Energy Efficiency Programs for Low-income Household Consumers[1] in Brazil:

Considerations for a Refrigerator-Replacement Program

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[1] The data and analyses which have been done throughout this report refer to those consumers who are legally connected to the grid and paying the Low Income – Social Tariff.

Glossary

ABRADEE – Associação Brasileira de Distribuidores de Energia Elétrica (Brazilian Association of the Power Distribution Utilities)

ANEEL – Agência Nacional de Energia Elétrica (National Electricity Regulator)

CDM – Clean Development Mechanism

CELPA - Centrais Elétricas do Pará S/A (Power Distribution Utility of Pará S/A; Pará is a State from the North Region)

CEMIG - Companhia Energética de Minas Gerais (Power Distribution Utility of Minas Gerais; state from the Southeast Region)

CERJ – Companhia de Eletricidade do Rio de Janeiro (Power Distribution Utility Company of Rio de Janeiro, currently called AMPLA; Rio de Janeiro is a state from the Southeast Region. AMPLA has a concession for the distribution of electricity in designated areas of the state)

CESP – Companhia Energética de São Paulo (Power Utility of São Paulo; former vertically integrated, it is currently a state generation utility after privatization)

CFC - Chlorofluorocarbons

COELBA - Companhia de Eletricidade do Estado da Bahia (Power Distribution Utility of Bahia; Bahia is a state from the Northeast Region)

COELCE - Companhia Energética do Ceará (Power Distribution Utility of Ceará; Ceará is a state from the Northeast Region)

CPFL - Companhia Paulista de Força e Luz (Power Distribution Utility of São Paulo; CPFL has a concession for the distribution of electric energy in designated areas of the State of São Paulo, which is from the Southeast Region)

E.C = Unidade consumidora (electricity consumers)

ELETROBRÁS – Centrais Elétricas Brasileiras S.A. (ELETROBRAS – holding of the Brazilian Power System that controls around 60% of the national electricity generation, 60% of the transmission grid and some distribution utilities)

Eletropaulo - Eletropaulo Metropolitana Eletricidade de São Paulo S/A (Power Distribution Utility of São Paulo; Eletropaulo has a concession for the distribution of electric energy in designated areas of the State of São Paulo, which is from the Southeast Region)

ESCELSA - Espírito Santo Centrais Elétricas S/A (Power Distribution Utility of Espírito Santo; Espírito Santo is a state from the Northeast Region)

HFCs - Hydrofluorocarbon

LIGHT - Light Serviços de Eletricidade S/A (Power Distribution Utility Company of Rio de Janeiro; Rio de Janeiro is a state from the Southeast Region. LIGHT has a concession for the distribution of electricity in designated areas of the state)

PNAD – Pesquisa Nacional por Amostra de Domicílios (National Household Sample Survey)

PROCEL – Programa Nacional de Conservação de Energia Elétrica (National Electricity Conservation Program)

1 Executive Summary

1. Around 37% of the Brazilian residential consumers are qualified and benefit from the Social Tariff, which is about 50% of the residential tariff. Particularly in the Northeast region, the figure reaches 66% of the residential consumers. There are almost 18 million consumers classified as low income in the country, of which 43% are concentrated in the Northeast region, followed by the Southeast (36%).
2. Even though their electricity consumption is low, on average 65 kWh per month (about 46% of the current national average), and the electric bill is on average R$ 9, the total amount of subsidies have been rising nationally and reaches R$ 1.4 billion per year. The situation can be much worse if we consider that there is a significant number of unmetered and non paying households in the country. Once they become regular customers they may be qualified for the Social Tariff, contributing to increase the annual amount required.
3. Field surveys carried out by COELBA (a utility from the State of Bahia) show that the refrigerator represents 70% of the total low-income household's electricity consumption whilst lighting accounts for 20%.
4. It is desirable to develop a strategy to phase out subsidies without negatively impacting the ability to pay of the consumers provided with the Social Tariff. Energy efficiency can be part of this strategy, unburdening those consumers who are actually subsidizing the inefficient electricity use by obsolete appliances found in low-income households.
5. The main objective of the present report is to analyze the potential impact of a refrigerators substitution program on low-income population who are provided with the Social Tariff. This report also verifies the potential and cost effectiveness of reducing low income household electricity consumption and consequently the reduction of the subsidies needed.
6. Although there have been several experiences with residential energy efficiency programs in Brazil, almost none have been properly documented and evaluated in ways that can provide secure guidelines or best practices for a refrigerator replacement program. However, more recent and specific programs for low-income households indicate the importance of "whole-house" measures including re-wiring and improving local electricity distribution. These findings are consistent with the experience in the US with programs for low income households. The US experience also indicates that the cost effectiveness of programs is not the main objective and measure of success. Other indicators such as indoor health, safety and well-being of households are more relevant.
7. Since 1998 energy efficiency programs have been implemented in low-income households, including also efforts to regularize illegal connections. Since year 2005 it is mandatory that 50% of each utility annual investment[2] in end-use efficiency is done in low-income households.
8. About 96% of the Brazilian households have refrigerators. The Northeast region has the lowest ownership, but even so reaching 92%. Around 30% of the Brazilian refrigerators are more than 10 years old. Furthermore, the majority of the oldest refrigerators, as expected, belong to the lowest-income families.
9. Several reasons contribute to make refrigerators attractive appliances for an energy efficiency program, especially to low-income consumers in Brazil: (a) high participation on the residential energy consumption, specially in the NE and N regions; (b) High appliance dissemination among low-income households; (c) Most

[2] Current regulation states that Distribution utilities must invest 0.5% of their annual net revenues in energy efficiency programs, which are submitted to the regulator's approval (see Table 1).

of low-income have refrigerators more than 10 years old; d) the energy consumption should be higher in such households due to the precarious electrical installations and consequently inadequate energy quality and voltage provision which reduce the performance of the appliance.

10. The analysis presented in this report shows that with the current subsidy scheme in place representing 53% of the tariff (on average) and the possibility of reducing the refrigerator's energy consumption by this value (at least), it is possible to withdraw the subsidies without increasing energy expenditures of the low-income households provided with the social tariff. It is also possible to propose a small participation by the consumer in the program costs. Depending on the financing scheme to be offered to the consumer, this participation can be increased. Brazil has already several experiences with rebate and payment programs through energy bills (some especially directed to low-income households), pointing out that such schemes can be used effectively.
11. The cost-benefit evaluation from society's perspective does not support the conclusion that it is more favorable for society to bear all program costs and recover the investment over the equipment lifetime assuming the values of the base case. It is necessary to make efforts to reduce the costs of the program as well as to maximize the reduction of energy consumption, i.e. seeking households where this reduction is higher in order to produce positive results.
12. Two regions stand out as the best candidates for a refrigerator-replacement program: Regions NE and N. The participation of refrigerator in total residential demand is 30% and 27% respectively (**Erro! Fonte de referência não encontrada.**) and these are the regions which receive the highest subsidy relative to the regular residential tariff compared to the other regions[3].
13. Currently utilities are investing about R$ 190 millions in low income residential programs as part of their compulsory energy efficiency programs. Most of these funds are being used in lighting, refrigerators, installation upgrades and solar heating. Is makes sense to use these funds in combination with a subsidy-removal strategy, since the capital is available and currently appliances are being donated to households.
14. In order for society to bear the integral costs of such a program, total costs should be reduced to R$ 300-350/refrigerator (assuming a rate of return of 15%) or to R$ 500-520/refrigerator (for a 6% rate of return), keeping the remaining parameters constant, such as tariffs, subsidy level and energy savings per refrigerator for the base case.
15. Alternatively, a reduction of the subsidy level (instead of a complete elimination) is another strategy to pursue in combination with efforts to reduce program costs.

[3] The subsidized tariff is 53% and 52% of the regular residential tariff for the NE and N regions respectively. For the other regions this share is 50%.

2 Introduction

The concern over the access to modern energy services to the whole population has been an important element of the Brazilian public policy for a long time. In the case of LPG, for instance, since the 60's there has been an effort towards the creation of a market for this fuel in order to replace fuel wood as the main cooking fuel in Brazilian households (Jannuzzi 1989). Subsidies were one of the main elements made necessary to substitute fuel wood and promote cooking fuel market transformation in the country[4] (Jannuzzi and Sanga 2004; Lucon, Coelho et al. 2004).

More recently, following the example of many countries, Brazil has created mechanisms to finance public interest activities during the restructuring of its power sector (Jannuzzi 2000; Jannuzzi 2000; Wiser, Murray et al. 2003), guaranteeing funds to invest in energy efficiency, research and development. Electricity distribution companies are required to invest part of their annual revenues in energy efficiency program under the regulator's supervision (Table 1). Since 1998 part of these funds has been used by the distribution companies to invest in energy efficiency programs for low-income consumers. During the period 2005/06 almost 61% (or R$ 190 millions) of the utilities investments in compulsory energy efficiency were low-income programs (Vidinich, 2006a).

In addition, from 2002 on, a specific residential tariff was created, called Social Tariff, for low-income consumers aiming to reduce the burden of the electric bill within the family's budget.

Around 37% of the Brazilian residential consumers are qualified and benefit from the Social Tariff, which is about 50% of the residential tariff. Particularly in the Northeast region of the country, the figure reaches 66% of consumers. Even though their electricity consumption is low, on average 65 kWh per month, and the electric bill is on average R$ 9, the total amount of subsidies have been rising and currently reaches annually R$ 1.4 billion.

The situation can be much worse if we consider that there are a significant number of un-metered and non paying households in the country. Once they become regular customers they may be qualified for the Social Tariff, contributing to an increase the annual amount required.

Studies carried out by the utilities CERJ, LIGHT, COELBA, ESCELSA and others indicate a significant waste of electricity in low income households due to inadequate electricity use, caused by the lack of information about its rational use, precarious electrical installation, use of refrigerators which are in bad condition and buildings without ventilation and natural lighting (Mascarenhas and Nunes 2005). Field surveys carried out by COELBA (a utility from Bahia State in Northeast Brazil) show that refrigerators represent 70% of total low-income household's electricity consumption whilst lighting accounts for 20% (Mascarenhas and Pinhel 2006).

It is desirable to develop a strategy to phase out subsidies without negatively impacting the ability to pay of those consumers provided with the Social Tariff. Energy efficiency can be part of this strategy, unburdening those consumers who are actually subsidizing the inefficient electricity use by obsolete appliances found in low-income households.

The main objective of the present report is to analyze the potential impact of a refrigerators substitution program on low-income population who are provided with the Social Tariff. This report also will verify the potential and cost effectiveness of reducing low income household electricity consumption and consequently the reduction of the subsidies needed.

Energy efficiency programs which seek to reduce the electricity consumption of these families can bring several benefits to society as a whole and to the utilities providing the

[4] From January 2002 on, LPG subsidies directed to all consumers were withdrawn and a new one (LPG-Voucher) was introduced to directly subsidize low-income consumers.

service. The latter could reduce the non-payment of electric bills, cut down on technical losses (and even commercial losses in the case of illegal power connections) and on reconnection expenses. Moreover, the utilities could also provide the energy saved to other customers and postpone the need for new capacity on the distribution power network systems, in addition to improving the relationship with their customers. For society, which ultimately is either directly or indirectly responsible for the subsidies, the reduction in subsidies and unpaid bills would mean a relevant cut down of these subventions.

Hence, energy efficiency programs can be an important part of a power market transformation strategy targeted to low-income households so that these consumers could depend less on subsidized rates without compromising their ability to pay the electric bill as well as increasing the level and quality of the services provided.

Table 1 presents the current allocations of Brazilian utilities' compulsory investments in energy efficiency and R&D programs. The total annual investments in energy efficiency programs is about R$ 300 millions (Vidinich, 2006a). Only Distribution utilities are required to invest in efficiency programs: amounting to 0.5% of their annual revenues. Public interest energy efficiency programs can be funded by the CTEnerg fund.

Table 1: Allocation of the 1% electricity revenues in Energy Efficiency and Energy R&D programs by the type of utility in Brazil (Law 9.991/00[5])

	% of the annual net sales revenues (minimum)			
	Energy Efficiency	R&D		
		CTEnerg	ANEEL	MME
Distribution	0.50%	0.20%	0.20%	0.10%
Generation and Transmission	0%	0.40%	0.40%	0.20%

Note: the required percentages allocated to energy efficiency and R&D by the distribution companies were modified on the 1st January 2006 to a minimum of 0.25% and 0.75%. The percentage to be charged from those companies whose energy sale market is below 1.000 GWh/year could be increased from 0.25% to up to 0.50%. **CTEnerg** is the public interest fund created to invest in energy efficiency and energy R&D administered by a board with representatives from government, academia and private sector (Jannuzzi, 2005). **ANEEL** is the Brazilian Electricity sector regulator. **MME** is the Ministry of Mines and Energy.
Sources: DOU, 2000 and ANEEL, 2005.

The present report is structured as follows: firstly, a brief analysis is made of the national and international experience regarding low-income energy efficiency programs. We also present an analysis on the household's ownership and characterization of refrigerators by region and income level. The current structure of residential subsidies and regional variations are also evaluated in the following section, since this will have an impact on the cost-benefit analysis of energy-efficiency programs to low income households. The report also presents a methodology to analyze the economic impacts of such programs from the low-income consumer's perspective, and from the society and utility viewpoint as well. We also analyze the case of replacing refrigerators.

The section discusses the results obtained from the cost-benefit analysis and conclusions are presented on the possibilities of implementing low-income refrigerator replacement programs as a strategy to reduce the amount of subsidies provided to low-income families.

[5] The Law 9.991/00 entered into force on 25 July 2000 (DOU, 2000) and modified by the Law 10.848/04 which in turn entered into force on 15 March 2004. The Law 9.991/00 refers to the obligation of the power utilities to invest a part of their annual net sales revenues in energy efficiency and R&D programs.

3 Energy Efficiency Programs for Low-income Household Consumers

3.1 The National and International Experience

3.1.1 National Experience

The domestic experience in Brazil on implementing energy efficiency programs[6] for low-income consumers is not so recent. It has been practiced for some time with different objectives by some utilities, especially through residential lighting programs whose objective is to substitute incandescent bulbs for compact fluorescent lamps. Such experiences have started in the early nineties by the utilities CPFL and CEMIG, followed by CESP (Jannuzzi, Dornelas et al. 1997) and afterwards by other utilities through the National Electricity Conservation Program (PROCEL).

It is worth mentioning the lighting program experiences for low-income households by CEMIG in the Vale do Jequitinhonha in 1995 and by COELCE in the State of Fortaleza in 1997. Since then, there is reasonable knowledge on different schemes and strategies to implement energy-efficient lighting programs, ranging from donation-based programs to more sophisticated mechanisms of commercialization, such as through rebates, financing or discount prices.

In Brazil there was the experience of using rebates, donations, and discount prices in the retail market (Jannuzzi, Dornelas et al. 1997). The experience of COELCE, including those focused on the low-income population, of using rebates through the local retail market seem to be a feasible implementing strategy, even though difficulties were faced in that period related to the product novelty and lack of preparedness by the retail market sector for this kind of campaign. One of the advantages of seeking the involvement of the local commerce in energy efficiency programs is the higher assurance of promoting a gradual market transformation for energy-efficient lighting equipment.

The program implemented by COELCE was the only one we are aware of that sought to carry out ex-ante and ex-post evaluations for its implementing process and impacts.

3.1.2 International Experience

Regarding the international experience, large energy-efficient lighting programs have been implemented; some of them taking into account the particularities of the low-income population (Friedmann and Jannuzzi 1999; Birner and Martinot 2005), as well as the existence of the Efficient Lighting Initiative – ELI (www.efficientlighting.net). In general, the main motivations of these programs were the concern over cutting down the social tariff subsidies and/or reducing problems related to power supply due to temporary energy crises or bottlenecks on the supply systems.

Other appliances such as refrigerators have been also targets of several energy efficiency programs. Some of them are restricted to the substitution of inefficient refrigerators while other programs encompass broader measures and longer duration, such as labeling and minimum energy efficiency standards for equipment (Singh and Mulholland 2000; Birner and Martinot 2005). Besides the energy efficiency aspects, the attractiveness of such programs for replacement of old equipment (refrigerators and freezers) which use chlorofluorocarbons (CFCs) is that they can be implemented as measures to comply with the Montreal Protocol. In those cases where refrigerators or freezers which also use reduced amounts of hydrofluorocarbons (HFCs; the substitutes of CFCs) are used, these programs could be conceived of as CDM projects[7], consequently accounting for the carbon credits commercialized.

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[6] In this work, the term "programs" refers to a set of projects or planned actions put in practice systematically.

[7] Clean Development Mechanism (CDM) under the Kyoto Protocol.

Voluntary labeling schemes have been applied in Brazil for more than 20 years when the National Labeling Program was created in 1984. This voluntary program made possible the reduction in electricity consumption of the models available to the Brazilian consumers, as can be seen in Figure 1. Besides this mechanism, since 1994 the PROCEL Label (Selo PROCEL) is issued annually to the more energy efficient appliances and equipment within their categories. It aims to stimulate the national manufacturing of more energy-efficient equipment and to enable consumers to compare the energy use of the models they are considering. In 2006 the introduction of a mandatory minimum energy efficiency standard for residential refrigerators started to be discussed, which should be implemented early in 2007.

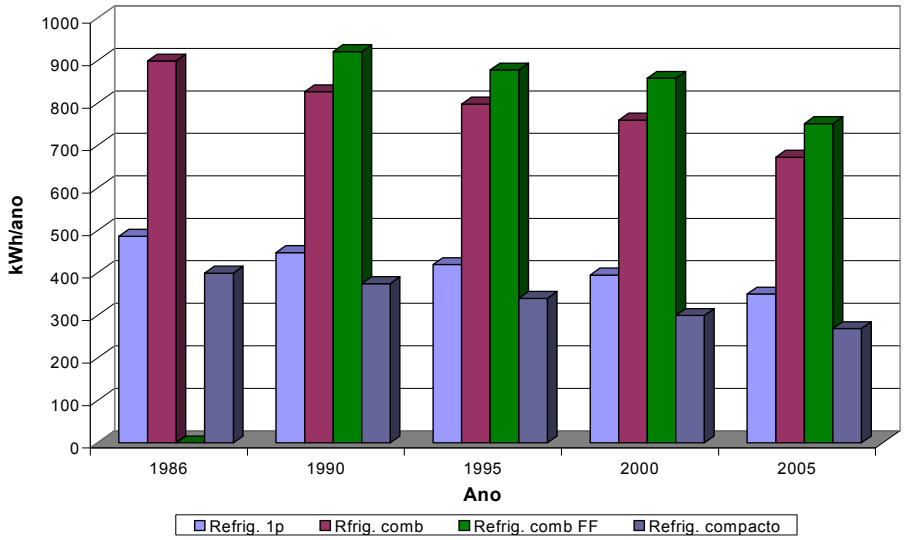


Figure 1: Evolution of the average energy consumption of the new residential refrigerators

Source: (Nogueira 2006). Note: 1p= one-door refrigerator, Refrig. Comb = refrigerator and freezer model, FF = frost free refrigerator and Refrig. Compacto = small refrigerator.

The United States has much experience in conducting energy efficiency programs for low-income consumers. There is a two-decade experience of implementing and evaluating such initiatives at the local, state and country levels. The more active states so far have been California, New York and Massachusetts. Many of these programs use public funds and some are focused to cover part of the electric bills, without necessarily being part of an energy efficiency program. However, many others combine grants to electric bill payments, information and discount price programs for equipment substitution and energy-related home repair (Flex your Power 2006). There is a specific federal assistance program to low-income consumers, the Low-Income Home Energy Assistance Program (LIHEAP), which coordinates the allotment of funds to the state programs and provides information to consumers.

The American experience is relevant especially regarding the monitoring and evaluating efforts of the programs. There is also an increasing amount of knowledge about the relationship between consumption in buildings and income and consumption patterns (Lutzenhiser and Lutzenhiser 2006). However, most programs deal with better housing insulation and assistance regarding payments of winter heating bills (Gardner and Skumatz 2006; Roth and Hall 2006), which are not suitable to the objectives of the present report and to the Brazilian reality. Nevertheless, some LIHEAP programs have expanded their focus to include refrigerator replacement along with other initiatives to reduce energy consumption especially during winter months. It is clear that energy

efficiency has been used in the US as a strategy to promote the reduction of unpaid electric bills in low-income households. This approach is something that certainly could be applied to Brazil.

3.2 Best Practices Of Low-Income Energy Efficiency Programs

In 2005, ACEEE[8] (Kushler, York et al. 2005) evaluated a set of the best low-income energy efficiency programs in the US in order to identify "best practices" to meet the basic energy needs of low-income families by reducing their energy consumption and energy payment burden. The selection was made by a panel of three specialists, in addition to the ACEEE staff, through a public call. Direct contact with organizations was made and they were asked to recommend exemplary programs to be analyzed. Personal contacts were done within several institutions and energy companies to guarantee a much broader sample of the main programs implemented in the US. Hence, it was possible to put together information on programs covering a broad range of end uses and appliance sizes from local cooperatives to state programs.

Eighteen programs which scored the higher ranks within the following points were selected:

- Demonstration of achieved energy savings (kWh, kW and $ saved by consumers);
- Replication;
- Evaluation of results: programs with good ex-post evaluation methodologies;
- Qualitative impacts: innovative content, consumer participation and satisfaction.

This study concluded that there is not a recommended model or specific type of successful program that meets the energy needs of low-income families. Good programs were conceived and were successful under different regulatory and legislative contexts, and with different institutions and end uses. However, the study points out a list of the most common features between the 18 selected low-income energy programs. Among these features, considering those with the higher adherence and application to the Brazilian conditions, we highlight the following:

- Programs developed through partnerships or in collaboration with social service agencies and community representatives;
- Community service agencies which are directly responsible for the program's implementation;
- Programs which are conceived taking into account clear evaluation methodologies (of impact and of process) and results monitoring;
- Programs aiming to improve home energy efficiency as a whole instead of a single end use;
- Consumer education as an integral part of the program;
- Programs' information materials are also distributed amongst the neighboring population (not necessarily low-income), increasing dissemination of information and free riders;
- The cost effectiveness of programs is not the main objective and measure of success. Other indicators such as indoor health, safety and well-being of households are more relevant.

[8] ACEEE is the American Council for an Energy Efficient Economy (www.aceee.org).

3.3 The Utilities Programs

3.3.1 The ANEEL's Guidebook

The utilities programs must follow the instructions of the Energy Efficiency Program Guidebook (period 2005/2006) (ANEEL, 2005). ANEEL is the acronym for the National Electricity Regulator. Utilities must submit end-use energy efficiency programs for residential, industrial, commercial and public sectors.

Since the creation of regulatory measures to ensure mandatory investments in energy efficiency programs in 1998, investments have been made in programs for low-income families. Since 2005 it is mandatory that 50% of the resources allotted to energy efficiency programs must be invested in low-income programs (ANEEL 2005).

Low-income programs include the following activities: information on energy efficient use, upgrade of the existing dwelling's electrical installation, donation of energy efficient appliances, replacement of electric showers with solar heaters, and installation of solar heaters to supply pre-heated water to electric showers. It also allows specific educational efforts towards these communities.

The regulator has also approved in the past the use of the resources allocated to energy-efficiency projects to purchase meters and regularize the connection of low-income households to the grid.

3.3.2 Evaluation of utilities' programs

There hasn't been rigorous ex-post evaluation of the several programs managed by utilities. The low-income programs completed to date range from the legalization of consumers through the installation of meters and adequate electrical connection, to lamps and refrigerator replacement and educational programs (Pires 2006), but it is difficult to compile relevant data and results that can indicate best practices.

It is possible to notice, though, that some utilities already have important experience with this class of consumers and it would be important to gather recommendations about their best practices.

The experience of Eletropaulo, a distribution utility from the State of São Paulo, indicates that even when consumers are receiving subsidized tariffs there still exists a rate of unpaid bills, meaning that there is a need to introduce new payment and debt renegotiation schemes. Another fact is that often there are also informal commercial activities carried out in these households, which results in the household surpassing the energy consumption ceiling allowed to receive the subsidized tariff and, therefore, increasing the rate of unpaid bills. Of all low-income consumers served by Eletropaulo with unpaid bills, 30% receive the subsidized tariff and 70% do not (Cavaretti 2006).

Within the Brazilian Association of the Power Distribution Utilities (ABRADEE), considerations are been made reflecting the national experience with energy efficiency programs. Regarding low-income programs, there is a recommendation that these consumers should share the equipment costs related to the programs (Mascarenhas 2006).

4 Energy Consumption To Low-Income Families

4.1 The Low-income Population

About 37% of the Brazilian residential consumers are considered low-income consumers and receive subsidies amounting to around R$ 120 million per month. The proportion of low-income consumers is higher in the Brazilian Northeast and North regions, respectively 66% and 43% of their residential consumers.

There are almost 18 million consumers classified as low income in the country, of which 43% are concentrated in the Northeast region, followed by the Southeast (36%). Information on low income consumers by region is provided in Table 2.

Table 2: Number of low-income consumers by region (2005)

Region	Number of low-income consumers (*)	%
South	1,667,749	10%
Southeast	6,282,718	36%
Northeast	7,457,974	43%
North	1,108,841	6%
Center West	948,194	5%
Total	17,465,476	100%

Source: Souza 2005. Note: data for October 2005.

Data from PNAD-2004 also show that the income of more than 30% of the Brazilian households is less than two minimum wages - SM[9] (Table 3).

Table 3: Distribution of the households by income classes in % (2004)

Monthly income of households by class (1)	Brazil (2)	North (2)	Northeast	Southeast	South	Middle West
Up to 1 SM	*11.4*	*11.1*	*23.1*	*6.9*	*6.7*	*8.4*
More than 1 to 2 SM	*20.5*	*23.9*	*29.9*	*16.2*	*15.9*	*21.3*
More than 2 to 3 SM	15.7	17.9	16.9	14.9	14.9	16.8
More than 3 to 5 SM	20.4	21.3	13.4	22.6	24.2	21.7
More than 5 to 10 SM	17.1	14.9	8.4	20.4	22.3	16.9
More than 10 to 20 SM	7.8	6.1	3.4	9.7	10.0	7.8
More than 20 SM	3.7	2.6	1.9	4.6	4.0	5.1
Without income (3)	1.1	1.1	1.2	1.2	0.8	1.3
Non declared	2.4	1.1	1.8	3.6	1.1	0.7

Note: SM is the unit of monthly minimum wage. In 2006 1 SM= R$350. In italics are the income groups more likely to be included in the Social Tariff schemes, however as shown in section 4.2.1 the criteria used may include households with higher incomes.
Source: IBGE, *Diretoria de Pesquisas, Coordenação de Trabalho e Rendimento, Pesquisa Nacional por Amostra de Domicílios 2001- 2004*. (1) Excluding the income of people who are pensioner, domestic worker, or domestic worker's sibling. (2) Including the households whose residents got only allowances.

4.2 The Subsidy Scheme

4.2.1 The Low-Income Social Tariff[10]

The Low-Income Social Tariff is a benefit created by the Federal Government in 2002 which concedes energy tariff discounts to low-income families. The consumers that can be granted the Social Tariff should fulfill the following requirements:

[9] SM (Salário Mínimo) means "minimum wage" . In 2006 it has a value of R$ 350/month.
[10] It was created by Law n. 10.438, as of 26th April 2002, and by the Resolutions n. 246 (30 April 2002) and n. 485 (29 August 2002).

- All households supplied with monophase power supply whose average monthly consumption ranges between 0 – 80 kWh based on the previous 12 months, without exceeding 220 kWh more than one time within this period.
- All households supplied with monophase power supply whose average monthly consumption ranges between 80 – 220 kWh based on the previous 12 months, in addition to be registered in the National Unified Register for Social Programs of the Central Government, or benefiting from the programs School Bursary (*Bolsa Escola*) or Food Allowance.

Table 4 presents the discount levels for the low-income consumers. The consumption intervals range between utilities.

Table 4: Discounts for low-income consumers by residential tariff practiced by the local utility

Consumption group[1]	Discount
0-30 kWh	65%
31-100 kWh	40%
101 kWh - regional limit[2]	10%

Notes: [1] the consumption intervals range between utilities; [2] varies from 140 kWh to 220 kWh (ANEEL 2002b).

The criteria required to define a low-income consumer, relying heavily on consumption levels and connection type[11], often are not adequate and may include consumers with higher income also having monophase connections to the grid. Nevertheless, there is also a large part of the population that is, despite being clearly considered low income, unable to receive a benefit from the subsidized tariff because of their high consumption; this has resulted in high rates of unpaid bills, leading several utilities to study their behavior.

By the end of year 2006, the total subsidies in Brazil will amount to R$ 1.4 billion per year (USD $ 650 millions). From the available data, it is possible to notice an annual rising trend in paid subsidies (Table 5). The largest part of the subsidies are provided in the Northeast region, followed by the Southeast, reflecting the combination of the large number of low-income households (Table 5), their average consumption and the average residential tariff of each region (Table 6).

Table 5: Amount of subsidies for low-income consumers by region and total

Region	2004	2005	2006(*)
South	13%	12%	12%
Southeast	27%	27%	26%
Northeast	43%	44%	43%
North	4%	4%	4%
Center-West	13%	14%	15%
Total (R$ million)	1.126	1.307	1.400

Source: Abradee (2006). Note: Estimated to Dec/2006 from partial results, up to June/2006 (R$ 708 millions).

[11] There are 3 types of residential connections: monophase, biphase and triphase.

The national monthly average consumption of the consumer who gets the Social Tariff is 64 kWh and varies from 56 kWh in the Northeast Region to 73 kWh in the Center-West Region. It represents a monthly average expense of R$ 9.18, ranging from R$ 6.63 in the Northeast Region to R$ 10.43 in the Southeast Region, already taking into account the tariff differences between regions. Table 6 presents this information and it is possible to verify the regional Social Tariff variations and the subsidy costs, which are important parameters for the forthcoming cost benefit analysis.

The residential average tariff in Brazil is R$ 295.30/MWh while the low-income tariff is 48% lower (R$ 142.74). Hence, for each MWh consumed by a low-income consumer, a subsidy of R$ 152.56 is provided.

Table 6: Low-income electricity consumption and subsidies (Brazil and Regions)

	North Region	Northeast Region	Southeast Region	South Region	Middle West Region	Brazil
Residential Low-income Class – Total (C.U)	1,100,323	7,846,611	6,130,981	1,840,052	987,336	17,905,303
Residential Class (C.U)	2,532,880	11,916,784	22,932,206	7,264,859	3,424,032	48,070,761
% Low-income consumers	43%	66%	27%	25%	29%	37%
Total low-income consumption (MWh)	69.62	437.68	439.42	132.54	72.04	1,151.31
Low-income consumption (kWh/C.U)	63.3	55.8	71.7	72.0	73.0	64.3
Average tariff (R$/MWh)	302.88	255.20	306.10	292.23	295.83	295.30
Low-income Monthly expense (R$/C.U)	9.23	6.63	10.87	10.43	10.74	9.18
Low-income average tariff (R$/MWh)	145.89	118.86	151.70	144.84	147.19	142.74
Subsidy cost (R$/MWh)	156.99	136.34	154.40	147.39	148.65	152.56

Source: (Vidinich 2006)b and own elaboration. Notes: values referred to June/2006. C.U. = consumer units (number of residential consumers)

5 The Refrigerators And The Low-Income Household Consumption[12]

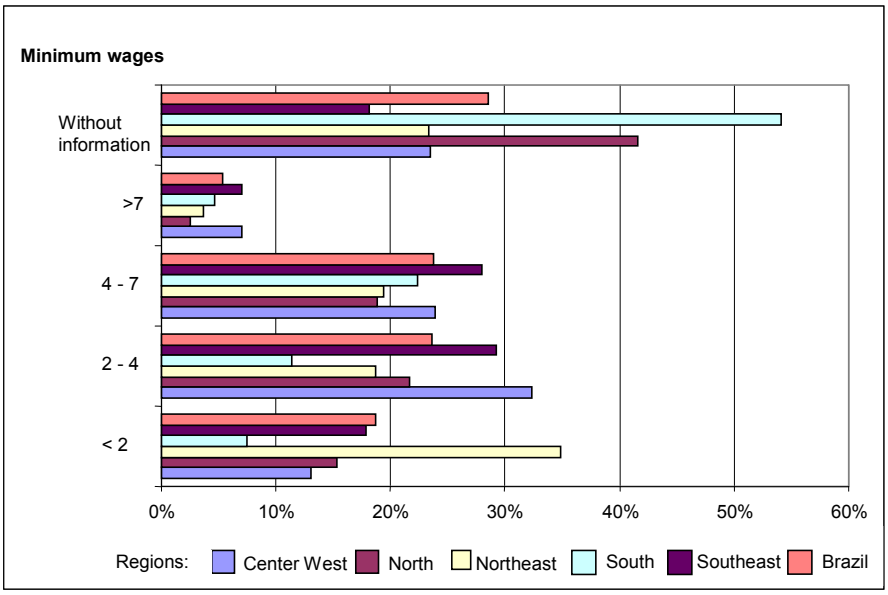
This report used the results of a country-wide field survey into household appliance ownership whose records were provided by ELETROBRÁS (Cordeiro 2006). For the present report, information was compiled related to household refrigerator ownership levels and refrigerator characteristics which were available from the survey. The survey

[12] Data for this section was processed by the graduate student C.A. Melo, University of Campinas from original survey raw data.

was conducted on a sample of 9,850 consumers selected from the Brazilian distribution utilities.

Figure 2 shows the distribution of consumers sampled by the survey according to regions and income. The percentage of consumers who did not provide information on their income is significant, especially in the South region. For the present analysis, information about appliance ownership and refrigerators features was tabulated by income class and it was assumed that most consumers who are granted subsidies earn less than 2 minimum wages.

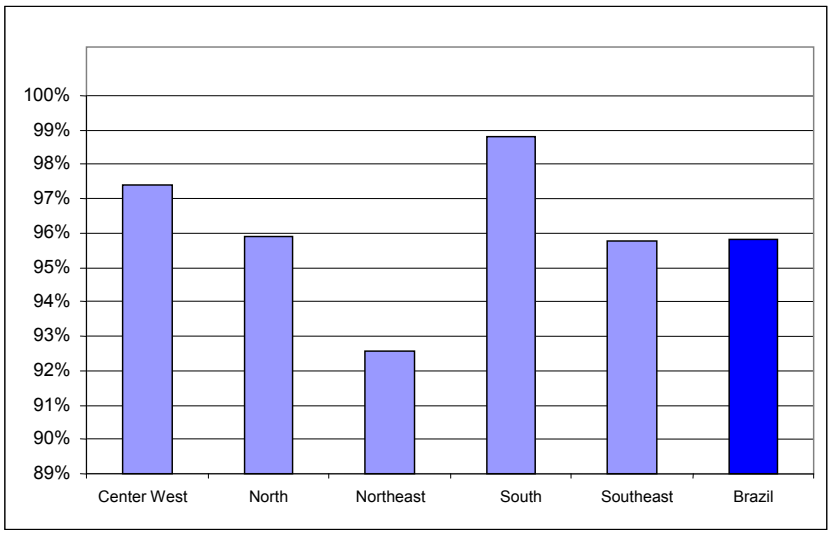
Figure 2: The distribution of residential consumers by income classes.



Source: Own elaboration from the Eletrobrás/PROCEL Survey (Cordeiro 2006).

About 96% of the Brazilian households have refrigerators (Figure 3). The Northeast region has the lowest ownership, but even so reaches 92%.

Figure 3: Saturation levels for residential refrigerators: Brazil and regions (% of electrified households)



Source: Own elaboration from the Survey Eletrobrás/PROCEL (Cordeiro 2006).

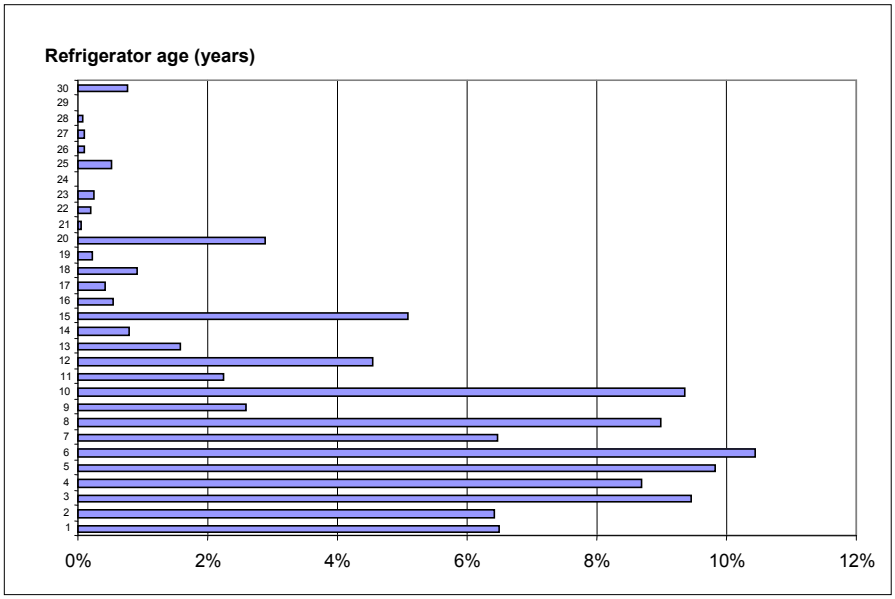
Around 30% of Brazilian refrigerators are more than 10 years old (Figure 4). Furthermore, the majority of the oldest refrigerators, as expected, belong to the lowest-income families, averaging 8 years old.

It was also possible to verify the most common refrigerator models in the surveyed regions. In the North and Northeast regions the model Consul 280 predominates; in the Southeast and Center West regions there is predominance of the model Brastemp 260 and in the South region, the model Brastemp 320. These are important inputs to carry out electricity consumption estimates. None of these models are grade-A labeled appliances.

The refrigerators' consumption was not measured by the survey, but other sources provide values which will be used in the next section for the substitution program cost-benefit analysis. Mascarenhas and Pinhel (2006) indicate an average consumption of 50 kWh/month. Fonseca (2006), through measures in 268 low-income households, presents an average of 167 kWh/month[13].

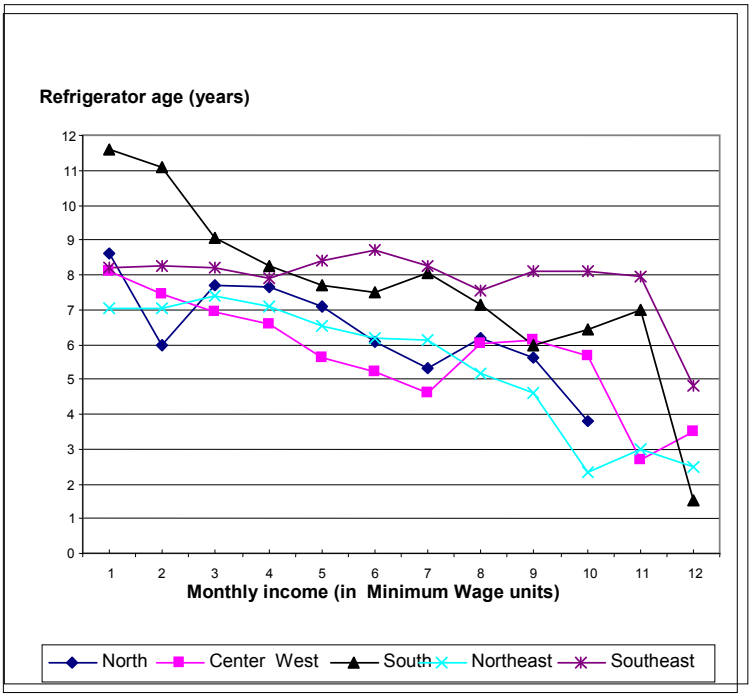
Figure 4: Refrigerators distribution in Brazil by their declared age (years)

[13] After a substitution program carried out by the utility CELPA, the average consumption dropped to 94 kWh, a reduction of 56%.



Source: Own elaboration from the Survey Eletrobrás/PROCEL (Cordeiro 2006).

Figure 5: Average refrigerator age by income class and region (in years)



Source: Own elaboration from the Survey Eletrobrás/PROCEL (Cordeiro 2006).

Table 7: Average refrigerator age by income class and region (in years)

Regions	Income (S.M)											
	1	2	3	4	5	6	7	8	9	10	11	12
North	8,58	5,99	7,69	7,63	7,11	6,07	5,34	6,17	5,60	3,80		
Center West	8,11	7,42	6,96	6,57	5,63	5,23	4,59	6,03	6,11	5,67	2,67	3,50
South	11,60	11,09	9,06	8,27	7,72	7,51	8,04	7,13	6,00	6,43	7,00	1,50
Northeast	7,03	7,04	7,38	7,10	6,54	6,20	6,11	5,18	4,62	2,33	3,00	2,50
Southeast	8,21	8,23	8,20	7,91	8,40	8,69	8,27	7,54	8,12	8,08	7,94	4,80

Source: Own elaboration from the Survey Eletrobrás/PROCEL (Cordeiro 2006). Note: S.M= minimum wage.

5.1 Parameters Influencing Consumption

It is important to know that, when designing a national program, the electricity consumption of refrigerators depends on some factors which may represent important variations. The most important, besides model and size, are related to outdoor temperature, age of the appliance and quality of power supply. All these parameters will influence the ultimate savings achieved from a replacement program and must be considered during the program design phase, in order to maximize the social benefits that arise from the efficiency savings.

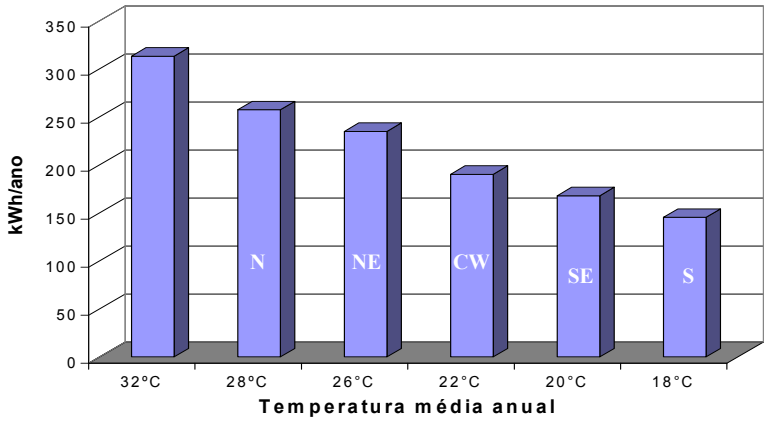
As already mentioned, the refrigerators owned by low-income households often are the oldest ones. According to information provided by the manufacturer Multibrás, the factors that reduce energy efficiency of refrigerators over time are:

- *Door seals* – from 5 years old onwards
- *Insulation* – from 5 years old onwards
- *Thermostat* –from 10 years old onwards
- *Compressor* –from 10 years old onwards

Until 5 years old, the energy efficiency of these appliances remains practically unaltered (Nogueira 2006).

The outdoor temperature in the regions also varies (Figure 6). For a 4°C variation, the energy consumption varies almost 20% (Nogueira 2006).

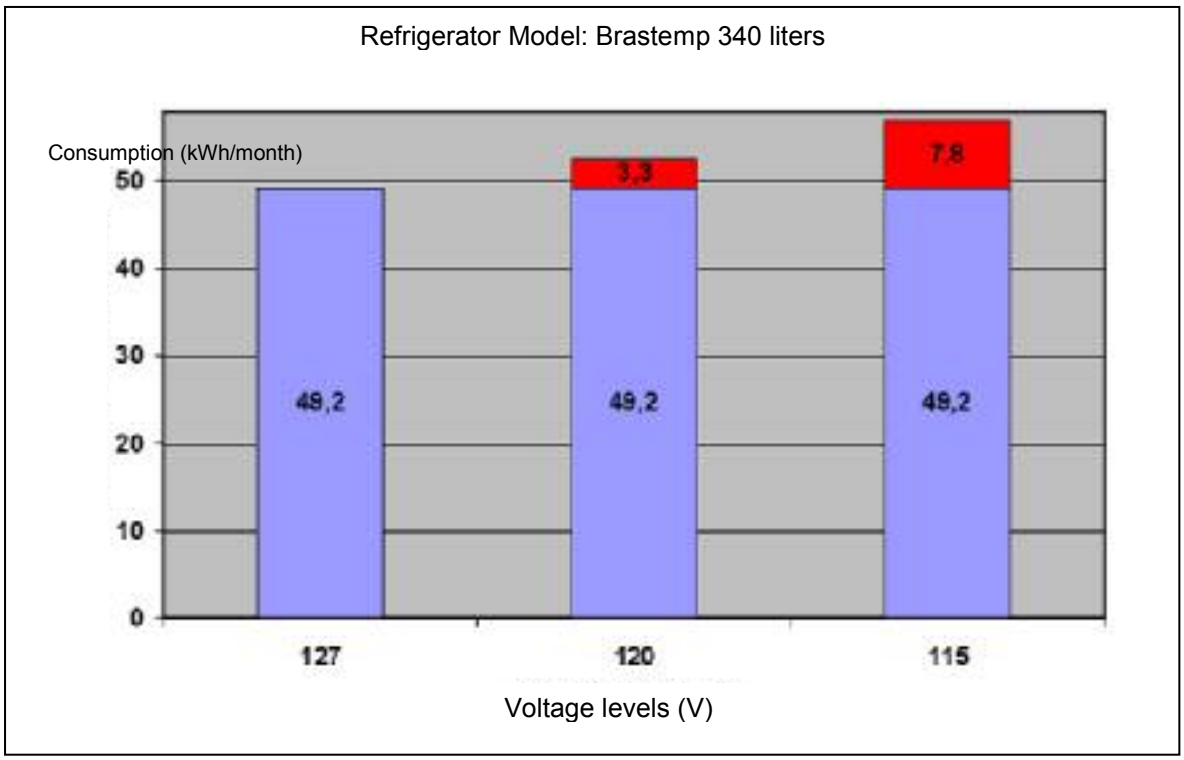
Figure 6: Regional average temperature and its effects on refrigeration consumption



Source: Nogueira 2006. Note: The laboratory test procedures for electricity consumption are done at 32°C.

Another important factor regarding energy consumption is the low-income household's electrical installation, where the supply of power may be at a voltage level significantly lower than the projected one (127 or 220 V). This effect can be observed from Figure 7. For a 9% reduction on the nominal voltage of 127V, the refrigerator's consumption rises almost 16%.

Figure 7: Measured results: the influence of voltage levels on the electricity consumption of refrigerators



Source: Carmeis 2002.

This information is relevant with regard to efforts to improve/upgrade the customer electricity installations in order to ensure optimal conditions for appliance operation and lifetime.

Table 8 provides a summary of information on energy consumption, refrigerator penetration rates and other usage patterns by region.

Table 8: Summary of the main regional information

	N	NE	S	SE	CO	Brasil
General characteristics						
Annual average temperature (degrees Celsius)	25.1	24.7	18	22.2	23.3	22.7
Number of consumers (million)	10.02	48.50	30.36	85.72	13.89	188.49
Number of households (million)	2.71	13.11	8.20	23.17	3.75	50.94
Average Consumption (kWh/Month/household) – Low Income	63.3	55.8	71.7	72.0	73.0	64.3
Average Residential expenses (R$/month/household) – Low income	9.23	6.63	10.87	10.43	10.74	9.18
Low-income population						
Low income population (as % of total) <2 SM	26.25%	45.50%	16.21%	17.88%	17.12%	
Number of consumers (million)	2.63	22.07	4.92	15.33	2.38	47.33
Number of households (million)	0.71	5.96	1.33	4.14	0.64	12,78
Refrigerators						
Refrigerator penetration	95.92%	92.55%	98.81%	95.77%	97.42%	95.83%
Number of refrigerators (million) Total	2.60	12.13	8.11	22.19	3.66	48.82
Number of refrigerators (million) owned by low income households (<2 SM)	0.68	5.52	1.31	3.97	0.63	
Average life (years)	8	7	11	8	8	8.4
Predominant model	Consul 240	Consul 240	Brastemp 320	Brastemp 260	Brastemp 260	

6 Refrigerator Replacement Analysis

6.1 Methodology

In this section a methodology is developed to analyze the costs and benefits of a refrigerator substitution program.

This type of analysis seeks to determine the economic impacts of promoting a reduction in electricity consumption through more energy efficient refrigerators as well as reducing the subsidies granted to low-income consumers. The major relevant parameters for this type of analysis are: program costs, electricity reduction per replacement, equipment lifetime, residential tariff, subsidized tariff and rate of return used to discount future cash flows.

After a substitution program, low-income consumers are concerned to know if their energy bills will be the more than before the program. Thus it is necessary to investigate the impacts of withdrawing subsidies together with the appliance replacement as well as the possibility of consumer participation in the program costs.

In this analysis, it also is necessary to verify the economic impacts on the utilities, which are currently being paid compensation for charging a lower tariff for low-income consumers, once less electricity is sold to these consumers. Hence, it is necessary to evaluate if this revenue reduction will be offset by the regular residential tariff.

The third evaluation perspective undertaken by this report refers to a "societal perspective", representing all electricity consumers who provide subsidies to low-income tariffs. This perspective compares the cost of promoting energy efficiency with the cost of subsidizing low income consumers.

The following section presents the equations conceived to represent the different evaluation perspectives.

6.1.1 The Consumer's Perspective

From the consumer' standpoint, the analysis is used to determine the impact of the new refrigerator on the consumer's electricity bill considering the absence of the subsidies. The eventual consumer participation in the program costs is considered to verify how this would affect the cost/benefit result of the program.

The cost of each kWh saved by the refrigerator replacement ($\underline{CCE}_{cons}$) represents the annualized capital cost[14] plus the change in monthly electricity consumption expense of the appliance

$$CCE_{cons} = \frac{\%_{cons} * CC + (kWh_n * T - kWh_a * TS)}{\Delta kWh}$$

Where

$\underline{\%}_{cons}$ is the percentage of consumer participation in the annual capital cost of the new refrigerator (or the program cost; this value would represent the annual installment of the financed refrigerator to the consumer); $\underline{CC}$ is the annual refrigerator cost discounted over its lifetime; $\underline{kWh}$ is the annual appliance electricity consumption, where $\underline{a}$= old refrigerator and $\underline{n}$= new refrigerator; $\underline{T}$ is the residential tariff without subsidies and $\underline{TS}$ is the subsidized residential tariff; ΔkWh is the electricity savings, as calculated by $kWh_n - kWh_a$.

The criterion to analyze the consumer cost-benefits is given by:

$$RCB_{cons} = \frac{CCE_{cons}}{TS} \langle 1$$

If the relation (RCB = cost/benefit ratio) above (as in all of the analyses presented here) is less than 1, the program benefits the consumer (is cost-effective).

6.1.2 The Utility's Perspective

The utility may incur a revenue reduction due to both the reduced consumption of the new refrigerator and the subsidies withdrawal[15]. The utility could participate, or not, in the program investments and the cost/benefit ratio is evaluated by the following equation:

---

[14] Different consumer participations to buy the new refrigerator are analyzed, from donation to complete buy.

[15] In fact, this reduction in the electricity consumption can be compensated by the commercialization of this amount to other markets. There are also other benefits, such as possibly prolonging the lifetime of the distribution equipment. These effects are not taken into account at the moment and require more specific information from each utility.

$$CCE_{concess} = \frac{\% * CC + (kWh_n - kWh_a) * T}{\Delta kWh}$$

The favorable cost-benefit ratio for the utility in this case is given by:

$$RCB_{concess} = \frac{CCE_{concess}}{T} \langle 1$$

6.1.3 The Society's Perspective

This case evaluates the situation when subsidies are used to pay the refrigerator substitution program. From society's standpoint, the transaction costs between the consumers and the utility are not accounted. The intent is to analyze investments made over the lifetime of the refrigerator in relation to the energy savings and the subsidy costs.

$$CCE_{soc} = \frac{\%_{soc} * CC}{\Delta kWh}$$

Considering S the subsidy cost (R$/kWh) which is used to cover the difference between the low-income tariff and the regular residential tariff, the favorable RCB criterion for society is:

$$RCB_{soc} = \frac{CCE_{soc}}{S} \langle 1$$

6.2 Results

As previously presented, some parameters were established (Table 9) in order to carry out an analysis that could serve as a reference for a cost-benefit evaluation for a refrigerator substitution program.

The analysis carried out based on such parameters (Table 9) is herein called the "base case." The base case illustrates the impacts of a refrigerator replacement program and subsidies reduction. The last section presents a discussion of the possible impacts on the program by changing key parameters of the analysis: program cost, subsidy levels, total of energy saved and the refrigerator's energy efficiency.

Table 9: Values used to analyze the cost-benefit of a base (reference) case for a refrigerator replacement program

Parameter	Value used	Reference
Regular residential tariff	0.255 R$/kWh	Table 6 (NE)
Social Tariff (low income)	0.12 R$/kWh	Table 6 (NE)
Subsidy	0.135 R$/kWh	Table 6 (NE)
Income class	< 2 SM	Table 2 **and** Table 3
Monthly expenditure	R$ 8.00/consumer	Table 6 (NE)
Old refrigerator consumption	65 kWh/month	Based on (Mascarenhas and Pinhel 2006)
New refrigerator consumption	29 kWh/month	Based on (Fonseca 2006; INMETRO 2006; Mascarenhas and Pinhel 2006; Nogueira 2006)
Program cost	R$ 1,000/refrigerator and R$ 700/refrigerator	Based on (Mascarenhas and Pinhel 2006) e ELETROPAULO
Discount rate	From 5% to 20%	
Refrigerator lifetime	15 years	Based on (Carmeis 2002; Nogueira 2006)

6.2.1 The Low-Income Consumer's Perspective

Based on the base case data, if consumers receive the new refrigerator as a donation, they will have a direct benefit on their energy bills with a reduction of R$ 0.01/kWh, which means that their annual expenditures with the refrigerator decrease from R$ 93.60 to R$ 88.74 for a discount rate of 15%[16] and other values as of Table 9.

Table 10 shows estimates of consumer's participation levels in the program costs considering that the actual electricity costs won't change. It can be noticed that even removing the subsidies, which means that this consumer pays the full residential tariff, the consumption reduction (kWh) is enough to offset the effect of paying a higher tariff.

For a program average total cost of R$ 1,000.00/refrigerator and in the case of guaranteeing the same annual electricity expenditures as before the program and keeping the participation of the consumer in the investment, the consumer's share should be limited to 2.9% of the program cost for an annual discount rate of 15%, raising to 6.8% for a discount rate of 6%.

In other words, it is still possible to have the consumers participate in the cost of a program without increasing the household's current expenditures in relation to the inefficient appliance and with the subsidies.

Table 10: Participation levels of the low-income consumer in the program costs

		Average total cost of the program (R$/refrigerator)	
		R$ 1,000.00	**R$ 700.00**
Annual cost of the energy bill (R$/consumer)		R$ 93.60	R$ 93.60
Consumer's participation in the program costs (%) for:	Annual discount rate 15%	2.9%	4.1%
	Annual discount rate 6%	4.7%	6.8%

As a consequence of the current subsidy level practiced, which represents 53% of the residential tariff considered, information in Figure 8 indicates that it is necessary to guarantee a reduction of the new refrigerator's energy consumption by at least this

[16] The report used arbitrary rates of return of 15% and 6% per year which are, in general, mostly used by the power sector and public sector, respectively.

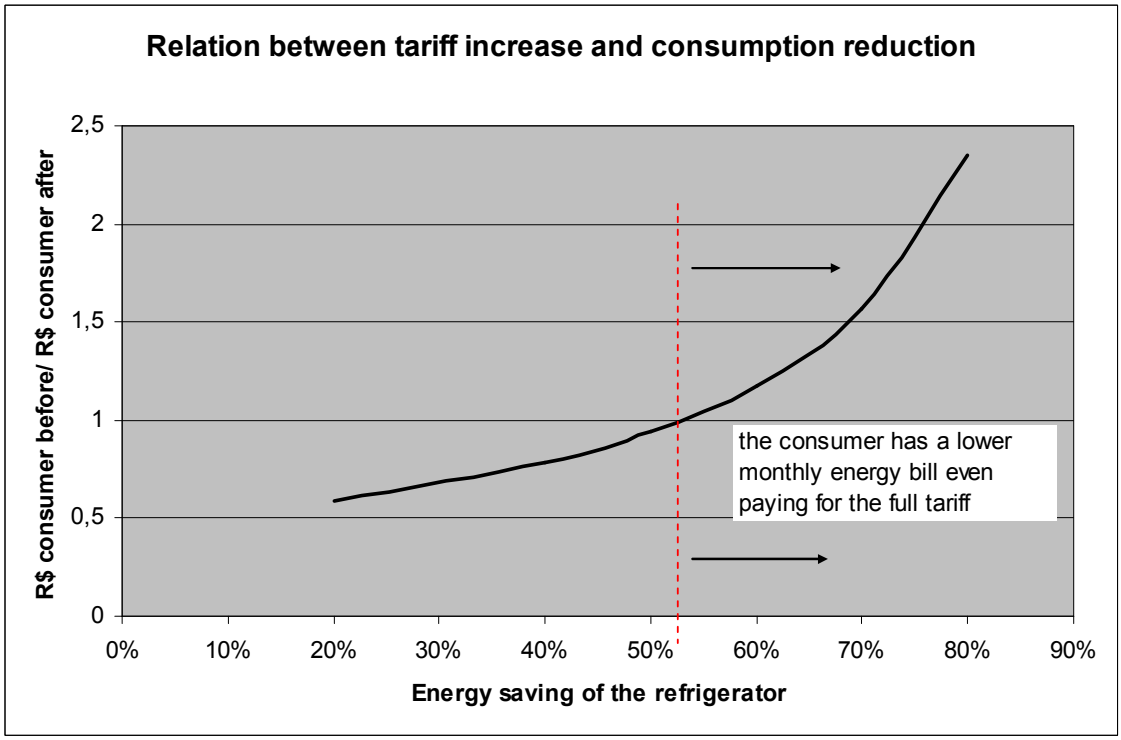
percentage in order to keep the same consumer's electricity expenditures when a tariff without subsidies is applied. The curve represents the relation given by the following equation:

$$R = \frac{R\$_a}{R\$_n} = \frac{kWh_a * TS}{kWh_n * T} = \frac{\frac{TS}{T}}{\frac{kWh_n}{kWh_a}}, which\_can\_be\_restated\_as \frac{\frac{TS}{T}}{1 - \frac{\Delta kWh}{kWh_a}}$$, where

$R\$_a$ represents the annual expenditures with the old refrigerator; $R\$_n$ the expenditures with the new refrigerator; TS is the subsidized tariff, T is the residential tariff without subsidies (full tariff); kWh_a is the annual energy consumption of the old refrigerator; kWh_n is the annual energy consumption of the new refrigerator; and ΔkWh the energy saved annually ($kWh_a - kWh_n$).

The figure illustrates the increasing marginal impact on the new energy bills as long as the refrigerator's energy efficiency is increased. This relation shows that by using even more energy efficient refrigerators, the impact on the consumers' energy bills will be proportionally higher.

Figure 8: Relationship between electricity expenditures by the old and new refrigerator and the energy consumption reduction



Notes: considering the base case from which the subsidy represents 53% of the residential tariff considered. The reduction of the refrigerator's consumption is given by the relation $\Delta kWh/kWh_a$.

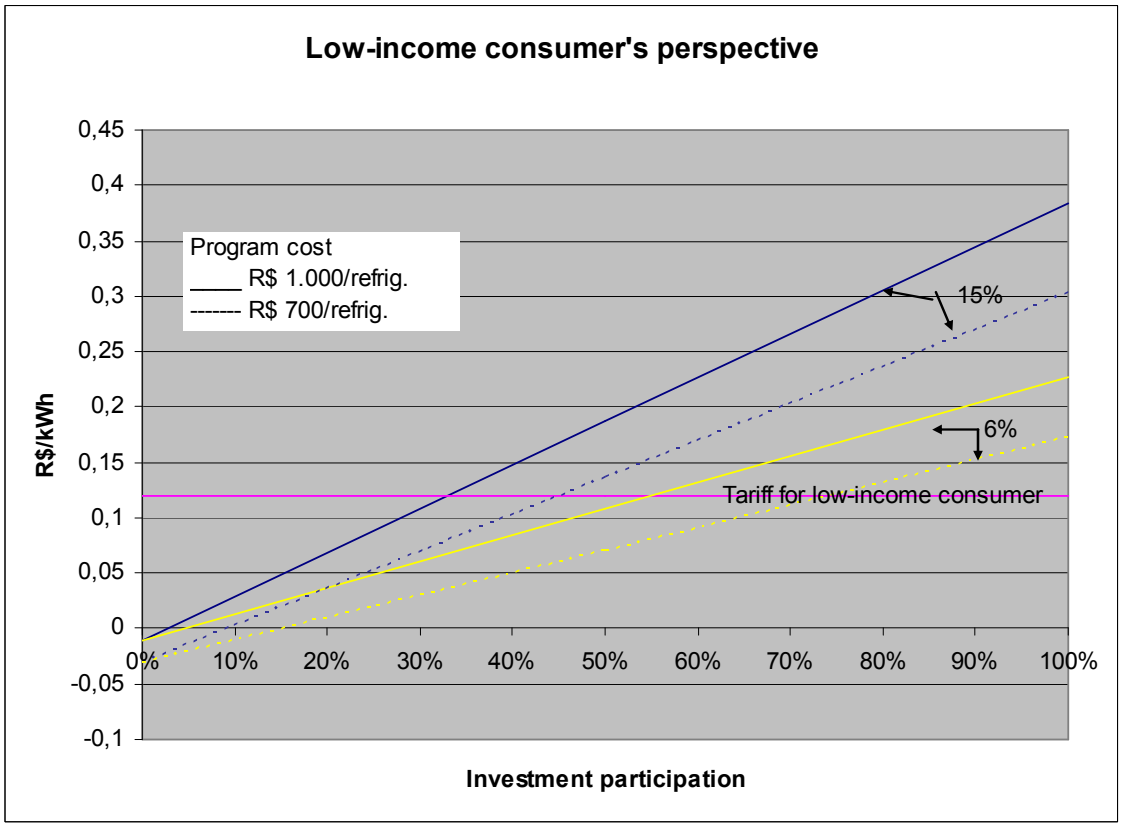
Figure 9 shows that, based on the data for the base case, it is possible to count on the consumers' participation in the program costs in as much as the energy saving costs do not exceed the subsidized tariff. We present the results considering the average program cost of R$ 1,000.00 and R$ 700.00[17]. Figure 9 shows a region where the costs of energy

[17] These are the values obtained for the COELBA and ELETROPAULO cases.

saving are lower than the tariff paid before the program (subsidized tariff). Depending on the discount rate used to evaluate the investment, the consumer's participation could reach 50%. It is possible to notice that reducing the overall program costs has a larger impact on reducing the cost of saved energy than increasing the consumer's participation in the program.

It is worth noting that the rates of return presented (15% and 6%) might not represent the rates compatible with the reality of such consumers because these rates are too low for them. In case a rate of return of 85% would be more adequate to represent their investment expectations, the consumers' participation in the program costs couldn't exceed 10% in order for the energy saving cost to remain lower than the subsidized tariff[18]. However, the values presented in Figure 9 can be used as a reference to possible funding schemes aimed at making low-income consumers' participation economically feasible assuming that the rates of 15% and 6% are similar to those used by the power sector and public sector, respectively.

Figure 9: Low-income consumer's perspective – costs and benefits of the program and investment participation



Notes: Energy saving cost estimates for annual discount rates of 15% and 6% and total program costs of R$ 1,000.00/refrigerator and R$ 700.00/refrigerator.

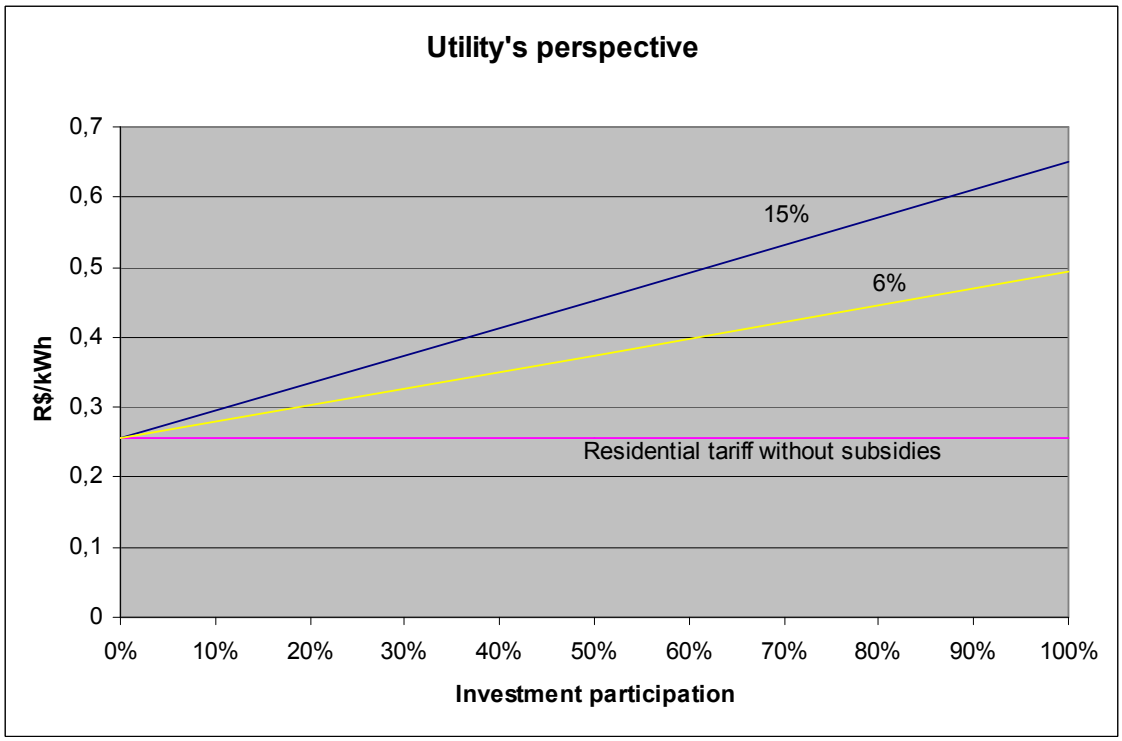
[18] As calculated previously, if the household's expenditure on electricity is to remain constant after the replacent and with the regular tariff, this would imply in a annual discount ratio higher than 100%.

6.2.2 The Utility's Perspective

Once the utility is compensated by ANEEL for the incurred costs with the low-income tariff, any investment from their own will imply energy saving costs higher than the regular tariffs paid by households (Figure 10).

The utility doesn't directly benefit from such programs in the subsidy scheme currently in force, unless other factors are considered, such as the reduction of unpaid bills by low-income consumers if their bills were reduced by the program.

Figure 10: Utility's perspective – costs and benefits of the program and investment participation



6.2.3 The Society's Perspective

As the subsidies are being paid by the other utility customers, the objective here is to verify the cost of saving one kWh compared to the subsidy provided.

Figure 11 shows that, assuming the costs and consumption reduction from the base case, it is necessary for consumers to participate in the program costs in order for the cost of the energy saved be lower than the subsidy.

The base case considers a consumption reduction of 55% for the new refrigerator (Table 9), which annually avoids the subsidy of R$ 58.32/replaced refrigerator. It represents a total of R$ 341.02 or R$ 566.42 for rates of return of 15% and 6%, respectively. These values refer to the most favorable case: average program cost of R$ 700/refrigerator (Table 11). Table 12 shows that the payback period of a program like this is still high, unless its costs are significantly reduced. Assuming a lifetime of 15 years, the program cost should be at least of R$ 700/replaced refrigerator (Table 12).

Table 11: Avoided subsidies (program cost - R$ 700/refrigerator)

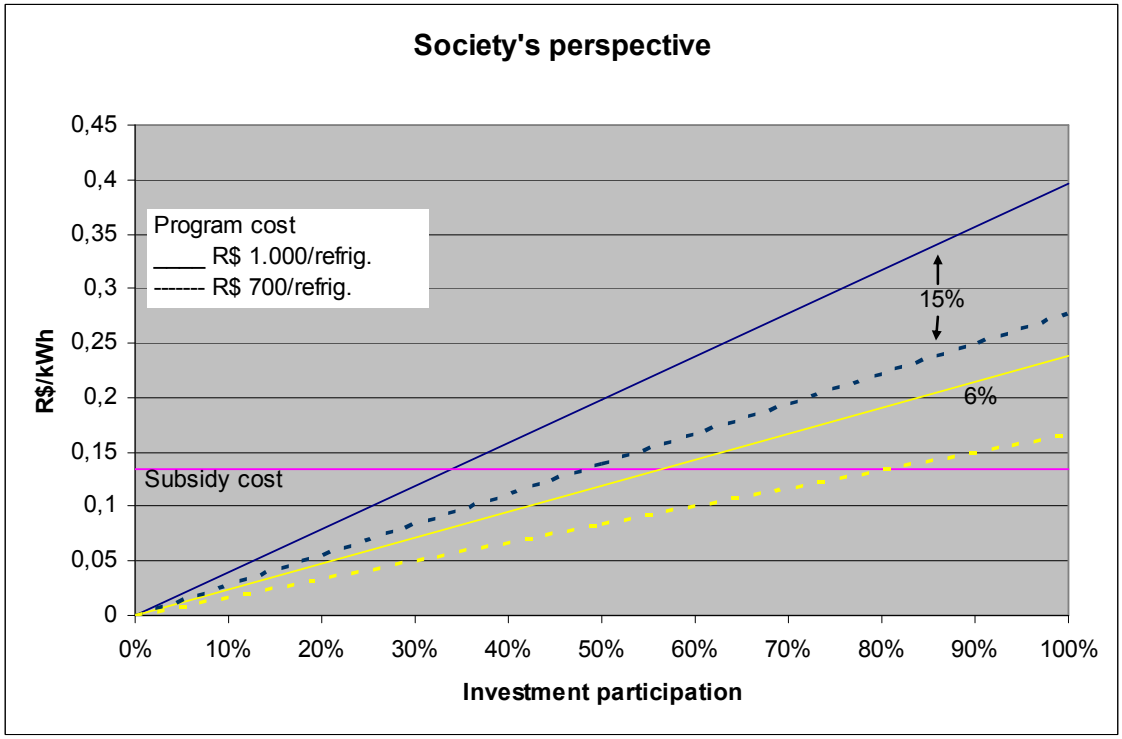
Consumption of the old refrigerator	65 kWh/month
Consumption of the new refrigerator	29 kWh/month
Subsidy	R$ 0.135/kWh
Annual avoided subsidies	R$ 58.32/refrigerator
Present value of the avoided subsidies over the refrigerator lifetime[a]	R$ 341.02/refrigerator * R$ 566.42/refrigerator **

Note: (a) lifetime of 15 years; * rate of 15% per year; ** rate of 6% per year.

Table 12: Payback of the substitution program and its cost

Program cost (R$/refrigerator)	Payback (years)
1000	17
700	12
600	10
300	5
200	3,4

Figure 11: Society's perspective – costs and benefits of the program and investment participation



Notes: Energy saving cost estimates for annual discount rates of 15% and 6% and total program costs of R$ 1.000,00/refrigerator and R$ 700,00/refrigerator.

6.2.4 Costs Of Replacing Lamps

Additionally, the economic benefits of promoting a lamp substitution program for low-income households were evaluated. A lamp substitution program is much more cost-

effective as can be seen by Figure 12. This figure compares the cost of saving 1 kWh with subsidies costs and residential tariff paid by the low income household, and shows the results both from the consumer and society's perspective.

The energy saving costs are lower than the Social Tariff, even when the consumer assumes the whole investment[19]. The same is verified when we consider the case of the cost of subsidizing 1 kWh and saving 1 kWh with a lamp replacement program: it costs less to society to promote the lamp replacement than to provide the subsidy, even if the society pays for all of the program.

The motivation to incorporate other opportunities to promote energy consumption reduction in energy efficiency programs can be found in the national and international experience. The low-income programs in the US recommend an integrated approach and the COELBA experience also points to this direction. Besides that, there is the possibility of improving the economic advantages of the investments either to the consumer or to society.

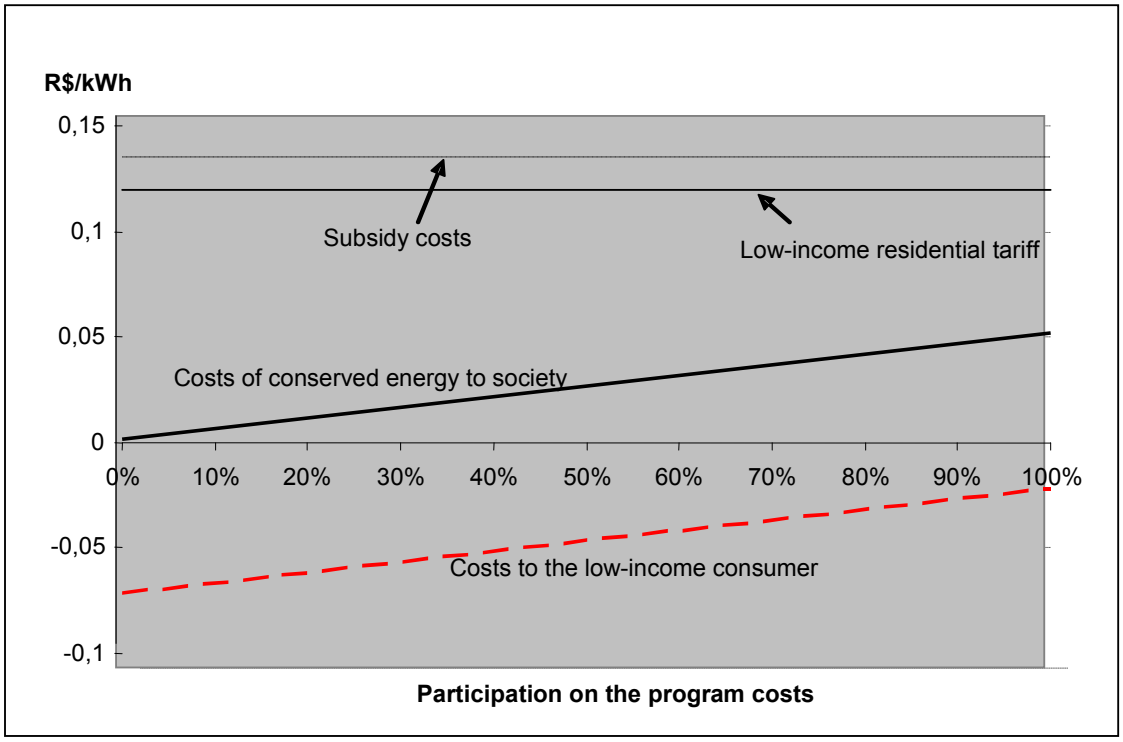


Figure 12: Costs of conserved electricity from a lamp replacement program

7 Conclusions

7.1 Energy efficiency programs for low-income household consumers

7.1.1 Strategy for subsidies removal/reduction

An energy efficiency program in Brazil that promotes the substitution of refrigerators might represent a significant contribution to a strategy to promote a gradual phasing out of low income electricity subsidies while minimizing the impacts of the increase of the tariffs for low-income consumers.

[19] It is clear that strategies should be taken into account to make the investment feasible for the consumer because the up-front cost of efficient lamps is a barrier.

The analysis presented in this report shows that with the current subsidy scheme in place representing 53% of the tariff (on average) and the possibility of reducing the refrigerator's energy consumption by this value (at least), it is possible to withdraw the subsidies without increasing energy expenditures of the low-income households provided with the social tariff. It is also possible to propose a small participation by the consumer in the program costs. Depending on the financing scheme to be offered to the consumer, this participation can be increased. Brazil has already several experiences with rebate and payment programs through energy bills (some especially directed to low-income households), pointing out that such schemes can be used effectively.

The cost-benefit evaluation from society's perspective does not support the conclusion that it is more favorable for society to bear all program costs and recover the investment over the equipment lifetime assuming the values of the base case. It is necessary to make efforts to reduce the costs of the program as well as to maximize the reduction of energy consumption, i.e. seeking households where this reduction is higher in order to produce positive results.

In order for society to bear the integral costs of such a program, the costs should be reduced to R$ 300-350/refrigerator (assuming a rate of return of 15%) or to R$ 500-520/refrigerator (for a 6% rate of return), keeping the remaining parameters constant, such as tariffs, subsidy level and energy saving for the base case.

Alternatively, a reduction of the subsidy level (instead of a complete elimination) is another strategy to pursue in combination with efforts to reduce program costs. A reduction of the subsidy level can increase the participation level of the consumer on the program costs.

Therefore, even if it is not possible to completely withdraw subsidies, a strategy of their gradual phasing out should be pursued as long as program costs are reduced and the energy saved are maximized.

7.1.2 The "whole-house" approach

A broader approach to promoting improvements for households can be found in the most successful international experience on low-income programs. Improvements in the electrical installation and the incorporating energy efficiency lighting programs into the overall efficiency effort can improve the overall cost-benefit of the investments in low-income energy efficiency programs. Hence, an integrated approach is recommended between the several possibilities of energy efficiency improvements for low-income households.

7.1.3 The utilities

Currently utilities are investing about R$ 190 millions in low income residential programs as part of their compulsory energy efficiency programs. Most of these funds are being used in lighting, refrigerators, installation upgrades and solar heating[20].

Is makes sense to use these funds in combination with a subsidy-removal strategy, since the capital is available and currently appliances are being donated to households.

Obviously this will meet some resistance from utilities as their compensation is withdrawn. Studies need to be undertaken and a broader perspective needs to be explored as these programs can also help reduce unpaid bills and utilities' commercial losses and therefore provide positive benefits to the utilities as well.

7.2 Refrigerators

Several reasons contribute to make refrigerators attractive appliances for an energy efficiency program, especially to low-income consumers in Brazil:

[20] Part of these funds are also being used by utilities to regularize informal connections as well as implementing energy efficiency measures in low income households.

1. High participation on the residential energy consumption;
2. High appliance dissemination among low-income households;
3. Most of them are more than 10 years old;
4. The energy consumption should be higher in such households due to the precarious electrical installations and consequently inadequate energy quality and voltage provision which reduce the performance of the appliance;
5. The largest percentage of the subsidies are provided to the North and Northeast regions, where the ambient temperatures are higher and therefore refrigerators consumption are higher;

Two regions stand out as the first candidates for a refrigerator-replacement program: Regions NE and N. The participation of refrigerator in total residential demand is 30% and 27% respectively (**Erro! Fonte de referência não encontrada.**) and these are the regions which receive the highest subsidy relative to the regular residential tariff compared to the other regions[21].

7.3 Issues to be solved

7.3.1 Data

Reliable data about electricity consumption by refrigerators are still precarious. A large range of values was observed and this parameter highly influences the cost-benefit analyses such as the one developed here.

Also, as new low-income households, who are presently unmetered but consume electricity irregularly, are connected and entitled to receive the Social Tariff, more information will be needed on their appliances and usage patterns.

The information used by the report show that there are significant regional variations related to subsidy and tariff structures, refrigerator's model, its energy consumption and the energy saving possibilities. Consequently, it is likely that there are cost-benefit variations of the programs in the different regions and/or in utilities' concession areas. Those variations could yield different parameters for programs concerning the choice of participants, limits of subsidy level reduction or its complete withdrawal. More information on the regional opportunities may also lead to different program design, financing and participation rules for low-income households.

7.3.2 Program cost and financing

There are important aspects concerning the capital cost to finance this type of energy efficiency program. As previously shown, different rates of return produce important impacts on the program's cost-benefit analysis.

As the utilities are obliged to undertake low-income energy efficiency programs, it is highly important to coordinate such efforts among utilities in order to attain economies of scale and higher program management capacity and share information in order to achieve program cost reduction. This effort must be concomitantly followed by ANEEL which would gradually phase out the subsidies as appropriate. This process should be accompanied by information programs to consumers.

7.3.3 Integrated energy efficiency programs

The data gathered should estimate possible combinations between energy saving possibilities in order to increase the ability to reduce and eventually withdraw the subsidies.

[21] The subsidized tariff is 53% and 52% of the regular residential tariff for the NE and N regions respectively. For the other regions this share is 50%.

The electricity consumption and the lifetime of the appliances depend on the quality of energy service provided to the consumers who participate in the program. Without it, the reduction goals and the program's cost-benefit could be compromised. Thus, a refrigerator substitution program should analyze the quality of the households' electrical installations and include the costs of improvements when this is necessary.

Moreover, the combination of energy efficient programs should be analyzed, such as the lighting substitution effort suggested inthis report. A combination of efficiency improvements should improve the global cost-benefit of the energy efficiency program and make increase the possibility of removing energy subsidies. The possibility of including the substitution of electric showers by solar heaters in the South and Southeast regions also should be analyzed.

7.3.4 Recommendations to deepen the analyses and utility programs

The utilities' annual energy efficiency programs could contemplate pilot projects which should be similarly planned between them so that it would be possible to collect homogenous information from the different country regions. This effort would also support the creation of a multi-utility team that could share experiences and negotiate with suppliers. Thus, it is highly desirable to promote more cooperation and coordination amongst utilities' programs.

These pilot projects could reproduce the analysis presented by this report in order to evaluate new regional limits and subsidy levels which could be reduced according to the impacts provided by the energy efficiency programs in each region.

These pilot projects could be undertaken during a one-year period to provide information that would support a larger scale, nationwide program combined with development of a public policy to determine an effective strategy for removing or phasing out the current program of energy subsidies.

During these pilot projects it should be investigated if the existing refrigerator models are suitable to the needs of low-income households, or if a different model is more appropriate. Therefore collaboration with local refrigerator manufacturers should be sought as part of the process of designing a large scale program.

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