Energy Analysis of an Academical Campus: The Case of the Federal University of CEARÁ

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Abstract

The present paper accomplishes an analysis of the energy situation of the Campus of Pici of the UFC, with proposals in the area of renewable energies, taking in consideration the consumption of electric power and water. In this analysis was evaluated the total consumption of electric power and water of the last four years. As a result, the consumption and demand growth for planning future was estimated leading to an orientation for the electric power and water supply contract.

In the energy-efficient strategies, the lighting and air conditioner system was replaced and the benefits obtained by the new energy-efficient system are demonstrated. In the renewable energy area is studied the use of photovoltaic (PV) water pumping systems.

Keywords: public buildings, energy savings, Public illumination, Efficiency Program.

1. Introduction

In order to better manage building's energy costs, it is necessary to understand how you are charged for used energy. Electricity can be charged based on two measures - consumption and demand. The consumption component of the bill is based on the amount of electricity, in kilowatt-hours (kWh), that the building consumes during a month. The demand component is the peak demand (in kilo-watts) occurring within the month. Demand charges can range from a few *reais* per kilowatt-month to upwards of R$ 23.00 per kilowatt-month. Because it can be a considerable percentage of your bill, you should take care to reduce peak demand whenever possible. On the other hand, the water is charged based in only one measure, the consumption in cubic meters.

This paper outlines areas where opportunities can described to manage better the use of energy and water at the Campus do Pici: lighting, air conditioner system and photovoltaic (PV) water pumping systems.

Using some efficient equipment it is possible to reduce the peak demand and the consumption. Energy efficiency or efficacy is defined as the percentage ratio of useful energy output to input energy. An example, for lighting, efficacy is expressed as lumens per watt, which means the ratio of light from a lamp to the electrical power consumed.

Aiming the application of motor-pumping groups of high efficiency with PV panels, in agreement with the climatic characteristics of the area, rising of the current situation of water pumping was accomplished at UFC, more specifically at the Campus of Pici.

The state of Ceará, for instance, it is characterized by irradiance up to 2,800 hours/year and a daily medium value for the daily solar irradiation on a horizontal surface up to 5 kWh/m^2/day (Silveira, 2004). Due to the proximity of Ecuador, this solar potential is available every month

of the year. Using that potential it is possible to reduce the local water supply company consumption.

2. Current Situation

Nowadays the Campus of Pici has your bill in the "blue hour-seasonal tax", it consumes an annual average of 9.7 GWh, paying for it an average of 2 million reais (table 01). Among the years 2000 and 2001, the electric power consumption was reduced in 17%, in the critical period of the energy crisis in Brazil (rationing), between 2001 and 2002, it was reduced in 23%, however, between 2002 and 2003 there was an increase of 4%.
In 2001, the CICE - Energy Interns Conservation Commission was implanted, its objective is to reaching the goal of consumption reduction for public buildings, established by the MME - Mines and Energy Ministry in the same year at 20%, because of the energy crisis (to place the reference). The goal proposal for UFC was surpassed, reaching the 23% in the Campus of Pici, in other units arriving to 30% that stimulated the saving energy felling and the creating of PROCEN - the Electric Power Consumption Efficiency Program of the Federal University of Ceará. PROCEN, in partnership with ELETROBRÁS - Brazil Electric Headquarters S.A. - and with COELCE - Electric Power Company of Ceará-, is proposing measures of electric power conservation through analysis of the billed bills and of the load risings and application of renewable sources.

Table 01. Campus of Pici - annual consumption of electric power.

Year	Annual Consumption	Total Value	
	GWh	Million of R$	
2000	12.4	R$	1.18
2001	10.2	R$	1.15
2002	7.9	R$	1.55
2003	8.3	R$	2.04
Average	**9.7**	**R$**	**1.48**

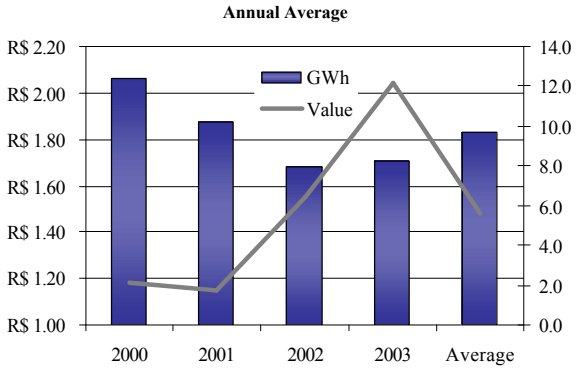

Figure 01. Campus of Pici - Graphic of annual consumption of electric power.

Table 02. Campus of Pici - average of annual consumption of water.

Year	Annual Consumption	Total Value	
	m3	Million of R$	
2000	171,052	R$	0.41
2001	198,208	R$	0.57
2002	204,654	R$	0.67
2003	212,206	R$	0.90
Average	**196,530**	**R$**	**0.64**

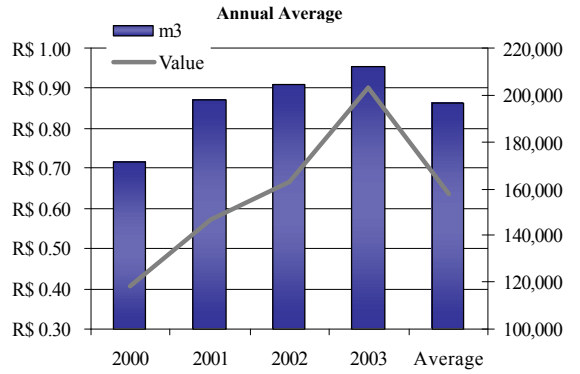

Figure 02. Campus of Pici - Graphic of annual consumption of water.

The annual average of the consumption of water is about 196.530 m^3, period 2000-2003 (see table 02 and graph 02). Between 2000 and 2003, an increase of 24% was registered, what represents seven percentile points more than the average of the period.

3. Proposals For Energy Savings

3.1. Public Illumination Systems

The public illumination efficiency involves not only the reduction of energy consumption, hower the quality increase, through improvement of efficiency of the illumination systems and the use of new equipments (for instance, more efficient lamps), and the efficient administration of those resources (La Rovere, 2001). Some of the advantages can be described as:

- Increase of the luminous flow and, therefore improvement of the quality of the public illumination;
- Reduction of the operational costs with the change of lamps, due to the longer useful life.

At begin of the project, August of 2004, the Campus of Pici had 591 posts, 296 of them with lamps of vapor of sodium of 250W and 443 of 400W, 739 lamps. The proposal was the substitution of all the luminaries for models with specular reflectors and new lenses, in this way, it was possible to reduce the number of lamps for 591, and all the ones can be 250W high pressure sodium vapor. The load reduction was of 123.55KW, generating an economy of 43%, calculated on the old system, as the table 03 indicates. The whole substitution work was concluded in October of 2004. The RBC - relationship benefits cost - of this project was larger than 7, calculated according to the criteria for economical evaluation, of the ANEEL - National Agency of Electric Power - Manual for Elaboration of the Program of Energy Efficiency, rectified in October of 2002.

COURRENT SYSTEM			
Lamps kind	**VSAP 250W**	**VSAP 400W**	**Total**
Amount	296	443	**739**
Power (lamps+ballasts)	287	454	**741**
Installed power (kW)	84.95	201.12	**286.07**
Energy consumed (MWh/year)	372.09	880.91	**1,253.00**
PROPOSED SYSTEM			
Tipo de lâmpada	**VSAP 250W**	**VSAP 250W**	**Total**
Amount	148	443	**591**
Power (lamps+ballasts)	275	275	**550**
Installed power (kW)	40.70	121.83	**162.53**
Energy consumed (MWh/ano)	178.27	533.59	**711.86**
OBTAINED RESULTS			
Power reduction (kW)	44.25	79.30	**123.55**
Conserved energy (MWh/ano)	193.82	347.32	**541.14**
Economy (%)	52%	39%	**43%**

Table 03. Public illumination systems.

3.2. Efficient Lighting and Climatization Upgrades

This project of energy efficiency of illumination systems in property facilities consists of the retreat the old illumination system, composed of luminaries with T12 fluorescent lamps of 1x20W, 1x40W, 2x20W, 2x40W, 3x20W, 3x40W, 4x40W and incandescent lamps, electromagnetic ballasts and installation of a new system, composed by T8 fluorescent lamps of 32W or of 16W with electronic ballasts and fluorescent reactors compact. The luminaries will not be substituted.
The climatization system analyzed just consists of window apparels. The proposed action was the substitution of existent apparels, at the end of useful life, for apparels technologically more advanced, with high EER.
In the table 04 there were the amount of fluorescent, compact fluorescent and incandescent lamps existent in the Campus of Pici, and the number of window air conditioner. It was showed the current potencies and proposal, it was taken consideration the potency dissipated in the ballasts. Observe that, the simple substitution of equipments could save 977 kW in the campus installed load. The RBC of this project was larger than 7, calculated according to the criteria for economical evaluation, of the ANEEL.

Table 04. Efficient lighting and climatization upgrades - summary.

	Amount	**Current Power (kW)**	**Proposed Power (kW)**
Fluorescent	16,003	690.6*	524.4*
Compact fluorescent	102	1.6	1.6**
Incandescent	388	24.6	4.7
Air conditioner	1,059	2,404.0	1,613.4
Total		**3,120.8**	**2,144.0**
Reduction of Load in KW			**976.8**
Economy % (illumination + climatization)			**31%**

*Lamps and ballasts power.
** There was not alteration in the fluorescent compact ones.

4. Proposals for Water Savings

4.1. PV Water Pumping

The Campus of Pici has a daily consumption of 543 m^3 of water, can have your need only supplied by the existent wells, which has capacity to supply 649 m^3. There are twenty-five wells, for which were calculated, for technical and financial viability, the necessary tubs, the group motor-pump and the panels PV for supply the group. In general, these wells are not being used.
The chosen system was of direct coupled, without use of batteries, storing water in tank for the readiness of twenty-four hours. the first step was to calculate the total head (Fedrizzi, 1997). Thus, it was necessary estimate the pipe and calculate the suction losses and press down. The used model was the one of a foot valve and a knee of 90^o for suction; a drawer valve totally open and a knee of 90^o for it press down (Figure 04). When the total head and the flow rate were known, the Requested Power for the requested flow rate (P_M) was found.
The concept of full sun was used to estimate the electric power. If all the daily solar energy available it was obtained under a constant radiation of 1,000 W/m^2, every daily consumption

should be supplied in this interval of time (full sun) (MARTINEZ, 2001), for the studied case, it was considered five hours of full sun a day.
The table 04 display the result of the project using a group motor-pump with efficiency of 85%. With a daily flow of approximately 649 m^3/day, it was required 11.5 kW; to this, was necessary twenty-three continuous current motors coupled to centrifuge pumps (Silveira, 2004).
The value of the investment is about of 1 million reais, with an annual cost of maintenance and operation of 51 thousand reais. The time of return of the investment, considering the annual medium expense with the company of water and local sewer of 780 thousand reais, would be in 1 year and 4 months.
In the table 05 can be verified that the application of the pumping PV in UFC is economically viable. The present value of the installation and of the operation and maintenance, considering the time of useful life of the system, represents only 2% of the liquid present value for payment of the bills water to the company of water distribution of the state for the period of 25 years.

Table 04. Mechanical power required for a motor pump 85% efficient.

Daily Flow Rate	**648.63 m3/day**
Power Required	**11,409.79 W**

Needed motor-pump groups	**Power (cv)**
14	0.5
1	0.75
5	1
3	1.5

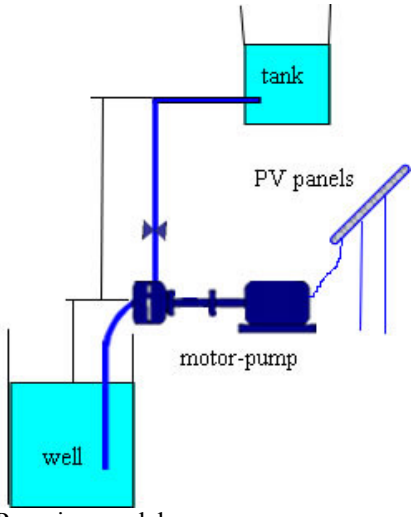

Figure 04. Pumping model.

Table 05 – Result of the analysis of financial viability.

Proposed system		
Annual benefit	R$	779,824.50
Interest rate		0.12
Investment	R$	1,020,249.72
Cost of maintenance and annual operation	R$	51,012.49
Time of Return of Capital in years		1.3
Life time in years		25.00
Liquid present value	**R$**	**1,420,347.74**
Current system		
Annual cost	R$	779,824.50
Present value of the cost for 25 years	**R$**	**73,395,264.44**
Percentage of VPL of the investment in relation to VPL of the cost with supply of water during the 25 years of useful life of the system		**2%**

5. Conclusion

The actions for reduction of electric power consumption described in this article do not demand an advanced technology, there was simple procedures, change of lamps, reactors and apparels of air conditioning type window. The table 06 display a results summary of the simulation of the total application of the proposed measures, if these were implanted in your totality, they would take the a reduction of electric power consumption more than 30% in relation to the annual average.

About the reduction of water consumption, the application of the PV technology is a cheap solution, it did not always happen with the several forms of use of the solar energy. It happened because of the simple model of PV water pump chosen and because it reduces the consumption of the concessionary at zero.

One year after the implantation of the measures proposed here, UFC would stop spending more than a million reais with water and electric power.

Table 06. Simulation results of the proposed measures total application.

	Demand reductions after application KW	**Annual consumption reductions MWh - year**
Public illumination	123.55	541.14
illumination	239.88	506.62
Climatization	788.17	2,080.76
Total	**1,151.59**	**3,128.52**

Acknowledgements

The UFC's Electric Energy Conservation Program – PROCEN – is thankful the support of the Energy Company of Ceará – COELCE – and the Power Plants of Brazil S.A. – ELETROBRÁS.

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