Regulation for energy efficiency labelling of commercial buildings in Brazil

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ABSTRACT

Despite of Brazil not being among the major world energy consumers, the consumption of electricity has significantly increased in the last years. The National Energy Balance of 2005, published by the Brazilian Ministry of Energy, showed that buildings consume 45% of the electric energy generated in the country. Standards and codes on energy efficiency can represent 12% of energy consumption savings in twenty years for developing countries according to a global survey developed by Duffie (1996).

In this paper, initially, a brief review of the initiatives taken by Brazilian Government aiming to limit and control the energy consumption in buildings is presented. Then, the regulation proposal containing the technical requirements to classify the energy efficiency level of buildings is shown.

The purpose of this voluntary regulation is to provide conditions to certify the energy efficiency level of Brazilian buildings (commercial and public). It specifies the methods for energy efficiency rating of buildings and includes requirements to attend energy conservation measures in three main issues: lighting system; air conditioning system and envelope. The regulation applies to large buildings (minimum total area of 500m^2 or when the energy demand is greater than or equal to 2,3kV, including: Conditioned buildings; Partially conditioned buildings and Naturally ventilated buildings.

Some of the benefits that the regulation can provide are: owners and developers can use the certification as a market strategy to promote sales, and the users can reduce the cost of the energy consumed by choosing more energy efficient buildings.

1. INTRODUCTION

1.1 Overview

The growth of energy consumption *per capita* is a reality for both developed and developing countries and it is becoming a main issue to be faced by the countries´s economy. Brazil is included in the developing countries group, the electric energy consumption in its territory is not yet as significant as it is in the developed countries that have equivalent territorial area, like USA or Australia. The energy consumption growth in building sector is related to the growth of Gross National Product. Figure 1 shows the evolution of electric energy consumption of residential, commercial and public buildings in Brazil, from 1987 to 2005, altogether with the economic growth. It can be observed that the residential buildings showed higher increase compared to the other sectors. The reduction in 2001 is due to the restraint of energy supply caused by lack of investments and lack of rain fall. Recent values are still below the energy consumption values before the restraint period, showing some penetration of efficient equipment and habit changes.

The economic growth provided an increase of the Gross National Product of 4,9%, in real values, from 2003 to 2004. The electric consumption reached 359,6 TWh in 2004, 5,1% higher then the previous year. This is caused by an increase in domestic appliances due to the increase of population and the recovering of income. According to the National Association of Household Appliances Manufacturers, the industry trade of electrical appliances increased 30,9% from 2003 to 2004 (BEN 2005).

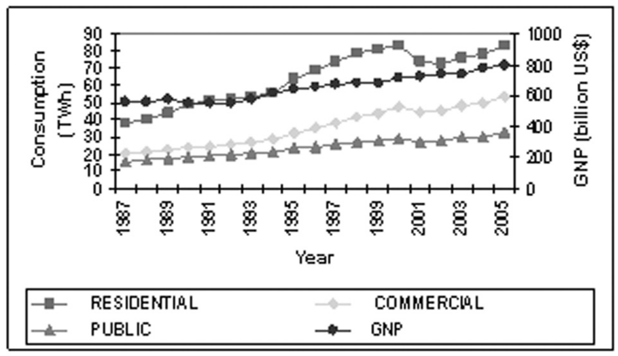

Figure 1: Energy Consumption Growth versus GNP.

Surveys on household appliances ownership and electricity consumption were carried out in 1998 and 2006, sponsored by PROCEL - Brazilian Program for Electricity Conservation [SINPHA, (1999); PROCEL, (2007)]. According to this recent survey, the end-use of air conditioning in the residential sector represents, in average, 20% of the total electric energy consumption in this sector, much higher than the value obtained in 1998, which was 8%.

1.2 History

The first initiative taken by the Brazilian government in the frame of introducing policies to provide building energy efficiency came up as a consequence of the energy

crises of 2001. In October 2001, the Law nº 10.295 was signed. It established the "National Policy of Conservation and Rational Use of Energy" (BRASIL, 2001a). This law states that the Government should develop mechanisms to provide energy efficiency in buildings. Two months later, the regulation was published under a Code (Decree 4.059) format stating, in the first paragraph, that "the maximum levels of energy consumption, or minimum energy efficiency of all equipment and appliances, (…), as well as new buildings, will be established based on technical indicators and specific regulations" (Brasil, 2001b). In the scope of this Code, a Manager Committee for the establishment of indicators and levels of energy efficiency was created (GT-MME). The Committee includes members of Ministries of Energy, Science and Technology, Development and Foreign Commerce, as well as members of National Agency of Electric Energy, National Agency of Petroleum, a representative of a Brazilian University and a Brazilian citizen. Also in the scope of this Code, a Technical Group for energy efficiency in buildings was created. In October, 2003, through the Action Plan for energy Efficiency in Buildings, the program PROCEL-Edifica was launched, establishing six actions: bioclimatic architecture; benchmarking for buildings; building materials and appliances certification; regulations and legislations; removing barriers to energy conservation; and education. Each plan presents a series of projects that aim to implement energy efficiency in the national culture of the construction industry, since the early stage of the design process, through education and certification of building materials, and the revision of energy efficiency laws for constant technology update. One of these projects is the development of the Regulation for Energy Efficiency Labeling of Commercial Buildings.
In June, 2004, an agreement between the Federal University of Santa Catarina and PROCEL (Brazilian Program for Electricity Conservation) was signed, with the aim to develop the technical base for the regulation. During the development process, some discussions arose, and it was verified that several efficient design solutions (envelope) in conjunction with the use of efficient equipments (lighting and HVAC) can lead the design solutions to different levels of energy efficiency of the building. Other important consideration is the high level of informality in the construction sector. Hence, it was decided to encourage the construction of buildings with higher efficiency instead of developing the minimum requirements. Facing this scenario, the Technical Group for energy efficiency in buildings has decided to develop a regulation for labelling buildings, instead a standard with minimum requirements, as it can be used as market strategy for buildings that are more energy efficient. In September, 2006, the experimental version of the regulation was approved by the Committee. This paper describes the methodology to classify the energy efficiency level of commercial and public buildings, according to the regulation.

1.3 International Survey

An international review was carried out to access the international experience with energy efficiency regulations and to assist in the development and implementation of energy related building code requirements for Brazil (Labeee, 2005a and Labeee, 2005b).
In the review, it was observed that all the codes have similar structures. Usually they separate "residential buildings" from "other buildings". The framework is usually similar for the two categories with different specific requirements. The main aspects that are considered for buildings, especially for non residential, are lighting and HVAC. The codes also focus on the building envelope and the main engineering systems including hot water systems, equipments, piping insulation and system controls. Most countries specified one or more regulatory approaches, which, generally, include:

- A performance approach;
- A prescriptive approach usually with tabular format;
- A trade-off approach, which compares a building of reference complying with the prescriptive tables with a proposed building.

The trade-off approach usually trades-off envelope R or U values but sometimes can allow tradeoffs to take into account heating and cooling systems as well.
The main requirements for buildings other than residential are usually divided in three categories:

- Envelopes: the prescriptive approach, in particular, for larger buildings can be very detailed taking into account thermal resistance of walls, floors, roof and windows as well as radiant gains through windows and skylights. The radiant gains means that shading devices, fenestration and building orientation become important. Usually the simplistic approach is based on value of window area not being exceeded.
- HVAC Systems: although the scope varies, most countries have requirement for HVAC systems in commercial and public buildings. Most cover the efficiencies for refrigeration and heating equipment electric motors, pumps and fans.
- Lighting Systems: most countries have requirements for: high efficiency lighting fittings; maximum lighting power density; zoning; switching; or automatic controls.

The main standards used in the United States for commercial buildings are: *International Energy Conservation Code* (IECC), which is the successor of the Model Energy Code since 1998; and ASHRAE 90.1 - *Energy*

Standard for Buildings Except Low-Rise Residential Buildings.

The ASHRAE Standard 90.1 has been established by the DOE (Department of Energy) as the commercial building reference standard for state building energy codes under the Energy Policy Act of 1992.

The original ASHRAE Standard 90.1 was published in 1975 and revised editions were published in 1980, 1989, and 1999 using the ANSI and ASHRAE periodic maintenance procedures. Since 1999, the standard is on continuous maintenance, permitting the standard to be updated several times each year through the publication of approved addenda to the standard. Updates were published in 2001 and 2004.

This standard provides minimum energy-efficient requirements for the design and construction of new buildings, additions of buildings and their systems, and new systems and equipment in existing buildings; and criteria for determining compliance with these requirements. The provisions of ASHRAE 90.1 apply to (ASHRAE, 2004):

- The envelope of the building;
- The systems and equipments used in conjunction with buildings: heating, ventilation and air conditioning; service water heating; electric power distribution and metering provisions; electric motors and lighting.

For the building envelope there are mandatory provisions and a prescriptive path, which establishes either Minimum Values of thermal resistance (R-value) of insulation, or Maximum Values of thermal transmittance (U-factor), thermal conductance (C-factor) or the perimeter heat loss factor for slab-on-grade floors (F-factor). There is also a building envelope trade-off option.

The total vertical area of the opening shall be smaller than 50% of the total area of the wall and compliance of with U-factors and solar heat gain coefficient (SHGC) shall be demonstrated for all fenestration.

For the lighting system the Interior Lighting Power Density Allowance shall be calculated.

Mechanical equipment and systems serving the heating, cooling or ventilation needs of the building shall comply with minimum equipments efficiencies and labeling requirements.

The building Energy Cost Budget method is an alternative to the prescriptive provisions of this standard. It may be employed for evaluating the compliance of all proposed designs, except designs with no mechanical system. The Energy Cost Budget is basically a method that compares annual energy costs of the proposed building to a similar prototype or reference building. The prototype or reference building, which is similar in size and usage to the proposed building, must meet all the requirements of the prescriptive criteria.

The American standards for commercial buildings such as ASHRAE and IECC have several approaches for achieving compliance with the requirements. Most of them are complex and demand expert professionals to use them and to evaluate the results. Hence, small buildings, usually, adopt a simpler method.

The European Union adopted in December 2002 the Directive on the Energy Performance of Buildings (EPBD) that, among other issues, required EU Member States to review their building energy regulations by January 2006, using a common methodology where cooling needs and AC Systems must be accounted for in all types of buildings. Also the Directive establishes requirements on the energy certification of buildings. According to the Directive, the process of certification may be supported by programmes to facilitate equal access to improved energy performance. Member States shall ensure that, when buildings are constructed, sold or rented out, an energy performance certificate is made available to the owner or by the owner to the prospective buyer or tenant, as the case might be. Also, Member States shall take measures to ensure that for large buildings (total useful floor area over 1000 m^2) occupied by public authorities and by institutions providing public services and frequently visited by these persons, an energy certificate shall be placed in a prominent place clearly visible to the public. The validity of the certificate shall not exceed 10 years (Directive, 2002).

With a view to reduce energy consumption and to limit CO2 emission, the Directive lays down requirements for regular inspections of heating and cooling systems. This theme comprises specifications and training requirements for experts and inspectors including indications on the resources needed at national level (how many experts and inspectors and level of expertise), quality assurance for experts, inspectors and certificates, criteria for accreditation, code of practice, insurance and liability. Each country is free to implement the EPBD in its own way, as long it complies with its basic requirements. According to Maldonado (2005), here lays, however, a major difficulty or a major weakness of the EPBD: it specifies a complex and comprehensive methodology for the energy characterization of buildings, but it lacks a legal text, e.g., a standard, that describes that model in all its technical details.

Although the EPBD measures will result in useful consequences, the main difficulties that Member States are facing include the existence of 30 European Standards (ENs) that are being revised to attend the Directive. While many of these standards have already been published, there are several others which currently are at various stages of the drafting process, together with a number of new items on which work started in 2004.

The European Commission has consequently estab-

lished initiatives to try to overcome these difficulties and move towards a certain degree of harmonisation on a voluntary basis. In January 2006, the EPBD Buildings Platform was created as an information service for helping the implementation of the Buildings' Directive (www.buildingsplatform.eu).
Other important project related to the Directive, the Altener project EPA-ED has been finalised in September 2004. The EPA-ED (Energy Performance Assessment of Existing Dwellings) method includes software and tools addressing the needs of both policy makers and consultants with respect to Energy Performance Certificates for existing dwellings within EPBD. The objective of the project was to conceptualise and develop a method for assessing the energy performance of existing dwellings on an European level. The EPA-ED project has resulted in an Energy Performance Assessment method for existing dwellings that can easily be applied in all the European member states. It provides the necessary data for the Energy Performance Certificate according to the EPBD (http://www.epa-ed.org/).
A substantial amount of know-how, tools and expertise is available within the European Union with regard to the energy performance of new buildings. Also on existing dwellings progress has been made in developing assessment methods. However, the existing non-residential (ENR) building sector still requires substantial support; support which covers a more complex set of considerations. Compared to dwellings, non-residential buildings are much more diverse in user patterns and building typology. The HVAC systems are complicated. An energy performance assessment method for non-residential buildings is therefore much more complex.
To cover that, EPA-NR addresses the implementation of the EC Energy Performance of Buildings Directive (EPBD) particularly with respect to energy performance assessment in existing Non Residential buildings. The EPA-NR method produces an Energy Performance Certificate for non-residential buildings with the possibility for additional advice. Tools will be developed to perform the assessment (check lists, inspection protocol and a software package for the energy calculation). Pilot projects (at least two in seven countries) will test the method and tools. Policy recommendations will be provided to all levels of government across Europe. The project, in which seven EU Member States are participating, started in January 2005 and will last for two years (http://www.epa-nr.org/).
In Brazil, the adoption of minimum prescriptions and criteria for compliance involves several issues:
- Lack of capable professionals in the city halls to request compliance with the standard;
- The need of supporting materials and training for developers and building professionals;
- In the Brazilian reality of construction practices, for small constructions, the lighting and HVAC systems are, usually, installed after the building is ready to occupation. This culture makes that the implementation of a compulsory energy standard of minimum requirements more difficult.
Based on that, it was decided for an easier start, through the implementation of regulation for labeling commercial and public buildings, then carry out tests and training on the methodology and, finally, to increase the complexity of Brazilian building energy efficiency regulation.

2. PROCESS DEVELOPMENT

In the proposed Brazilian regulation, there are two approaches to achieve compliance with: following the **Prescriptions** for Lighting, Air Conditioning and Envelope, or using **Simulation** to compare the results to a similar building that complies with the initial prescriptions. Trade-off approaches are not adopted in this regulation.
A general equation was developed based on electricity end-use of commercial buildings, which focus in three main separate groups: lighting and air conditioning systems and envelope characteristics.
Lighting systems prescriptions aims to limit Lighting Power Density, according to room characteristics and necessary luminance level.
Air conditioning systems requirements are based on Brazilian Appliance Labeling Program or minimum requirements of energy efficiency defined in ASHRAE 90.1.
Envelope compliance is achieved by using a multi-variable regression equation, which was developed with the simulation of six basic building prototypes and its design alternatives. The prototypes were a result of a survey on five Brazilian cities. Simulation was carried out for one climate for each Brazilian Bioclimatic Zone: ZB1 to ZB8, resulting in 4831 simulations to develop 12 regression equations. During the process, electricity consumption similarities were found between some Bioclimatic Zones, as ZB2 and ZB3 in one group and ZB6 and ZB8, in another group. Two regression equations were found for each Zone or Group Zone, one for floor areas smaller than 500 m^2 and another for larger floor areas. A unique equation was not possible to be developed for any building and, even the found equations have restricted applications according to building shape and size (Shape Factor). Since the equations were developed with average building characteristics, the equations do not describe properly unusual buildings, which dimensions are too large or too small.
The envelope equations are used to estimate electricity

consumption indicators using: ILD (Internal Loads Density), hourly occupation for a typical weekday, a size indicator, a number of floors indicator, WWR (Window to Wall Ratio), angles of window solar devices and window Solar Heat Gain Coefficient. Uvalue (Thermal Transmittance) of external walls were excluded from the entry data since its augmentation could increase or decrease electricity consumption according to several building characteristics and climate variation. Also, Uvalue of roof caused some variations on electricity consumption curves and it was maintained constant on the equation.

3. REGULATION

3.1 Overview

The Regulation for energy efficiency labeling specifies the technical requirements, as well as the methods for classification of commercial and public buildings according to their energy efficiency. It is voluntary, and will be implemented in 2007, becoming compulsory in five years from the implementation date. The purpose of this regulation is to provide conditions to certify energy efficiency level of Brazilian buildings (commercial and public). The provisions of this regulation apply to buildings with minimum total useful area of 500 m^2; or when the energy demand is greater than or equal to 2,3 kV, including conditioned buildings; partially conditioned buildings; and naturally ventilated buildings.

The initial text of the regulation was elaborated by the Laboratory of Energy Efficiency in Buildings, Civil Engineer Department of Federal University of Santa Catarina. The text has been discussed and adjusted by a Technical Group, and finally it was approved by the National Committee (GT-MME).

The regulation is divided in three main requirements: Lighting System; Air Conditioned System; and Building Envelope. The methods are described below. The requirements have levels of efficiency that vary from A (more efficient) to E (less efficient).

To be able to get the general classification of the building, each stage must be evaluated according to the specific method, resulting in a final classification. To do that, each requirement has a weight, and according to the final score, a general classification is obtained, which also varies from A to E. Initially, the Technical Group discussed the possibility to attribute equal weights for the requirements. Later, due to the growth of the air conditioning end use in the commercial sector, it was decided to attribute a higher weight to the air conditioning system requirement. The weights are distributed as follow:

- Lighting System (LPD) = 30%
- Air Conditioning System (AC) = 40%
- Building Envelope (ENV) = 30%

The general classification of the building is calculated according to the weight distribution, using the following equation:

PT = 0,30 x (EqNum LPD) + 0,40 x {(EqNum AC x CA/UA) + [(1- CA/UA) x 5]} + 0,30 x {(EqNum Env x CA/UA) + [(1- CA/UA) x 5]}

Where:

CA: conditioned area;

UA: useful area

The numerical equivalent adopted (EqNum) for the efficiency levels of each requirement are obtained from Table 1:

Table 1: Numerical Equivalent for each efficiency level

A	**5**
B	**4**
C	**3**
D	**2**
E	**1**

The total score (PT) obtained from the equation above will define the general classification of the building:

Table 2: General Classification

PT	**Final Classification**
4,5 to 5	A
3,5 to 4,4	B
2,5 to 3,4	C
1,5 to 2,4	D
1 to 1,4	E

Initiatives that provide extra energy efficiency to the building can get extra score (up to one point) in the general classification. This must be judged and decided by the Committee for Buildings of INMETRO (National Institute of Metrology). To be able to get the extra score, the initiatives must be justified and the energy saving proved. These can be: System and equipments that provide Water Use Reduction; Renewable Energy Source; combined Heat and Power, and Technology Innovations that increases energy efficiency in buildings.

As a general requirement for the building to be eligible to the label, the building must have an electrical network, which allows central measurement for each end use: lighting, HVAC system and others. Besides this, there are some minimum requirements for the building to meet level A:

- if a building requires a hot water system, it should use either a solar heating system, a heat pump, or heat recovery system;
- If the building has more than one elevator, it must have intelligent traffic control;
- The building must use certified water pumps.

3.2 Lighting System

This section specifies the method for determining the interior Lighting Power Density. It applies to interior spaces of a building, with the aim to classify the energy efficiency level of the lighting system.

The method specifies the maximum allowance of Lighting Power Density by 100lux (W/m²/100lux) as a function of the ambient index, which is defined for each level in Table 3. The values of lighting power density were calculated based on a study carried out considering different lighting systems with different levels of efficiency. The necessary luminance level (lux) is defined for each ambient by using the Brazilian Standard NBR 5413 – Indoor Luminance Level (ABNT, 1992).

Table 3: LPD Allowance for each level in W/m²/100lux

Ambient Index K	Level A	Level B	Level C	Level D
0,60	2,84	4,77	5,37	6,92
0,80	2,43	3,86	4,32	5,57
1,00	2,34	3,38	3,77	4,86
1,25	2,12	3,00	3,34	4,31
1,50	1,91	2,79	3,11	4,01
2,00	1,88	2,53	2,77	3,57
2,50	1,88	2,38	2,57	3,31
3,00	1,74	2,31	2,46	3,17
4,00	1,74	2,16	2,33	3,00
5,00	1,71	1,91	2,24	2,89

The maximum allowance of Lighting Power Density for each ambient will be given by the product of the obtained values (W/m²/100lux) and the required luminance level (lux).

A lighting system classified with energy efficiency level A corresponds, for example, to use T5 fluorescent lamps of 28W, luminaries with aluminum reflector and electronic ballasts, while a lighting system with E level corresponds to use T12 fluorescent lamps of 40W and electromagnetic ballasts.

Besides the maximum allowance of Lighting Power Density, there are mandatory requirements of Lighting System Control according to the level intended: Automatic Lighting Shutoff; Space Control; and Daylighting Control.

3.3 Air Conditioning System

According to the regulation, to be able to get the certification, it is compulsory that mechanical equipment and systems serving heating, cooling or ventilation shall be labeled by INMETRO or have the international energy efficiency ratio measured (COP).

- Using domestic air conditioning equipment and SPLIT with efficiency labeled by the Brazilian Appliance Labeling Program – PBE/INMETRO.
- Other Systems according to ASHRAE 90.1.

The classification by INMETRO is based on the performance index of the equipment. Tables with the energy efficiency classification according to the minimum requirements for each category can be found at INMETRO website – www.inmetro.gov.br.

Other systems, which are not yet regulated by INMETRO, are classified according to the minimum requirements of energy efficiency based on ASHRAE 90.1:

a) Level A: Air conditioners, water chilling packages, condensing units and cooling towers shall have minimum efficiency requirements in accordance with **ASHRAE 90.1 – 2004** and the whole system shall meet the mandatory requirements for this level (see below).

b) Level B: Air conditioners, water chilling packages, condensing units and cooling towers shall have minimum efficiency requirements in accordance with **ASHRAE 90.1 – 2004**.

c) Level C: Air conditioners, water chilling packages, condensing units and cooling towers shall have minimum efficiency requirements in accordance with **ASHRAE 90.1 – 1999**.

d) Level D: Air conditioners and water chilling packages shall have minimum efficiency requirements in accordance with **ASHRAE 90.1 – 1989**.

e) Level E: Systems those are not included in the levels above.

To get the level A, the air conditioning system shall meet the following requirements: Detailed Load calculations; Zone thermostatic controls; Automatic shutdown; Thermal zone isolation; Ventilation System design and control; Heat recovery; Hydronic system design and control; Heat rejection equipment design.

3.4 Envelope

This section specifies requirements for the building envelope and describes the method to classify the energy efficiency of the envelope based on a Consumption Indicator, which is obtained by using an equation.

When a skylight exists, to get the energy efficiency level A or B, the building shall meet the following requirement: the maximum solar heating gain coefficient (FS) of the glass or of the opening system according to the respective Percentage of the skylight in the roof – PAZ, obtained from Table 4. For buildings with PAZ greater than 5%, and intending to meet A or B level, simulation shall be performed, according to the section "**Simulation**" of the regulation.

Table 4: Percentage of Skylight in the roof x Solar Heat Gain Coefficient

PAZ	0 to 2%	2,1 to 3%	3,1 to 4%	4,1 to 5%
FS	0,87	0,67	0,52	0,30

Two equations for each Brazilian Bioclimatic Zone were developed: one representing buildings with projection roof area (A_{pcob}) smaller than 500m² and the second one for buildings with projected area greater than 500m². The Brazilian Bioclimatic Zoning is established in NBR 15220-3 (ABNT, 2005).

The equations were developed from simulations analyses of energy performance of prototypes that represent the most common characteristics of a sample or building group in Brazil. Photography and site surveys were performed to provide information for the establishment of a building prototype for office and institutional buildings. The survey has identified the external characteristics of the buildings, such as shape and dimension, percentage of opening in the façade, the existence of shading devices and solar heating gain coefficient of glazing (Carlo et al, 2005) and it has originated five prototypes, each one with a distinct volume and representing a different commercial activity: hotels, large offices, small office, large and small store. These prototypes were modified for the worst case scenario of each commercial activity and evaluated under different situations (Carlo and Lamberts, 2006). After that, energy conservation measures were applied to the less efficient prototype aiming to verify their relevance on providing energy efficiency. The most relevant measures, which are related to the envelope, are considered in the equation to calculate the Consumption Indicator.

The Consumption Indicator for the envelope shall be calculated according to the city and Bioclimatic Zone where the building is located. The equations for A_{pcob} greater than 500m² are valid to a minimum Shape Factor allowed $(Aenv/Vtot)_{min}$. The equations for A_{pcob} smaller than 500m² are valid to a maximum Shape Factor allowed $(Aenv/Vtot)_{max}$. Above or below that, the limit values shall be used.

Next, as an example, valid equations are shown for buildings located in the Bioclimatic Zone of Florianópolis (Southern Brazil):

A_{pcob} <500m²:

Maximum Shape Factor $(Aenv/Vtot)_{max} = 0,92$

$IC_{env} = -175,30 \times (Apcob/Atot) - 212,79 \times (Aenv/Vtot) + 21,86 \times PAF_T + 5,59 \times FS - 0,19 \times AVS + 0,15 \times AHS + 266,79 \times (Apcob/Atot) \times (Aenv/Vtot) - 0,04 \times PAF_T \times FS \times AVS - 0,45 \times PAF_T \times AHS + 190,42$

A_{pcob} >500m²

Minimum Shape Factor $(Aenv/Vtot)_{min} = 0,15$

$IC_{env} = -14,14 \times (Apcob/Atot) - 113,94 \times (Aenv/Vtot) + 50,82 \times PAF_T + 4,86 \times FS - 0,32 \times AVS + 0,26 \times AHS - 35,75 \times (Vtot/Aenv) - 0,54 \times PAF_T \times AHS + 277,98$

Where:

PAF_T = Percentage of opening in the façade (%)

FS = Solar Heat Gain Coefficient

AVS = Vertical Shading Angle

AHS = Horizontal Shading Angle

The obtained Consumption Indicator (IC) shall be compared to a numerical scale, which is divided in intervals that represent a level of performance classification, varying from A to E. The smaller the indicator obtained, the more efficient the envelope will be. The numerical scale of the efficiency level is variable and it shall be determined for each building volume as following:

- The upper limit of IC shall be determined by the same equation, however some parameters are fixed (PAF_T = 0,60; FS = 0,61; AVS = 0 and AHS = 0). The IC_{max} represents the maximum indicator that the building can reach to obtain D level. Above that maximum value, the building shall be classified as level E.
- The lower limit of IC is also calculated by the equation, however using the fixed parameters (PAF_T = 0,05; FS = 0,87; AVS = 0 and AHS = 0).
- The IC limits represent the scale that the building shall be fitted within. The scale is divided in four intervals; each interval represents a level of classification that varies from A to E.

3.5 Simulation

The building simulation method is an alternative to the prescriptive provisions of this regulation to classify the energy performance of a building.

The method can be used to evaluate conditioned buildings; naturally ventilated buildings, or buildings that have conditioned area - of long permanence – smaller than the total useful area.

a) Conditioned buildings: the method compares the performance of the proposed design building (real) with to a similar building (reference), whose characteristics shall be in accordance to the efficiency level intended. Using simulation, the final energy consumption of the proposed building design shall be compared to the energy consumption of the reference building design. It should be demonstrated that the energy consumption of the proposed design shall be equal or smaller than the energy consumption of the reference building design. Therefore, two models representing the same building shall be modeled: one representing the proposed design building (according to the proposed design) and one model representing the reference building (according to the level intended).

The method is based on the Energy Cost Budget from ASHRAE 90.1, however considers energy consumption instead of cost.

b) Naturally ventilated building or buildings that have areas of long permanence not conditioned: it is compulsory to prove by using simulation that the ambient of the not conditioned areas provide internal temperatures in the comfort zone during 95% of occupied hours.

The software to be used in the simulation has to pass ASHRAE Standard 140.

3.6 Certification

The certification process includes two phases:

- Design and Documentation: a certificate is emitted with a label proving the efficiency level met;
- Auditing in the building (occupied and with all systems installed) by an accredited professional: a certificate can be exposed in the building.

4. discussion and concluding remarks

There is a large potential for avoiding higher growth of electric energy consumption in developing countries like Brazil, even with the increase of PIB (Gross National Product), by adopting energy efficiency measures. To control the growth of energy consumption associated to the economic growth of the country, it requires a series of measures to save energy. Among these measures, standards and laws to provide energy efficiency can contribute to the residential, commercial and public sectors. The initiative of providing a label with the level of energy efficiency classification to new buildings can encourage consumers to choose more efficient building, as well as it can work as market strategy to promote trades: "leadership by example".

The Brazilian Regulation is nowadays under test stage in the Brazilian Universities network of thermal comfort laboratories. Each laboratory shall apply the methodology in some new buildings or buildings in final stage of construction with the aim of testing the regulation steps and also to produce a data base of buildings and their energy efficiency level in different Brazilian climates. According to the results of the testing stage, the regulation can be adjusted and, for the next year, it is supposed that the regulation shall be launched in the market. After that, a schedule for the regulation becoming compulsory will be defined and approved.

Next, a Regulation for labeling energy efficiency of residential buildings is being studied and should be implemented. Regulation for existing buildings is also planed for the near future.

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