ENERGY EFFICIENCY CODE IN BRAZIL: EXPERIENCES IN THE FIRST PUBLIC BUILDING LABELED IN BRASILIA

Cláudia Naves David Amorim[1], Milena Sampaio Cintra[2], Caio Frederico e Silva[2], Júlia Teixeira Fernandes[2], Larissa Olivier Sudbrack[3].
[1]Professor of University of Brasília - Brazil. [2]Graduate Student of University of Brasília - Brazil.
[3]Undergraduate Student of University of Brasília – Brazil.

ABSTRACT

The new energy efficiency code for commercial, public and service buildings was officially launched in Brazil in 2009, as a proposal for new rules concerning building envelope, lighting and conditioning systems. The evaluation methodology is performed by prescriptive criteria and by energy performance simulations. The first labeled building in Brasilia is a public office studied by the Laboratory of Environmental Comfort and Energy Efficiency-LACAM, of the University of Brasilia. This article aims to present the process of labeling and its difficulties, especially those found in the process of energy performance simulations, indicating the results obtained in this first experience. The conclusion points out how the prescriptive method in this case gave the same results from simulations. It also showed the need of improvement of the simulation capacity in the Laboratories to improve the team's expertise, to the cases in which the prescriptive method doesn't fit well enough. This process must be done in a short period of time, allowing rapid expansion and absorption of this energy efficiency code all over the country. Keywords: labeling, energy efficiency, office building, Brasilia – Brazil.

INTRODUCTION

From 2001, with the energy crisis that took place in Brazil, a national concern about rational use and energy conservation was encouraged by the Law of Energy Efficiency, Law n°. 10,295/2001 (Federal Government, 2001). The reasons were the concrete possibility of diminishing the energy offer and the high cost of implementation of new hydroelectric plants in the country.

The PROCEL (National Program of Energy Conservation, part of the Energy Ministry) promotes the rational production and consumption of electricity in the country, looking for waste reduction and more investments in the sector, besides the reduction of environmental impacts. For Eletrobras (Brazil Energy Central) there is a trend of growth in the electricity consumption, due to the stability of Brazilian economy, better income distribution and higher urbanization rates. 50% of the electricity produced in Brazil is consumed not only in operation and maintenance of buildings, but also in artificial systems for environmental comfort (lighting, air conditioning and water heating).

The Quality Technical Regulation for Energy Efficiency in Public, Commercial and Service Buildings - RTQ-C (Inmetro, 2009a) specifies technical requisites, as well as the methods to classify buildings regarding their energy efficiency. The Regulation was based in the ASHRAE 90.1, American standard for energy efficiency that includes requisites for building envelope, lighting, water heating and air conditioning. The prescriptive option establishes limits of physical properties of envelope materials and components, and equipments efficiency. There is also an option that requires computer simulation to prove that energy consumed by an architectural project won´t be higher than a similar building that fulfills the prescriptive option. (ASHRAE, 2001 *apud* CARLO e LAMBERTS, 2005).In the Brazilian Regulation, the prescriptive option fixes limits of some physical properties of envelope materials and components, as thermal transmittance of walls and roofs, solar shading coeficient of glazing and solar shading elements.

The first phase of Regulation application is voluntary for new and existent buildings; in some years it will be compulsory for all buildings. During the year of 2010 a new version of the regulation will be published also for residential buildings.[1]

[1] Some Brazilian norms (Thermal and Lighting Performance in Buildings and Brazilian Bioclimatic Zoning) together with international methods, allowed the elaboration of Brazilian Energy Regulation in the Labeling Brazilian Program (PBE), where the Energy Conservation National Label (ENCE) to the energy performance of buildings is defined.

The labeling process is composed by two evaluation steps: building project and constructed building, where is obtained the authorization for labeling use. The labeling can be applied to buildings with useful area higher than 500 m² or served by high tension energy. The building can be given a general label, or partial labels referring to the building envelope, building envelope and lighting system, or building envelope and air conditioning system. The level of labeling varies from A (more efficient) to E (less efficient).

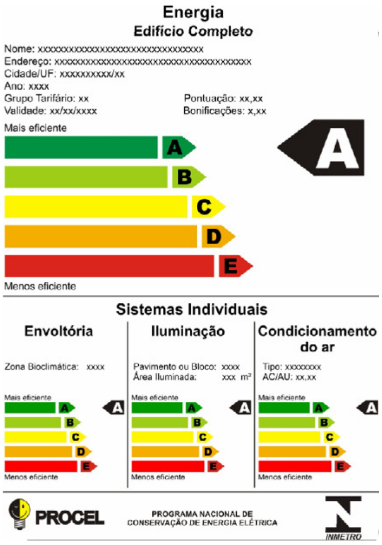

Figure 1: Model of the National Label of Energy Efficiency – ENCE. Source: Inmetro (2009a).

The importance given to the building envelope in this regulation is clear, because the label is compulsory to this part of the building, while lighting and air conditioning systems are optional. Relative weights are proposed to each system: building envelope counts for 30%, lighting system 30% and air conditioning system 40%. An equation calculates these systems, and are included to the final score some Bonus that can be obtained with technical innovations for energy efficiency, use of renewable energy, cogeneration or water reuse.

In order to define the level of a building's energy efficiency two methods can be used: prescriptive or computer simulation. The first one establishes equations and tables of values for building envelope, lighting and air conditioning systems. The second method is based on computer simulations, where the project is compared to reference models. Most of the buildings can be evaluated by the prescriptive method only, which is faster and more practical. In case of special situations or in buildings with natural ventilation skills it is mandatory to use the computer simulation method[2].

To the national labeling process it is essential that a net of Laboratories in the Universities is organized, integrating the Building Energy Efficiency Net (R3E). In this structure there are Consultancy Laboratories that assist architects and engineers during the design process, and also Inspection Laboratories, accredited by Inmetro (National Institute of Metrology, Normalization and Industrial Quality), able to give out the labels after exam of the presented documentation about the project.

The LACAM (Laboratory of Environmental Control and Energy Efficiency) from the Faculty of Architecture and Urbanism of University of Brasília (FAU-UnB) is currently into a training process to the building's labeling, with a research project supported by the CNPq (National Council of Scientific Development). This process looks for the consolidation of its performance in the area of environmental quality and energy efficiency of buildings, in the academy and in the society, by means of applied researches, courses and support to design process.

In this context, this article intends to show the results of the first labeled building in Brasília, showing the prescriptive and energy performance simulation methods, their results, difficulties found throughout the process and future perspectives.

CASE STUDY: THE FIRST LABELED BUILDING IN BRASÍLIA

The labeled building is located in Brasília – Federal District. The city of Brasília (Lat. 15.55° South, long. 48°West) is situated in the Brazilian Bioclimatic Zone 4 (see figure 2), with Tropical of Altitude climate, characterized by two distinct seasons: dry and cold (from April to August) and hot humid (from September to March). The average annual temperatures are around 21°C.

[2] The prescriptive method of the RTQ-C considers only air conditioned buildings. Buildings with no conditioned areas should prove by computational simulation that temperatures are among comfort zones in at least 80% of the year to obtain the label "A". Inmetro (2009b, p. 56)

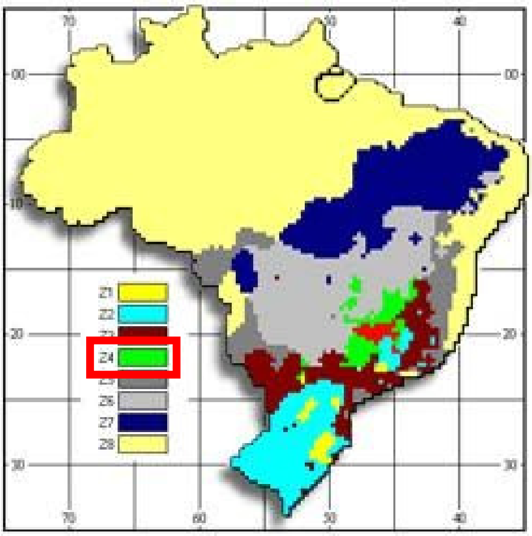

Figure 2: Brazilian Bioclimatic Zoning, showing Bioclimatic Zone 4. Source: NBR-15,220.

The building is the headquarter of the CONFEA (National Council of Architects and Engineers) with offices and auditoria, occupying a rectangular plot of 2,146.00 m², with largest east and west facades. Theses facades are very similar, withal glazed and solar protection made of green textiles (awning fabrics). Vertical circulation takes place along the north facade, connected to the main building by catwalks enclosed by glass (see Figure 3). The south facade does not have any openings. The materials of the walls are concrete panels with internal gypsum, separated by air gap.

Figure 3: Building perspective. Source: Database CONFEA

The principal use of the building are offices. The building is fully air conditioned, with a multisplit system. The installed lighting power is about 10 W/m2. Occupancy pattern is from 8 to 18 pm, with 0,18 people/m2 in average.

METHODOLOGY AND RESULTS

Prescriptive method

The prescriptive classification of the building envelope, according to the RTQ-C, is done from the determination of a suite of indexes regarding the physical characteristics of the building. The values of absortance and thermal conductance of the facade and roofing opaque materials are pre-requisites; other characteristics of the building such as shape, number of windows, shadings and translucent windows are used in multivariate regression equations specific for each Bioclimatic Zone in Brazil.

After the thermal conductance calculation of all layers, it was found that the studied building corresponds to the pre-requisites for the label "A", because its roofing has a medium thermal conductance of 0.795 W/m²K (maximum allowed = 1.0 W/m²K for conditioned room), and the external walls have 0.56 W/m²K (maximum allowed = 3.0 W/m²K). In the same way, the building accomplishes the pre-requisites of the surfaces absortance, because the external walls are partially covered with apparent concrete and a green textile (awning fabrics), which value doesn't exceed the maximum value of 0.4%.

The most important concept of the prescriptive method is the Envelope Consumption Index (IC), which is a parameter for the comparative evaluation of the energy efficiency. For each Bioclimatic Zone there are two different equations for the IC, according to the building's projection area (Ape): for Ape lower than 500 m² and for Ape higher than 500 m². For each one of these equations there are maximum and minimum values for the Shape Factor (FF = Aenv/Vtot).

Ape > 500 m²

Limit: Minimum Shape Factor (Aenv/Vtot) = free

$$IC_{env} = 511.12xFA + 0.92xFF - 95.71xPAF_T - 99.79xFS - 0.52xAVS - 0.29xAHS - 380.83xFA.FF + 4.27/FF + 729.20xPAF_T.FS + 77.15$$

Equation 01: IC Calculation for ZB4. Source: Inmetro, 2009a, Eq. 3.6, RTQ, p.22.

In the case study were calculated all variables related to the building that were necessary to feed the IC equation. They are: Vertical Shading Angle (AVS), Horizontal Shading Angle (AHS), Area of the building's horizontal projection (Ape), Roofing projection area (Apcob), Total floor area (Atotal), Height Factor (FA = Ape/Atot), Shape Factor (FF= Aenv/Vtot), Solar Heat Gain of glazing, Window percentage in the Facade (PAFt), Total Volume (Vtot). The variable that requested the higher level of attention was the Window Percentage (PAF) due to the particularity of the green textile in the eastern and western facades. According to the RTQ-C, if the shading occupies an area that is parallel to the facade, and is physically connected to the building, it is considered as facade, being part of the PAF calculation. In the studied building, the textile was considered as facade and the PAF was calculated as the portion of glazing seen right-angled through the perforation of the textile. The area of the holes was calculated in a pre-determined area, and the value used for the calculation was the percentage found.

The data and equations were organized in an Excel table, generating a pattern for the future evaluations (figure 4). The results of the prescriptive calculation of the building envelope indicated the classification as label "B". Due to the particularity of the green textile skin as a shading device, it was important to make the evaluation of the energetic performance of the building envelope through computer simulations.

Dados do edifício		
Área de cobertura do edifício ENTRA NO FA	Apcob	956,40
Área de projeção do edifício (m²) EQUAÇÃO	Ape	956,40
Área total de piso (m²)	Atot	10125,00
Área da envoltória (m²)	Aenv	3883,12
Ângulo Vertical de Sombreamento (graus)	AVS	9,00
Ângulo Horizontal de Sombreamento (graus)	AHS	12,00
Percentual de Abertura na Fachada (adimensional)	PAFT	0,22
Volume total da edificação (m³)	Vtot	18694,60
Fator solar	FS	0,61
Zona Bioclimática	4	
Indicador de consumo (adimensional)	IC	146,48

Intervalos dos níveis de eficiência (tabela 3.4, p.26)					
Eficiência	A	B	C	D	E
lim mín	-	130,95	183,07	235,19	287,31
lim máx	130,94	183,06	235,18	287,30	-

FATOR DE FORMA de cálculo (Aenv/Vtot):	0,21
FATOR DE ALTURA (Apcob/Atot):	0,09

B

Fig.4: Excel table of the prescriptive calculation.

ENERGY PERFORMANCE SIMULATION METHOD

Methodology

The labeling process can be done by energy performance simulations, besides the prescriptive method. The simulation is used to confirm comfort conditions in at least 80% of the hours of year, in case natural ventilation is used; or, in some cases, the use of innovating systems in building envelope can be tested with more certainty also by this method (Inmetro, 2009b, p. 56)

The software used to the energy performance simulation should follow minimum requirements, as well as the climatic file, in order to reach consistent results. The software should have the following characteristics: be able to evaluate energy consumption in buildings; be validated by ASHRAE Standard 140; model 8,760 hours by year; model hourly variations of occupancy, lighting power, equipments and air conditioning, daily defined; model thermal inertia effects; allow modeling of thermal multi zones; have the ability of simulate bioclimatic strategies; in the case of air conditioning systems, the program should allow the modeling of all systems listed in ASHRAE 90.1 Appendix G; to produce hourly reports of final use of energy (Inmetro, 2009a).

Regarding the climatic file, it should present hourly values for all parameters required for simulation (temperature and humidity, wind speed and direction, solar radiation); the format must be those published in www.eere.energy.gov (TRY, TMY, SWEC, CTZ2...) (Inmetro, 2009a).

The evaluation process of the building by means of simulation uses two building models: a building model (real), with all building characteristics, and a reference model, similar to the real model, with characteristics that varies according to the intended level. The reference model should be submitted to the prescriptive method, in order to identify some parameters according to the intended level of energy efficiency (for example, the solar factor of the glazing, the glazing area, the absence of solar protections). After the identification of characteristics in both models (real and reference), they must be simulated by the same simulation software with the same climatic file. The simulation results must confirm that the building model (real project) presents equals or lower energy consumption than the reference model to the intended level.

Case study simulation

In the evaluated building, the simulation was done only to the building envelope. The simulation had the objective of understanding the influence of the green textile skin in the building energy efficiency.
The software used to the simulation was EnergyPlus version 3.1 from GARD Analytics (University of Illinois and LBLN, 2009) and the interface from Design Builder version 2.0.4. This software allows the modeling of buildings with design characteristics similar to real, as the simulation of functioning of many devices, such as windows, curtains and so on. With this tool the necessary models were created and simulated. Thus, the building model had all characteristics of real building, regarding architectural design, use patterns, lighting and air conditioning.
The building modelling was done precisely, with location, orientation, building materials, occupancy patterns, lighting and air conditioning data. The simulation was done based on the TRY climatic file of year 2002, from Federal University of Santa Catarina - UFSC.

Although the library of the software presents many types of building materials, it was a real challenge to define the textile skin, since there was no similar material in the library. Many studies were made, until the skin was correctly modeled (fig. 5).

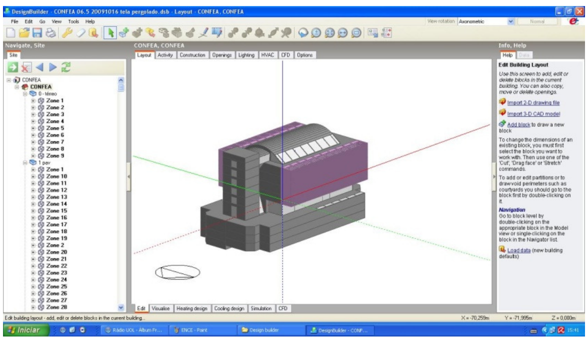

Fig. 5: DesignBuilding interface and the building modeling.

After the construction of this model the parameters to the reference models were established. The prescriptive method fixes solar factor of glazing in 0.61; there are no solar protections and the percentage of openings varies according to the intended label (Fig.6). For the reference building label "A" the percentage of openings was 14%.

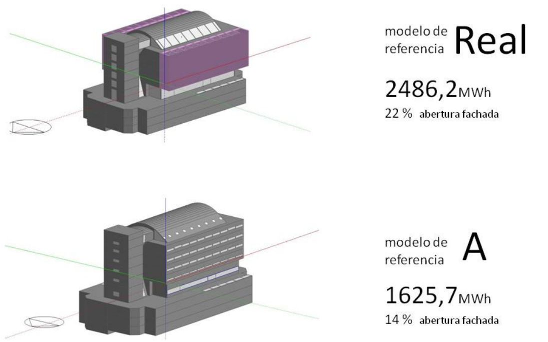

Fig. 6: Models constructed for each label (reference A and Building Model).

In this case only one reference building was modeled considering the possibility of reaching the label "A", because the building was at first classified as B by the prescriptive method.
The simulation results showed that the building model presented higher energy consumption than the reference building simulated.
The annual energy consumption of the building model (label "B") simulated was about 2,486.20 MWh, and the building with label reference "A" was about 1,625.78 MWh (see figures 7 and 8).

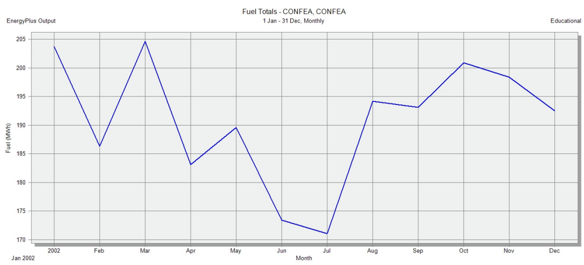

Fig. 7: Building's model annual energy consumption.

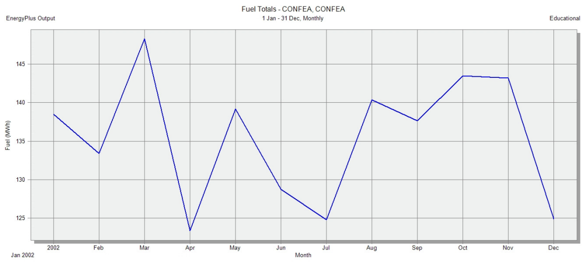

Fig. 8: Reference “A” building’s annual energy consumption.

In this case the label of the building envelope didn´t change, remaining “B”, once the certification process made by simulation doesn’t discard the prescriptive method results.

CONCLUSIONS

Some considerations can be made about the results and the process of this first labeling experience.

We can conclude that the envelope building label, done by simulation, is coherent with the prescriptive method and has confirmed the label “B” to the building envelope. The annual energy consumption simulated for the real building was 2,486.20 MWh, and the energy consumption for label reference “A” was 1,625.78 MWh. In this case, the label of the building envelope didn’t change from the calculated by the prescriptive method, remaining “B”, once the certification process made by simulation doesn’t discard the prescriptive method results.

There are possibilities to improve the label of the building envelope, changing parameters like solar factor of glazing, or reducing the quantity of windows. A major attention from architects and engineers is expected to propose better solutions for energy efficiency in Brazilian buildings. The building envelope should be designed with this objective since the beginning, making architecture more sustainable.

This first labeling has represented a good experience to the Laboratory. The team had the possibility to learn the prescriptive method and to test the results with the simulation. The simulation was especially interesting to verify the performance of some special characteristics of this building, like the green textile skin in the facade.

These results showed that the team is able to perform the labeling process of a building envelope in the prescriptive and simulation methods. But is clear also that the team’s simulation capabilities must be improved, in cases in which the prescriptive method is not enough. This process must be done in a short period of time, allowing rapid expansion and absorption of this energy efficiency code all over the country.

REFERENCES

ASHRAE Standard 140. 2004. Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs.

Federal Government (2001). Law of Energy Efficiency. Law n°. 10.295/2001.

Inmetro – Nacional Institute of Metrology, Standardization and Insdustrial Quality. 2009a. Regulamento Técnico da Qualidade do Nível de Eficiência Energética Para Edifícios Comerciais, de Serviços e Públicos. Rio de Janeiro, Brasil.

Inmetro - Nacional Institute of Metrology, Standardization and Insdustrial Quality. 2009b. Manual de Uso do Regulamento de Avaliação da Conformidade do Nível de Eficiência Energética Para Edifícios Comerciais, de Serviços e Públicos. Rio de Janeiro, Brasil. 2009.

Inmetro - Nacional Institute of Metrology, Standardization and Insdustrial Quality 2009c. Table on the energy label for air conditioning equipment.

NBR 15,220-3. Normas Brasileiras de Desempenho Térmico para Edificações – Parte 3: Zoneamento Bioclimático Brasileiro e Diretrizes para Habitações Unifamiliares de Interesse Social, Rio de Janeiro, 2005.

NBR 6401. Normas Brasileiras para Instalações Centrais de Ar-condicionado para conforto – Parâmetros básicos de Projeto, Rio de Janeiro, 1980.

University of Illinois and LBNL. DesignBuilder Software Ltd, 2009.