POTENTIAL FOR ENERGY SAVINGS IN RETROFITING OF AN OFFICE BUILDING IN SÃO PAULO / BRAZIL

Fernando Ernesto Pasquali[1], Paulo Otto Beyer[2], Anna Maria Hennes[3] and Clarissa Sartori Ziebell[4]
[1]Promec, Federal University of Rio Grande do Sul, Porto Alegre, Brazil
[2] Promec, Federal University of Rio Grande do Sul, Porto Alegre, Brazil
[3] H&S Arquitetos Associados Ltda., Porto Alegre, Brazil
[4] Propar, Federal University of Rio Grande do Sul, Porto Alegre, Brazil

ABSTRACT

The aim of this study is to identify the most effective strategies to improve energy performance of an existing typical office building in the city of São Paulo/Brazil, by simulating the results of various retrofit interventions in EnergyPlus. Appropriate lighting levels were determined and the potential of natural light was simulated. Various air conditioning systems were simulated, comparing the performance of VRF (variable refrigerant flow) split systems with and the use of economizer. The building envelope was treated to reduce solar heat gain, specially through the glazing facades. The work dealt with different arrangements of external louvers, to achieve the ideal combination of horizontal and vertical shading devices. The conclusion shows an enormous potential for improvement on the performance of existing buildings in one of the biggest cities on the planet.

INTRODUCTION

Global warming is unequivocal and clear from observations of increases in average air and ocean temperatures, melting of polar ice and rising sea levels. (IPCC, 2007)

Most of the observed warming in global temperature is very likely caused by increased emissions of greenhouse gases generated by human activity. (IPCC, 2007)

According to the Brazilian Ministry of Mines and Energy, the electricity consumption in Brazil has been increasing gradually in recent years. The planned expansion in electricity generation during the years 2011 to 2013, is equivalent to 22,634.5 MW. Of these, 12,039.4 MW will be generated via burnig of gas, oil, coal or biomass, representing 53% of the planned expansion. (MME, 2011) The operation of these plants will represent an increase on the emissions of greenhouse gases.

Parallel to this, the level of electricity consumption of residential and commercial sectors is related to variations in ambient temperature, and in most regions of the country, this change is directly proportional, which means the increase in ambient temperature leads to increased energy consumption, caused by artificial cooling of buildings. (Oliveira et al, 2000)

Table 1 indicates the consumption records and maximum consumption in March 2011 for different regions of Brazil.

The analysis of the season and the time of peak electricity consumption indicates that even in the south, where consumption for heating in winter is substantial, the record follows the pattern of consumption in other regions of Brazil, occurring in summer and times of the day probably the hottest.

Therefore, it is important to reduce energy consumption for artificial conditioning of buildings not only to reduce operational costs, but also to reduce emissions of greenhouse gases and to reduce the peak in energy consumption, which is responsible for the need of costly new investments in electricity generation.

Table 1
Maximum Electricity Consumption by Regions in Brazil.

Maximun (MW)	Southeast Centerwest	South	Northeast	North	National Grid
March 2011 Maximun	43,593 28th March 14:37 h	12,881 24th March 14:26 h	10,039 31st March 14:51 h	4,476 19th March 19:09h	69,056 25th March 14:46 h
Record	44,758 22nd Feb 15:48 h	13,545 27th Jan 14:35 h	10,269 9th Oct 18:46 h	4,476 19th March 19:09h	71,052 22nd Feb 14:35 h

Source: MME. (2011)

Daily average solar radiation on a tilt surface in Brazil varies from around 4.5 to 6.5 kWh/m²/day (Swera, 2005). This intensity, added to the already warm air temperatures experienced on most of the year, has a considerable effect on the heat load of buildings with large glazing areas, increasing substantially the energy consumption for air conditioning of these buildings.

At the same time, still persist in these days, on the brazilian commercial real estate market, a trend to copy architectural prototypes of developed countries, without considerations on the climate differences between them, with large use of unshaded glass facades and air conditioning.

For the reasons above, it becomes especially important the analysis of design strategies aiming to reduce energy consumption on office buildings with large glazed facades and specially the strategies aiming to reduce heat gain through these glazed facades.

Considering also the large stock of existing buildings using large glazed areas on its envelope, and consequently having high energy consumption, it is important that such strategies can be applied to existing buildings, providing subsidies for future intervention in order to reduce energy consumption.

The work evolves from an existing building in São Paulo, the object of a national competition for retrofiting project with the goal of reducing energy consumption, backed by OTEC - Energy Optimization for Construction, in 2010.

OBJECTIVE

The aim of this study is to analyze and compare different strategies to improve energy performance of an existing typical office building in the city of São Paulo/Brazil, by simulating the results of various retrofit interventions in EnergyPlus, and to identify the most effective interventions on the building to reduce its energy consumption.

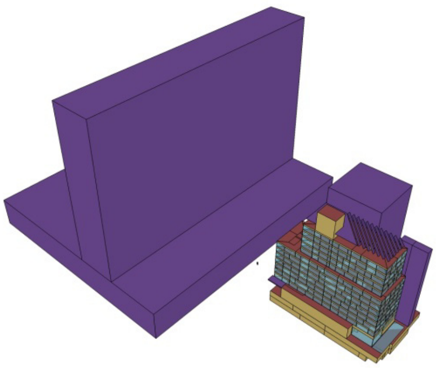

Figure1 Model of building and urban environment

METHODOLOGY

The methodology consists of analyzing the effects on the annual energy consumption of the building for each proposed retrofit intervention, by comparing the results of computer simulations done in EnergyPlus.

The object of study consists of a commercial building comprising of two basements with parking, ground floor and 12 typical floors occupied by offices and communal areas of a single company in Sao Paulo, amid dense urban fabric. The building has a rectangular plan with the shortest facades being the front and back, oriented to northeast and southwest. The largest facades form the side walls and are facing northwest and southeast. On the typical floors, all the facades are composed of a glass skin from floor to ceiling. The only opaque surfaces on these facades are the solid surfaces between the lintel of one story to the floor level of the story above.

The building has a total area of 11.870m ², 7.140m ² being air-conditioned.

The building's energy consumption will be largely influenced by the type of internal occupation. Number of people, hours of occupation and quantity of equipment installed will have a major influence on the internal heat load and therefore on the overall performance of the building. Depending on the amount of heat released inside the building from people and equipment, the building as a whole, and specifically the facades should receive or lose heat in order to the internal conditions to remain within the comfort zone.

To be representative of a typical office building, the study used the actual characteristics of the existing building with regard to the density of occupation and equipment, as well as hours of operation, provided in the competition and representative of a densely occupied office building.

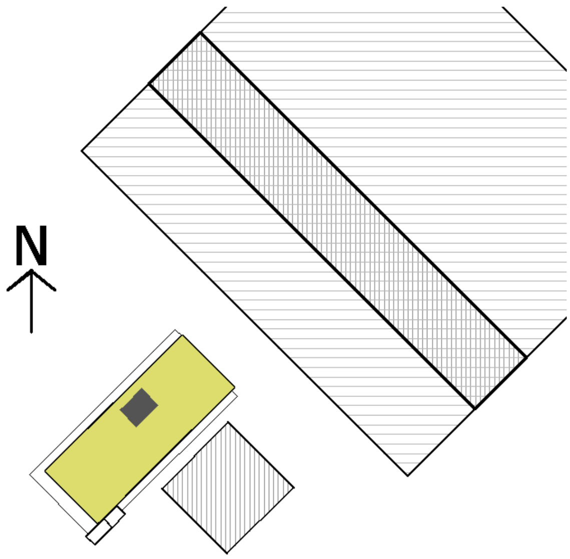

Figure2 Site plan

Figure 3 shows the annual end use of energy within the existing building (Simulation n.1).

Interior equipment, while contributing largely for the annual consumption not only directly but also indirectly due to the heat generated inside the building, will not be changed or analyzed, since considered not part of the building structure and systems itself.

Therefore, the analysis of Figure 3 reveals the two end uses with the largest energy consumption and potential for savings as being cooling and lighting.

There is an interrelation between the energy end uses and between these and the physical characteristics of the building envelope.

The efficiency of the lighting systems will largely influence the heat load inside the building and therefore the energy consumed in air conditioning.

The proposals for the lighting began by determining adequate power densities of lighting per square meter, for different types of internal spaces, using as a basis simulations on the software Dialux. For these, the proposal use efficient light fittings for fluorescent lights on the office spaces and a combination of compact fluorescent and led on circulations and communal areas. The proposed light power densities per square meter are show on Table 2 and the results represented by Simulation n. 2.

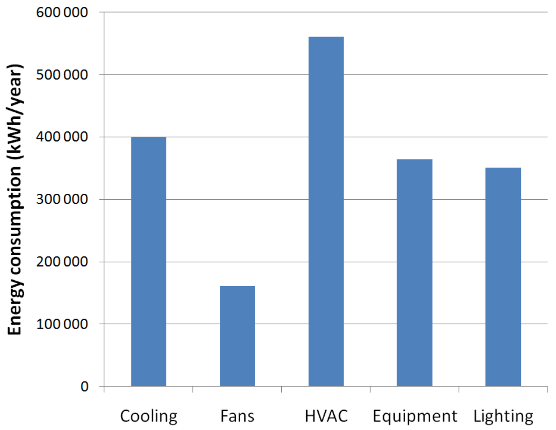

Figure 3 Annual energy consumption of existing building by end user

Table 2
Light power density at internal zones (W/m²).

Use	Density of instalation (W/m²)
Offices	7.67 - 9.10
Meeting rooms	6.40
Stairs	1.96
Corridors / horizontal circulation	3.71
WCs	3.50 - 3.60

In order to take advantage of the natural light coming from the glazed facade, natural light sensors were proposed for each zone with access to an external glazed facade. The lighting levels proposed for each zone were based on the Brazilian standard NBR5413-Interior lighting - Specification, adapted to provide better visual comfort and user satisfaction (Light Right Consortium, 2007). The levels proposed are show on Table 3 and the results are represented by Simulation n. 3.

Table 3
Lighting levels at internal zones (lux).

Use	Lighting level (lux)
Offices	500
Meeting rooms	200
Stairs	100
Corridors / horizontal circulation	100
WCs	150

The proposed internal lights on the perimeter zones of the building are therefore dimed and regulated to complement the natural light.

HVAC is the single largest item of energy consumption of the building. Therefore, the efficiency of the system will probably have a profound effect on the building´s annual energy consumption.

The floors were divided into peripheral and core zones. The peripheral areas are largely influenced by the external climate and have dedicated HVAC system. Core zones are less influenced by external climate and have separate air conditioning units.

The proposed and simulated air conditioning systems were based on its performance and the possibilities of installation on the existing structure, which poses some restrictions in terms of low floor to floor distance. This restriction makes difficult the use of systems based on large air distribution ducts.

The first proposal was based on the use of the external air during hours were the temperature outside were favourable, know as economizer. Units located along the facades would take external air and blow to the peripheral zones, complemented by units on the core, served by short ducts bringing outside air to these core zones. (Simulation nº 4)

The second proposal uses 'splits' on the peripheral areas, fixed on the ceiling near the windows, with external air intake on the facade. Core areas will have cassete type units with ducts for external air supply above the ceiling with fans on long ducts. The external machines have compressors with variable speed, in order to meet the variable thermal load of the installation. These will be located on each floor, to reduce the length of interconnection lines, therefore reducing energy consumption of the system.

The consumption of the indoor machines is simulated by the efficiencies of electric motor and fan and the differential pressure produced by the motor fan. It was selected as reference a 'cassette' with cooling capacity of 7.3 kW, with drive power of 66W for an air flow of 308 L /s, manufacturer's catalog data (Daikin 2006).

Using the equation of a power flow machine

$$P = \frac{\dot{V}\Delta p}{\eta} \qquad (1)$$

and efficiency of the electric motor of 80% and 70% of the fan, the pressure found is of 120 Pa. These efficiencies and pressure are reported to EnergyPlus, which calculates the flow rate of each machine and the resulting energy consumption. The external machine used was of type 'High COP Series (Energy Saving Series)' Daikin (2006). A machine with external cooling capacity of44.8 kW and heating (reverse cycle) of 50 kW was taken as a reference. These capacities were found for wet bulb temperature entering the evaporator at 19 C and dry bulb temperature at the entrance of the condenser of 35 °C

at cooling cycle. For heating (reverse cycle) conditions were of dry bulb temperature at 20 °C at the entrance of the condenser and dry bulb temperature of 7 C at the evaporator inlet.In the above cooling conditions, the external unit produces 44.8 kW of cooling and demands 10.5 kW of electricity, including the external fan, representing a Coefficient of Performance COP 44.8/10.5 = 4.3, used in EnergyPlus.
In heating condition, the external unit produces 50 kW of heating, demanding 11.5 kW of electricity, resulting in a COP of 50/11, 5 = 4.3, also reported to EnergyPlus.
The above demands and capacities are variable depending on internal and external temperatures, and therefore influence the annual consumption of the air conditioning system. To improve the quality of the simulation results, EnergyPlus works with the equation below to adjust capacities and demands, as a function of the operating temperatures of the equipment.

$$TotCapTempModFac=a+b(T_{wb,i})+c(T_{wb,i})^2+d(T_{c,i})+e(T_{c,i})^2+f(T_{wb,i})(T_{c,i}) \quad (2)$$

where Twb,i is the wet bulb temperature at the evaporator inlet and Tc,i is the dry bulb temperature at the entrance of the condenser. The coefficients a, b, c, d, e and f should be adjusted by the manufacturer performance tables of the equipment.
Using the manufacturer's data (Daikin 2006) and using Excel program, the coefficients of equation:

$$y = b+m1*x1+m2*x2+m3*x3+m4*x4+m5*x5 \quad (3)$$

were adjusted, resulting in Table 4.

Table 4
Adjustment of capacity equation coefficients

m5	-1.02288E-03
m4	-9.53786E-05
m3	2.20103E-02
m2	-4.35838E-03
m1	2.40040E-01
b	-1.98558E+00

The adjustment for the energy consumption according to temperatures is done by the equation:

$$EIRTempModFac = a + b(T_{wb,i}) + c(T_{wb,i})^2 + d(T_{c,i}) + e(T_{c,i})^2 + f(T_{wb,i})(T_{c,i}) \quad (4)$$

where the coefficients a, b, c, d, e, f should be adjusted with the performance data of the equipment provided by the manufacturer. With these, the following equation can be adjusted, with the results on Table 5:

$$y = b+m1*x1+m2*x2+m3*x3+m4*x4+m5*x5 \quad (5)$$

Table 5 - Adjustment of demand equation coefficients

m5	-5.96048E-05
m4	2.47004E-0
m3	2.02206E-02
m2	-5.96372E-03
m1	2.74474E-01
b	-2.81131E+00

The second system was based on a VRF (variable refrigerant flow) split system with minimum fresh air intake for sanitary purposes. (Simulation nº5)
Complementing the proposals to enhance the performance of the lighting and air conditioning systems, the proposals for the building envelope aims to reduce the thermal load coming from excessive solar radiation on the glazed facades.
The comparison between different shading options for the facade is based on the analysis of the total annual energy consumption of the building, kept in comfortable conditions by artificial conditioning systems under the conditions established in the model and times of occupation.
The following shading devices were simulated:

1. All openings with plain glass without any external shading devices. Building partially shaded by the urban environment (Simulation nº 5);
2. The above with external shading by solid horizontal walkways between floors, 800mm wide (Simulation nº 6);
3. All openings with simple glass, shaded by horizontal walkways between floors 800mm wide and solid parapet at the outer limit of the walkway, with 1000mm height (Simulation nº 7);
4. The above with all openings shaded by horizontal external louvers, fixed at 90 degrees, measuring 250x10mm, spaced 187.5 mm and located 700mm from the face of the glass above the solid parapets of the external walkway (Simulation nº 8);
5. The above with vertical louvers the same dimensions and distances (Simulation nº 9).

In order to determine the best configuration of external louvers for each façade, 32 simulations were done analyzing the independent effect of louvers systems described below, in each of the four facades, keeping the other without protection. These were:

a. fixed vertical louvers, as described in item 5 above, applied to one facade at a time;
b. fixed horizontal louvers as described on item 4 above, applied to one facade at a time;
c. vertical louvers with the dimensions according to item 5, triggered automatically when intensity of solar radiation in the window module is greater than 200W/m2, regulated to follow the sun path and to block beam radiation, maintaining openness to natural light when possible;
d. vertical louvers as per item ´c´ above, triggered when intensity of solar radiation in the window module is greater than 100w/m2;

e. vertical louvers as per item ´c´ above, triggered when intensity of solar radiation in the window module is greater than 50w/m2;

f. horizontal louvers according to item 4 above, triggered automatically when intensity of solar radiation in the window module is greater than 200W/m2, regulated according to item c;

g. horizontal louvers according to item 4 above, triggered automatically when intensity of solar radiation in the window module is greater than 100W/m2, regulated according to item c;

h. horizontal louvers according to item 4 above, triggered automatically when intensity of solar radiation in the window module is greater than 50W/m2, regulated according to item c;

Using the results of the simulations to determine the most effective configuration of external louvers for each facade, the simulation nº 6 uses what could be called the most effective combination of louvers for the building in question (Simulation nº 10).

RESULT ANALYSIS

Figure 4 shows the monthly energy consumption by end use on the existing building. It shows that the combined consumption for cooling and air handling (fans), represented as HVAC is the highest consumption on every single month, including the coldest months of the winter.

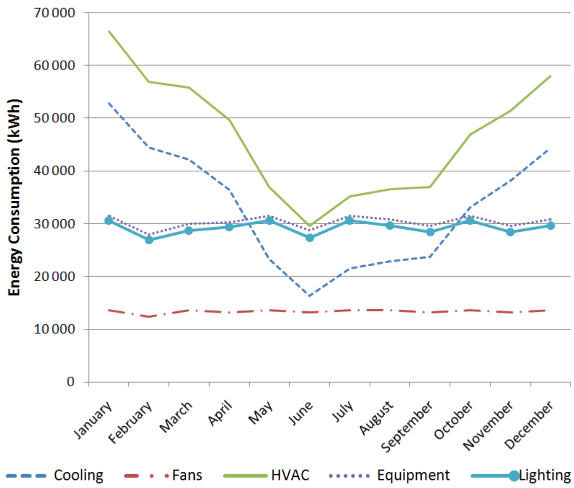

Figure 4 - Monthly energy consumption of existing building

Table 6 -Annual energy consumption of different interventions on the existing building

Simulation	COOLING	FANS	HVAC	LIGHTING	EQUIPMENT	TOTAL
1. EXISTING BUILDING	399 275	161 125	560 401	350 395	363 754	1 274 550
2. NEW LIGHT FITTINGS /POWER DENSITY	350 391	147 577	497 968	203 104	363 754	1 064 826
3. USE OF DAYLIGHT	323 286	141 042	464 328	102 437	363 754	930 519
4. AC WITH ECONOMIZER	162 670	398 946	561 616	102 437	363 754	1 027 807
5. VRF SPLIT SYSTEM	168 320	122 404	290 724	102 437	363 754	756 915
6. SHADING HORIZONTAL WALKWAYS	145 485	98 470	243 955	111 231	363 754	718 940
7. HORIZONTAL WALKWAYS + PARAPET	143 380	96 975	240 355	113 206	363 754	717 315
8.WALKWAYS W/ PARAPET AND FIXED HORIZONTAL LOUVERS	124 065	73 288	197 353	129 912	363 754	691 019
9.WALKWAYS W/ PARAPET AND FIXED VERTICAL LOUVERS	125 938	71 534	197 473	130 634	363 754	691 861
10. BEST COMBINATION OF MOVEABLE LOUVERS	118 219	66 319	184 538	119 274	363 754	667 566

Table 6 shows the results of various proposals on the total annual energy consumption of the building by end use.

The comparison of the effect of an efficient lighting system and a rational distribution of power densities based on simulations of the achieved lighting levels on a variety of spaces, shows a potential for savings of 42% of energy consumed on lighting (Simulation

2) when compared to the existing building. Apart from this direct saving, the reduction on the heat load generated by the artificial lights also leads to savings in cooling and air handling, with savings on HVAC of 11.14%. Combined, these savings represent a total reduction of 16.45% on annual energy, or 209,724 kWh/year.

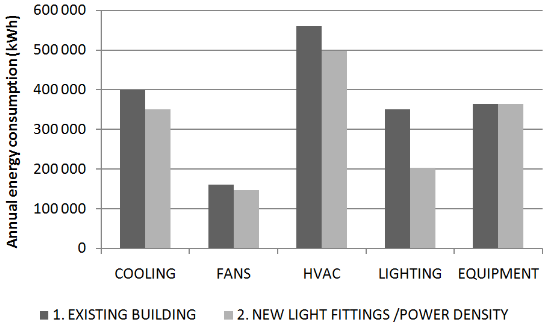

Figure 5 - Variation of annual energy consumption with new light fittings and power density

The effects on the use of natural light are shown on simulation nº 3. With the introduction of lighting sensors on the internal zones with access to glazed facades and automated control, the lights will be turned on and receive the necessary amount of energy to complement the natural light already entering each zone. The results show savings of 49,56% on energy consumed by the lighting system, when compared to the same fittings and power densities without the daylight control. This saving also causes a reduction on HVAC of 6,76% and a total annual reduction of 12,61% on energy consumed by the building when compared to simulation 2.

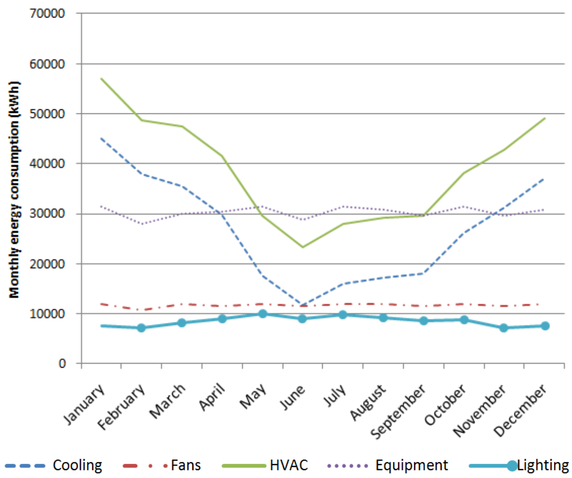

Figure 6 - Results of simulation nº 3 - monthly energy consumption of building with daylight

When compared to the existing building, the interventions on the lighting systems, with the use of efficient fittings and bulbs and the use of natural light represent a reduction of 70,77% on the energy used for lighting directly and the indirect reduction of 17.14% on HVAC, with a total annual saving of 26,99% equivalent to 344,031 kWh/year.

Simulations nº 4 and nº 5 represent the results of two retrofit proposals for the air conditioning systems.

The use of external air for cooling, know as economizer did not, however, bring any savings in terms of total energy consumption. The savings in cooling were of 49.68%, or 160,616 kWh/year. The energy consumed by fans have an increase of 182,86%, or 257,905 kWh/year, surpassing the savings in cooling and generating an increase of 10,45%, or 97,289 kWh/year on the total annual energy consumed. Figure7 shows the comparison of simulation nº3 with the existing air conditioning system and the proposal of a new system using economizer.

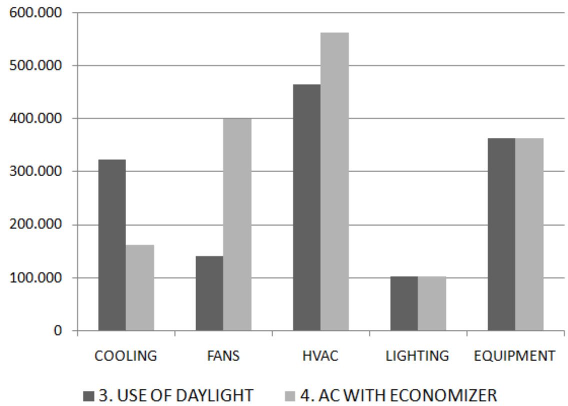

Figure 7 - Comparison of existing HVAC and the use of economizer

The second proposal for retrofit of the air conditioning system was more successful in terms of total energy savings.

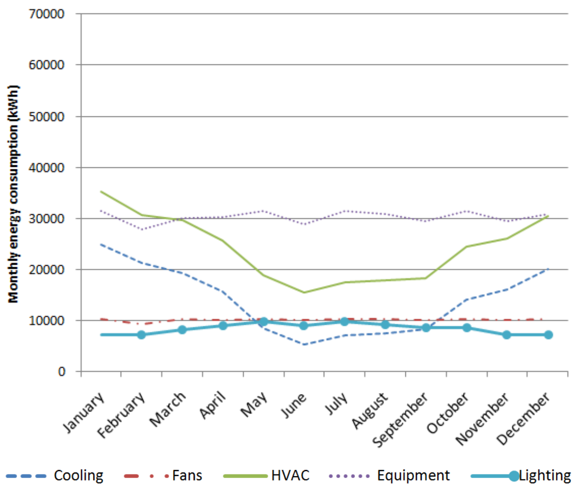

Figure 8 - Results of simulation nº 5 - monthly energy consumption of building with split VRF system

The comparison was with the existing HVAC system and the building already fitted with an efficient lighting system utilizing daylight when possible. The VRF split system achieved reduction in cooling energy of 47,93% or 154,966 kWh/year, complemented by saving in fans of 13,21% or 18,638 kWh/year, representing total savings of 18,66% or 173,604 kWh/year.

The simulations of the effect of shading devices uses simulation nº 5 as baseline for comparison. This means, the building fitted with efficient lighting systems utilizing natural light and also efficient HVAC, using VRF split systems is used as baseline.

The inclusion of a continuous solid external walkway on each floor along all the facades has the effect of reducing energy consumption for HVAC in 16.09%, or 46,769 kWh/year. The shade provided by these walkways has, however, also the effect of reducing the availability of natural light, causing the increase in energy consumption for lighting in 8.58%. The total net savings are 5.02%, equivalent to 37,975 kWh/year.

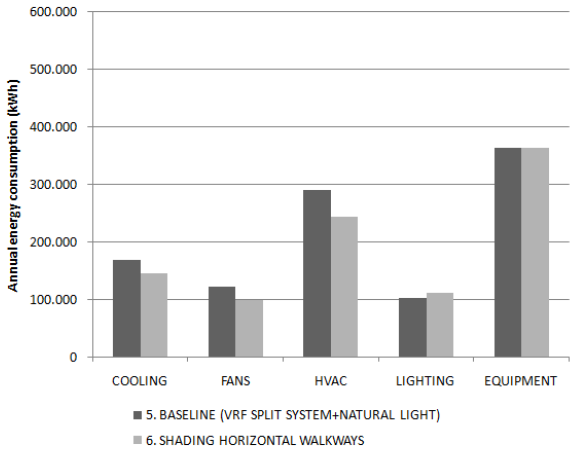

Figure 9 - Effect of shading by horizontal walkways

Simulation nº 7 shows the inclusion of a solid parapet on the external edge of the walkway, with a further total net saving 0.23%, or 1,625 kWh/year.

The inclusion of fixed horizontal louvers or blinds on all the facades, added to the horizontal walkways with solid parapets has the effect of reducing the HVAC energy consumption in 17,89%. The additional shading will increase the energy consumption in lighting by 14,76%, with net total energy saving of 3,67% or 26,296 kWh/year when compared to the same configuration without the louvers.

The use of fixed vertical louvers on all facades will produce savings in HVAC of 17,84% when compared with the same building without the louvers. The light consumption will increase by 15,40%, with total net saving of 3.55% or 27,921 kWh/year.

Comparing the use of horizontal and vertical louvers on all facades, the horizontal louvers have a slightly larger saving of total 0.12% of the building annual energy consumption, or 842 kWh/year.

This simulation, however do not shows which louvers orientation is more appropriate for each facade.

The simulations shown on Table 5 were carried out applying different configuration of louvers on each of the 4 facades, leaving all the others shaded only by the horizontal walkway with parapet, as in simulation nº7.

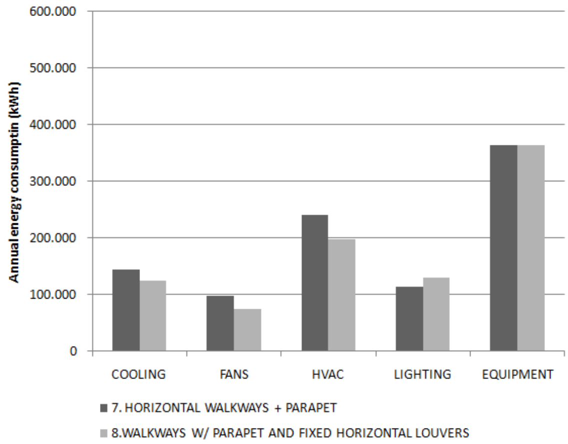

Figure 10 - Effect of fixed horizontal louvers on annual energy consumption

Table 5 - Annual energy consumption with different shading devices on the facade indicated (kWh/year).

\FACADE TYPE OF SHADING	NW	NE	SW	SE
FIXED VERTICAL	701 928	715 613	**706 346**	722 099
FIXED HORIZONTAL	**700 454**	**715 442**	707 603	**721 529**
MOVEABLE VERTICAL w/ SETPOINT 200W/m²	699 080	715 647	706 014	713 767
MOVEABLE VERTICAL w/ SETPOINT 100 W/m²	**692 693**	714 569	703 223	712 618
MOVEABLE VERTICAL w/ SETPOINT 50W/m²	693 770	**714 243**	703 295	717 191
MOVEABLE HORIZONTAL w/ SETPOINT 200 W/m²	703 172	716 008	705 951	713 765
MOVEBALE HORIZONTAL w/ SETPOINT 100 W/m²	697 285	714 898.46	**703 035**	**712 401**
MOVEABLE HORIZONTAL w/ SETPOINT 50 W/m²	697 623	714 480	703 059	716 698

These simulations show that for fixed louvers, the best configuration would be horizontal louvers on NW, NE and SE facades and vertical louvers on the SW façade of the building in question.

The overall best performance of louvers would be achieved with moveable vertical louvers on the NW façade with setpoint at 100 w/m² and on the NE façade with setpoint at 50 w/m². And on the SW and SE facades the best performance is achieved by moveable horizontal louvers with setpoint at 100 w/m². These configurations were used on simulation nº10, in order to check the combined effect of these different shading configurations on the overall energy consumption of the building. The results show a small increase in performance in terms of energy savings. HVAC consumption have a reduction of 6,49% in relation to simulation nº 8 with fixed horizontal louvers, lighting has a reduction of 8,19% comparing to the same case, and the overall net saving is 3,39%, or 23,454 kWh/year.

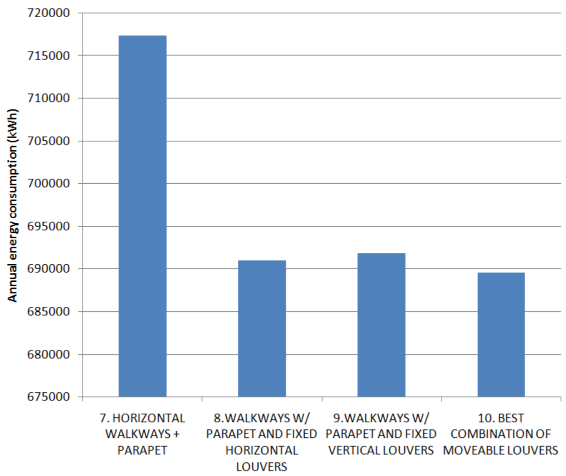

Figure 11 - Energy consumption with different shading devices

Figure 12 shows the monthly energy consumption of the building with the most effective combination of moveable louvers, as per Simulation nº 10.

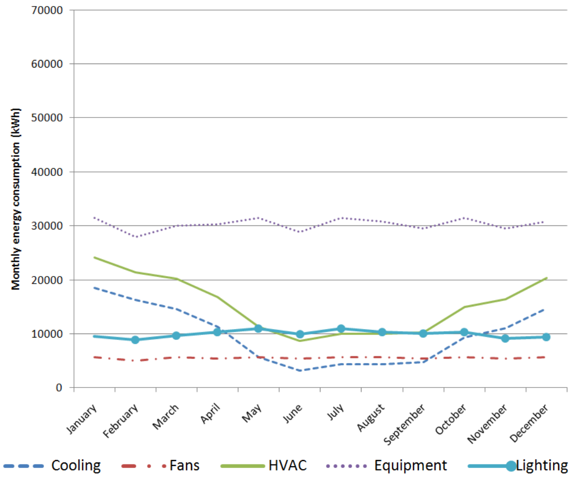

Figure12 - Results of simulation nº 10 - monthly energy consumption of building with most effective combination of moveable louvers

Figure 13 shows the differences in annual energy consumption between the existing building and the proposal with the best performance,by end use.

Figure 14 shows a graph with the variation on total annual energy consumption by end use, for each of the interventions and simulations as described above.

The maximum achieved energy reduction on the building analysed is achieved by a combination of interventions on the lighting and ar conditioning systems and the use of moveable louvers as described above. This shows a reduction in 47,62% of total annual energy consumption of the building, equivalent to 606,984 kWh.

CONCLUSION

It becomes clear, throughout the development of the work, the importance of computer simulation of energy performance as a tool for analysis of the strategies to improve the energy performance in real buildings, whose complexity hinders the choice of solutions based only on theoretical concepts. At the same time, the work demonstrates the potential savings on efficient air conditioning and lighting systems, specially with the use of natural light, and the importance of external shading to reduce energy consumption. Furthermore, by simulating all these retrofit interventions, its also demonstrates the potential for saving in the existing building stock.

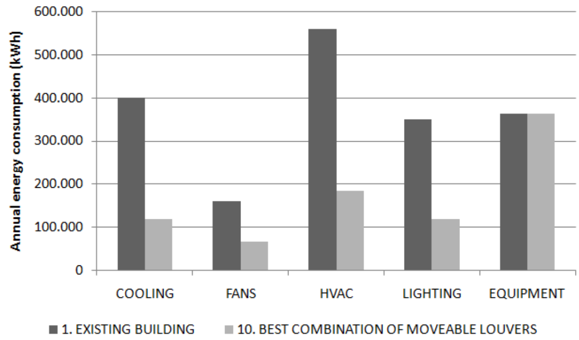

Figure 13 - Annual energy consumption of existing building and final simulation

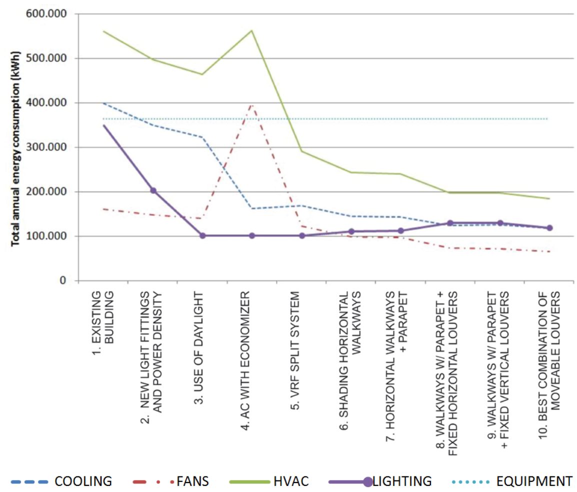

Figure14 - Total annual energy consumption by type of retrofit intervention

REFERENCES

Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: Synthesis Report, IPCC, Valencia, Spain.

Ministério de Minas e Energia. 2011. Boletim Mensal de Monitoramento do Sistema Elétrico Brasileiro - Março de 2011, MME, Brasília, Brazil.

Oliveira, A., Silveira, G.B., Braga, J.M. 2000, Diversidade sazonal do consumo de energia elétrica no Brasil. Pesquisa e Planejamento Econômico, Instituto de Pesquisa e Planejamento Econômico v.30, n.2, p.211-258, Rio de Janeiro, Brazil.

Light Right Consortium. 2007. Ergonomic Lighting, Nova Iorque, USA.