

BRAZILIAN EXPERIENCE IN SOLAR WATER HEATING FOR LOW INCOME HOUSES - "MY HOUSE, MY LIFE" PROGRAM

Elizabeth M. D. Pereira¹, Ana Dolabella², Jorge B. Batista², Mara L. A. Motta³ and Jean R. Benevides³

¹ Polytechnic Institute / UNA, Belo Horizonte (Brazil)

²Department of Climate Change / Ministry of Environment, Brasília (Brazil)

³ National Environment Management / Caixa Econômica Federal, Brasília (Brazil)

1. Introduction

Brazil has great potential for solar energy: almost all regions of the country receive more than 2200 hours of insolation per year. Solar water heating (SWH) is technically mature in the country, and the market has grown over the past 5 years at average rates of 20% per year. According to data from ABRAVA (2011), the installed collector area in 2010 was 967,000 m², with an accumulated area of 6.24 million square meters (4038 MW_{th}). Notwithstanding the strong growth during the last few years, market penetration is still low, and the current penetration, 23 kW_{th} / 1000 inhabitants, represents a level approximately 10 times lower than what Austria and Greece had in 2008, IEA(2009).

The residential sector is responsible for 72% of the total installed collector area, mostly in high income single and multi-family buildings. However, there have been several initiatives in the last ten years to increase the use of solar water heating in low income dwellings, such as the Energy Efficiency Program conducted by the electrical utilities and supervised by the National Electrical Energy Agency (ANEEL). To quantify the real benefits resulting from the replacement of electric head showers by solar water heaters for low-income families, measurements were taken from 2000 to 2005 at Conjunto Sapucaias, a housing development in the metropolitan region of Belo Horizonte, Minas Gerais. The average savings achieved in 100 houses in this period was 34.6% of the total household electricity usage, if compared to that of 1999, before the installation of the solar water heaters, (FANTINELLI, 2006). The average electricity consumption for the houses with SWH was 82 kWh / month and 141 kWh / month for the houses with electrical head showers only.

However, only in 2010 the Brazilian federal government took an active role on the coordination of efforts towards the implementation of SWH in the country, with effective coordination of government actions and clear definitions of roles and responsibilities for each agency and ministry participating in the GT SOL – a workgroup on Solar Thermal Energy. This group, coordinated by the Ministry of the Environment, is composed by representatives from the Ministry of Mines and Energy, Eletrobras / PROCEL, Ministry of Cities, Caixa Econômica Federal, Ministry of Industrial Development and Foreign Trade and by the National Institute of Metrology, Quality and Technology. Other institutions supporting the GT-SOL are GIZ, ABRAVA and the International Labor Organization - ILO. This way, the government expects to achieve better results through the combination of efforts and resources, especially through an integrated planning process within the working group.

GT-SOL was in charge of developing a strategic plan for the dissemination of SWH in Brazil, which set a goal for the accumulated installed area of 15 million m² for water heating in Brazil by 2015. As a first action, the GT-Sol prioritized the support to the introduction of SWH within the My House, My Life Program, presented below.

2. My House, My Life Program (Minha Casa Minha Vida - PMCMV)

According to studies by the Fundação João Pinheiro (Ministry of Cities, 2010), the basic housing deficit in Brazil is 5.89 million dwellings, 4.14 million of which are concentrated in urban areas and 82% of this total are related to families with monthly incomes below three minimum salaries (722 €). Figure 1 shows examples of houses either inadequate or built on risk areas which are part of Brazilian housing deficit.



Figure 1: Examples of inadequate housing in the country

To remedy such situation the My House, My Life Program was created. The program includes the land acquisition and houses construction in state capitals and other municipalities with population equal or greater than 50 thousand inhabitants. In 2010, approximately 400,000 new single and multi-family units, as shown on Fig. 2, were contracted by Caixa Econômica Federal, a state owned bank which manages the program, with a maximum of 500 houses per development.



(single-family houses)

(multi-family buildings)

Figure 2: Examples of housing built by My House, My Life Program.

As part of the program, the federal government decided to recommend the implementation of SWH for up to 40,000 of those 400,000 houses contracted in 2010. The main objectives were to add value to the housing developments and to improve the families' financial conditions by significantly reducing their utility expenses. Thus, requirements were defined by the Ordinance 9324 of 02/24/2010, of the Ministry of Cities, for the acquisition and installation of solar heating systems for social housing projects. South, Southeast and Midwest regions were given priority due to the high market penetration of electric head showers in those

regions (PROCEL, 2007). However, it should be noted that the decision to implement SWH was left to the builders, which were paid an additional amount to do so. Ordinance 9324 of the Ministry of Cities defined the maximum value paid by the government for the installed SWH systems, which also included the cost of adding hot water piping to the house. The maximum amount paid by the government for multi-family buildings was set at €1.116 per dwelling and €804 for single-family houses.

3. Implementation of the Solar Heating System in PMCMV

The implementation steps of the program are summarized in Fig. 3 and are detailed below.



Figure 3: General steps for the implementation of SWH in the My House, My Life Program.

The first training course preceded the publication of the Ordinance, and its main goal was to demonstrate the benefits of solar thermal technology to close to 35 engineers from Caixa Econômica, from several parts of the country. The scope of the course included the presentation of the various components of natural circulation solar water heating systems and an introduction to systems planning, thermal efficiency and basic simulations methods such f-chart. The course also included site visits to a housing development with 378 housing units with solar water heating and a central solar heating system with forced circulation installed on a high income, multi-unit building.

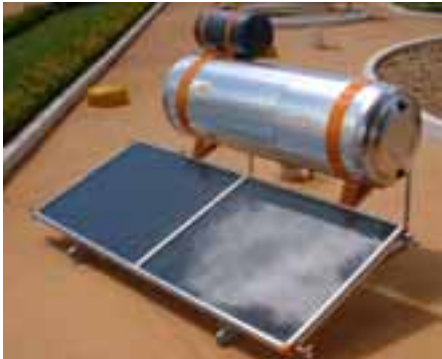
The second course was held in São Paulo after the publication of the Ordinance, again for Caixa Econômica engineers. Both courses had the support of Eletrobras / Procel, GIZ and Abrava and the state housing agencies for Minas Gerais and São Paulo state.

This step is considered critical to the success of the program because it is believed it minimized potential objections to the program by Caixa's engineers, by providing them with information and guidance regarding solar water heating.

The Step *Preparation of the Term of Reference* dealt with the development of the document that would set the technical requirements for the systems with the participation of all stakeholders and it was widely discussed within GT-SOL. After several simulations for different climates within the three priority regions and using data for products certified by the Brazilian Labelling Program / INMETRO, the basic SWH to be installed was defined and can be seen on Table 1.

The installation conditions had to fulfill the requirements set by the Brazilian standard NBR 15569: 2008 "Solar water heating systems in direct circuit - Design and Installation". Thermally insulated Polymer (PPR, EPDM, CPVC) and metal piping were approved for the installations and the inner vessel of the solar storage tank could be manufactured either in stainless steel or polymers.

Table 1: Basic solar water heater used for the PMCMV.

Key Components	Example of SWH
<p><u>SOLAR COLLECTORS</u></p> <ol style="list-style-type: none">1. INMETRO Rating: A or B2. Monthly production of energy, calculated for an average day in Brazil, greater than 150 kWh / month <p><u>STORAGE TANKS</u></p> <ol style="list-style-type: none">1. Certified by INMETRO2. Nominal capacity: 200 liters	

After approval within GT-SOL, the Term of Reference underwent, through a series of meetings and workshops, a broad consultation process (*Presentation and Discussion*) with all stakeholders,. This led, for example, to the identification of the need for additional training with Caixa engineers and builders (*Training Step - Part 2*), which was held in Minas Gerais, Mato Grosso do Sul and Rio de Janeiro.

In Minas Gerais state, due to the strong local drive for SWH implementation, technical workshops were organized with CAIXA engineers, local building companies, manufacturers of SWH equipment and the builders association (SINDUSCON), besides a hands-on course for solar energy installers. The strengthening of the chain value for the segment was sought after through quality assurance of products and installations and the integration of builders into the process. A completely different situation occurred in Rio de Janeiro and Mato Grosso do Sul, where many meetings were held in order to overcome local objections to the use of SWH.

By the end of 2010, 41,449 new houses were contracted with solar water heaters (SWH), therefore exceeding the initial goal of the Program. Figure 4 shows examples of integration of solar water heaters in single family homes and in residential buildings of PMCMV.

Participation of each state in the South, Southeast and Midwest regions is shown in Figure 5. The states of Minas Gerais and São Paulo accounted for 34.2% and 28.6% of total contracted systems, respectively. It is interesting to note that these states also have both the highest percentage of the total area of solar collectors installed in Brazil and of manufacturers with products rated by INMETRO (Minas Gerais - 15 and São Paulo - 28 industries).

In the step *Critical Analysis of Results*, several factors that contributed to the success of the program were identified, such as:

- the continued monitoring of local actions by CAIXA Econômica engineers, allowing the early identification of barriers and difficulties in several areas of the country. In those cases, the institutions participating in the GT SOL acted together, offering technical and strategical support for the solution of problems;

- the verification of available and sufficient funds to ensure achievement of the goal;

- the motivation of all players (installers, designers, builders and manufacturers) to develop this new niche market in the country, making investments and studies to improve the current installing capacity.



(Single - family houses in the state of São Paulo)



(22 multi-family building in the state of Rio de Janeiro)

Figure 4: Solar Water Heaters in Different Types of PMCMV housing units.



Figure 4: Solar Water Heaters Installed in the Brazilian States in the regions given priority by PMCMV in 2010.

However, many lessons were learnt, thus generating recommendations for the next stage of the Program, to be implemented between 2011 and 2014, such as:

- to review of the Term of Reference that, despite setting minimum technical requirements in accordance with the standards and specific local conditions, left gaps that have caused problems, especially in relation to installation details of the solar water heaters. This review is due on August/2011 by GT-SOL;

- the need to establish Training Centers in all regions of Brazil to train professionals in various fields of knowledge and levels of activity, the greatest need being at the installer level;

- the implementation of programs for results monitoring and verification (M&V), based on national and international protocols, in order to quantify the real economy achieved by the replacement of electric showers by solar heaters, including the reduction of peak electricity demand. Eletrobras / PROCEL is funding the construction of seven new Training Centers in five regions of the country and a M&V program in four housing projects in the South, Southeast (single-family houses and multifamily building) and the Midwest regions;

- development of awareness programs and training for residents on installation and maintenance of solar water heaters;

- development of Marketing and Social Technologies Programs, interacting with the communities, based on the development of reusable methodologies and techniques so that solar heaters can contribute in the effective action for social transformation.

New partnerships are under discussion within GT SOL in order to meet these last two items.

Thus, in its first phase, the inclusion of solar heating at My House, My Life Program can be seen as a large demonstration project in three regions of the country, reinforcing the concept that this technology is feasible for low-income housing under different weather conditions.

The positive results obtained and ongoing corrective actions led the federal government to make SWH mandatory in the second phase of the program My House, My Life for all single-family houses of the program and for all regions of Brazil, starting in 2011.

4. References

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