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Simulation of Energy Efficiency Labeling in Homes in the City of Manaus/AM

Andreza Assunção Gama[1], Fabiana Rocha Pinto[2]

[1]Academic department, University Center FAMETRO, Manaus/ Amazonas, Brazil
Email: andrezagama08@gmail.com
[2]Academic departament, University Center FAMETRO, Manaus/ Amazonas, Brazil
Email:fabiana.floresta@gmail.com

Abstract**—***Energy efficiency is one of the strategies to conserve energy, which means reducing consumption and reducing costs. For this, measures to increase energy efficiency are necessary to mitigate the impacts on the electricity sector. The objective of this study is to simulate the application of the Energy Efficiency Labeling system in four residences, seeking to evaluate their level of energy efficiency, the residences presented low levels, for not using cross ventilation, besides the choice of the types of material to be used in buildings to reduce this heat transmission to the interior of the buildings. However, this is the reality of most residences in the city of Manaus, most of them still old, the lack of structure and knowledge about this process of energy efficiency, makes it necessary policies that are more effective and actions to minimize this condition of most residences.*
Keywords**— RTQ-C, efficiency, labelling.**

I. INTRODUCTION

Seeking to ensure the optimization of energy generation and consumption with a view to rational use, energy efficiency is having its most evident moment, given the perception about the importance of energy conscious use, besides becoming something yet more economical and contribute to the environment.

Energy efficiency should be considered as an essential factor of long-term sustainability. Policymakers in private sector partner should encourage economic growth from investment in energy efficiency, showing new business models, technological innovations and economic measures [1].

Energy efficiency programs are linked to the government as the electricity distribution service is linked to a public scale, which promotes market transformation and stimulates the development of new technologies, always in search of benefits as a form of energy saving [2].

The National Electric Energy Conservation Program (Procel) together with the National Energy Conservation Label (ENCE) indicates to the consumer the products that have the best levels of energy efficiency within its category, informing the classification of products ranging from the most efficient (A) to the least efficient (E) depending on the product. The Brazilian Residential Labeling Program follows the same principle where it allows quantifying the gain with energy efficiency following changes that seek to combat waste, besides presenting proposals for bonuses for more dwellings Efficient [3].

Thus, INMETRO launched the National Energy Conservation Label for multifamily homes and buildings, taking into account population development in recent years we have seen the increase in housing, and sequentially the increase in the quantity of electronic devices. Thus, we tried to demonstrate in a simulated way the labelling service for these dwellings in order to present the performance of cost reduction [4].

The National Energy Conservation Label (ENCE) is obtained by evaluating the building based on the requirements contained in the Technical Quality Regulation applied to Residential Buildings RTQ-R, which consists of a classification method, through prerequisites, which generates a score on the energy efficiency of the residence [5].

The labeling process consists of two consecutive steps, the design inspection and inspection of the built building, after which ence is issued for project (optional for existing buildings) and the ENCE of Built Building, Respectively.

The aim of this study is to analyze the application of the Energy Efficiency Labeling system in homes proposed in the Technical Quality Regulation applied to Residential Buildings (RTQ-R) seeking to evaluate the level of this energy efficiency and have measures to increase this level by proposing bonuses, depending on their classification.

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II. MATERIAL AND METHOD

Area of Study

In this study for energy efficiency analysis, four residences located in the east of Manaus/AM were evaluated. In order to obtain sizes of the rooms, and the materials used in the construction for the proposition of the analysis.

The study was divided into two parts, the first data collection and the second, the application of the RTQ-R manual to obtain the level of energy efficiency on site and presenting an action plan for increasing this level if necessary.

The proposed method for evaluation was based on the evaluation process of the Eifice PBE, the RTQ-R, which assesses the wrap, the water heating system and bonuses and for the calculation base. The "performance calculation spreadsheet of the housing unit (UH) developed by the Brazilian Center for Energy Efficiency of Buildings was used in partnership with other bodies [6].

Data collection

Data were collected in four residences, which are located on the same land, with a size of 56m² (R1), 56m² (R2), 55.25m² (R3) and 48m² (R4). With the performance of a previous survey, it was found that the analysis evaluating the water heating system was not considered, being excluded from the study.

It was necessary to obtain the coefficient of the bioclimatic zone of the region, according to ABNT NBR 15220-3 (2003) "Thermal performance of buildings - Part 3", which classifies the Brazilian territory in eight bioclimatic zones, with its respective recommendations and constructive strategies for single-family homes of social interest, for the different areas of [7].

As described in ABNT NBR 15220-3 (2003), the city of Manaus/AM is located in zone eight, described in the ZBBR software, according to Figure 1 [8].

Fig. 1: *Bioclimatic Zoning of City Manaus/AM*
Source: [8].

The level of efficiency in residence described in the RTQ-C manual as a standalone housing unit is the result of the following (equation 1):

$$PT_{UH} = (a \times EqNumEnv) + [(1-a) \times EqNumAA + Bonuses$$

Equation for total efficiency level score (1)

Where:

- PT_{UH}*:* total score of the efficiency level of the autonomous housing unit;
- *a:* resulting coefficient according to the geographic region in which the building is located, where the coefficient in the North and Northeast regions, is equal to 0.95 and must be changed to 0.65 whenever there is a water heating system designed or installed.
- EqNumEnv*:* numerical equivalent of the thermal performance of the wrap of the autonomous housing unit when naturally ventilated;
- EqNumAA*:* numerical equivalent of the water heating system;
- Bonuses*:* score attributed to initiatives that increase the efficiency of building.

The level of the classification, the level of efficiency is assigned according to the score of the result of this equation, in which it is presented in the table 1.

Table 1: Efficiency level classification.

Score (PT)	Efficiency Level
PT ≥ 4,5	A
3,5 ≤ PT < 4,5	B
2,5 ≤ PT < 3,5	C
1,5 ≤ PT < 2,5	D
PT < 1,5	E

Source: [4].

III. RESULTS AND DISCUSSION

The residences were analyzed individually to obtain their energy efficiency levels as shown in Table 2. R1 corresponds to the residence number one, R2 to residence number two, R3 to residence number three and R4 corresponds to residence number four.

Through the maps generated for the analysis and occupation of the soil in the city of Manaus, from 1985 to 2015, it was possible to analyse the process of balance of the areas with vegetation (green areas) and increase of the areas of ubrban occupation (red area) regardless of the type of the use of the soil, with the losses of arborisation, landscape and further information that characterize these region.

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Table 2. Results obtained from requirements.

REQUIREMENTS/ RESIDENCES	R1	R2	R3	R4
Absortment of the external façade (α)	66,5	65, 6	73,6	41,0
Thermal transmittance of the walls (W/m²K)	1,85	1,85	1,85	1,85
Thermal capacity of walls materials (kJ/m²K)	1,61	1,61	1,61	1,61
Thermal coverage transmittance (W/m²K)	1,75	1,76	1,76	2,05
Thermal capacity of components (kJ/m²K)	21	16	16	232
The windows of the long-stay environments (m²)	6,36	5,76	5,9	5,76

Source: Authors, (2019).

The requirement of absortment to solar radiation provides us with the coefficient of solar radiation rate absorbed by a surface, by the rate of solar radiation incident on the same surface (NBR 15220-1, 2003). The absortment values of the facades of the residences correspond to the colors, terracotta, yellow, blue and orange, respectively. Values obtained based on a study conducted [9].

R3 has greater absortment on its façade because it is a darker color compared to the others. Solar absortment has a great impact on thermal performance, as they determine heat gains due to the incidence of solar radiation, that is, when radiant energy reaches an opaque surface, part of this energy is reflected and another absorbed [10].

The colors of buildings, as simple as it may seem, can provide us with a gain in relation to reducing energy consumption by cooling systems, as it can be easily changed without large financial investments. Remembering that absortment exerts greater influence on situations of need for cooling than heating [11].

The values of the requirement of thermal transmission and thermal capacity (of the walls and roofs presented), refer to heat transmission through an element or component, in this case refers to walls and covers, and the coefficient of radiation rate that crosses the element or component. As all residences have the same constructive material on the walls, then the values are equal and were obtained based on the "Manual A of the bioclimatic zone eight" [12].

A portion of the energy spent on the air conditioning of an environment owes thermal exchanges between external and internal media, that is, the form that occurs the heat passage of a wall in a given direction, this energy is being transmitted from a larger surface temperature for lower temperature [13].

The cover is the element most exposed to the incidence of sun's rays, since part is reflected to the outside and part is absorbed by the material and consequently being emitted into the interior in the form of heat [14].

The requirement of the windows of extended environments in the residences gave us information on the use of natural lighting and natural ventilation. Naturally ventilated buildings have the potential to offer thermal comfort in different Brazilian regions, it is worth mentioning that the wrap is one of the main elements of transmission of heat external to the environments [15].

For the application of the RQT-C manual, the spreadsheet (Made available by the Brazilian Center for Energy Efficiency of Buildings (CB3E) was used to calculate and obtain the level of efficiency of the residences [6]. After completing all the data in the worksheet, the following results were obtained (Figure 4).

Fig. 1: *Bioclimatic Zoning of City Manaus/AM*
Source: Authors, 2019..

Given the results obtained, we noticed that households have a media classification to low energy efficiency. In the residences it was observed that the fact occurs given the amounts of openings are insufficient for the environments, or due to their positioning, which ends up making it difficult for questions such as natural ventilation, so on typical summer days, there is an increase in electricity demand for cooling.

R1 uses two-sheet aluminum windows, i.e. only part of the window provides us with opening. The other residences use two-leaf wooden windows, and provides us with the total opening of the same.

Although residences two and three have better results compared to the others, the non-use of cross

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ventilation makes their energy efficiency level not the most indicated. When the environment has only one opening, fresh air does not enter, because there is a pressure inside the site that does not allow its entry, when the ambient openings are on adjacent walls, the direction of the airflow behaves differently relatively to what happens in openings rented on opposite walls [16].

To increase wrap score, cross ventilation should be improved by positioning windows on facades so that it has better lighting during the day and makes it allow for better wind passage [3].

In the city of Manaus there is a lower average speed of air, that is, a lower wind intensity, in addition to the average temperature of 30 °C, which would cause the heating of the environment instead of allowing better conditions in terms of thermal comfort [16].

We also have to take into account the choice of types of material to be used in buildings, where we can reduce the portion of solar thermal load that is transmitted to the inside of buildings. Currently there is a great search for the improvement of known techniques for the reduction of electricity consumption aimed at obtaining thermal comfort [17].

All residences presented a significant level of bonuses, due to the use of natural lighting, and the use of air conditioners with Procel seal. The gain of these bonuses guarantees for homes an average improvement of 10% in performance [3].

To achieve bonuses in the water rationing ite, and as a way to reduce waste of water use, techniques are used for its reuse of rainwater for non-drinking purposes [4].

Through the final score of the survey it is perceived that the residences have the same standard, having a low level of energy efficiency. In view of this, investment in energy efficiency becomes an advantageous alternative when compared to energy production, since it is cheaper to save energy than to produce. In addition to contributing a lower energy expenditure can provide the user with better environmental comfort inside their residence [18].

IV. CONCLUSIONS

The labeling system for energy efficiency in homes can be paramount, with regard to energy consumption, indicating improvements in this process and obtaining economic and environmental results in order to satisfy the use of the resource efficiently.

In the residential units, the need for adequacy was noted, given the lighting, ventilation and material part used, mainly linked to the climatic conditions of the region, where they are.

However, this is the reality of more than 50% of the residences of the city of Manaus, given the lack of government incentives, mostly still old housing projects, in addition to the lack of structure and knowledge about this process of energy efficiency.

Thus, more effective policies and actions are needed that minimize this condition of most homes, since use of the parties, which are in fact considered today concerns only appliances and lamps.

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