Energy Actions to Sustainable Campus: The Brazilian Case of University of São Paulo

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Abstract

This paper describes the expertise acquired which accrued to the University of São Paulo from implementing the Program on Energy Efficiency and Conservation and Use of Renewables (PUREFA) which, conceived and run under the scope of the Permanent Program for Efficient Use of Energy at USP (PUREUSP), has as its goals to foster through those interdisciplinary measures the better usage of energy resources in the University facilities, diversifying its energy base, raising awareness among college personnel and constituency and working towards the gradual building of the integration of knowledge areas as a means to achieve sustainability of university campi. The main purpose is to spread knowledge on energy management and other concepts pervading energetic, economic and environmental issues along the community by spreading information on the feasibility of such measures and accruing benefits, since public resources are scarce and proper use of available energy resources is becoming more and more necessary. Main measures by PUREFA comprehend: energy use monitoring, retrofits on lighting and air conditioning systems, standard setting on efficient buildings and equipment, installing solar heating and photovoltaic systems, biogas usage and installing of gas using systems. Educate people for planetary citizenship and sustainability is the challenge facing this work in the current society, which has been forced to rethink its existence and accruing environmental impacts, so as to begin a much needed discussion on sustainable education grounded on conscious consuming through scientific information and sensitizing, which is the first step towards sustainability of society as a whole.

Introduction

We have been witnessing along the last few decades the emergence of sustainable development as a major trend for social development in the broad sense not in words only but as an actual practice. In a near-limit conjuncture, in the absence of such a safe framework mankind may destroy its habitat.

Parallel to the age of real time information, economic globalization, virtual reality and the loss of significance of national borders, man has been developing a productive model which is quasi predatory in its exploitation of the environment.

Though human development is a comprehensive and sometimes still poorly defined concept, it may very well be used to assess quality of life by means of health, longevity, psychological maturity, schooling, clean environment, community spirit and creative leisure indexes. Aforementioned characteristics are indicative of a sustainable society, capable of meeting its ends without depriving future generations of such capability.

The University of São Paulo is most internationally renowned institution in the entire Latin American scientific, educational and cultural scene. It is inserted in this globalized scene, as modified by a mankind hungry for dignity, comfort, safety and social development.

In terms of graduate studies it offers 229 courses spread along all knowledge areas, distributed among 40 unities and catering to about 56 thousand students. More than 2,000 PhDs major there a year (25% overall national figures), more than major at the larger American and Latin American universities. It comprises 8 campi and above 22,000 postgraduate students, including international

exchange programs. Founded at 1934, is currently a reference for the Brazilian society, acknowledged as a standard both by public and private teaching institutions.[1]

The University of São Paulo (USP) is a major power fostering technological innovation and a standard for social behavior, as well as providing indexes to guide transformations in the community in terms of acceptance of concepts and market entry of products. Its prestige in the community is significant and notorious, which increases the responsibility of the entire university community, particularly of researchers and scientists.

In 1997, the University of São Paulo created the Permanent Program for Efficient Use of Energy at USP (PUREUSP), a pioneering program for a Brazilian public university, having as its goals to implement energy saving measures and raising awareness of the importance of energy efficiency and conservation of natural resources among the university community. PURE-USP was devise, thus, in order to enhance social uptake of those key concepts on energy conservation and management, as a response to the perception by teachers and researchers in this field that the University as a whole did not adhere, in its facilities, to their teachings and classes on energy efficiency.

And yet, its initial actions were techno-administrative in scope, evolving in time to include broader scopes in the fields of education and awareness raising on the need for conscious and efficient use of energy in every sector of the University.

Energy Management Methodology at USP

Energy management methodology adopted by PURE-USP encompasses the following goals:

- manage energy, striving to operate facilities in an energy efficient fashion and raise awareness on the importance of rational usage, besides training technical personnel and reducing costs;
- become a national reference for energy management programs, attuned to the related environmental issues;
- plan and operate every energy management action in an ethical manner;
- to be transparent, divulging results to the society at large and incentivizing by force of example the standardizing of efficiency actions; and
- striving for continual improvement of all energy management procedures.

Technical Performance by PURE-USP

Several fronts of action were encompassed in every sector of all 24 cities hosting USP facilities. Savings accruing from actions taken under PURE-USP totalized 34.86 million Euros up to 2009, which is roughly equivalent to 210GWh.

A few techno-administrative activities taken under PURE-USP:

- billing management, allowing for identification of inaccurate or otherwise improper billing by electric power utilities and so on;
- energy utility contracting management: administrates all contracts of every USP Unity in search of optimized cost-benefit ratios, thus contributing for proper use of public resources;
- management tools: make easier and or feasible analyses, comparisons and other studies in electric installations throughout USP campi. Principal ones are the Online Energy Measurement and Management System (Sisgen) and the databank storing every energy related data at USP since 1997 (known as the Contaluz System);
- energy efficiency projects: retrofitting of electric installations to improve energy efficiency of buildings by replacing lamps, lamp reactors, luminaries, air conditioning equipment and energy sources for water heating. Up to now, about 15,000 reactors, 28,000 lamps and 1,000 luminaries were replaced; and

[1] www.usp.br, as of July 30th, 2010

- technical specifications for materials: update and improve technical specifications present at the databanks in the University purchase department, in order to prevent the purchase of obsolete and inefficient lamps.

Educational Nature of PURE-USP

There are two main foci of education and training on and divulging of energy efficiency and sustainability issues in the University.

The first comprises behavioral and human issues at large, being called Training and Diffusion. This activity is permanent and very important, since it is the channel through which the Program communicates with society at large. Sensitization of USP community is achieved by divulging actions on energy saving and efficiency, raising awareness on the importance of energy in our daily activities and of taking part in the Program.

Deployed diffusion tools are:

- Publication of research papers divulging results, as well as of related Master degree thesis by team members;
- Distribution of promotional material such as: folders, bookmarkers, adhesive labels for light switches and computers reminding users to turn them off;
- Banners, out-doors and other media;
- Columns and articles in newspapers and magazines;
- Interviews and press-releases for both the inside and the outside University press.

To celebrate its 10-year anniversary, PURE-USP adopted an innovative communication channel to spread concepts and foster action on energy efficiency. Three comics characters were created which, in comic strips, discuss on positive and negative attitudes towards usage of natural and energy resources.

Those comics aim at raising reader's awareness on the large potential that daily attitudes have on reducing global usage of natural resources and their importance in the transition for a future of sustainable development.

The Program celebrated some partnerships for diffusion of aforesaid comics, always in order to spread concepts on energy efficiency, teach techniques for efficient use of energy and foster educational action on sustainable development, through larger and larger constituencies.

There is a partnership with ABESCO – Brazilian Association of Energy Conservation Companies – to divulge the comics through their Electronic Billboard, which is published twice a month for 10,000 site members and is made available for site visitors.

Strips are also present on every issue of the Em Foco journal, an informative bulletin of USP Hospital for Rehabilitation of Craniofacial Anomaly Patients, which circulates 5 thousand copies in addition to their online version.

Training activities

Training activities were run in the University by PURE-USP since 1998, so as to:

- through an acculturation process, spread or recycle knowledge, skills or attitudes pertaining to task performing or behavior towards sustainability, energy efficiency and conscious consuming; and
- providing recycling and new concepts for stakeholders, PURE-USP enlists active sympathizers of advocated for changes on behavioral issues so as to make energy efficiency and sustainability into established norms. They may thus serve also as multiplying agents spreading concepts and new procedures into the community pool of knowledge, skills and attitudes, so as it may change the personal baggage of people.

Program provided training sessions are listed below:

1998 – 1999: first lecturing cycle on energy efficiency for Rectorate personnel, comprising energy saving tips and notions on sustainability and natural resources.

2000 – 2001: the **Energy Agents** program, in a partnership with PURA (the USP Program on Rational Use of Water) and USP RECICLA (the USP program on conscious use and waste reduction), trained more than 50 students in several courses at USP in order to spread energy efficiency related concepts at unities in USP campi. Along auditing processes, those agents filled critical reports for the Program with verifications and data ascertained for each unity.

2001: The CONSERVUSP expo, bridging gaps among several sectors and the PURE-USP, PURA and USP Recicla programs through open Working Groups encompassing:

- Selective Solid Waste Collection at USP – institutional, economic and social issues;
- Challenges and Perspectives on the Use of Water Distillers at USP;
- Challenges and Perspectives in Generation of Harmful Waste at USP;
- Divulging of positive experiences on energy, water and waste along several unities.

2001 – 2002: Training for electricians at USP in a partnership with the student council of the Power Systems Engineering course at the Engineering School, this 16 class hour course was imparted to all electricians working at USP at the time, divided into five 50 person classes. Its syllabus comprised from a review on electricity related concepts to notions on energy efficiency. PURE-USP, acknowledging the competence of the students in the University, allowed them themselves to impart those classes;

2002 – 2003: Course on maintenance of air conditioning equipment, in partnership with SENAI (National Service for the Industrial Sector), taking up to 5 days, for three 40 worker classes;

2004 – 2005: 120 lecture cycle on tips on energy saving along all USP unities, enlisting about 1,200 students and personnel, spreading energy efficiency related knowledge and practical guidance on energy saving, conscious consuming and education on environmental issues.

2008: Environment Week: Water, Waste and Energy – Who Calls – A sustainable live for us and for the future generations, in a partnership with PURA and USP RECICLA. First such action specifically devised to act in the cultural front, this one week initiative comprising an opening seminar and debated film sessions exhibit was a landmark in the Environment Week at USP in 2008.

Results of above actions, as expected, included:
- increase in personnel productivity;
- improved quality of provided services;
- reduced costs and need for redo;
- energy efficiency in building equipment and systems;
- energy saving in the Unity;
- Unity support for PURE-USP interventions and other activities;
- enhanced self-motivation; and
- acknowledgment of the professional in the energy area at his Unity.

Program on Energy Efficiency and Conservation and Use of Renewables – PUREFA

Terminated in 2007, the Program on Energy Efficiency and Conservation and Use of Renewables run energy related infrastructure projects, supported by CTInfra (Brazilian Fund for Infrastructure) resources, in order to implement energy efficiency, rational use of energy and use of renewables. FINEP (Financer to Project Studies) funded this enterprise, contracted at R$ 2,200,000.00. This project was partitioned into 14 goals, comprising action in about every campi of USP, resulting in more efficient and rational use of energy. This project encompassed actions on solar water heating, retrofit of lighting systems, training in maintenance of air conditioning equipment, standard setting for installations and buildings and photovoltaic and biogas driven power generation. This project aimed, thus, at reducing energy use and wasting, increasing the share of renewables in the energy base,

incentivize spreading of guidance on energy efficiency and conservation by research groups and raise awareness of the university community on how to currently better deal with issues related to restrictions on energy usage, building maintenance, environment and human behavior, so as to give a positive contribution in the search for a sustainable development. Being USP both a think tank and an opinion leader in its role of service provider towards the society at large, it has been consolidating the use of natural gas and renewables such as biomass and photovoltaic systems in the context of rational and efficient use of energy, thus providing society at large grounds on which to rethink energy use and conscious consuming related behaviors and attitudes.

PUREFA has been, through its goals, multiplying actions on behalf of energy efficiency at USP. Increase in energy usage from 2002 onwards, when actions by PUREFA first took place, was lesser than that observed along the 1995-2000 period (2% and 5.4%, respectively). This figure is particularly positive in the light of the fact that energy usage in 2002 was similar for the 2001 figure, being 2001 an year in which energy rationing took place in Brazil. This proves that PUREFA goals allowed USP to maintain and even expand energy saving practices along its several campi. The table below displays data on energy savings after the project termination in 2006.

Tablel 1: Summary of savings accruing from PUREFA actions to the University of São Paulo

Goal	Annual Energy Savings	unity	Average energy price (R$/MWh)	Annual Savings € Data from August 4th 2010
1	Non measurable			
2	835	MWh/year	220	79,181.00
3	Non measurable			
4	156	MWh/ year	220	14,793.00
5	Non measurable			
6	13.8	MWh/ year	220	1,308.00
7	2.8	MWh/ year	220	266.00
8	9.7	MWh/ year	220	920.00
9	70	MWh/ year	220	6,640.00
10	15000	kg GLP/ano		14,656.00
11	Non measurable			
12	Non measurable			
13	22	MWh/ year	220	900.00
14	127	MWh/ year	220	12,043.00
Total (eletricity)	**1,236.3**	**MWh**	**Total (R$):**	**130,707.00**
Total (LPG)	**15,000**	**kg LPG**		

Implemented project goals are described in detail below:

1 – Implementing of the energy management system
2 – Retrofitting of lighting systems
3 – Retrofitting of air conditioning systems
4 – Retrofitting of public lighting systems
5 – Standard setting on energy efficiency for buildings and appliances
6 – Expansion of the photovoltaic driven power generation system installed at the façade at the Energy and Electrotechnics Institute from 6.0 to 12.3kW – São Paulo campus
7 – Installing 4kW of photovoltaic driven power generation at a down country campus
8 – Installing a solar heating system in the student dorm
9 – Installing a solar water heating system at the Piracicaba student dorm
10 – Installing a solar water heating system at the central cafeteria of the São Paulo campus
11 – Installing a biogas generation, purification and storage system
12 – Installing biogas driven electric power generation

13 – Installing a gas driven heating system at the student dorm
14 – Installing a gas driven water heating system at the Athletic Facility of the São Paulo campus

Results achieved by actions taken under PUREFA

Goal 1

- Expansion of the Sisgen physical infrastructure along the several University campi, encompassing current and voltage transformers, electric transducers, data loggers, concentrators and data transmission network (wi-fi, optic fiber, etc);
- Implementing of new energy efficiency projects and improved energy savings;
- Data on energy demand and consumption made available for use in several studies, as well as in the role of research reference for continual improvement of the monitoring software;
- Measurement of all energy efficiency actions at USP, be they PUREFA related or not; and
- Improved control of energy bills: detection and rectifying of recurrent billing errors accruing from inaccurate measurement.

Goal 2

CENA – Center for Nuclear Energy in Agriculture (Piracicaba campus):

- Conforming to standards on architectural lighting design, presenting illuminance levels appropriate to the tasks to be performed there and enriching local environs;
- Installed power reduced by 44% in the main building and 32% in the Class Central, about 40% energy savings in the main building.

Power Systems Engineering / POLI (São Paulo campus):

- Conforming to standards on architectural lighting design, presenting illuminance levels appropriate to the tasks to be performed there and enriching local environs;
- Retrofit reduced power requirements by 7.8kW, an 18% demand reduction by the lighting system catering to the common areas at the Power Systems Engineering / POLI buildings.

IME – Mathematics and Statistics Institute (São Paulo campus):

- Installed power at room B02 was reduced by 38%, illumination levels rose 40% and there was a significant improvement on visibility conditions at the blackboard plane.
- Installed power was reduced at the auditory and at classroom B05 by 12% and 48%, respectively.
- Installed power at room B16 was reduced by 38%.
- Snack bar presents 10% energy savings and a 30% increase in illuminance levels.
- Illuminance level in the corridor presents a 164% increase.
- Conforming to standards on architectural lighting design, presenting illuminance levels appropriate to the tasks to be performed there and enriching local environs.

Psychology Institute (São Paulo campus):

- Energy savings, for a 4.86kW reduction in installed power and a 34.24% reduction on demand. Aforementioned savings make for an approximate 3.8-year payback.

Total energy saved: 835MWh/year.

Goal 3

Power consumption and demand was significantly reduced in the analyzed environments, with reductions on demand greater than those on consumption due to user behavior issues. Improved thermal, acoustic and visual comfort in the retrofitted facilities.

Consumption reductions accruing from goal 3 related measures at the Engineering School – Mechanical Engineering (São Paulo campus), CENA (Piracicaba campus) and FFLCH – Faculty of Humanities (Ribeirão Preto campus) ranged between 21% and 34%, while demand reductions ranged from 25% to 48%. Reductions accruing from specific interventions in each environment averaged at 33% and 26%, respectively.

Goal 4

The new system improved the lighting efficiency, with improvements in the 2.26 to 3.24 times range. Energy savings were estimated at 13MWh/month (156MWh/year), which is about 70% of the original levels.

Goal 5

Handbooks on energy efficiency policies for buildings were written, and their short and long term impacts assessed. Technical specifications for air conditioning systems used by the USP purchase department were assessed, as well as the market supplying such appliances. Thus acquired data were used as grounds on which to define new and better purchase criteria and technical specifications, and an installation and maintenance handbook was written accordingly.

Didactic materials and a 40-hour course were prepared and used to train 112 workers at the several campi of USP.

Goal 6

Installation of its new modules expanded installed capacity of the photovoltaic system at façade of the IEE administration building at USP to 12.3kWp, and a low-pass filter was added to the data acquisition part of the monitoring system, eliminating noise and fully preserving data acquisition.

A monitoring system comprising a sensor array, a "Sunny Data Control Plus" module and an electric and meteorological parameters data logger was installed; and an external display was assembled so as to provide easy visual access to system productivity data for building visitors and users.

From January to December 2004, this system remained functional every day and its monthly contribution to the meeting of energy needs of the building topped 33% most of the time, up to 1.3MWh/month figures (accounting for variations along the year, about 13.8MWh/year).

Goal 7

Data logger registries allowed figures for power production to be assessed at 944kWh in the January to April 2005 period, for an average 236kWh/month (2,8MWh/year) figure.

Goal 8

Electric power energy savings accruing from installation of solar water heating for the showers at the São Carlos campus Athletic Facility averaged 9,7MWh (42% reduction), amounting to R$3,720.00. Payback period is assessed at about 6 years.

Goal 9

Electric power energy savings accruing from installation of solar water heating for the showers at CEU, a building housing USP students in Piracicaba, averaged 70MWh/year (for a 73% reduction), amounting to R$19,700.00. Payback period is assessed at about 4 years.

Goal 10

General data on appliances and usage were estimated, and potential savings were appraised in a preliminary fashion. Technical specifications and installation were prepared for a solar heating system, as well as its operation and maintenance handbook and copies of technical specifications of all of its component parts.

Overall savings totalized 15,000kg LPG/year (17% of total consumption), amounting to R$34,000.00.

Goal 11

No more leakage detected at the Biodigester level.

The Empresa Ambiental Laboratório e Equipamentos Ltda. enterprise was hired to analyze liquid wastes; COMGAS requested to perform two chemical composition assessments on the biogas; White Martins contracted to provide analysis services.

The biogas outlet section was elongated and the biogas capture system was designed and installed.

A gas tank was installed to storage the biogas which is to supply the Otto cycle motor.

Due to inefficiency of the initially proposed system, a flow gauge was acquired and installed in order to inform the real biogas flow figures.

Equipment housing was built by Famosa Engenharia, in accordance to the respective engineering project.

The project team itself developed the biogas purification system instead of acquiring it from the market. Aforesaid system was confirmed as efficient in the removal of both humidity and H_2S.

Results were logged for physical and chemical analyses of both biogas and liquid wastes, actual gas flow as indicated by the flow gauge and hour meter and on exhaust gases by the generator group.

Goal 12

A low power rating (18kW) generator group was chosen with its respective control and test panels; masonry works do not house the purification system, for it was developed and installed in the biogas capture piping;

Equipment installation design, as well as its purchase, instalation and operation were all successful.

The following data were acquired:

- Daily figures on biogas storage;
- Biogas amount the motor consumes each hour;
- Energy produced by the generator;
- Motor-generator group operation time;
- Results of analyses on the generator exhaust gases.

Goal 13

Energy savings accruing from substitution of the gas heating system for the electric showers averaged 22MWh/year.

Goal 14

Housing built for the thermal central and gas tanks and gas heating system installed in substitution for the electric showers.

Approximate total savings: 127MWh. All expenses included, annual savings totalize R$14,000.00 (47%). From manufacturer provided consumption characteristics and specifications, the payback period is assessed at about 27 months.

Conclusions

It is important to highlight the fact that, once action on energy efficiency pervades major issues such as schooling, civic citizenship and conscious consuming, the society at large adheres completely to the required behavior and feels that it has a role in this transformation process, adding their personal baggage and other contributions to it. It is thus important to build new educational paradigms, even though they are simple, to incentivize to spur citizens to change, which is a key element for the transformations and implementing of actions on energy saving and efficiency. It is an immediate realization that work and actions by PURE-USP could not be successful if its main interventions were not supported by the university community acting, reacting, building and contributing to them.

Training on and diffusion of important sustainability and energy efficiency related concepts deeply influenced all stakeholders in the University along the Program, be they alumni or faculty, which clearly shows that they are to be valued and cherished in the interdisciplinarity intrinsic to all sustainability issues. Stakeholders become better persons and citizens, more aware of and responsible for their effective participation in the process of changing technologies, society and the energoenvironmental scene not only in Brazil but for the whole world.

For PURE-USP, the campi of the University of São Paulo became a huge laboratory which may house practical demonstration of knowledge which has to be spread along the society at large. In a concrete fashion, such knowledge then comes to the attention of the community in an easy, non compulsory manner in its daily life. In the University, this healthy closeness to science makes feasible the gradual incorporation of themes

and concepts from the concrete plane to the abstract, opening paths and substituting personal experience for empiric knowledge.

This is the way to emphasize the importance of environmental education and the need for its comprehensive inclusion in every techno-administrative task in areas pervading engineering, technology and science. The human factor and the collectivity are crucial elements driving the great social changes accruing from technological innovations. There lies the great role of science and technology as educators, serving man so as to make the difference in the current capitalist society. And that because this intellectual and moral development of man brings to the fore his capabilities for learning, creating and putting into practice new conceptions and ways of living, educating and living in society – as an individual, with other people and in the environment – that may replace the old obsolescing ways.

Finally, to place the role of PURE-USP in relation to society, it is important to highlight that in times of environmental constraints, of challenges and struggles, when ethics and morals are more important than ever, it is indispensable to make sure that one has legated a good example for those which are to build the future and are certainly to live with restricted access to natural resources and witness the astounding and astonishing inventions which will come to be in future times.

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