Implementation and Evaluation of Residential Lighting Projects in Brazil

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ABSTRACT

THE BRAZILIAN UTILITIES' EFFORTS TO implement and evaluate efficient residential lighting technologies programs are analyzed to accumulate knowledge for use in future endeavors. Although the programs were small-scale pilot projects, they were important to acquire more knowledge on more effective ways to conceive delivery mechanisms, and establish new relationships with customers, lamp manufacturers and retailers. The need to establish more rigorous evaluation methodologies for assessing the performance and results of residential lighting programs has become more evident to program managers and to the National Electricity Conservation Program (PROCEL) as they strive to incorporate lessons from the pilot programs into future large-scale energy efficient-lighting programs. This article first give a brief picture of the role of residential lighting, discuss the Brazil's experience in residential lighting projects and report the main results achieved.

INTRODUCTION

Residential electricity consumption doubled during the seventies, continued to show high growth rates during the eighties, and averaged 6% per year during 1990-96. About 92% of the households in Brazil are electrified (IBGE 1995). Growth in residential electricity demand, partly as a result from the economic stabilization plan, was the primary factor causing total electricity use to rise rapidly in the past three years. Residential electricity demand is expected to continue to rise faster than total demand in the next decade, as a consequence of population growth (1.6% per year, IBGE projections) and increase in per capita consumption (2.0% per year, ELETROBRÁS projections), since the main end-uses are not saturated.

Lighting accounts for about 17% of total electricity use in Brazil (45 TWh in 1996) and residential lighting represents approximately one third of this amount (Geller et al 1996). The residential sector is responsible for about 20-35% of the evening peak demand across typical Brazilian utilities. Residential lighting represents about 10% of the evening peak (Jannuzzi, 1993, Leonelli et al 1996).

There is great potential in improving residential lighting energy use replacing incandescent lamps by CFLs since incandescent lighting represents about 95% of the lighting electricity use (Jannuzzi 1993). Since this is also an end-use that contributes for peaking capacity, savings contribute to improve utility load factors and may avoid new capacity and T&D investments.

There is an increasing interest in implementing residential lighting programs in Brazil. The National Electricity Conservation Program (PROCEL) has plans to promote the substitution of 8 million incandescent lamps over two years, and estimates total savings of about 500 GWh and 166 MW of peak capacity (ELETROBRÁS/PROCEL 1996a) [1)]. Some utilities are also taking initiatives to promote the adoption of CFLs. For example, one utility has been planning to finance the installation of up to 180,000 CFLs in the residential sector in the city of Fortaleza in Ceará state, with consumers paying for the lamps through the monthly utility bill. Another utility is planning a bulk purchase of 135,000 CFLs for a giveaway program for low-income households in the city of Vitória da Conquista in Bahia state. In both cases, the local distribution utility is interested in reducing peak demand in order to delay transmission and distribution system investments. We estimate that the economic benefits of implementing such programs are quite significant and capital investments could be avoided with the deferred installed capacity by this program.

Although the projects already undertaken for the residential sector are small scale pilot projects, the experience gained in implementation and evaluation methods is relevant for future endeavors.

This paper reviews the Brazilian experience of implementing and evaluating residential lighting projects. We analyze four projects implemented by three Brazilian utilities: CEMIG (Minas Gerais State Energy Company), CESP (São Paulo State Energy Company) and CPFL (São Paulo Light and Power Company). These were the only utilities involved in residential lighting programs in the country up to year 1995. The data collected for this work was based on interviews with the project managers of each project and documents that were made available.

BRAZIL'S EXPERIENCE IN RESIDENTIAL LIGHTING PROJECTS

MOTIVATION AND OBJECTIVES FOR THE IMPLEMENTATION OF LIGHTING PROJECTS

The four projects developed by CEMIG, CESP and CPFL had different underlying motivating factors. Thus their objectives and implementation schemes differed.

CEMIG faced concrete problems with electricity supply and financial constraints to expand its transmission system in a particular region (Vale do Jequitinhonha) [2], where low-income households and electric consumption predominate. These aspects convinced CEMIG to use a CFL give-away program for the region. CEMIG's objective was to reduce 1.8 MW during peak period and increase residential energy consumption during off-peak hours, so that it would not loose revenues (residential customers pay only flat energy rates [3], which do not vary according to the time of use). The company would also improve its system load factor.

The project implemented by CESP was motivated by their interest in understanding the consumer behavior towards the new CFLs. CESP objective was to determine market response due to a marketing campaign and discount levels offered for the CFLs. Its evaluation procedure included a questionnaire with items such as customers satisfaction with the lamps, the marketing campaign, reaction to the CFLs prices, and reasons for customer participation.

The two projects developed by CPFL were guided by the desire to promote conservation programs to extend the lifetime of their existing distributing installations (substations and transformers) in areas where continued demand growth would require significant and costly upgrades. CPFL objective was to investigate the impacts (cost-benefits and energy savings) of different delivery and dissemination mechanisms. Project (I) tested 3 different rebate levels and project (II) offered financing via a monthly payment system for the CFL purchased.

PROJECT STRATEGIES

Table 1 below summarizes the main efforts of the three utilities during 1993-95. The projects can be considered modest in scale, specially if we compare them with the international experience. The total number of lamps commercialized through each project varied from 2,000 to 90,000. Total costs varied from about US$19,000 to US$700,000. The delivery mechanisms tested by the utilities consisted of giveaway, rebate and monthly payment options.

In CEMIG the implementation of the full scale program was preceded by a pilot project. The CFLs were given and installed in homes with monthly energy consumption up to 50 kWh. CFLs were purchased by the utility and local technicians were hired to install the lamps. The project distributed only one type of CFL.

CESP's project was essentially based on marketing and information effort and a 30% discount given by the manufacturers. A discount coupon was given with the electricity bill. One type of CFL was offered and no limit was placed on the number of lamps purchased. The project took place in four cities of the State of São Paulo[4] (Atibaia, Franco da Rocha, Ubatuba e Campos do Jordão). Although four lamp manufacturers participated in the program only one type of product was marketed (9 watt lamp) with small differences in lamp-ballast design.

The CPFL project (I) used three different rebate levels (30%, 60% and 70%) in three different cities [5] (Americana, Marília and Franca) and the same information and marketing campaign. The rebate coupon was mailed directly to the customers. Thirteen different types of lamps were marketed. The project was based on reduced prices and allowed customer to purchase a maximum of three lamps. The utility limited a total of 10,000 CFLs for each city (see Jannuzzi and Santos 1995 for more details on this project).

The CPFL II project was done in two cities (Botucatu and Valinhos). A small discount of US$2.00 that could be paid in up to four monthly installments was offered and also a marketing and information campaign was developed and used in the two cities. This project marketed seven different types of CFLs and there was no limit on the number of lamps purchased by the consumer. A total of 50,000 CFLs were available for CPFL (II).

RESULTS

Table 2 shows the results of the four projects. Except for the give-away project, the highest participation rates (5-9%) were achieved by the CPFL (I) project, but it is important to highlight that there were limitation on the total number of lamps that were made available to the customers. In the other projects this information was not used by the utility as an indicator of their performance. The number of lamps per participating customer varied from 1-2 (CEMIG), an average of 1.7 (CESP) and 2.5-2.9 for the CPFL (I) project (this project had a limit of 3 lamps/customer).

Prices seem to be an important parameter determining lamp purchases. In CPFL (I) the most sold product was the cheapest lamp: a circular, magnetic ballasted lamp which replaced a 60W incandescent lamp.

Several issues were leaned from these experiments. The give-away strategy presented a high participation rate, a lower CFL price and the program was targeted to areas were the utility had particular interest in electricity savings. On the other hand this strategy do not include the partic-

Table 1: Main characteristics of the residential lighting projects.

Characteristics		Utility		
	CESP	CPFL (I)	CPFL (II)	CEMIG
Year	1993	1994	1995/1996	1995/1996
Type of project	bonus	rebate	monthly installments	direct install
CFLs costs to customer	US$11.00	US$29.04 toUS$4.82	US$25.20 to US$10.40	none
CFL regular price in stores	US$16.00	US$41.49 to US$16.06	US$27.20 to US$12.40	~US$8.00[a]
Total customers in project	76,889	153,775	43,101	~52,000
Project costs[b]	US$19,270	US$670,00.00	not available	~US$740,000
Lamp type	CFL	CFL and circular	CFL and circular	CFL
Ballast type	electromagnetic	electronic-electromagnetic	electronic-electromagn.	electromagnetic
Wattage (fluor. Lamp)	9	15 to 32	15 to 32	9
Project duration	40 days	1 month or when	6 months	1 year

NOTES: All financial values are in current US$ and refer to the year of the project;
a) average cost per installed CFL;
b) costs include: CESP: information campaign; CPFL: rebate, project administration, information campaign, implementation and evaluation; CEMIG: CFL and installation costs (estimated).

Table 2: Main results of the residential lighting projects.

Characteristics			Utility			
	CESP		CPFL (I)		CPFL (II)	CEMIG
		30%	60%	70%		
Total number of lamps	2,232[a]	5,700	11,050[b]	10,058	not available	~ 89,000
Participation rates[c]	~1.7%[d]	5%	9%	5%	not available	~100%d
Estimated savings					not available	
kW	69	203	357	352		1,845
MWh/yr	324	325	602	593		857

a) after the project sales were over an additional 881 CFLs were sold over the following month.
b) more than 10,000 CFLs were sold due to problem in accounting for the lamp during the last day.
c) participation rate: participating households/potential participants.
d) authors' estimates.

ipation and interaction of all actors of the regular lamp market (vendors, consumers, lamp manufacturers) and provides a passive customer behavior towards energy conservation. It is, however, very suitable for emergency supply/distribution situations.

Other projects which marketed CFLs allowed the participation of the utility, lamp manufacturer, vendors and customers. It was also possible to analyze the effects of the marketing and information campaign and consumer preference. It must be observed that there were problems with the supply of CFLs, and indications that lamp manufacturers had their own strategies. Another important aspect that can be seen from these experiments is that for the first time these utilities had to develop a different service to their customers, and had to involve different areas of their companies and hire outside experts.

PROJECT EVALUATION METHODS

CEMIG was the only utility to perform ex-ante measurements using the information collected previously to design its implementation strategy. Its ex-ante evaluation included a household survey (collecting data on appliance ownership and consumption habits) and electrical measurements in appropriate transformers and substation feeders. It also performed an ex-post evaluation 90 days after end of the CFL installation, applying questionnaires to collect information on customer satisfaction, and performed new measurements to detect actual electricity demand and use savings accrued from the project. Up to now CEMIG only performed a preliminary program cost analysis while it awaits the completion of the CFL distribution in the area.

Our analysis shows that CEMIG was able to define clearly the project objectives and the evaluation objectives were conceived in parallel and consistent with the project objectives.

The evaluation process performed by CESP focuses on verifying items directly related to some specific objectives such as campaign recall, CFL sales, lamp usage patterns and consumer satisfaction, consumer's reaction to lamp prices, socio-economic profile of program participants and non-participants. A household survey was performed 180 days after the program ended, but no information was collected before the program was implemented. Energy and demand savings were inferred from CFL sales. The results of this project are being considered by CESP to design a new project.

CPFL (I) conceived an evaluation method in order to assess the participant rate, information campaign, lamp usage patterns, customer satisfaction with the CFLs and implementation campaign, and costs and benefits to the customer and utility. The energy and demand savings were estimated from lamps sales and customers declarations.

CPFL (II) applied a questionnaire to households when they came to the stores to purchase the lamps. A second set of questionnaires were applied to samples of participating and non-participating households when the lamp sales period ended. Most of this data is still being processed. No ex-ante information was collected in the case of CPFL (I) and (II).

As a result from the analysis performed upon these program an evaluation methodology has been proposed to PROCEL in order to assess the performance of future programs in terms of process and impact evaluation techniques. A more rigorous procedure is being recommended for ex-ante evaluations, which have the objective of determining the reference case and guide the establishment of implementation strategies. Ex-post evaluations need to be performed in several periods and must also help to characterize effects of free-riders and free-drivers.

DISCUSSION

In spite of the large potential for improvements in residential lighting energy use by substituting fluorescent for incandescent lamps, most of the DSM efforts so far can be classified as small-scale pilot projects. These efforts have been made by several utilities, some with support from PROCEL.

These small residential projects have nevertheless led to a significant increase in CFL sales in the country. CFL sales increased by a factor of five in the last five years, to about three million lamps sold in 1996, which is equal to 1% incandescent lamp sales (Geller et al. 1997). The influence of PROCEL and the utility projects is believed to have contributed to 10% of observed lighting electricity savings in 1996 (Geller et al. 1996).

The projects were important to acquire more knowledge on more effective ways to conceive delivery mechanisms, establish new relationship with customers, lamp manufacturers and retailers. The need to establish more rigorous evaluation methodologies for assessing the performance and results of residential lighting programs has also become more evident to program managers and for the National Electricity Conservation Program. The lessons learned from the analysis of the programs presented have contributed to that end.

ENDNOTES

1. This plan has been postponed at the time of writing. Meteorological conditions improved and guaranteed the reliability of the country's hydroelectric system, apparently shifting ELETROBRÁS interest away from these initiatives.

2. Vale do Jequitinhonha: very poor region, dedicated to agriculture and cattle raising. Household average electricity consumption is around 30 kWh/month.

3. Electricity used by low-consumption residential customers and large industrial customers is highly subsidized. But on average, electricity tariffs are not low from an international standard point of view and are adequate to cover operating costs alone. Even so, they are not adequate to cover the enormous debt service and capital investments required by the Brazilian power sector. The prevailing yearly average electricity tariffs in 1995, excluding taxes, were about US$46.74/MWh for industrial customers, US$14.44/MWh for commercial customers, and US$84.01/MWh for residential customers, or on average US$64.60/MWh (ELETROBRÁS 1996b).

4. These cities present distinct socio-economic characteristics.

5. These cities present similar socio-economic characteristics and have similar population and electricity consumption patterns. ●

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