Analysis and Development of Sustainable Solutions for the Inclusion of Low-income Customers in the Electric Power Network

Jose Edimilson Canaes, Jose Aquiles Grimoni

***Abstract*—** The democratization of Brazil in the early 1990s set off a process of economic development and social inclusion, leading to the creation of a burgeoning middle class eager and able to purchase goods and services, including high-quality electric power. However, social stratification is not enough to address and define the behavior of these new customers. The diversity of behavior found in this new social group impacts the utilities companies' operations in terms of increased of non-technical losses. The culture of non-payment for public services elevates total losses to levels higher than 50%. The inclusion of this new middle class is fundamental to the reduction of the non-technical losses. To achieve this, the utility companies face a threefold challenge: (i) to fully include the group (in social, electrical and digital terms); (ii) to maintain them as regular customers in compliance with the contractual obligations implied in the electricity supply; and (iii) to educate them around energy efficiency. Unlike most developed countries, the energy efficiency programs in Brazil and in other developing countries seek to teach methods of rational use of energy mainly for new electricity customers. However, this is not a simple issue and one of the most difficult issues is creating sustainable energy efficiency programs to guarantee that new customers are able to pay for the amount of energy they use. Through the VI Energy Efficiency Program, created by Change through Digital Inclusion (CDI) for Light, a Brazilian Electricity Utility operating in Rio de Janeiro State, these new included customers can make savings upwards of 47kWh/month per customer, representing a 22% saving in energy.

***Index Terms*—** energy efficiency, energy inclusion, digital inclusion, reduction in non-technical losses, social inclusion.

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I. Introduction

Founded in 1995, Change through Digital Inclusion (CDI) uses technology as a medium to fight poverty, stimulate entrepreneurship and create a new generation of "change agents" (CANAES [8]). Through its 821 CDI Community Centers in Brazil and abroad (CDI operates in 13 countries including the UK and Jordan), the organization "transforms lives and strengthens low-income communities by empowering people with information and communication technology".

Most CDI Community Centers are located in low-income communities in both rural and urban areas. There are also centers in prisons, institutions for the physically or mentally disabled, indigenous and river-based communities, and juvenile detention centers. The centers offer ITC courses, employment programs and Internet Cyber Cafes for research, to use online government services or for business use. In 2008, CDI created for Light – Rio de Janeiro's utility company- a tailored educational program addressing the sustainable use of electricity. The program was implemented in CDI Community Centers in Rio de Janeiro, located in many of the city's poorest neighborhoods. The main goal of the Light Project, which was implemented from October 2009 to November 2010, was to develop solutions for the sustainable inclusion and formalization of non-paying users of the electricity network.

The creation of sustainable energy efficiency programs is, for most Brazilian utilities, a new experience. The traditionally programs are implemented in the form of short projects in each community. One of the most important issues is to perform actions to guarantee that new electrical energy customers have the ability to pay for their consumption, while maintaining a good quality of life and ensuring that their consumption is environmentally sustainable.

This paper presents the Light Energy Efficiency Project; lays out its contribution to scholarly and professional work; describes the main issues Brazilian utilities face in low-income communities and the methodology used by CDI to develop and implement the project; in addition to discussing the results obtained by the project.

II. Light Project

Light supplies electricity to around 6 million customers, while suffering from commercial losses of around 40% in low voltage distribution, a level which it desperately needs to decrease. The losses are mainly due to non-official connections to its networks and fraudulent practices in low-

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income areas, in particular in communities dominated by drug trafficking, where the government has only limited access.

Among several actions and solutions designed to address the problem, Light sponsors the development of projects related to the efficient use of energy in low-income communities. As with other Brazilian electrical utilities, Light uses the funds that it contributes to the National Electricity Regulatory Agency (ANEEL), to fund this kind of project.

The three objectives of Light Project were: (1) the regularization of informal customers; (2) to stimulate switches to more efficient electrical appliances, such as more modern refrigerators and fluorescent lights; and (3) the implementation of electric efficiency courses.

The third objective seeks to change the energy consumption patterns of low-income consumers, without negatively impacting their quality of life. All the objectives are designed to decrease Light's commercial losses; to help Light avoid buying extra quantities of energy, in excess of actual requirements; and to prevent Light investing in a distribution system based on the non-rational and unsustainable use of electricity by these low-income customers.

III. Contributions of the paper

The principle contribution of this paper is to demonstrate the potential for integrating sustainability and energy efficiency lessons into inclusion programs for new electricity customers, creating programs focused on empowering customers through digital inclusion and actions for integrating education and income generation.

Evaluations carried out during the Light Energy Efficiency Project demonstrate that there is great potential for integrating social actions with the technical activities of energy efficiency programs. The awareness of a society based on concepts of rights and duties can be created by empowering new customers with opportunities for social and economic integration. Such programs have the potential to definitively break the patterns of non-payment and, moreover, the continued social exclusion of this growing class.

IV. Social-Digital inclusion enabling Electrical Inclusion

CDI's educational programs are divided into seven activities designed to improve understanding of energy efficiency and to generate actions in the communities based on the concepts of citizenship, with a focus on the rights and duties of citizens in a democracy. The seven activities are:

1) Digital inclusion through informal courses where the topic of energy efficiency is discussed as a cross-cutting theme;
2) Community outreach through workshops, lectures, and training courses for managers;
3) Providing a space for online activities in the communities, where residents can research, access data on Internet and enter onto the online Energy Efficiency Portal;
4) Actions to increase employability and stimulate entrepreneurship;
5) The creation of an online Energy Efficiency Portal to enable communication and the dissemination of information on the issue;
6) Holding events on energy efficiency in the communities;
7) The creation and distribution of newsletters on energy efficiency.

Digital inclusion is well recognized as a key generator of social and economic development. According to the UN, the installation of an Internet access point leads to an average rise of 1% in the GNP of a previously unconnected area. Digital inclusion has the potential to generate social inclusion, increasing the compliance of electricity consumers by improving their economic stability through better jobs and entrepreneurship, while creating increased awareness and ability to fulfill their rights and duties as citizens.

In Brazil and particularly in Rio de Janeiro, full inclusion is normally attained when the new customer receives their electricity bill at their new home mail address, something largely unthinkable before the start of the ongoing pacification of the city's favelas. The pacification program was initiated in 2008 and signifies an important step forward in improving the socio-economic conditions of thousands of the city's poorest residents.

V. The culture of non-payment worsens default

Most of Brazil's electricity utilities endure high levels of default derived from the non-payment culture prevalent in major cities and even in rural areas. There are a variety of reasons that account for the existence and growth of the culture of non-payment in Brazil, which can vary from factors in other countries that also experience widespread non-payment of public utilities.

In South Africa the culture of non-payment flourished as a form of protest against apartheid and has continued since the end of the regime. This ongoing trend can in part be attributed to the continuing economic segregation of the country.

In Brazil and particularly in the city of Rio de Janeiro, non-payment in most instances is a result of non-official connections to the electricity network. Such illegal connections predominantly occur in low-income communities controlled by drug trafficking rings. In such areas a technical problem in the network takes on average 10 times longer to be repaired than the normal standards. These poor conditions encourage customers to find alternative sources of electricity supply; in other words, a non-official connection to the electricity network. In this sense, for the full inclusion (social, electrical and digital) of low-income consumers, in particular those living in areas formerly controlled by drug traffickers, programs must have a far larger scope than customer relations management, instead offering services that transform excluded people into citizens with full rights and responsibilities.

In addition, the cultural complexity of Brazilian society generates other incidences of non-payment. Inspections conducted by Brazilian electricity utilities identified that many residents of wealthy neighborhoods are employing

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various strategies to avoid paying electricity bills, from non-official connections to meter interference. According to these findings, non-payment behavior extends from the low-income communities dominated by drug dealers to the wealthy areas.

When addressing these issues in the favelas (slum areas) of Rio de Janeiro, it is important to note the changes brought on by the "pacification" process. This process entails the return of state-funded services to these historically neglected communities; such as policing, mail, electricity, water, public transport and garbage collection. In many cases the state had previously been unable to enter the areas due to their domination by drug gangs, before the installation of "Police Pacification Units".

For the electricity utilities the main challenges relating to these changes are (i) legalizing or/and regularizing the meters and networks; (2) eliminating the non-payment culture imbedded in these new customers through the installation of special fraud-prevention equipment developed by the energy industry; and (iii) educating residents on energy efficiency and implementing energy efficiency programs, in most cases funded through the regulatory contribution and the utility's own resources.

While most of the energy efficiency programs focus on customers at the base of the social pyramid, utilities often fail to understand the characteristics and needs of these new customers.

Furthermore, the actions taken as part of these programs usually lack sustainability, i.e. they lack the coordination, range and depth of implementation needed to maintain the synergies necessary to transform the behavior of these new customers.

VI. Electricity Losses

Total Losses of electrical power are the sum of "Technical" and "Commercial Losses". "Technical Losses" are the energy losses incurred in the transportation of electricity through the distributor's network, while "Commercial Losses" (or non-technical losses) is the remaining difference between the energy injected into the distributor network and energy supplied by means of this network (considered as the captive and free consumers):

Injected Energy - Energy Delivered - Free Consumption = Energy Losses in Distribution

Energy Losses in Distribution = Technical Losses + Commercial Losses

The injected energy is the reference for the calculation of the percentage of energy losses in distribution:

$$\textit{Energy Losses in Distribution (\%)} = \frac{Distribution\ Losses\ (MW)}{Injected\ Energy\ (MW)} \times 100\%$$

$$\text{Technical losses (\%)} = \frac{Technical\ Losses\ (MW)}{Injected\ Energy\ (MW)} \times 100\%$$

$$\textit{Commercial Losses (\%)} = \frac{Commercial\ Losses\ (MW)}{Injected\ Energy\ (MW)} \times 100\%$$

Energy Losses in Distribution (%) = Technical losses (%) +Commercial Losses (%)

Current regulations do not provide adequate incentives for carriers to simultaneously tackle the issue of adding new customers while maintaining the sustainability of these customers, who usually suffer from social and economic instability. Additionally, some goals to combat delinquency are unrealistic; combating the loss is not economically feasible when this cost exceeds the incremental revenue arising from the operation (ACENDE BRASIL [2]).

Studies by the Institute Ascende Brasil (IABRASIL, [5]) indicate that energy theft and non-payment of electricity bills generates losses of around US$4 billion a year in the country. Non-technical losses are also becoming a more important issue globally, given the trend for increased technical losses, predominantly in developing countries. Table 1 shows the result of a World Bank study on the issue:

TABLE 1:
THE LOSSES IN THE WORLD (GEOPOLITICAL AREAS)

Region	No. of countries	Losses in 1980	Losses in 2000	Variation
West Europe	17	7,71	7,56	-0,15
East Europe	24	9,68	18,18	+8,50
Africa	11	11,18	19,63	+8,45
NAFTA	3	9,67	9,38	-0,29
South America	9	15,50	21,68	+6,18
South Asia	5	25,20	27,55	+2,35
Southeast Asia	7	12,14	13,32	+1,18
East Asia, Australasia	6	8,67	7,65	-1,02
Global average		11,69	16,22	+4,54

Source: World Bank, 2003 (ARAUJO, SIQUEIRA [3]).

Figure 1 shows different types of energy frauds that AMPLA, a Brazilian electricity utility, detected in the cities of Niteroi and Sao Goncalo in the Rio de Janeiro state.

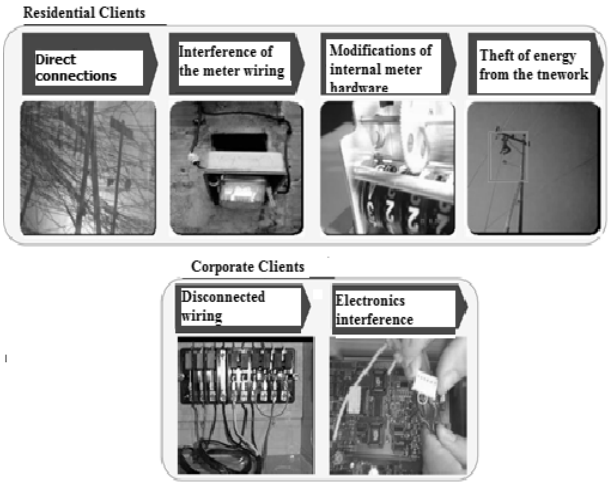

Figure 1: Types of energy frauds
Source: AMPLA [4]

VII. Ecosystem for the Inclusion of New Customers

The transformation of electric energy users into integrated and sustainable customers is a demand that goes beyond the purely technical and requires the involvement of other stakeholders (BENEVIDES, [1]). The stakeholders should take part in a set of actions for achieving sustainability, forming a network where the synergies of an integrated

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program improve the sustainability of the process of formalization and the integration of new customers. The correct identification of these stakeholders and with the right alignment of resources is a difficult issue for most energy utilities. The activities required to integrate these new customers should begin in poor and marginalized communities, pass through different stakeholders from investors but also partnerships with government and civil entities. Local NGOs are often in a strong position to carry out these actions, since they will normally benefit from an ongoing and positive relationship with the community and its leaders.

The creation of a sustainable energy efficiency program is new for most Brazilian utilities. It involves an innovative kind of joint-venture, between the companies themselves, organized communities, NGOs and the government. More than technical issues, the programs should address a wide range of services, advice and training that can generate the full inclusion of new customers.

In this sense, for the full inclusion (social, electrical and digital) of low-income consumers, many of whom living in areas formerly dominated by drugs and violence, it is important that the programs go well beyond the usual customer relations management project, instead looking to stimulate citizenship and an awareness of the rights and responsibilities of each individual in society.

VIII. Methodology

CDI methodology is designed to empower students with the tools they need to effect real changes in their lives and communities: Digital Literacy + Civic Education + Entrepreneurship. Most of the activities are conducted in CDI Community Centers, which are founded on three principles: that they are self-managed, that they are self-sustainable, and that they implement CDI's educational approach. This unique approach stipulates that by the end of each four-month course, students will have used technology as the main tool to initiate, plan, and implement a "social action project". The project will tackle an issue facing the students' lives or communities that has been collectively identified and decided on by the group.

The CDI Light programs seek to unite two areas; (i) technical training aimed at changing energy consumption behavior and, (ii) increased social awareness through the exploration of the environmental & social implications of the action and the consumer's relationship with the electricity company. The focus of this training is to stimulate positive behavior change and to improve relations between the supplier and its new customers.

The project has 3 pillars: (i) digital inclusion through digital literacy, (ii) formalization and actions to generate income through increased employability and entrepreneurship (iii) communication activities, including the development of an online energy efficiency platform where people can share best practices, seek advice etc. Figure 2 shows the three principles of the Project.

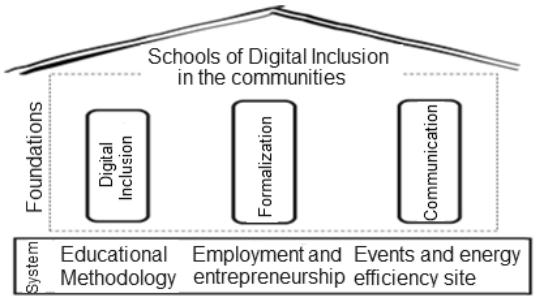

Figure 2: The three principles of the Project

IX. Discussion

The project reached 17,295 people through a variety of activities, including IT courses, film-showings and other events, all addressing the theme of energy efficiency. As a result of the program, there were over 205,000 accesses to the Internet in the CDI Community Centers, 384 people gained employment, 45 entrepreneurs received coaching and 3,367 people were referred for formal employment. The workshops reached communities in the process of pacification and regularization. In total, 99 events were held addressing the topic of energy efficiency, over 32,000 online newsletters were sent out and an online portal on energy efficiency was created: www.energiasocial.org.br .

An evaluation of 1,161 participants who took part in educational activities as part of the project showed that each student saved on average 47kWh per month after the course. The evaluation was based on 7% of all project participants. The Table 2 shows the total of the investment and the price of each kWh consumption avoided.

A second evaluation focused on the question of increasing the students' income level. This evaluation was conducted through interviews with 100 students from three centers. It found that 40% of them increased their earnings from US$ 576.00 to US$ 4,000.00 within a year of the project.

TABLE 2:
SUMMARY OF THE RESULTS OF CDI'S ENERGY EFFICIENCY PROGRAM

Item	Value
Investment	US$ 457,465.00
Number of participants	17.295
Cost per person	US$ 26.45
Energy per year saved per person	576 kWh
Energy cost per kWh avoided	US$ 0.044

X. Conclusions

The results of the program demonstrate that there is an opportunity to bring Energy Efficiency Programs closer to the consumer, to empower and inspire customers as citizens and thereby ensure the long-term sustainability of their inclusion.

Figure 3 illustrates this potential shift, moving the programs from rational or welfare models to more effective, sustainable models.

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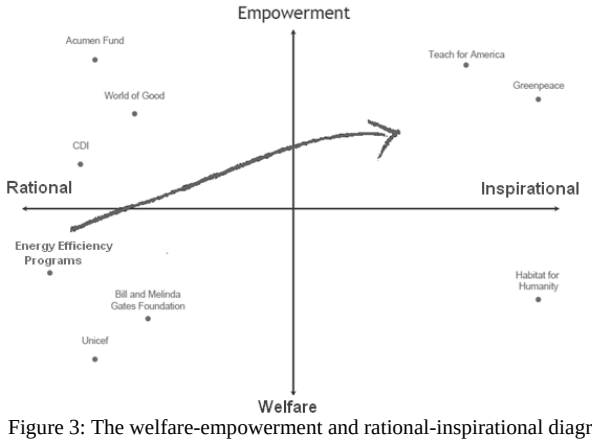

Figure 3: The welfare-empowerment and rational-inspirational diagram of citizenship
Source: CDI – Tatil [7]

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