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013 - The Energy Efficiency Evolution of the Water Heating Process in Brazil´s Residential Sector: The PROCEL Seal Program contribution

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Abstract

The Brazilian "National Electricity Conservation Program" – PROCEL runs regular surveys in the electric energy consumption market in order to assess the number of electric equipments owned by each household as well as their respective types and usage. These studies are not only used as valuable database to plan better the actions of this Program; they also evaluate its performance by identifying the level of penetration of the most efficient electric equipments within the residential sector in which PROCEL runs its main lines of action: to make available and to promote the most efficient technologies.
In the case of solar energy, PROCEL´s orientation is to encourage its wider use for water heating as well as to improve technological advance in heating solar collectors and thermal tanks.
In this context, the purpose of this work is to present an overview of: the usage and the efficient utilization of solar energy for water heating in Brazil; the evolution of energy efficiency in these types of equipments as well as the main technological advances in this sector.

Keywords: PROCEL Seal, water heating, solar energy, market assessment

1. Introduction

PROCEL was established in December 1985 by the Brazilian Government in partnership with the Ministries of Mines and Energy (MME) and of Trade and Industry (MIC) [1]. Eletrobrás is the Brazilian holding for the generation, the transmission and the distribution of electric energy nationwide [2] in charge of the implementation of PROCEL. Its objective is to promote awareness about electric energy consumption in order to avoid waste and to lower the costs and the investments made to respond to the increasing demand in the electrical sector. PROCEL runs numerous activities through various sub-programs to foment the efficient use and usage of electric energy. In turn, these sub-programs focus at the level of different sectors such as Residential, Trade, Industry, Education, Sanitation and Public Lighting [3]. Following the 2001 national electric energy crisis and the subsequent rationing of this input, PROCEL´s actions have been drawing more and more attention. PROCEL´s action frameworks are based on a nationwide survey, regularly ran, to assess the existing number, type and usage of electric equipments called Studies about the Ownership and the Utilization of Equipments (Pesquisa de Posse de Equipamentos e Hábitos de Uso – PPH in Portuguese) [4] which assist the strategic planning of the Brazilian electrical sector and define PROCEL´s action priorities and its achievements.

The latest survey, ran in 2005, was supported by the Global Environment Facility (GEF) as part of the Energy Efficiency Project (PEE in Portuguese), the result of a partnership between the World Bank and Eletrobrás_ the latter actuating as the institution obtaining and transferring the funds

donated to the Brazilian Government [5]. This survey was lead by the Papal Catholic University-Rio de Janeiro (PUC-RJ in Portuguese), hired by Eletrobrás. It was run on equipments from sectors of both high and low voltages. Representative of the residential sector, for example, a total of 9,847 households [6], from 21 separate electric energy utilities, were investigated.

In Brazil, since 2007, projects encouraging the use of solar energy for water heating, in particular, have turned more and more common to meet the Mecanisms for Clean Progress (Mecanismos de Desenvolvimento Limpo-MDL in Portuguese). Indeed, heat generation at peak-hour represents a very high percentage of the total electric energy consumption in Brazil, because electric systems are designed and built to meet the maximum demand requested at any given time. Considering these facts, one can only ponder the unfortunate contribution to Global Warming and its subsequent negative effects on the environment.

2. The impact of water heating on the overall consumption of electric energy in Brazil

Based on the results from the latest survey, it is estimated that 22.6% of the electric energy consumption of the residential sector is using an electric shower device (Figure 1) which instantaneously heats the water as it flows through it commonly called Instantaneous Electric Shower Device; in turn, this represents about 6% [7] of the electric energy consumption in the whole of Brazil (± 22 TWh).

Fig. 1. Electric shower device instantaneously heating the water

The graph of the average residential load curve in Figure 2 reveals that it is at peak-hour_ normally between 06:00PM and 09:00PM_ that the use of electric shower as a water heating device is the most widely spread [1].
The value indicated in brackets in the key corresponds to the percentage in electric energy consumption for each domestic piece of equipment.
The load curve of the Brazilian Electrical System-BES, on a typical day, is shown in Figure 3 [11].

Fig. 2. Residential Average Load Curve (W)

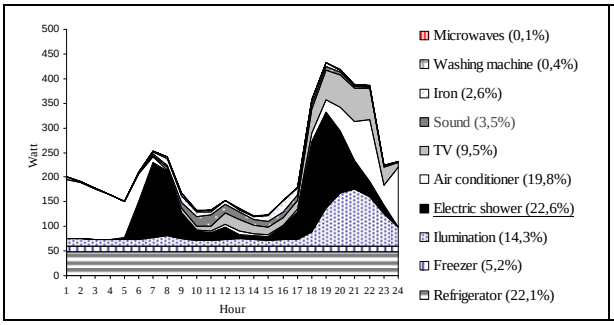
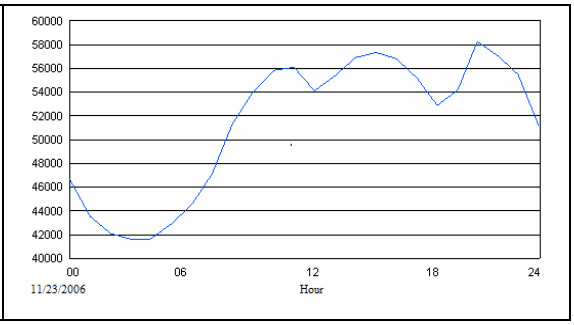


Fig. 3. Load Curve of the BES (MW)



These studies about the Ownership and the Utilization of Equipments (Pesquisa de Posse de Equipamentos e Hábitos de Uso – PPH in Portuguese) coordinated by PROCEL/Eletrobrás, are also meant at qualifying the type of ownership, using a customised questionary but with the same standards of measurement from other research institutes for relevant comparison. Through the careful analysis of the individual answers from end consumers regarding the use of their domestic equipments, it is possible to raise important data about living conditions and socio-economic information for example, as well as about the quality of the electric energy supply as a whole, market changes following the electric energy rationing of 2001, domestic appliances purchasing habits etc.

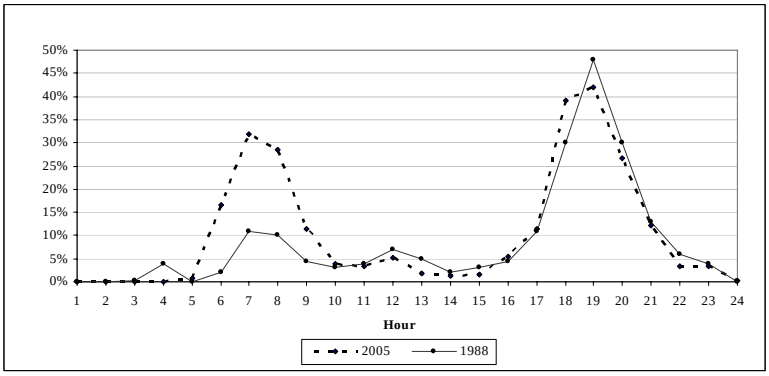
Table 1 shows a summary of the comparative data from the various surveys ran by PROCEL between 1988 and 2005 about instantaneous electric shower ownership in Brazil: it is clear that the number of households using this device increased over those 17 years.

Table 1. Percentage (%) of Brazilian households with electric shower

	BRAZIL	North	Northeast	Center-West	Southeast	South
1988	67.6	7.9	15.2	73.0	83.6	88.2
2005	73.3	4.0	30.3	85.5	91.1	98.6

In 2005, 42 % of all residencial electric showers were turned on between 06:00PM and 07:00PM causing the Brazilian Electrical System-BES to reach its maximum level in electric energy demand.
There was also a noticeable change of habits in the first hours of the day. Whilst in 1988, 10% of all households in the country had at least one person using this equipment between 06:00AM and 08:00AM, in 2005 this percentage had increased to 31%. (Figure 4).

Fig. 4. Use of electric shower (typical day)



According to Table 2, the Southern region not only has the highest index in electric shower use as well as the highest average ownership with 1.17 electric shower per household_ way above the national average of 0.89.

Table 2. Average ownership of electric shower per household in unit (2005)

BRAZIL	North	Northeast	Center-West	Southeast	South
0.89	0.05	040	1.08	1.10	1.17

Futhermore, it appears that 21% of all interviewees, by 2005, had already switched electric shower devices for solar heating systems. A new demand is also emerging by means of the efforts of a few Brazilian municipalities´councils to integrate within their City Planning Directives the obligation, for all new buildings, to offer solar collectors installation facilities.

PROCEL has been focusing, with partner entities and enterprises, on promoting the technological development of equipments using solar energy for water heating.

3. Energy Efficiency and solar heating systems in Brazil

According to data from the Brazilian Association of Heating – ABRAVA in Portuguese [9], there was an increase in the sales of solar collectors in 2001 reaching 480,000 m² _ way above the average of previous years. However, sales fell down in the following years to an average 350,000 m² per year. Whereas countries like Austria and Greece attend up to 12% and 22% of their population respectively [10], with solar thermal energy, Brazil´s index doesn´t even reach 1%.

In order to understand better the current situation, it is important to take into consideration the high initial cost of installing solar systems in comparison to the much lower cost of acquiring an electric shower device in addition to how easy the latter is to install. These three factors represent a serious barrier to the growth of the solar energy market in Brazil.

As an example: a low-cost solar system, sold over the Internet [11] and made of PVC with only two solar collectors and a storage unit of 200 liters, has a price tag of about €400 excluding installation costs. The price tag of another equipment made of metals, subsequently offering better results, can reach double this value. In Brazil, one can easily buy an instantaneous electric shower device of 5,400 Watts for about €10 [12] with no extra installation cost as it is a quick and easy "Do It Yourself – DIY" job.

Another current barrier, is the absence, in some big Brazilian cities, of specialized companies or professionals to install the solar equipments as well as to maintain them.

The partial results of an on-going nationwide study, coordinated by PROCEL in partnership with Papal Catholic University-Minas Gerais (PUC–MG in Portuguese), point out the existence of a €40,000 solar water heating system for a gym´s swimming pool in a residential area of Rio de Janeiro which started causing problems ever since it was installed back in 2006. The company it was bought from still hasn´t been able to offer a practical solution for it to work properly and thus the use of the system was switched to a system using natural gas.

These examples indicate the delay of solar heating systems in penetrating the Brazilian market. Considering that 81.5% of all Brazilian households heat water to take showers, 90.8% of the time it is using electric energy while only 7.3% of the time it is using natural gas [4].

In 2000, as one of its main lines of action and within its solar energy heating dissemination strategy, PROCEL launched its awarding process of the PROCEL Energy Saving Seal (Figure 5) to solar collectors and thermal tanks in association with the National Institute of Norms, Measurements and Industrial Quality – INMETRO in Portuguese [13].

Fig. 5. PROCEL Seal

The purpose of PROCEL Seal is to stimulate the national production of more efficient equipments and domestic appliances giving consumers information and guidelines in order to buy more energy efficient equipments thus contributing towards technological development and the reduction of the environmental impact.

The PROCEL Seal is annually awarded to equipments with the most efficient indexes of energy efficiency, in its respective category, usually characterized with an "A" at the top of the National Energy Conservation Label – ENCE in Portuguese (Figure 6). Please note that for a couple of specific product categories, further technical and qualitative features are required of the equipments, to be checked and considered towards the awarding of the PROCEL Seal. (Example: the proven electrical safety of the equipment).

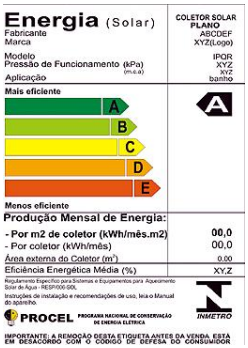


Fig. 6. ENCE

In order to be awarded the PROCEL Seal, the product is submitted to various technical tests run by impartial and competent labs indicated by PROCEL. The adhesion of the producing companies for labelling, to this day, is volunteered.

While at its beginning, the program counted only two participating product manufacturers, in 2007, 160 types of solar collectors were listed from 29 different manufacturers [13], representing more than 50% marketshare.

The PROCEL Seal has been awarded to solar collectors since 2000 thus contributing to the significant improvement of the performance of those currently available on the market.

Figure 7 shows the evolution of the average monthly production of specific energy from solar collectors for shower water heating between 2000 and 2007, for all collectors labelled by the INMETRO as well as those awarded the PROCEL Seal.

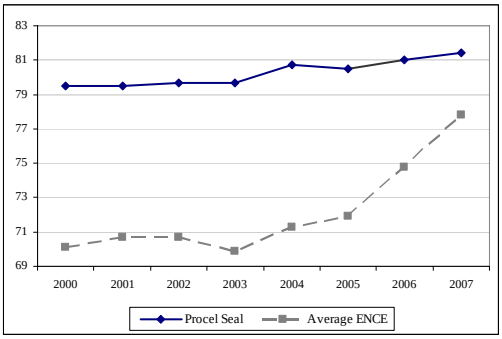


Fig. 7. Evolution of the average monthly production of specific energy from solar collectors (kWh/month per m2)

Whilst the PROCEL Seal has been awarded to the thermal tanks of solar heating systems since 2002, these equipments have already been receiving the ENCE label since 2001. Until 2003 there were no difference in the criteria required for the awarding of the PROCEL Seal and the ENCE label. However, from that year onwards, distinctive indexes were established in relation to the specific loss of monthly energy for both of them, to be consistent with the PROCEL Seal´s indexes which are constantly upgraded.

Figure 8 shows the evolution of the specific loss of energy´s monthly average of 200 liters thermal tanks labelled between 2001 and 2007. The curve points out to the significant improvement of these equipments´ performance and available on the market over the years.

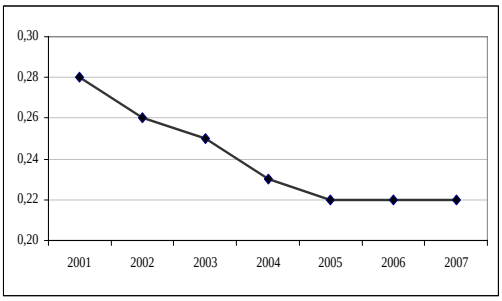


Fig. 8. Evolution of the specific loss of energy´s monthly average in thermal tanks

(kWh/month/liter)

In 2000, the university PUC-Minas Gerais and PROCEL, in partnership with the City Council of Contagem (Minas Gerais), took part in a project to install 100 solar water heating systems with a capacity of 200 liters each. This project was the largest of its kind in terms of the ratio scale/number of households, in Brazil. It also provided valuable data which allowed for the addition of solar heating systems on the list of electric energy utilities´energy efficiency projects thus meeting the National Agency of Electric Energy´s (ANEEL in Portuguese) legal requirements_ a compulsory investment of 0.5% of these companies´net income.

The Contagem´s Project corroborated an average reduction in electric energy consumption of up to 40%, depending on the type of heating systems installed, proportionate to savings of up to 60% in utility bills [14]. This project has demonstrated the financial viability of the use of solar heating systems for the lower-income population. Based on these results, the Electric Energy Distribution Utility of Minas Gerais (CEMIG in Portuguese) stimulated a number of this kind of projects which turned the state of Minas Gerais pioneer in the use of solar systems nationwide.

In 2005, PROCEL, in the context of PEE, acquired equipments to expand the technical capacity of the University PUC-MG´s Solar Laboratory which is responsible for testing solar collectors towards the ENCE and the PROCEL Seal labelling process. This technical expansion, thanks in particular to a solar simulator imported from Germany, allows for most of the tests to be ran indoors by the laboratory thus speeding up the overall process_ from a month to less that a week_ reducing the impact of the weather condition. This equipment is the first of its kind in the whole of Latin America out of 5 in existence in the whole world and it cost USD 500,000, donated by GEF (Figure 9).

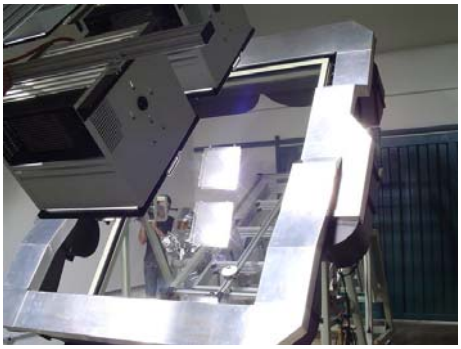


Fig. 9. Solar Simulator at PUC-MG

In the same way, the Laboratory at the Technology Research Institute in São Paulo (IPT in Portuguese) benefited from PROCEL´s help in acquiring new equipments for tests on thermal tanks with the same positive effects.

There are various ongoing studies being carried out to demand the labelling of all solar collectors and thermal tanks with ENCE. However, to become compulsory, this process needs to clarify policies as well as to provide the minimum energy efficiency indexes to be indicated as established by the law #10.295 of 2001 [15], also known as “Energy Efficiency Law”. These initiatives will empower the sector to generate new mechanisms to further advance the quality of solar heating equipments.

In this context, the carrying out by PROCEL, in partnership with PUC-MG, of the studies mentioned earlier represent a new step since they are destined for the accurate assessment of solar heating systems´ installations found in Brazil today be it in: the residential sector (showers and swimming pools), the service sector (hotels, gyms and schools) or the industrial sector. Involving about 60 professionals such as university professors, researchers, consultants and scholarship holders from various large Brazilian cities such as Belo Horizonte, Rio de Janeiro, Porto Seguro, Brasília, Campinas, the nationwide project´s main objective is to lay the strategic plan towards further technical development and dissemination of the solar energy in Brazil.

4. Conclusion

As the studies carried out by Eletrobrás/PROCEL (PPH) have shown, the use of electricity is predominant for water heating amongst Brazilian households due to the overwhelming presence of electric showers as the device most commonly used for this purpose. The immediate consequence of this fact is reflected in the inflated demand during the electric system´s peak-hour.
It has been asserted that the consumption of electric energy for water heating in Brazil is overall considerably high and historical data is pointing out at an ongoing growth trend should no provision, whether political or technical, be made rapidly for this sector.

Thus, the use of solar energy for water heating in Brazil has huge growth potential since less than 1% of the population currently makes use of this type of energy. Taking these facts into consideration and notwithstanding the favorable climate in the country, with approximately 2,200 hours sunshine per year [10], one can assert that the most recommended alternative for this end use is to substitute the electric shower with alternative sources of energy such as solar energy. In this context, PROCEL has been achieving a series of carefully planned and controlled activities towards the dissemination and the stimulation in the use of solar heating systems in Brazil. These activites can count on the collaboration of significant business partners such as INMETRO, PUC-MG, IPT, ABRAVA as well as the Manufacturers´Association. These partnerships are essential to

reach the results sat through our objectives. One of PROCEL ´s main lines of action has been the structuring of the testing laboratories supporting ENCE and the PROCEL Seal´s labelling process.

Since the use of solar heating systems is not recommended in all regions nor all conditions, there are constant efforts made by manufacturers, laboratories and PROCEL itself not only to contribute to the overall improvement in the efficient consumption of electric energy, but also of water and electric safety in water heating electric equipments. Indeed, these equipments were amongst the first to be considered for labelling with ENCE. Despite all of these combined effortst and the results shown by the success of the projects already running, there is still a long way to go in order to encourage nationwide the expansion of the use of this water heating technology: one of the most important step is to add it in the financing program of popular housing.

Water heating solar equipments are currently being taken into consideration by the Ministry of Mines and Energy (MME) to be added to the existing energy efficiency law. This should be implemented as of the year 2009 which will represent a true landmark in the sector´s advances.

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