Energy Analysis Report for Fluminense Football Club - Laranjeiras

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For:

Deutsche Gesellschaft für

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Energy Analysis Report for Fluminense Football Club

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Objective

Analyze the operations of the Fluminense Football Club site in Laranjeiras in order to develop measures of energy efficiency and decentralized electricity generation to provide sustainable solutions to reduce energy cost and to meet the energy demand of the site.

Summary

The energy analysis for Fluminense Football Club in Laranjeiras is based on an on-site inspection and the information made available by Fluminense.

During the on-site inspection the main 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 17 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 14 electrical energy saving measures, 1 gas saving measure and 2 energy generating measures, a Photovoltaic (PV) System and an electrical generator operated with gas. The electrical energy saving measures have a potential to save 614.459 kWh/year corresponding to 42,7 % of the current electricity consumption. The gas saving measure has the potential to save 646.116 kWh/year of the energy demanded for water heating, representing 60,8 % of the current energy provided by the heaters operated with gas. The implementation of the electrical energy and gas saving measures has the potential to reduce a total of 324.339 kg of CO_2 per year. The implementation of the PV System would supply 23,3% of the energy consumption after the previous measures have been implemented, and would reduce CO_2 emissions by 11.413 kg per year. The gas driven electrical generator which is going to be installed as reported by Fluminense would supply 13 % of the energy consumption operating during the peak load hours and would increment CO_2 emissions by at least 37.066 kg per year. With the implementation of all 17 measures a total annual CO_2 emissions reduction of 298.684 kg can be achieved.

As the following table shows, the implementations of all 17 measures result in yearly energy cost saving of R$ 761.748 with a projected investment of R$ 4.339.200 the respective payback time corresponds to 5,7 years.

The investments of 2.090.800 R$ for the energy saving measures alone are paying back in 4,5 years, the investment for the generators of 1.250.000 R$ in 4,7 years and the PV system with a corresponding investment of 998.400 R$ in 27,8 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)	1.440.343 kWh/year	1.062.420 kWh (106.242 m³)	1.002.332 R$/year	568.574 kg/y		
15 Energy Saving Measures (Reduction)	614.459 kWh/y	646.116 kWh/y	459.857 kWh/y	324.339 kg/y	2.090.800 R$	**4,5 years**
	42,7 %	60,8 %	45,9 %	57 %		
17 Measures (Reduction)	862.019 kWh/year	284.839 kWh/year	761.748 R$/year	298.684 kg/y	4.339.200 R$	**5,7 years**
	59,8 %	**26,8**	**76 %**	**53%**		

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

Laranjeiras

This Energy Analysis Report provides detailed information on the following:

- Existing conditions for 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 operational 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 when data becomes available or when additional detailed measurements are possible.

2 Facility Description

The Fluminense facility is located in Laranjeiras, Rio de Janeiro.

The following data characterizes the building:

Table 2: Basic Building Data

Basic Site Data	
Year of Construction	1919
Number of Buildings	4
Build Area (approximate)	4.133,24 m²
Opening Hours	07:00 - 22:00 Monday - Sunday
Employee Schedule	05:00 - 22:00 Monday - Sunday

The plan below shows the site of Fluminense Football Club in Laranjeiras.

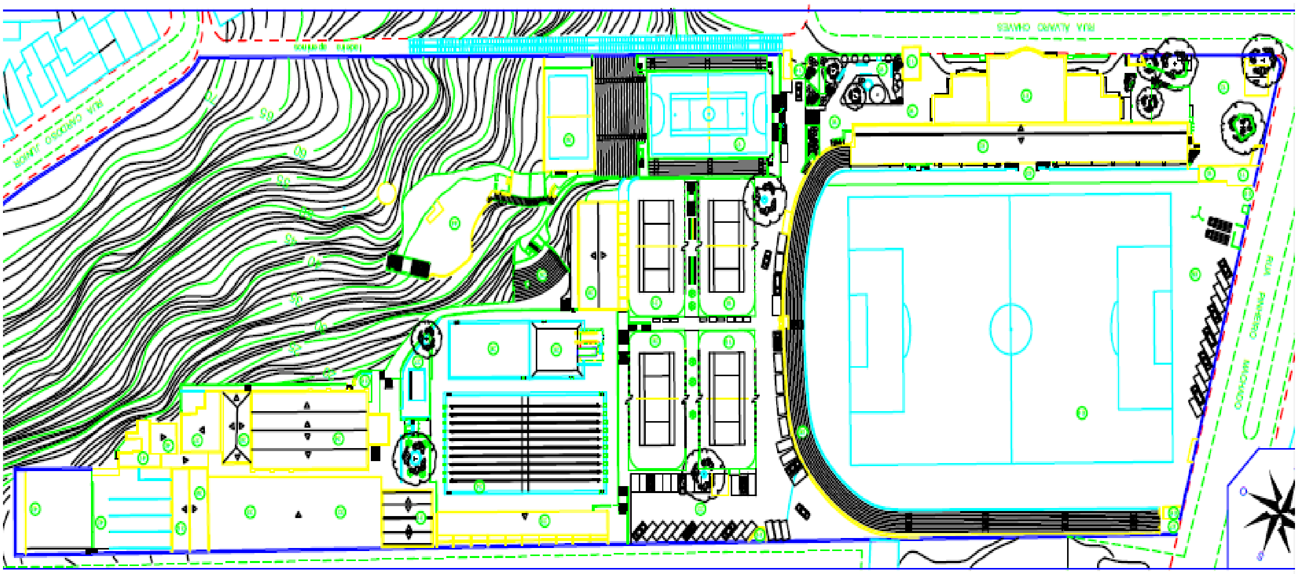


Figure 1: Fluminense Football Club, Laranjeiras

3 Energy Consumption and Cost Overview

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

3.1 Electrical Energy

For the purpose of the energy analysis, electricity bills and power demand records, provided by the electricity supply company and made available by Fluminense, have been analyzed.

The electrical energy is supplied by the company Light under the tariff structure A4-Horo Sazonal Azul.

The total electricity consumption for the year 2012 was stated 1.440.343 kWh with a maximum power load of 447,6 kW according to the records of the electricity bills. Based on this information the site has a full load operation time equivalent to 3.217,92 hours per year. With an estimated total operation time of 5.475 hours, the site would be working at full capacity during 58,7% of the total operation time. The electricity consumption per built area is estimated to be 348.47 kWh/m²/year. It should be noted that the site has some considerable energy consumption in the open area as well, as they have lighting, such as the football field, different courts and pools.

The characteristic consumption values are shown on table 3.

Table 3: Characteristic Consumption Values, Registered period: January 2012 - December 2012

Characteristic Consumption Data/ Indicators	Values
Total Consumption	1.440.343 kWh
Highest Peak Load	447,6 kW
Electricity Consumption per Build Area	348.47 kWh/m²/year
Contracted Power (December – April)	400 kW
Contracted Power (May – November)	360 kW
Full Load Hours	3.217,92

The following graph shows the electricity consumption and the power demand registered for the period of the year 2012.

There is differentiated contracted power during the year, for the dry season months of May to November there is a contracted power of 360 kW and the rest of the months it is 400 kW. The highest peak load is registered in July during the high tariff hours with a value of 447,6 kW which exceeds by 87,8 kW the contracted power of 360 kW in that month, with a fee per exceeded kW in high tariff schedule of R$ 137,56 this represents a cost of R$ 12.050,69 for July only. As seen on the graph, in seven of the twelve months the peak loads exceed the contracted amount, mostly on the high tariff schedule. The fee for exceeding power is charged when it exceeds the contracted power amount by more than 5%.

It should also be noted that the contracted power is charged with a fixed value per kW even for the months were the demand is lower than the contracted values.

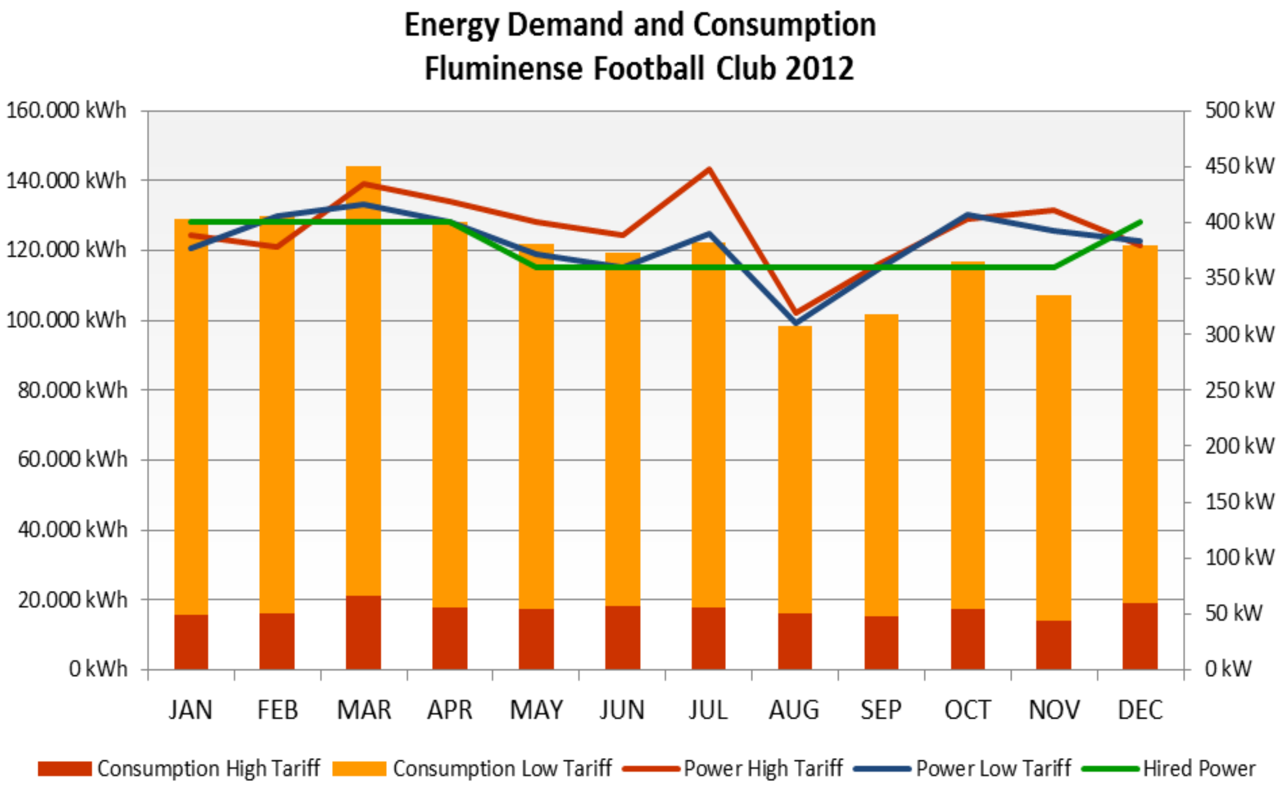


Figure 2: Graph of Electricity Consumption and Power Demand Record, Year 2012.

Table 4: Electricity Consumption and Power Demand Registered on the invoices of year 2012

Month	Power High Tariff	Power Low Tariff	Charged Exceeding Power High Tariff	Charged Exceeding Power Low Tariff	Consumption High Tariff	Consumption Low Tariff
JAN	388 kW	377 kW	-	-	15.906 kWh	113.098 kWh
FEB	378 kW	406 kW	-	-	15.945 kWh	113.983 kWh
MAR	435 kW	416 kW	35 kW	-	21.098 kWh	122.818 kWh
APR	419 kW	400 kW	-	-	17.917 kWh	110.441 kWh
MAY	400 kW	372 kW	40 kW	-	17.248 kWh	104.695 kWh
JUN	389 kW	360 kW	29 kW	-	18.200 kWh	101.282 kWh
JUL	448 kW	390 kW	88 kW	30 kW	17.688 kWh	104.587 kWh
AUG	320 kW	310 kW	-	-	16.242 kWh	82.037 kWh
SEP	364 kW	360 kW	-	-	15.306 kWh	86.378 kWh
OCT	404 kW	407 kW	44 kW	49 kW	17.550 kWh	99.122 kWh
NOV	410 kW	393 kW	50 kW	33 kW	14.085 kWh	93.290 kWh
DEC	379,3 kW	384 kW	-	-	19.194 kWh	102.233 kWh
			Total		**206.379 kWh**	**1.233.964 kWh**

Based on the prices shown on the electricity bills, considering power demand and electricity consumption the overall cost for the period was R$ 852.022,3.

Considering the costs of electricity consumption and power demand on the different tariffs per kWh consumed, the average specific cost of energy was R$ 0,59 per kWh.

The different tariffs are shown on table 5 and the summarized costs on table 6.

Table 5: Valid Prices on November 2012

Price per kW per Month (High Tariff)	R$ 69,802247
Price per kW per Month (Low Tariff)	R$ 24,45440
Price per Exceeding kW per Month(High Tariff)	R$ 139,604493
Price per Exceeding kW per Month(Low Tariff)	R$ 48,92888
Price per kWh (High Tariff)	R$ 0,4368919
Price per kWh (Low Tariff)	R$ 0,2738091
Reactive Energy Tariff	R$ 0,1962

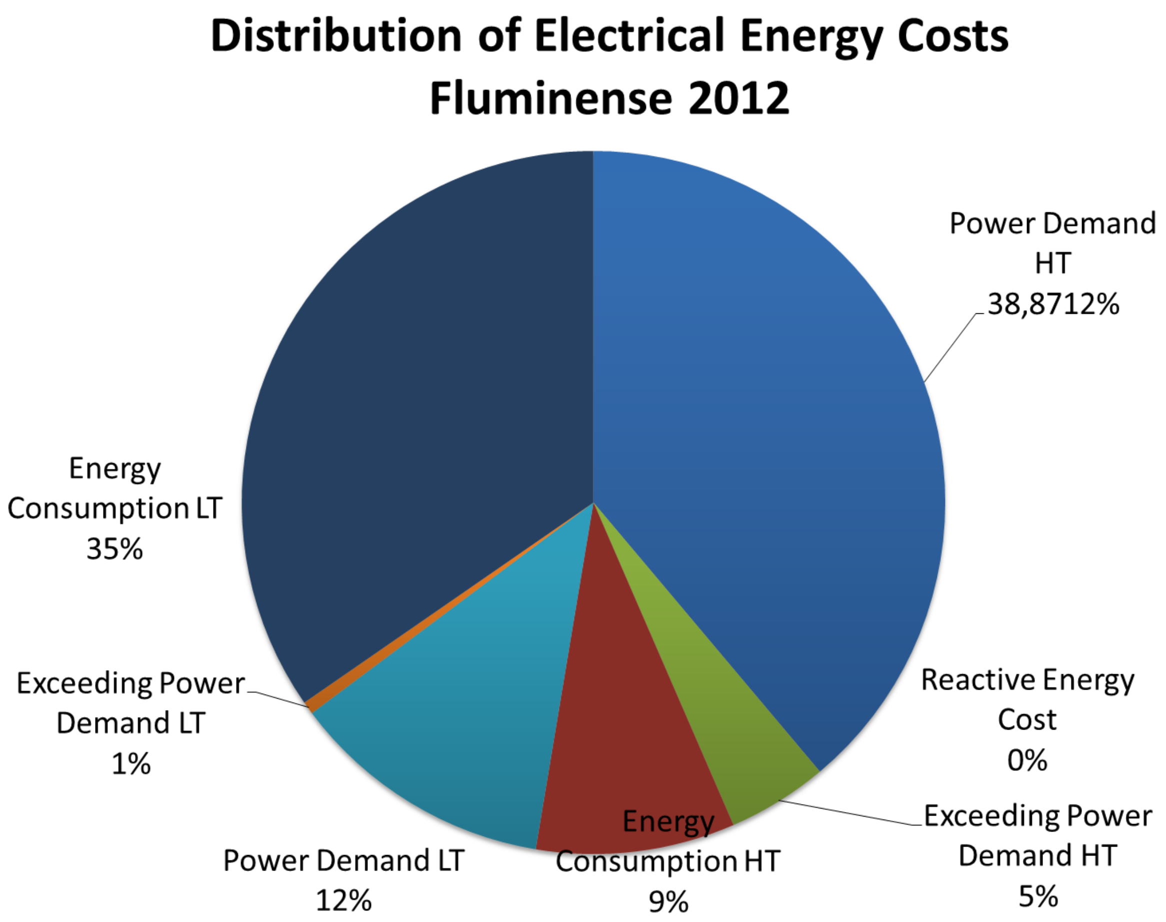


Figure 3: Energy Costs, Fluminense, 2012.

Table 6: Electricity Costs for 2012

Power Demand (High Tariff)	**Power Demand (Low Tariff)**	**Exceeding Power Demand (High Tariff)**	**Exceeding Power Demand (Low Tariff)**	**Energy Consumption (High Tariff)**	**Energy Consumption (Low Tariff)**	**Reactive Energy Cost**
R$ 331.191,06	R$ 103.469,84	R$ 39.258,46	R$ 5.028,07	R$ 77.941,33	R$ 295.104,03	R$ 29,50
38,8712 %	12%	5%	1%	9%	35%	0,003 %

3.2 Characteristic Power Demand

The data used to describe the characteristic daily power demand, was provided by the electricity company Light. This data is recorded every 15 minutes. The load profile for October 2013 is shown on the graph below.

The base load is seen at 100 kW, from 23:00 to 6:00. A higher load is demanded from 6:00 to 22:00, with values that rise up to 412,99 kW. A higher density of load increments is observed from 17:00 to 21:00 which can be explained by higher number of visitors during these times and higher use of outside lighting. This period corresponds to the high tariff schedule; therefore this rise in demand causes an augmentation of the costs.

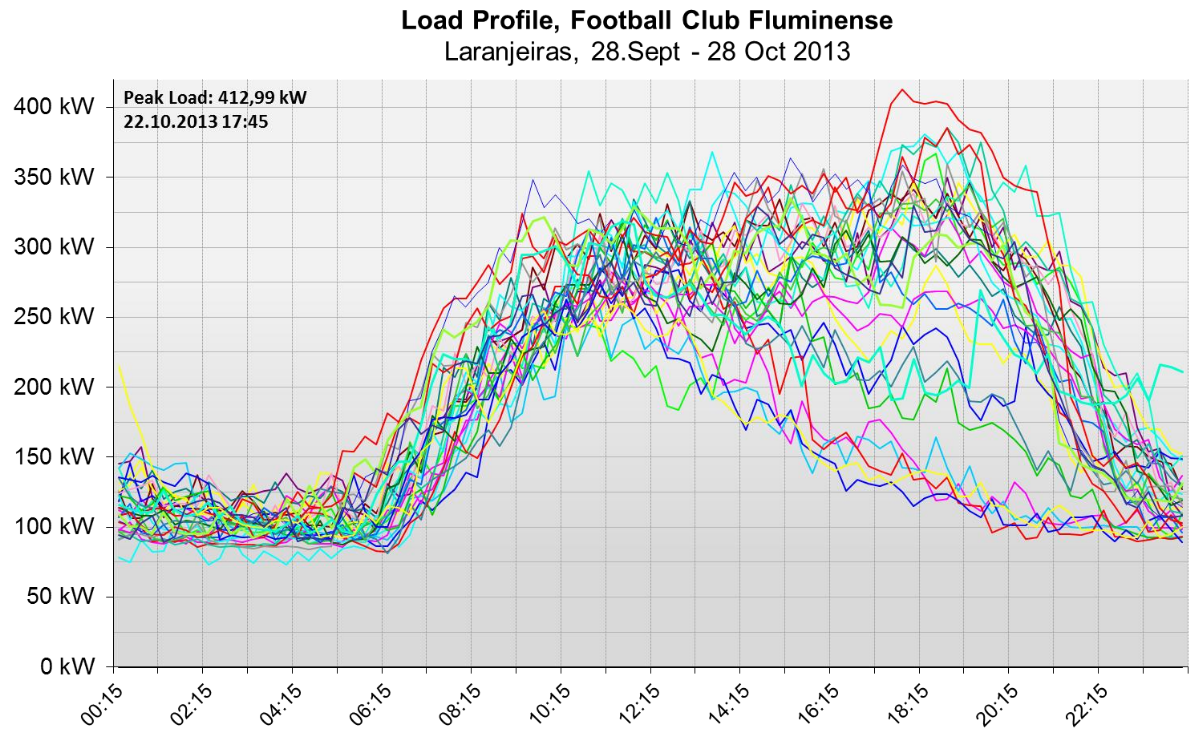


Figure 4: Load Profile of Fluminense Football Club, Laranjeiras, 28.Sept – 28.Oct 2013.

Figures 5 to 11 show the load profile for each day of the week. On Thursdays and Fridays the load profile shows almost the same behavior. A remarkable load decrease can be observed on Weekends and the days with the higher demand are Mondays (385 kW), Tuesdays (413 kW), Wednesdays (385).

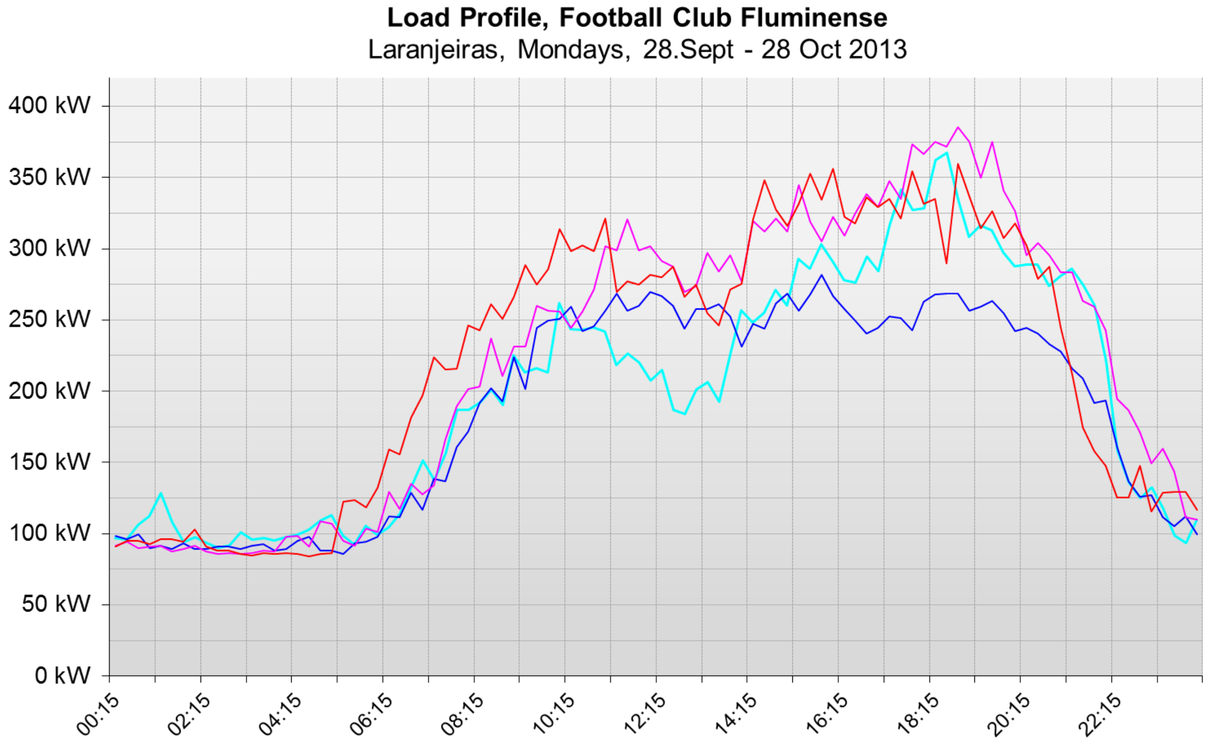


Figure 5: Load Profile of Fluminense Football Club, Laranjeiras, Mondays on the period of 28.Sept – 28.Oct 2013.

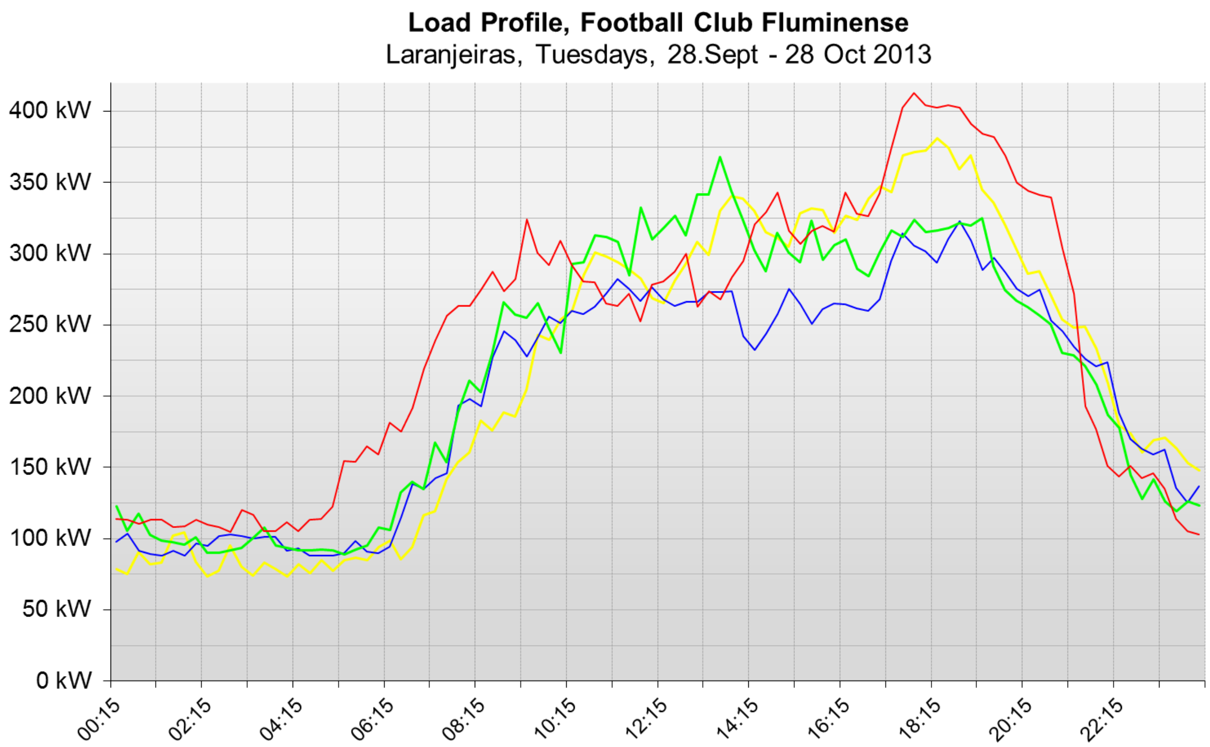


Figure 6: Load Profile of Fluminense Football Club, Laranjeiras, Tuesdays on the period of 28.Sept – 28.Oct 2013.

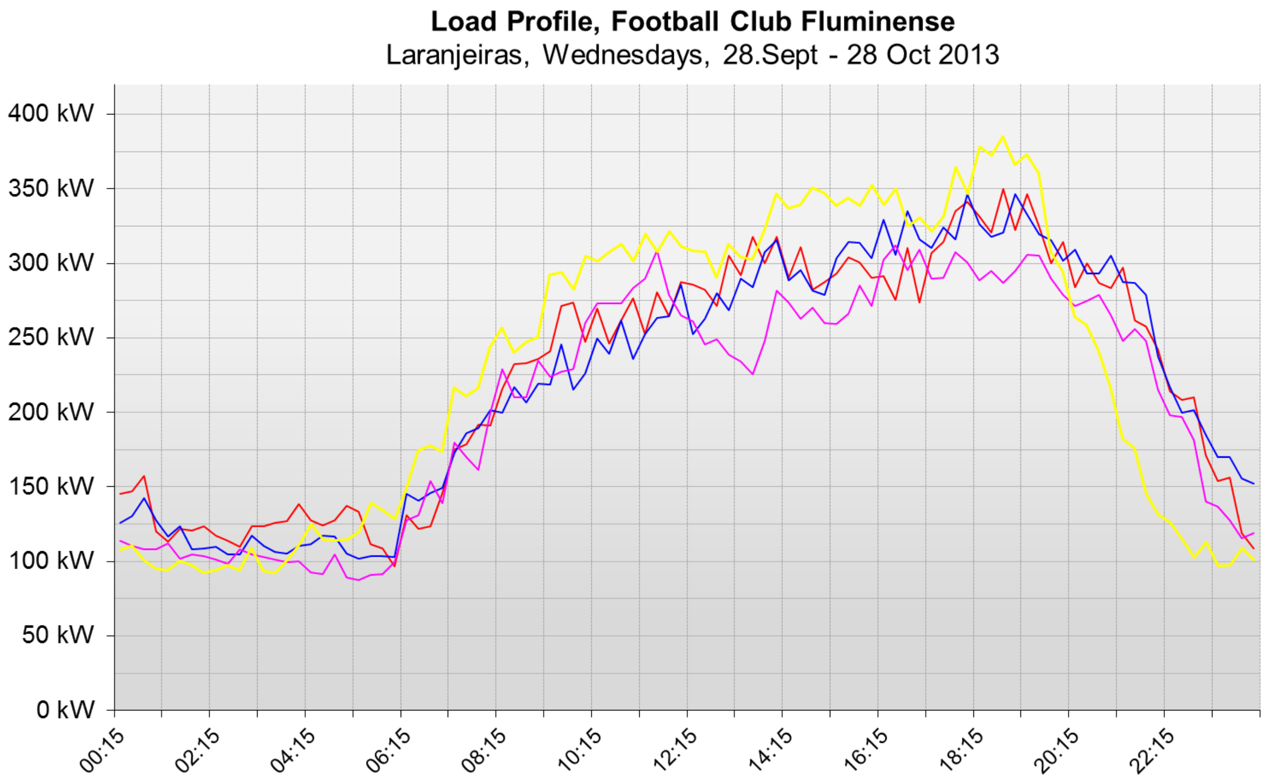


Figure 7: Load Profile of Fluminense Football Club, Laranjeiras, Wednesdays on the period of 28.Sept – 28.Oct 2013.

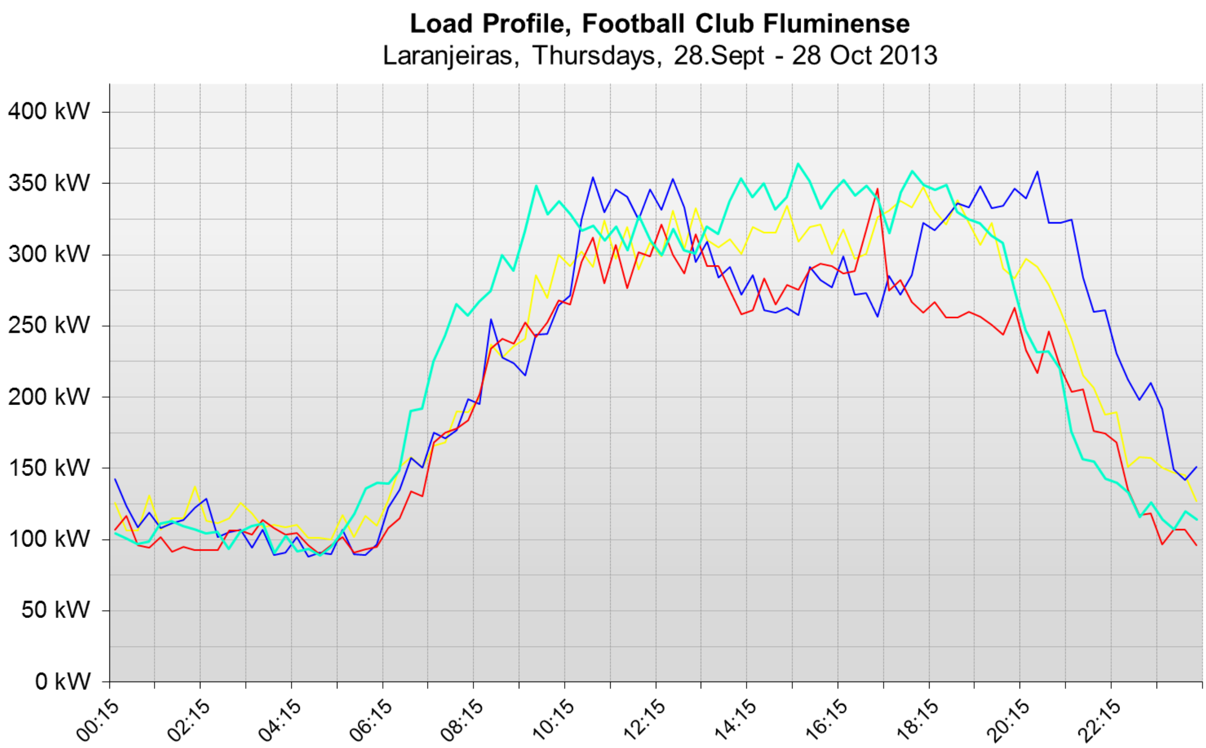


Figure 8: Load Profile of Fluminense Football Club, Laranjeiras, Thursdays on the period of 28.Sept – 28.Oct 2013.

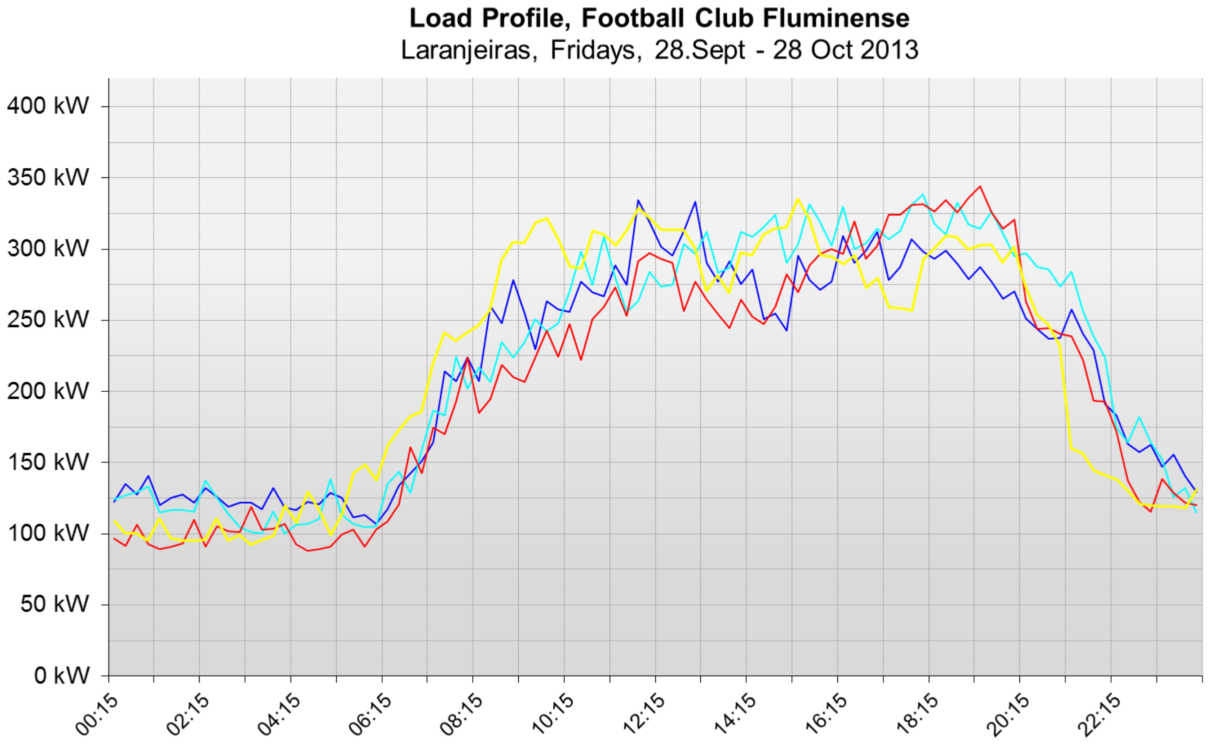


Figure 9: Load Profile of Fluminense Football Club, Laranjeiras, Fridays on the period of 28.Sept – 28.Oct 2013.

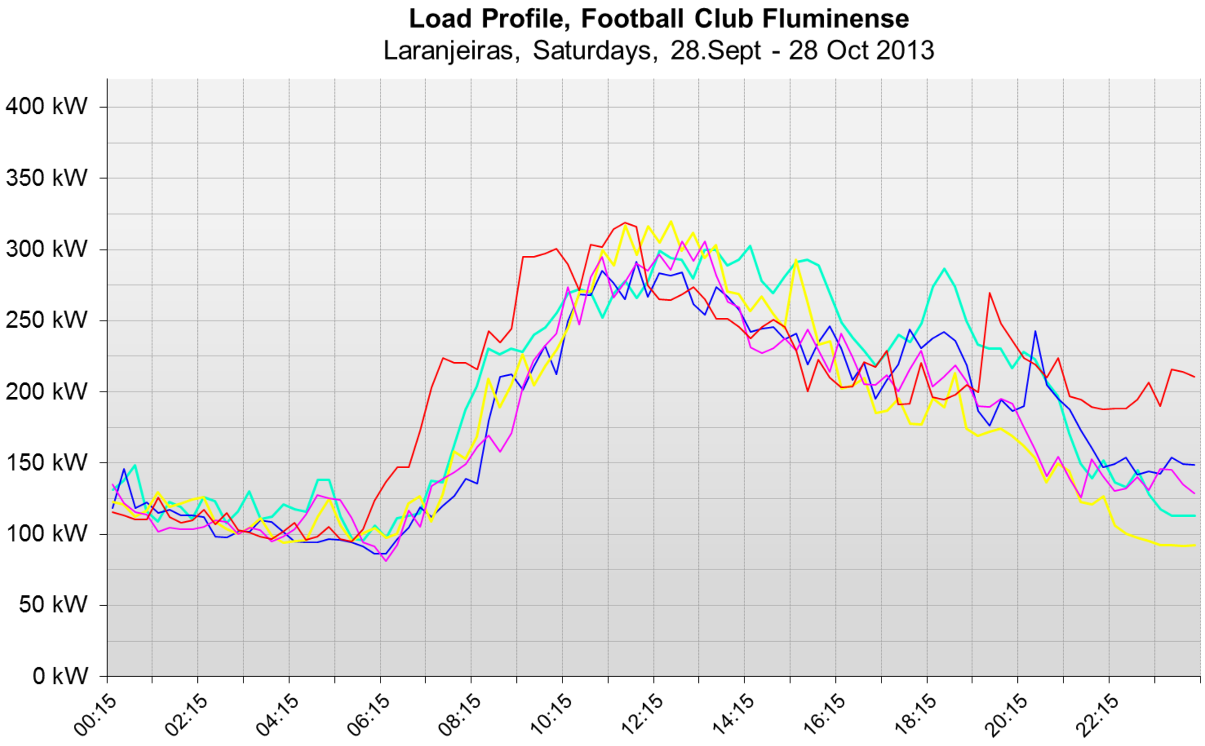


Figure 10: Load Profile of Fluminense Football Club, Laranjeiras, Saturdays on the period of 28.Sept – 28.Oct 2013.

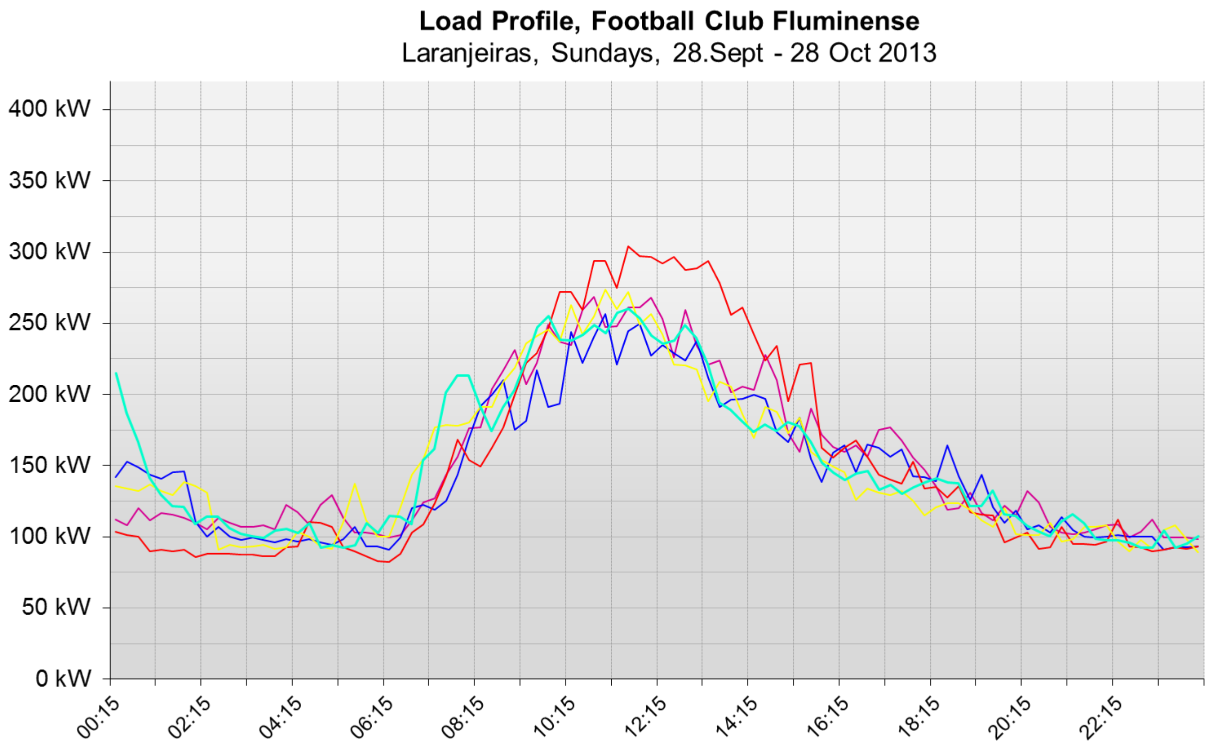


Figure 11: Load Profile of Fluminense Football Club, Laranjeiras, Sundays on the period of 28.Sept – 28.Oct 2013.

The sorted load curve of October 2013 shows that the building is in operation with a power demand higher than 360 kW (contracted power) during 35 15-minutes periods, respectively in 8,75 hours.

The minimum load (base load) is around 100 kW. The operations are approximately at base load during 640 15-minutes, respectively 160 hours.

The load record for the rest of the year 2013 was not available, therefore it should be considered that due to seasonal changes, there are some variations in the loads throughout the year. The highest load in October of 412,99 kW could be exceeded by the load of another month.

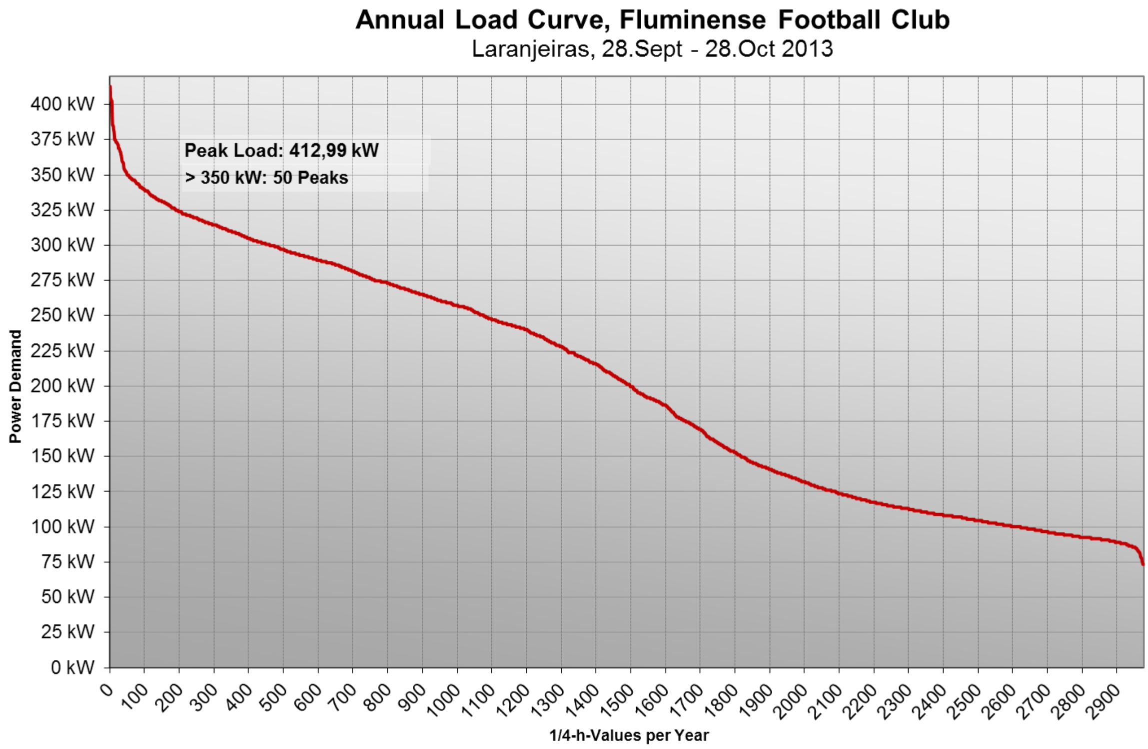


Figure 12: Annual Load Curve, 28 Sept – 28 Oct 2013

3.3 Gas Consumption

The overview of the gas consumption is shown on the next graph; the total registered cubic meters of supplied gas are 106.242 m³, based on the gas invoices of the year 2012. The highest value 31.961 m³ was registered in July. The total costs of gas consumption for the monitored period were R$ 150.339,26/year. There is a very notable variation in the gas consumption, this is due to the weather variations. In the hot period from September to March the pool water heating system was not operated.

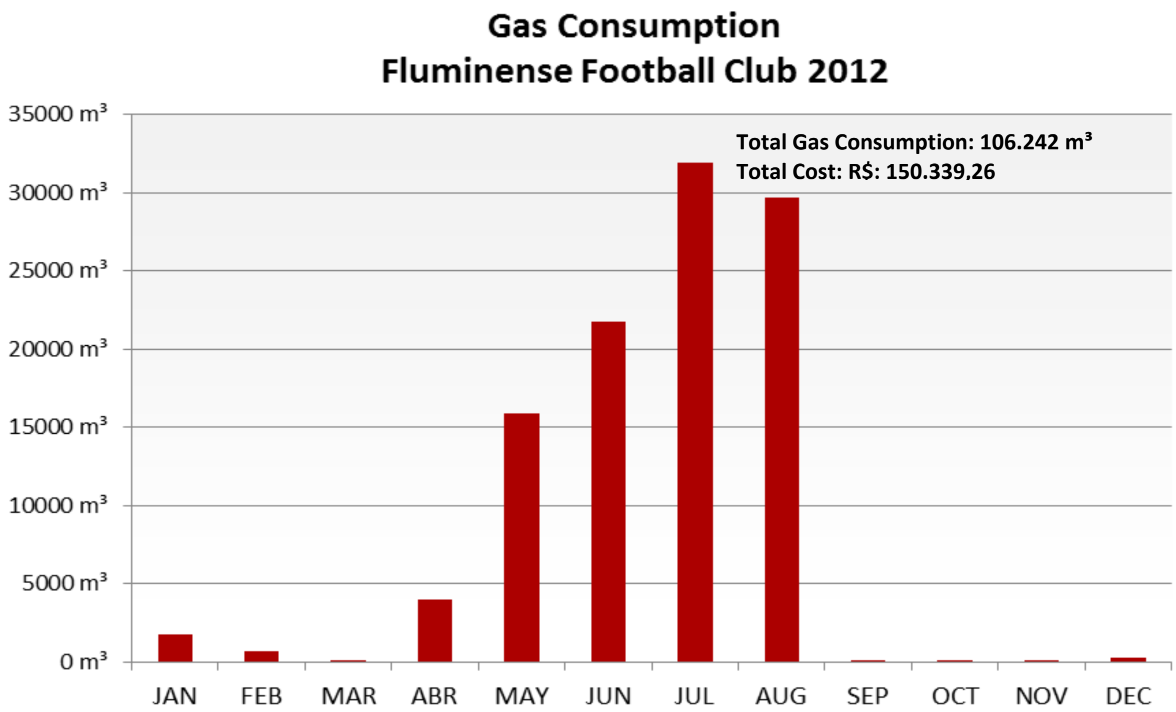


Figure 13: Gas Consumption 2012

Table 7: Gas Consumption and Cost (Invoices from 2012)

Gas consumption	Gas Cost	
1.721 m³	R$	3.453,91
690 m³	R$	1.633,98
11 m³	R$	38,32
3.948 m³	R$	7.382,58
15.923 m³	R$	25.298,83
21.776 m³	R$	32.996,36
31.961 m³	R$	46.304,60
29.667 m³	R$	31.433,79
41 m³	R$	142,50
125 m³	R$	434,07
120 m³	R$	416,71
259 m³	R$	803,61
Total		
106.242 m³	**R$**	**150.339,26**

4 Energy Relevant Equipment

The identified energy consuming equipment's are:

- Lighting
- Air Conditioning and
- Electrical Water Heating System
- Water Pumps
- Other Electrical Equipment
- Pool Water Heating System

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

4.1 Lighting System

The data of the lighting systems was as well gathered in the onsite inspections and made available by Fluminense. The site has a total of 2015 lamps installed, corresponding to 230,73 kW.

Table 8: Lamp Inventory

Area		Equipment	Quant	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No	Name	Lighting				
1	Statue	Halogen	1	85 W	0,09 kW	4.368 h/year
1	CANTEIRO	T5	3	50 W	0,15 kW	3.640 h/year
1	Plaques	T12	2	43 W	0,09 kW	4.368 h/year
1	Plaques	T12	1	45 W	0,05 kW	4.368 h/year
1	Social Entrance	T12	6	43 W	0,26 kW	8.736 h/year
1	Saint Statue	Fluorescent	1	14 W	0,01 kW	8.736 h/year
2	Lobby	Mercury Vapor	1	435 W	0,44 kW	4.368 h/year
2	Open Parking lot	Mercury Vapor	5	435 W	2,18 kW	2.184 h/year
2	Bank	T12	4	43 W	0,17 kW	2.184 h/year
2	Lobby 2	T12	4	43 W	0,17 kW	4.368 h/year
2	Men’s Dressing Room	T12	10	43 W	0,43 kW	6.552 h/year
2	Women’s Dressing Room	T12	6	43 W	0,26 kW	7.280 h/year
2	Women’s Dressing Room	T12	4	43 W	0,17 kW	2.184 h/year
2	Men’s Dressing Room	T12	10	23 W	0,23 kW	2.184 h/year
3	Field	Mixed	24	2017 W	48,40 kW	624 h/year
3	Tribune	Mercury Mixed Light	2	275 W	0,55 kW	624 h/year
3	Tribune	Sodium vapor	12	178 W	2,14 kW	624 h/year
4	Poles	Mercury Vapor	1	435 W	0,44 kW	1.092 h/year
4	Kids park	Mercury Mixed Light	10	275 W	2,75 kW	1.092 h/year
5	Court 1	Mercury Vapor	64	409 W	26,16 kW	2.184 h/year
5	Court Superior 1	Mercury Vapor	12	418 W	5,01 kW	2.184 h/year
5	Court Superior 2	Mercury Vapor	16	409 W	6,54 kW	2.184 h/year
5	Corridor	Mercury Mixed Light	4	275 W	1,10 kW	2.184 h/year
5	Entrance	Fluorescent	4	50 W	0,20 kW	2.184 h/year
5	Hallway	T12	7	25 W	0,18 kW	2.184 h/year
6	Bocha	Mercury Vapor	4	435 W	1,74 kW	1.456 h/year
6	Bocha	Mercury Mixed Light	2	275 W	0,55 kW	1.456 h/year
6	Poles	Fluorescent	2	50 W	0,10 kW	1.456 h/year
7	Pool	Mercury Vapor	4	435 W	1,74 kW	1.456 h/year

Area		Equipment	Quant	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No	**Name**	**Lighting**				
7	Pool	Mercury Vapor	10	275 W	2,75 kW	1.456 h/year
8	Gymnasium	Mercury Vapor	8	435 W	3,48 kW	1.456 h/year
8	Side Block	Mercury Vapor	20	409 W	8,18 kW	1.456 h/year
9	Shooting ring	Mercury Vapor	8	435 W	3,48 kW	4.368 h/year
10	MURAL	Halogen	6	188 W	1,13 kW	3.120 h/year
10	Hallway	Halogen	15	140 W	2,10 kW	3.120 h/year
10	Trophies	Halogen	50	85 W	4,25 kW	3.120 h/year
11	Salon/ Lounge	Halogen	2	85 W	0,17 kW	3.640 h/year
11	Room 1	Halogen	1	85 W	0,09 kW	1.456 h/year
11	Room 2	Halogen	4	85 W	0,34 kW	1.092 h/year
11	Reception	Incandescent	2	60 W	0,12 kW	3.640 h/year
11	Chairs	T12	14	23 W	0,32 kW	3.640 h/year
11	Hallway	T12	2	25 W	0,05 kW	3.640 h/year
11	Kitchen	T12	2	23 W	0,05 kW	3.640 h/year
11	Room	T12	14	21 W	0,29 kW	3.640 h/year
11	Room 1	Fluorescent	4	19 W	0,08 kW	1.456 h/year
11	Room 2	Fluorescent	1	19 W	0,02 kW	1.820 h/year
12	Social area	Mercury Vapor	60	435 W	26,10 kW	2.912 h/year
12	Social Area	Mercury Mixed Light	65	275 W	17,88 kW	2.912 h/year
12	Social Area	T12	464	45 W	20,88 kW	2.912 h/year
12	Social Area	T12	136	25 W	3,40 kW	4.368 h/year
12	Social Area	T12	220	25 W	5,50 kW	5.824 h/year
12	Social Area	T12	128	25 W	3,20 kW	2.912 h/year
13	General Department	Mercury Mixed Light	11	275 W	3,03 kW	2.496 h/year
13	General Department	Halogen	20	85 W	1,70 kW	2.496 h/year
13	General Department	T12	344	45 W	15,48 kW	2.912 h/year
13	General Department	T12	96	25 W	2,40 kW	2.496 h/year
13	General Department	T12	82	25 W	2,05 kW	2.496 h/year
		LED				
			2015		**230,73 kW**	

The trophy room is equiped with 50 Halongen lamps of 85 W each.

Figure 14: Halogen lamps in trophy room

Fluorescent lamps with different wattage ratings are installed in several areas.

Figure 15: Fluorescent Lamps

Figure 16: 400 W Mercury Vapour Lamps Installed in Tennis Courts.

Figure 17: LED

4.2 Air Conditioning

The buildings in Fluminense, Laranjeiras are cooled by split and window units. According to the information available, a total of 74 split and window units and 12 multi splits are currently installed. The installed equipment has different cooling capacities, variating from 2,19 kW_{th} (7.500 BTU/h) to 35,16 kW_{th} (120.000 BTU/h). A total of 828,95 kW_{th} (2.828.500 BTU/h) of cooling capacity is installed which represents a total installed capacity of approximately 218,7 kW_{el}. The following table shows the equipment inventory.

Table 9: Air Conditioning Equipment Inventory

Area		Equipment	Quant.	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No.	Name	Cooling				
2	Bank	Split Unit	1	1,64 kW	1,31 kW	2.808 h/year
3	Football Academy	Split Unit	2	6,03 kW	9,65 kW	2.340 h/year
3	Dressing room football	Split Unit	2	1,64 kW	2,62 kW	2.340 h/year
3	Wardrobe	Split Unit	1	2,29 kW	1,83 kW	2.340 h/year
3	Warehouse	Split Unit	1	1,53 kW	1,22 kW	2.340 h/year
3	Football material	Split Unit	1	2,86 kW	2,29 kW	2.340 h/year
7	Physiotherapy	Split Unit	1	6,12 kW	4,89 kW	2.340 h/year
7	Aquatic sports	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
7	Physiotherapy amateur sport	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
7	Swimming Academy	Split Unit	1	6,03 kW	4,83 kW	2.340 h/year
7	Physiology/ Football	Split Unit	1	4,59 kW	3,67 kW	2.340 h/year
7	Physical test, medical room	Split Unit	1	1,53 kW	1,22 kW	2.808 h/year
8	Olympic Sports	Split Unit	2	1,64 kW	2,62 kW	2.340 h/year
8	Pilates	Split Unit	1	4,97 kW	3,98 kW	2.340 h/year
9	Shooting ring	Split Unit	2	3,82 kW	6,12 kW	2.340 h/year
10	Trophies	Split Unit	3	5,25 kW	12,60 kW	3.276 h/year
10	Trophies	Split Unit	2	3,62 kW	5,79 kW	3.276 h/year
11	Kitchen	Split Unit	1	1,53 kW	1,22 kW	2.808 h/year
12	Meeting Room	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
12	Office	Split Unit	2	0,96 kW	1,53 kW	2.340 h/year
13	Social Area	Split Unit	1	1,64 kW	1,31 kW	2.808 h/year
	Marketing	Split Unit	1	1,23 kW	0,99 kW	520 h/year
	Marketing	Split Unit	1	1,09 kW	0,87 kW	2.808 h/year
	Marketing	Split Unit	1	2,10 kW	1,68 kW	2.808 h/year
	Marcelo Penha	Split Unit	1	1,73 kW	1,38 kW	2.600 h/year
	Legal department	Split Unit	1	3,06 kW	2,45 kW	2.600 h/year
	Financial	Split Unit	1	1,48 kW	1,18 kW	2.340 h/year

Area		Equipment	Quant.	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No.	Name	Cooling				
	Department					
	Operator	Split Unit	1	1,64 kW	1,31 kW	3.276 h/year
	Procurement Department	Split Unit	1	1,53 kW	1,22 kW	2.340 h/year
		Split Unit	1	1,64 kW	1,31 kW	2.808 h/year
	Secretary	Split Unit	1	2,47 kW	1,98 kW	2.808 h/year
	Management	Split Unit	1	1,53 kW	1,22 kW	2.808 h/year
	Management	Split Unit	1	1,27 kW	1,02 kW	1.040 h/year
	Management	Split Unit	1	2,05 kW	1,64 kW	3.276 h/year
	Presidency	Split Unit	1	3,82 kW	3,06 kW	1.040 h/year
	Presidency	Split Unit	1	1,53 kW	1,22 kW	1.040 h/year
	FUTSAL	Split Unit	1	2,29 kW	1,83 kW	1.040 h/year
	Informatics	Split Unit	1	2,29 kW	1,83 kW	8.736 h/year
	Football	Split Unit	1	1,73 kW	1,38 kW	2.340 h/year
	RODRIGO CAETANO	Split Unit	1	1,53 kW	1,22 kW	2.340 h/year
	MARCELO TEIXEIRA	Split Unit	1	1,09 kW	0,87 kW	2.340 h/year
	Recovery Room	Split Unit	1	1,23 kW	0,99 kW	2.340 h/year
	Medical Department Football	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
	Football Clinic	Split Unit	1	1,15 kW	0,92 kW	2.340 h/year
	Nutrition	Split Unit	1	1,15 kW	0,92 kW	2.340 h/year
	Technical Room	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
	Room of Masseurs	Split Unit	1	1,23 kW	0,99 kW	2.340 h/year
	Press Room	Split Unit	1	1,48 kW	1,18 kW	416 h/year
	Room of ANA FRAZÃO	Split Unit	1	1,64 kW	1,31 kW	2.340 h/year
	Cafeteria	Split Unit	1	2,47 kW	1,98 kW	3.276 h/year
	Warehouse	Split Unit	1	1,27 kW	1,02 kW	2.080 h/year
	Football table	Split Unit	2	1,64 kW	2,62 kW	1.040 h/year
	Trophies room/pool	Split Unit	1	1,53 kW	1,22 kW	2.340 h/year
	Emergency Room	Split Unit	1	1,27 kW	1,02 kW	2.340 h/year
	Auditorium	Split Unit	1	3,62 kW	2,90 kW	2.340 h/year
	Swimming Academy	Split Unit	1	3,62 kW	2,90 kW	2.340 h/year
	Massage Room	Split Unit	1	1,53 kW	1,22 kW	2.340 h/year
	Rest Room	Split Unit	1	1,15 kW	0,92 kW	2.340 h/year
	Living room	Split Unit	2	1,53 kW	2,45 kW	2.340 h/year
	Reception	Split Unit	1	1,15 kW	0,92 kW	3.276 h/year
	Salao Nobre	Multi Split Unit	12	7,55 kW	72,48 kW	208 h/year

Area		Equipment	Quant.	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No.	**Name**	**Cooling**				
	FUTSAL room	Split Unit	1	1,15 kW	0,92 kW	1.040 h/year
	Flu memoria antigo	Split Unit	1	0,96 kW	0,76 kW	520 h/year
	ACESSORIA DE IMPRENÇA	Split Unit	1	2,29 kW	1,83 kW	2.340 h/year
	Swimming teacher's room	Split Unit	1	15,29 kW	12,23 kW	2.340 h/year
			86		**218,66 kW**	

Figure 18: Installed Split Units

Figure 19: Installed Split Units

Figure 20: Installed Condensers

Figure 21: Condensing Units of Multi Split Units

4.3 Electrical Water Heating System

Hot water for the showers is supplied through 12 electrical water heaters. The total power demand is estimated to be 66,5 kW.

Table 10: Electrical Water Heaters Inventory

Area		**Equipment**	**Quant.**	**Nominal Power Demand per Unit**	**Real Power Demand**	**Operation Hours**
No.	**Name**	**Heaters**				
	Women staff locker room	Shower	2	2,75 kW	5,50 kW	3.282 h/year
	Men staff locker room	Shower	2	2,75 kW	5,50 kW	3.282 h/year
3	Football locker room	Boiler	1	18,00 kW	18,00 kW	1.254 h/year
3	Football locker room	Shower	2	2,75 kW	5,50 kW	4.103 h/year
5	Women tennis locker room	Boiler	1	4,00 kW	4,00 kW	3.526 h/year
5	Men tennis locker room	Boiler	1	4,00 kW	4,00 kW	3.526 h/year
8	Gym locker room	Boiler	1	18,00 kW	18,00 kW	2.351 h/year
8	Sauna	Boiler	1	4,00 kW	4,00 kW	3.526 h/year
8	Sauna	Boiler	1	2,00 kW	2,00 kW	7.052 h/year
			12		**66,50 kW**	

4.4 Water Pumps

There are currently installed 6 water pumps for the pools, which in total add up 52,94 kW. The pumps run at constant volume stream all the time.

Table 11: Water Pump Inventory

Area		Equipment	Quant.	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
No	**Name**	**Pools Pumps**				
	Amateurs	Water Pump	2	5,590 kW	7,83 kW	8.320 h/year
	Olympic	Water Pump	1	18,640 kW	13,05 kW	8.320 h/year
	Diving	Water Pump	1	18,640 kW	13,05 kW	8.320 h/year
	Storage for return water	Water Pump	2	2,240 kW	3,14 kW	8.320 h/year
			6		**37,058 kW**	

4.5 Other Electrical Equipment

Other energy consuming equipment is installed on the site among which there are computers, televisions, refrigerators and kitchens. In total they add up 85 kW.

Table 12: Other equipment

Area	Equipment	Quant.	Nominal Power Demand per Unit	Real Power Demand	Operation Hours
Name	**Others**				
Restaurant/ Cantina	Drink Refrigerators	12	0,6 kW	5,76 kW	8.736 h/year
	Electric Ovens	6	1,5 kW	7,20 kW	520 h/year
	Micro Wave Ovens	6	0,700 kW	3,36 kW	520 h/year
	Coffee machines	10	1,200 kW	9,60 kW	5.096 h/year
	Dish Washers	6	1,200 kW	5,76 kW	1.092 h/year
	Cooling Shelves and Displays	10	0,500 kW	4,00 kW	8.736 h/year
	Hot Plates	6	1,200 kW	5,76 kW	2.184 h/year
	Ventilation Exhaust Kitchen	1	3,000 kW	3,00 kW	5.096 h/year
Office Equipment					
	Computers	100	0,016 kW	1,28 kW	2.080 h/year
	Printers	33	0,750 kW	19,80 kW	2.080 h/year
	Copy machines	25	0,950 kW	19,00 kW	2.080 h/year
		215		**85 kW**	

4.6 Pool Water Heating System.

The water from the pools is heated through a gas water heater. The estimated heating demand in a year for the pools is 900.100 kWh. This would represent a consumption of 106.242 m³ of gas, considering losses due to efficiency and distribution.

5 Distribution of the Energy Usage

The basis to calculate the distribution of the energy usage has been a detailed inventory and the analysis of the operation of the installed equipment.

The calculated energy usage is shown in categorized consumer groups with the following graph (Figure 22 Sankey-Diagram) and the summarized information is shown on Table 13 and 14.

Table 15 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. A total of 637,47 kW are installed, with according to the peak load of 447,6 kW, the simultaneity factor is 0,7.

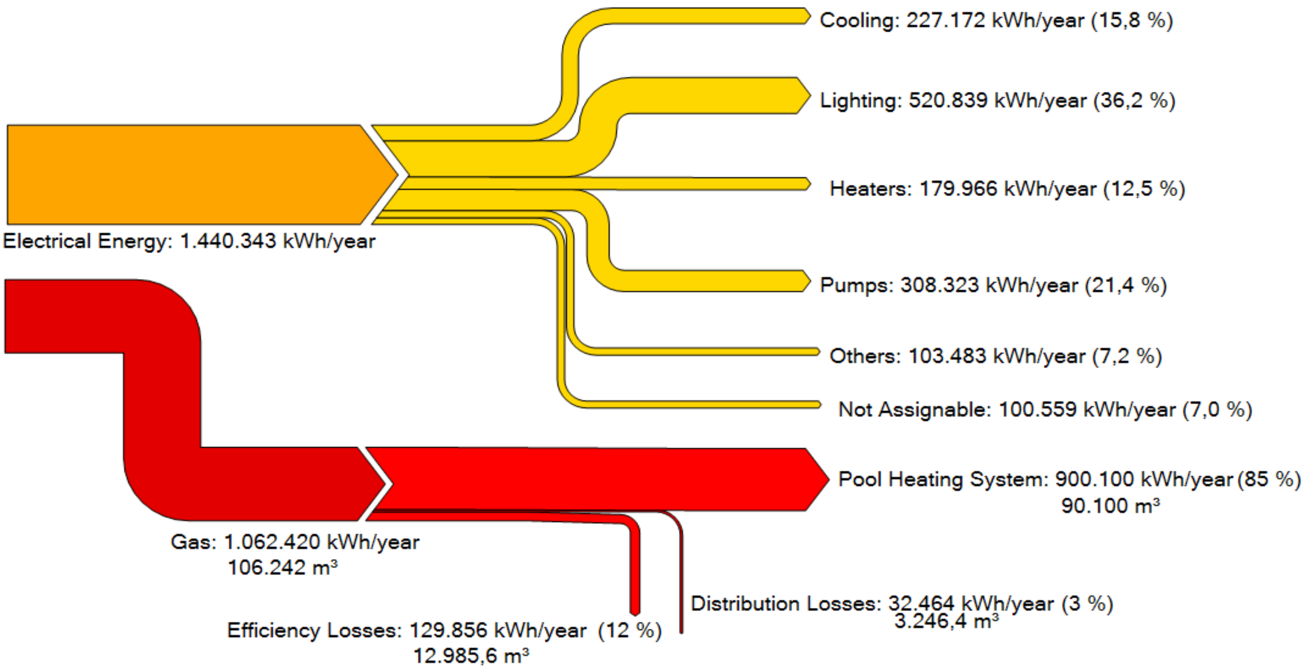


Figure 22: Energy Distribution Diagram (Sankey-Diagram)

Table 13: Distribution of Electrical Energy Consumption

Cooling	Lighting	Heaters	Pumps	Others	Not Assignable
227.172 kWh/y	520.839 kWh/y	179.966 kWh/y	308.323 kWh/y	103.483 kWh/y	100.559 kWh/y
15,8 %	36,2 %	12,5 %	21,4 %	7,2 %	7 %

Table 14: Distribution of Gas Consumption

Pool Heating System	Efficiency Losses	Distribution Losses
900.100 kWh/y	129.856 kWh/y	32.464 kWh/y
85 %	12 %	3 %
90.010,0 m³	12.985,6 m³	3.246,4 m³

Table 15: Energy Consumption Distribution

Area		Equipment	Quant.	Real Power Demand	Energy consumption
		Cooling			
2	Bank	Split Unit	1	1,31 kW	2.210 kWh/year
3	Football Academy	Split Unit	2	9,65 kW	13.555 kWh/year
3	Dressing room football	Split Unit	2	2,62 kW	3.684 kWh/year
3	Wardrobe	Split Unit	1	1,83 kW	2.576 kWh/year
3	Warehouse	Split Unit	1	1,22 kW	1.717 kWh/year
3	Football material	Split Unit	1	2,29 kW	3.212 kWh/year
7	Physiotherapy	Split Unit	1	4,89 kW	6.870 kWh/year
7	Aquatic sports	Split Unit	1	1,31 kW	1.842 kWh/year
7	Physiotherapy amateur sport	Split Unit	1	1,31 kW	1.842 kWh/year
7	Swimming Academy	Split Unit	1	4,83 kW	6.777 kWh/year
7	Physiology/ Football	Split Unit	1	3,67 kW	5.152 kWh/year
7	Physical test, medical room	Split Unit	1	1,22 kW	2.061 kWh/year
8	Olympic Sports	Split Unit	2	2,62 kW	3.684 kWh/year
8	Pilates	Split Unit	1	3,98 kW	5.586 kWh/year
9	Shooting ring	Split Unit	2	6,12 kW	8.587 kWh/year
10	Trophies	Split Unit	3	12,60 kW	24.767 kWh/year
10	Trophies	Split Unit	2	5,79 kW	11.385 kWh/year
11	Kitchen	Split Unit	1	1,22 kW	2.061 kWh/year
12	Meeting Room	Split Unit	1	1,31 kW	1.842 kWh/year
12	Office	Split Unit	2	1,53 kW	2.147 kWh/year
13	Social Area	Split Unit	1	1,31 kW	2.210 kWh/year
	Marketing	Split Unit	1	0,99 kW	308 kWh/year
	Marketing	Split Unit	1	0,87 kW	1.462 kWh/year
	Marketing	Split Unit	1	1,68 kW	2.830 kWh/year
	Marcelo Penha	Split Unit	1	1,38 kW	2.159 kWh/year
	Legal department	Split Unit	1	2,45 kW	3.817 kWh/year
	Financial Department	Split Unit	1	1,18 kW	1.662 kWh/year
	Operator	Split Unit	1	1,31 kW	2.579 kWh/year
	Procurement Department	Split Unit	1	1,22 kW	1.717 kWh/year
		Split Unit	1	1,31 kW	2.210 kWh/year
	Secretary	Split Unit	1	1,98 kW	3.329 kWh/year
	Management	Split Unit	1	1,22 kW	2.061 kWh/year
	Management	Split Unit	1	1,02 kW	636 kWh/year
	Management	Split Unit	1	1,64 kW	3.224 kWh/year

	Presidency	Split Unit	1	3,06 kW	1.908 kWh/year
	Presidency	Split Unit	1	1,22 kW	763 kWh/year
	FUTSAL	Split Unit	1	1,83 kW	1.145 kWh/year
	Informatics	Split Unit	1	1,83 kW	9.618 kWh/year
	Football	Split Unit	1	1,38 kW	1.943 kWh/year
	RODRIGO CAETANO	Split Unit	1	1,22 kW	1.717 kWh/year
	MARCELO TEIXEIRA	Split Unit	1	0,87 kW	1.219 kWh/year
	Recovery Room	Split Unit	1	0,99 kW	1.386 kWh/year
	Medical Department Football	Split Unit	1	1,31 kW	1.842 kWh/year
	Football Clinic	Split Unit	1	0,92 kW	1.288 kWh/year
	Nutrition	Split Unit	1	0,92 kW	1.288 kWh/year
	Technical Room	Split Unit	1	1,31 kW	1.842 kWh/year
	Room of Masseurs	Split Unit	1	0,99 kW	1.386 kWh/year
	Press Room	Split Unit	1	1,18 kW	296 kWh/year
	Room of ANA FRAZÃO	Split Unit	1	1,31 kW	1.842 kWh/year
	Cafeteria	Split Unit	1	1,98 kW	3.884 kWh/year
	Warehouse	Split Unit	1	1,02 kW	1.272 kWh/year
	Football table	Split Unit	2	2,62 kW	1.637 kWh/year
	Trophies room/pool	Split Unit	1	1,22 kW	1.717 kWh/year
	Emergency Room	Split Unit	1	1,02 kW	1.431 kWh/year
	Auditorium	Split Unit	1	2,90 kW	4.066 kWh/year
	Swimming Academy	Split Unit	1	2,90 kW	4.066 kWh/year
	Massage Room	Split Unit	1	1,22 kW	1.717 kWh/year
	Rest Room	Split Unit	1	0,92 kW	1.288 kWh/year
	Living room	Split Unit	2	2,45 kW	3.435 kWh/year
	Reception	Split Unit	1	0,92 kW	1.803 kWh/year
	Salao Nobre	Multi Split Unit	12	72,48 kW	9.046 kWh/year
	FUTSAL room	Split Unit	1	0,92 kW	572 kWh/year
	Flu memoria antigo	Split Unit	1	0,76 kW	239 kWh/year
	ACESSORIA DE IMPRENÇA	Split Unit	1	1,83 kW	2.576 kWh/year
	Swimming teacher's room	Split Unit	1	12,23 kW	17.174 kWh/year
		Lighting			
1	Statue	Halogen	1	0,09 kW	371 kWh/year
1	CANTEIRO	T5	3	0,15 kW	546 kWh/year
1	Plaques	T12	2	0,09 kW	371 kWh/year
1	Plaques	T12	1	0,05 kW	197 kWh/year
1	Social Entrance	T12	6	0,26 kW	2.228 kWh/year

1	Saint Statue	Fluorescent	1	0,01 kW	122 kWh/year
2	Lobby	Mercury Vapor	1	0,44 kW	1.900 kWh/year
2	Open Parking lot	Mercury Vapor	5	2,18 kW	4.750 kWh/year
2	Bank	T12	4	0,17 kW	371 kWh/year
2	Lobby 2	T12	4	0,17 kW	743 kWh/year
2	Men’s Dressing Room	T12	10	0,43 kW	2.785 kWh/year
2	Women’s Dressing Room	T12	6	0,26 kW	1.856 kWh/year
2	Women’s Dressing Room	T12	4	0,17 kW	371 kWh/year
2	Men’s Dressing Room	T12	10	0,23 kW	491 kWh/year
3	Field	Mixed	24	48,40 kW	30.202 kWh/year
3	Tribune	Mercury Mixed Light	2	0,55 kW	343 kWh/year
3	Tribune	Sodium vapor	12	2,14 kW	1.333 kWh/year
4	Poles	Mercury Vapor	1	0,44 kW	475 kWh/year
4	Kids park	Mercury Mixed Light	10	2,75 kW	3.003 kWh/year
5	Court 1	Mercury Vapor	64	26,16 kW	57.133 kWh/year
5	Court Superior 1	Mercury Vapor	12	5,01 kW	10.942 kWh/year
5	Court Superior 2	Mercury Vapor	16	6,54 kW	14.283 kWh/year
5	Corridor	Mercury Mixed Light	4	1,10 kW	2.402 kWh/year
5	Entrance	Fluorescent	4	0,20 kW	437 kWh/year
5	Hallway	T12	7	0,18 kW	382 kWh/year
6	Bocha	Mercury Vapor	4	1,74 kW	2.533 kWh/year
6	Bocha	Mercury Mixed Light	2	0,55 kW	801 kWh/year
6	Poles	Fluorescent	2	0,10 kW	146 kWh/year
7	Pool	Mercury Vapor	4	1,74 kW	2.533 kWh/year
7	Pool	Mercury Vapor	10	2,75 kW	4.004 kWh/year
8	Gymnasium	Mercury Vapor	8	3,48 kW	5.067 kWh/year
8	Side Block	Mercury Vapor	20	8,18 kW	11.903 kWh/year
9	Shooting ring	Mercury Vapor	8	3,48 kW	15.201 kWh/year
10	MURAL	Halogen	6	1,13 kW	3.519 kWh/year
10	Hallway	Halogen	15	2,10 kW	6.552 kWh/year
10	Trophies	Halogen	50	4,25 kW	13.260 kWh/year
11	Salon/ Lounge	Halogen	2	0,17 kW	619 kWh/year
11	Room 1	Halogen	1	0,09 kW	124 kWh/year
11	Room 2	Halogen	4	0,34 kW	371 kWh/year
11	Reception	Incandescent	2	0,12 kW	437 kWh/year

11	Chairs	T12	14	0,32 kW	1.147 kWh/year
11	Hallway	T12	2	0,05 kW	182 kWh/year
11	Kitchen	T12	2	0,05 kW	164 kWh/year
11	Room	T12	14	0,29 kW	1.056 kWh/year
11	Room 1	Fluorescent	4	0,08 kW	111 kWh/year
11	Room 2	Fluorescent	1	0,02 kW	35 kWh/year
12	Social area	Mercury Vapor	60	26,10 kW	76.003 kWh/year
12	Social Area	Mercury Mixed Light	65	17,88 kW	52.052 kWh/year
12	Social Area	T12	464	20,88 kW	60.803 kWh/year
12	Social Area	T12	136	3,40 kW	14.851 kWh/year
12	Social Area	T12	220	5,50 kW	32.032 kWh/year
12	Social Area	T12	128	3,20 kW	9.318 kWh/year
13	General Department	Mercury Mixed Light	11	3,03 kW	7.550 kWh/year
13	General Department	Halogen	20	1,70 kW	4.243 kWh/year
13	General Department	T12	344	15,48 kW	45.078 kWh/year
13	General Department	T12	96	2,40 kW	5.990 kWh/year
13	General Department	T12	82	2,05 kW	5.117 kWh/year
		LED			
		Heaters			
8	Gym locker room	Boiler	1	18,00 kW	42.312 kWh/year
8	Sauna	Boiler	1	4,00 kW	14.104 kWh/year
8	Sauna	Boiler	1	2,00 kW	14.104 kWh/year
5	Women tennis locker room	Boiler	1	4,00 kW	14.104 kWh/year
5	Men tennis locker room	Boiler	1	4,00 kW	14.104 kWh/year
3	Football locker room	Boiler	1	18,00 kW	22.566 kWh/year
3	Football locker room	Shower	2	5,50 kW	22.566 kWh/year
	Women staff locker room	Shower	2	5,50 kW	18.053 kWh/year
	Men staff locker room	Shower	2	5,50 kW	18.053 kWh/year
		Pools Pumps			
	Amateurs	Water Pump	2	7,83 kW	65.112 kWh/year
	Olympic	Water Pump	1	13,05 kW	108.559 kWh/year

	Diving	Water Pump	1	13,05 kW	108.559 kWh/year
	Storage for return water	Water Pump	2	3,14 kW	26.092 kWh/year
		Others			
	Restaurant/ Cantina	Drink Refrigerators	12	5,76 kW	30.192 kWh/year
		Electric Ovens	6	7,20 kW	2.621 kWh/year
		Micro Wave Ovens	6	3,36 kW	1.223 kWh/year
		Coffee machines	10	9,60 kW	9.784 kWh/year
		Dish Washers	6	5,76 kW	4.403 kWh/year
		Cooling Shelves and Displays	10	4,00 kW	20.966 kWh/year
		Hot Plates	6	5,76 kW	8.806 kWh/year
		Ventilation Exhaust Kitchen	1	3,00 kW	15.288 kWh/year
	Office Equipment				
		Computers	100	1,28 kW	2.130 kWh/year
		Printers	33	19,80 kW	4.118 kWh/year
		Copy machines	25	19,00 kW	3.952 kWh/year
		Total of Energy Consumption			**1.339.784 kWh/year**
		Rest, not assignable			**100.559 kWh/year**
		Total Loads and Energy Consumption		**637,47 kW**	**1.440.343 kWh/year**
		Simultaneity Factor		**0,702**	
		Real Power Demand		**447,60 kW**	

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.

Summing up it can be said, that in total 15 electrical energy measures could collectively reduce the yearly electrical energy consumption of the Fluminense site in Laranjeiras 42,7 %.

Additionally, there is one gas saving measure with the potential to 60,8 % of the current gas consumption.

With the implementation of the energy saving measures it is estimated that 324.339 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, 0,4315 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 459.857 R$ per year considering the implementation of the energy saving measures alone. A corresponding investment of 2.090.800 R$ would be needed with a payback time of 4,5 years. The CO_2 emission reductions would be 324.339 kg.

Furthermore, in combination with the implementation of 2 energy generation measures reduces 59,8 % of the electricity consumption from the grid. Of which 9,66 % corresponds to the generation of electricity through the PV System. The PV system would reduce 11.413 kg of CO_2 per year.

It must be noted that the implementation of the planned gas based electricity generators, as stated by Fluminense will increment the gas related CO_2 emissions. Therefore, CO_2 reductions after the implementation of all 17 above stated measures will fall back to 298.684 kg/year.

With the implementation of all 17 measures the cost savings of 761.748 R$/year can be achieved, corresponding to 76 % of the current energy costs. A total investment of 4.339.200 R$/year would be needed, with an average payback time of 5,7 years.

The following measures were identified:

1. Replace Halogen Lamps by LEDs
2. Replace Fluorescent Lamps by LEDs
3. Replace Outside Mercury Vapor Lamps by LEDs

4. Motion Sensor for Light Control in Dressing Rooms and Restrooms
5. EC-Motors and Variable Air Volume Stream for Exhaust Air Fan of Kitchen
6. "Energetic Maintenance" of Cooling Units
7. Increase Set Point of Room Temperatures
8. Variable Volume Stream for Water Pumps of Pools
9. Solar Thermal System for Hot Water Supply for the Showers
10. Solar Thermal System for Hot Water Supply for Pools
11. Base Load Reduction
12. Peak Load Reduction by Management System
13. Peak Load Reduction by Electrical Generator
14. Install PV-System
15. Improve Maintenance
16. Energy Controlling
17. Training for Employees

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

6.1 Proposed Measures for Lighting Systems

6.1.1 Replace Halogen Lamps with LEDs

Current situation:

The trophy room is equipped with 99 halogen lamps in total.

The wattage of the halogen is as follows:

Table 16: Installed Halogen Lamps in Trophy Room

Quantity of Lamps	Wattage
78	85 W
15	144 W
6	180 W
TOTAL: 99	**TOTAL: 9870 W**

The average light output of the halogen lamps is around 20 lm/W. The operation times are between 1.092 and 4.368 h.

Table 17: Base Line Energy Consumption of Halogen Lamps

Energy consumption of the actual situation	
Power demand HT	9,87 kW
Power demand LT	9,87 kW
Energy consumption LT	23.594 kWh/year
Energy consumption HT	5.889 kWh/year
Total Energy consumption	29.493 kWh/year

Figure 23: Installed Halogen Lamps in Trophy Room

Figure 24: Installed Halogen Lamp

Proposed measure:

It is recommended to replace the Halogen Lamps by LEDs.

Figure 25: LED Halogen Lamp Replacement

Energy, CO_2 and cost savings:

By replacing the Halogen lamps by LED electricity savings of 23.594 kWh per year are expected as well as a load reduction of 8 kW, corresponding 16.058 R$ savings per year. The estimated investment is 21.250 R$ and has a payback time of 1,3 years. The installation of the LEDs will result also in less maintenance cost and a lowered cooling demand. The energy saving estimation is shown on table 18 and the economic analysis is shown on the Table 19.

Table 18: Energy Savings LED Solution Calculation

Area N.	Room Name	No. of Lamps	Operating Hours	Actual Energy Consumption	Energy Consumption LED-Solution	Energy Savings
1	Statue	1	4.368 h/a	378 kWh/y	76 kWh/year	302 kWh/y
10	Mural	6	3.120 h/a	3.547 kWh/y	709 kWh/year	2.838 kWh/y
11	Hallway	15	3.120 h/a	6.622 kWh/year	1.324 kWh/year	5.298 kWh/y
10	Trophies	50	3.120 h/a	13.494 kWh/y	2.699 kWh/year	10.795 kWh/y
11	Salon/ Lounge	2	3.640 h/a	630 kWh/y	126 kWh/year	504 kWh/y
11	Room 1	1	1.456 h/a	126 kWh/y	25 kWh/year	101 kWh/y
11	Room 2	4	1.092 h/a	378 kWh/y	76 kWh/year	302 kWh/y
13	General Department	20	2.496 h/a	4.318 kWh/y	864 kWh/year	3.454 kWh/y
Total		**99**		**29.493 kWh/y**	**5.899 kWh/y**	**23.594 kWh/y**

Table 19: Replace Halogen Lamps with LEDs - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	8,005 kW
Reduction power demand in LT-times	8,005 kW
Reduction in energy consumption HT	4.719 kWh/year
Reduction in energy consumption LT	18.876 kWh/year
Total energy consumption savings	**23.594 kWh/year**
Cost savings	
Reduction cost for power demand HT	6.712 R$/year
Reduction cost for power demand LT	2.434 R$/year
Reduction cost for energy consumption HT	2.036 R$/year
Reduction cost for energy consumption LT	4.877 R$/year
Total Cost Savings	**16.058 R$/year**
CO_2 Savings	**1.935 kg/year**
Investment	**R$ 21.250**
Payback time	**1,3 years**

6.1.2 *Replace Fluorescent Lamps by LEDs*

Current Situation:

Most luminaries installed on site (in total 1.570 luminaries) are equipped with fluorescent lamps. The average light output over the life time of these lamps is 65 lm/W, the observed operation times are around 3.000 hours per year with some variations.

Table 20: Base Line Energy Consumption of Fluorescent Lamps

Energy consumption of the actual situation	
Power demand HT	61,6 kW
Power demand LT	61,6 kW
Energy consumption LT	164.795 kWh/year
Energy consumption HT	41.199 kWh/year
Total energy consumption	205.994 kWh/year

Proposed measure:

It is recommended to replace the florescent lamps by LEDs

Figure 26: LED Solution

Energy, CO_2 and cost savings:

The expected energy savings are 84.270 kWh per year with a load reduction of 25,217 kW, corresponding to 53.500 R$ saved per year. The estimated investment is 399.600 R$ and has a payback time of 7,5 years. The installation of the LEDs will result also in less maintenance effort. The detailed savings calculation and summary of savings is shown on the following tables.

Table 21: Energy Savings LED Solution Calculation

Area Number	Room Name	No. of Lamps	Actual Energy Consumption	Energy Consumption LED-Solution
1	CANTEIRO	3	584 kWh/y	345 kWh/y
1	Plaques	2	402 kWh/y	237 kWh/y
1	Plaques	1	212 kWh/y	125 kWh/y
1	Social Entrance	6	2.411 kWh/y	1.425 kWh/y
1	Saint Statue	1	153 kWh/y	90 kWh/y
2	Bank	4	402 kWh/y	237 kWh/y
2	Lobby 2	4	804 kWh/y	475 kWh/y
2	Men’s Dressing Room	10	3.014 kWh/y	1.781 kWh/y
2	Women’s Dressing Room	6	2.009 kWh/y	1.187 kWh/y
2	Women’s Dressing Room	4	402 kWh/y	237 kWh/y
2	Men’s Dressing Room	10	568 kWh/y	336 kWh/y
5	Entrance	4	467 kWh/y	276 kWh/y
5	Hallway	7	436 kWh/y	257 kWh/y
4	Poles	2	156 kWh/y	92 kWh/y
11	Chairs	14	1.325 kWh/y	783 kWh/y
5	Hallway	2	207 kWh/y	123 kWh/y
11	Kitchen	2	189 kWh/y	112 kWh/y
11	Room	14	1.234 kWh/y	729 kWh/y
11	Room 1	4	131 kWh/y	77 kWh/y
11	Room 2	1	41 kWh/y	24 kWh/y
12	Social Area	464	65.532 kWh/y	38.723 kWh/y
12	Social Area	136	16.930 kWh/y	10.004 kWh/y
12	Social Area	220	36.516 kWh/y	21.578 kWh/y
12	Social Area	128	10.623 kWh/y	6.277 kWh/y
13	General Department	344	48.584 kWh/y	28.709 kWh/y
13	General Department	96	6.829 kWh/y	4.035 kWh/y
13	General Department	82	5.833 kWh/y	3.447 kWh/y
Total		**1.571**	**205.994 kWh/y**	**121.724 kWh/y**

Table 22: Daylight Sensor in Vestibule - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	25,217 kW
Reduction power demand in LT-times	25.217 kW
Reduction in energy consumption HT	67.416 kWh/year
Reduction in energy consumption LT	16.854 kWh/year
Total energy consumption savings	**84.270 kWh/year**
Cost savings	
Reduction cost for power demand HT	21.144 R$/year
Reduction cost for power demand LT	7.666 R$/year
Reduction cost for energy consumption HT	7.272 R$/year
Reduction cost for energy consumption LT	17.418 R$/year
Total Cost Savings	**53.500 R$/year**
CO_2 Savings	**6.910 kg/year**
Investment	**R$ 399.600**
Payback time	**7,5 years**

6.1.3 Replace Outside Mercury Vapor Lamps by LEDs

Current situation:

The lighting of the outside area (pools and sport fields) is mainly done with mercury vapor lamps of 250 and 400 W. In total 307 lamps are installed. The average light output of the mercury vapor lamps over their lifetime is around 55 lm/W. The operation hours are between 624 and 4.368 hours per year.

Table 23: Base Line Energy Consumption of Outside Lighting Systems (Mercury Vapour Lamps)

Energy consumption of the actual situation	
Power demand HT	114,1 kW
Power demand LT	114,1 kW
Energy consumption LT	218.304 kWh/year
Energy consumption HT	54.576 kWh/year
Total energy consumption	272.880 kWh/year

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 136.440 kWh per year with a power reduction of 57,035 kW. The corresponding costs savings are 105.135 R$ per year. The estimated investment for this measure is 429.300 R$ which is expected to payback in 4,1 years.

Table 24: Energy Savings LED Solution Calculation

Area Number	Room Name	No. of Lamps	Actual Energy Consumption	Energy Consumption LED-Solution
2	Lobby	1	1.900 kWh/y	950 kWh/y
2	Open Parking lot	5	4.750 kWh/y	2.375 kWh/y
3	Tribune	2	343 kWh/y	172 kWh/y
4	Poles	1	475 kWh/y	238 kWh/y
4	Kids park	10	3.003 kWh/y	1.502 kWh/y
5	Court 1	64	57.133 kWh/y	28.567 kWh/y
5	Court Superior 1	12	10.942 kWh/y	5.471 kWh/y
5	Court Superior 2	16	14.283 kWh/y	7.142 kWh/y
5	Corridor	4	2.402 kWh/y	1.201 kWh/y
6	Bocha	4	2.533 kWh/y	1.267 kWh/y
6	Bocha	2	801 kWh/y	400 kWh/y
7	Pool	4	2.533 kWh/y	1.267 kWh/y
7	Pool	10	4.004 kWh/y	2.002 kWh/y
8	Gymnasium	8	5.067 kWh/y	2.533 kWh/y
8	Side Block	20	11.903 kWh/y	5.951 kWh/y
9	Shooting ring	8	15.201 kWh/y	7.600 kWh/y
12	Social area	60	76.003 kWh/y	38.002 kWh/y
12	Social Area	65	52.052 kWh/y	26.026 kWh/y
13	General Department	11	7.550 kWh/y	3.775 kWh/y
Total		**307**	**272.880 kWh/y**	**136.440 kWh/y**

Table 25: Replace Outside Mercury Vapor Lamps by LEDs - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	57,035 kW
Reduction power demand in LT-times	57,035 kW
Reduction in energy consumption HT	27.288 kWh/year
Reduction in energy consumption LT	109.152 kWh/year
Total energy consumption savings	**136.440 kWh/year**
Cost savings	
Reduction cost for power demand HT	47.822 R$/year
Reduction cost for power demand LT	17.339 R$/year
Reduction cost for energy consumption HT	11.774 R$/year
Reduction cost for energy consumption LT	28.200 R$/year
Total Cost Savings	**105.135 R$/year**
CO_2 Savings	**11.188 kg/year**
Investment	**R$ 429.300**
Payback time	**4,1 years**

6.1.4 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 30 fixtures are installed. The lamps are operated for at least 2.184 hours per year in some dressing rooms and others operate up to 7.280 hrs per year. At least during 8 hours per day, the required light levels are exceeded. This is the case in approximately 2.920 hours per year. We assume that the installation of motion sensors for light control, as proposed measure will take place after the T12 lamps have been replaced by LEDs; therefore the baseline energy consumption is estimated based on the LEDs.

Table 26: Base Line Energy Consumption of Lighting in Dressing Rooms and Rest Rooms

Energy consumption of the actual situation	
Energy consumption LT	2.241 kWh/year
Energy consumption HT	560 kWh/year
Total energy consumption	2.802 kWh/year

Proposed measure:

It is recommended to install a motion sensor to control the lighting system in the dressing rooms and the restrooms.

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 1.212 kWh per year with a corresponding cost saving of 328 R$. The investment to implement this measure would be 2.000 R$, with a payback time of 6,1 years. The savings calculation is shown on the table below.

Table 27: Install Motion Sensor for Light Control in Dressing Rooms and Restrooms - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction in energy consumption HT	224 kWh/year
Reduction in energy consumption LT	897 kWh/year
Total energy consumption savings	**1.121 kWh/year**
Cost savings	
Reduction cost for energy consumption HT	97 R$/year
Reduction cost for energy consumption LT	232 R$/year
Total Cost Savings	**328 R$/year**
CO_2 Savings	**92 kg/year**
Investment	**R$ 2.000**
Payback time	**6,1 years**

6.2 Proposed Measures for Ventilation System

6.2.1 EC-Motors and Variable Air Volume Stream for Exhaust Air Fan of Kitchen

Current situation:

The existing ventilation unit of the kitchen is equipped with standard fan motors and operated at a scheduled constant air flow and constant speed. The nominal power of the motor is about 3 kW.

Table 28: Base Line Energy Consumption of Kitchen Ventilation System

Energy consumption of the actual situation	
Power demand HT	3 kW
Power demand LT	3 kW
Energy consumption LT	12.230 kWh/year
Energy consumption HT	3.058 kWh/year
Total energy consumption	15.288 kWh/year

Figure 29: Kitchen Ventilation Unit

Proposed measure:

It is recommended to install a highly efficient ventilator with EC – Motor and variable speed control. A temperature sensor will need to be installed in the exhaust air duct for the speed control of the ventilator.

Energy, CO_2 and cost savings:

The higher efficiency of the motor itself and the usage of its variable speed function could reduce the yearly energy consumption of the fan drive by 40%. The savings calculation is shown on the table below.

Table 29: EC-Motors and Variable Air Volume Stream for Exhaust Air Fan of Kitchen- Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	0,3 kW
Reduction power demand in LT-times	0,3 kW
Reduction in energy consumption HT	1.223 kWh/year
Reduction in energy consumption LT	4.892 kWh/year
Total energy consumption savings	**6.115 kWh/year**
Cost savings	
Reduction cost for power demand HT	252 R$/year
Reduction cost for power demand LT	91 R$/year
Reduction cost for energy consumption HT	528 R$/year
Reduction cost for energy consumption LT	1.264 R$/year
Total Cost Savings	**2.134 R$/year**
CO_2 Savings	**501 kg/year**
Investment	**R$ 9.000**
Payback time	**4,2 years**

6.3 Proposed Measures for Cooling System

6.3.1 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 energy relevant cooling units is 212.832 kWh/year. Their remaining power demand is around 105,72 kW.

Table 30: Base Line Energy Consumption of Air Conditioning Units

Energy consumption of the actual situation	
Power demand HT	105,72 kW
Power demand LT	105,72 kW
Energy consumption LT	170.266 kWh/year
Energy consumption HT	42.566 kWh/year
Total energy consumption	212.832 kWh/year

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 12.770 kWh per year and the load reduction would be 6,343 kW. The corresponding cost savings are 10.988 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 31: Increase Set Point of Room Temperature - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	6,343 kW
Reduction power demand in LT-times	6,343 kW
Reduction in energy consumption HT	10.216 kWh/year
Reduction in energy consumption LT	2.554 kWh/year
Total energy consumption savings	**12.770 kWh/year**
Cost savings	
Reduction cost for power demand HT	5.319 R$/year
Reduction cost for power demand LT	1.928 R$/year
Reduction cost for energy consumption HT	1.102 R$/year
Reduction cost for energy consumption LT	2.639 R$/year
Total Cost Savings	**10.988 R$/year**
CO_2 Savings	**1.047 kg/year**
Investment	**R$ 0**
Payback time	**Instant**

6.3.2 Energetic Maintenance of Cooling Units

Current situation:

In total, 86 cooling systems are installed on site. There are different installation dates among the 86 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 86 cooling systems 19 are operated in very short time periods only (Marketing, Press Room, Salão Nobre, Flu Memória Antigo, Management and Presidency) and are thus not very relevant for energy management measures. After having increased the set point the remaining systems consume approximately 200.062 kWh/year. The COP of the units is estimated to be very low, around 2,3, due to their partly bad conditions.

Table 32: Base Line Energy Consumption of Air Conditioning Units

Energy consumption of the actual situation	
Power demand HT	99,38 kW
Power demand LT	99,38 kW
Energy consumption LT	160.050 kWh/year
Energy consumption HT	40.012 kWh/year
Total energy consumption	200.062 kWh/year

Figure 30: Major Deformities in Heat Exchanger Ribs

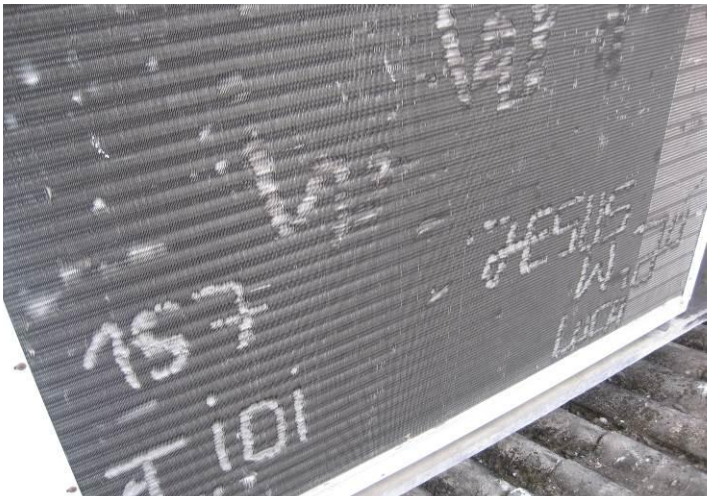


Figure 31: Major Deformities in Heat Exchanger Ribs

Figure 32: Old Damaged Units

Figure 33: Condensing Units Exposed Without Any Shading Over Them.

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 3,0 can be reached for all the cooling units. The estimated achievable energy saving are 46.681 kWh per year and 23,188 kW of load reduction, which translates in a total cost saving of 40.168 R$ per year. The corresponding investment to implement this measure would be around 250.000 R$ with a payback time of 6,2 years.

The savings calculation is shown on the table below.

Table 33: “Energetic Maintenance” of Cooling Units - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	23,188 kW
Reduction power demand in LT-times	23,188 kW
Reduction in energy consumption HT	9.336 kWh/year
Reduction in energy consumption LT	37.344 kWh/year
Total energy consumption savings	**46.681 kWh/year**
Cost savings	
Reduction cost for power demand HT	19.442 R$/year
Reduction cost for power demand LT	7.049 R$/year
Reduction cost for energy consumption HT	4.028 R$/year
Reduction cost for energy consumption LT	9.648 R$/year
Total Cost Savings	**40.168 R$/year**
CO_2 Savings	**3.828 kg/year**
Investment	**R$ 250.000**
Payback time	**6,2 years**

6.4 Proposed Measures for Pool Water Pump Systems

6.4.1 Use Variable Volume Stream for Pool Water Pumps

Current situation:

The water pumps of the pools are always running under full load 24/7. In total there are 6 pumps with a total power demand of 45,1 kW.

Table 34: Base Line Energy Consumption of Pool Water Pumping System

Energy consumption of the actual situation	
Power demand HT	45,110 kW
Power demand LT	45,110 kW
Energy consumption LT	246.658 kWh/year
Energy consumption HT	61.665 kWh/year
Total energy consumption	308.323 kWh/year

Proposed measure:

It is recommended to install highly efficient variable speed pumps. The volume stream should then be controlled depending on the respective number of swimmers in the pools.

Energy, CO_2 and cost savings:

It is expected that the full load operation time of the pool pumps can be reduced at least by 30%. Besides of the energy consumption, the highly efficient pumps will also reduce the respective power demand. The total energy savings are expected to be 92.497 kWh per year and the load reduction would be 4,5 kW. The corresponding cost savings are 32.253 R$ per year. The implementation of this measure requires an estimated investment of 100.000 R$ which would have a corresponding payback time of 3,1 years.

The savings calculation is shown on the table below.

Table 35: Use Variable Volume Stream for the Pool Water Pumps - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	4,511kW
Reduction power demand in LT-times	4,511 kW
Reduction in energy consumption HT	18.499 kWh/year
Reduction in energy consumption LT	73.998 kWh/year
Total energy consumption savings	**92.497 kWh/year**
Cost savings	
Reduction cost for power demand HT	3.782 R$/year
Reduction cost for power demand LT	1.371 R$/year
Reduction cost for energy consumption HT	7.982 R$/year
Reduction cost for energy consumption LT	19.118 R$/year
Total Cost Savings	**32.253 R$/year**
CO_2 Savings	**7.585 kg/year**
Investment	**R$ 100.000**
Payback time	**3,1 years**

6.5 Proposed Measures for Water Heating System

6.5.1 Solar Thermal System for Hot Water Supply for the Showers

Current situation:

The hot water demand of the showers is supplied by 12 electrical heaters, with an estimated energy consumption of 179.966 kWh per year. It is assumed that the water for the showers is heated to 40 °C. With a water supply at 23,7 °C the energy necessary to heat one kg of water to 40 °C is 18,93 W.

Table 36: Base Line Energy Consumption of Shower Water Heating System

Q.	Location	Users	liters per shower	kg per day	Thermal Energy required per day	Thermal Energy required per year	Electrical energy required per year (eff=0,98)
1	Gym locker room	150	40	6.000 kg/day	114 kWh/day	41.466 kWh/y	42.312 kWh/y
1	Sauna	50	40	2.000 kg/day	38 kWh/day	13.822 kWh/y	14.104 kWh/y
1	Sauna	50	40	2.000 kg/day	38 kWh/day	13.822 kWh/y	14.104 kWh/y
1	Women tennis locker room	50	40	2.000 kg/day	38 kWh/day	13.822 kWh/y	14.104 kWh/y
1	Men tennis locker room	50	40	2.000 kg/day	38 kWh/day	13.822 kWh/y	14.104 kWh/y
1	Football locker room	80	40	3.200 kg/day	61 kWh/day	22.115 kWh/y	22.566 kWh/y
2	Football locker room	80	40	3.200 kg/day	61 kWh/day	22.115 kWh/y	22.566 kWh/y
2	Women staff locker room	64	40	2.560 kg/day	48 kWh/day	17.692 kWh/y	18.053 kWh/y
2	Men staff locker room	64	40	2.560 kg/day	48 kWh/day	17.692 kWh/y	18.053 kWh/y
						176.367 kWh/y	**179.966 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.

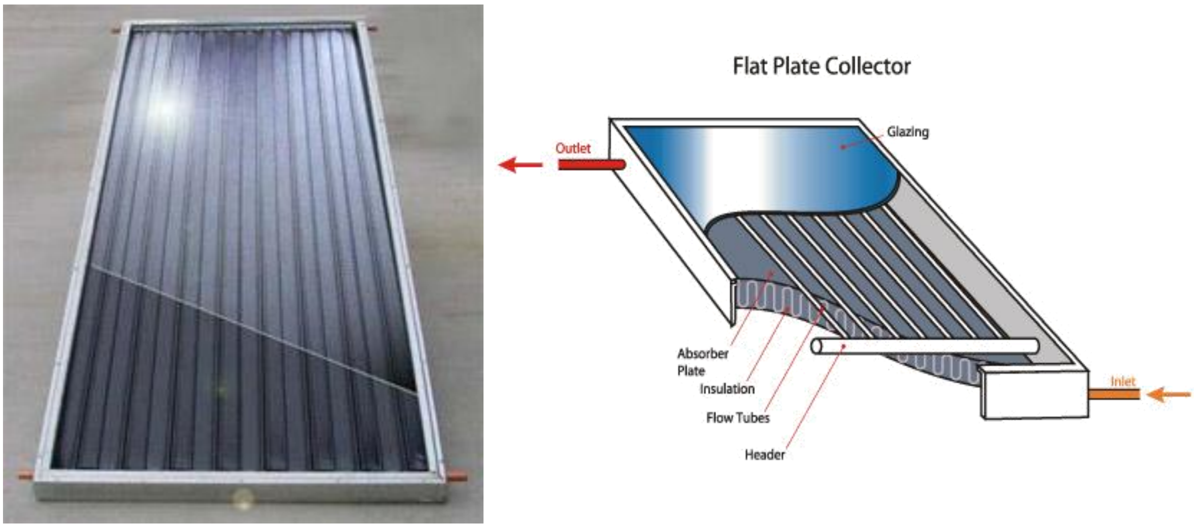


Figure 34: Glazed Solar Collector

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 300 m² with storage capacity of 100 l/m², which will provide 91 % 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 300 m², upgrading the storage temperature from 100 l/m² to 150 l/m² will result only in 2,9 % higher solar fraction. Comparably, increasing the area to 360 m² will increment the solar fraction by 5%.

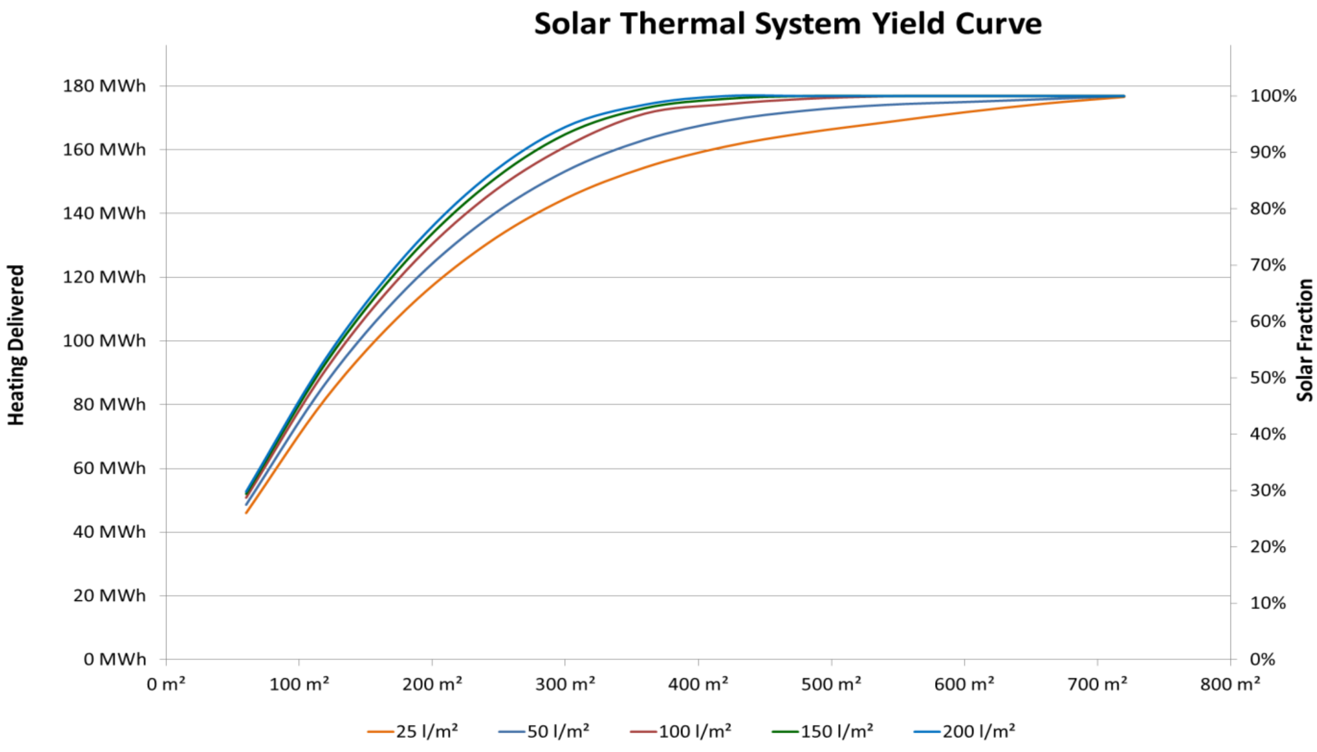


Figure 35: Solar Thermal System Yield Curve

Table 37: Solar Collector Yield Sensitivity Analysis

Storage		25 l/m²		50 l/m²		100 l/m²		150 l/m²		200 l/m²	
N Collecto	Collecto r Area	Solar Fraction	Total Energy	Solar Fraction	Total Energy	Solar Fraction	Total Energy	Solar Fraction	Total Energy	Solar Fraction	Total Energy
25	**60 m²**	26%	46,0 MWh	27%	48,6 MWh	29%	50,8 MWh	29%	52,0 MWh	30%	52,7 MWh
50	**120 m²**	46%	82,1 MWh	48%	86,9 MWh	51%	91,1 MWh	53%	93,2 MWh	53%	94,6 MWh
75	**180 m²**	62%	109,8 MWh	66%	116,3 MWh	69%	122,0 MWh	71%	125,0 MWh	72%	127,0 MWh
100	**240 m²**	74%	130,2 MWh	78%	138,0 MWh	82%	145,0 MWh	84%	148,7 MWh	85%	151,2 MWh
125	**300 m²**	82%	144,7 MWh	87%	153,3 MWh	91%	161,0 MWh	93%	164,9 MWh	95%	167,2 MWh
150	**360 m²**	87%	154,5 MWh	92%	163,2 MWh	96%	171,4 MWh	98%	173,1 MWh	98%	174,2 MWh
175	**420 m²**	91%	161,0 MWh	96%	169,1 MWh	98%	174,3 MWh	99%	176,0 MWh	100%	176,9 MWh
200	**480 m²**	93%	165,3 MWh	97%	172,3 MWh	99%	176,0 MWh	100%	176,9 MWh	100%	176,9 MWh
225	**540 m²**	95%	168,6 MWh	98%	174,1 MWh	100%	176,8 MWh	100%	176,9 MWh	100%	176,9 MWh
250	**600 m²**	97%	171,8 MWh	99%	175,0 MWh	100%	176,9 MWh	100%	176,9 MWh	100%	176,9 MWh
275	**660 m²**	99%	174,5 MWh	99%	175,9 MWh	100%	176,9 MWh	100%	176,9 MWh	100%	176,9 MWh
300	**720 m²**	100%	176,6 MWh	100%	176,9 MWh	100%	176,9 MWh	100%	176,9 MWh	100%	176,9 MWh

A total of 300 m² of solar collectors should be installed with storage capacity of 100 l per m² of solar collector, dived in smaller systems as follows.

Location	Solar Collector Area
Gym locker room	71,0 m²
Sauna	23,4 m²
Sauna	23,4 m²
Women‘s tennis locker room	23,4 m²
Men‘s tennis locker room	23,4 m²
Football locker room	37,5 m²
Football locker room	37,5 m²
Women‘s staff locker room	30,1 m²
Men‘s staff locker room	30,1 m²

Energy, CO_2 and cost savings:

It is expected that the solar collectors cover 91% of the demand of hot water. Therefore, the total energy savings are expected to be 161.970 kWh per year and the load reduction would be 19,65 kW. The corresponding cost savings are 64.296 R$ per year. The implementation of this measure requires an estimated investment of 341.250 R$ which would have a corresponding payback time of 5,3 years. The savings for energy consumption where calculated based only in the low tariff schedule, since no statics of the shower use is available. The savings can be expected to be much higher due to the use of the showers in the High Tariff schedule. The savings calculation is shown on the table below.

Table 38: Solar Thermal System for Hot Water Supply for the Showers - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	69,87 R$/kW and month
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Price energy HT	0,431 R$/kWh
Savings	
Reduction power demand in HT-times	19,650 kW
Reduction power demand in LT-times	19,650 kW
Reduction in energy consumption LT	161.970 kWh/year
Total energy consumption savings	**161.970 kWh/year**
Cost savings	
Reduction cost for power demand HT	16.476 R$/year
Reduction cost for power demand LT	5.974 R$/year
Reduction cost for energy consumption LT	41.846 R$/year
Total Cost Savings	**64.296 R$/year**
CO_2 Savings	**13.282 kg/year**
Investment	**R$ 341.250**
Payback time	**5,3 years**

6.5.2 Solar Thermal System for Hot Water Supply for the Pools

Current situation:

The pools are heated with gas boilers. Based on the gas invoices of 2012 the total gas consumption for heating the pool water is 106.242 m³ with an estimated equivalent of 1.062.420 kWh. Invoices do not show the price per m³ of gas, therefore an average value of 1,41 R$/m³ was estimated with the total m³ and total cost. It is considered that the desired temperatures for the pools are 27 °C.

Table 39: Base Line Gas Consumption of Pool Water Heating System.

Gas consumption of the actual situation	
Gas Consumption	106.242 m³
Energy Consumption (Gas)	1.062.420 kWh
Heating Demand of the Pools	900.100 kWh/year
Losses (distribution and efficiency)	162.320 kWh/year

Proposed measure:

It is recommended to install unglazed solar collectors for Hot Water Supply to the pools. The unglazed solar collectors are proper for desired temperatures under 35°C and have very low cost. A total of 1.221 m² of solar collectors should be installed, which is expected to cover 61% of the Hot Water Demand.

Figure 36: Unglazed Solar Thermal Collector

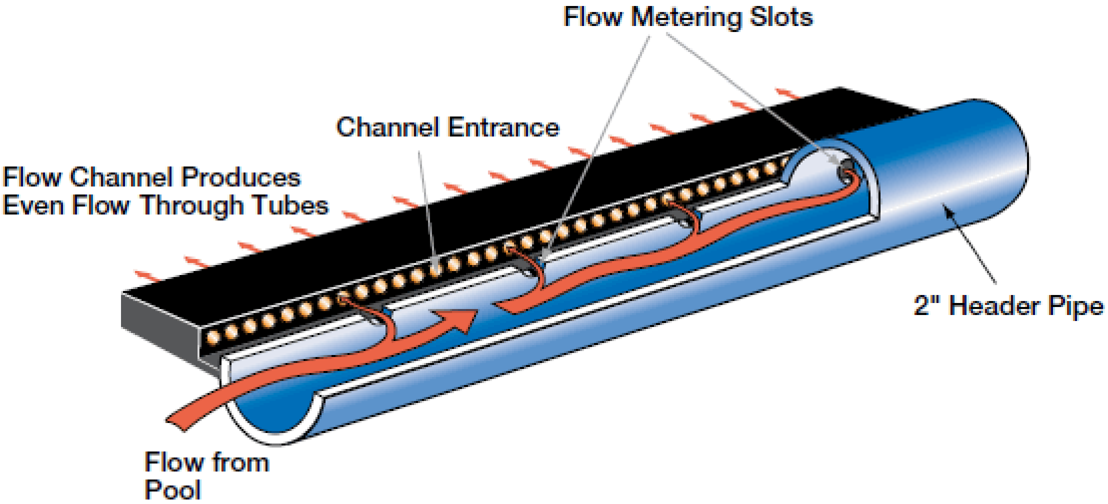


Figure 37: Unglazed Solar Thermal Collector Scheme

Energy, CO_2 and cost savings:

According with the calculation done with the clean energy project analysis software RETScreen 4, the heating delivered with the solar thermal system is 547.400 kWh per year, with a gas heater efficiency of 84,72 % this would be equivalent to 646.116 kWh saved per year, corresponding to 64.612 m³ per year.

Table 40: Solar Thermal System for Hot Water Supply for the Pools - 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	547.400 kWh/year
Reduction of Gas Consumption	**646.116 kWh/year**
Reduction of Gas Consumption	**64.612 m³/year**
Cost savings	
Total Cost Savings	**91.102 R$/year**
CO_2 Savings	**273.953 kg/year**
Investment	**R$ 488.400**
Payback time	**5,4 years**

6.6 Proposed Measures for Energy Supply System

6.6.1 Base Load Reduction

Current situation:

The base load currently is in the range of 100 kW to 125 kW, as seen on section 3.2 Characteristic Power Demand. It is considered that a lot of equipment specially lights and split units operate during night time without being needed.

Table 41: Base Load

Energy consumption of the actual situation	
Power demand LT	125 kW

Proposed measure:

It is recommended, to switch off the equipment that is not needed during night time, for example split units and lighting in unoccupied areas. To do so, switch clocks controlling the systems can be installed and programmed to switch off the systems at 23:00 or at the time, when the area is not any more occupied.

Energy, CO_2 and cost savings:

It is expected, that the load could be reduced by 20 kW during base load operation time from 23:00 pm to 6:00 am.

The total energy savings are expected to be 49.000 kWh per year. The corresponding cost savings are 18.740 R$ per year. The implementation of this measure requires an estimated investment of 10.000 R$ which would have a corresponding payback time of 0,5 years. The savings calculation is shown on the table below.

Table 42: Base Load Reduction - Energy Savings, Costs Savings and CO2 Savings

Electricity Cost	
Price power demand LT	25,33 R$/kW and month
Price energy LT	0,258 R$/kWh
Savings	
Reduction power demand in LT-times	20 kW
Reduction in energy consumption LT	49.000 kWh/year
Total energy consumption savings	**49.000 kWh/year**
Cost savings	
Reduction cost for power demand LT	6.080 R$/year
Reduction cost for energy consumption LT	12.660 R$/year
Total Cost Savings	**18.740 R$/year**
CO_2 Savings	**4.018 kg/year**
Investment	**R$ 10.000**
Payback time	**0,5 years**

6.6.2 Peak Load Reduction by Management System

Current situation:

The peak load currently is in the range of 325 kW to 448 kW. The peak load occurs always in the evening hours between 17:00 pm and 21:00 pm. During the high tariff period, the maximum load exceeds the hired power (360 kW) by 87,8 kW. This period corresponds to the high tariff schedule. The daily analysis shows, that the highest peak loads are appearing on Tuesdays, less frequency on Mondays and Wednesdays, none from Thursdays to Sundays. 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 so far recommended measures, the peak loads will be reduced by approximately 144 kW x 0,7 (simultaneity factor) = 100 kW. Most of the load reduction will realized with the installation of efficient luminaries. Thus, most of the load reduction will already be affected in the evening hours (high tariff period). For that reason, the fee for the exceeding power will already be avoided, when the recommended measures are realized.

It is expected, that after the realization of the efficiency measures the real peaks in the load curves could be less than 30 kW.

Table 43: Peak Load after Recommended Measures have been Implemented

Energy consumption of the actual situation	
Power demand	348 kW

Proposed Measure:

It is recommended to install a peak load management system for the reducing the peak loads of about 30 kW in the high tariff period. Electrical consumers like the redundant electrical water heaters, the pool pumps and some 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 30 kW, corresponding to yearly cost savings of 25.154 R$/year. The investment needed for the peak load management system would be around 40.000 R$ with a payback time of 1,6 years. The savings calculation is shown on Table 44.

Table 44: Peak Load Reduction by Management System - Energy Savings, Costs Savings and CO_2 Savings

Electricity Cost	
Price power demand HT	68,87 R$/kW and month
Energy Savings	
Reduction power demand in HT-times	30 kW
Cost savings	
Reduction cost for power demand HT	25.154 R$/year
Total Cost Savings	**25.154 R$/year**
Investment	**R$ 40.000**
Payback time	**1,6 years**

6.6.3 Peak Load Reduction by Electricity Generator

Current situation:

The peak load currently is in the range of 325 kW to 448 kW. The peak load occurs always in the evening hours between 17:00 pm and 21:00 pm. During the high tariff period, the maximum load exceeds the hired power (360 kW) by 87,8 kW. This period corresponds to the high tariff schedule. The daily analysis shows, that the highest peak loads are appearing on Tuesdays, less on Mondays and Wednesdays, none from Thursdays to Sundays. 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 scheduled training courses and sports activities.

It has to be considered, that after the realization of the so far recommended measures, the peak loads will be reduced by approximately 144 kW x 0,7 (simultaneity factor) = 100 kW. Most of the load reduction will be realized with the installation of efficient luminaries. Thus, most of the load reduction is affected in the evening hours (high tariff period). For that reason, the fee for the exceeding power would already be avoided, when the recommended measures were realized.

It is expected, that after the realization of the efficiency measures the real peaks in the load curves could be less than 30 kW.

Table 45: Peak Load After Recommended Measures Have Been Implemented

Energy consumption of the actual situation	
Power demand LT	348 kW_{el}
Power demand HT	348 kW_{el}
Energy consumption after realizing the measures (LT)	108.383 kWh_{el}/y
Energy consumption after realizing the measures (HT)	647.953 kWh_{el}/y
Energy consumption after realizing measures	756.336 kWh_{el}/y

Measure:

Installation of a generator (720 kW_{el}) for peak load generation in High Tariff times;

Energy, CO_2 and cost savings:

It is expected that the load is reduced by 348 kW of peak load during high tariff schedule, corresponding to 108.383 kWh_{el} per year.

The total value of the generated power and electricity adds up 338.550 R$ per year. It is estimated, that the total costs of operating the generator (including operation cost, consumption of gas) add up 72.607 R$/year. Considering that the investment is done through a loan with 3% interest and that is paid back in ten years, the yearly cash flow (annuity) would be 119.433 R$/year.

Evaluating the investment as one payment in the first year without interests, the payback time would be 4,7 years.

It is recommended to operate the generator just in High Tariff times, since in HT the electricity costs are lower than the costs of operating the generator. Conversely, in the LT times no savings would be obtained by operating the generator due to lower electricity costs.

The economic analysis is shown on table 47. No CO_2 savings will take place, on the contrary the CO_2 emissions will increase by operating the generator.

Table 46: Generated Power and Electricity

Electricity Cost	
Price power demand HT	69,87 R$/kW$_{el}$ and month
Price power demand LT	25,33 R$/kW$_{el}$ and month
Price of energy consumption HT	0,431 R$/kWh$_{el}$
Price of energy consumption LT	0,258 R$/kWh$_{el}$
Operation and Power Generation of Generators	
Total Electrical Power of Generators (2 x 360 kW$_{el}$)	720 kW$_{el}$
Average Electrical Efficiency of the Generators	30,0 %
Gas Power Required for Generators	2.400 kW
Maximum Full Load Hours of installed Capacity (Generator 1 and 2) in HT-Period	151 hours/year
Reduction power demand in HT-times	348 kW$_{el}$
Generated Electricity, Reduction Energy Consumption in HT-Period	108.383 kWh$_{el}$/year
Full Load Operation Time of Generator during HT-Period	2,9 hours/week
Yearly Gas Consumption of Generator	361.276 kWh/year
Value of Generated Power	
Value of Generated Electricity HT-Period (kWh)	46.762 R$/year
Value of Generated Power HT (kW)	291.788 R$/year
Total Value of Generated Power	**338.550 R$/year**

Table 47:Capital, Maintenance and Operation Costs of Generator.

Capital Costs	
Specific Cost of Generator	1736,11 R$/kW$_{el}$
Absolute Cost of Generator	1.250.000 R$
Depreciation period	10,0 years
Interest Rate	3,0%
Annuity Factor	0,1172
Yearly Capital Cost of Generator	**146.500 R$/year**
Operation Costs	
Specific Maintenance Cost	0,20 R$/kWh$_{el}$
Yearly Maintenance Cost	**21.667 R$/year**
Consumption Cost	
Yearly Gas Consumption of Generator	361.276 kWh/a
Specific Gas Price	0,141 R$/kWh
Yearly Gas Costs	**50.940 R$/year**
Total Costs	**219.117 R$/year**

Table 48: Cash Flow

Cash Flow	**119.433 R$/year**
Savings (Value of Generated Power - Operation Costs – Consumption Cost)	**265.933 R$/year**
Payback Time	**4,7 years**

Due to the complexity of all the elements involved in this measure and the high investment that is required for its implementation, a sensitivity analysis was done.

Table 49: Sensitivity Analysis

Variation	-30%	-20%	-10%	0%	10%	20%	30%
	Payback Time						
Gas Price	4,4 years	4,5 years	4,6 years	4,7 years	4,8 years	4,9 years	5,0 years
Generator Efficiency	5,1 years	4,9 years	4,8 years	4,7 years	4,6 years	4,6 years	4,5 years
Maintenance Costs	4,6 years	4,6 years	4,7 years	4,7 years	4,7 years	4,8 years	4,8 years
Electricity Tariffs	7,6 years	6,3 years	5,4 years	4,7 years	4,2 years	3,7 years	3,4 years

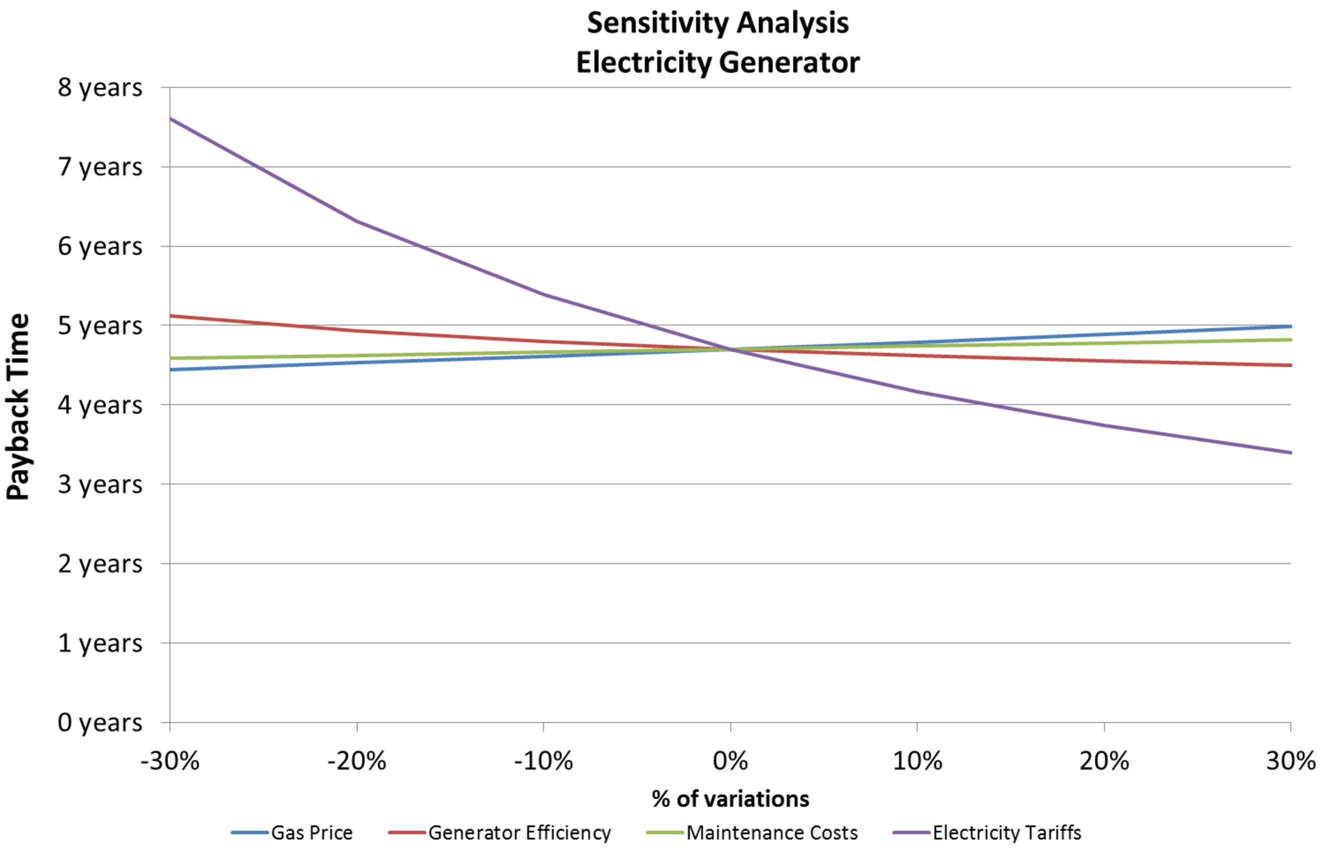


Figure 38: Sensitivity Analysis, Electricity Generator.

As it can be seen on the Figure 38 and on the table 49, the most sensible variables are the electricity prices and the generator efficiency. Therefore, it is especially important to make sure that the generator will run in optimum conditions. To do so, proper maintenance should be given, and it needs to run in the load recommended by the manufacturer. Running on partial loads causes the efficiency to decrease significantly as it is shown on Figure 39. Running on part loads not only does the efficiency drop, but also the CO_2 emissions increase.

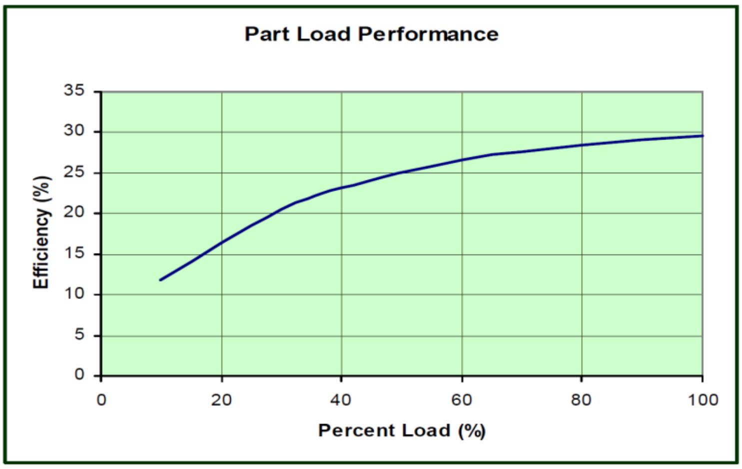


Figure 39: Typical Part Load Derivate Curve. Source: EEA/ICF

The option of 720 kW_{el} generator capacity is evaluated in this measure to assess the current installed capacity and evaluate if this capacity corresponds to the power demand. But as it can be seen Figure 40 the generators are oversized, the installed capacity is at all times much higher than the highest peak load. Each generator has a capacity of approximately 360 kW_{el}, after the previously recommended energy saving measures are implemented the estimated peak load is 348 kW_{el}, therefore one generator would cover this easily and the other one would be unused. Furthermore, in peak load, the generator would work in a part load ratio, hence with a efficiency lower than the nominal efficiency. With the load values of the month of October it was calculated that the average operating load ratio of the generator will be 66%. Which according to Figure 39 would reduce the average efficiency to about 27%.

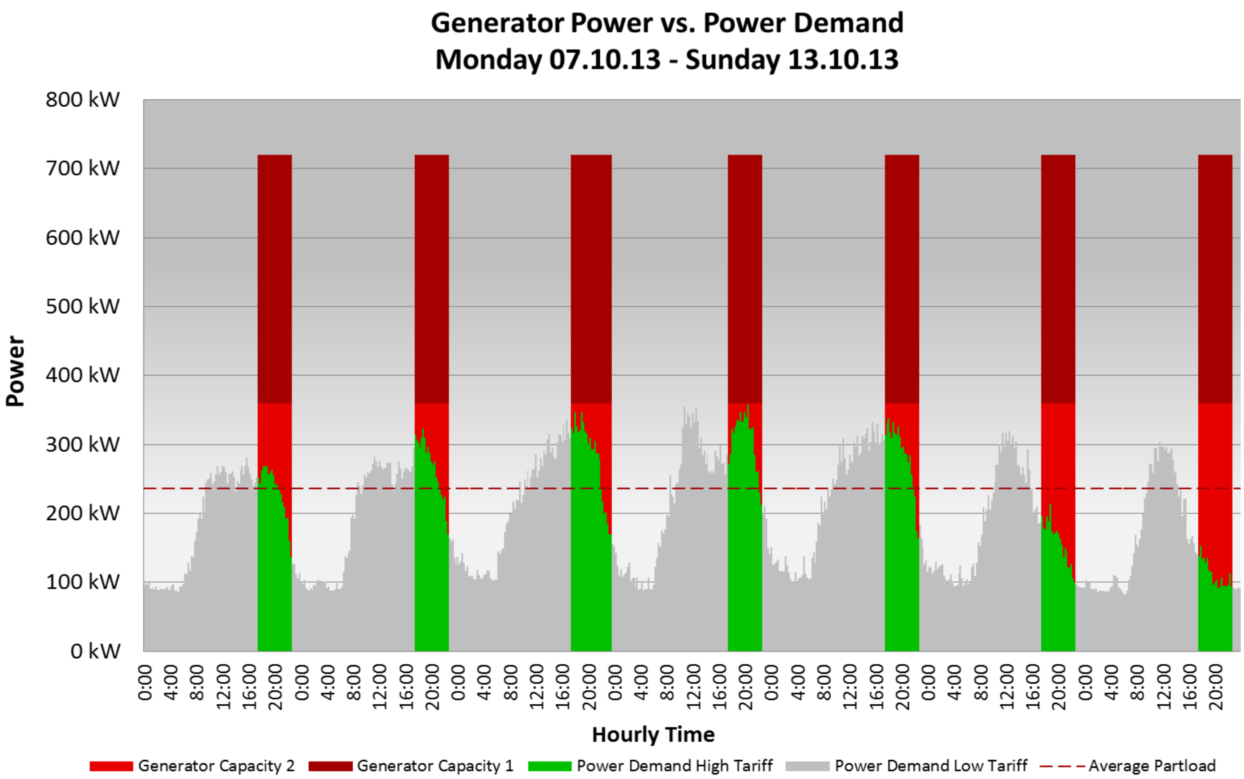


Figure 40: Generator Sizing Analysis.

6.7 Proposed Measures for Electrical System

6.7.1 Install PV-System

Current situation:

No PV-System installed;

Table 50: Base Line Energy Consumption

Energy consumption of the actual situation	
Final energy consumption of the site after all measures	614.459 kWh/year

Proposed measure:

It is recommended, to install a PV-System with a power of 124,8 kW_{Peak} (according to the following schematic), after the preceding measures have been implemented, which provides a solar fraction of 23,3 %, meaning it produces 23,3 % of the electrical energy demand of the site.

Figure 41 shows the roof taken into consideration for the design of the PV System. The estimated area is 990 m².

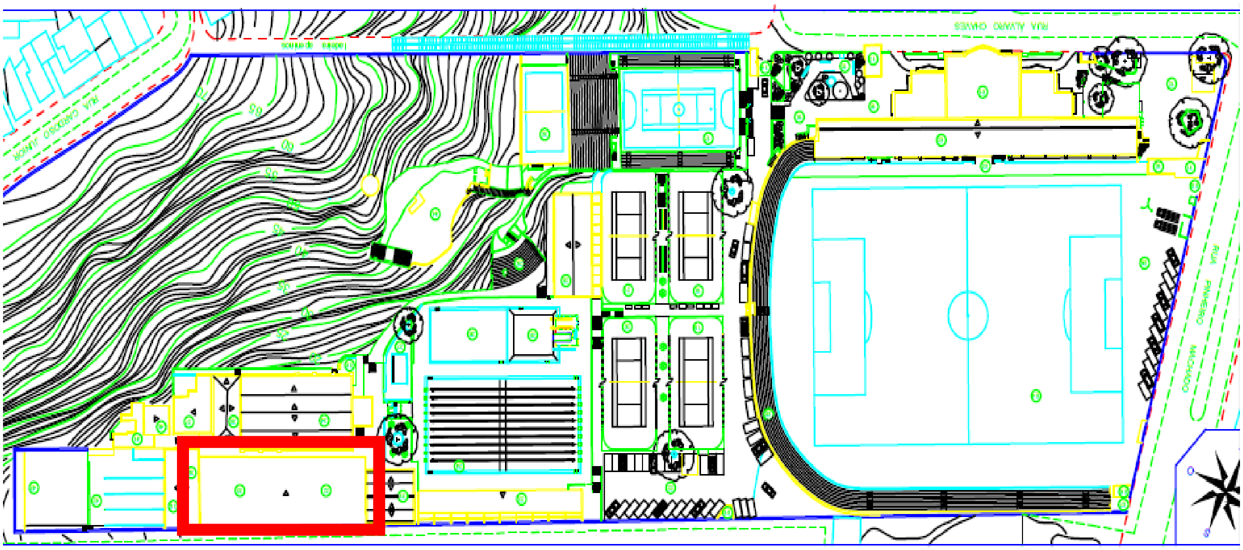


Figure 41: Selected Roof for PV System

The proposed PV System is shown on the following scheme.

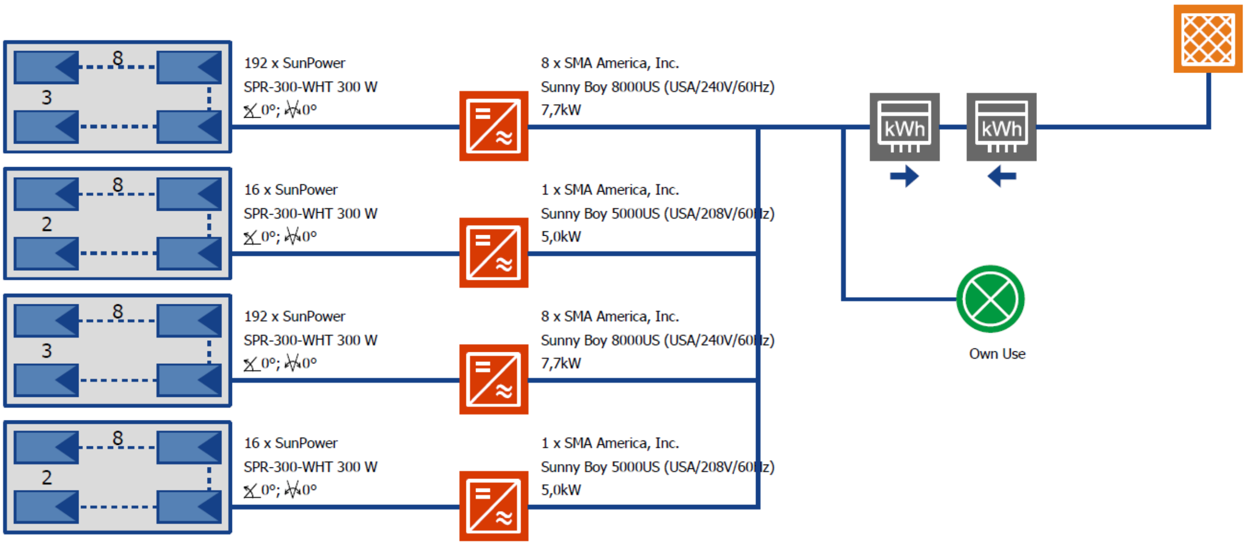


Figure 42: PV System Scheme. PV*Sol Expert 4.0 (R9)

Figure 42 shows the panel configuration in 2 blocks.

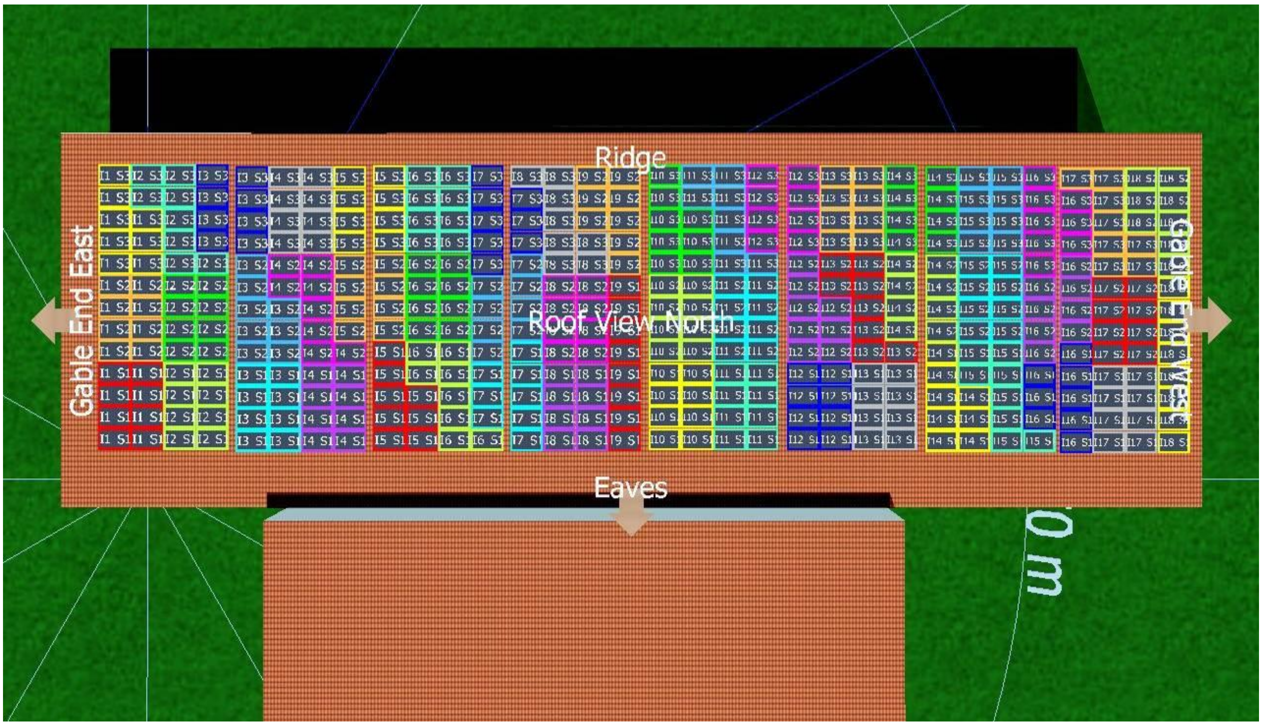


Figure 43: Arrangement

Table 51: PV System Arrangement

Block	Modules	Inverters	Arrangement per Inverter
1	192 x SunPower SPR - 315 - WHT 315 W	8 x SMA SB 8000	8 Modules x 3 Strings
	16 x SunPower SPR - 315 - WHT 315 W	1 x SMA SB 5000	8 Modules x 2 Strings
2	192 x SunPower SPR - 315 - WHT 315 W	8 x SMA SB 8000	8 Modules x 3 Strings
	16 x SunPower SPR - 315 - WHT 315 W	1 x SMA SB 5000	8 Modules x 2 Strings

Figure 44 shows the shading frequency of the PV System. The simulated shading is due to the adjacent building, it should be evaluated if there are other objects in the roof causing shading. There is a yield reduction of 5% caused by shading because the site is surrounded by mountains and tall buildings.

Figure 44: Shading Frequency

Energy, CO_2 and cost savings:

According to the simulation in the Software PV*Sol Expert 4.0 (R9) the proposed system of 124,8 kW_{Peak} would generate 143.407 kWh per year, based on the load profile behavior 139.177 kWh of the solar production will be directly used.

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

Table 52: Energy Production PV System.

Energy Production	
Energy Produced by PV Array (AC)	143.407 kWh
Energy to Grid	1.529 kWh
Consumption Requirement	825.884 kWh
Direct use of PV Energy	139.177 kWh
Energy from Grid	475.409,4 kWh
Yield Reduction Due to Shading	5 %

Table 53: PV System Performance Indicators

System Performance Indicators	
Solar Fraction	23,3%
System Efficiency	13,9 %
Performance Ratio	75,9 %
PV Array Efficiency	15,4 %
Inverter Efficiency	93,2%
Sizing Factor of Inverters	96%
Specific Annual Yield	1.148 kWh/kWp

Table 54: Install PV-System - Energy Savings, Costs Savings and CO_2 Savings

Electricity Costs	
Price energy LT	0,258 R$/kWh
Savings	
Energy Savings	**139.177 kWh/year**
Cost savings	
Reduction cost for energy consumption LT	35.958 R$/year
Total	**35.958 R$/year**
CO_2 savings	**11.634 kg/year**
Investment	**R$ 998.400**
Payback Time	**27,8 years**

6.8 Proposed Measures for Organization

6.8.1 Improve Maintenance

Current situation:

The current state of the air conditioning system is not adequate, due to neglected maintenance.

Proposed measure:

The maintenance procedures need to be improved to keep the air conditioning system in optimum conditions, which would not only by itself represent energy savings. It would also assure to maintain the energy savings obtained by the implementation of the previously mentioned measures.

The heat exchangers and filters need to be clean from the inside as well as from the outside.

The Air conditioning Units need to be inspected regularly to assure that there are no leakages and always filled with the right amount of refrigerant.

All sensor and controlling equipment needs to be well calibrated.

6.8.2 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.

6.8.3 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.

Table 55: Overview of Energy Saving Measures

Measures			Savings				Economics		CO_2
No.	System	Description	Electricity	Electrical Power (HT or LT)	Gas	Cost	Investment	Payback-Time	
1	Lighting System	Relpace Halogene Lamps by LEDs	23.594 kWh/year	8,0 kW	0 kWh/year	**16.058 R$/year**	**21.250 R$**	**1,3 years**	**1.935 kg/year**
2	Lighting System	Relpace Fluorescent Lamps by LEDs	84.270 kWh/year	25,2 kW	0 kWh/year	**53.500 R$/year**	**399.600 R$**	**7,5 years**	**6.910 kg/year**
3	Lighting System	Relpace Outside Mercury Vapor Lamps by LEDs	136.440 kWh/year	57,0 kW	0 kWh/year	**105.135 R$/year**	**429.300 R$**	**4,1 years**	**11.188 kg/year**
4	Lighting System	Motion Sensor for Light Control in Dressing Rooms and Restrooms	1.121 kWh/year	0,0 kW	0 kWh/year	**328 R$/year**	**2.000 R$**	**6,1 years**	**92 kg/year**
5	Ventilation System	EC-Motors and Variable Air Volume Stream for Exhaust Air Fan of Kitchen	6.115 kWh/year	0,3 kW	0 kWh/year	**2.134 R$/year**	**9.000 R$**	**4,2 years**	**501 kg/year**
6	Cooling System	Increase Set Point of Room Temperatures	12.770 kWh/year	6,3 kW	0 kWh/year	**10.988 R$/year**	**0 R$**	**0,0 years**	**1.047 kg/year**
7	Cooling System	"Energetic Maintenance" of Cooling Units	46.681 kWh/year	23,2 kW	0 kWh/year	**40.168 R$/year**	**250.000 R$**	**6,2 years**	**3.828 kg/year**
8	Pool Pumping System	Variable Volume Stream for Water Pumps of Pools	92.497 kWh/year	4,5 kW	0 kWh/year	**32.253 R$/year**	**100.000 R$**	**3,1 years**	**7.585 kg/year**
9	Hot Water System	Solar Thermal System for Hot Water Supply for the Showers	161.970 kWh/year	19,7 kW	0 kWh/year	**64.296 R$/year**	**341.250 R$**	**5,3 years**	**13.282 kg/year**
10	Hot Water System	Solar Thermal System for Hot Water Supply for Pools	0 kWh/year	0,0 kW	646.116 kWh/year	**91.102 R$/year**	**488.400 R$**	**5,4 years**	**273.953 kg/year**
11	Energy Supply	Base Load Reduction	49.000 kWh/year	20,0 kW	0 kWh/year	**18.740 R$/year**	**10.000 R$**	**0,5 years**	**4.018 kg/year**
12	Energy Supply	Peak Load Reduction by Management System	0 kWh/year	30,0 kW	0 kWh/year	**25.154 R$/year**	**40.000 R$**	**1,6 years**	
13	Energy Supply	Peak Load Reduction by Electrical Generator	108.383 kWh/year	348,0 kW	-361.276 kWh/year	**265.933 R$/year**	**1.250.000 R$**	**4,7 years**	**-37.067 kg/year**
14	Electrical System	Install PV-System	139.177 kWh/year	0,0 kW	0 kWh/year	**35.958 R$/year**	**998.400 R$**	**27,8 years**	**11.413 kg/year**
15	Organization	Improve Maintenance	0 kWh/year	0,0 kW	0 kWh/year	**0 R$/year**	**0 R$**	**0,0 years**	
16	Organization	Energy Controlling	0 kWh/year	0,0 kW	0 kWh/year	**0 R$/year**	**0 R$**	**0,0 years**	**-**
17	Organization	Training for Employees	0 kWh/year	0,0 kW	0 kWh/year	**0 R$/year**	**0 R$**	**0,0 years**	**-**
Total Savings (without Measure 13 & 14)			**614.459 kWh/year**	**194,2 kW**	**646.116 kWh/year**	**459.857 R$/year**	**2.090.800 R$**	**4,5 years**	**324.339 kg/year**
Baseline			**1.440.343 kWh/year**	**-**	**1.062.420 kWh/year**	**1.002.332 R$/year**	-	-	**568.574 kg/year**
Savings percentage (without Measure 13 & 14)			**42,7%**	**-**	**60,8%**	**45,9%**	-	-	57%
Total Savings (with Measure 13 & 14)			**862.019 kWh/year**		**284.839 kWh/year**	**761.748 R$/year**	**4.339.200 R$**	**5,7 years**	**298.684 kg/year**
Savings percentage (with Measure 13 & 14)			**59,8%**	**-**	**26,8%**	**76,0%**	-	-	**53%**

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 1.148 kWh per year per installed kW_{peak} can be expected.

For the operation of the generator is very important that it is kept in optimum conditions and a proper maintenance program is performed. A failure of the system can jeopardize its economic feasibility. The operation is recommended only for High Tariff times, since only at these times it would be economically feasible. The installed capacity is higher than the power demand after implementing the energy saving measures, therefore putting one generator out of use can be considered. Furthermore, caution should be taken regarding the noise pollution and gas emission, to guarantee that it will not disturb the comfort of the site and of its visitors.

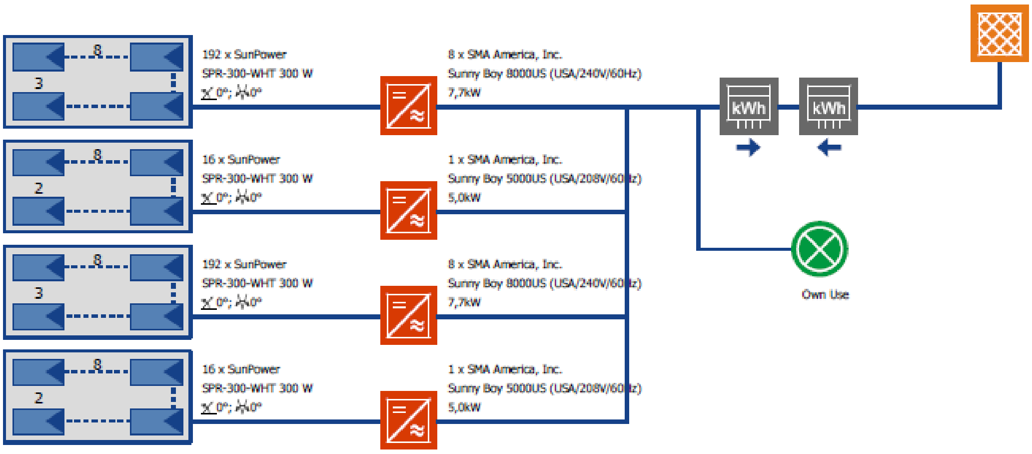
To sustain the adequate and efficient energy use, the operation of the equipment needs to be monitored and well maintained, for which the staff should be properly trained and an organizational commitment should take place.

Appendix A

Table 56: Electricity Tariffs From 2012

Cost per kW per month (High Tariff)	Cost per kW per month (Low Tariff)	Cost per kW per month of exceeding power (High Tariff)	Cost per kW per month of exceeding power Low Tariff	Cost per kWh (High Tariff)	Cost per kWh (Low Tariff)
68,4474886 R$/kW	21,659067 R$/kW			0,3444840 R$/kWh	0,2219634 R$/kWh
68,4996192 R$/kW	21,675552 R$/kW			0,3451028 R$/kWh	0,2221325 R$/kWh
68,4683313 R$/kW	21,665651 R$/kW	136,936663 R$/kW		0,3449451 R$/kWh	0,2220310 R$/kWh
68,930104 R$/kW	21,811771 R$/kW			0,3472715 R$/kWh	0,2235284 R$/kWh
69,004143 R$/kW	21,835200 R$/kW	138,008286 R$/kW		0,3828602 R$/kWh	0,2442074 R$/kWh
68,6984419 R$/kW	21,738466 R$/kW	137,696883 R$/kW		0,3811640 R$/kWh	0,2431255 R$/kWh
68,7825023 R$/kW	21,765066 R$/kW	137,565005 R$/kW	43,530131 R$/kW	0,3816304 R$/kWh	0,2434230 R$/kWh
68,5831936 R$/kW	21,701998 R$/kW			0,3805246 R$/kWh	0,2427176 R$/kWh
69,4302918 R$/kW	21,970048 R$/kW			0,3852246 R$/kWh	0,2457155 R$/kWh
68,362444 R$/kW	21,632715 R$/kW	136,728489 R$/kW	43,265430 R$/kW	0,3793098 R$/kWh	0,2419428 R$/kWh
69,802247 R$/kW	24,454440 R$/kW	139,604493 R$/kW	48,928880 R$/kW	0,4368919 R$/kWh	0,2738091 R$/kWh
69,872573 R$/kW	25,333738 R$/kW			0,4314532 R$/kWh	0,2583585 R$/kWh

Appendix B



Location:	RIO DE JANEIRO
Climate Data Record:	RIO DE JANEIRO
PV Output:	124,80 kWp
Gross/Active PV Surface Area:	678,38 / 678,95 m²

PV Array Irradiation:	1.027.567 kWh
Energy Produced by PV Array (AC):	143.407 kWh
Energy to Grid:	4.230,1 kWh
Consumption Requirement:	614.459 kWh
Direct Use of PV Energy:	139.177 kWh
Energy from Grid:	475.409,4 kWh
Yield Reduction Due to Shading	5 %

Solar Fraction:	23,3 %
System Efficiency:	13,9 %
Performance Ratio:	75,9 %
Specific Annual Yield:	1.148 kWh/kWp
CO2 Emissions Avoided:	89.124 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..

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