# Energy Efficiency Labeling Program for Buildings - A Review

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## ABSTRACT

Regulations are being promulgated and reviewed in order to achieve the maximum energy savings in buildings, both in developed and in developing countries. One important strategy employed to turn these laws and regulations effective is through building certification. The benefit of such practice may reflect in energy savings, reduction of carbon dioxide emissions, to end-users and real estate owners. This article aims to make a literature review concerning energy efficiency policies and regulations for buildings, highlighting how the Brazilian labeling program could be improved compared to the American and Portuguese programs. Comparison among different countries building labeling programs may contribute for a better understanding of advantages and drawbacks of each approach.

**Keywords:** Energy savings, Construction, Certification Energy, label Energy, efficiency policy Buildings energy regulation

## 1. INTRODUCTION

Electricity is essential to economic progress and quality of life of humankind. Linked to social mobility and human development, energy consumption is growing every year in Brazil and worldwide. Statistics indicate that China is now the world's biggest energy consumer, overtaking the United States in 2009[1].

While the U.S. primary energy consumption in buildings accounted for about 41% of total energy consumption [2], in China this figure was estimated around 23% [3]. On the other hand, in Brazil, this value represents around 14% [4].

International Energy Agency (IEA) developed a set of 25 energy efficiency policy recommendations, in order to help its members to promote energy efficiency measures across their countries. These policies are oriented towards the following seven priority areas: Cross-sectorial; Transport; Buildings; Industry; Appliances and Equipment; Energy Utilities; and Lighting. In regarding to buildings, IEA recommends: (i) mandatory building codes and minimum energy performance standards; (ii) net-zero energy consumption in buildings; (iii) improved energy efficiency in existing buildings; (iv) building energy labels or certificates;

and (v) energy performance of building components and systems [6]. The major contributors to energy consumption in buildings are HVAC (Heating, Ventilating, and Air Conditioning), water heating, lighting, and appliances [7]. One of the measures applied to reduce appliances energy consumptions is the 4E Program, Energy Efficient End-Use Equipment, which is implement by the International Energy Agency (IEA) and aims to support policy towards the promotion of energy efficient appliances worldwide [8]. The importance on energy efficiency policies implementation relies on energy security, economic development and greenhouse gas emissions reduction.

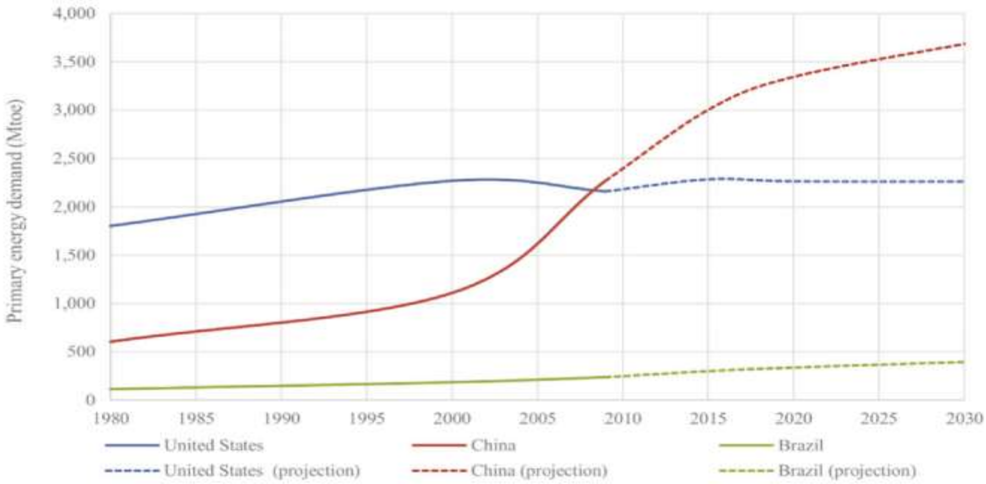


**Fig.1**. Primary energy demand in Brazil, China and the United States, from 1980 to2010 measured data and form 2010 to 2035 projected data

In the United States, the building-related emissions is about 776,090 thousand tons of CO2eq per year [12]; while in Brazil and Portugal, these emissions are circa 19,923 thousand tons of CO2eq per year [13] and 3292 thousand tons of CO2eq per year [14], respectively. However, when analyzing these figures in terms of primary energy, Brazil contributes less, with 1.54 tCO2eq/toe in comparison to the United States, 2.34 tCO2eq /toe, and Portugal, 2.06 tCO2eq/toe [15]. The reason for the smaller Brazilian contribution on CO2eq emissions lays down on its higher share of renewable energy on the total primary energy consumption. The share of renewable energy sources in Brazil, Portugal and USA is 39%, 24% and 6%, respectively [15].

Energy consumption in buildings is gaining a wider scale.

final energy consumption in the building sector, around 37%, is already the highest, the two other sectors main sectors – industry, around 28% and transportation circa 32% [7]. The importance in energy consumption in buildings might be explained by a crescent demand for an improvement in the comfort levels of the buildings, a greater time spent by people inside buildings, an increase in the urban population, as well as in the per capita income [16]. Two mechanisms to achieve reductions in energy consumption in building sector are through energy regulation and energy certification: the first one establishes a minimum energy performance, and, the second aims to reach higher energy performances [16].

## 2.THE ENERGY EFFICIENCY BUILDING CERTIFICATION POLICY IN BRAZIL

The first public measure to promote the application of energy efficiency measure in Brazil occurred in 1981, with the creation of the Conserve Program. This program aimed to promote the energy conservation in industries, the development of efficient products, and the replacement of imported energy resources for national ones.

In the following year, the Energy Mobilization Program (Programa de Mobilização Energética) was launched, which encouraged the application of energy conservation measures and the replacement of oil for alternative energy recourses [19].

The Law No. 8631/1993 [21] established that Brazilian Power Plants should assign resources for expanding and improving the public energy supply. Four years later, the Law No. 9478/1997 [22] was approved, founding the National Energy Policy Council (Conselho Nacional de Política Energética – CNPE), whose goal was to “promote the country's rational utilization of energy resources”.

## 3.BUILDING ENERGY CERTIFICATION POLICY IN SELECTED COUNTRIES

### *3.1. United States*

Standards for energy efficiency have been applied in US for more than thirty years, as an example of the development of the Standard 90 – Energy Conservation in New Buildings Design and the Title 24/1978 [32,33]. During the 90's, the Environmental Protection Agency, EPA, developed the Green Lights program, in order to apply more efficient lighting systems for commercial and industrial buildings. A few years later, the Green Lights merged with the Energy Star Buildings program, which use is voluntary and has as main goal to contribute to the reduction of greenhouse A.d.C.P. Lopes et al. / Renewable and Sustainable Energy Reviews 66 (2016) 207–219 209 gases. According to EPA, the benefit of this label is evident, as certified buildings with Energy Star emit, in average, 35% less carbon dioxide equivalent compared to similar buildings which do not have the label [34]. In 2011 was launched in the United States the first phase of the Building Energy Quotient Program – bEQ, developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, ASHRAE and based on the European experience. The first phase encompassed the “In Operation” label. In the subsequent year was launched the “As Designed” label. Both are voluntary and applicable to commercial buildings only, whether existing prior or after bEQ was launched. The score of each label is divided into seven categories, from Aþ (net-zero energy) to F (unsatisfactory) – Fig. 3. A certificate, an assessment report and a plaque for public display is provided with the label, containing detail information of the energy performance of the building and suggestions for improvements to enhance building performance [35].

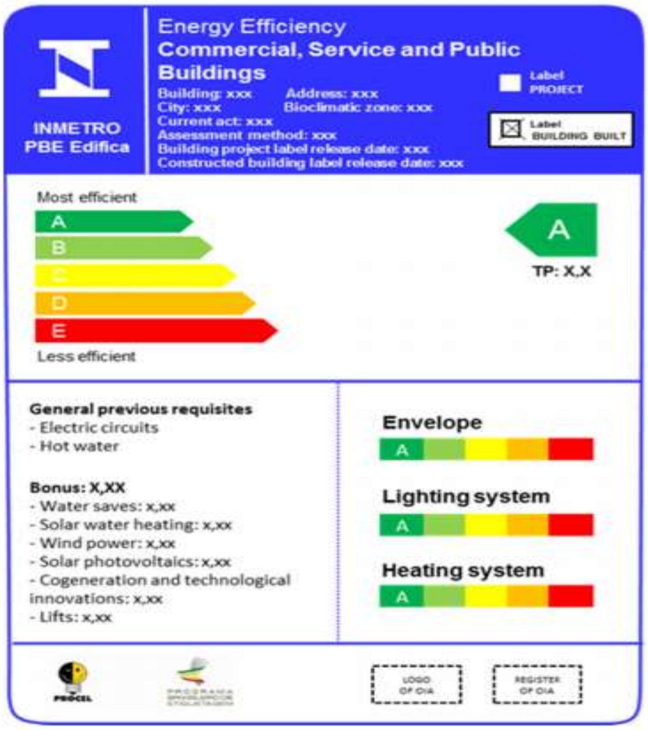


**Fig.2**. Sample of national energy conversation label for energy conversation Commercial Service and public building Brazil

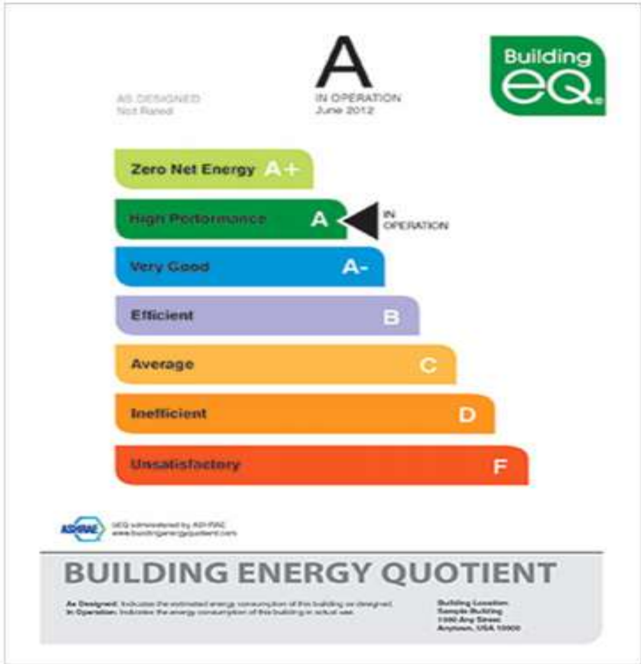


**Fig.3**. Sample of national label for commercial buildings USA

*3.2. Portugal*

Although one of the first standards regarding energy efficiency dates back to 60's in Europe, the first legal instrument of Portugal related to energy conservation in buildings was introduced by Decree-Law No. 40/90 [40–42].

The label was introduced in stages, starting in 2007 for all new residential and non-residential buildings with a floor area greater than 1000 m2 . In 2008, the second stage was initiated, including all new buildings. The final stage (2009) included existing buildings when sold or rented. The buildings are labeled following the guidelines imposed by the regulations and by different assessment methods for residential and service buildings. The certification provides a labeling system from Aþ (high energy efficiency) to G (poor efficiency); however, all new buildings must be between Aþ and B labeling level [46]. A sample of the label is showed in Fig. 4.

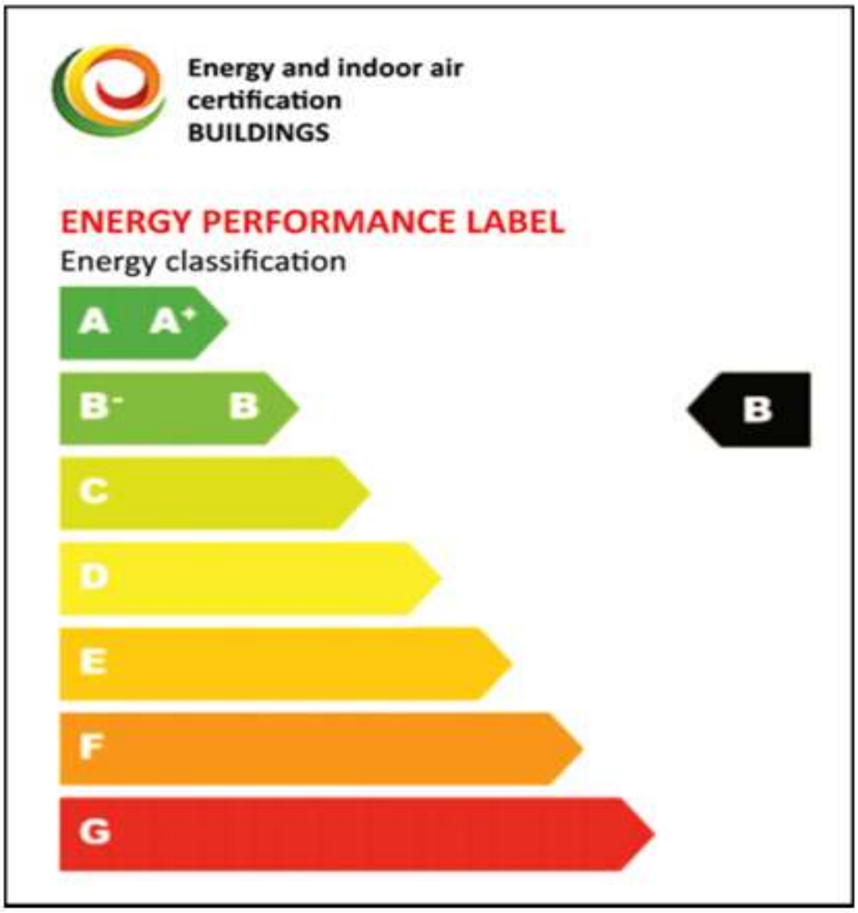


**Fig.4.** Sample of national energy conservation label for service and residential buildings_Portugal(translated to English and adapted by the authors0.

## 4. COMPARISON AMONG THE CERTIFICATION PROGRAMS

Pérez-Lombard et al. [18] propose seven questions that should be considered to develop energy certification programs. These questions will outline the comparison of the three energy certification program in analyses: Brazilian Labeling Program for buildings (Programa Brasileiro de Etiquetagem para edifícios, PBE), Building Energy Quotient, bEQ from US, and the Portuguese National System for Energy and Indoor Air Quality Certification, SCE. In order to be able to compare the labeling system from Brazil, Portugal and US, the following must be clear that:

1. In Brazil, the regulation studied, classified the buildings as: commercial, service, public and residential ones. The residential buildings are subdivided into: multi-dwelling unit, public areas of multi-dwelling unit and dwelling unit, which one will be focused on this study;

2. In Portugal the regulation classified the buildings as: services and residential ones; and

3. In US, the regulation studied classified the buildings as commercial only.

4.1. What should be calculated in order to assess building energy efficiency?

*4.1.1. Brazil*

For commercial, service, and public buildings, the envelope, lighting system, and air conditioning system are considered typical for any building; therefore they were parameters selected to be assessed in order to label the energy efficiency. The adopted indicators were energy consumption for envelope (methodology described by Carlo and Lamberts [32]), Lighting Power Density, and the Coefficient of Performance for artificial HVAC systems. As an alternative to allow the use of passive strategies, naturally conditioned buildings can be assessed through simulation, which indicator is the indoor thermal comfort, based on the following international standards: ISO 7730, ASHRAE 55 or EN 15,251. The latter evaluation method was provided due to the lack of building information on whether artificial or natural air conditioning is more relevant, although it is known that both are usual. It is important to highlight the weight of each assessed system from the final score: 30% is due to the building envelope, 30% is the lighting system and 40% is the air conditioning and ventilation. For all the aspects both the passive and active characteristics are considered, i.e. natural air circulation is valued, as well as, the artificial air ventilation. For residential buildings, the evaluation encompasses the water system heating and the indoor performance when naturally ventilated, since Brazilian residential buildings are mainly naturally ventilated – only about 12% of dwellings in Brazil have artificial HVAC system [48]. The indoor performance is assessed using degree hours for summer and referential electricity consumption for winter conditions. Artificially conditioned indoor environments, which indicator is the referential electricity consumption, do not influence on the final building score, unless the HVAC environment is assessed as bonus.

The energy labeling system may improve its level by bonus, which are issued as a function of the: (i) For commercial, service, and public buildings: local renewable electricity generation or solar water heating, water use, and cogeneration or any technological innovations that result in energy savings, not previewed in the regulation [5]; (ii) For residential buildings: maximization of day lighting, efficient artificial lighting, natural ventilation, efficient artificial HVAC equipment, water use and efficient domestic appliances [29]. The efficient water use for both the residential and commercial buildings is considered to be: (i) efficient water use appliances; (ii) water re-use, e.g.: re-use of gray water for lavatory flush or garden irrigation; (iii) and rain fall water utilization.

*4.1.2. Portugal*

For dwellings (with or without artificially HVAC systems) and small service buildings without or with artificially HVAC systems with lower 25 kW, the calculation includes the primary energy use for acclimatization and for water heating.

*4.1.3. United States*

The “As Designed” label is based on building design components such as envelope, orientation and lighting system. The “In Operation” label measures energy use of a building, based on a combination of structure and features of the building; on how it is Fig. 4. Sample of national energy conservation label for service and residential buildings – Portugal (translated to English and adapted by the authors) [47]. A.d.C.P. Lopes et al. / Renewable and Sustainable Energy Reviews 66 (2016) 207–219 211 operated; and on its actual utilities bills [35].

**4.2. How should energy performance be calculated?**

*4.2.1. Brazil*

The energy performance of a building is calculated through prescriptive or simulation method. The prescriptive method provides an algorithm with a set of equations to determine directly the building efficiency [27,29]. These equations take in consideration the energy efficiency of the building envelope, lighting, air conditioning and water heating systems. The result of these set of equations refers to a total punctuation, which is correlated to the building labeling scale.

*4.2.2. Portugal*

The building energy performance can be calculated through a software tool produced by National Institute of Engineering, Technology, and Innovation; on a spreadsheet; or by any software in compliance to ASHRAE Standard 140-2004 (based on IEA's BESTest criteria). The choice of the assessment method depends on the building type [46].

*4.2.3. United States*

The “As Designed” label is based on simulated energy cost (ASHRAE Standard 90.1 2007), which the building under evaluation should have costs equal or lower than a baseline model cost, according to the Energy Cost Budget method. The “In Operation” label is based on actual energy use and on operational and on occupancy variables [35].

**4.3. How should the limit for energy efficiency be set?**

*4.3.1. Brazil*

A score from high energy efficient buildings to low energy efficient buildings was created to measure the energy efficiency of a building using the simulated energy consumption of commercial, service, and public buildings prototypes, according to its size and activity: office buildings, retail, food services, accommodations, educational and health services. The overall building energy range have the following characteristics: (i) no minimum performance is mandatory and (ii) the maximum efficiency level would be a netzero energy building, which was not reached until the present moment. The residential efficiency limits, on its turn, were based on an existing national survey which included constructive characteristics and energy end use. The architecture features (envelope and indoor requirements) are based on degree hours for summer and on a consumption index for winter; the overall energy efficiency range is a combination of the architectural and the water heating variations.

*4.3.2. Portugal*

For residential buildings (with or without artificially HVAC systems) and for small service buildings (floor area smaller than 1000 m2 and with artificially HVAC systems lower than 25 kW or without artificially HVAC systems), the energy demand is transcribed to equivalent kilograms of oil per m2 and per year; the ratio, R, between this value and its acceptable primary energy defined by the dwelling consumption range, is calculated, giving the energy scale of the building.

*4.3.3. United States*

The ASHRAE bEQ scale is the same basic scale used in the European Union for commercial buildings: the net-zero energy – score 0, is at the top and the typical building - score 100, is toward the middle of the scale. Below the typical buildings are the worst ones, with 125 or greater score [39]. The score represents the ratio between the assessed building energy consumption and the average energy consumption of its building type. Energy consumption unit assumed is expressed as kBtus/sq.ft./yr (4,089,633 J/m2 /s) [36]

**Table 1**
Energy efficiency building rate according to range score – Brazil [27,29].

| Range score | Energy efficiency rate |
|---|---|
| $T_p{}^{a} \geq 4.5$ | A |
| $3.5 \leq T_p < 4.5$ | B |
| $2.5 \leq T_p < 3.5$ | C |
| $1.5 \leq T_p < 2.5$ | D |
| $T_p < 1.5$ | E |

[a] Total punctuation.

**Table 2**
Energy efficiency rate for residential buildings (with or without HVAC systems) and small service buildings (with HVAC systems lower than 25 kW or without HVAC systems) – Portugal [49].

| Ratio (R) | Energy efficiency rate | Consumption range |
|---|---|---|
| $R \leq 0.25$ | A+ | $C_a{}^{a} \leq 0.25\ C_r{}^{b}$ |
| $0.25 < R \leq 0.50$ | A | $0.25\ C_r < C_a \leq 0.50\ C_r$ |
| $0.50 < R \leq 0.75$ | B | $0.50\ C_r < C_a \leq 0.75\ C_r$ |
| $0.75 < R \leq 1.00$ | B– | $0.75\ C_r < C_a \leq 1.00\ C_r$ |
| $1.00 < R \leq 1.50$ | C | $1.00\ C_r < C_a \leq 1.50\ C_r$ |
| $1.50 < R \leq 2.00$ | D | $1.50\ C_r < C_a \leq 2.00\ C_r$ |
| $2.00 < R \leq 2.50$ | E | $2.00\ C_r < C_a \leq 2.50\ C_r$ |
| $2.50 < R \leq 3.00$ | F | $2.50\ C_r < C_a \leq 3.00\ C_r$ |
| $3.00 < R$ | G | $C_a > 3.00\ C_r$ |

[a] Energy consumption of the building under assessment.
[b] Energy consumption of the reference building.

**Table 3**
Building energy efficiency rate for ASHRAE, bEQ evaluation – USA [36].

| Score (S) | Energy efficiency rate | Description | Consumption range |
|---|---|---|---|
| $S \leq 0$ | A+ | Net zero energy | $C_a{}^{a} \leq 0$ |
| $1 \leq S \leq 25$ | A | High performance | $1.00C_r \leq C_a \leq 0.25C_r{}^{b}$ |
| $26 \leq S \leq 50$ | A– | Very good | $0.26C_r \leq C_a \leq 0.50C_r$ |
| $51 \leq S \leq 75$ | B | Good | $0.51C_r \leq C_a \leq 0.75C_r$ |
| $76 \leq S \leq 100$ | C | Fair | $0.76C_r \leq C_a \leq 1.00C_r$ |
| $101 \leq S \leq 125$ | D | Poor | $1.01C_r \leq C_a \leq 1.25C_r$ |
| $S > 125$ | F | Unsatisfactory | $C_a > 1.25C_r$ |

[a] Energy consumption of the building under assessment.
[b] Energy consumption of the reference building.

### 4.4. To what should the building energy efficiency be compared?

#### *4.4.1. Brazil*

Energy efficiency targets are being studied, having as base the first published labels, in order to propose benchmarks [52]. A pioneer survey was published in 2008 involving different commercial buildings such as hotels, banks, supermarkets, education institutions and hospitals, describing its final energy use and its consumption patterns [53]. The residential benchmarks are more developed in this requisite; researches about the final electricity consumption by residential buildings has being done since 1988 [52,54]. The surveys were used to establish the energy use requirements for the residential buildings on the simulation method – RTQ-R [29].

*4.4.2. Portugal*

The certificate provides operational costs for residential buildings according to one of the 32 available typologies, to the year of construction and to the location. A review of the certification requirements is previewed for 2012/2013, which will include building simulation of a proposed building model and a reference model. The results might be compared to net-zero energy buildings, NZB, performance for different buildings typologies, since NZB will be included in the review process [45].

4.4.3. United States

The "As Designed" label is designed to have a particular relevance for real estate transactions, expressing an integral measure of the building's inherent energy efficiency. Thus, it is possible to compare the results among similar buildings according to the building type, within a size range and of the same occupancy type within a climate zone [55].

**4.5. How should building energy efficiency be labeled?**

*4.5.1. Brazil*

Both the design and the constructed building should be assessed by an institution certified by the National Institute of Metrology, Standardization and Industrial Quality (INMETRO) after the owner request. The evaluation is based on the Technical Regulations of Quality Level of Energy Efficiency for Commercial, Service or Public Buildings (RTQ-C) or for Residential Buildings (RTQ-R). The assessment must follow two steps: (i) first the building design must be assessed and then (ii) the existing building is evaluated. Fig. 5 shows the label issue steps.

*4.5.2. Portugal*

Qualified experts graduated in Architecture or Engineering with at least five years of experience on HVAC systems are eligible for energy audits after a training program [58]. The qualified expert assesses the existing or the new constructed building according to the specific requirements (RCCTE or RSECE), issuing the certificates, which are necessary for requesting the license for building use, sale or renting. At the designed phase, the qualified expert might issue a "pre-certificate" called Statement of Regulatory Compliance, which says that the building project is in accordance with minimum requirements and can receive a license to construction. Fig. 6 shows when the certificates must be issued for the building design, construction or use [59].

*4.5.3. United States*

Through a professional certificated by ASHRAE (Building Energy Assessment Professional Certification Program), the model is evaluated for the asset rating "As designed" and the building is audited and analyzed after one year of use for the operational rating ("In

Operation") [60,61]. The procedures for obtaining the operational label are summarized in Fig. 7. 4.6. What energy efficiency improvements should be recommended?

*4.6.1. Brazil*

No detailed recommendations are provided, but only a compliance report is available to the owner along with the label, indicating the parameters used in the calculations, as well as the assessment results. The label is available for the public knowledge while the report is exclusively for the owner.

4.6.2. Portugal Besides recommendations for the building energy improvements, the certification also shows the expected costs of the energy conservation measures implementation, the potential reduction on the energy bill, the payback time and the new building classification if all the highlighted suggestions were applied. It also presents detailed information about the measures for subsequent budgets [60].

*4.6.3. United States*

Through the certification program, it is possible to identify potential energy savings opportunities, as well as the description of each opportunity, including an estimation of energy savings, budget implementation costs, and simple payback [35].

**4.7. What information should the energy certificate include?**

*4.7.1. Brazil*

Information included on the label varies according to the building type. In general, the energy certificate indicates the energy efficiency level of the building according to an alphabetic scale, from "A" – highest level - to "E" – lowest level. The certificate also includes "partial labels", indicating the efficiency level of each assessed system. Therefore, for commercial, service and public buildings, the partial labels refer to the envelope, the lighting system and the HVAC system. For residential buildings, the partial labels refer to the envelope performance during the winter, the envelope performance during the summer and the water heating system. The label also shows the final bonus score achieved using other systems, which also enhances the buildings energy efficiency.

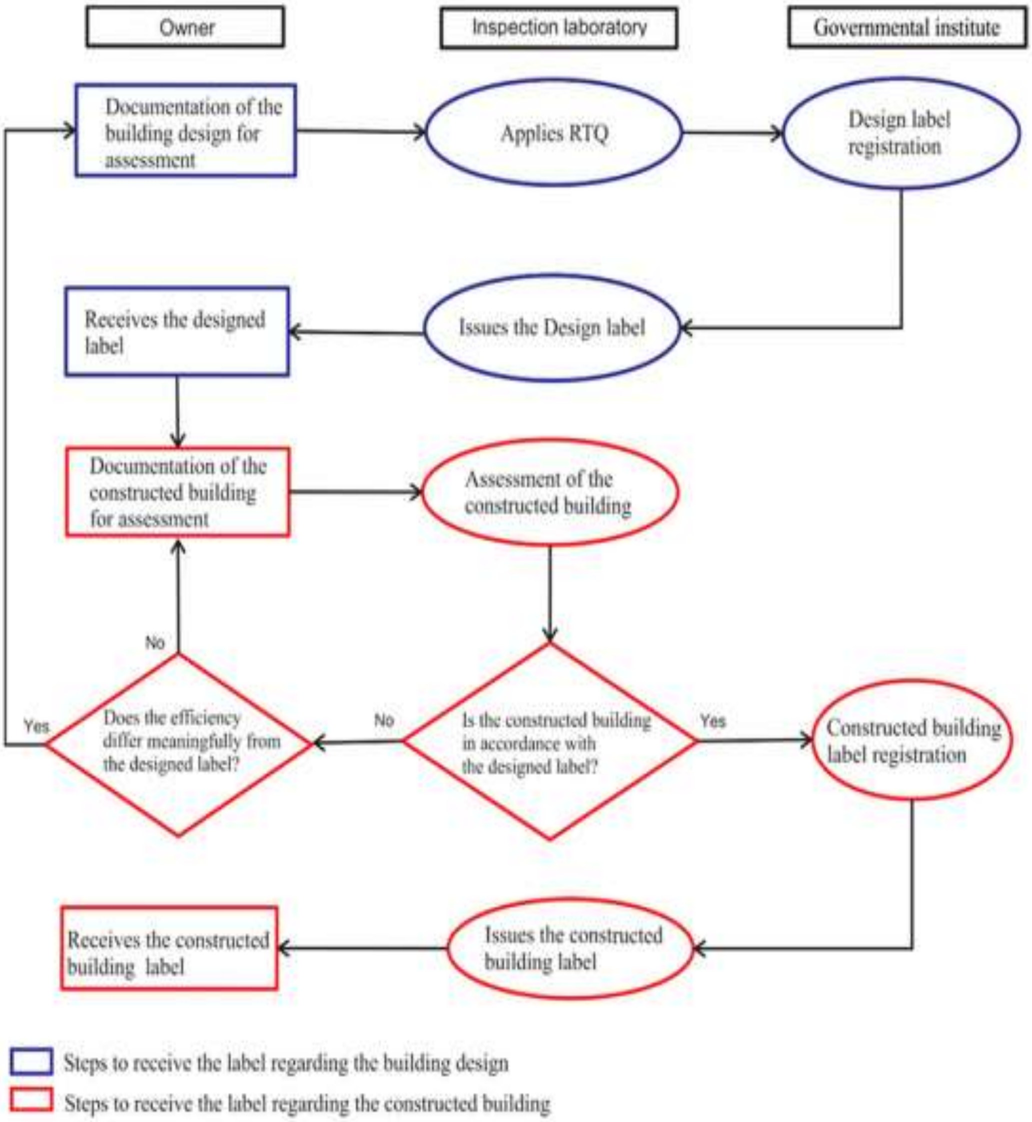


**Fig.5.** Process to obtain the energy efficiency building labels in Brazil for design and constructed building

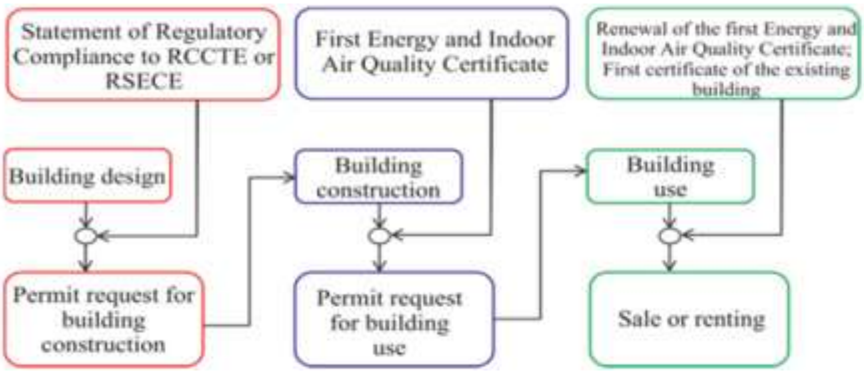


**Fig.6**. Process to obtain the energy efficiency building label in Portugal,for design,construction and use

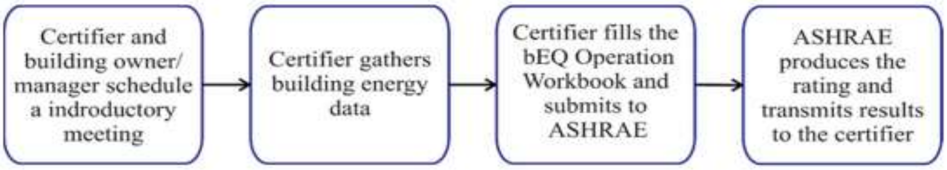


**Fig.7.** Procedures for obtaining the building energy efficiency In Operation label_USA

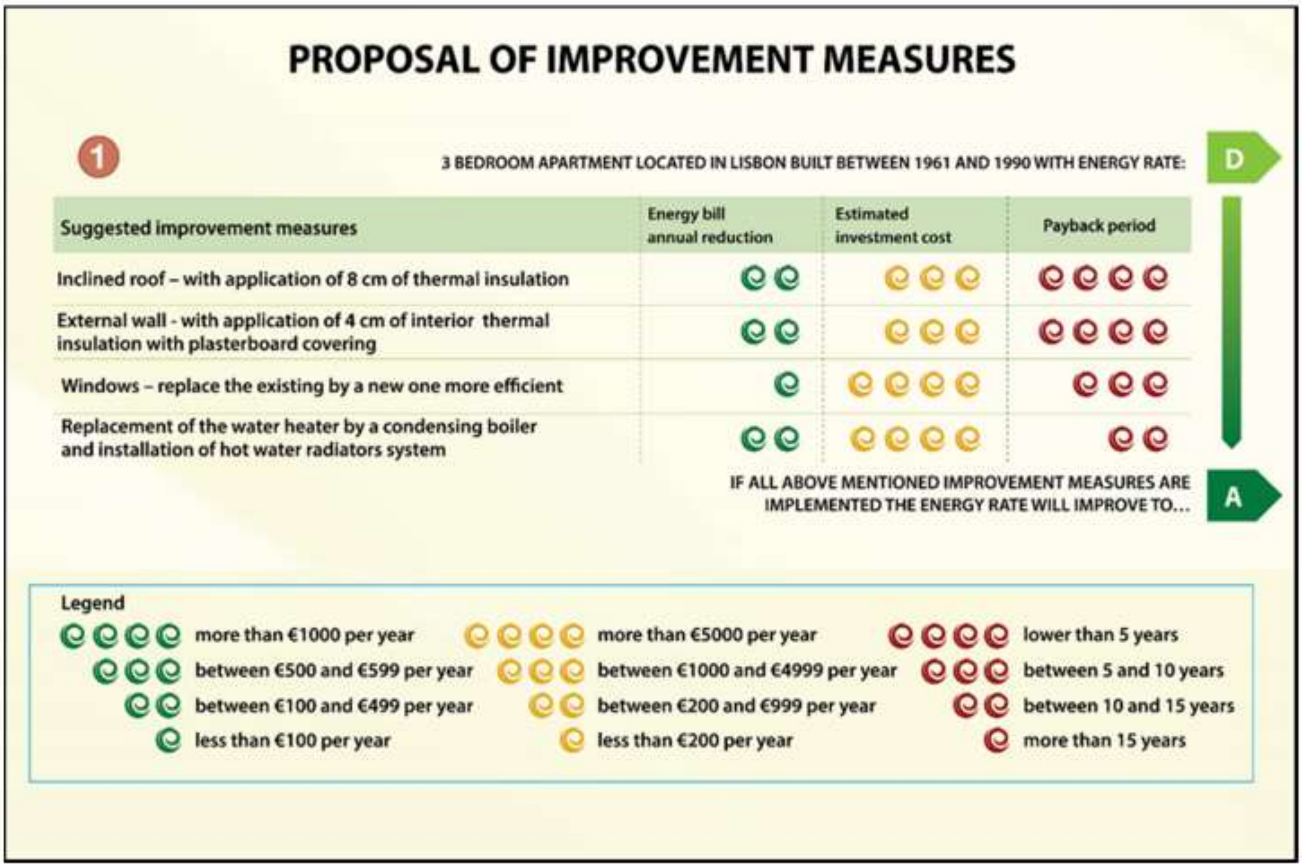


**Fig.8.** Improvement measures proposal in the Portugues certificate of energy efficiency and indoor air quality

*4.7.2. Portugal*

The Portuguese certificate is formatted as a report, with a minimum of three pages. Alike the Brazilian label, some information included on the label varies according to the building type. In general, the certificate includes the building identification, the qualified professional who was responsible for the assessment, the building primary energy use, and the amount of GHG emission related to the assessed systems. The certificate also contains energy conservation measures to enhance the building energy performance, costs and its payback time (Fig. 8). Other information found on the following pages is for budget purposes. For building service certificate, information about the indoor air quality is also described [45,58].

*4.7.3. United States*

Besides the label provided to be set on site, the building's owner also receives a report with more detailed information. Among the information included on the certificate are the building identification, energy use summary, suggested improvement measures and the amount of carbon dioxide emission equivalent (tons/year) [35,63]. 5. Results and discussion In the countries studied, building energy efficiency labeling program employment is relatively new. The United States are the pioneer (Energy Star – 1999; bEQ 2011), followed by Portugal (SCE – 2006), and Brazil (Procel Edifica – 2009). Fig. 9 shows laws and programs about energy efficiency in buildings, from 1970 to 2011, adopted by each studied country. While in the United States an important regulation regarding building energy efficiency dates back to 70's – ASHRAE 90, in Brazil the most important law about energy savings in buildings was promulgated only thirty years.

later, with the Law 10,295. In Brazil and Portugal, the government is responsible for the labeling program. On the other hand, in the United States the proposed program is regulated by a non-governmental organization, ASHRAE. Even though ASHRAE exercises a remarkable influence to society, only the U.S. Government may turn regulations proposed as mandatory. The main reason identified for the difference between the Brazilian energy efficiency scale and the American and Portuguese is that the first is directly related to the building performance, while the other two programs are related to the energy consumption. This difference may be to the absence of benchmark data and a building stock market mainly composed of naturally ventilated buildings, in Brazil. In Brazil, there is a lack of data on energy use in buildings, therefore, the PBE may have not taken into account the benchmark scoring the efficiency of a building as other countries. In order to overcome this gap, the evaluation is made according to the performance of the building under evaluation. In other labeling programs, such as the bEQ (USA) and SCE (Portugal), the final score is based on benchmarks. The benchmarks are in development in Brazil by the Brazilian Sustainable Construction Council and it is expected to bring enrichment to the labeling program, since the energy efficiency of a building is a function not only of its physical features, but also of how it is used [64].

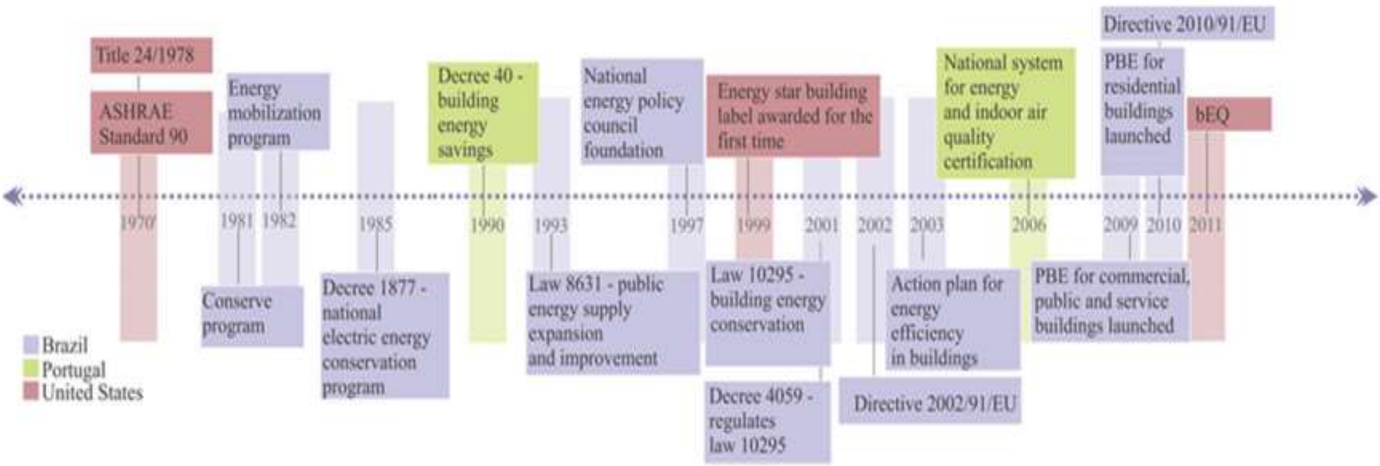


**Fig.9.** Buildingss energy efficiency timeline in Brazil,Portugal and United Sates, from 1970 to2011

Government role is important considering it can propel, by public policies, the application of energy conservation in buildings; and, studies indicate that energy efficiency programs often fails because there is no sufficient attention given by the government to support the implementation of the program [65,66]. Besides that, failure in applying energy efficiency measure lay on that gap that separates the theoretical potential from what can really be achieved practically; therefore it is important a cooperation between governments, industries, business, associations, donors and international institutions [66].

Implementation of a mandatory labeling system must be cautious in Brazil, since (i) there are not enough professionals in the area trained to certify buildings and there is just one entity allowed to label buildings until now; (ii) the building assessment is a lengthy process, sometimes requiring technical information from third-parties, extending even more to issue the label; if a mandatory program be launched without a consolidated infra-structure, the system might become overloaded, impairing the energy labeling program efficacy; and (iii) in general, people might not be aware of their homes energy consumption and neither the importance of energy efficiency implementation [69].

Buildings quality is likely to improve, providing a better environmental comfort to the end-user. Furthermore, with a mandatory labeling, consumers will easily identify buildings with best energy savings.

Therefore, the influence of occupancy behavior in energy efficiency in buildings is another issue that is being intensely researched [17,72]. Much of the energy is wasted during nonworking hours, because of human inadequate behavior, i.e., many occupants left the lights on after work [72].

Thus, for a more accurate rating energy system, the Brazilian Labeling Program should consider the occupancy on its assessment, so the energy efficiency assessment would represent more faithfully the real energy consumption of the building. In order to boost the labeling program in Brazil, research centers are developing a faster assessment method that uses simplified spreadsheets. This new methodology is very important, since Brazil is a huge country and lacks of capable professionals for labeling buildings

While in Brazil buildings must be assessed by Accredited Inspection Entities, in U.S. and in Portugal it may be certified by a professional responsible for the building assessment.

Comparing the Brazilian label to the North-American and Portuguese labels, the Brazilian Program lacks some information. A detailed documentation about improvements measures should be taken into account on the Brazilian PBE. A study launched by the Energy Portuguese Agency pointed out from the people who made some renovation or maintenance on their homes, the majority took into account the improvement suggestions listed on the certificate [74].

Although the usefulness of the inclusion of suggestions for energy efficiency improvement on the certificate, the PBE would face some barriers: (i) need to adapt of a consolidated labeling program - the PBE started during 1980, covering the certification of appliances, pumps, vehicles, and other products, based only on measuring the energy performance of a product; and (ii) possible market competition, consultants in energy efficiency in buildings.

It is important to highlight that CO2 emission is not considered on the Brazilian label as it is on the Portuguese and U.S. ones. Some reasons might be (i) the Brazilian energy grid which is majority composed of renewable sources, while in Portugal, and in countries of the Northern Hemisphere, it is mostly composed of fossil fuels; (ii) the Brazilian Labeling Program for Buildings does not look to analyze the energy grid but only energy consumption; and (iii) it is at an initial stage, needing to consolidate as a reliable assessment method. Finally, the building energy efficiency assessment methods discussed in this paper take into account the building as single element, not considering the influence of surrounded environment, such as the influence of trees and other buildings around the evaluated one.

## FINAL CONSIDERATIONS

Currently, the world is in a globalization pressure, where the desire for economic growth often prevails. The development of mechanisms that contribute to environmental sustainability and do not impact the economy negatively is the synthesis of sustainable development challenge. Therefore, the countries are facing with the key questions: Does the labeling system that value the high efficient building a priori in order to save energy a posteriori really means to promote a more sustainable development? Does the energy expend for the construction of a high efficient building is paid in the building life expectancy? Labeling buildings, already adopted by several countries, is becoming an option for both development and sustainability to grow entwined. The application of labels that evaluate how economic, in terms of energy, a construction is seems to be a promising idea, however there must be a careful analysis on this matter. Positives points and drawbacks must be highlighted, so continuous improvements in the energy efficiency labeling field are possible. Forecasts indicate that future energy savings and reduced carbon emissions from sustainable buildings are promising for countries more dependent on non-renewable energy; however, it requires a joint effort of governments, the private sector and society. Finally, it must be clear that the implementation of energy saving program for buildings must be cautious. Therefore, in fact, this idea can become a reality, benefiting the environment; the final end user who might have fewer expenses on power and more indoor comfort; and the government, which might need to face a lower demand of electricity by conventional power plants. The final goal mixtures economy and natural resources, and seems to be a typical Integrated Resource Planning task. Acknowledgements The authors would like to thank FAPEMIG, UFV-CREDI and ELETROBRAS for the financial support.

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