Energy Analysis Report for Fluminense Football Club – Xerém

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For:

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Energy Analysis Report for Fluminense Football Club - Xerém

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Summary

For the purpose of realizing the energy analysis of the Fluminense facility in Xerém an onsite inspection was carried out. Through this, the relevant installed energy-consuming equipment was identified. The characteristic energy consumption of the different systems was analyzed and the energy savings opportunities were identified.

As a result, a catalogue of 12 measures is presented. Most of these measures address the operation of the systems and require low investments in capital and effort for their implementation.

The proposed measures consist of 10 electrical energy saving measures, 1 gas saving measure and 1 energy generating measures, a Photovoltaic (PV) System.

The electrical energy saving measures have a potential to save 95.359 kWh/year corresponding to 35,2 % of the current energy consumption. Accordingly, they would reduce 8.115 kg per year of CO_2 emissions, corresponding to 16 % of the current CO_2 emissions.

The gas saving measure comprises a solar thermal system that has the potential to save 66.123 kWh/year of the energy provided by gas for water heating, representing 93 % of the current gas consumption and would reduce the CO_2 emissions by 28.036 kg per year.

The expected electrical energy generation of the PV System is 152.878 kWh per year. The electrical generation would balance the consumption left after the 10 energy saving measures have been implemented. Accordingly, the implementation of the PV System would reduce 12.536 kg of CO_2 per year.

As the following table shows, the implementations of all the 12 measures result in yearly energy cost saving of R$ 132.040 with a projected investment of R$ 1.313.560 the payback time corresponds 9,9 years.

From which the investments of the PV system with a value of R$ 1.028.160 pays back in 26 years and the investment of R$ 43.200 for the solar thermal system pays back in 4,6 years.

Table 1 shows the summary of results.

Table 1: Summary Results

	Electrical Energy Use/Reduction	Gas Consumption	Economic Cost/Savings	CO_2 Emissions	Investment	Payback Time
Baseline (consumption from 2012)	270.571 kWh/year	71.100 kWh (7.110 m³)	166.394 R$/year	52.333 kg/y		
10 Energy Saving Measures	95.359 kWh/y	-	83.219 kWh/y	8.115 kg/y	242.200 R$	**2,9 years**
(Reduction)	35,2 %	-	50 %	16 %		
12 Measures	248.237 kWh/year	66.123 kWh/year	132.040 R$/year	48.687 kg/y	1.549.400 R$	**9,9 years**
(Reduction)	**91,7 %**	**93,0 %**	**79,4 %**	**93%**		

As a next step, planning for the implementation of the energy saving measures is recommended as these measures have different complexities and investment requirements.

1 Introduction

Energy Analysis Report

for

Fluminense Football Club, Xerém

Figure 1: Fluminense Football Club – Xerém

This Energy Analysis Report provides detailed information on the following:

- Existing conditions of the building along with current energy performance which includes energy baselines on usage and demand
- Description of the existing energy-related HVAC mechanical systems
- Description of potential energy conservation measures including peak load reductions
- Economics and payback period for investments in energy savings and peak-load reductions
- Recommendations on next steps for further evaluation and for the implementation of energy conservation measures

This report and its defined measures are based upon on-site inspections, interviews with technical personnel, available energy data, available technical documentation, access to the operations parameters and direct measurements by the energy audit team.

In some cases, where data has not been immediately available, theoretical assumptions were used. These assumptions are technically justified and can be validated or modified when data becomes available or when additional detailed measurements are possible.

2 Facility Description

In the site of Fluminense in Xerém are located two buildings one serves as training facility and the other one serves as a hotel for the athletes.

The following data characterizes the building:

Table 2: Basic Building Data

Basic Site Data	
Number of Buildings	2
Build Area	1.550 m²
Operating Hours	07:00 - 22:00 Monday - Sunday

Figure 2: Fluminense Footbal Club, Xerém

3 Energy Consumption and Cost Overview

The facility uses gas and electricity as primary energy source for its operation.

3.1 Electrical Energy

For the purpose of the energy analysis, electricity bills and load records made available by Fluminense, were analyzed.

There is different metering for the training center and for the Hotel. The electricity is supplied by the company Light, under the tariff structure A4-Horo Sazonal Azul.

The A4 group is for the consumers with a supply tension between 2,3 and 25 kV.

The group Horo Sazonal Azul is a supply structure for differentiated tariffs according to the time of the day and season of the year. High Tariff schedule is from 18:30 to 21:30 in summer, and 17:30 to 20:30 the rest of the year.

There is no differentiated tariff structure for the Hotel.

The available data showed the consumption record from February 2012 to December 2012. To have an overview of the yearly consumption the month of January was calculated as an average of the other months of the year. For the cost calculation of January, the prices for the month of February where used. The total consumption for the Training Center in 2012 is 221.716 kWh, with a peak load of 82,1 kW, consequently 2.700 hours of full load operation where calculated. The hotel had a total electrical energy consumption of 48.855 kWh in 2012, there is no record of power demand.

The characteristic consumption values are shown on the following table.

Table 3: Characteristic Consumption Values, Fluminense Training Center, Xerém

Registered period: February 2012 - December 2012

Characteristic Consumption Data/ Indicators	Values
Training Center Total Active Electrical Energy Consumption	221.716 kWh
Hotel Total Active Electrical Energy Consumption	48.855 kWh
Total Active Energy Consumption	**270.571 kWh**
Training Center Electricity Costs	R$ 144.356
Hotel Electricity Costs	R$ 23.239
Total Electricity Costs	**R$ 167.595**
Training Center Total Reactive Electrical Energy Consumption	993 KVA_{rh}
Training Center Highest Peak Load	82,1 kW
Training Center Contracted Power	40 kW
Training Center Full Load Hours	**2.700 hours**

The following graph (Figure 3) shows the electricity consumption and the power demand registered for the period of January 2012 to December 2012, based on the data registered on the respective invoices and summarized in table 4.

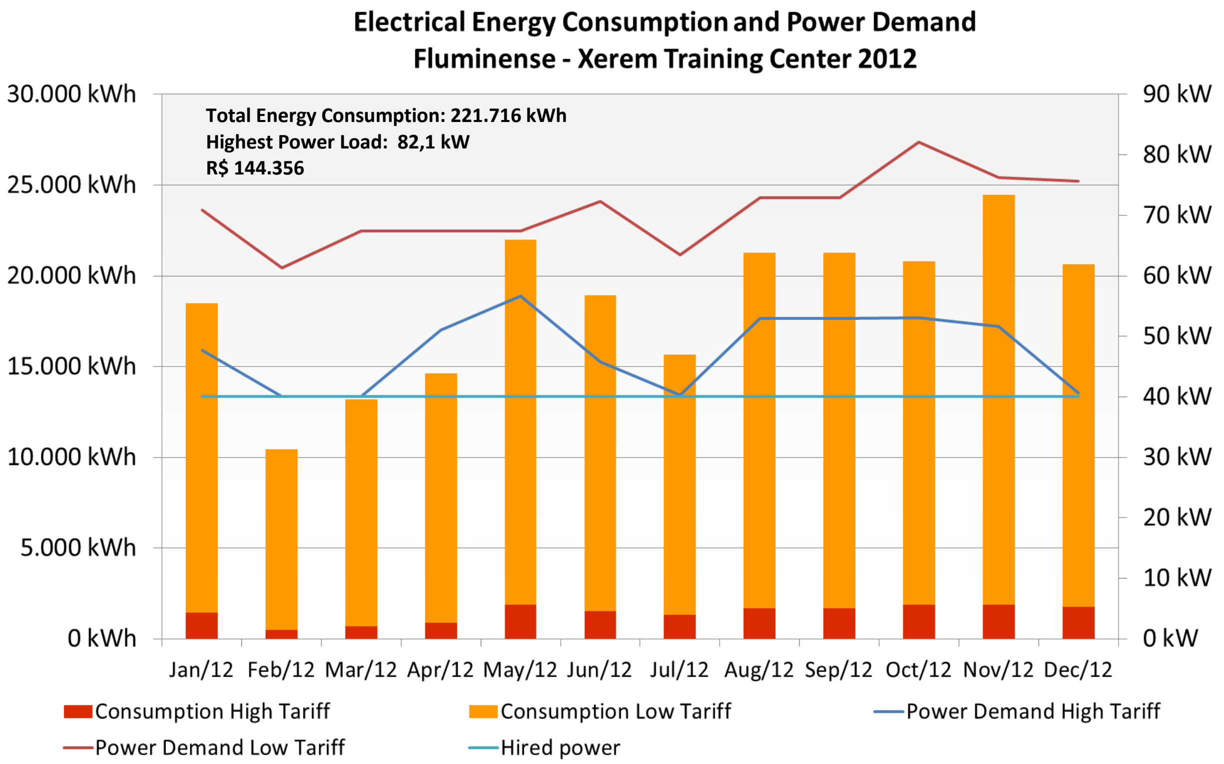


Figure 3: Energy Consumption and Power Demand Fluminense Training Center, Xerém, February to December 2012

Table 4: Electrical Energy Consumption and Power Demand, Fluminense Training Center, Xerém Registered period: February 2012 - December 2012

Date	Power Demand High Tariff	Power Demand Low Tariff	Exceeding Power Demand High Tariff	Exceeding Power Demand Low Tariff	Consumption High Tariff	Consumption Low Tariff	Reactive Energy High Tariff	Reactive Energy Low Tariff
Jan/12	48 kW	71 kW	8 kW	31 kW	1.422 kWh	17.055 kWh	11 kVArh	79 kVArh
Feb/12	40 kW	61 kW	0 kW	21 kW	474 kWh	9.965 kWh	43 kVArh	238 kVArh
Mar/12	40 kW	67 kW	0 kW	27 kW	668 kWh	12.521 kWh	44 kVArh	274 kVArh
Apr/12	51 kW	67 kW	11 kW	27 kW	888 kWh	13.723 kWh	31 kVArh	151 kVArh
May/12	57 kW	67 kW	17 kW	27 kW	1.894 kWh	20.096 kWh	1 kVArh	94 kVArh
Jun/12	46 kW	72 kW	6 kW	32 kW	1.503 kWh	17.438 kWh	1 kVArh	36 kVArh
Jul/12	40 kW	64 kW	0 kW	24 kW	1.299 kWh	14.371 kWh	2 kVArh	36 kVArh
Aug/12	53 kW	73 kW	13 kW	33 kW	1.696 kWh	19.562 kWh	0 kVArh	7 kVArh
Sep/12	53 kW	73 kW	13 kW	33 kW	1.696 kWh	19.562 kWh	0 kVArh	7 kVArh
Oct/12	53 kW	82 kW	23 kW	42 kW	1.886 kWh	18.907 kWh	0 kVArh	7 kVArh
Nov/12	62 kW	76 kW	12 kW	38 kW	1.892 kWh	22.550 kWh	0 kVArh	14 kVArh
Dec/12	41 kW	76 kW	0 kW	36 kW	1.742 kWh	18.907 kWh	0 kVArh	7 kVArh
					17.060 kWh	**204.657 kWh**	**133 kVArh**	**950 kVArh**

The total electricity consumption registered from February to December of the year 2012 is 203.240 kWh, and the calculated consumption of January is 18.477 kWh. The contracted power is 40 kW, this value is exceeded the whole year in the low tariff schedule by at least 21,3 kW to 42 kW and in the high tariff schedule is exceeded 7 of the 11 documented months by at least 5,8 kW to 22 kW. The highest peak load is registered in October in the low tariff hours with a value of 82 kW, with a fee per exceeded kW in low tariff schedule of R$ 43,25 this represents R$ 3.158,43.
For the training building, based on the prices shown on this electricity bill considering power demand and electricity consumption the electrical energy costs for the period of February 2012 to December 2012 are R$ 132.760,68, taking into consideration the calculation of January this rises to R$ 144.356.

The average specific cost of energy is R$ 0,65 kWh. This is considering the costs of electricity consumption and power demand on the different tariffs per kWh consumed.

The costs are summarized in Table 5 and their respective share is shown in Figure 4

The tariff valid in December 2012 are shown on Table 4, these where used for the economical calculation of the energy saving measures. The different tariffs in year 2012 can be consulted in Appendix A.

Table 5: Electricity prices according to Horo Sazonal Azul A4 (Dec 2012)

Tariff	Value R$
Cost per kW per month (High Tariff)	69,8700 R$
Cost per kW per month (Low Tariff)	25,3337 R$
Cost per kW of exceeding power per month (High Tariff)	137,7897 R$
Cost per kW of exceeding power per month (Low Tariff)	50,8600 R$
Cost per kWh (High Tariff)	0,41 R$
Cost per kWh (Low Tariff)	0,26 R$
Cost reactive energy (High Tariff)	0,19 R$
Cost Reactive energy (Low Tariff)	0,24 R$

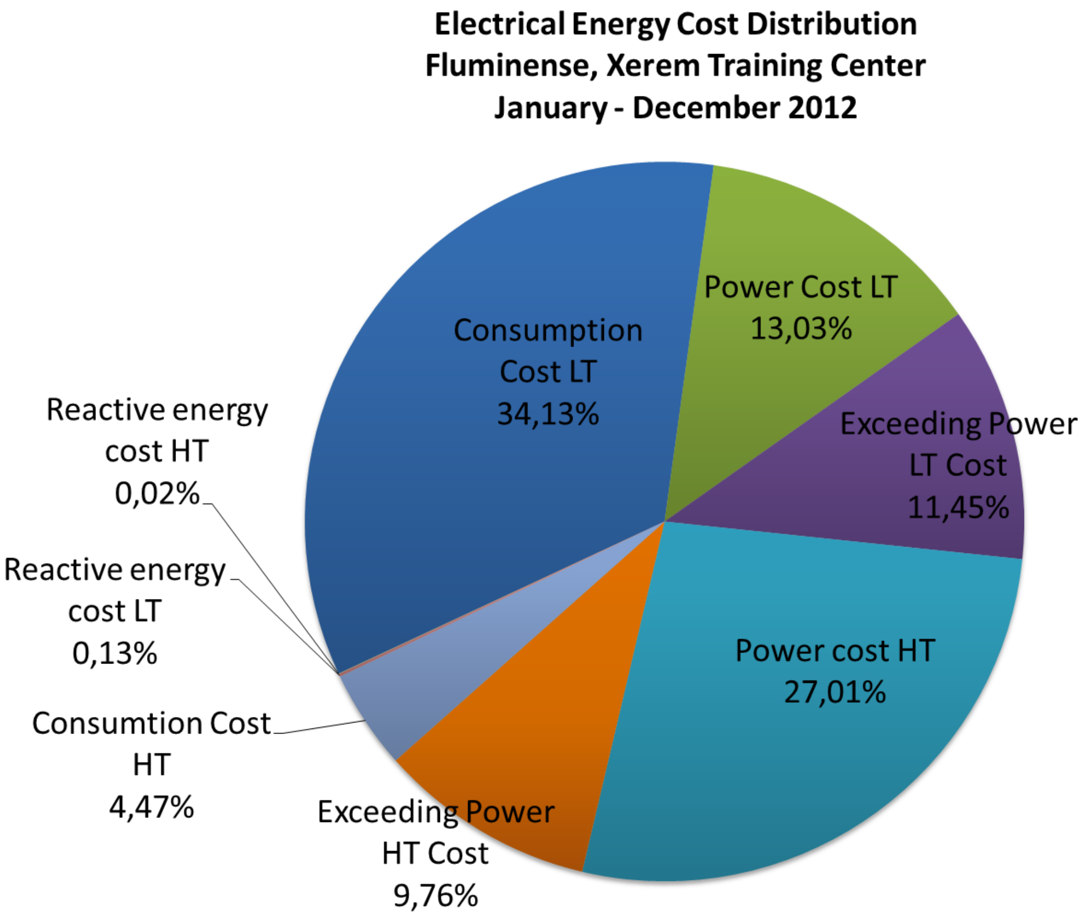


Figure 4: Electrical Energy Cost Distribution, Fluminense Training Center, Xerém, February to December 2012

Table 6: Summarized Electrical Energy Costs for Fluminense Training Center , Xerém, in the Period of February 2012 to December 2013

Cost Elements	Cost	Share
Electrical Energy Consumption Costs Low Tariff (LT)	R$ 49.266,95	34,13 %
Electrical Energy Consumption Costs High Tariff (HT)	R$ 6.451,09	4,47 %
Power Demand Costs Low Tariff (LT)	R$ 18.815,75	13,03%
Exceeding Power Cost Low Tariff (LT)	R$ 16.527,29	11,45 %
Power Demand Cost High Tariff (HT)	R$ 38.996,89	27,01%
Exceeding Power Cost High Tariff (HT)	R$ 14.088,95	9,76 %
Reactive energy cost Low Tariff (LT)	R$ 183,51	0,13 %
Reactive energy cost High Tariff (HT)	R$ 25,65	0,02 %
TOTAL	**R$144.356**	

In Figure 5 it is shown the electrical energy consumption of the Hotel with a total of 48.855 kWh. The month with the higher energy consumption is March with 7.600 kWh. There is no record of a differentiated tariff according to schedule or of power demand on the invoices. Table 6 shows the data from the invoices of 2012.

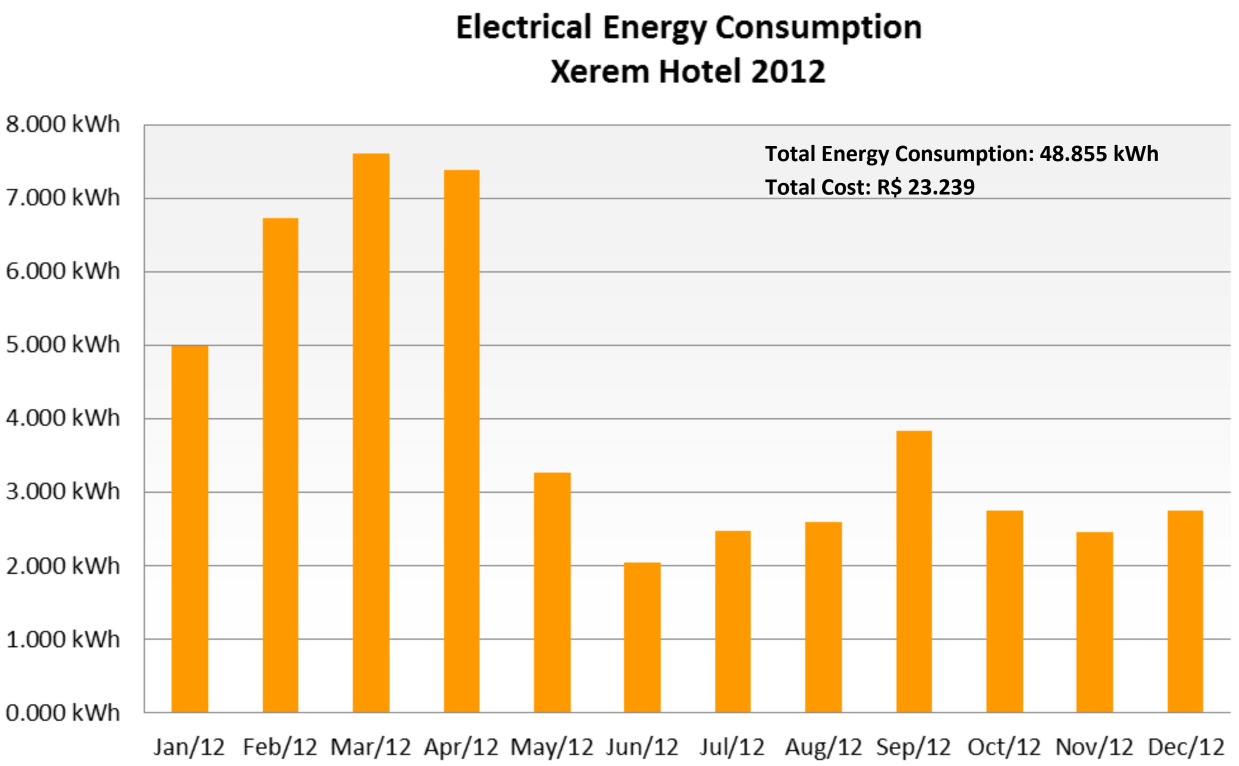


Figure 5: Energy Consumption Fluminense Hotel, Xerém, January to December 2012

Table 7: Electrical Energy Consumption and Costs, Fluminense Hotel, Xerém Registered period: January 2012 - December 2012

Date	Electrical Energy Consumption Low Tariff	Cost per kWh Low Tariff	Total Cost
Jan/12	4.986 kWh	R$ 0,4781	R$ 2.383,81
Feb/12	6.727 kWh	R$ 0,47117	R$ 3.169,56
Mar/12	7.600 kWh	R$ 0,47095	R$ 3.579,22
Apr/12	7.380 kWh	R$ 0,47413	R$ 3.499,08
May/12	3.258 kWh	R$ 0,47464	R$ 1.546,38
Jun/12	2.041 kWh	R$ 0,47253	R$ 964,43
Jul/12	2.480 kWh	R$ 0,4731	R$ 1.173,29
Aug/12	2.600 kWh	R$ 0,47174	R$ 1.226,52
Sep/12	3.832 kWh	R$ 0,47757	R$ 1.830,05
Oct/12	2.746 kWh	R$ 0,47023	R$ 1.291,25
Nov/12	2.459 kWh	R$ 0,47174	R$ 1.160,01
Dec/12	2.746 kWh	R$ 0,51544	R$ 1.415,40
Total	**48.855 kWh**		**R$ 23.239,00**

Summarizing the consumption of the training center building and the hotel, the total electrical energy consumption on 2012 of the site is 270.571 kWh and a total cost of R$ 167.595.

3.1.1 Gas

The overview of gas consumption over the year 2011, according to the data made available by Fluminense, is shown on the Figure 6. The total gas consumption for Xerém is 7.110 m³.

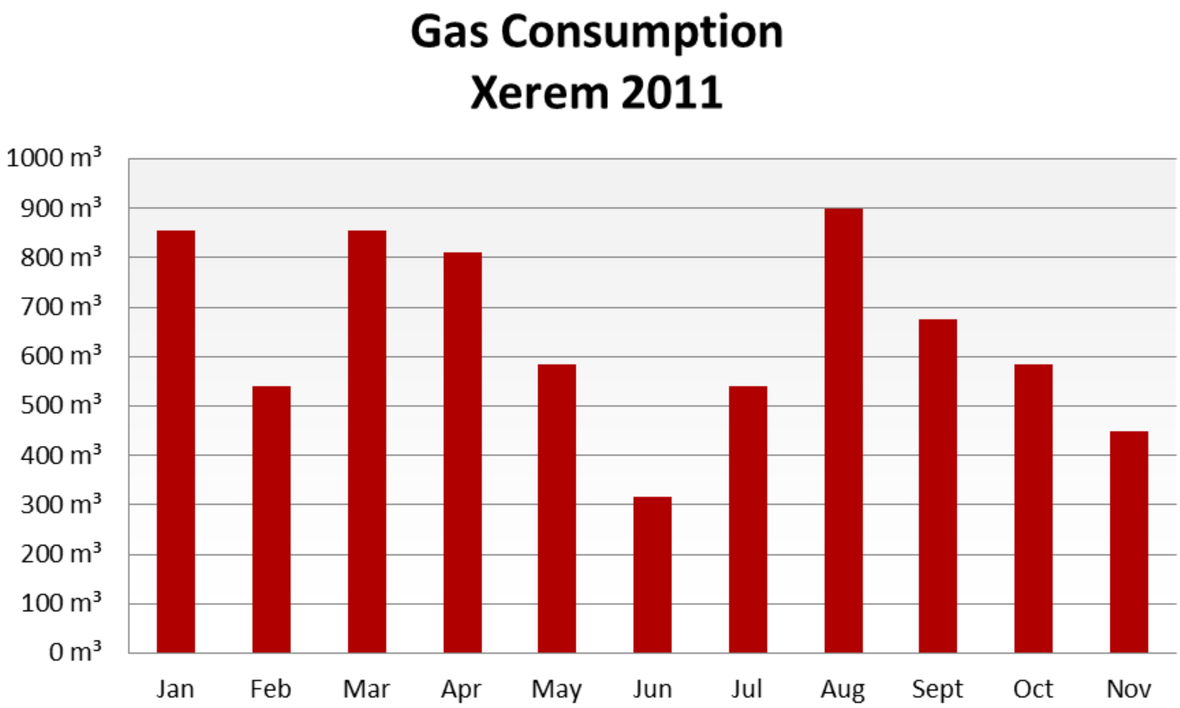


Figure 6: Gas Consumption, Fluminense, Xerém, January to November 2011

No gas costs where available so far, therefore it was taken the average price that Fluminense Football Club in Laranjeiras receives of 0,1410 R$/m³. This makes a total gas cost for 2011 of R$ 10.025.

3.2 Characteristic Power Demand

The data used to describe the characteristic daily power demand, was provided by the electricity company. The data shows the recorded power demand every 15 minutes.

The load profile is graphed in Figure 7 for the period of 12th of September to 13th of October 2013. The operations of the site are at a base load between 27 kW and 16 kW, with a tendency to rise up to 62,21 kW at noon, which can be explained by higher cooling demand. The power demand decreases to a range between 35 kW to15 kW during 18:00 to 22:00 and then stays at base load.

A decrease in load can be seen from 5:00 to 7:00, and then it increases towards the highest point at noon. This decrement could be explained by switching off the split units of the dormitories and lights that run at night. A concentration of increments raging 25 kW to 43 kW can be seen from 16:15 to 18:15, part of this period falls in the High Tariff period.

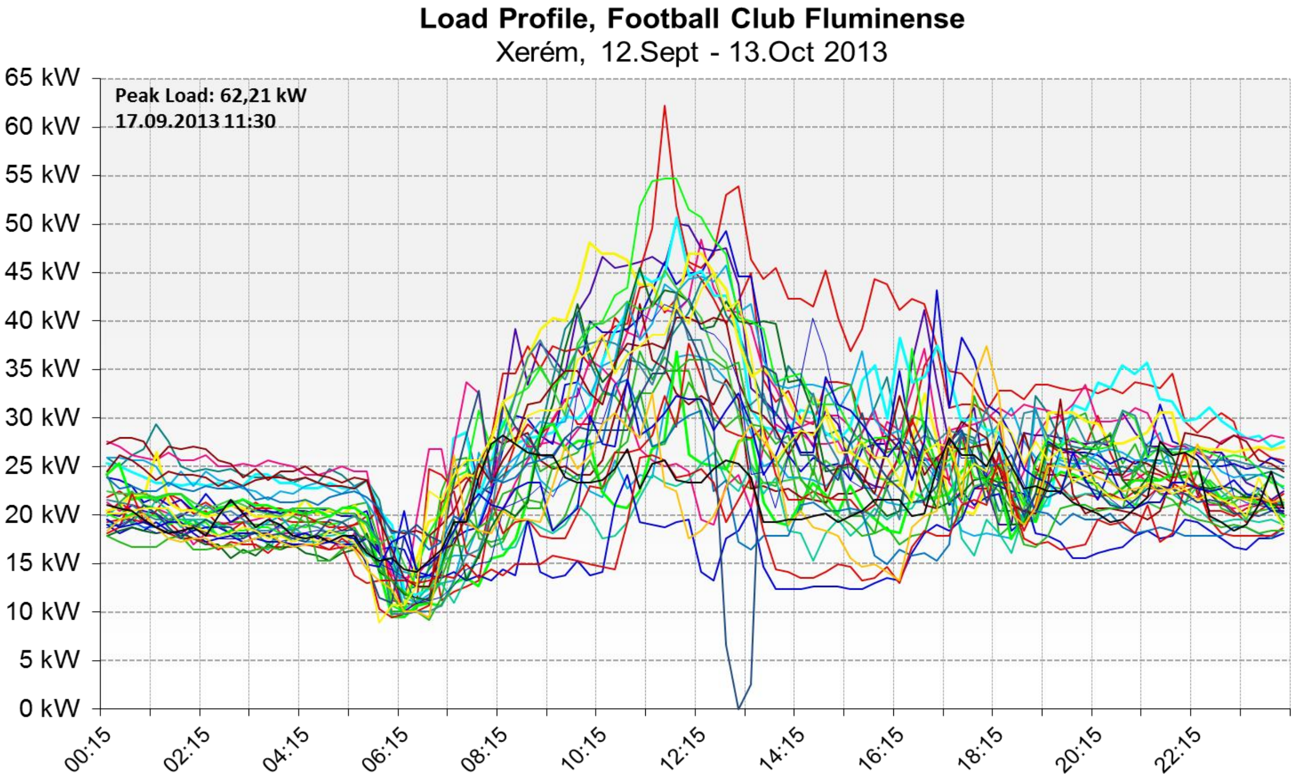


Figure 7: Load Profile for Fluminense, Xerém, 12.Sept 2013 – 13. Oct 2013

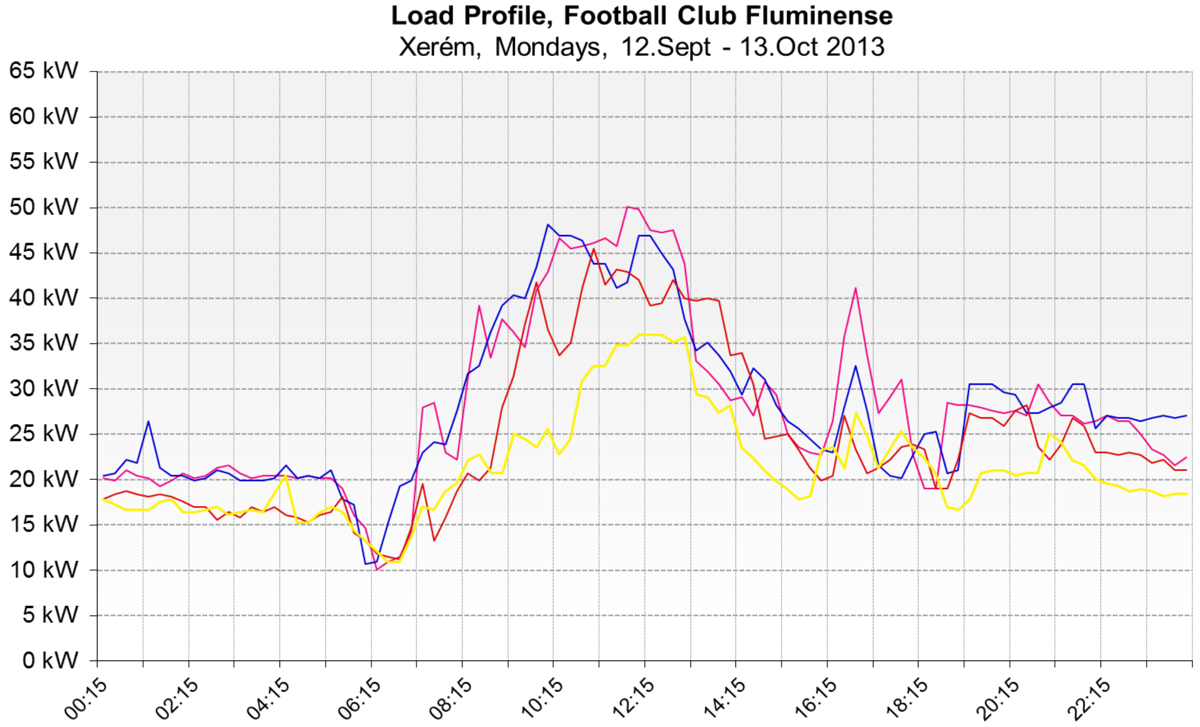


Figure 8: Load Profile for Fluminense, Xerém, Mondays, 12.Sept 2013 – 13. Oct 2013

As it can be seen on the following figure, the load profile for Tuesdays has a considerably high peak at noon that reaches 62,21 kW. Overall it maintains a high load compared to the other days. This could be explained by higher number of courses during Tuesdays or special events.

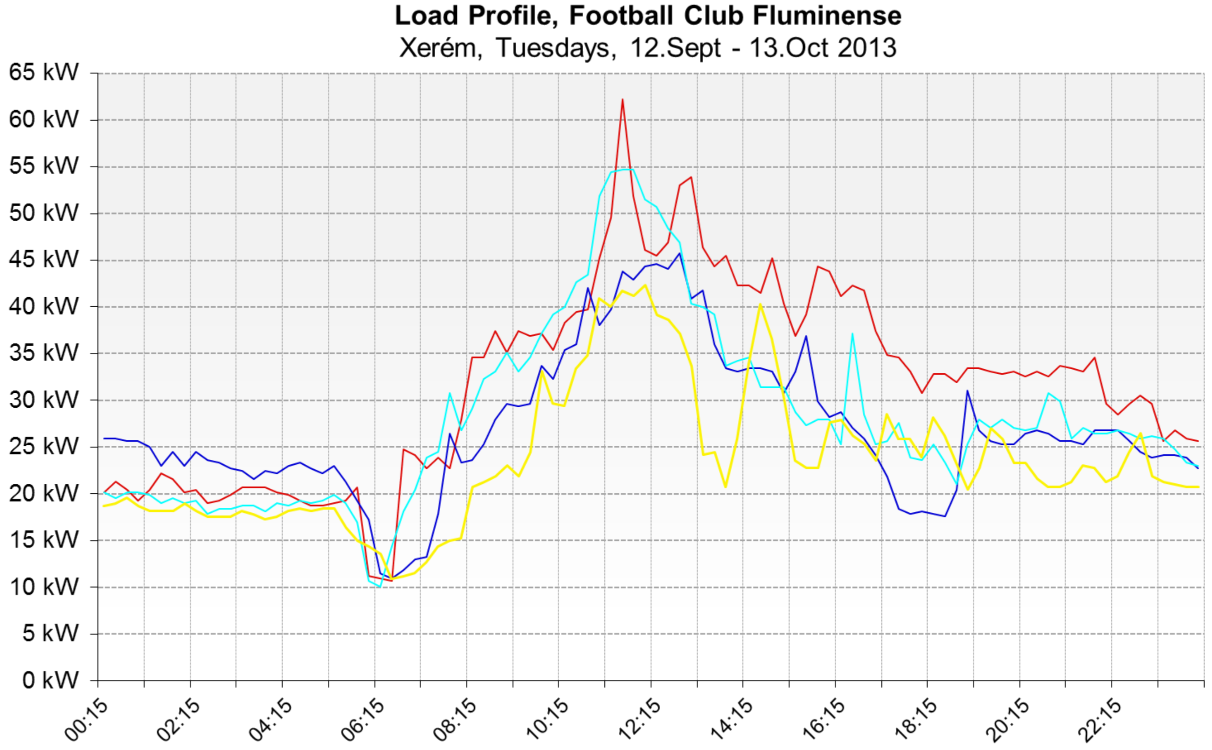


Figure 9: Load Profile for Fluminense, Xerém, Tuesdays, 12.Sept 2013 – 13. Oct 2013

Wednesday in the observed period are showing lower load relative to the other weekdays.

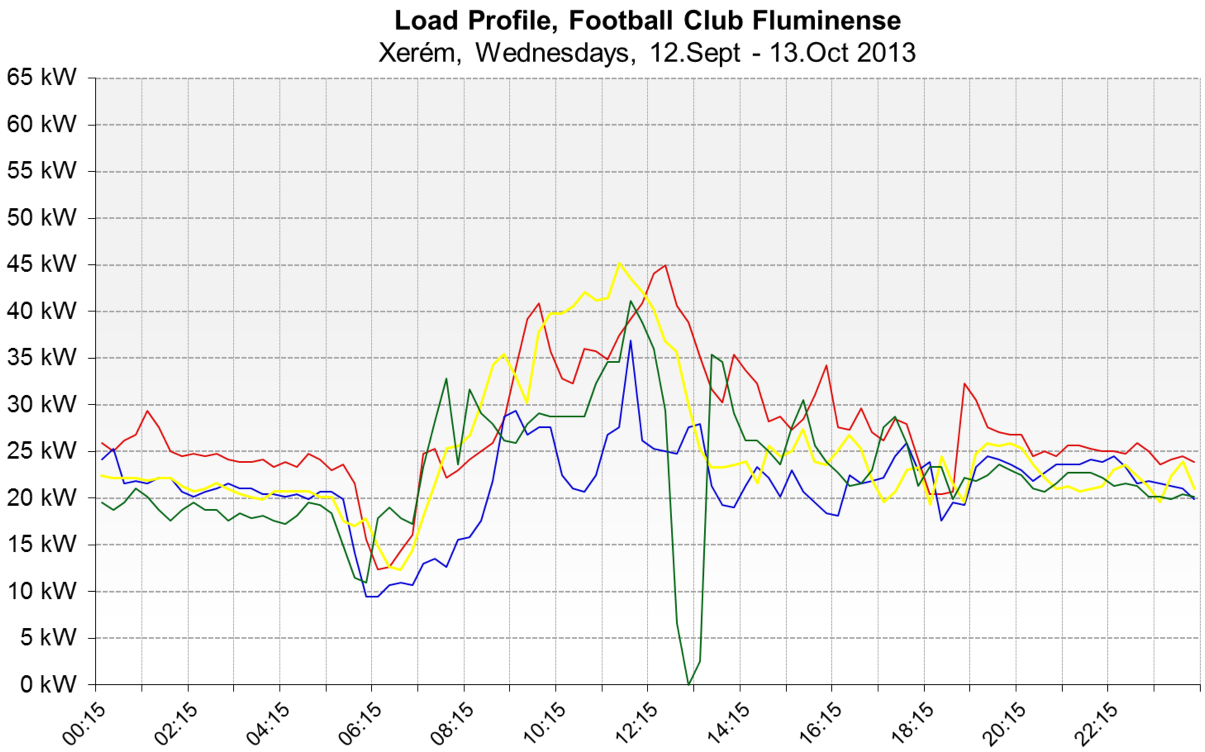


Figure 10: Load Profile for Fluminense, Xerém, Wednesdays, 12.Sept 2013 – 13. Oct 2013

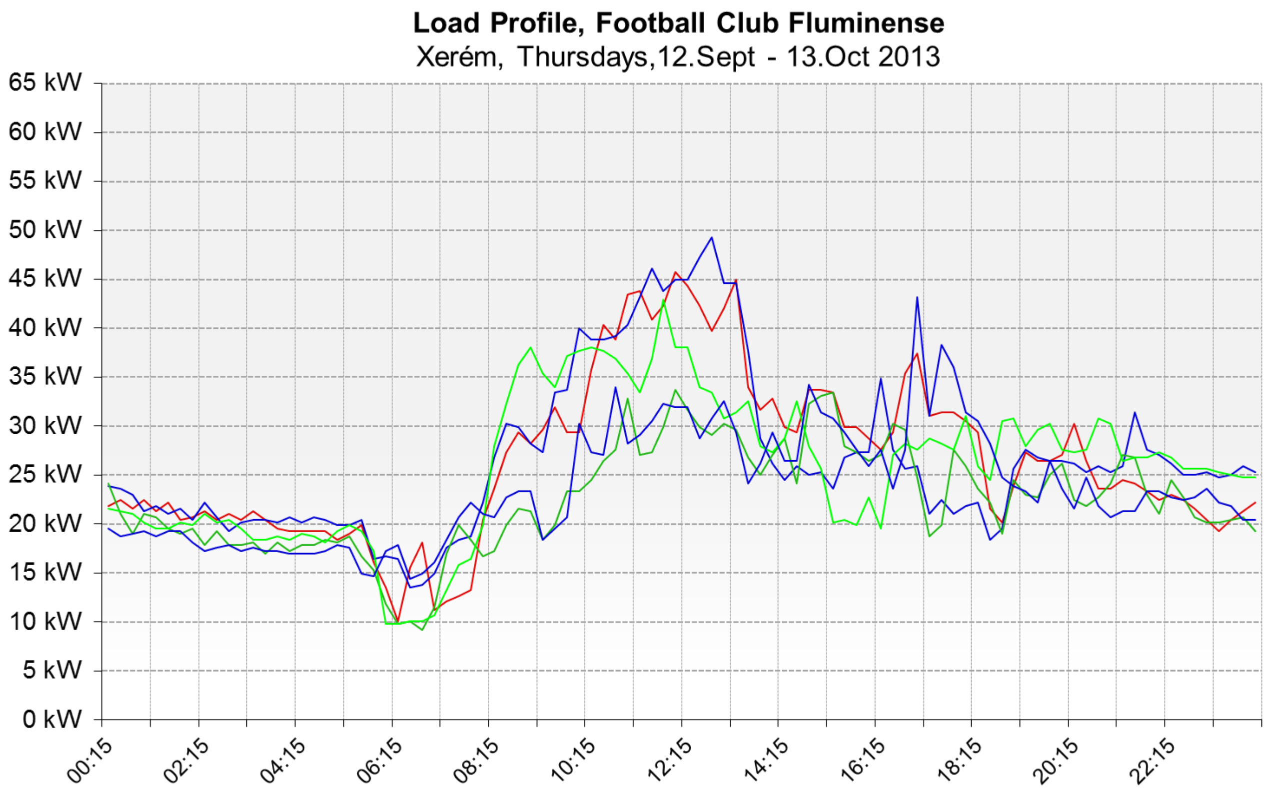


Figure 11: Load Profile for Fluminense, Xerém, Thursdays, 12.Sept 2013 – 13. Oct 2013

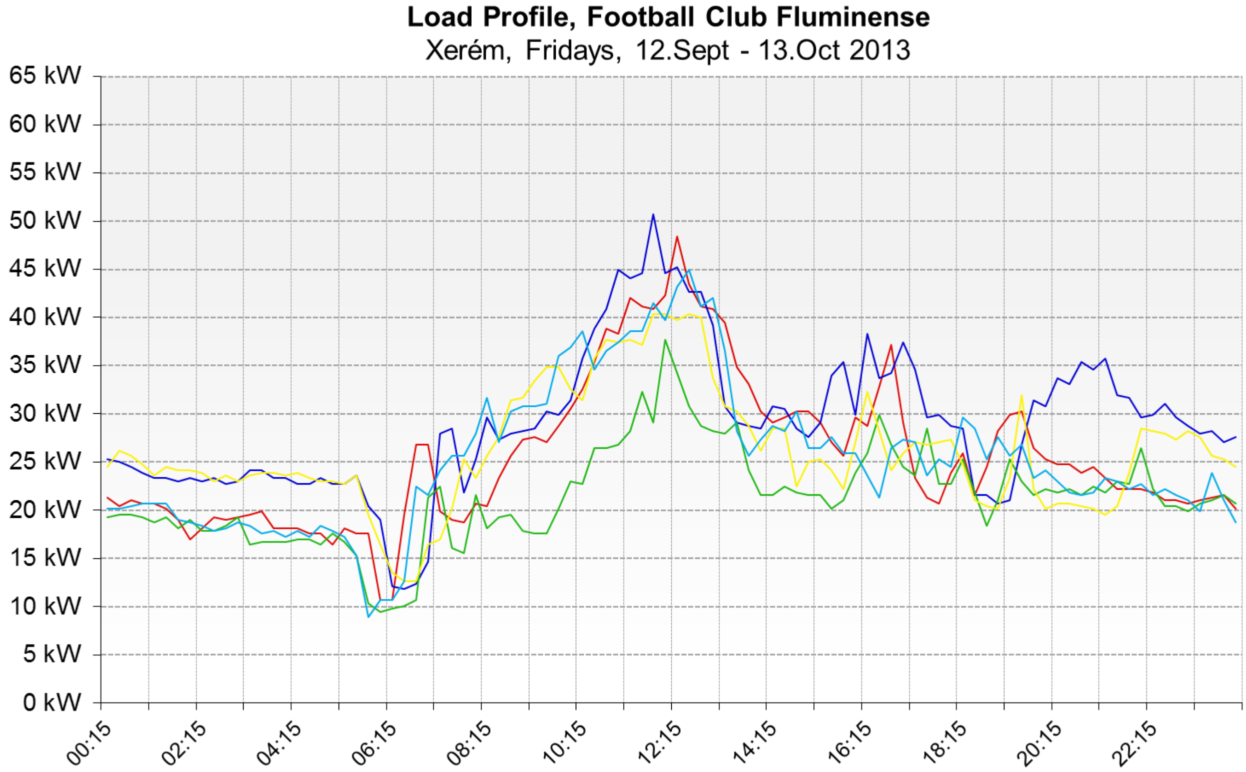


Figure 12: Load Profile for Fluminense, Xerém, Fridays, 12.Sept 2013 – 13. Oct 2013

On weekends, despite the low activity a load ranging 10 kW to 40 kW is observed.

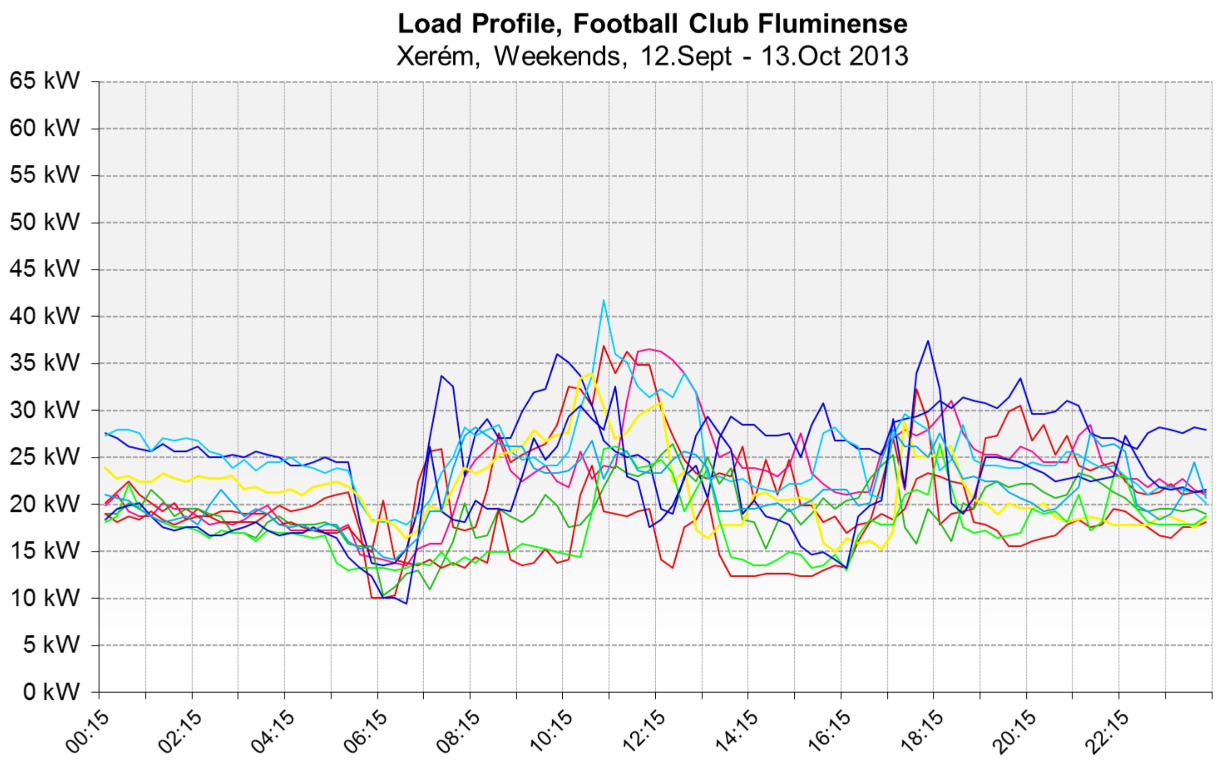


Figure 13: Load Profile for Fluminense, Xerém, Weekends, 12.Sept 2013 – 13. Oct 2013

The sorted load curve (Figure 14) of Fluminense shows that the building is in operation with a power demand higher than 40 kW during 154 15-minutes periods in one month respectively 38,5 hours.

The minimum load (base load) is around 13 kW.

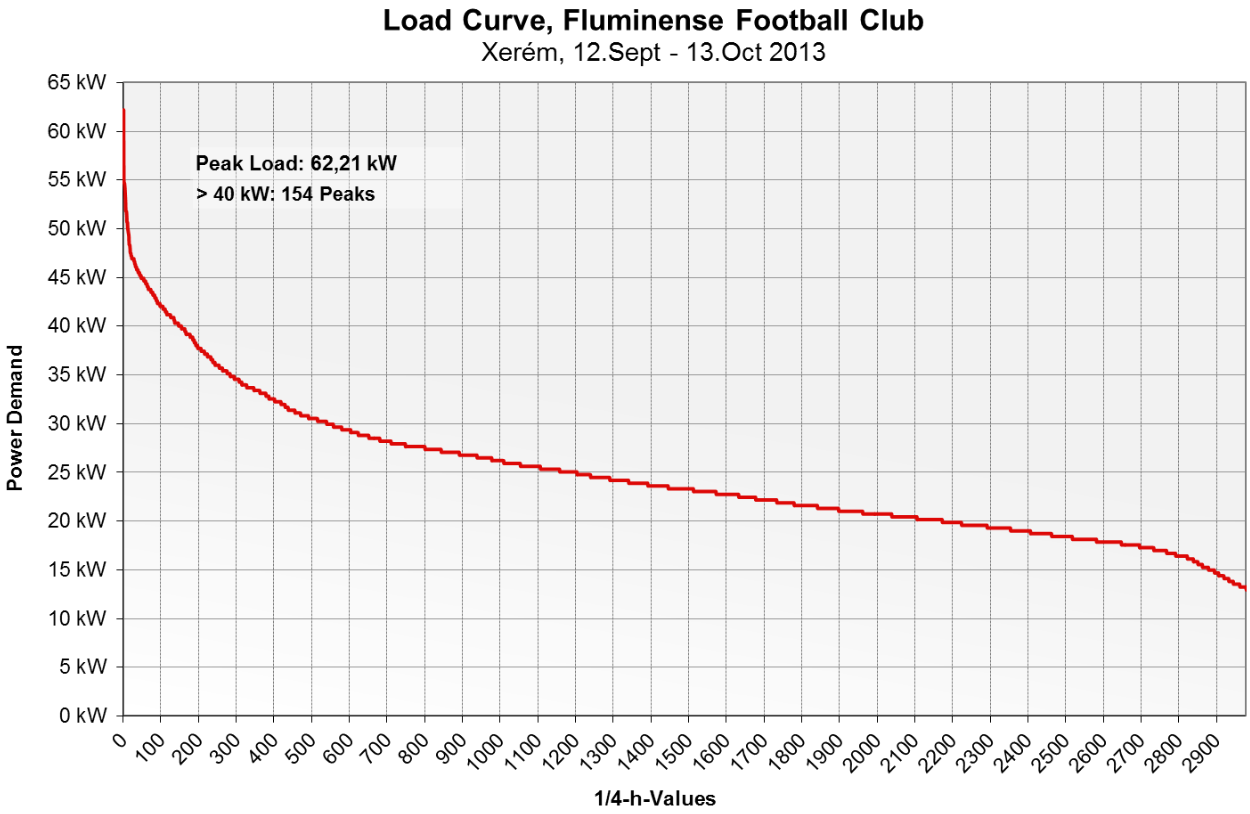


Figure 14: Load Curve, 12.September 2013 – 13.October 2013

4 Energy Relevant Equipment

The identified energy consuming equipment is organized within three categories:

- Lighting
- Air Conditioning
- Water Heating
- Other

The following sections describe the installed equipment in Fluminense Football Club, Xerém.

4.1 Lighting System

The data of the lighting systems was gathered in the onsite inspections and from information made available by Fluminense. The site has a total of 23,14 kW installed in lighting. Most areas of the building have T12 lamps of 20 W or 40 W.

Figure 15: Installed T12 Lamps

Figure 16: Installed T12 Lamps

Figure 17: Installed 250 W Mercury Vapour Lamps

The following table gives a comprehensive overview of the installed lighting systems in the bank branch.

Table 8: Lamp Inventory

Area		Lamp Type	Quant	Nominal Power per Unit	Total Nominal Power Demand	Operating hrs/year
Code	Name					
1	30 Rooms	CFL	30	25 W	0,75 kW	1.456 h/y
1	30 Rooms	T12	60	40 W	2,61 kW	1.456 h/y
1	30 Rooms	T8	60	16 W	0,96 kW	1.456 h/y
2	Corridor, stairway	CFL	41	25 W	1,03 kW	1.456 h/y
2	Balconies, monitors	T12	2	20 W	0,05 kW	4.368 h/y
3	Management/ Phisiology	Electronic	16	25 W	0,40 kW	2.912 h/y
4	Auditorium	Electronic	5	25 W	0,13 kW	1.092 h/y
4	Auditorium	Incandescent	4	60 W	0,24 kW	1.092 h/y
5	Medical Department				0,00 kW	2.912 h/y
6	Men's Bathroom	T12	4	20 W	0,09 kW	2.912 h/y
7	Women's Bathroom	T12	4	20 W	0,09 kW	2.912 h/y
8	Psychologist/ Social Assistent	T12	4	40 W	0,17 kW	2.184 h/y
8	Psychologist/ Social Assistent	T12	4	20 W	0,09 kW	2.184 h/y
9	Weight training	T12	16	40 W	0,70 kW	1.820 h/y
10	Cafeteria	T12	16	40 W	0,70 kW	2.548 h/y
11	Phisiotherapy	T12	16	40 W	0,70 kW	2.912 h/y
12	Closet	T12	6	20 W	0,14 kW	2.912 h/y
13	Women's Bathroom (Employees)	T12	6	20 W	0,14 kW	2.912 h/y
14	Men's Bathroom (Employees)	T12	6	20 W	0,14 kW	2.912 h/y
15	Kitchen + Kitchen office	T12	10	20 W	0,24 kW	6.552 h/y
15	Kitchen + Kitchen office	Electronic	7	25 W	0,18 kW	6.552 h/y
16	Cold room	Incandescent	2	60 W	0,12 kW	728 h/y
17	Nutrition	Fluorescent	2	60 W	0,12 kW	2.184 h/y
18	Warehouse	Electronic	2	40 W	0,08 kW	728 h/y
19	Technical Evaluation	T12	6	20 W	0,14 kW	2.912 h/y

Area		Lamp Type	Quant	Nominal Power per Unit	Total Nominal Power Demand	Operating hrs/year
Code	**Name**					
19	Technical Evaluation	T12	4	40 W	0,17 kW	2.912 h/y
20	Supervision + Management	T12	6	20 W	0,14 kW	3.640 h/y
20	Supervision + Management	T12	6	40 W	0,26 kW	3.640 h/y
21	Attic	Electronic	4	25 W	0,10 kW	364 h/y
22	Poles	Mixed	30	250 W	8,70 kW	4.368 h/y
23	Maintenance Deposit	Electronic	2	25 W	0,05 kW	364 h/y
24	Ordinance room + commissions	Electronic	10	25 W	0,25 kW	4.368 h/y
25	Laundry Room	Electronic	5	45 W	0,23 kW	3.640 h/y
25	Laundry Room	Electronic	1	25 W	0,03 kW	3.640 h/y
26	Masseuse Room	Mixed	2	250 W	0,50 kW	4.368 h/y
27	Kids dressing room	T12	28	40 W	1,22 kW	2.912 h/y
28	Reflectors	Mixed	3	500 W	1,50 kW	728 h/y
		Total	**430**		**23,14 kW**	

The total nominal power demand, includes 3,5 W of ballast loses per fluorescent tube lamp.

4.2 Air Conditioning Systems

The buildings of Fluminense, Xerém are cooled by split units. According to the information available a total of 43 splits units are currently installed. With cooling capacities in the range of 2,19 kW_{th} (7.500 BTU/h) to 16,99 kW_{th} (58.000 BTU/h). A total of 144 kW_{th} (492.500 BTU/h) of cooling capacity is installed which represents a total installed capacity of 50,51 kW_{el}. The inventory of split and window units is shown on the following table.

Table 9: Cooling Units Inventory

Area Area		**Model**	**Quant.**	**Nominal Power Demand per Unit**	**Total Nominal Power Demand**	**Operating Hours**
No.	**Name**					
1	Room	LG Gold	1	1,0 kW	0,95 kW	1.560 h/y
1	Rooms	Consul CCF07DBANA	30	0,8 kW	22,62 kW	1.560 h/y
3	Administration	Springer 42RWCA022515LS	1	2,1 kW	2,14 kW	2.080 h/y
3	Management	Midea CLP-48CR V2	1	4,9 kW	4,85 kW	2.080 h/y
3	Management	Springer Duo	1	1,0 kW	0,97 kW	2.080 h/y
4	Auditorium	Springer 38XCC036651MS	1	3,6 kW	3,62 kW	52 h/y
4	Auditorium	Springer Minimax	1	1,2 kW	1,17 kW	104 h/y
10	Cafeteria	Midea 42MPCA60M5	1	6,1 kW	6,13 kW	1.820 h/y
11	Physiotherapy	Springer Mundial	1	2,2 kW	2,18 kW	1.560 h/y
	Academy	AirMaster Consul	1	2,1 kW	2,05 kW	1.560 h/y
	Academy	Springer Duo	2	1,0 kW	1,94 kW	1.560 h/y
	Estoque	Springer Mundial	1	1,0 kW	0,95 kW	1.560 h/y
	Lan Hause	Springer Mundial	1	1,0 kW	0,95 kW	52 h/y
		Total	**43**		**50,51 kW**	

Figure 18: Installed Ceiling Split Unit

Figure 19: Installed Air Conditioning Unit

Figure 20: Condensing Units

4.3 Water Heating Systems

The hot water for the field dressing rooms is supplied by 10 electrical heaters.

Table 10: Heater Inventory

Area	Equipment	Quant.	Nominal Power Demand per Unit	Total Nominal Power Demand	Operating Hours
Field dressing room	Electric Heaters	10	2,50 kW	25,00 kW	156 kWh/y
Room Showers	Gas Boilers	3			71.100 kWh/y

The hot water for the dormitories showers is provided by 3 gas boilers, no nominal capacity was provided to calculate full load hours of operation.

4.4 Other Equipment

A total of 49,9 kW is installed in other equipment, such as televisions, computers, refrigerators, fans and drinking fountains.

Table 11: Electric Heater Inventory

Area		Equipment	Quant.	Nominal Power Demand per Unit	Total Nominal Power Demand
No.	**Name**	**Cooling**			
1	Internet Room/ Offices	Computers	10	0,16 kW	1,60 kW
1	Rooms	TV's	30	1,20 kW	36,00 kW
1	Rooms/ Others	Fans	30	0,14 kW	4,20 kW
15	Kitchen	Cold rooms	2	1,50 kW	3,00 kW
15	Kitchen	Kitchen Equipment	1	2,50 kW	2,50 kW
		Ice Machines	2	0,25 kW	0,50 kW
		Ice Boxes	2	0,50 kW	1,00 kW
		Drinking Water Fountains	5	0,07 kW	0,35 kW
25	Laundry Room	Washing Machines	2	3,00 kW	6,00 kW
25	Laundry Room	Dryers	2	3,00 kW	6,00 kW
Total			**86**		**61,15 kW**

Figure 21: Ice Storage

Figure 22: Installed Fans

5 Distribution of the Energy Usage

Based on the detailed inventory and analysis of the operations, the distribution of energy usage has been calculated.

The calculated energy usage is shown in categorized consumer groups with a Sankey Diagram and the summarized information is shown on Table 12 and 13.

Table 14 shows the respective equipment, its expected real power demand and its yearly energy consumption. To calculate the distribution of the energy usage, load factors and realistic operation times were used and taken as a basis. The total real power demand is 94,24 kW, with according to the peak load of 82,1 kW, the simultaneity factor is 0,87. Which means, when the highest peak occurs (82,1 kW), 87 % of the equipment is operating simultaneously.

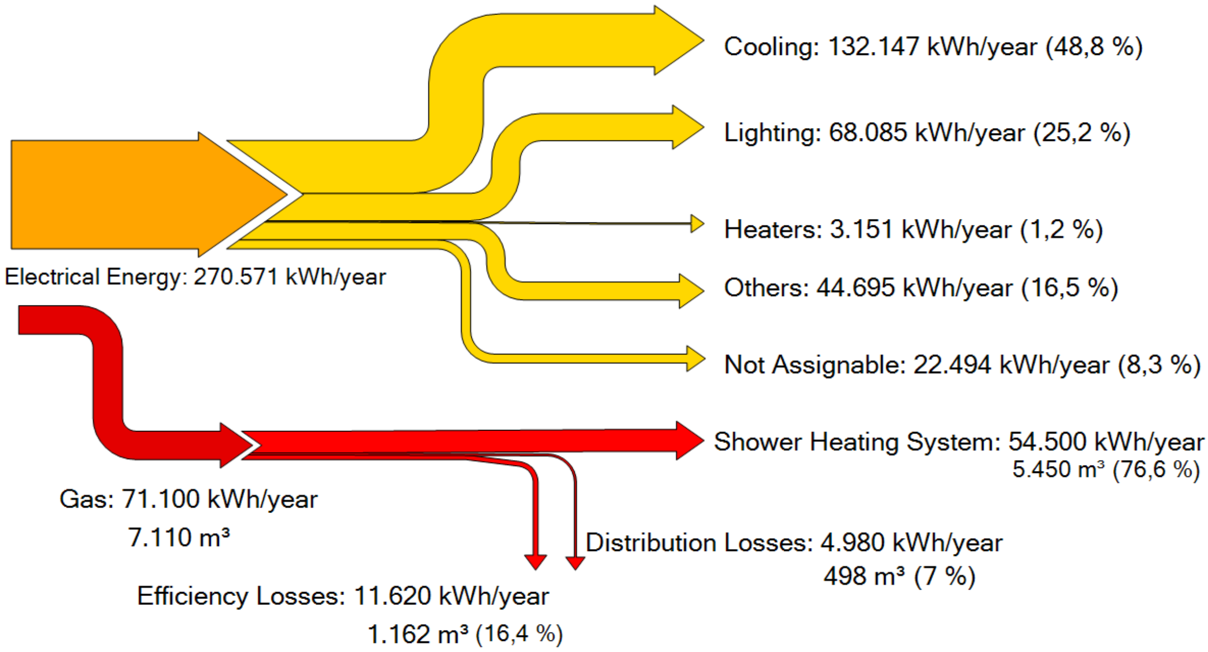


Figure 23: Energy Distribution Diagram (Sankey-Diagram)

Table 12: Distribution of Electrical Energy Consumption

Cooling	Lighting	Heaters	Others	Not Assignable
132.147 kWh/y	60.085 kWh/y	3.151 kWh/y	44.695 kWh/y	22.494 kWh/y
48,8 %	25,2 %	1,2 %	16,5 %	8,3 %

Table 13: Distribution of Gas Consumption

Shower Heating System	Efficiency Losses	Distribution Losses
54.500 kWh/y	11.620 kWh/y	4.980 kWh/y
76,6 %	16,4 %	7 %
5.450 m³	1.162 m³	498 m³

Table 14: Energy Consumption Distribution

Area		Equipment	Quant	Real Power Demand	Energy consumption
N.	**Name**	**Cooling**			
1	Room	LG Gold	1	0,81 kW	4.233 kWh/y
1	Rooms	Consul CCF07DBANA	30	19,23 kW	100.780 kWh/y
3	Administration	Springer 42RWCA022515LS	1	1,82 kW	2.648 kWh/y
3	Management	Midea CLP-48CR V2	1	4,12 kW	6.002 kWh/y
3	Management	Springer Duo	1	0,82 kW	1.200 kWh/y
4	Auditorium	Springer 38XCC036651MS	1	3,08 kW	560 kWh/y
4	Auditorium	Springer Minimax	1	0,99 kW	180 kWh/y
10	Cafeteria	Midea 42MPCA60M5	1	5,21 kW	7.584 kWh/y
11	Physiotherapy	Springer Mundial	1	1,85 kW	2.698 kWh/y
	Academy	AirMaster Consul	1	1,74 kW	2.537 kWh/y
	Academy	Springer Duo	2	1,65 kW	2.401 kWh/y
	Estoque	Springer Mundial	1	0,81 kW	1.176 kWh/y
	Lan Hause	Springer Mundial	1	0,81 kW	147 kWh/y
		Lighting			
1	30 Rooms	CFL	30	0,75 kW	1.092 kWh/y
1	30 Rooms	T12	60	2,61 kW	3.800 kWh/y
1	30 Rooms	T8	60	0,96 kW	1.398 kWh/y
2	Corridor, stairway	CFL	41	1,03 kW	448 kWh/y
2	Balconies, monitors	T12	2	0,05 kW	205 kWh/y
3	Management/ Phisiology	Electronic	16	0,40 kW	1.165 kWh/y
4	Auditorium	Electronic	5	0,13 kW	65 kWh/y
4	Auditorium	Incandescent	4	0,24 kW	125 kWh/y
5	Medical Department			0,00 kW	0 kWh/y
6	Men's Bathroom	T12	4	0,09 kW	274 kWh/y
7	Women's Bathroom	T12	4	0,09 kW	274 kWh/y
8	Psychologist/ Social Assistent	T12	4	0,17 kW	380 kWh/y
8	Psychologist/ Social Assistent	T12	4	0,09 kW	205 kWh/y
9	Weight training	T12	16	0,70 kW	1.267 kWh/y
10	Cafeteria	T12	16	0,70 kW	1.773 kWh/y
11	Phisiotherapy	T12	16	0,70 kW	2.027 kWh/y
12	Closet	T12	6	0,14 kW	411 kWh/y
13	Women's Bathroom (Employees)	T12	6	0,14 kW	411 kWh/y
14	Men's Bathroom (Employees)	T12	6	0,14 kW	411 kWh/y
15	Kitchen + Kitchen office	T12	10	0,24 kW	1.540 kWh/y
15	Kitchen + Kitchen office	Electronic	7	0,18 kW	1.147 kWh/y

Area		Equipment	Quant	Real Power Demand	Energy consumption
16	Cooling room	Incandescent	2	0,12 kW	87 kWh/y
17	Nutrition	Fluorescent	2	0,12 kW	262 kWh/y
18	Warehouse	Electronic	2	0,08 kW	58 kWh/y
19	Technical Evaluation	T12	6	0,14 kW	411 kWh/y
19	Technical Evaluation	T12	4	0,17 kW	507 kWh/y
20	Supervision + Management	T12	6	0,14 kW	513 kWh/y
20	Supervision + Management	T12	6	0,26 kW	950 kWh/y
21	Attic	Electronic	4	0,10 kW	36 kWh/y
22	Poles	Mixed	30	8,70 kW	38.002 kWh/y
23	Maintenance Deposit	Electronic	2	0,05 kW	18 kWh/y
24	Ordinance room + commissions	Electronic	10	0,25 kW	1.092 kWh/y
25	Laundry Room	Electronic	5	0,23 kW	819 kWh/y
25	Laundry Room	Electronic	1	0,03 kW	91 kWh/y
26	Masseuse Room	Mixed	2	0,50 kW	2.184 kWh/y
27	Kids dressing room	T12	28	1,22 kW	3.547 kWh/y
28	Reflectors	Mixed	3	1,50 kW	1.092 kWh/y
		Heaters			
	Field dressing room	Electric Heaters	10	22,50 kW	3.151 kWh/y
		Others			
	Internet Room/ Offices	Computers	10	1,28 kW	1.597 kWh/y
1	Rooms	TV's	30	28,80 kW	15.725 kWh/y
1	Rooms/ Others	Fans	30	3,78 kW	1.376 kWh/y
15	Kitchen	Cold rooms	2	2,40 kW	10.483 kWh/y
15	Kitchen	Kitchen Equipment	1	1,88 kW	683 kWh/y
15	Kitchen	Ice Machines	2	0,40 kW	1.747 kWh/y
15	Kitchen	Ice Boxes	2	0,80 kW	3.494 kWh/y
	Other	Drinking Water Fountains	5	0,26 kW	229 kWh/y
25	Laundry Room	Washing Machines	2	4,50 kW	4.680 kWh/y
25	Laundry Room	Dryers	2	4,50 kW	4.680 kWh/y
		Total of Energy Consumption			**248.077 kWh/y**
		Rest, not assignable			**22.494 kWh/y**
		Total Loads and Energy Consumption		**94,24 kW**	**270.571 kWh/y**
		Calculated Simultaneity Factor		**0,871**	

In the following the energy saving measures addressing the different equipment are presented.

6 Energy Saving Measures

Based on the energy analysis several energy saving measures were identified and documented.

Summarizing it can be said, that in total 10 electrical energy measures could collectively reduce the yearly electrical energy consumption of the Fluminense site in Xerém by 35,3 %.

With the implementation of the energy saving measures it is estimated that 8.115 kg per year of CO_2 will be reduced.

The prices valid on December 2012 where used for the economic analysis (0,2584 R$/kWh and 25,33 R$/kW and month in low tariff times, 0,5 R$/kWh and 69,87 R$/kW per month in high tariff times). For the gas an average price of 1,41 R$ per m³ or 0,141 R$ per kWh was considered.

The cost savings are estimated to be 83.219 R$ per year considering the implementation of the energy saving measures alone. A corresponding investment of 242.200 R$ would be needed with a payback time of 2,9 years.

Furthermore, in combination with the implementation of the PV System an equivalent to 91,7 % of the electrical energy would be saved. The PV system would reduce 12.536 kg of CO_2 per year.

Additionally, the implementation of solar collectors would save the gas consumption by 93 % and reduce CO_2 emissions by 28.036 kg per year.

With the implementation of all 12 measures the cost savings of 132.040 R$ per year can be achieved, corresponding to 79,4 % of the current energy costs. A total investment of 1.313.560 R$/year would be needed, with an average payback time of 9,9 years.

The following measures were identified:

1. Replace Fluorescent Lamps by LEDs
2. Replace Outside Mercury Vapor Lamps by LEDs
3. Motion Sensor for Light Control in Dressing Rooms and Restrooms
4. Increase Set Point of Room Temperatures
5. "Energetic Maintenance" of Cooling Units
6. Solar Thermal System for Hot Water Supply for the Showers
7. Base Load Reduction
8. Peak Load Reduction by Management System

9. Install PV-System
10. Merge the different distribution systems into one
11. Energy Controlling
12. Training for Employees

These measures are arranged in groups and are documented in the following by explaining the actual situation, describing the proposed measure and showing the calculation of the energy and cost savings.

6.1 Proposed Measures for Lighting Systems

6.1.1 Replace Fluorescent Lamps by LEDs

Current Situation:

Most luminaries installed on site (in total 174 luminaries) are equipped with fluorescent lamps. The average light output over the life time of these lamps is 60 lm/W with at least 15 % lumen depreciation over life time. The observed operation times are around 3.000 hours per year with some variations.

Table 15: Base Line Energy Consumption of Fluorescent Lamps

Energy consumption of the actual situation	
Power demand HT	7,8 kW
Power demand LT	7,8 kW
Energy consumption LT	15.123 kWh/year
Energy consumption HT	3.781 kWh/year
Total energy consumption	18.904 kWh/year

Figure 24: Installed T12 Lamps

Proposed measure:

It is recommended to replace the florescent lamps by LEDs

Figure 25: LED Solution

Energy, CO_2 and cost savings:

The expected energy savings are 9.210 kWh per year with a load reduction of 3,797 kW, corresponding to 7.162 R$ saved per year. The estimated investment is 67.200 R$ and has a payback time of 9,4 years. The installation of the LEDs will result also in less maintenance effort, and less replacement costs, as the T12 needs to be replaced approximately every 2 years and the LED every 5 years. The detailed savings calculation and summary of savings is shown on the following tables.

Table 16: Energy Savings LED Solution Calculation

Area		No. of Fixture	No. of Lamps per Fixture	Actual Energy Consumption	Energy Consumption LED-Solution
1	Rooms	30	2	3.800 kWh/y	1.949 kWh/y
2	Balconies, monitors	2	1	205 kWh/y	105 kWh/y
6	Men's Bathroom	4	1	274 kWh/y	140 kWh/y
7	Women's Bathroom	4	1	274 kWh/y	140 kWh/y
8	Psychologist/ Social Assistent	4	1	380 kWh/y	195 kWh/y
8	Psychologist/ Social Assistent	4	1	205 kWh/y	105 kWh/y
9	Weight training	16	1	1.267 kWh/y	650 kWh/y
10	Cafeteria	16	1	1.773 kWh/y	909 kWh/y
11	Phisiotherapy	16	1	2.027 kWh/y	1.039 kWh/y
12	Closet	6	1	411 kWh/y	211 kWh/y
13	Women's Bathroom (Employees)	6	1	411 kWh/y	211 kWh/y
14	Men's Bathroom (Employees)	6	1	411 kWh/y	211 kWh/y
15	Kitchen + Kitchen office	10	1	1.540 kWh/y	790 kWh/y
19	Technical Evaluation	6	1	411 kWh/y	211 kWh/y
19	Technical Evaluation	4	1	507 kWh/y	260 kWh/y
20	Supervision + Management	6	1	513 kWh/y	263 kWh/y
20	Supervision + Management	6	1	950 kWh/y	487 kWh/y
27	Kids dressing room	28	1	3.547 kWh/y	1.819 kWh/y
Total		**174 luminaires**		**18.904 kWh/y**	**9.694 kWh/y**

Table 17: Replace Fluorescent Lamps by LED - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	3,797 kW
Reduction power demand in LT-times	3,797 kW
Reduction in energy consumption HT	1.842 kWh/year
Reduction in energy consumption LT	7.368 kWh/year
Total energy consumption savings	**9.210 kWh/year**
Cost savings	
Reduction cost for power demand HT	3.184 R$/year
Reduction cost for power demand LT	1.154 R$/year
Reduction cost for energy consumption HT	921 R$/year
Reduction cost for energy consumption LT	1.904 R$/year
Total Cost Savings	**7.162 R$/year**
CO_2 Savings	**755 kg/year**
Estimated Investment	**R$ 67.200**
Payback time	**9,4 years**

6.1.2 Replace Outside Mercury Vapor Lamps by LEDs

Current situation:

A total of 32 mercury lamps of 250 W are installed, taking into consideration a ballast of 40 W per lamp a total of 9,28 kW are installed. Of these lamps 30 are used for outside lighting and 2 for the massage room. The average light output of the mercury vapor lamps over life time is around 55 lm/W.

Table 18: Base Line Energy Consumption of Outside Lighting Systems (Mercury Vapour Lamps)

Energy consumption of the actual situation	
Power demand HT	9,28 kW
Power demand LT	9,28 kW
Energy consumption LT	32.428 kWh/year
Energy consumption HT	8.107 kWh/year
Total energy consumption	40.536 kWh/year

Figure 26: Installed Mercury Vapour Lamps

Figure 27: Installed Mercury Vapour Lamps

Proposed measure:

It is recommended to replace the mercury vapor lamps by LED.

Figure 28: LED Solution for Outdoors

Energy, CO_2 and cost savings:

The estimated energy savings are 20.268 kWh per year with a power reduction of 4,64 kW. The corresponding costs savings are 11.662 R$ per year. The estimated investment for this measure is 48.000 R$ which is expected to payback in 4,2 years.

Table 19: Energy Savings LED Solution Calculation

Area Number		No. of Fixture	Actual Energy Consumption	Energy Consumption LED-Solution
22	Poles	30 luminaires	38.002 kWh/year	19.001 kWh/year
26	Masseuse Room	2 luminaires	2.534 kWh/year	1.267 kWh/year
Total		**32 luminaires**	**40.536 kWh/year**	**20.268 kWh/year**

Table 20: Replace Outside Mercury Vapor Lamps by LEDs - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	4,64 kW
Reduction power demand in LT-times	4,64 kW
Reduction in energy consumption HT	4.054 kWh/year
Reduction in energy consumption LT	16.214 kWh/year
Total energy consumption savings	**20.268 kWh/year**
Cost savings	
Reduction cost for power demand HT	3.890 R$/year
Reduction cost for power demand LT	1.411 R$/year
Reduction cost for energy consumption HT	2.027 R$/year
Reduction cost for energy consumption LT	4.189 R$/year
Total Cost Savings	**11.662 R$/year**
CO_2 Savings	**1.662 kg/year**
Estimated Investment	**R$ 48.000**
Payback time	**4,2 years**

6.1.3 Install Motion Sensor for Light Control in Dressing Rooms and Restrooms

Current situation:

The dressing rooms and the restrooms are always illuminated, even when nobody is using them. In total 48 fixtures are installed. The lamps are operated for at least 2.912 hours per year. We assume that the installation of motion sensors for light control will take place after the T12 lamps have been replaced by LEDs. Therefore, the baseline energy consumption is estimated based on the LEDs.

Table 21: Base Line Energy Consumption of Lighting in Dressing Rooms and Rest Rooms

Energy consumption of the actual situation	
Energy consumption LT	2.536 kWh/year
Energy consumption HT	634 kWh/year
Total energy consumption	3.170 kWh/year

Proposed measure:

It is recommended to install a motion sensor to control the lighting system in the dressing rooms and the restrooms. In total 6 motion sensors are needed, one for each room.

Figure 29: Motion Sensor

Energy, CO_2 and cost savings:

It is expected that the operation time of the lighting system can be reduced at least by 40%. The total energy savings are estimated to be 1.268 kWh per year with a corresponding cost saving of 389 R$. The investment to implement this measure would be 2.000 R$, with a payback time of 5,1 years. The savings calculation is shown on the following table.

Table 22: Install Motion Sensor for Light Control in Dressing Rooms and Restrooms - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,5 R$/kWh
Savings	
Reduction in energy consumption HT	254 kWh/year
Reduction in energy consumption LT	1.015 kWh/year
Total energy consumption savings	**1.268 kWh/year**
Cost savings	
Reduction cost for energy consumption HT	127 R$/year
Reduction cost for energy consumption LT	262 R$/year
Total Cost Savings	**389 R$/year**
CO_2 Savings	**104 kg/year**
Estimated Investment	**R$ 2.000**
Payback time	**5,1 years**

6.2 Proposed Measures for Cooling System

6.2.1 Increase Set Point of Room Temperature

Current situation:

The real operative room temperatures of the site are varying between 20°C to 22°C. The energy consumption of the cooling units is 132.147 kWh/year. Their power demand is around 42,94 kW.

Table 23: Base Line Energy Consumption of Air Conditioning Units

Energy consumption of the actual situation	
Power demand HT	42,94 kW
Power demand LT	42,94 kW
Energy consumption LT	105.718 kWh/year
Energy consumption HT	26.429 kWh/year
Total energy consumption	132.147 kWh/year

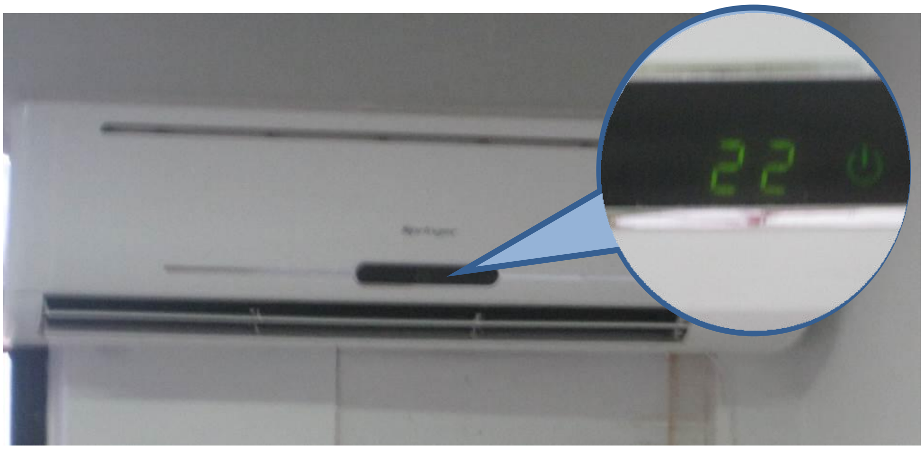


Figure 30: Set Point

Proposed measure:

It is recommended, to increase the operative room temperature of the various locations on the site about 2 K, from 22°C to 24°C.

Energy, CO_2 and cost savings:

An increase of the operative room temperature about 2 K will accordingly increase the evaporation temperature of the cooling units. Each Kelvin of increased evaporation temperature will save around 3% of electricity. Hence, a 2 K higher evaporation temperature of the cooling units will save 6% of their electrical energy. The total energy savings are expected to be 7.929 kWh per year and the load reduction would be 2,576 kW. The corresponding cost savings are 5.375 R$ per year. The implementation of this measure does not require investment. Therefore the payback time is instant.

The savings calculation is shown on the table below.

Table 24: Increase Set Point of Room Temperature - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,5 R$/kWh
Savings	
Reduction power demand in HT-times	2,576 kW
Reduction power demand in LT-times	2,576 kW
Reduction in energy consumption HT	1.586 kWh/year
Reduction in energy consumption LT	6.343 kWh/year
Total energy consumption savings	**7.929 kWh/year**
Cost savings	
Reduction cost for power demand HT	2.160 R$/year
Reduction cost for power demand LT	783 R$/year
Reduction cost for energy consumption HT	793 R$/year
Reduction cost for energy consumption LT	1.639 R$/year
Total Cost Savings	**5.375 R$/year**
CO_2 Savings	**650 kg/year**
Estimated Investment	**R$ 0**
Payback time	**Instant**

6.2.2 *Energetic Maintenance of Cooling Units*

Current situation:

In total, 43 cooling systems are installed on site. There are different installation dates among the 43 systems. Some of them are quite new, but the majority of the cooling units are relatively old. It is assumed that many of the installed cooling units (split units or window systems) are working with a reduced COP and increased energy consumption.

Even with implemented maintenance procedures, various reasons can cause that. Maintenance is done in most cases under the aspect of operational availability only and not for energy management reasons. Even if the cooling units are providing the expected cooling, the following reasons can lower their efficiency:

- lack of refrigerant
- dirty condensers
- dirty evaporators
- bad locations of the condenser units
- longer scheduled operation times than necessary
- mechanical or electrical damages

Of the installed 43 cooling systems 3 are operated in very short time periods only (Auditorium, Lan Hause) and are thus not very relevant for energy management measures. The remaining systems consume approximately 123.331 kWh/year, which is about 49 % of the total energy consumption of the site. The COP is estimated to be around 2,3, which is low.

Table 25: Base Line Energy Consumption of Air Conditioning Units

Energy consumption of the actual situation	
Power demand HT	40,36 kW
Power demand LT	40,36 kW
Energy consumption LT	98.665 kWh/year
Energy consumption HT	24.666 kWh/year
Total energy consumption	123.331 kWh/year

Figure 31: Major Deformities in Heat Exchanger Ribs

Figure 32: Major Deformities in Heat Exchanger Ribs

Figure 33: Old Damaged Units

Proposed measure:

It is recommended, to maintain all the cooling units under the aspect of energy management, which addresses the proper mechanical and electrical functioning of the systems but also the proper use of the systems. The "Energetic Maintenance" includes:

- keeping the refrigerant at proper levels
- cleaning the condensers and evaporators
- checking the locations of the condenser units and, if necessary, they should be moved to where they can receive better air flow and shade
- adapting the operation schedules to the real needs
- repairing the mechanical or electrical damages (for example the severely damaged condensers).

In some cases, the replacement of cooling units could make sense for economic reasons.

Energy, CO_2 and cost savings:

It is expected, that the "Energetic Maintenance" will increase the overall efficiency of the cooling units significantly. For calculating the energy savings, it is assumed, that an average COP of 3,5 can be reached for all the cooling units. The estimated achievable energy saving are 42.285 kWh per year and 13,839 kW of load reduction, which translates in a total cost saving of 28.779 R$ per year. The corresponding investment to implement this measure would be around 80.000 R$ with a payback time of 2,8 years.

The savings calculation is shown on the following table.

Table 26: “Energetic Maintenance” of Cooling Units - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	13,839 kW
Reduction power demand in LT-times	13,839 kW
Reduction in energy consumption HT	8.457 kWh/year
Reduction in energy consumption LT	33.827,9 kWh/year
Total energy consumption savings	**42.285 kWh/year**
Cost savings	
Reduction cost for power demand HT	11.603 R$/year
Reduction cost for power demand LT	4.207 R$/year
Reduction cost for energy consumption HT	8.740 R$/year
Reduction cost for energy consumption LT	4.228 R$/year
Total Cost Savings	**28.779 R$/year**
CO_2 Savings	**3.467 kg/year**
Estimated Investment	**R$ 80.000**
Payback time	**2,8 years**

6.3 Proposed Measures for Water Heating System

6.3.1 Solar Thermal System for Hot Water Supply for the Showers

Current situation:

The field locker room is equipped with 10 electrical heaters for hot water supply for the showers. This is used only about once or twice per week.

The hot water supply for the 30 dormitories showers is supplied by 3 gas boilers.

The hot water demand of the showers supplied by the gas heaters, has estimated energy thermal energy demand of 54.600 kWh, due to the efficiency of the boilers this translates to 71.100 kWh provided by gas (7.110 m³). It is assumed that the water for the showers is heated to 40 °C. With a water supply at 22,1 °C the energy necessary to heat one kg of water to 40 °C is 20,79 W.

Table 27: Base Line Energy Consumption of Shower Water Heating System

Q.	Location	Number of showers per day	kg per day	Thermal Energy required per day	Thermal Energy required per year	Electrical energy required per year (eff=0,77)
3	Dormitories	120	7.200 kg/day	150 kWh/day	54.600 kWh/y	71.100 kWh/y

Proposed measure:

It is recommended to install solar collector to provide the hot water. There are three types of solar collectors, unglazed, glazed, and vacuum tubes. The unglazed solar collectors are good for uses requiring low heating temperatures, single glazed solar collectors have a selective coating, which allows them to reach higher temperatures as the unglazed systems, and the vacuum tubes have very low heat losses which allows them to reach temperatures between 60 °C and 80°C at a good efficiency and to operate in cold climates. For the case of the Fluminense, which is located in hot climate and which needs the collectors for the shower warm water supply, the glazed solar collectors are recommended.

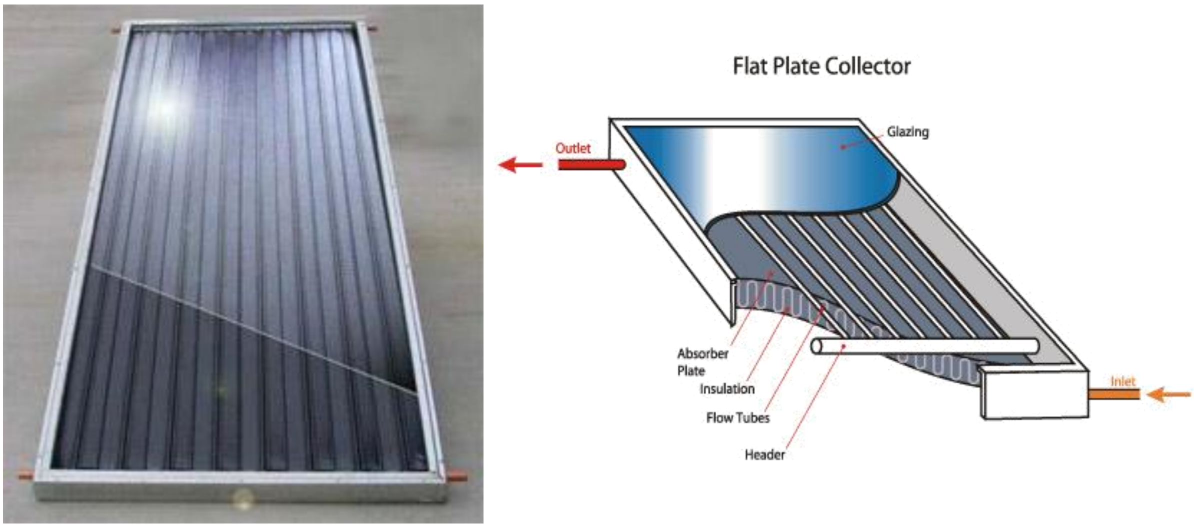


Figure 34: Glazed Solar Collector

For the sizing of the solar thermal system, a sensitivity analysis was done with the clean energy project analysis software RETScreen 4.

As it can be seen on Figure 35 that the optimum size of the solar thermal system is 96 m² with storage capacity of 100 l/m², which will provide 93 % of the heating demand. Lower solar collector area and storage capacity will have lower heating production, and greater solar collector area or storage do not result in significant increments of heat production. As shown in Table 37 when the solar collector area is 96 m², upgrading the storage temperature from 100 l/m² to 150 l/m² will result only in 2 % higher solar fraction. Comparably, increasing the area to 120 m² will increment the solar fraction by 5%.

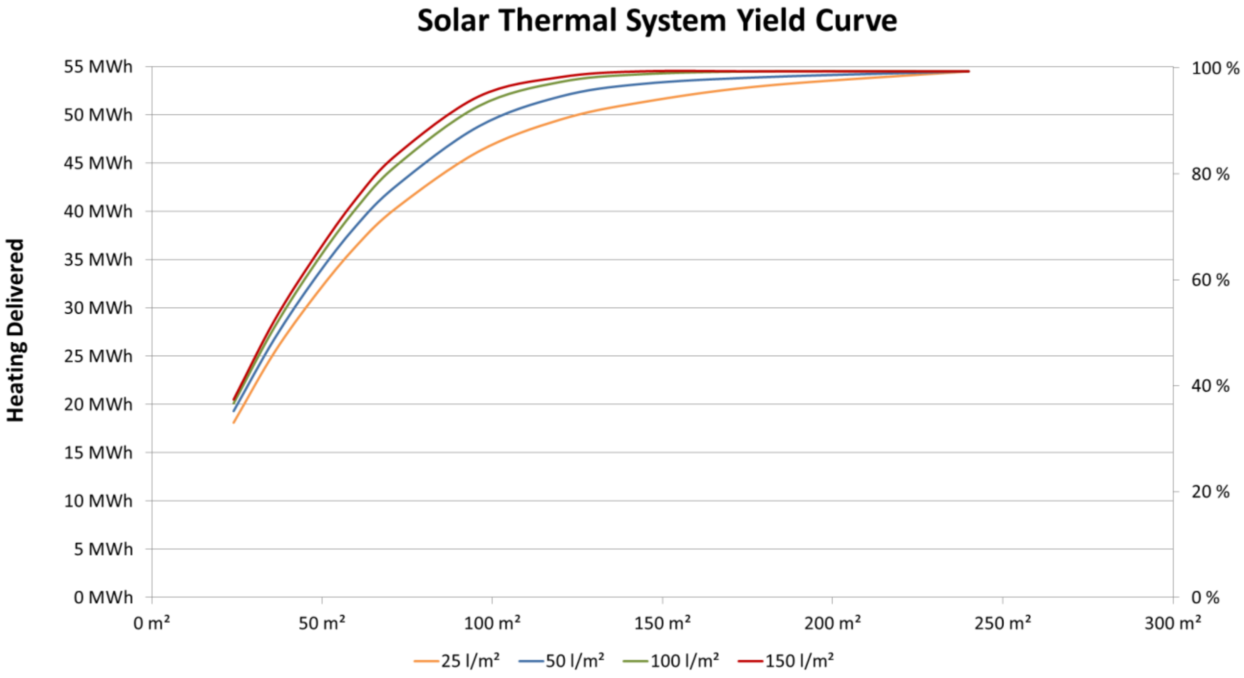


Figure 35: Solar Thermal System Yield Curve

Table 28: Solar Collector Yield Sensitivity Analisis

	Storage	25 l/m²		50 l/m²		100 l/m²		150 l/m²	
N Collectors	**Collector Area**	**Solar Fraction**	**Total Energy**	**Solar Fraction**	**Total Energy**	**Solar Fraction**	**Total Energy**	**Solar Fraction**	**Total Energy**
10	**24 m²**	33%	18,1 MWh	35%	19,3 MWh	37%	20,1 MWh	38%	20,5 MWh
15	**36 m²**	46%	25,4 MWh	49%	26,8 MWh	51%	28,0 MWh	53%	28,7 MWh
20	**48 m²**	57%	31,4 MWh	61%	33,2 MWh	64%	34,7 MWh	65%	35,5 MWh
25	**60 m²**	67%	36,4 MWh	70%	38,5 MWh	74%	40,3 MWh	76%	41,3 MWh
30	**72 m²**	74%	40,4 MWh	78%	42,7 MWh	82%	44,8 MWh	84%	45,9 MWh
40	**96 m²**	85%	46,2 MWh	89%	48,8 MWh	**93%**	**50,9 MWh**	95%	51,9 MWh
50	**120 m²**	91%	49,5 MWh	95%	51,9 MWh	98%	53,4 MWh	99%	53,9 MWh
60	**144 m²**	94%	51,3 MWh	97%	53,2 MWh	99%	54,2 MWh	100%	54,5 MWh
75	**180 m²**	97%	53,0 MWh	99%	53,9 MWh	100%	54,5 MWh	100%	54,5 MWh
100	**240 m²**	100%	54,5 MWh	100%	54,5 MWh	100%	54,5 MWh	100%	54,5 MWh
110	**265 m²**	100%	54,5 MWh	100%	54,5 MWh	100%	54,5 MWh	100%	54,5 MWh

Energy, CO_2 and cost savings:

It is expected that the solar collectors cover 93% of the demand of hot water. Therefore, the heating delivered with the solar thermal system is 50.685 kWh per year, with a gas heater efficiency of 76,653 % this would be equivalent to 66.123 kWh saved per year, corresponding to 6.612,3 m³ per year. To calculate the corresponding cost savings the average price of gas supply in Fluminense Xerém was used, 0,141 R$/kWh, resulting in 9.323 R$ per year. The implementation of this measure requires an estimated investment of 43.200 R$ which would have a corresponding payback time of 4,6 years.

Table 29: Solar Thermal System for Hot Water Supply for the Showers - Energy Savings, Costs Savings and CO_2 Savings

Gas Cost	
Estimated Gas Price	1,41 R$/m³
Estimated Energy Equivalent Price	0,141 R$/kWh
Savings	
Solar Heat Production	50.685 kWh/year
Reduction of Gas Consumption	**66.123 kWh/year**
Reduction of Gas Consumption	**6.612,3 m³/year**
Cost savings	
Total Cost Savings	**9.323 R$/year**
CO_2 Savings	**28.036 kg/year**
Estimated Investment	**R$ 43.200**
Payback time	**4,6 years**

6.4 Proposed Measures for Energy Supply System

6.4.1 Base Load Reduction

Current situation:

The base load currently is in the range of 20 kW to 25 kW, as seen on section 3.2 Characteristic Power Demand. It is considered that a lot of equipment specially lights and air conditioning units operate during night time or in unoccupied spaces like the dormitories during the day without being needed.

Table 30: Base Load

Energy consumption of the actual situation	
Power demand LT	25 kW

Proposed measure:

The proper equipment usage can reduce the base load about 3 kW, for example switching off the air conditioning of the rooms during daytime when no one is there, or when the weather conditions allow it. The recommended maintenance of equipment will also contribute to the base load reduction.

Energy, CO_2 and cost savings:

It is expected that the load is reduced by 3 kW for 6.000 hrs per year.

The total energy savings are expected to be 18.000 kWh per year. The corresponding cost savings are 8.948 R$ per year. This measure would require no investment; therefore the payback would be instant.

Table 31: Base Load Reduction - Energy Savings, Costs Savings and CO2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	3 kW
Reduction power demand in LT-times	3 kW
Reduction in energy consumption HT	3.600 kWh/year
Reduction in energy consumption LT	14.400 kWh/year
Total energy consumption savings	**18.000 kWh/year**
Cost savings	
Reduction cost for power demand HT	2.515 R$/year
Reduction cost for power demand LT	912 R$/year
Reduction cost for energy consumption HT	1.800 R$/year
Reduction cost for energy consumption LT	3.720 R$/year
Total Cost Savings	**8.948 R$/year**
CO_2 Savings	**1.476 kg/year**
Estimated Investment	**R$ 0**
Payback time	**0 years**

6.4.2 Peak Load Reduction by Management System

Current situation:

The peak load currently is in the range of 60 kW to 80 kW, according to the data registered in the invoices of February 2012 to December 2012. The peak load occurs always at noon. This could be explained by a higher cooling load and also preparation of meals. The daily analysis shows, that the highest peak loads are appearing only on Tuesdays. The weekday with lower peak load is Wednesday with 45 kW, which still exceeds the contracted power of 40 kW. The variance of the peak loads of each weekday is relatively narrow. It seems obvious, that the load curve of the site is mainly determined by the scheduled training courses and sports activities.

It has to be considered, that after the realization of the previously recommended measures, the peak loads will be reduced by approximately 22,5 kW x 0,87 (simultaneity factor) = 19,57 kW.

It is expected, that after the realization of the efficiency measures the real peaks in the load curves could be less than 60 kW.

Table 32: Peak Load after Recommended Measures have been implemented

Energy consumption of the actual situation	
Power demand	62,4 kW

Proposed Measure:

It is recommended to install a peak load management system for the reducing the peak loads of about 15 kW. Electrical consumers like cooling unit can then be switched off temporarily in a controlled way, when a peak load situation is to loom. Also, some of the loads can be shifted to the low tariff period, starting after 21:00 pm.

Energy, CO_2 and cost savings:

It is expected to reduce the peak load by 15 kW, corresponding to yearly cost savings of 13.715 R$/year. The investment needed for the peak load management system would be around 30.000 R$ with a payback time of 2,2 years. The savings calculation is shown on Table 33.

Table 33: Peak Load Reduction by Management System - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand LT	25,33 R$/kW and month
Price per exceeding kW LT	50,86 R$/kW and month
Energy Savings	
Reduction power demand in LT-times	15 kW
Cost savings	
Reduction cost for power demand LT	4.560 R$/year
Reduction cost for exceeding power demand LT	9.155 R$/year
Total Cost Savings	**13.715 R$/year**
Estimated Investment	**R$ 30.000**
Payback time	**2,2 years**

6.5 Proposed Measures for Electrical System

6.5.1 Install PV-System

Current situation:

No PV-System installed;

Table 34: Base Line Energy Consumption

Energy consumption of the actual situation	
Final energy consumption of the site after all measures	188.719 kWh/year

Proposed measure:

Figure 36 shows the roofs taken into consideration for the design of the PV System. The total estimated roof area is 1.175 m². For the installation of the systems the statics of the roof structure must be checked.

Figure 36: Selected Roof for PV System

The simulation of the system was done with the software PV*SOL Expert 4.0 (R9). The systems were designed and simulated as two separate systems.

The capacity of system 1 is 90,72 kW_{peak} and would produce 107.088 kWh per year. System 2 has a capacity of 37,8 kW_{peak} and would produce 45.790 kWh. Summarizing the systems would be producing 152.878 kWh equivalent to 87 % of the electrical energy needed by the site operations after the previous measures have been implemented.

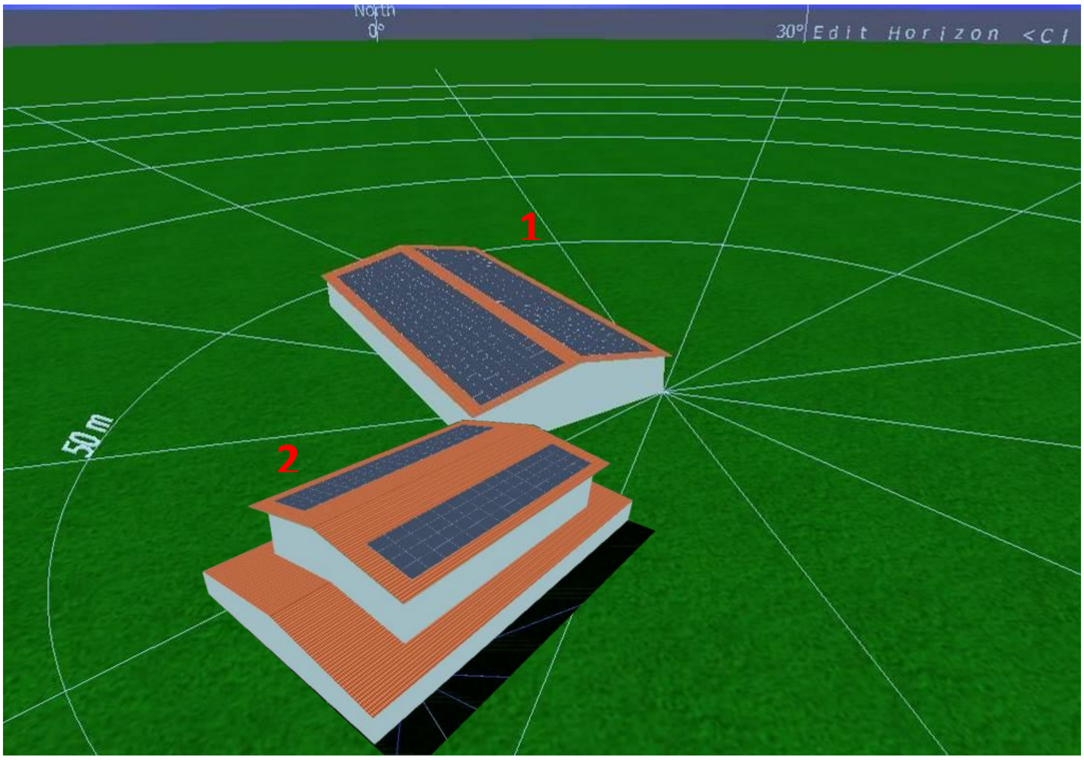


Figure 37: PV System 2

The following figures show the schematics of the systems.

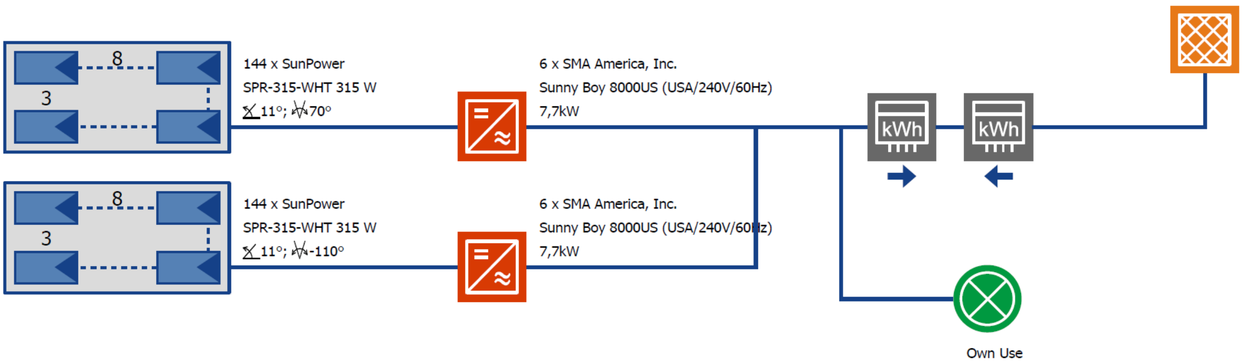


Figure 38: PV System 1 Scheme. PV*Sol Expert 4.0 (R9)

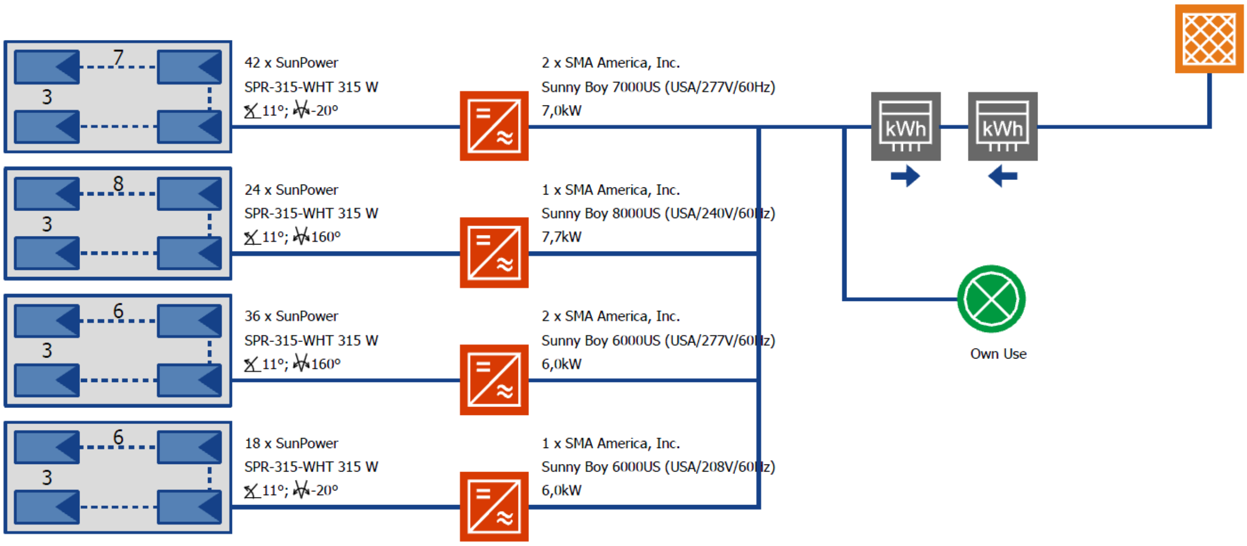


Figure 39: PV System 2 Scheme. PV*Sol Expert 4.0 (R9)

The following figures show the arrangements of the systems.

Figure 40: Arrangement, System 1

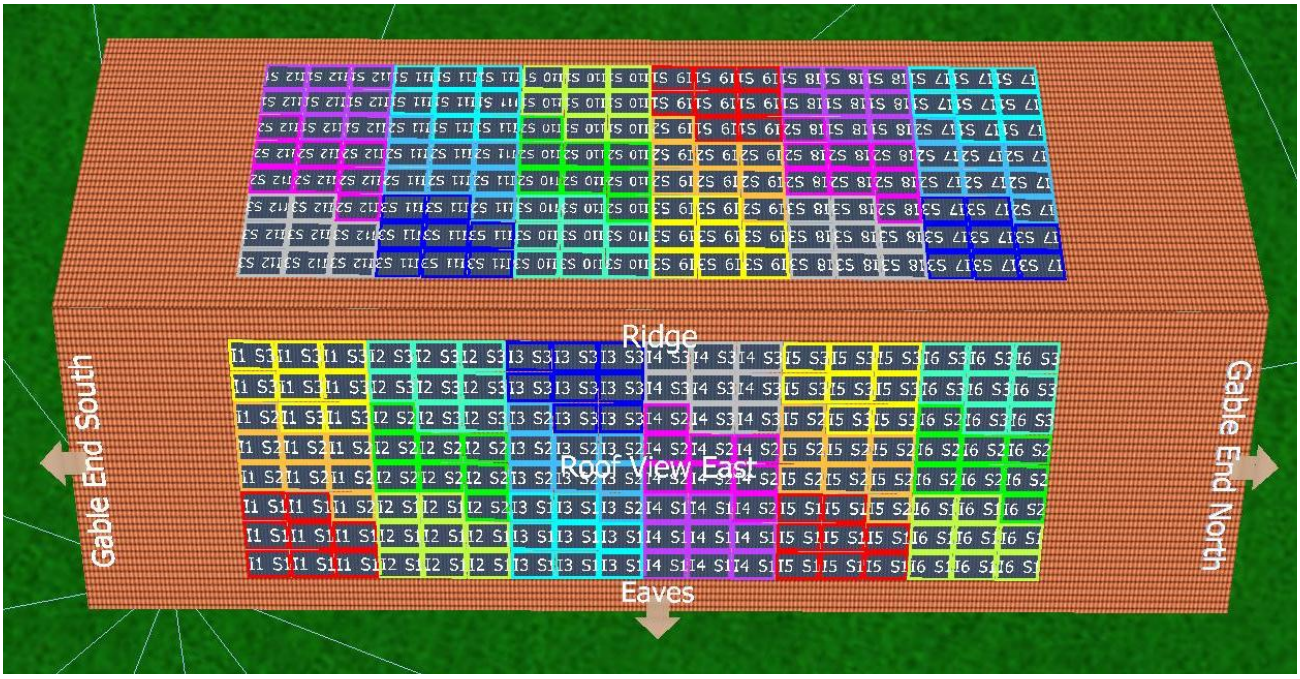


Table 35: PV System Arrangement, System 1

Block	Modules	Inverters	Arrangement per Inverter

1	144 x SunPower SPR - 315 - WHT 315 W	6 x SMA SB 4000	8 Modules x 3 Strings
2	144 x SunPower SPR - 315 - WHT 315 W	8 x SMA SB 8000	8 Modules x 3 Strings

Figure 41: Arrangement, System 2

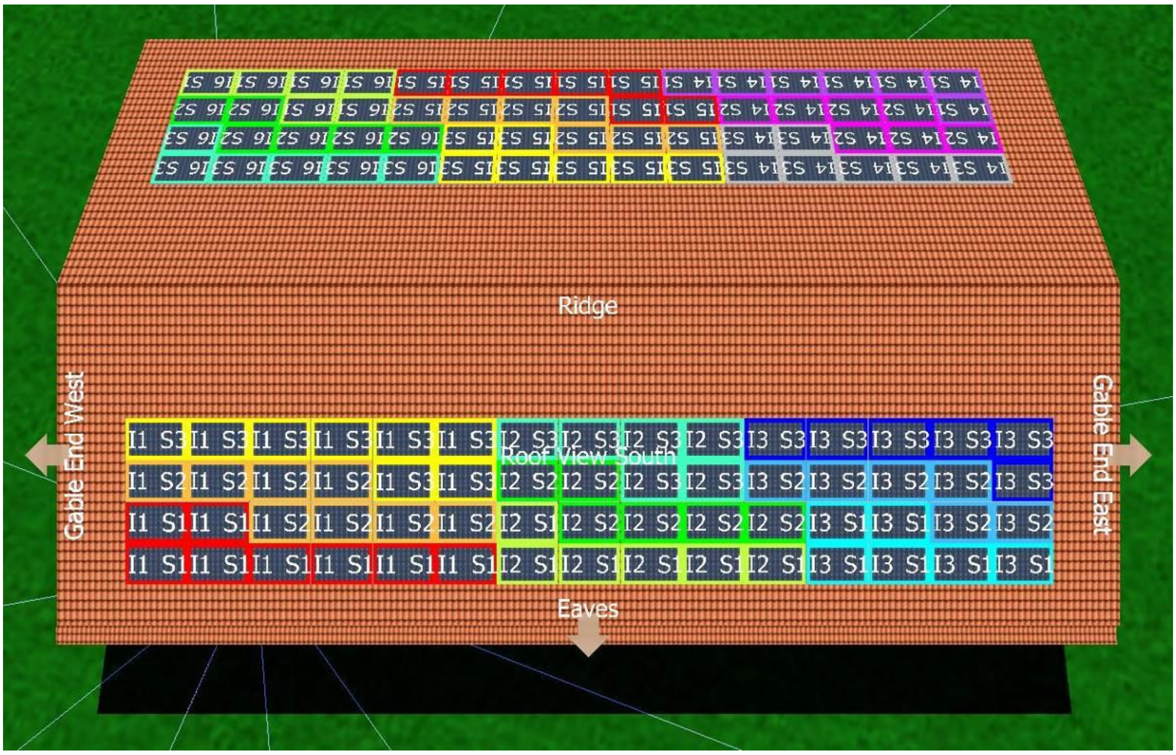


Table 36: PV System Arrangement, System 2

Block	Modules	Inverters	Arrangement per Inverter
1	42 x SunPower SPR - 315 - WHT 315 W	2 x SMA SB 7000	7 Modules x 3 Strings
	24 x SunPower SPR - 315 - WHT 315 W	1 x SMA SB 8000	8 Modules x 3 Strings
2	36 x SunPower SPR - 315 - WHT 315 W	2 x SMA SB 6000	6 Modules x 3 Strings
	18 x SunPower SPR - 315 - WHT 315 W	1 x SMA SB 6000	6 Modules x 3 Strings

Energy, CO_2 and cost savings:

According to the simulation in the Software PV*Sol Expert 4.0 (R9) the proposed system of 128,52 kW_{Peak} would generate 152.878 kWh per year.

The energy production and system performance indicators obtained from the simulation of the proposed system are summarized as follows:

Table 37: Energy Production PV System.

Energy Production	System 1	System 2
Energy Produced by PV Array (AC)	107.088 kWh	45.790 kWh
Energy to Grid	35.004,3 kWh	3.314 kWh
Consumption Requirement	175.212 kWh	175.212 kWh
Direct use of PV Energy	72.084 kWh	42.476 kWh
Yield Reduction Due to Shading	2 %	2%

Table 38: PV System Performance Indicators

System Performance Indicators	System 1	System 2
System Efficiency	15,1 %	
Performance Ratio	78,3 %	
PV Array Efficiency	16,2 %	
Inverter Efficiency	94,5 %	
Sizing Factor of Inverters	96 - 101%	
Specific Annual Yield	1.179 kWh/kWp	1,210 kWh/KWp

Table 39: Install PV-System - Energy Savings, Costs Savings and CO_2 Savings

Electricity Costs	
Price of energy LT	0,258 R$/kWh
Savings	
Energy Savings	**152.878 kWh/year**
Cost savings	
Reduction cost for energy consumption LT	39.497 R$/year
Total	**39.497 R$/year**
CO_2 savings	**12.536 kg/year**
Estimated Investment	**R$ 1.028.160**
Payback Time	**26 years**

6.5.2 *Merge the different distribution systems into one*

Current situation:

There is a different metering for the accommodation building and the training facility. The different metering also uses different tariffs. The tariff for the hotel is 0,5154 R$ per kWh for the month of December 2012, with no differentiated low and high schedule times or charge for power demand. For the training center the tariffs of December 2012 are:

Table 40: Electricity prices according to Horo Sazonal Azul A4 (Dec 2012)

Tariff	Value R$
Cost per kW per month (High Tariff)	69,8700 R$
Cost per kW per month (Low Tariff)	25,3337 R$
Cost per kW of exceeding power per month (High Tariff)	137,7897 R$
Cost per kW of exceeding power per month (Low Tariff)	50,8600 R$
Cost per kWh (High Tariff)	0,41 R$
Cost per kWh (Low Tariff)	0,26 R$
Cost reactive energy (High Tariff)	0,19 R$
Cost Reactive energy (Low Tariff)	0,24 R$

The current electrical energy consumption of the hotel is 48.855 kWh, after the measures have been implemented it is expected to be 34.051,9 kWh.

Table 41: Base Line Energy Consumption of Hotel

Energy consumption of the actual situation	
Energy consumption LT	6.810 kWh/year
Energy consumption HT	27.242 kWh/year
Total energy consumption	34.051,9 kWh/year

Proposed measure:

When there is no technical limitation the two different distribution systems should be merged into one. For this, it should be checked that the transformer and cables have enough capacity.

Energy, CO_2 and cost savings:

The following savings are calculated based on the assumption that after merging the metering, the tariffs of the training facility will be used. No increment on cost of power demand is expected, since the peak load occurs at noon, and the dormitories do not have high usage during those times.

Table 42: Merge the Different Distribution Systems into One - Energy Savings, Costs Savings and CO2 Savings

Electricity Cost	
Price of power demand HT	69,87 R$/kW and month
Price of power demand LT	25,33 R$/kW and month
Price of energy LT	0,258 R$/kWh
Price of energy HT	0,431 R$/kWh
Price of energy Hotel	0,5154 R$/kWh
Cost savings	
Reduction cost for energy consumption HT	105 R$/year
Reduction cost for energy consumption LT	7.230 R$/year
Total Cost Savings	**7.335 R$/year**
CO_2 Savings	**0 kg/year**
Estimated Investment	**R$ 15.000**
Payback time	**2,0 years**

6.6 Proposed Measures for Organization

6.6.1 Energy Controlling

Current situation:

Currently no energy controlling is done.

Proposed measure:

Implement the energy controlling and the system parameter monitoring, to guarantee proper operation and be able to identify any abnormalities. With energy controlling an hourly, monthly and yearly reading of the energy consumption and loads would be possible, therefore keeping the historic consumption and operational behavior.

6.6.2 Training for Employees

Current situation:

So far, the employees have not been trained for efficient use of energy.

Proposed measure:

The employees should be properly trained to give adequate maintenance to the systems. Especially in the case of the Air Conditioning Units it is necessary, that they are well prepared to check the functioning of the systems and the refrigerant levels.

Furthermore, an organizational strategy should be developed, since this is the key to achieve a sustained efficient performance. Organizations with energy programs, that achieve results, have senior-level support, sufficient energy program staff and management structures that empower staff to address energy efficiency issues directly.

Investing in training that promotes employee development, helps ensure the success of the energy program by building overall organizational capacity. Informed employees are more likely to contribute ideas, operate equipment properly and follow procedures.

The training can range from workshops in good practices of energy use to more formal trainings that lead to certifications.

7 Energy Measures and Savings Overview

The following table gives an overview over the recommended measures.

Measures			Savings				Economics		CO_2
No.	System	Description	Electricity	Electrical Power (HT or LT)	Gas	Cost	Investment	Payback-Time	
1	Lighting System	Relpace Fluorescent Lamps by LEDs	9.210 kWh/year	3,8 kW	0 kWh/year	**7.162 R$/year**	**67.200 R$**	**9,4 years**	**755 kg/year**
2	Lighting System	Relpace Outside Mercury Vapor Lamps by LEDs	20.268 kWh/year	4,6 kW	0 kWh/year	**11.517 R$/year**	**48.000 R$**	**4,2 years**	**1.662 kg/year**
3	Lighting System	Motion Sensor for Light Control in Dressing Rooms and	1.268 kWh/year	0,0 kW	0 kWh/year	**389 R$/year**	**2.000 R$**	**5,1 years**	**104 kg/year**
4	Cooling System	Increase Set Point of Room Temperatures	7.929 kWh/year	2,6 kW	0 kWh/year	**5.375 R$/year**	**0 R$**	**0,0 years**	**650 kg/year**
5	Cooling System	"Energetic Maintenance" of Cooling Units	42.285 kWh/year	13,8 kW	0 kWh/year	**28.779 R$/year**	**80.000 R$**	**2,8 years**	**3.467 kg/year**
6	Hot Water System	Solar Thermal System for Hot Water Supply for the Showers	0 kWh/year	0,0 kW	66.123 kWh/year	**9.323 R$/year**	**43.200 R$**	**4,6 years**	**28.036 kg/year**
7	Energy Supply	Base Load Reduction	14.400 kWh/year	3,0 kW	0 kWh/year	**8.948 R$/year**	**0 R$**	**0,0 years**	**1.476 kg/year**
8	Energy Supply	Peak Load Reduction by Management System	0 kWh/year	15,0 kW	0 kWh/year	**13.715 R$/year**	**30.000 R$**	**2,2 years**	**-**
9	Electrical System	Install PV-System	152.878 kWh/year	0,0 kW	0 kWh/year	**39.497 R$/year**	**1.028.160 R$**	**26,0 years**	**12.536 kg/year**
10	Electrical System	Merge the different distribution systems into	0 kWh/year	0,0 kW	0 kWh/year	**7.335 R$/year**	**15.000 R$**	**2,0 years**	**-**
11	Organization	Energy Controlling	0 kWh/year	0,0 kW	0 kWh/year	**0 R$/year**	**0 R$**	**0,0 years**	**-**
12	Organization	Training for Employees	0 kWh/year	0,0 kW	0 kWh/year	**0 R$/year**	**0 R$**	**0,0 years**	**-**
Total Savings (without PV System and Solar Collector)			**95.359 kWh/year**	**42,9 kW**	**0 kWh/year**	**83.219 R$/year**	**242.200 R$**	**2,9 years**	**8.115 kg/year**
Baseline			**270.571 kWh/year**	**-**	**71.100 kWh/year**	**166.394 R$/year**	-	-	**52.333 kg/year**
Savings percentage (withot PV System and Solar Collector)			**35,2%**	**-**	**0,0%**	**50,0%**	-	-	**16%**
Total Savings(with PV System and Solar Collector)			**248.237 kWh/year**		**66.123 kWh/year**	**132.040 R$/year**	**1.313.560 R$**	**9,9 years**	**48.687 kg/year**
Savings percentage (with PV System and Solar Collector)			**91,7%**	**-**	**93,0%**	**79,4%**	-	-	**93%**

8 Recommendations

It is recommended that detailed planning to implement the proposed measures should be conducted. The results in energy and costs savings need to be carefully documented and monitored so that it can be clearly shown if the goals are being achieved.

The strategy of implementation should follow the easy to implement measures to the more complex and expensive measures.

It is also recommended, that the PV-System is installed once the energy savings are achieved. Other roof spaces can be evaluated to install several other PV Systems. According to the simulation, considering the weather conditions, shading, and proposed arrangement 1.179 kWh to 1.209 kWh per year per installed kW_{peak} can be expected.

For the merging of the two different supply systems, proper negation is required, to verify under which tariff the consumption from the hotel would be charged. When the peak load continues to be higher than the contracted power the costs of contracting more power versus the costs of the amount that exceeds the contracted power should be analyzed, since this is causing considerably high costs in the current situation.

To sustain the adequate and efficient energy use, the operation of the equipment needs to be monitored and well maintained, for which the staff should be properly trained and an organizational commitment should take place.

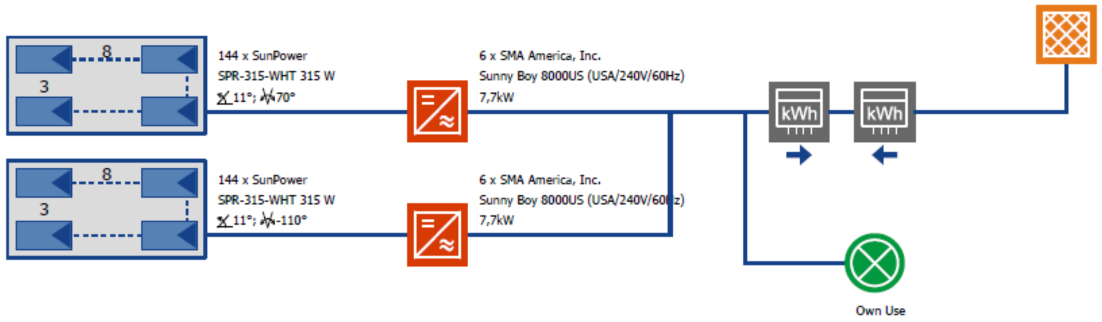
Appendix A

Electricity prices according to Horo Sazonal Azul A4; 2012

Date	Cost per kW High Tariff	Cost per kW Low Tariff	Cost per kW of exceeding power High Tariff	Cost per kW of exceedin g power Low Tariff	Cost per kWh High Tariff	Cost per kWh Low Tariff	Cost reactive energy High Tariff	Cost Reactive Energy Low Tariff
Feb	69,49 R$/kW	21,67 R$/kW		43,35 R$/kW	0,35 R$/kWh	0,22 R$/kWh	0,19 R$/kVArh	0,19 R$/kVArh
Mar	68,46 R$/kW	21,66 R$/kW		43,33 R$/kW	0,34 R$/kWh	0,22 R$/kWh	0,19 R$/kVArh	0,19 R$/kVArh
Apr	68,93 R$/kW	21,81 R$/kW	137,86 R$/kW	43,82 R$/kW	0,34 R$/kWh	0,22 R$/kWh	0,19 R$/kVArh	0,19 R$/kVArh
May	59,00 R$/kW	21,83 R$/kW	138,06 R$/kW	43,67 R$/kW	0,38 R$/kWh	0,24 R$/kWh	0,20 R$/kVArh	0,19 R$/kVArh
Jun	68,7 R$/kW	21,74 R$/kW	137,39 R$/kW	43,47 R$/kW	0,38 R$/kWh	0,24 R$/kWh	0,19 R$/kVArh	0,19 R$/kVArh
Jul	68,78 R$/kW	21,76 R$/kW		43,53 R$/kW	0,38 R$/kWh	0,24 R$/kWh	0,19 R$/kVArh	0,19 R$/kVArh
Aug	69,43 R$/kW	21,97 R$/kW	138,86 R$/kW	43,94 R$/kW	0,38 R$/kWh	0,25 R$/kWh	0,00 R$/kVArh	0,19 R$/kVArh
Sep	69,43 R$/kW	21,97 R$/kW	138,86 R$/kW	43,94 R$/kW	0,38 R$/kWh	0,25 R$/kWh		0,19 R$/kVArh
Oct	68,39 R$/kW	21,53 R$/kW	136,73 R$/kW	43,25 R$/kW	0,39 R$/kWh	0,25 R$/kWh		0,19 R$/kVArh
Nov	68,9 R$/kW	22,40 R$/kW	137,79 R$/kW	44,82 R$/kW	0,39 R$/kWh	0,25 R$/kWh	0,00 R$/kVArh	0,19 R$/kVArh
Dec	68,87 R$/kW	25,33 R$/kW		50,86 R$/kW	0,50 R$/kWh	0,25 R$/kWh	0,00 R$/kVArh	0,24 R$/kVArh

Appendix B

System 1



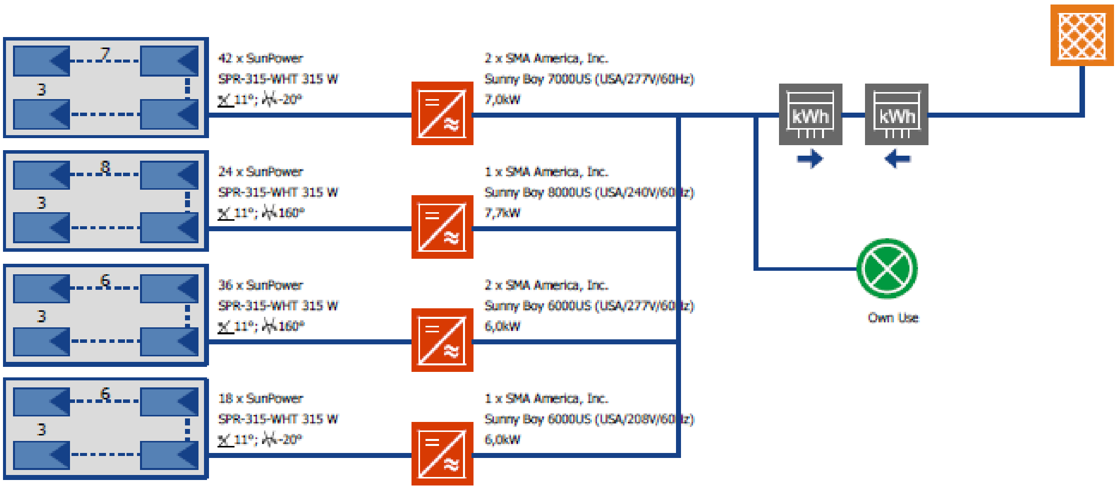
Location:	RIO DE JANEIRO
Climate Data Record:	RIO DE JANEIRO
PV Output:	90,72 kWp
Gross/Active PV Surface Area:	469,65 / 470,16 m²

PV Array Irradiation:	727.156 kWh
Energy Produced by PV Array (AC):	107.088 kWh
Energy to Grid:	35.004,3 kWh
Consumption Requirement:	188.719 kWh
Direct Use of PV Energy:	72.084 kWh
Energy from Grid:	116.723,5 kWh
Yield Reduction Due to Shading	2 %

Solar Fraction:	56,7 %
System Efficiency:	14,7 %
Performance Ratio:	76,3 %
Specific Annual Yield:	1.179 kWh/kWp
CO2 Emissions Avoided:	75.219 kg/a

The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system..

System 2



Location:	RIO DE JANEIRO
Climate Data Record:	RIO DE JANEIRO
PV Output:	37,80 kWp
Gross/Active PV Surface Area:	195,69 / 195,90 m²

PV Array Irradiation:	302.592 kWh
Energy Produced by PV Array (AC):	45.790 kWh
Energy to Grid:	3.314,0 kWh
Consumption Requirement:	188.719 kWh
Direct Use of PV Energy:	42.476 kWh
Energy from Grid:	146.287,1 kWh
Yield Reduction Due to Shading	2 %

Solar Fraction:	24,2 %
System Efficiency:	15,1 %
Performance Ratio:	78,3 %
Specific Annual Yield:	1.210 kWh/kWp
CO2 Emissions Avoided:	28.989 kg/a

The results are determined by a mathematical model calculation. The actual yields of the photovoltaic system can deviate from these values due to fluctuations in the weather, the efficiency of modules and inverters, and other factors. The System Diagram above does not represent and cannot replace a full technical drawing of the solar system..