PV COMES TO THE MAINSTREAM: 30.000 SHS INSTALLED BY UTILITY IN BRAZIL UNDER A NEW DISTRIBUTION PLANNING MODEL

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ABSTRACT: By the end of 2004, Brazilian Electric Energy Regulating Agency (ANEEL) had established norms for the use of Individual Electric Energy Generation Systems through Intermittent Sources (SIGFI), increasing the number of available technology options for the electrification of rural market. The resolution prescribes procedures and conditions under which solar photovoltaic, wind power or hybrid systems can be accepted by ANEEL under the National Rural Electrification Program. The regulation of the use of these systems fills a legal, institutional and managerial gap, made evident from surveys of existing projects and programs. Brazil has already around 50 thousand installed PV systems, used to serve rural consumers. Implemented as pilot projects and outside any regulatory framework, their maintenance having been delegated to local associations/users and NGO's without any guarantee of sustainability. Furthermore, regular use of these systems can reduce the total investment of the bold program of universal access undertaken for the Brazilian government, calculated in US$ 3.3 billion, whose goal is to eliminate the electric exclusion of the country. Universal access plan proposed by COELBA, Bahia's electricity utility, where there are more than 350 thousand non-electrified households, foresees the installation of 30.000 SHS, nearly 10% of the non-electrified total.
Keywords: Rural Electrification, PV Systems, Regulation.

1 INTRODUCTION

The Brazilian Congress and government's decision to promote universal access — through a combination of obligations to the existing, mostly private, distribution companies and a new public incentive program — was of great interest to infrastructure policymakers worldwide for a variety of reasons: (a) rural electrification is explicitly prioritized as a key element of Brazil's overall poverty alleviation strategy; (b) the emerging strategy focus on services and end uses, not just access; (c) overall sector revenues allow for the ambitious goal of universal service coverage in about five years; (d) existing electrification programs had to be adjusted to ensure efficiency and equity on the way to universal access; and (e) topology and demand patterns of remaining rural users require that decentralized service solutions be mainstreamed fast to minimize investment costs.

Following the restructuring of Brazilian electric sector, with split of utilities into generation, transmission and distribution companies, and a voluntary rural electrification program, with federal incentives, Congress approved the Law 10.438 in 2002, in which rural electrification has been characterized by ever-increasing change. The Law obliges all regulated distribution agents, either concessionaires or permissionaires[1], to provide full electricity coverage following specific schedules (defined in 2003 by the federal regulatory agency ANEEL), without financial contribution by the new consumers toward initial investment. The initial investments are to be recovered through tariffs (with social tariffs for low-income consumers). However, the competing policy goals covered by this law (rural access, power generation from alternative national resources, social tariffs and "emergency generation") have created uncertainties regarding the future availability of funding for electrification. By November 2003, new government has succeeded to have approved by new Congress a new Law – 10.762 – amending the previous one, in order to assure funds for anticipating deadlines defined by regulatory agency and to restrict the exemption of financial contribution to those new consumers with load up to 50 kW.

To reach the policy goal of universal electricity access, new solutions for the more challenging regions are being implemented overcoming a future time lag (and equity issues) once all the "low-hanging fruit" would have been picked and only the most difficult areas would be left behind. Already, connection costs under the previous Luz no Campo program for some of the more difficult user segments (such as "dispersed" households in Bahia with more than four poles per user) have risen beyond US$4,000 per household—well above international benchmarks and the Luz no Campo average (about US$950). In addition, lack of coordination among funding sources has sometimes prevented an efficient allocation of public funds in the past. The current institutional, regulatory, and financial frameworks for rural electrification have involved all DisCos, and some of them are incorporating decentralized options, particularly the recently regulated PV systems as an option of supply. That is the case of COELBA, in the state of Bahia.

2 THE NEW PARADIGM

Law 10.438, approved in 2002, was a key step in shaping the legal framework for future electrification efforts in Brazil. This law obliges concessionaires and permissionaires to provide "universal electricity service

coverage," without financial contribution by the new consumers toward initial investments (which are to be fully recovered through tariffs). However, the law was not a pure "rural electrification norm", as it covered a series of (competing) policy goals, namely rural access, power generation from alternative national resources (renewable energies, natural gas, and coal), social tariffs, and "emergency generation." This created some uncertainties regarding the future availability of sufficient funding for electrification. Based on the preliminary estimates, significant additional funding would be needed to achieve the ambitious mandated increase in electricity access - this key issue had to be resolved. This was overcome by Law 10.762, from November 2003, which assured enough funding either in the form of grants or soft loans.

Although Law 10.438 had included urban and peri-urban households, the main challenge was toward rural users. The immediate policy tasks at hand for a successful rural electrification strategy became pending from the implementation of this law, and the clarification of its implications. The National Board of Energy Policy (CNPE) created a committee to propose the main policy issues: volume of additional resources required, deadlines and tolerable impact in the national tariffs. On the other hand, the Regulatory Agency (ANEEL), based on this policy guidance, established operational rules, but appropriate quality standards for rural electrification (including new solutions for remote and dispersed users) were not made available.

The first step toward the implementation of Law 10.438 was the establishment of long-term obligation targets by ANEEL. For the least electrified areas, full coverage was mandated by 2015 at the latest. The relatively long-term targets were less ambitious then the deadlines that had been proposed by CNPE Committee and under discussion among some of the stakeholders, reflecting the somewhat unclear funding situation for the universal access mandate in 2003. These long-term targets could be anticipated if federal, state, and municipal governments allocated additional funds in a coherent and efficient way. With the new government installed in 2003, this was a primary objective of the new National Electrification Program. Law 10.762 overcomes difficulties of implementation left by previous mandate translating national energy sector priorities into concrete rules and incentive schemes.

The new Brazilian Rural Electrification Strategy solved a number of key challenges. The main challenges arouse from the fact that successful past rural electrification efforts (namely, Luz no Campo) have focused by and large on the "low hanging fruit" in the form of grid extension to densely populated areas in relatively better-off states. In contrast, serving the remaining users on the way toward universal electrification would become more and more challenging and would require new approaches suited to meet the different set-ups encountered in poorer states with weaker DisCos, still controlled by state or federal governments, and dispersed, remote, and low-income users. As mentioned before, regulatory agency established deadlines to a distant 2015, for less developed states.

Therefore, the new national electrification strategy developed by the government installed from 2003 have integrated two quite different approaches: (a) a scale-up of the successful Luz no Campo approach under a slightly improved framework, and (b) greater effort to demonstrate new solutions for the more difficult areas and the timely adoption of a market framework to allow for fast replication of these new solutions. Finding the right balance between those two approaches was challenging, but not impossible. Amazonian Region is still without an evident solution, but the rest of the Country has already alternatives to grid extension fully regulated. Well targeted demonstration projects for use of new technologies and subsequent flexible regulatory framework are key issues to accelerate rural electrification effort by more DisCos.

When the universalization program was launched, ANEEL has estimated the total required investment on the range of US$ 3 billion. This was a preliminary amount, which would be come more accurate with the operational plans to be submitted by DisCos, as even the precise figures of non-electrified population and their situation were not available.

Provided that universalization became an obligation, the mandate would imply in an impact in the financial and economic situation of those companies, and it would not be equally distributed. Most of non-connected population is in rural areas, and some states are clearly more urbanized than other, with different sizes and different profiles of consumption. Some DisCos cover areas in which more than 50% of their consumers are low-income consumers and the remaining population to be connected would increase those figures.

In order to solve this problem, Law 10.762 increased the volume of incentives to be allocated to rural electrification, from those collected from national levy on electricity consupmtion and reduced the number of new consumers which have not to contribute with connection fees. Those with installed capacity over 50 kW would have to contribute in the investment to be made by local DisCo.

On top of that, federal government created through a Presidential Decree[2] the Luz para Todos Program (Light for all), transforming a state program into a governmental program, with antecipated deadlines, access to grants and soft loans in a way to minimize increase of tariffs, keeping them as equal as possible and possibility of supply by grid, decentralized mini-grids or individual systems.

3 BRAZIL'S WAY TOWARDS UNIVERSAL ELECTRICITY ACCESS

Based on several analyses of existing barriers to rural electrification, a series of criteria were taken into consideration in the formulation of Brazil's new national electrification strategy, such as:

3.1 Prioritize policy goals

The first step toward any successful rural electrification effort at the national level is a clear definition of electrification priorities, and their place in the country's overall energy sector policy and rural development priorities. There are important tradeoffs between policy goals, and their prioritization has to be defined in advance to allow for efficient incentive structures and regulation—and to send clear and reliable signals to the private sector.

The main objective defined by the policy was to electrify rural areas [3] up to 2008, and this was part of a national policy to promote social inclusion. Other important elements of the program was the definition of priorities, promoting (a) increase of efficiency and equity; (b) increase of productivity, development of demand, and implementation of cross-sectoral synergies to increase development impact; and (c) mobilization of private participation with public incentives.

Another important issue is the series of criteria adopted to prioritize the areas to be electrified at the beginning of the program, including:

I. Projects in Municipalities with rates of electrification below 80%, according to data from Census 2000;
II. Projects benefiting populations affected by the construction of dams;
III. Projects which promote the productive use of electricity and local integrated development/
IV. Electrfication of rural schools, public shealth services and water supply;
V. Electrification of ressettlements of land reform program; and
VI. Projects promoting the development of family agriculture programs.

3.2 Secure funding

Providing electricity to Brazil's rural users would require an investment of about US$ 3 to 4 billion (depending on the success of cost reduction strategies and on policy decisions regarding rural service quality). As most remaining users cannot afford to pay the full cost of service through tariffs (typical willingness to pay for electricity in the remaining rural areas is under US$5 per month), investments could not be recovered directly through tariffs, and had to be subsidized.

The funds for Brazil's universalization efforts came from a partnership involving the distribution companies, national levy funds (Account to Energy Development – CDE and Global Reversion Reserve – RGR), and the state governments.

3.3 Complement and coordinate regulation and incentive schemes

Rewards and penalties had to be adjusted and complementary according to the mandate of legal framework established by Laws 10.438 and 10.762 and Presidential Decree 4.873. This adjustment, promoted by ANEEL, was in flux and went beyond the framework for rural electrification, as it was closely related to the overall power sector (mainly regarding the tariff setting for distribution companies).

3.4 Reduce costs - Introduce appropriate regulation to allow for low-cost solutions

Taking into account the volume of resources involved, it was crucial to achieve significant potential for cost reduction in light of the goal to reduce impacts on tariffs. The investment costs could clearly be reduced significantly by increasing the menu of technology options, and allowing for service levels adapted to rural demand.

Among the technology options listed by the Luz para Todos Program in order to achieve their objectives of universal coverage and optimization of public funds were low cost grids, decentralized generation systems and individual systems, particularly solar home systems (SHS) and wind home systems. However, the condition to the approval of decentralized systes is based on the requirement that the costs of the project (generation, local grid and O&M costs) per consumer unit be below of the costs of grid extension. Alternative technologies include:

- Micro and mini hydroelectric plants, including zero head plants;
- Small hydro plants;
- Small thermal plants based on diesel or biomass;
- Solar and wind systems;
- Hybrids systems.

3.5 Introduce appropriate regulation to allow for low-cost solutions.

A key step toward reducing service costs in rural areas is to introduce appropriate regulation. Flexible service standards can be implemented without signaling the creation of "second class" service, whenever they aim at meeting the real demand patterns of rural users. Flexible regulation can include more appropriate technical equipment specifications, service quality requirements (hours of daily operation, frequency and duration of outages), and reporting or billing requirements for rural users.

4 APPROPRIATE REGULATION TO ALLOW THE USE OF SOLAR HOME SYSTEMS BY DISTRIBUTION COMPANIES

The use of decentralized generation systems either mini-grid or individual systems, despite being listed in the Presidential Decree were not regulated by ANEEL, precluding concessionaires and permissionaires of including them as supply options to fulfill their mandates of providing full coverage. This situation was initially changed with the enactment of Normative Resolution 83/2004[4] by ANEEL, regulating the use of solar home systems. This Norm responded to an old demand of several stakeholders involved in rural electrification issue, particularly those which advocated the use of cleaner and environmentally friend technologies to replace diesel generation sets, so far, the unique alternative to grid considered by DisCos.

The following aspects synthesize the procedures adopted by the Resolution:

a) Electric power must be provided in alternate current, and voltage and frequency should be the same of that of the grid in the region. The power of the inverter is presented in Table 1, and is compatible to the daily/monthly amount of energy made available to the new consumers.

b) The supply system to be adopted must be in one of the classess presented in Table 1. There are five classes of supply reflecting the daily and monthly consumption, varying from 13 kWh/month to 80 kWh/month. The autonomy of at leat two days must be assured to any of

the classes of supply, even the concessionaire decides to adopt systems over 80 kWh/month. If the concessionaire decides to use systems with a monthly availability over 80 kWh/month , it must also provide an autonomy of at least two days. However, the Norm does not clarify the selection criteria for allocation one of the classes of supply to new consumers. It is not clear how the interaction between the new consumer and the concessionaire should happen. It risks of concessionaires always decide to allocate the smallest system to all consumers. Ideally, consumers should have the size of their systems chosen on their ability to pay the monthly tariff.

Table I: Classification and Availability of Electricity Provision through SHS

Classes	Daily Consumption (Wh/day)	Minimal Autonomy (days)	Minimal Power of Inverter (W)	Monthly Availability (kWh)
SIGFI13	435	2	250	13
SIGFI30	1000	2	500	30
SIGFI45	1500	2	700	45
SIGFI60	2000	2	1000	60
SIGFI80	2650	2	1250	80

c) Meters must be installed in consumer units whose monthly provision is above 30kWh/month. In these systems the billing must be based on effective measured energy. In the other cases, the billing will be based on the installed system.

d) There is a reliability index which limits the individual duration of outage, and will be used to assess the quality of service supply. No consumer can have his service interrupted for more than 216 hours in the month or 648 hours in a year. These figures are much more flexible than those required to the service provided by the grid.

e) Each new consumer has to sign a contract with the concessionaire. This contract establishes the conditions of the relation between him and the company.

The establishment of these rules has opened a window for concessionaires to include SHS as a real option in the fulfillment of the obligation to provide full coverage. Provided they have a deadline and limited funds for investment, SHS can be a cost-effective solution fully accepted by regulatory agency and governmental program, with more flexible requirements than those required to grid.

However, the same flexibility was not awarded to mini-grids yet. The supply to villages with higher loads, where individual systems are not very convenient, but, on the other side cannot be considered urban profiles yet, still have to be made under the same conditions required to grid extension. Clearly, these requirements of service quality and standards of provision are not necessary to the remote villages in the middle of Amazonian Region. Under these circumstances, concessionaires tend postpone the obligation to the end to their timeframe and basically make use of conventional diesel sets. Thus, diesel generation sets or hybrids systems using solar photovoltaic equipment, wind and diesel sets should also received a differentiated treatment when is the only option to villages.

The excess of regulation over grid extension which is extended to the service by mini-grids has resulted in informal service to certain remote areas, Local governments, NGO`s, cooperatives and associations provide service outside of any regulatory framework, outside of any standards of quality or reliability. This situation used to be the same when solar photovoltaic systems were installed by associations and local governments. Two important programs: PRODEEM, at National level, with more than 3,000 community systems and Produzir, in the state of Bahia, with more than 25,000 SHS, have presented very poor results with less than a third of systems in operation in less than four years of operation. Main problem was centered in the management of the systems without a clear responsible for maintenance or reposition of spare parts.

It is evident that a combination of mandatory supply, flexible regulation and freedom to the concessionaires to make their choices based on the most cost-effective alternatives, SHS and other renewable sources has an important role to play in any rural electrification program. Other conditions which help the dissemination is the knowledge lessons learned of previous projects, even they are not fully successful, and a minimal network of dealers and suppliers.

Several segments worried with the supply of energy to Amazonian Region have initiated the proposition of a new regulatory framework for off-grid rural electrification, to fill the current regulatory gap that makes private players reluctant to enter this market segment.

5 THE EXPERIENCE OF COELBA – DISCO FROM THE STATE OF BAHIA, IN BRAZIL

The state of Bahia has an area of more than 550,000 km^2, and more than 350,000 households without access to electricity. Around 133,000 new consumers were connected to the grid under the first rural electrification program – Luz no Campo, after the privatization of COELBA, disco which provide the service to the state. The state had a long tradition of use of SHS by a Poverty Alleviation Program, co-sponsored by the World Bank. These SHS were installed by local associations, providing very precarious service. A network of dealers and a couple of suppliers have been set up in the state.

With the mandate to provide full coverage, COELBA started to study supply options. A pilot project installed 3,000 SHS still outside any institutional framework. Once the new government has anticipated the deadline to 2008, and ANEEL regulated the use of SHS, COELBA started to consider it as a real alternative of supply. With the implementation of this framework, the utility had the instruments to include alternatives to grid extension.

Several operational arrangements were introduced by COELBA in order to incorporate SHS in its portfolio of supply options, particularly as regards the logistics to maintenance. Some modifications were also introduced in the conventional billing process adopted by the company. Training was also necessary to engineers and technical teams, however cultural restrictions still persist, particular among technicians responsible by maintenance.

At planning level, a methodology has been developed to allow the concessionaire to select the best strategy of supply, between conventional alternative of grid extension and the use of SHS. This methodology has

requested technical and economic parameter definitions which allow the comparison of the supply alternatives, including the construction of a database with geo-referenced information of existing grid and non-connected households, besides information on relief, hydro and solar resources, parks roads and environment, coupling data related to distance, dispersion, environment, etc. Additionally, based on former experience of company with pilot project previously mentioned, O&M costs were taken into account, despite being very preliminary. A software for the application of this methodology was developed and linked to geo-referenced distribution planning database of the company. Surveys on the performance of previous programs and its own pilot project were compiled under a R&D project with Universidade Salvador – UNIFACS. Similarly, an analysis of consumption profile of the new rural consumers incorporated over the last five years gave certain sensitiveness on the general number of potential users of SHS.

As a result of these studies, the Universalization Plan proposed by COELBA includes the installation of 30,000 SHS, representing more than a third of population presently not connected to the state grid.

An initial bid for the installation of 9,000 SHS was won by Kyocera company, which used to provide SHS to the Produzir Program, previous mentioned, and succedded to establish a network of dealers in the state. In this initial bid, COELBA has adopted only SIGFI 13 systems, as presented in Table 1, which represents the smallest size systems with a monthly output of 13 kWh.

After a preliminry compilation of data on recently electrified population, COELBA has opted to include other sizes of SIGFI systems in a second bid of another 9,000 SHS, also won by Kyocera. More precise studies will clarify the real size of the market which can be supplied by SHS and the range of number and size of the systems to be considered. Eventually, some hybrids systems can also be included in the final portfolio of options.

Thus, under the rationale of the more efficient use of investment funds, looking for minimizing the impact of universal coverage on the tariffs offered to its clients, COELBA is refining the stratification of its market searching to defining the limits of grid extension, the role to be played by SHS and finally the gray area, which can be supplied by mini-grids, in which PV systems can also play a role coupled with other alternatives such as wind and diesel systems.

6 CONCLUSIONS.

Brazil, with nearly 10 million of inhabitants without access to electric energy service has started the correction of this distortion with the enactment of Law 10.438 and the subsequent establishment of a legal and regulatory framework composed of amenment in previous law, presidential decree and normative resolution by regulatory agency.

The initial deadline to 2015 was antecipated to 2008 with the allocation of additional grants and soft loans and a partnership involving national funds, state governments and concessionaires. Funds were secured over a long period assuring the sustainability of the program. Priority was given to residential consumers in rural areas, provided urban can be considered low-hanging fruits, and easily incorporated into conventional expansion plans of concessionaires

The challenge of supply such a huge population in a relatively short period of time, and the possibility of adoption different forms of supply, with flexible standards of quality service opened space to concessionaires adopt non-conventional forms of supply, including SHS.

The establishment of a proper regulatory framework allowing to conecessionaires to use cost-effective alternatives, and fulfilling the mandate of full coverage is crucial in the inclusion of SHS among the portfolio of options to rural electrification.

This framework is not statical, a continuous process of improvement is in course. The individual systems are regulated but in certain regions the established limits are not totally suitable, mini-grids should still fulfill the same requirements of grids. A processs of constant public consultations and hearings allow different stakeholds to participate and contribute to final framework.

Thus, for the first time in Brazil, a rural electrification program implemented by concessionaires has included renewable alternatives sources of energy to the conventional use of grid extension and diesel generation.

All this legal and institutional framework has opened space for the distribution company of the state of Bahia to adopt the use of SHS in almost 10% of population to be supplied. This amount represents around 30.000 SHS, adding up nearly 3.5 MWp, if only the smallest systems – (SIGFI 13 or 13 kWh/month), however the trend is to incorporate systems of bigger size and hybrids systems, with a PV component.

A turning point to convince concessionaire, and even federal government, to adopt SHS was an analysis of the connection costs of the 18,000 more expensive consumers, which would add up US$ 190 million. On the other side the same consumers could be supplied with SHS at a cost of US$ 39 million, resulting in an economy of nearly US$ 151 million. This latter option will reduce the impact of universal coverage on the tariffs of the consumers of Bahia`s state, besides an economy in the total investment, which in the case of the concessionaire would be around US$ 30 million.

Another important element supporting the concessionaire`s decision was the evidence that 25% of its consumers, connected by previous rural electrification programs, have an average consuption under 15 kWh/month, while average consumption of these same consumers is around 45 kWh/month .

Despite all these evidences, new challenges still exist, including a proper regulation for mini-grids in order to diversify alternatives beyond the use of diesel generation systems, particularly creating conditions to implement hybrids systems and use of endogenuous biomass resources.

It is evident that every country has its own development strategies, but several of the steps taken by Brazil can clearly accelerate the supply of electricity to remoter areas by leapfrogging steps of more traditional strategies, and incorporating more cost-effective alternatives of supply.

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