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ENERGY EFFICIENCY: STRATEGIC PROGRAMS AND INNOVATIVE TECHNOLOGIES IN SELECTED COUNTRIES

EFICIÊNCIA ENERGÉTICA: PROGRAMAS ESTRATÉGICOS E TECNOLOGIAS INOVADORAS EM PAÍSES SELECIONADOS

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Abstract: Energy efficiency is widely accepted as one of the strategies currently used to reduce energy consumption and Greenhouse Gas (GHG) emissions. To promote energy efficiency it is necessary to develop environmental policies that foster innovative technologies. In this context, the research aims to present a general comparison in selected countries in the area of energy efficiency, in order to propose relevant aspects to improve the Brazilian case. Thus, a systematic mapping was conducted along with a patent analysis in order to provide an overview of the area. We evaluated 34 studies resulting from the application of the determined methodological flow. As a result, the research demonstrated applications of program strategies in the area of energy efficiency in selected countries that can be consolidated in Brazil in private and public sector partnerships to enable improvements in energy use, without accounting for the environmental advantages. In addition, the progress and evolution of technologies in different economic sectors of Brazil and information of published patent documents in different countries were exposed.

Keywords: Energy Efficiency. Strategic Programs. Innovative Technologies.

Resumo: A eficiência energética é amplamente aceita como uma das estratégias utilizadas atualmente para reduzir o consumo de energia e as emissões de Gases de Efeito Estufa (GEE). Para promover a eficiência energética é necessário desenvolver políticas ambientais que fomentem tecnologias inovadoras. Nesse contexto, a pesquisa tem como objetivo apresentar um comparativo geral em países selecionados na área de eficiência energética, a fim de propor aspectos relevantes para melhorar o caso brasileiro. Assim, um mapeamento sistemático foi conduzido juntamente com uma análise em patentes com o propósito de fornecer uma visão geral da área. Foram avaliados 34 estudos resultantes da aplicação do fluxo metodológico determinado. Como resultado, a pesquisa demonstrou aplicações de estratégias de programas na área de eficiência energética em países selecionados que podem ser consolidadas no Brasil em parcerias do setor privado e público para possibilitar melhorias do uso de energia, sem contabilizar as vantagens ambientais. Além disso, o progresso e a evolução de tecnologias em diferentes setores econômicos do Brasil e informações de documentos de patentes publicadas em diferentes países foram expostas.

Palavras-chave: Eficiência Energética. Programas Estratégicos. Tecnologias Inovadoras.

1 INTRODUCTION

The process of globalization and the establishment of a highly competitive economy have demanded greater efficiency in society's activities. Efficient energy use in the direct form, with energy flows such as heat and electric energy, or indirectly, with products and services, not only results in cost reduction, but also in environmental impacts (BAJAY, 2010; VIANA et al. 2012; CAMIOTO et al., 2015). The oil crisis in the 1970s and the population increase in urban centers in the 1980s served as a warning for many countries to research new sources of energy resources. As the available sources presented high costs, large environmental impacts and required long periods of implementation, the alternative of increasing energy efficiency became a viable option (LAMBERTS et al., 2005, ALTOÉ et al., 2017; ANDERSSON et al., 2017).

In addition, energy efficiency is a key element in reducing fossil fuel consumption and, therefore, Greenhouse Gas (GHG) emissions. In this context, the development of programs that seek to provide concrete measures to save energy is introduced by environmental policies (GRAUS et al., 2011; REUTER et al., 2017). However, little research is available with detailed information on the potential of improving energy efficiency in a global context, while at the same time analyzing the energy demand and supply sectors (SOUZA et al., 2009; BAJAY, 2010; CHAVATAL, 2014; RITI and SHU, 2016; REUTER et al., 2017). In the Brazilian case, the consistency of national programs that unify both voluntary and compulsory understandings has transformed the country into an international reference for energy efficiency programs (COSTA, 2011).

Thus, traditional energy efficiency programs that focus on energy savings are integrating new techniques to improve the performance of the current model. Factors capable of stimulating demand management, integrated resource planning, and especially the development of innovative technologies, are used to provide the new sustainable scenario for strategic energy programs (LIU, 2016). Thus, increasing efficiency consists of incorporating a portfolio of technologies available in the market that are dynamically fundamental to increment the new steps of sustainability in the efficient use of energy (BARBIERI and PALMA, 2017). An alternative to target technological change is the prospection of information in patents from countries with sound guidelines in energy efficiency programs (YOON et al., 2013; CAMIOTO et al., 2016; GAO et al., 2016).

Thus, the present work consists of the systematic mapping of regulations on energy efficiency programs in the following countries: the United States of America (USA), Canada and the European Union (E.U.). The present research intends to make a systematic mapping along with an analysis in patents on energy efficiency with the purpose of providing an overview of the thematic. The importance of these publications is that they present measures that can improve the quality of energy efficiency in the industrial sector. In light of the presented context, the work initially consists of a theoretical presentation on innovative energy efficiency technologies, including considerations on the main regulations for energy efficiency in Brazil. Subsequently, it is exposed the methodological typology adopted in the empirical part of the study. Finally, the results and conclusions of the study are presented.

2 LITERATURE REVIEW

2.1 Innovative energy efficiency technologies

Energy efficiency consists in the rational use of energy and its sources. In the case of Brazil, the energy sources commonly used to supply the energy demand are: hydraulics, gas, oil, firewood, diesel oil and fuel oil, all of which are non-renewable energy sources. Thus, the role of energy efficiency is characterized as reducing the waste of energy sources (BAJAY, 2010; LAMBERTS et al., 2014). To improve energy conservation in industrial, commercial, and residential sectors it is vital to reduce the need for global energy. In addition to decreasing carbon dioxide (CO_2) in the atmosphere, systems can provide significant economic benefits (VIANA et al., 2012; BANDYOPADHYAY, 2015; BAXI YE and DING, 2015).

For industries, practices aimed at reducing energy demand in production are known as Energy Management (EM). The EM system can reduce operating costs and generate significant financial incentives (BANDYOPADHYAY, 2015). According to Altoé et al. (2017), energy conservation can increase through the development of industry modernization and more stringent standardization implementations that enact energy use appropriately in conjunction with medium - and long - term planning actions. In general, all these factors are key elements to form an alternative to traditional strategic planning, since they encompass environmental issues with an emphasis on

the consequences of the use of fossil energy sources in the current planning (COLLAÇO and BERMANN, 2017).

The adoption of innovative "cleaner" technologies in the energy sector has increased over the past decade in the international market as a necessary alternative to minimize energy consumption and waste (GERSTLBERGER et al., 2016). Electronic equipment and software used to control processes, machines characterized by high performance and usage habits are being analyzed according to their energy efficiency and are considered economically viable for implementation costs or incorporation of innovative technologies and avoided energy. Thus, it is important to mention the indirect benefits of environmental mitigation, which are responsible for systematizing the potential of use and the advantages of innovative technologies in energy efficiency programs that positively contribute to sustainable development in the industrial sector (CNI, 2010).

The new technologies contemplate different production systems. With the general use (Cross Technologies) of innovative technologies it is possible to overcome the problem of energy intensive use of industries and increase the competitiveness of industries today. In this context, Cloud Computing is one of the tools that seeks energy efficiency in the productive processes of organizations. Another alternative is the Smart Grid and the high-performance electric motors (Premium Class) that are used in countries such as USA, Canada and the E.U. to save energy (CNI, 2010). However, it is necessary to stimulate the interest of entrepreneurs and the creation of bolder goals through easy credit access and tax exemptions to develop equipment that guarantees energy efficiency in the general context (SANTANA and BAJAY, 2016).

Thus, in recent years, more attention has been paid to energy policy issues in countries such as the US and Japan. In the US, the Environmental Protection Agency (EPA) regulates guidelines for the electricity sector through the Clean Energy Plan. In Japan, with the highest visibility among the general public, energy policy has priority for national and local governments with issues related to nuclear power plants, considered to be controversial policy factors. Thus, to understand the regulations that are responsible for energy efficiency, it is important to consider the political factors that foster the development of "energy efficient" technologies (ARIMURA and TARUI, 2017).

2.2 Main regulations for energy efficiency in Brazil

A policy intervention is needed to promote the development of clean technologies. It is thus possible to achieve ambitious goals involving the transformation of national energy systems into renewable energies (REXHÄUSER and LÖSCHEL, 2015). In Brazil, there are several mechanisms to promote energy efficiency and energy conservation from the support and/or incentive of the Ministry of Mines and Energy (MME), both from the point of view of laws and decrees that regulate the sector, and of programs (VIANA et al., 2012). Below are the main brazilian regulations and their main reasons:

i) Law n° 9.478, August 6th, 1997: reestablishes the principles and objectives of the "National Energy Policy", which defines, in its article 1, the brazilian state's competence to protect the environment and promote the conservation of energy, among other subjects;

ii) Law n° 9.991, July 24th, 2000: determines the application of the 0.5% of net operating revenue - ROL - of electric energy distribution concessionaires in energy efficiency projects aimed at end use;

iii) Law n° 10.295, October 17th, 2001 (regulated by Decret n° 4.059, December 19th, 2001): known as the "Energy Efficiency Law" (regulated by Decree nº 4,059 of December 19th, 2001), establishes the procedure for the adoption of "maximum levels of specific energy consumption, or minimum energy efficiency, of energy consuming machines and appliances manufactured or marketed in Brazil";

iv) National Program for the Conservation of Electric Energy - PROCEL: consists of several subprograms, among which are highlighted actions in the areas of public lighting, industrial, sanitation, education, buildings, public buildings, municipal energy management, information, technological development and dissemination;

v) National Program for the Rationalization of the Use of Petroleum and Natural Gas Derivatives - CONPET: aims to encourage the efficient use of these non-renewable energy sources in transportation, residences, commerce, industry and agriculture;

vi) Sectorial Funds: created with the objective of financing research, development and innovation projects in Brazil and contribute to national expansion in science, technology and innovation;

vii) PROESCO: aims to support the implementation of projects that are proven to contribute to energy savings, with focus on lighting, motors, process optimization, compressed air, pumping, air conditioning and ventilation, refrigeration and cooling, steam production and distribution, heating, automation and control, energy distribution and energy management; and

viii) Brazilian Labeling Program (PBE): aims to provide consumers with information that allows them to evaluate and optimize the energy consumption of home appliances, select products that are more efficient in relation to consumption, allowing savings in energy costs.

The National Label of Energy Conservation (ENCE) classifies equipment's, vehicles and buildings in categories – generally **A** would be the most energetically efficient and **E** the less efficient. The PBE Label - Edifica is part of the PBE and was developed in partnership between Inmetro and Eletrobrás/PROCEL Edifica. They can be obtained for commercial, service and public buildings and residential buildings, these being of three types: autonomous housing units, multifamily buildings and aspects of common use (HADDAD, 1999).

3 METODOLOGY

From the concept formulated as a general objective, the methodology was established for each stage of the study. For the definition of the survey phase, two macro categories were determined for data collection: (i) determination of the term "efficiency"; and (ii) mapping terms in the literature. Initially, the term "efficiency" was defined. It is observed that this is referred to together with "efficacy", which, according to Maranhão and Macieira (2008), are two basic terms for the management study of organizations. The regulation NBR ISO 9001 defines the term effectiveness as the "extent to which activities are carried out and the results achieved, achieved". Efficacy is related to the results of the process, without linking to how to execute it. Since only the results will be observed and compared, it does not characterize the quality of a process completely. The term efficiency is defined by NBR ISO 9001 as "the relationship between the result achieved and the resources used". It can be said, therefore, that efficiency is related to cost-benefit, in which it seeks to obtain the

minimum of losses and/or waste. It consists, then, in the relationship between the results and the resources obtained (NBR ISO 9001, 2015).

Subsequently, a systematic survey was carried out in the literature through a database query, according to the periodicals and search keywords listed in Table 1. Besides that, some patents were identified in order to verify the energy efficient technologies that are being developed in selected countries. The scan is characterized as theoretical-conceptual (LOPES and CARVALHO, 2012). The scope of the literature review includes articles published in journals that address the importance of energy efficiency, programs that foster innovation and the development of guidelines in the energy efficiency sector.

Table 1 – Details of term mapping on literature

Goals	Data base	Search keywords
Contextualize research relay	Science Direct Google Academic Springer SciELO	Energy Efficiency Reduction of Energy Consumption Energy sustainability
Analyze informations of patent in intelectual effect	Google Academic National Institute of Intellectual Property (INPI)	Energy Efficiency Green Patents Systems for the Efficient Control of Energy

Source: Elaborated by the authors

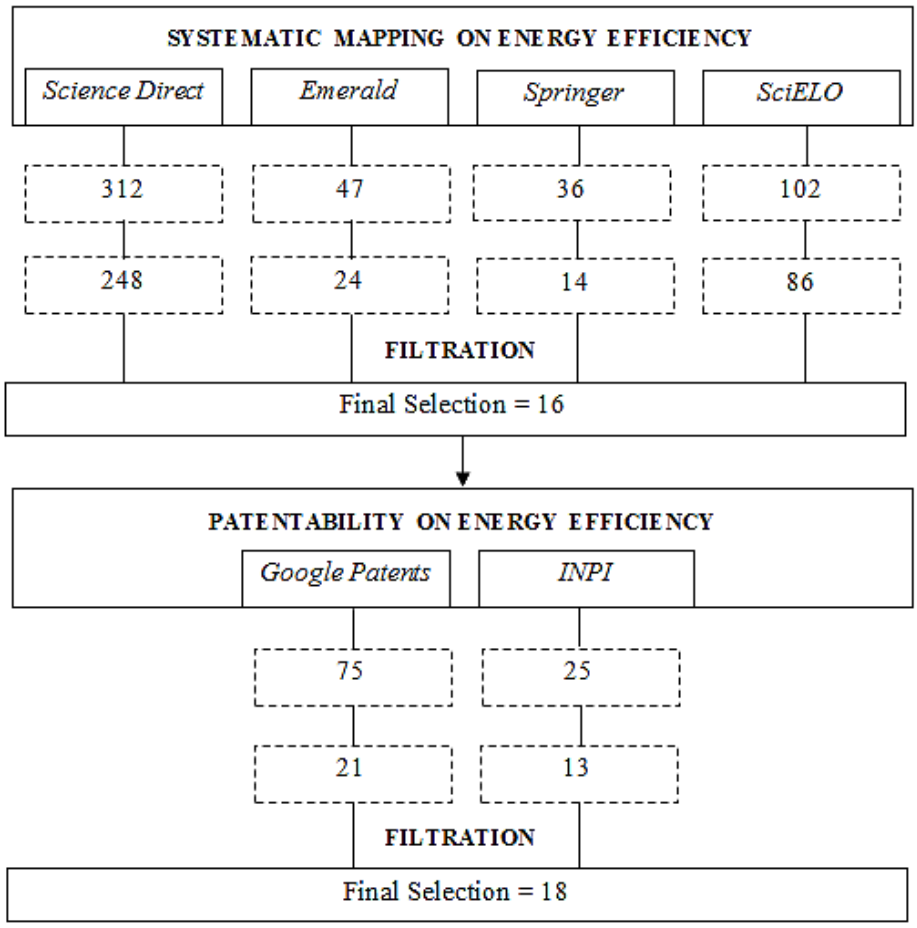
The study consisted of three steps: (1) define the purpose and purpose of the research; (2) select keywords and databases; (3) identify and review relevant articles and patents. At a more detailed level, the objective is to answer the following research questions: Q1. What are the main research on energy efficiency? Q2. What are the types of studies of government programs on energy efficiency? After defining the purpose and the questions, we proceeded to the step of selecting the keywords and the databases to carry out the study. Thus, the keywords and terms identified in the introductory analysis on energy efficiency were initially used. The databases were selected because they are the most comprehensive and in order to create some information and give better efficiency to the research. It was necessary to adopt logical operators available for advanced searches, thus, the keywords (without quotes and without refinement by area of knowledge) to be used in the theoretical survey in the databases were established.

After searching the databases, the refinement of the research considered all available years and adopted the criteria of language (portuguese/english), document types (article/review) and areas of knowledge (energy/efficiency). The articles resulting from the search were analyzed according to the relevance of the study. For the files available in full, it was necessary to make a complete reading and their references were observed to ensure that other relevant works were not detected in the original research. After the application of the initial filtration, approximately 497 articles were identified.

The secondary filtering occurred from the literature found, since many articles were duplicated and did not contemplate the purpose of the subject. Analyzing the duplication in the bases Science Direct and SciELO, 82 articles were excluded. In the remaining files, a summary of the empirical studies was made as an exclusion criterion. The analysis was done with the help of Mendeley and NVivo® software. In addition, the research contemplated a patent analysis to verify the development of energy efficient technologies in selected countries. The general methodological flow of the research is shown in Figure 1.

The collection of technological information extracted from patents is related to the definition of new routes that present potential to improve existing products and processes in the area of energy efficiency. Thus, the filters used followed the criteria adopted in the systematic mapping. However, with different databases and with an emphasis on the technological panorama of the period from 2010 to 2017. It should also be noted that the typology of the research is characterized as technological prospecting and patenting, being necessary to evaluate the evolution of the development of the technology in national and international documents in order to identify markets and their innovative capacities and demonstrate a new specific field of research (SCOPEL et al., 2013).

Figure 1 – Results of systematic mapping and patentability filters



Source: elaborated by the authors

4 RESULTS AND DISCUSSIONS

From a bibliographic study it was possible to identify different perspectives of energy efficiency programs. The following are the country-bound considerations. It is highlighted that the efficient use and conservation of energy has positioned itself as an auxiliary tool to decarbonize the energy system. Thus, regulatory challenges are low energy density, high initial capital investment, and relatively precarious reliability and availability of the industry. All these factors were proposed in the Kyoto Protocol in 1997 to improve efficiency across the energy chain of the countries participating in the international agreement (SOUZA, GUERRA, KRUGER, 2011).

4.1 United States of America

The USA develops a series of energy efficiency programs, both at the federal level and within state governments and some utilities and natural gas utilities (BAJAY, 2010). The projections of spending and saving of electric programs are based on the specific assumptions of the States regarding the effective energy efficiency policies with current implementation and also with regard to the impacts of different market conditions in their amplitude (BARBOSE et al., 2013; TRIANNI, CAGNO, FARNÉ, 2016). At the national level, the most important is the Industrial Technology Program (ITP). The actions contemplated in the ITP are divided into three subprograms, as expressed in Table 2. In addition, the current performance of the policies indicate challenges and opportunities to improve the integration of distributed generation. Thus, energy efficiency and distributed generation are aimed at reducing the profits of electric utilities (ARIMURA and TARUI, 2017).

Table 2 – Actions of USA over the energy area

Subprogram	Specific Purpose	Target
Energy-intensive Industries	To form partnerships with private companies in P&D projects aimed at the development of technologies that allow for lower energy costs and increase competitiveness in eight segments of the energy-intensive electric industry.	Aluminum, pulp and paper, glass, metal casting, chemical, mining, petroleum refining and steel industries.
Technologies of wide use on industries	Save energy in industrial processes with more intense consumption, by promoting P&D programs aimed at more efficient equipment in four common technological areas, including thermal energy and electricity.	Areas of technology combustion, materials, sensors and systems of energy conversion and process control.
Better practices	Encourage private investments in energy efficiency through industry-oriented partnerships and strategies. To this end, energy diagnostics and information on the best practices found in the industry in terms of motors, pumps, fans, direct heating, process steam and compressed air are made.	Small e medium size companies.

Source: adapted from Bajay (2010)

The government works with the industry to identify priorities in P&D and makes technical and marketing analyzes that facilitate the identification of technologies and areas with potential to generate energy savings (BAJAY, 2010). Determining and comparing energy efficiency at different levels of planning is one of the main challenges

for small and medium-sized enterprises. The factors are related to the lack of transparency and information of the main energy consumers at the level of the industrial plant, in the production and in the machines (STICH, BRANDENBURG, KROPP, 2012).

In addition, traditional energy efficiency programs focus on energy savings. However, there is a political interest in the impacts resulting from the system's maximum demand (LIU, 2016). Various energy efficiency policy measures can promote the production or purchase of equipment that contributes to improving energy efficiency. In USA, standardization for the minimum energy efficiency of appliances has contributed to reducing the growing demand for energy. They are mandatory standardizations that set standards that contemplate political approaches that encourage market supply and demand (BLUM, ATKINSON, LEKOV, 2013).

4.2 Canada

The energy sector is responsible for moving much of the country's economy. Government investments that aim at energy efficiency directly influence income generation, foreign and domestic trade, and especially the labor market (SOUZA NASCIMENTO, SILVA, ANJOS JÚNIOR, 2014). In Canada, there are three main institutions operating in the area of energy efficiency, as shown in Table 3. At the national level, the Energy Efficiency Office (OEE) and the Varennes Energy Technology Center (CTEC), both linked to the Ministry of Natural Resources (NRCAN). In the private sector, Canada has a major company operating in about 60 countries in the area of energy efficiency, called Econoler International, which develops projects for energy management, making it possible to identify sources that have excess consumption in companies.

Table 3 – Canadian actions in the energy area

Program	Purpose	Financing
Substantial improvements in energy-intensive industrial plants	Enable the realization of projects that lead to large reductions without electricity consumption by large industrial consumers. The minimum reduction of energy	Corresponds to the lower of the following options: i) the amount necessary to raise the investment return period to three years; ii) 50% of the project's allowable investment expense; iii) 0.10 CAD per kWh saved by the project, calculated

	consumption to 50 GW per year for 10 years.	over a year; and (iv) CAD 30 million per project.
Analysis and industrial demonstration for large consumers	Raise awareness among customers about energy efficiency and demonstrate the advantages of more efficient technologies, which can reduce energy consumption. The development of energy diagnostics for the reduction of the global consumption of plants and the realization of demonstration projects to establish the efficiency of a new technology are fundable.	Corresponds to the smaller amount among the options below: For energy diagnosis: i) up to 50% of diagnostic costs; (ii) up to 25 thousand CAD per diagnosis; iii) up to 50 thousand CAD for more than one diagnosis. For demonstration projects fulfillment: i) up to 50% of the project's allowable costs; ii) up to 300 thousand CAD per project; iii) up to 600 thousand CAD for more than one diagnosis.
Industrial initiative	Reduce specific electricity consumption by replacing or installing more efficient equipment, installing solar panels and using geothermal energy. Each project has a maximum duration of 18 months and the payback of the investment must be less than 10 years.	Corresponds to the smaller amount among the options below: i) the amount necessary to reduce the payback period to one year; ii) 75% of the project cost; iii) 0.15 CAD per kWh spared by the project, calculated for the period of one year; iv) 350 thousand CAD per project. Financial aid can be granted to several projects, up to a maximum cumulative amount of 8 million CAD per company. The return on investment is limited to 10 years.

Source: adapted from Bajay (2010)

It is important to mention that in Canada the standardization of many federal program procedures form an important reference for the private sector. Thus, the measures adopted to consolidate the provision of services that result in energy efficiency in the public sector are responsible for the development of measures that can be used in the private sector (INEE, 2001). In addition, Canada's geographic location and climate typology represents a specific consumer profile for energy, with approximately 30% of energy use in transportation and about 40% for heating. Unlike Brazil, Canada does not have a single interconnected system of energy generation. The Canadian federal energy system is based on the reality of each province (state) and the concept and limits of interventions are distinct for each provincial situation (ARAÚJO and BARCELLOS, 2014).

4.3 European Union

The European Union (E.U.) has a division that is specifically responsible for energy issues, the European Commission's Directorate-General for Energy and

Transport (DGTREN). It promotes, among other activities, a series of intergovernmental programs to promote energy conservation (BAJAY, 2010). A "Green Agenda" was developed in the E.U. in order to keep the economy competitive, with low carbon emissions and with the efficient and sustainable use of resources. The purposes include the development of new technologies and ecologically sound production systems. Governments have mandated regulations to stimulate changes in industries that can improve energy efficiency (GERSTLBERGER et al., 2016). Table 4 shows the Intelligent Energy in Europe (IEE) policy measures, which acts as a general panel to which are added more specific programs, broken down by area of interest (with emphasis on renewable energy, transport and energy efficiency) and application sectors, ManagEnergy, Odissey and Promot.

According to Rosenow et al. (2017), energy efficiency plays a central role in the energy and climate planning of the E.U. committee. However, a governance structure is conservative and compromised when the Union's effectiveness objectives are adequate, whether in Member States or in any union. In this way, a common E.U. energy strategy is included in the proposal and includes guidelines entitled Energy. In this document, they are addressed as main lines and be followed by member countries in the area of energy efficiency (SOUZA et al., 2009; BAJAY, 2010). In Brazil, there are well-developed environmental management programs in some industrial segments. Nevertheless, a systematic use of energy measurement programs is still rare in the country. In this context, energy management standards in the industry, compatible with ISO 9000 and ISO 14000, can be introduced in some energy-intensive segments, led by associations representing the industry as a whole, such as the CNI and/or employers' associations (SOUZA et al., 2009).

Table 4 – E.U. actions over the energy area

Program	Purpose	Financing
Smart Energy in Europe	Enable energy conservation projects in various branches of the economy. The priority areas for the period 2004-2013 are the areas of instruments for energy management, audits and performance	Energy Management for Small and Medium Enterprises: Supports ESCOs in the implementation of energy management in companies. European Campaign for the Development and Documentation of 1000 Small-scale Cogeneration Projects in European Cities. Dissemination, Extension and application of the Motor Challenge Program: It aims to extend the application of the European program for the efficient use of electric motors, through campaigns, seminars, workshops, conferences and portals on the Internet. It includes both the management and the exchange of engines. Energy Diagnosis for Small Craft Companies: seeks to reduce between 15% and 30%

	comparisons, support for ESCOs and encouragement of cogeneration and polygeneration.	the average energy consumption in companies. It uses a standard instrument capable of identifying energy-saving potentials for this type of industry and makes recommendations. Optimum Integration of Polygeneration in the Food and Beverage Industry. It has online tools to calculate the energy saving potential.
ManagEnergy	Support agents working in the area of energy conservation and renewable energy at both local and regional level.	Its main support tools include the Sectorial Council, training programs, workshops, online events, case studies, best practices, information on European legislation and some energy efficiency programs. The Sector Council provides assistance, in the short term, to local and regional participants in energy conservation programs. Case studies on good practice are available in its publications archive.
Odissey	Provide detailed information on energy efficiency indicators to enable a performance assessment of member countries.	The historical database enables each E.U. country to benchmark performance against both the advancement of energy efficiency in each sector of the economy and the end use that is made, and thereby assess the decline in carbon dioxide emissions. The industry is disaggregated into 18 segments, for which information is collected on energy consumption, added value and physical production. Regular workshops are organized to compare national experiences in the field of energy efficiency.
Promot	Assist the decision process in the efficient selection of powertrain equipment in the industrial and tertiary sectors.	The selected equipment is: Electric motors - supports the replacement of old motors by high performance motors and performs engine sizing based on its load factor; Heating, ventilation and air conditioning systems: focuses on systems that contain coolers. Pumping systems - best practices for installation, maintenance and control system design.

Source: adapted from Bajay (2010)

Another effective strategy that is rarely used in Brazil to achieve long-term energy efficiency gains and to achieve sustainable competitiveness in industry is P&D projects with efficient industrial processes and equipment. Public-private partnerships can be set up to mitigate the risks and uncertainties associated with these activities (BAJAY, 2010; ANDERSSON et al., 2017). In the short term, the CNI, together with the most motivated sectorial associations, could negotiate with the MCT and the MME the use of resources available at FINEP and in sectorial funds. In the medium term, new sectorial funds, geared specifically for the scientific and technological development of some industrial segments considered of strategic interest to the Federal Government, could be created (SOUZA et al., 2009). In addition, as in the U.E. member countries, the development of energy auditing programs can be adopted in Brazil as useful tools to identify energy opportunities and energy saving potentials (ANDERSSON et al., 2017).

4.4 Deposited patents in Brazil and energy efficiency technologies

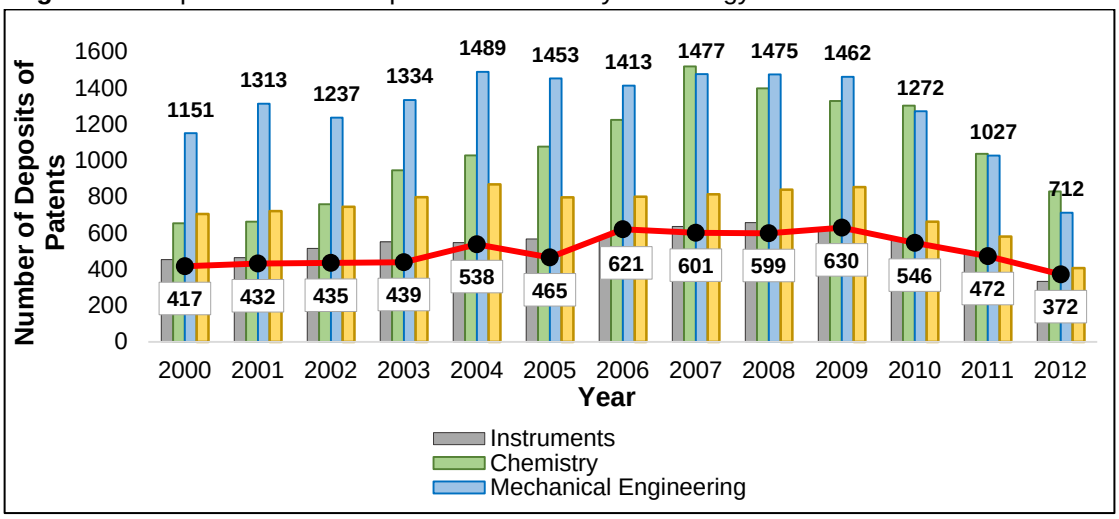
The progress and evolution of technologies in different economic sectors of the country can be analyzed through the number and information of published patent documents. The patent is a tool that helps identify the holders of competing technologies, technological trends and markets that present greater potential for future investments. Moreover, they are important in stimulating the development of innovative technologies or in the improvement of existing technologies, since the patents present technical details on inventions (SCOPEL et al., 2013). This information reflects the technological level an organization is in and even the P&D situation of a country (TEIXEIRA and SOUZA, 2013).

In Brazil, the National Institute of Intellectual Property (INPI) is the federal authority responsible for guaranteeing intellectual property rights for the industry. The institution is linked to the Ministry of Development, Industry and Foreign Trade and official representative of the country. Among the services that are provided by INPI are trademark registrations, industrial designs, geographical indications, computer programs, among others. In 2004, there was a regimental restructuring implemented at INPI, known as the Patent Bank, Center for Disclosure, Documentation and Information Technology (CEDIN), which provides industrial information on the development of innovative technologies that require patents. CEDIN data are available for public access and provide free general information on a subject (FERREIRA, GUIMARÃES, CONTADOR, 2009).

Thus, in order to verify the development of energy efficiency technologies in Brazil, an analysis of the evolution of resident patent deposits by technological sector was initially developed. The numbers of patents deposited in the electrical engineering and electronics and mechanical engineering sectors were highlighted in order to demonstrate their amplitudes and the trend in the development of technologies. Figure 2 shows the patent deposits residing in Brazil by technological sector between the years 2000 and 2012. It is noted that in 2009 the electrical and electronics engineering sector had the largest number of patent filings and in 2012 there was growth. Considering the two points of greatest discrepancy between the periods analyzed, a difference of approximately 59% in the number of Brazilian resident patents deposited is identified. Patents deposited in the mechanical engineering sector in 2012 with

respect to the electrical engineering and electronics industry in the same year correspond to a total of 52% more registrations.

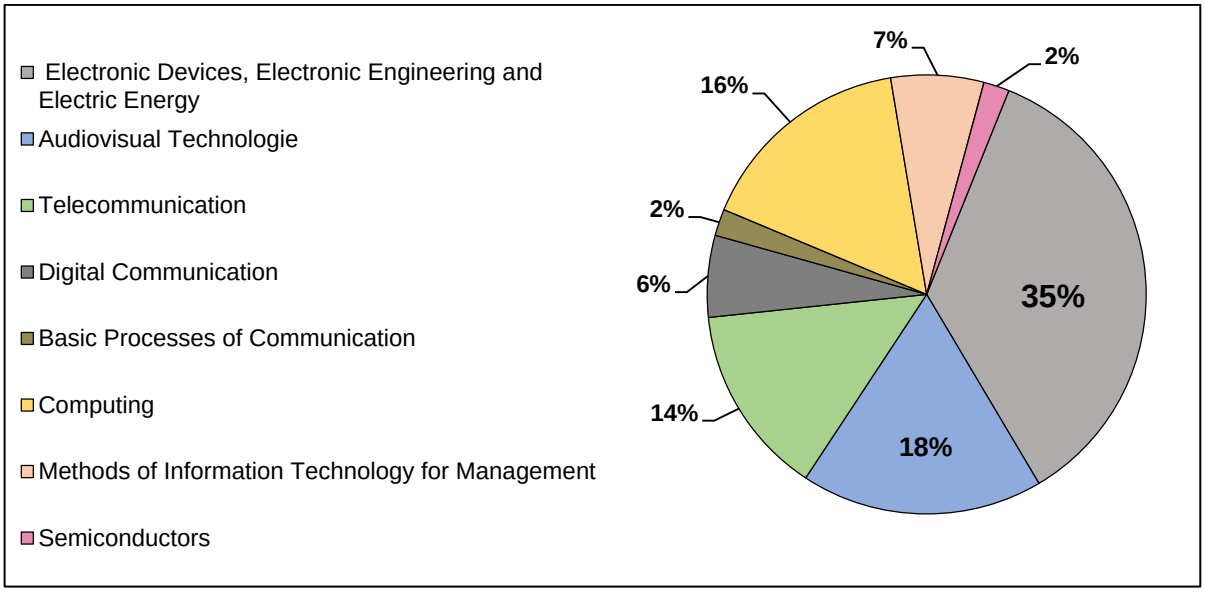
Figure 2 – Deposits of resident patents in Brazil by technology sector between 2000 and 2012



Source: elaborated based on (INPI, 2016)

Subsequently, the different areas of the Electrical and Electronic Engineering sector were identified with the objective of verifying the development of technologies with the highest number of patents deposited for the period between 2000 and 2012. According to Figure 2, the area of Electronic Devices, Electronic Engineering and Electric Energy presented the highest index of deposits of Brazilian resident patents, with approximately 35% in the total representation of patents. In this context, it is noted that Brazil presents technologically and productively based implementations that aim to use energy efficiently. However, government policies to foster innovation and technology transfer do not represent a significant transformation in the Brazilian intellectual property context for the energy efficiency sector (MUSSKOPF and LUZ, 2015; ANDERSSON et al., 2017).

Figure 3 - Participation of the different areas of the electrical engineering and electronics sector in the deposit of patents residing in the years 2000 to 2012



Source: elaborated based on (INPI, 2016)

According to the authors Dechezleprêtre et al. (2017), patents are one of the main indicators used in the evaluation of innovation systems. In addition, innovations foster a competitive and productive differential for companies and states. Thus, the role of government, particularly in relation to taxes, is highlighted, which has consequences in the process of developing corporate innovation. Countries such as USA and E.U. members have a current tax system that encompasses a number of beneficial factors aimed at increasing their respective innovative activities. In this way, the government allows the patent deposit process and, in some cases, enables a technology domain, and consequently a greater capacity to innovate (GIORDANELLI et al., 2014; GAO et al., 2016).

In high-tech sectors, patenting and information dissemination activities help in making future strategic decisions. With the analysis in different patent bases it is possible to effectively identify the technological trends of a given technology (YOON et al., 2013). With the purpose of explaining the technological prospects of energy efficiency, a patent analysis was structured, with information that allows to understand its main descriptions, title, registration number, inventors and the countries in which they were published and deposited. The diagnosis considered patents with greater relevance in analogy with the criteria adopted in the methodology and that belong to the area of Electronic Apparatus, Electronic Engineering and Electric Energy. At the outset, the United States stands out with systems and technology methods that provide

a reduction in energy consumption by incorporating equipment that works in conjunction with applications to improve communications infrastructure and ensure efficient energy management performance (CHAMBERS and SMITH, 2010; BRICKFIELD et al., 2011; DEMPSTER, ERPELDING, HANNA, 2012; FADELL et al., 2014).

Selected patents in China and Germany make it possible to determine the best power network in industrial systems that present data (GIORDANELLI et al., 2014; BAXI YE and DING, 2015). Energy efficiency can increase and at the same time maintain an adequate level of service to organizations by increasing these methods. Energy consumption for the Information Technology (IT) infrastructure has a high environmental impact from CO_2 emissions and affects the costs of the companies that own the data centers. The energy consumption in data centers will be dominant in the coming years, both in terms of efficiency, control and management (BAXI YE and DING, 2015). In Brazil, the first patent consists of a device that must be allocated in a mobile unit, such as trucks, to analyze the technical and economic viability of future projects that must generate electricity through the biogas feedstock. The second patent is intended for the storage and transfer of thermal energy resulting from incident solar radiation used in a solar power plant to produce energy by integrating different technical components of a device (SILVA and LYRA, 2017; MAGALDI, MICHELE, DONATINI, 2017).

After developing the research, it is possible to have a conception of how patent information is used in the context of energy efficiency and, by means of actions compared with selected countries, provide a favorable environment for the increment of new techniques or technologies that the promote. In addition, technical areas with potential for stimulated policies to promote P&D, stimulate the manufacture of efficient products and the training of professionals qualified to act in the area of energy efficiency were represented. According to research by Camioto et al. (2016), energy efficiency not Brazil and China is related to investments in low-energy technology. However, according to the same author, energy efficiency tends to be better when countries are better conditions, as well as high expectations of life, which guarantees a fair income distribution, as happens in the countries of the E.U.

Table 5 – Main technologies developed in order to improve energy efficiency

Patent Title	Year	Number of registration	Description	Country
System and Method for Management of Energy Consumption.	2010	US20100262313A1	It is an energy management system comprising as a communication control center coupled to the remotely located computer and configured to perform data analysis operations using the energy consumption data and the data previously stored to generate instructions for controlling the respective electrical component.	United States of America
Automatic Energy Management and Reduction of Energy Consumption, Especially in Commercial and Multi-Building Systems.	2011	US8078330B2	Provide an urban power system with function such that the demand for urban energy can be predicted in advance and the expected demand can be corrected.	
Systems and Methods to Control the Efficiency of Energy Consumption.	2012	US8219250B2	A controller is configured to exchange information with a building automation system and includes several programs to determine a real-time operational efficiency, simulating predicted or theoretical operating efficiency, comparing the same, and then adjusting one or more operating parameters equipment used by the building's air conditioning system.	
Systems and Methods for the Efficient Control of Energy of an Energy Consumption System.	2014	US20140316581A1	A method for efficiently controlling energy consuming systems, such as: heating, ventilation, or air conditioning systems through one or more electronic devices configured to control the system.	
Energy Efficiency Assessment and Life Improvement Methods for Heat Exchanging Networks.	2015	CN102939605B	The present invention provides a method for the management of industrial plants to evaluate the energy efficiency of the heat exchanger network and improved.	China
System of Energy Saving in Corporate Data Centers.	2014	DE112012003307T5	It is a method for assigning a computational load to the servers of a data center that uses the virtual machine, intended to reduce the energy consumed in the energy of the data center and at the same time maintaining a level of service suitable for the client of the data center itself.	Germany

Modular System of Analysis of Productive Capacity and Energy Efficiency in the Generation of Electric Energy by Biogas.	2017	BR1020150241844A2	The patent consists of a set formed by interconnected modules arranged in a mobile unit, capable through a joint operation, analyze the technical and economical feasibility of future projects generating electric energy having as main raw material the biogas.	Brazil
Device, System and Method with High Level of Energy Efficiency to the Storage and Use of Thermal Energy of Solar Origin.	2017	BR1120140236283A2	It is a device for the storage and transfer of thermal energy associated with incident solar radiation, which is used in a solar power plant for the production of energy, based on the configuration of an optical power plant that causes the convergence of solar radiation.	Brazil

Source: elaborated by the authors

However, it should be emphasized that the thematic analyzed is new and needs disclosure to progress. It is important to emphasize that ultimately the decision maker is the consumer and his change of behavior and even of culture requires an integrated policy that induces the adoption of sustainable measures with the use of energy (SOUZA, GUERRA, KRUGER, 2011; CGEE, 2013). In addition, there are numerous problems that modern society must face in the quest to secure a sustainable energy supply while at the same time seeking to reduce energy use. The rapid increase in global energy consumption makes the problem even more complicated. The energetic crises experienced have shown how societies are vulnerable to geopolitics and climatological influences for their supply (CAMIOTO, MARIANO, REBELATTO, 2014, MARIANO et al., 2017).

5 CONCLUSION

From the analysis of the literature review and the results of the empirical research on general comparative to selected countries in the area of energy efficiency, some final considerations can be presented. Initially, it should be pointed out that in relation to the segmentation and selection of target markets, it is recommended that Brazilian agencies in the energy area develop properly delimited strategies, such as focusing and formalizing target customer types based on more planned methods, structured and deliberate. In addition, it is worth noting the adoption of energy efficiency measures for the public sector, including energy service companies.

With regard to the work carried out, it is an extension of the academic study on the application of strategies of programs in the area of energy efficiency and the use of patent information, a field of research considered still lacking by different authors and researchers. Thus, the presentation of the research results provides the academy with a set of detailed and necessary information about the application, deficiency and importance of energy efficiency strategies and their programs, a branch of activity that, according to the analysis of the research, despite its importance in the Brazilian economic context, needs adjustments in the legislation issue and of partnerships between companies and public power.

The research differential is related to the analysis of the forms of energy efficiency to propose practices both industrial and public power that covers energy efficiency research in the industrial sector. The State must use its apparatus to foster economic agents, allocating public resources already assured by law, according to priorities defined by favorable benefit/cost relationships, always aiming at the development and consolidation of structures that make this market, in the medium and long term, less dependent on government intervention. It is important to point out that an intense process of formulation and detailing of the National Energy Efficiency Plan (PNEf) is underway, led by the Ministry of Mines. The targets are ambitious and were set out in the National Energy Plan 2030, which determines a 10% reduction in energy demand according to the objectives proposed in the Kyoto Protocol.

Suggestions for future work may include: i) identifying the main Brazilian states that are developing innovative technologies for the context of energy efficiency through an INPI patent analysis; ii) verify whether universities are seeking international relations to improve Brazilian programs that contemplate energy efficiency; iii) analyze how energy management in Brazilian states presents risks related to oscillations in the supply of electric energy and whether programs that promote the reduction of energy losses with these characteristics are beneficial to eliminate the problems; and (iv) assess energy efficiency focused on the National Climate Change Plan (PNAC), including the impact on CO_2 emissions.

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