoro.

…………………………………………………………………………………..
…………………………………………………………………………………..
…………………………………………………………………………………..

4) "L'università dovrebbe diventare meno dipendente dalle energie non rinnovabili":

Completamente d'accordo ☐ Parzialmente d'accordo ☐ Incerto☐ In parziale disaccordo ☐ In completo disaccordo ☐

5) l'università ha una politica energetica? Sì ☐ No☐ Non lo so ☐

6) C'è un risponsabile dei consumi energetici nella sede universitaria di via valleggio?

Sì ☐ No☐ Non lo so ☐

7) Quali tipi di energia pensa che siano attualmente utilizzati nel nostro campus di Como?

Elettricità ☐ Gas ☐ Solar ☐

Altro ☐ Non lo so ☐

8) Quale è il livello della sua conoscenza sul costo dell'energia e sulle cause di dispersione? (indicare solo una risposta)

☐ So cosa sono i costi energetici e so dove principalmente si spreca energia.

☐ Sono consapevole dei costi energetici, ma non so dove l'energia venga sprecata.

☐ Non sono a conoscenza dei costi energetici ma so dove sono gli sprechi.

☐ Non sono a conoscenza nè dei costi energetici né degli sprechi.

9) Dove pensa sia più importante risparmiare energia?

☐ Cerco di risparmiare energia sia a casa che all'università e nei posti pubblici.

☐ Cerco di risparmiare energia solo a casa.

☐ Cerco di risparmiare energia solo in Università e nei posti pubblici

☐ Raramente cerco di risparmiare energia.

10) Quanto pensa sia il costo medio relativo al consumo annuo di energia nel nostro campus in via Valleggio? (comprendendo gas ed elettricità)

☐ 50.000 a 100.000 euro all'anno

☐ 100.000 a 200.000 euro all'anno

☐ 200.000 a 300.000 euro all'anno

☐ Più di 300.000 euro all'anno

11) Vorrei sapere di più sui modi per migliorare l'efficienza energetica:

Completamente d'accordo ☐ Parzialmente d'accordo ☐ Incerto☐ In parziale disaccordo ☐ In completo disaccordo ☐

12) Quanto è motivato a migliorare l'efficienza energetica?

☐ Sono molto motivato e cerco di sensibilizzare anche i miei colleghi.

☐ Sono motivato e cerco di realizzarla.

☐ Sono motivato ma non so come fare.

☐ Non sono motivato al risparmio energetico.

13) Quale è il motivo principale per cui Lei cerca di risparmiare energia? (Indicare solo una risposta)

☐ Per proteggere la natura.

☐ Per risparmiare sui costi.

☐ Perché l'Università dove lavoro sia tra quelle che praticano risparmio energetico.

☐ Non c'è un motivo particolare mi hanno abituato così

14) Quali delle seguenti abitudini sono normalmente osservabili nella nostra università?(contrassegnare tutte le voci pertinenti)

Si spengono sempre le luci uscendo da un locale.	☐
Non si usano altri apparecchi di riscaldamento o di condizionamneto nei singoli locali in aggiunta agli impianti centralizzati.	☐
Quando si termina il lavoro tutte le apparecchiature elettriche (computer, stampante, fax, fotocopiatrici, ecc) negli uffici sono spente.	☐
Stampanti e fotocopiatrici vengono utilizzate solo quando strettamente necessario.	☐
Quando è in funzione il riscaldamento o il condizionamento, le porte esterne sono chiuse.	☐
I docenti spengono luci, proiettori, videocamere e altri apparecchi al termine della lezione.	☐
Il Laboratorio di Pc si spegne automaticamente dopo un certo periodo di inattività	☐
si utilizza il più possibile la luce naturale rispetto a quello artificiale.	☐
Gli ascensori si utilizzano solo per i piani più alti.	☐
Gli utenti sono informati sulle modalità di risparmi energetico.	☐
L'impianto di riscaldamento/condizionamento si modifica automaticamente in base all'utilizzo del locale.	☐
Sono installate fotocellule, timer, sensori di movimento o acustici per controllare l'illuminazione.	☐
Tutte le luci sono spente durante la notte.	☐

15) Come vorrebbe ricevere dall'università informazioni sui modi di risparmio energetico?

E-mail ☐ Sito Università☐ facebook ☐

Seminari ☐ Volantini / Manifesti ☐ Altro ☐

16) Quante ore trascorre in università al giorno?

Più di 6 ☐ Tra 3 e 6 ☐ Tra 1 to 3 ☐ Meno di 1 ☐

17) Come valuta il livello degli impianti installati nell'edificio di via Valleggio?

	Molto scarso	**Scarso**	**Sufficente**	**Buono**	**Ottimo**
Riscaldamento	☐	☐	☐	☐	☐
Condizionamento	☐	☐	☐	☐	☐
Illuminazione	☐	☐	☐	☐	☐
Ventilazione	☐	☐	☐	☐	☐

18) Come valuta il livello di efficienza energetica nell'edificio di via Valleggio?

Molto scarso ☐ Scarso ☐ Sufficente ☐ Buono ☐ Ottimo ☐

Grazie!

Appendix C – University staff and students energy conservation suggestions

Action	Freq of answers
Putting PC in standby mode.	1
Shutting down the computer when they are not necessary to be on.	10
Turning off the toilet lights.	11
Closing the door of the balcony close to the library.	1
Switching off the lights.	22
Taking the stairs instead of the lift.	13
Closing the doors to maintain the temperature.	2
Turning my computer on only when it is necessary.	1
Putting PC in the power saving mode.	3
Not charging my laptop till it is necessary.	4
Switching off the lights when leaving the class.	3
Closing the windows and doors in winter.	7
Opening window's shutter.	2
Switching off the air conditioning.	3
Switching off lights in empty rooms.	8
Closing the doors when air conditioner is on.	6
Shutting down the computer in computer rooms.	1
Closing the water tap in the toilet after use. Sometimes students leave it open.	3
Closing the doors and windows.	4
Using low notebook illumination.	1
Taking advantage of sun light.	4
Stopping heaters in empty rooms.	1
It's out of my control, I can't do anything.	1
Less air conditioning in summer.	2
Using power saver lamps.	1
Using double glazing windows.	1
Using photocopy machines only when necessary.	1
Don't turn on heating system in summer. Sometimes it happens.	1
Don't turn on cooling system in winter. Sometimes it happens.	1
Central heating and cooling system does not work sometimes, it's good to repair that.	1
Using photocells in toilets to turn the light on only when someone is in.	1
Respecting the normative temperatures defined by the municipality in winter.	1
Turning off the lights and other devices when leaving the office for a long time.	5
Turning off the conditioning system when the temperature is acceptable.	4
Leaving the conditioning system turned on only for a few hours.	2
Trying to have minimum energy dispersion to outside.	1
Making users sensible to energy saving.	1
Turning off the printers, lights and PC at the end of the working day.	3
Closing the windows when using the conditioner and use if only if necessary	1
Turning on only the needed printers.	1
Equip the offices with thermostats.	1
Better regulation of conditioners.	1
Closing the doors in summer.	1