INSOLATION EVALUATION IN THE LABELLING OF THE 'PROCEL EDIFICA' PROGRAM

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Abstract

This work shows a general sight of the National Conservation of Energy Label in comercial buildings, service and publics in Brazil. Introduce the historic of Procel Edifica, that grants the label. Explain the objectives and which proceeding to label a building from his energetic efficience. Show the way of valuation of the individual sistems introducing the requirements to an A general concept. Exposes some architectonic details that can improve the energetic profit that the local clime presents. In the present paper the issue of insolation and solar protection is evaluated in the individual system of the building construction focusing on the Brazilian law.

1. Introduction

Brazil is a country with continental dimensions. The majority of its area is located in tropical and subtropical regions, where great part of the energy consumption of the buildings is used with air conditioner systems. In contrast with cold regions, where solar energy is used for heating, in hot climates, the greatest approach must be with shade and solar protection, objects of this study**.** The main objective of this study is to identify, in the law, the references to the use of shading and sun protection in buildings, when there is the necessety to stop the excessive insolation.

Law N^{o} 10,295, which discourses about Law on Energy Efficiency, was created in 2001, establishing the criteria for the National Policy of Conservation and Rational Use of Energy. Decree N^{o} 4059 of 2001 regulates that law, establishing the "maximum levels of energy consumption, or minimum energy efficiency of machinery for energy produced or sold in the country, as well as the buildings." Based on this law, it was created PROCEL - National Electricity Conservation Program, initially with home appliances.

With the objective to stimulate the creation of energy efficient buildings, it was created in 2009 the program Procel Edifica, specially focusing in Environment Comfort. [1] The intention of Procel Edifica is to label commercial, service and public buildings, therefore, these sectors are responsible for approximately 23% of the consumption of electric energy in Brazil. [2]

The efficient energy is, in many aspects, a key factor for a country's economy. The improvement of energy efficiency reduces the necessity to increase the generation capacity and new investments, releasing resources for investment in measures of environment protection, security and improvement in the already existing generating unities, in clean technologies, among others. [3]

2. National Labelling of Energy Conservation – ENCE

The energy efficiency of Procel Edifica is established by 3 groups of requirements: building envelope, illumination and air conditioning. The 3 groups are evaluated individually, obtaining partial levels of efficiency, which combined in an equation, results in a punctuation that indicates the level of general efficiency of the building. There is five levels of efficiency, as much for the partial classifications as for the total, being A(more efficient), B, C, D and E (less efficient). [1]

Partial Labels can be formed by: envelopment; envelopment and lighting system; envelopment and air conditioning system. The existing buildings can receive parcial Labels of lighting or air conditioning systems after refitment in these systems in order to improve energy efficiency if, and only if, the building envelope already have or are also subject to the partial label. [4]

2.1 Bonifications

The program stimulates the use of solutions that raise the efficiency of buildings. These buildings final classification might generate extra marks to be proven through calculation memorials. There are four main items, which are:

- Systems and equipment that rationalize the use of water, providing 20% of annual consumption saving.

- Systems or sources of renewable energy: water heating, taking care of at least 60% of the hot water demand; wind energy or photovoltaic panels, with minimum savings of 10% of the annual consumption.

-Energy Cogeneration, with minimum savings of 30% in the annual consumption of electrical energy of the building;

-Systems or technical innovations that increase the efficiency, providing savings of 30% in the annual consumption of electrical energy. [4]

The evidence of the use and the results of these incentives generates bonifications that increase the classification of the building. The partial labels can be formed by: building envelope; building envelope and illumination system ; building envelope and air conditioning system. [5]

2.2 Individual Systems and Prerequisites

The strategies of natural energy exploitation of each region depend on the climatic characteristics of the same ones and the intention is to obtain thermal and visual comfort using the maximum possible of natural illumination and ventilation in the buildings. [6] Law NBR 15220-3 defines the Brazilian Bioclimatic Zoning, dividing the Brazilian territory in 8 bioclimatic regions with relatively homogeneous climate (figure 1) and lists 330 Brazilian cities. [7]

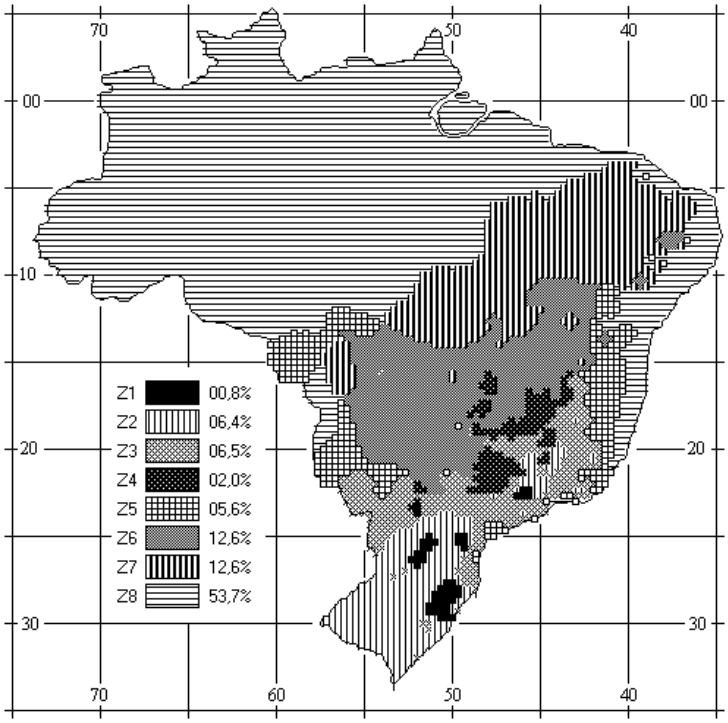

Figure 1 – Brazilian Bioclimatic Zoning [7]

This law indicates a set of technical and constructive recommendations for each zone that optimize the thermal performance of buildings, adapting them to the climate. In the method for bioclimatic classifying, a Bioclimatic Charter was adopted, adapted from the one suggested by Givoni. [8]

The bioclimatic zone 1, region of southern Brazil, with cold winters, fits in areas of buildings with solar heating and with thermal mass for heating. In this region, medium-sized windows are recommended for ventilation with shading, indicating a need for insulation in winter only. The shape, orientation and implantation of the building, besides the correct orientation of glazing can help to optimize its heating during the cold period of the year by solar radiation. The external color of components also plays an important role in the heating of internal environments through the utilization of solar radiation. In external seals, light walls and insulated roof are recommended. In concerning of the passive thermal conditioning, it recommends solar heating of the building and heavy internal seals with thermal inertia that can help to keep the inside of the building warm in winter. [7]

Bioclimatic zone 2, also in southern Brazil, fits in areas of ventilation, solar heating and thermal mass for heating the building and, as well as in the previous zone, the windows for ventilation must be medium-sized and shaded, allowing sunlight during the winter. The external walls should be light and the cover light and isolated. The strategies of passive thermal conditioning recommend cross ventilation in summer, with attention to the prevailing winds, and in winter, solar heating of the building and heavy internal seals with high thermal inertia to keep the inside of the building warm, emphasizing that passive conditioning is insufficient in the coldest period of the year. [7]

The bioclimatic zone 3, in southern and southeastern Brazil, also fits in areas of ventilation, solar heating and thermal mass for heating the building, and windows for ventilation should also be medium-sized and shaded, allowing sunlight during the winter. The external walls should be light and reflective light, and the cover light and isolated. The strategies of passive thermal conditioning in the summer, recommend cross ventilation and in winter, solar heating of the building and internal heavy seals with high thermal inertia to keep the interior warm. [7]

The bioclimatic zone 4, in the southeastern region, fits in areas of ventilation, solar heating and thermal mass for heating and cooling the building, and windows for ventilation should also be medium-sized and shaded all year round, without the need of sunlight in winter. The external walls should be heavy, with greater thermal mass, so that the heat stored inside during the day keeps the environment warm at night, when outside temperatures drops. The coverage should be light and isolated. The passive thermal conditioning strategies are evaporative cooling and thermal mass in summer for cooling and ventilation in warm periods, in which the internal temperature exceeds the outside. In winter, it is recommended solar heating of the building with heavy internal walls, whose thermal mass helps to keep the interior of the building heated. [7]

Bioclimatic Zone 5, in southeast and central-west regions of Brazil, is an area for ventilation and thermal mass for heating. Mean sized and shaded windows are recommended for ventilation all year round, without the need of sunlight in winter. External walls should be light and reflective and the coverage light and insulated. The strategies for passive thermal conditioning are cross ventilation for the summer, and heavy internal seals with high thermal inertia in winter to keep heated the interior of the building.[7]

The Bioclimatic Zone 6, in the midwest region, is an area for ventilation and thermal mass for heating. Mean sized windows are indicated for ventilation, which should be shaded the entire year. The external walls should be heavy and the cover light and insulated. The strategies of passive thermal conditioning are evaporative cooling, thermal mass and ventilation for cooling in summer, warm periods when the internal temperature exceeds the outside one. For the winter, heavy internal seals with high thermal inertia are recommended to contribute to the maintenance of heating inside the building. [7]

The Bioclimatic Zone 7, in the northeast region, is an area for ventilation, thermal mass cooling and evaporative cooling, with an indication of shaded and smal windows. The external walls and

cover should be heavy with high thermal inertia. The strategies of passive thermal conditioning, for summer, are evaporative cooling, thermal mass for cooling and ventilation when the internal temperature exceeds the outside one. Because it is a hot and dry region, the thermal sensation during the summer can be mitigated through water evaporation. Evaporative cooling can be achieved through the use of vegetation, water sources or other resources that facilitate the evaporation of water directly into the environment that needs to be cooled. [7]

The Bioclimatic Zone 8, in northern Brazil, is an area where the windows should be large and shaded and external walls and roofs must be light and reflective. The cover with clay tile roof has no lining, even thought it does not meet the recommendations of bioclimatology, it may be accepted, provided that the tiles are not painted or varnished. Is also admissible coverings with thermal transmittances above tabulated values, provided they contain openings in at least two opposing eaves for ventilation and the openings occupy the whole length of their facades. The strategies of passive thermal conditioning in the summer are recomended permanent cross ventilation, with the reservation that the passive conditioning will be insufficient during the hottest hours of the day. [7]

The windows and other openings to ventilation are considered small if its area is equivalent to 10-15% of the floor area, average 15-25% of the floor area and large if its area is greater than 40% of floor area. External seals data for thermal transmittance, thermal delay factor and solar heat permitted are those listed in Table 1. [7]

Table 1 –Limits of thermal transmittance, thermal retardation factor and solar heat admissible [7]

External seals		Thermal transmittance - U W/m^2.K	Heat delay - φ Hours	Solar Factor - FS_o %
Walls	Light	$U \leq 3{,}00$	$\varphi \leq 4{,}3$	$FS_o \leq 5{,}0$
	Light and reflective	$U \leq 3{,}60$	$\varphi \leq 4{,}3$	$FS_o \leq 4{,}0$
	Heavy	$U \leq 2{,}20$	$\varphi \geq 6{,}5$	$FS_o \leq 3{,}5$
Covers	Light and insulated	$U \leq 2{,}00$	$\varphi \leq 3{,}3$	$FS_o \leq 6{,}5$
	Light and reflective	$U \leq 2{,}30$ FT	$\varphi \leq 3{,}3$	$FS_o \leq 6{,}5$
	Heavy	$U \leq 2{,}00$	$\varphi \geq 6{,}5$	$FS_o \leq 6{,}5$

2.3 Pre-requisite for envelopment

The evaluation of the building envelope is defined as the classification of the bioclimatic building site. [4] For the formulation of constructive guidelines for each of the Brazilian bioclimatic zones and for the establishment of strategies for passive thermal conditioning, are considered the following parameters and boundary conditions:

a) size of the openings for ventilation;
b) protection of openings;
c) external seals (type of external walls and coverages)
d) strategies for passive thermal conditioning.

Openings are considered all areas of the building envelope, with translucent or transparent closing, and allowing the entry of light and / or direct or indirect solar radiation, including windows, plastic panels, skylights, doors made of glass (with more than half glass area) and walls of glass blocks. Good positioned openings may ensure air circulation in indoor environments, beeing advised to locate it in a crossed form, facilitating the air flow. [6]

The orientation of the facades influences the envelope efficiency due to solar radiation, being necessary to define the orientation of each and evaluate how they are shaded.
This evaluation is done through the construction of a building within a quadrant defined according to table 2.

To quantify the effect of shading systems in the openings, are presented two complementary concepts: Vertical Shading Angle (AVS) and Horizontal Shading Angle (AHS). The AVS

measures, in the vertical plane, the effect of horizontal sun protections, while the horizontal AHS measures, in the horizontal plane, the effect of vertical sun protections.

Table 02 – Geographical orientation of facades [7]

Geographical orientation	Angles
North	0º to 45,0° and 315,1° to 360,0°
East	45,10° to 135,0°
South	135,10° to 225,0°
West	225,10° to315,0°

The angles are measured between the planes of glass laminas and the farthest edge that belongs to the solar protection. For use in the RTQ-C (Technical Regulation on Quality Level of Energy Efficiency of Commercial, Public and Service Buildings), the angle used is given by the weighted average of the angle of shading according to the area of the openings, however, the final maximum angle to be used is 45º. For the Bioclimatic zones 6 and 8, with a building projection area inferior to 500m², the AVS has a major constraint, with a limit of 25º. This limit goal is to avoid the excessive use of protecions that might affect the penetration of diffuse natural light in indoor. [9]

The AHS must always be considered on both sides of the opening. This way, the AHS of a window is the average angle of the two sun protection. Casting sun protections allow a greater entry of solar radiation when compared to other sun protection with the same protection angle and, for this reason, a correction factor ir adopted. A correction factor equal to one represents a casted sun protection where the shaded portion is the same as in a not casted sun protection with the same angle.

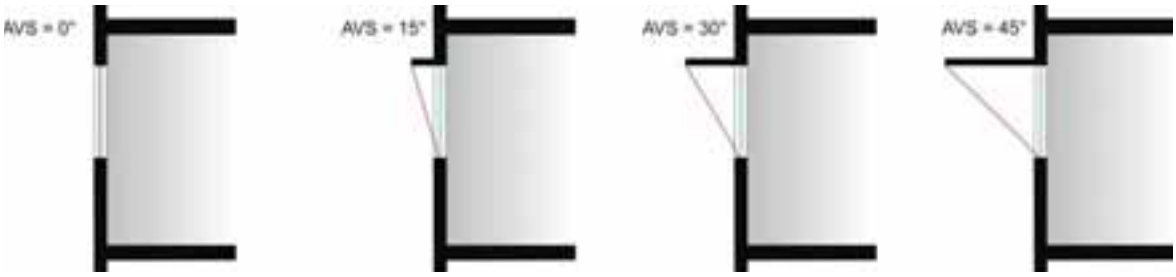

Figure 2 – Vertical Shading Angle – AVS [4]

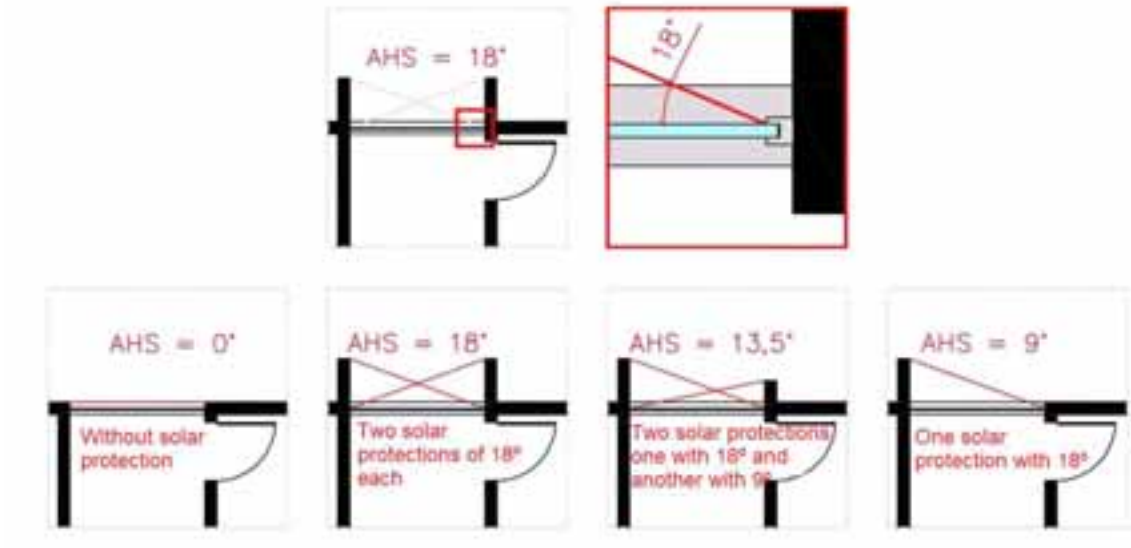

Figure 3 – Horizontal Angle Shading – AHS [4]

For the strategies of passive thermal conditioning are considered the Thermal Transmittance of roof and walls. In obtaining the envelope classification, the thermal transmittance of the coverage, at any bioclimatic zone, shall not exceed the limits shown in Table 3 and the Thermal Transmittance of external walls, must not exceed limits imposed by Table 4, for the corresponding bioclimatic zones. [9]

Table 3 – Limits of Thermal Transmittance of roofs [9]

Environments	**Label A**	**Label B**	**Label C e D**
Conditioned artificially	1,0 W/m²K	1,5 W/m²K	2,0 W/m²K
Not conditioned	2,0 W/m²K	2,0 W/m²K	2,0 W/m²K

Table 4 – Limits of Thermal Transmittance of Walls [9]

Bioclimatic Zones	**Label A**	**Label B**	**Label C e D**
Zone 1 to 6	3,7 W/m²K	3,7 W/m²K	3,7 W/m²K
Zone 7 to 8 – walls with thermal transmitance ≤ 80 KJ/m²K	2,5 W/m²K	2,5 W/m²K	2,5 W/m²K
Zone 7 to 8 - walls with thermal transmitance > 80 KJ/m²K	3,7 W/m²K	3,7 W/m²K	3,7 W/m²K

The use of bright colors on the outside of the buildings increase the reflection of solar radiation, reducing heat gain. [6] Colors and the surface absorbency are of mandatory analysis in areas 2 to 8, an its limits are given in Table 5.

Table 5 – Limits of Colors for Outside Revestment and Coverage. [9]

Environment	**Label A**	**Label B**	**Label C e D**
Outside Revestment	$\alpha < 0,4$ (bright color)	$\alpha < 0,4$ (bright color)	Do not have
Coverage	$\alpha < 0,4$ (unglazed ceramic tiles and roof garden)	$\alpha < 0,4$ (unglazed ceramic tiles and roof garden)	Do not have

If zenithal illumination exists, it should respect the relative limits of zenithal openings(PAZ) and solar factor(FS) for glass and opening systems, indicated in table 6. [6] Because PAZ is just horizontal, it is recomended the use of mansards or shed, instead of skylights and light shafts. [4]

Table 6 – Percentage of Zenith Opening Lighting and Solar Factor. [9]

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

2.4 Pre requisite for lighting systems

The program Procel Edifica[9] imposes criteria limits for control of the lighting system according to the desired level of efficiency and the necessary characteristics it serves: [9]

- Division of the circuits for each area enclosed to the ceiling by walls or partitions with manual control device for the independent operation of the internal lighting of the environment, located in visible place and with easy access, according to the classification sought.

- Contribution of natural light: environments with windows facing the outside environment or with access to natural light through a hallway not covered or with translucent cover and over a row of lights parallel to the windows must have an installed control, manual or automatic, for independent operation of the row of lights nearest the window, providing use of natural light available.

- Automatic turn off of the lighting system for environments larger than 250m² with automatic lighting shutdown system with pre-programmed schedule or presence sensor that turns off the lights 30 minutes after the departure of the occupiers. There may be exceptions in special circumstances and environments that should work 24 hours intermittently, where there is treatment

or repose of patients, or where the automatic shutdown of lighting can provide proven risk to the physical integrity of the users.

The determination of the lighting efficiency sets the power limit for each internal environment of the building. Levels range from A (most efficient) to E (least efficient). The final equivalent is the pondering of the efficiency of indoor lighting for each environment.

2.5 Pre requisite for Air Conditioning Systems

The thermal loads of the design of the heating and cooling air systems must be calculated in accordance with the standards and manuals for general acceptance of the professionals. The temperature of each thermal zone should be individually controlled by thermostats and the system must prevent reheating or any other form of heating and cooling simultaneously. The classification is given according to the assessment of air conditioning devices provided by PBE / Inmetro. When theres more than one independent system of air conditioning in the same building, its numerical equivalent is obtained by weighting the area of environment and its respective system, achieving a level of efficiency for the entire building. [9]

To obtain the level of efficiency A, the air conditioners, when it exists, window type or split type units, must be permanently shaded and with adequate ventilation, in order to not interfering with their efficiency.

3.Calculation of Energy Efficiency of the Envelopment

The calculation of the Indicator of Construction Consumption (IC_{env}) [3] is performed based on quoted items and other items concerning physical characteristic of the building, such as projection area of the building (A_{pe}), total floor area (A_{tot}), construction area (A_{env}), vertical shaded angle (AVS), horizontal shaded angle (AHS), form factor (FF), height factor (FA), opening percentage in the total facade (PAF_t) and construction total volume (V_{tot}). Commercial, service and public buildings are active during the day, the period of greater heat and also greater illumination. To prevent direct incidence of solar light in the environment, it is recommended external solar protections such as sun breakers, eaves and marquees, or interns, as curtains and blinds. [9]

The criteria for the complete classification of the level of the building's energy efficiency ratings are obtained by partial classificationof the envelopment, of the lighting system and of the air conditioning system, through an equation that considers these systems with pre-set weights in the regulation, corresponding 30% to Envelopment, 30% to the Lighting System and 40% to the air conditioning systems . The bonuses mentioned in 2.1 are initiatives that could be added to score the efficiency of the building, with a maximum of one point in the point standings.

The granting of the label can be accomplished in project phase of the construction or in existing building.

4. Conclusion

The evaluation of the building envelope is an important prerequisite for the Labelling and it is defined as the classification of the bioclimatic building zone. For the formulation of constructive guidelines, passive thermal conditioning for each Bioclimatic Brazilian Zone considers size and sun protection of openings and external seals.

In all zones of the Brazilian Bioclimatic Zoning, there are recommendations for openings with shading. Zones 1, 2 and 3 – medium-sized windows for shaded ventilation. Zones 4, 5 and 6 – medium-sized windows for ventilation , shaded all year round, with no need of sunlight in winter. In Zone 7 – small windows, shaded and external seals. In Zone 8 - the openings should be large, shaded and external seals, walls and roofs, should be bright and reflective.

The orientation of the facades influences the efficiency of the building envelope due the solar radiation incident on each one, being necessary to define the orientation of each. In addition to the

above, the Energy Conservation National Labeling (ENCE) consideres, in calculating the indicator of consumption Envelopment (ICenv), [3] vertical shading angles (AVS) and horizontal shading angle (AHS).

With appropriate design and shading, natural ventilation can be obtained in the building, but to get an A-level classification without artificial air conditioning, it must have proved thermal comfort for a period of the day. [6]. In case of need for air conditioning system, it can only be level A, if the condensing air unit is shaded. [4]

Qualitative evaluation of this work shows that to obtain a certification of energy efficiency in buildings in Brazil, of predominantly hot climates, the greatest concern should be with shading and sun protection. The first step in an analysis of the energy efficiency of comercial, service and publics buildings in Brazil, was given by legislation recently aproved. At the time, only as a recommendation, and soon will be mandatory.

The bonifications of the legislation also represent a progress in evaluating the efficiency of the building. Legislation to evaluate and label the energy efficiency of residential buildings is under development and should be completed by the end of 2010.

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