Chapter 2

Smart Grid Implementation in Brazil Must Focus on Consumer Behavior and Markets, Regulation, and Energetic Mix Availability

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Additional information is available at the end of the chapter

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Abstract

In Brazil, although some critical components are already monitored, such as interface audit meters as well as large customers meters, the data analyses are not systematic nor in real time for all dealers. In the best of cases, when some kind of accounting science is applied to this information, this knowledge becomes sectored and used to support a business segment.

Therefore, sensing, metering, data presentation, and their systematic usage, including simulation environment, tests, business intelligence reports, and electricity quality, need a business (re)organization to go through this focus.

An evaluation of the Brazilian market was done, considering the up-to-date international experiences and running local pilots, specially built to demonstrate the domestic consumption, as a case studies, and the required evolution of systems and strategies to move on to this historical moment of development and reorganization of the energy market as well as the legislation/regulation. Metering possibilities are presented to improve smart grid implementation goals, recognizing customers' profiles, promoting innovative products and business.

Keywords: consumer, energy efficiency, energy planning, metering, smart grid

1. Introduction

The smart grid technologies present themselves as opportunities to create new energy business. All stakeholders must be involved with organizing, building, and upgrading the power grid in its aspects of quality, availability, infrastructure, standards, reliability, interconnectivity, and sustainability. It is necessary the awareness of supply-demand target, incomes, and a strongly understanding of clients. The governmental strategies must be clear, with regulatory and legislative initiatives to foster new business and protect the public interest. Consumers (as clients) must be heard, as they become active players in the energy market. As far as they develop a dynamic relationship with the operating power industry, new conditions and requirements need to be created in order to lead the strategic transformation inside and outside regional businesses.

Deals on new energy sources, new technologies, new possibilities of differentials service and prices have been studied. Around the world, incentives as well as the evolution of regulation rules have been seen as fundamental roles to maintain and to expand the power supply and demand-side management, with implications for a better relationship between client-consumers, dealers, and incomes/revenues on invested capital. It also has been important to relate and to rethink the affordability of the tariffs and energy delivery costs to clients.

The way worldwide smart grid solutions are interrelating with the energy sector, resulting in the enterprise transformation, is not working in the same way in Brazil energy sector organization. Regional and social improvement or adaptation are expected but current monopoly way to offer energy must be transformed into a client provider relationship, aggregating new products/services to the sector portfolio to start the (re)evolution. A national energy modernization planning must be established in the near future, pointing out renewable and distributed energy generation as services possibilities, and large-scale smart metering and home metering deployment as efficient tools to achieve information and energy consumption habits modification. Standardization and equipment appropriation (costly and technically) appropriated are expected soon.

Evolving energy business in Brazil does not appear in this analysis merely as a possibility but as fact to be accomplished and a business to be investigated. The governmental strategies must be clear, with regulatory and legislative initiatives to foster new business and protect the public interest, yet considering the climate and the unique energetic mix of the country. Questions related to investments and their profits should be answered according to the regional energy business, as well as the consumers' participation and obviously new legislation and market regulation. Services and products to be offered by the Brazilian energy dealers should evolve correspondingly in order to improve business and recognition as energy solution providers.

Consumers (as clients) must be heard, as they become active players in the energy market. As they develop a dynamic relationship with the operating power industry, new conditions and requirements need to be created. A level of commitment to an energy efficient and sustainable model will depend on a number of rearrangements at the Brazilian energy industry and country governmental guidelines, such as the adequacy structure of energy generation and delivery, regulation, and standardization reinforcement, and also the understanding of customers' needs and socio-cultural efforts to motivate the conscious use of energy.

In the following, some scenarios will be discussed, based on the up-to-date international experiences and running local pilots, especially built to demonstrate the domestic consumption, as a case studies. These implemented cases are presented in order to demonstrate the domestic consumer impact to the energy use as well as the required evolution of systems and strategies to move on to this historical moment of development and reorganization of the energy market as well as the legislation/regulation. The local energy industry should forecast strategies to evolve to this new market while been considered as an energy and services provider. Metering possibilities are presented herein to improve smart grid implementation goals. The Brazilian Regulator with the Governmental support must be in charge and promote the essential of smart grid directions to obtain the economic and social advantages as the rest of the world have been exercising.

2. Worldwide smart grid context as reference

Smart grid has a role on developing new business opportunities, as technically and strategically presents itself as the renewal of the world power industry. Its reflexes, mainly in emerging countries, where it should and can guarantee the presence of these countries as economic powers in the near future, or influence their tendencies toward development. Following this path of changes, one can find the structural and operating conditions for the evolution of the Brazilian power grids, forecasting possibilities and issues which reflect a different reality from those in European, American, and Japanese markets.

In this way, the knowledge of the structures, which guide the business, must be investigated and organized from the generation until the effective delivery of electricity to the customer/end user. This paper also sought to analyze a more effective participation of this new agent, the customer, who can also be a generator and active participant in the electric grid.

A wider offer, with the availability of associated resources/services, must go through a cultural change in relationships and new commitments, as well as being regulated and motivated by present public benefits associated to this new setting. A new perspective of regulating entities must be established in order to start the transformation process proposed by smart grid and to validate the transition of a network in obsolescence into a controlled, controllable, and guaranteed business space for all stakeholders.

The need for electricity, fuels, telecommunications, and/or water utilities to take part in this process reflects the concern with the possibilities and demands of this change, in a broad sense, involving both political and social movements. The necessary effective participation of water supply companies in the Brazilian market reflects the characteristics of the national electricity matrix based on hydroelectric generation. Different from Europe, USA, and Japan, gas companies are only now starting to take over their place in thermo-electrical generation in Brazil, with a differentiated representation in the process and on the influence over operational treaties.

The techno and operational smart grid moment in Brazil is based on proving the concept, adapting models. and testing these models to regional reality. Due to the large social and cultural diversity, the great territorial extent and the differentiated demand for energy by region, this adaptation is of utmost importance. This is necessary as both an opportunity and a challenge in the adhesion to the efficiency and updating of energy business structures. Offerings of new energy sources, new technologies, new service possibilities, and different pricing should be carefully studied. The structuring of incentives and the evolution of regulating devices are fundamental to the maintenance/broadening of the energy offering, and of commitment possibilities between client-customer, dealers,[1] and return on invested capital.

Many opportunities are presented by the characteristics of current electricity grids, whose energy delivery systems [1] are almost entirely mechanical, with a modest usage of sensors, minimal electronic communication and usually with no electronic control. Electricity companies, following the trend of other industries, must update themselves with the use of sensors, communication, and computational skills to expand the overall functionality of supplying electricity, controlling and through feedback, continuously self-adjusting.

This technological gap and apparent simplicity in presenting the evolution as a change to the digital environment can be translated, however, in a multitude of possibilities, broadened by the questionings of energy usage and climate change, poised from COP-16 [2]. COP-21 reinforced all the world efforts to the conscious energy generation and consumption. These possibilities bring along business variables that need to be researched, and mainly, dynamically integrated in the future business moment [3]: new energy sources and electricity generation, storage, transmission, distribution, electric cars, distributed resources, voltage distribution practices, consumption, demand, and end-user commitments, reliability, energy usage optimization, mitigation of environmental impact, and also energy industries assets management, controls and costs (return on investments). Other variables, with more subjective connotations than those presented at this moment, such as welfare user commitment and customer relationship must also be considered and listed to measure the general impact on the planning of changes.

It is expected that with Smart grid as an advanced system, there will be a productivity increased, with consequent repercussion in the electricity usage. At the same time, it is expected that smart grid will organize the backbone for implementing new technologies in the future. In Brazil and other countries under developing economies, this conscious positioning strategically assures the guarantee of necessary energy conditions for future growth that they have been preparing themselves.

Some actions and samples are presented herein on the implementation of smart grids from projects and results of actions to promote grids development and business intelligence. Certain interest points are highlighted and should be used as reference for a Brazilian new electricity business modeling:

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[1] In Brazil, the energy business has been regulated ever since 1995 (Concessions Act – Law # 8987 from February 13th, 1995), with the market being formatted through the concession to private consortia for exploiting the market of either in electricity generation, transmission and distribution/trading. Some Brazilian regions are still served by government electricity companies due to regional low performance operation situations, which so far have made it impossible for them to be privatized. In December 1996, Law #9427 created Agência Nacional de Energia Elétrica (ANEEL) as regulatory agency for the sector.

- United Kingdom: the British structure to customer choice, with implementation of intelligence for the electricity offering as a free market (where the customer could elect its energy supplier), places England one step ahead in the restructuring of the energy business [4]. Their energetic mix, the conception of sensing into their grids, their customer care and services associated offerings, yield an apparatus that should allow, without traumas, the (re)evolution of their electricity services and transition to Smart grid. They are still discussing the customer data organization. Consumers will expect to have a choice of tools for viewing and managing home energy use. In the English model, the cost and acquisition of meters are customer responsibility;
- Japan: the country has a well-designed plan, which is being applied, for the efficiency of equipment, appliances, household gadgets, buildings, transport, and industrial production, with established targets and regulations [5, 6];
- United States: there were several test fields for the Smart grid concepts and definitive installation, and these must be evaluated in their achievements and as learning centers. Traditional and emerging forms of electricity on site generation had evaluated in some residences and verified the efficiency of this type of grid improvement [7];
- European Community: several projects have been implemented, as tests and even in national levels [8].

As presented, the consumption and growth environment needs to be understood to improve the grid and the customer relationship. Considering the grids digitization heralded by smart grid, sensing and metering represent a substantial possibility of significant change in the relationship between the distributor and the consumer, capable of assembling demand management mechanisms. However, it means an investment of high figures considering the amount of consumers that shall be assisted. These sensors/meters must be integrated through a close to real-time communication system. Data must be managed through a fast simulation system and computational modeling capacity, being presented in order to empower both operators and managers.

At this point, it is necessary to prove the concept, adapt models, and test these models to the regional reality. The structuring of incentives and the evolution of regulating devices are fundamental to the maintenance/broadening of the energy offering, and of commitment possibilities between client-customer, dealers[2] and return on invested capital.

3. Overview of functional structure of a smart grid operation

Considering the current stage of technology at the electricity companies, mainly in Brazil, from the basic concept of its distribution grids up to the operational organization of its business

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through billing, many changes, systems, and cultural transformations that smart grid concepts should improve and smart metering will be the vehicle. Smart metering needs a smart telecommunication and data infrastructure to be useful as innovative business solution and could improve products and services offering. This paradigm of consumer recognition, privacy information security, and market (profits) possibilities will evolve. Anyway, functionalities and commitments are highlighted, which can be grouped as:

Visualization of real time energy system: the grid sensing (metering) is a relevant item for the electricity system, broadening the knowledge over the grid and supporting critical components operation. These sensors must be integrated through a real-time communication system. Data must be managed through a fast simulation system and computational modeling capacity, being presented in order to empower both operators and managers and improving grid self-healing.

Sensing, data presentation, their systematic usage, simulation environment, tests, business intelligence reports, as well as electricity quality need a business (re)organization to go through a well-defined focus. Directly, it implies in structural changes, investments, operational commitments in the scope of current routines, which are falling into obsolescence. In the Brazilian reality, this can also imply business possibilities, such as the creation of bundled services as well as an electricity offering based on seasonal or real time prices. This last topic will need a new organization on tariffs regulation.

In Brazil, although some critical components are already monitored, such as interface and audit meters as well as large customers meters, the data analyses are not systematic nor in real time for all dealers. In the best of cases, when some kind of accounting science is applied to this information, this knowledge becomes sectored and used to support a business segment (such as, loyalty of free (large) customers, those who can chose the structure of its supply, due to its high consumption).

In general, for the domestic customers in Brazil, there is no detailed information collected on the daily electricity consumption and their consequent analyses. Moreover, there is no specialization in the usage of such a piece of information and the knowledge gathered from it.

Broadening this monitoring and keeping the current Brazilian business model, with the registration of only monthly measurements, will incur in costs. For positive accountancy results, the large volume of information generated must be organized into a systematic, automated system, signaling the low-demand consumers information as a guidance of the usage (e.g., in order to detect theft, "leakage of electricity" or points to efficiency). This could derive and incentive strategic change in customer relationship, with a differentiated operational dynamic.

It may appear obvious that there will be a short-term return on the investment made in sensing (remote and tele-connected metering), mainly in regions where there is high default or electricity deviation. Although, this action must involve two subjective and relationship items: the commitment of the customer and value the electricity delivered services.

Incentives must be implemented to best practices and regulatory guidance, mainly for the regions or sub-regions with low-consumption customers and social commitment, seeking a cultural change. Actions to make this consumption more efficient, and the understanding of the specific regional needs, may guarantee the breaking of the cycle regulation-cost-default-cut-theft. The creation of income conditions and the broadening of the feeling on electricity value, respecting both commitments and rights, are very important to minimize these issues that are both social and cultural in nature.

The analysis of Brazilian domestic consumption also brings the singularity of income distribution considering, that have an average monthly expenditure in electricity of less than 30 € (or less than 156 KWh) [9], with obvious implications in the business structures of the regional dealers.

Storage and retrieval information: these aspects are related to the legacy information technology systems, many times inappropriate to store and organize huge data volumes collected and exported in nearby real time. This problem, or from a pragmatic point of view, this solution, is a current structural practice in telecommunication companies, which have, historically, similar requirements to sense and supervise its network elements, its customers individually, as well as its entire capturing and data exchange system (boarder measuring, registration for tickets and clearing), geo-positioning of assets and interconnectivity, as well as price composing and billing according to timing and usage.

This cultural and structural change in storing and processing high volumes of data presents an appropriate cost-benefit relationship currently, with the technological evolution/availability of servers, storages, and cloud computing [10], ensuring strength and marketable products. Nowadays, in the Brazilian market, the electricity dealers are updating and also making investments in information technology, as well as changing its control processes. This is, therefore, a very favorable moment of (re)planning investments and organization for a differentiated operation, incorporating telecommunication infrastructure into the grid or assuming it as part of the new core business.

However, it is important to conduct an extensive cultural change work and improve operational processes for the future "smart business."

Information qualification and systems interoperability: these topics must be warned, according to smart grid current specifications, norms, and standards. Information capture and transfer (communication technologies), data gateway and applications need systems and suppliers interoperability. From the energy demand preview to increasing the share of renewable sources and taking advantage of intelligent network technologies and customer relationship, it is important to solve the present lack of knowledge and data necessary to manage the new business.

Basically, tests conducted with smart grid sensing focus on the qualification of the communication requirements, as well as the validation, quantification, and characterization of relevant parameters for an effective sensing, according to the perception of the dealer or energy company (standardization examples can be found at IEC Standards [11, 12]).

It is also important to mention, in a way that is coherent with its responsibility focused on the current energy service business, the lack knowledge and training in communications for

Brazilian electricity companies. It is worth mentioning also, the restrictions related to the Brazilian regulation model to electricity dealers to operate and offer different services from electricity, such as in the area of telecommunications. The obsolete or low networks connectivity is an action field. This knowledge is necessary for the maintenance of a sensing infrastructure and remote measuring requirements into a smart metering network. It is also both a business opportunity and a commitment. In the United States, this issue is also handled by the Federal Communications Commission (FCC), as mentioned in reference [13], reinforcing the involvement of several knowledge sectors for the composition of a business solution with all the necessary guidance.

In Brazil, this evolution and "joint" business opportunity among the electricity dealers and telecommunication system operators is a future commercial assumption, although some dealers have already ventured in studies on the supply of basic telecommunication services using their own infrastructure and the capillarity of their electricity grids.

Increase in system capacity: basically canalize efforts to build or reinforce the capacity in the high-voltage systems. The building of lines and transmission circuits must also characterize investments toward the (re) structuring of substations, adding criteria of robustness and failure tolerance, the broadening of control centers, systems, and protection and relay schemes. For instance, the great distances to be overcome to deliver energy generated in hydroelectric plants planned in Brazil, in the basin of Madeira River (Jirau with 3300 MW and Santo Antônio with 3150 MW), in the Amazon region, in the North of the country, to the cities in the Southeast, are engineering challenges yet to be solved.

There are approximately 2400 km of transmission lines to be built, with all their environmental impact still under studies. The interconnection, protection and operation of the system with this new generation are questions yet to be answered [14].

Coordination of areas, regions, and national control system and integration of electricity grids: this sector clearly must have special attention. A series of interrelated structural coordination roles must be conducted for an economic and trustworthy operation of the electrical system. Charging compensation and balancing, generation system coordination, transportation and distribution dealers, electricity market operations, government and emergency operation centers are included. The elements of smart grid in this context might include the collection of measurements of the entire system to determine its state and quality of electricity, and coordinate actions to increase the economic efficiency, reliability, environmental compliance, and respond to disruptions or systemic failures.

The need for regulation concerning these functions in the integration arena is evident, as well as the updating existing Brazilian control system. This system is presented as robust, but its conditions of self-adjustment, control, and recovery in case of simultaneous failures, of isolating problems and rebooting still need to evolve. The blackout events in several Brazilian regions from 2010 to 2014 had shown that the interconnected national system control must be improved and needs more intelligent and dynamic mechanisms to the decision making recovering procedures. These occurrences lighted the generation infrastructure and the composition of the electricity matrix as well as the transmission grid resources.

More and more actions and operational indicators must be defined, obtained, controlled, and managed by operators and by systems, a great challenge for the Interconnected National System [15].

System's bottlenecks and self-recovery control: controls for eliminating or at least recognition of the attention points or controlled overload. Together with the analysis of the system capacity, functionality includes increase power flow, enhanced voltage support, manage fault currents, allowing the operation, reaction and recovery from failures in the system in an effective and dynamic base. Surely, much technology is yet to be developed toward this effective control, such as power electronic devices, power electronic circuit breakers and others controllers, from the high-voltage grid control to the distribution grid.

The focus on robust interconnectivity, failure control, and recovery is evidenced, mainly when the aim is to ensure the automation of real time actions. It also reinforces the importance of regulating, guiding, and controlling entities on the interconnectivity between dealers, vendors, grids, generation fabrics, and systems. Many interoperability and multi-vendor tests have been made to ensure the robustness and self-recovery in the structures of the Brazilian transmission and distribution networks. Residential microgeneration are starting up into Brazilian energy grids and the two-way connection and control are in the initial evaluation.

Quality indicators: must be resultant from implementation and used to demonstrate systems efficacy. One polemic issue in the set of guidelines from the Brazilian regulatory agency (ANEEL) is associated to the models organization that figure out the delivered energy quality and the indicators reliability that show operational performance of the systems and their interfaces. These guidelines are presented in the models proposed for the reference company in the electric sector and in public referendum for the electronic meters [16, 17]. It is expected to reach the offering of services guided by levels (SLA—Service Level Agreement), such as in the telecommunication market.

The near horizon (until 2020) signals the exchange of 73.5 million meters in Brazil [9], in a migration to electronic metering technology, and if possible, intelligent. It will seek updating the installed metering devices and the entire measuring system, as well as improve electricity supply quality, reducing operational costs for distributors, fighting the losses and aiming toward energy efficiency [17].

The establishment of commitments is questioned as subject as implementation, tariffs, and incentives conditions which need to be granted that the costs of this process could be feasible in the current dealer regulation structure and to the customers. The vendors have been mobilized to supply devices and systems. Those should validate the requirements of interoperability, standardized interfaces, and certified by Brazilian measurement entities, following standards that are also under analysis.

Connectivity (broadened) empowerment for consumers and tariff model: all the prior functionalities are reflected on the end user care, recognized as the relationship on the customer point of view. This broadened view directly shows on the offering of connected services to the delivery of electricity (e.g., additional information for billing and real-time pricing (according to criteria established depending on the demand and load shape objectives), evaluation started by

ANEEL [18]), value-added services (such as safety and monitoring applications), and services involving the existing or added electricity infrastructure, established by smart grid implementation (such as Internet and data communication services).

It is intentional in the evolution of the Brazilian tariff model [18], several changes in the form of dividing the tariff components among the several users of the system. This shall cause specific tariff variations for each customer, depending on the group/sub-group/tariff category of the consumer, its consumption profile, as well as tariff flags creation and the dealer tariff review performance process. These flags must be extended to all the low-consumption customers (domestic and others), with signals in three time points: at the peak, intermediary, and out of the peak. Its implementation and viability are conditioned to the implementation of electronic meters (substitution of current electro-mechanic by electronic ones that allow the registration and differentiation of consumption by hours in a day). According to the agency, this change must not involve other expenses to consumers.

This discussion is also under regulation and must provide the conditions for the necessary evolution at the onset of structural changes for the intelligent grid.

4. Metering evolving and demand proving

According to Altvater [19], presented in [22]:

> The environment is not a limiting factor as long as it doesn't require too much with regards to the absorptive capacity of the global ecosystems. But a capitalist, industrial society is expansive in time and space; it grows, and rapidly. Even with zero growth, which is viewed by a number of ecologists as the solution for environmental problems, electricity and raw materials are consumed, despite zero or negative economic/monetary growth. It may even be that, with zero growth, the environmental burden becomes greater than with growth, because of the need to spare costs in the economic system. Therefore, the problem lies not in the dimension of the economic growth rates, but in how this "metabolism" is regulated: the material exchange between nature, individuals and society.

"Humans use natural resources (in the realm of the expanding economic system) progressively, as a source and as a deposit for undesired products." The advancement and incorporation of the environmental revolution's principles (energy efficiency, recycling, pollution control, and environmental design) should advance within the productive system through a sustainable guidance of public policies [20].

Therefore, in terms of energy efficiency and water demand management, these resources must be rationalized, but simply monitoring consumption is not enough. A cultural change in a population's habits must also be achieved

Public policies demand involvement and active citizenship by the consumers and require that the production-generation-delivery-consumption chain be monitored and audited. Organized market conditions are required from a consumption standpoint as are the amounts actually consumed and their financial counterpart (amounts paid). To achieve this goal, data (as information and as knowledge) must be organized, the amounts saved due in consumption habits must be indicated and a trend survey should be held (not only for the consumer but also for the utilities). It is also essential to monitor the entire system. Monitoring information allows incidents such as leaks to be detected and provides a review of operation procedures and consumption incentives and awareness to achieve the desired efficiency.

Digitalization and the advancement of the current control and telecommunications systems, as well as the lower costs of these systems, have allowed new operational possibilities. The current demand is for water and electricity management tools that will also allow customers to monitor and control their consumption in specific points of their residence. Some kind of system must be provided, as a platform for analyzing and monitoring consumption, providing automation of remote residential metering and sub-metering (internal to the residence). This platform must be integrated into a dedicated server and knowledge structure (centralizing the processing of meter readings), allowing behavior qualification, evaluation the actions taken for consumption reduction and/or awareness of use, as well as the planning of educational actions and grid expansion warnings.

In physical terms, the relationship environment receives the measurements collected from both commercial electronic electricity and water meters. Partial consumption measurements within households must be determined through water and electricity sub-meters (or smart plugs) installed at points of interest. Communication resources must be coupled to these devices so that the individual measurements can be transmitted to the centralized processing center at pre-set timeframes.

Additionally, this integration environment should be designed as a tool for Internet access and digital inclusion by supporting and valuing the communities' web knowledge and use. This feature naturally integrates into the global trends regarding service and universal access to information, access to knowledge, discretion over the use of services and serving the basic needs of the underprivileged populations.

“Management of natural resources may, in theory, through planning, anticipate, prevent and mitigate environmental impacts, as scientific knowledge allows this, and public pressure and demand make the policies become enforceable” [21]. However, there is a need for corporate and government policies to encourage cultural and educational changes related to conscious consuming.

With this platform, the energy industry should contribute with solutions that expand the availability of information and provide conditions for conscious, participatory decision making regarding consumption and thus promoting changes in habits and culture. It allows for a new perspective on the electricity and water businesses and in client/consumer relationship, with the latter auditing and verifying the efficiency of the former.

4.1. Field tests and results

Some clients' energy usage scenarios were prepared to validate and spotlight the challenges some company should find at smart grid/smart metering implementation. The researches look for governance and solutions for organizing and controlling information for customers within this new paradigm of knowing their actual consumption. One of that had the financial support of FINEP—Financiadora de Estudos e Projetos do Brasil (Study and Project Funding for Brazil) —from its 2008–2010 Economic Subsidy program. It resulted in a test lab and research on use, allowing the monitoring of the system, of the data collected and of the participant's level of involvement [22]. Another larger test was done by Inter-American Development Bank (IDB) support at one of the largest energy distributer company in Brazil as part of its smart grid field tests. Some results are presented below.

Two test fields were established at the initial lab tests [22]. The first lab consisted of a low-income housing complex—a vertical environment with several residential consumer units. The second test field was represented by a commercial consumer (horizontal environment), in an area of 2000 m^2, at an entity that deals with the autistic people education. They consume a lot of electricity and water and need to go through an energy efficiency and management better infrastructure. Management tools for efficient electricity and water were made available by treating the consumption measurements of each customer site. These measurements were collected through sensors and commercial electronic meters approved by the Brazilian metrological institute, composing an infrastructure designed for this purpose that integrates the electricity and water supply services, with the addition of telecommunications resources.

Another test field involving two hundred families (from different social classes at the same geographical region in Brazil) was organized to demonstrate a larger influence of efficiency improvement to those families, lighting the local habits and home appliances usage, as well as the recognition the real energy demand. Training, speeches, and monitoring actions were done to guarantee social compromising and conscious energy habits during the available pilot analysis.

Meters and home plug appliances used:

1. General meter: customers had installed meters that represent their monthly energy usage, with a timeframe of 1 information per minute;

2. Home appliance meter or logger: synchronized by a local router, at least 4 loggers per customer site were provided, with a timeframe of 1 information per minute available per logger and home device, organizing a reference warehouse to consumer habits analysis.[3]

First, the research demonstrates that it is necessary a sustainability, performance, and robustness of the technological solution for measuring consumption and qualifying its efficiency, integrating the electricity, water supply, and telecommunications services. It was necessary to integrate the consumer in this process, as a client and decision-maker, as agents in charge of their conduct that demonstrates the commitment to the planet and to their community.

From the consumer's standpoint, the improvement presented may broaden their individual opportunities as citizens through digital inclusion also associated with a more extensive

[3] One minute timeframe used at the pilots permit a near real-time energy information. The loggers and meters provided consumption data (Wh—watt hora) and peek of energy required (W). One can easily infer the nearby energy demand, by household, by circuit, and else by region. Weekly and monthly information provided important analysis of customer habits and derivate actions, from grid maintenance (to avoid grid or transformer overload and better quality of energy offered) to customers' efficiency speeches (focusing on how to avoid peak energy usage time, better home appliances performance and habits × comfort compromises).

culture that indicates their consumption; for example, it allows discretion in the use of the utilities. The pilot environments become a live laboratory, with the synergy of the technological elements and the community.

Smart meters and systems provided consumption history, daily consumption reports, and forecast savings for the undergoing month arising from changes in consumption habits. It allowed monitoring and controlling daily consumption pattern, as well as the monetary value that may be saved, depending on consumption habits and comfort decided. Additionally, it provided useful information for a life and resources governance commitment.

For the process governance, the impacts related to the sustainability of the energy demand were organized to represent some consumption indicators and features. The architecture organization is presented at the **Figure 1**. Some indicators are organized, according to [22], into some features as

- administrative functions to control user and customer management services and to control meta-data, events, and consumption ranges;
- ranking by consumer unit consumption;
- total consumption;
- consumption at peak times;
- percentage of total consumption (meters and sub-meters);
- indicators of consumption stationing level;
- indicators of drastic increase/decrease in the level of consumption;
- indicators of fluctuations in consumption levels (ping-pong effect);
- indicators of attempted intrusion or damage.

The functions listed below were defined to meet the consumers' needs:

- monthly consumption records;
- storage of images of the customer's premises;
- consumption profile;
- consumption in the past 12th months for each meter and sub-meter;
- monthly comparatives;
- comparison of the month's consumption with consumption averages;
- percentage per sub-meter;
- maximum, average, and minimum consumption;
- consumer unit comparison with ranges;
- consumption reduction tips based on performance;

- consumption forecasts for the current month and the economic expenditure forecast arising therefore;
- consumption targets and subsequent analysis;
- general tips for saving energy and water (leaflets).

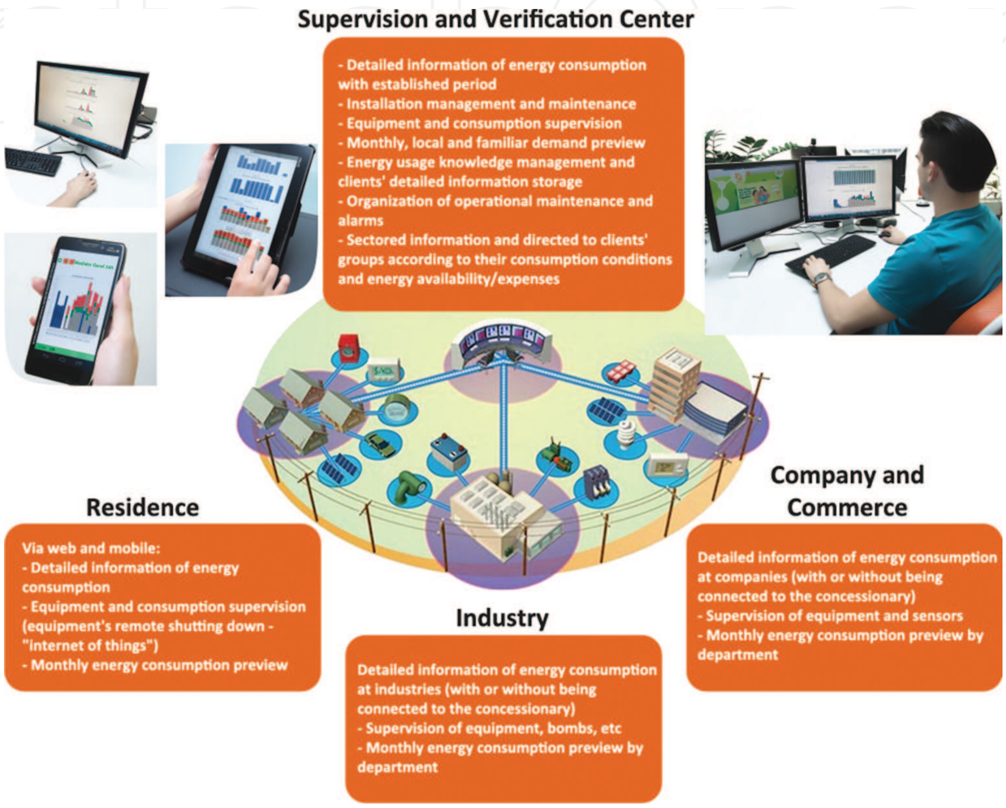

Figure 1. A smart metering knowledge architecture organization.

The second customer field test was organized to evaluate the customer equipment usage (habits) as well as the energy demand. A consumer habits survey started the process, looking for customer energy efficiency compromising and home appliances usage recognition. Five hundred customers were pre-selected, two hundred customers participated in the survey and had smart metering and appliances home plugs installed. Based on their declared energy habits and home appliances usage an estimated load curve was done presented at **Figure 2**. For example, between 7:00 and 10 PM, energy peak usage represents families' habits, watching TV, washing clothes, and take their shower at the same time (using electric showers, a historical Brazilian way to locally heat shower water).

At the survey, the families declared their habits and the home appliances specifications that helps the pre-evaluation done. Others appliances were studied but electric shower, refrigerator, TV, and washing machine were more representative of the energy demand at the region under analysis.

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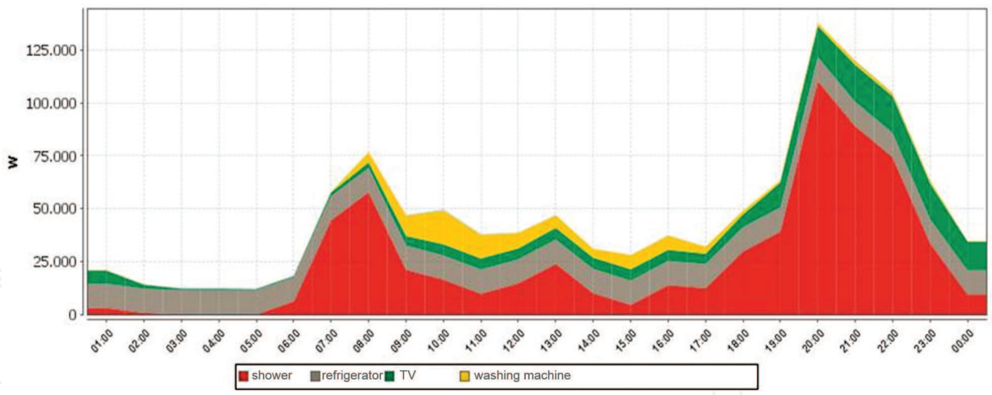

Figure 2. Estimated daily load curve from the major home appliances at households under analysis.

A daily demand (based on a 1-minute timeframe measures) proved the estimated load curve and is presented at **Figure 3**. This kind of information from the smart metering, energy usage day by day, helped the distribution utility at its grid evaluation and energy provisioning, as well as thief prevention, quality of energy qualification and regional services offerings. Smart metering as a tool could provide a business improvement, from grid maintenance to customer support organization.

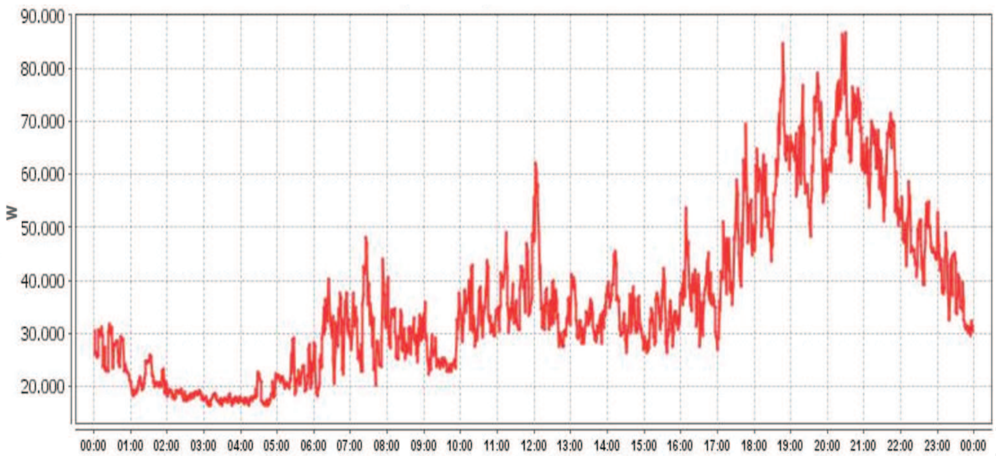

Figure 3. Daily demand measuring.

The historical energy usage (monthly usage—**Figure 4**) and daily demand (**Figure 5**) were presented to the customer, in a friendly way, involving the family with the energy efficiency compromising with their own energy usage performance. Mobile apps were provided to a daily home energy performance, with tips of better energy usage and costs simulation. After the test period, the families were conscious of their energy usage, appliances obsolescence as well as lighting influence, social and environmental compromising. After that, they could decide about their comfort and costs associated with. This research improved the energy distributor relationship and the knowledge about the regional expectation with smart grid (metering) implementation and possibilities.

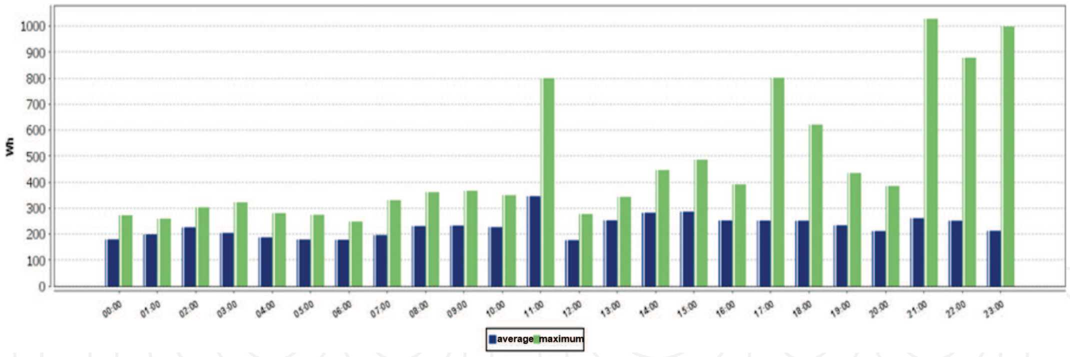

Figure 4. Customer's hourly average/maximum consumption during a month.

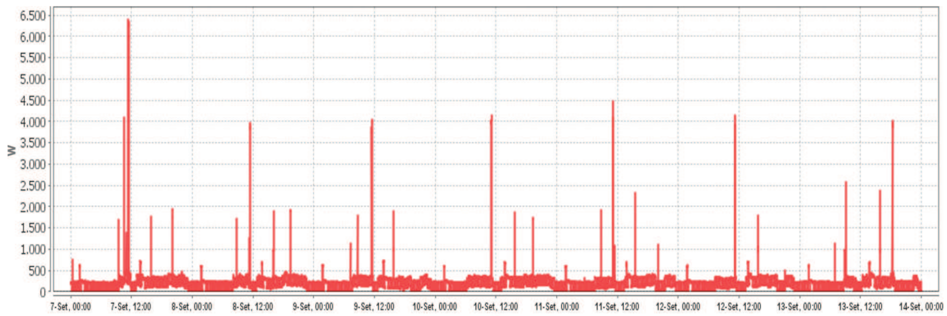

Figure 5. Seven days' customer's measuring (1-minute timeframe).

Basically, the analysis of the smart grit concept in Brazil is complex according to the effects of modernization and natural obsolescence on energy efficiency, the return on investments, communication and information safety, multiple suppliers, integration, and standardization. These considerations bring to light the commercial interests of meter vendors and concerns associated with demand increase and country energy planning.

In addition to metering issues, some other factors must be addressed to ensure effective grid operation as the integration of distributed generation, micro-generation, storage resources, and demand response infrastructure. The products that are used and will be used by customers, such as intelligent appliances and electric vehicles, are important components in this field of study, as well as generation of renewable energies derived from biomass, wind and solar sources.

With smart grid technologies, mainly smart metering, with continuous and dynamic data reading, demand information can be organized and used to improve performance and reliability of the electric system. For Brazil, these issues are also relevant, and there are presently, several ongoing experiments on distributed generation using technical approaches. Although, there has been great interest on smart grids and distributed generation, both within utilities and in academies, the extent directly related to consumer behavior is not explored nor their ability to modulate their demand, the answer to more efficient power use, reactions to fare variations, and even their interest in own generation investment opportunities.

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Brazilian providers and regulatory agencies currently support research and innovation on the regulation of responsibilities and the requirements of future energy offerings, the incentives in the execution of projects, the implementation of advanced metering solutions, the evaluation of electricity quality, and the remote control of equipment. There are some experiments exploring Brazilian smart cities, including R&D projects as [23], looking for organizing and planning the new energy businesses.

The near future requires equating how this technological development and the role of consumers may affect the existing network, centralized generation system as well as deciding about their energy usage profile. It is necessary to consider more explicitly the role and behavior of the producer-consumer, without losing sight of the main objective of the network and generation system, which is to warrant reliable access, at lower cost, of power services for all users.

5. Conclusion

Sustainable development, within a context of social productivity and potential surplus to expand the frontiers of development, carries the contradictions and operational dynamics related to each social organization, and its ethics, culture, and history. Progress leads to questions concerning the advancement of individual, political, and economic liberties and of social opportunities within the context of relationships and the appropriate use of the environment to maintain diversities [24]. In Brazil, the uneven income and consumption distribution, migration, and urbanization lead to issues regarding sustainable development and direct government actions involving the investment in the rational use and quality of energy and water for the population, mainly for low-income communities. Given this context, education and tools should be used to show the individual efficiency in light of the collective well-being and the use of finite resources. Transparency and the participation of individuals and communities must also be included in the scope of audits and published [22].

Operating in this realm, the organization presented allows the management of energy efficiency in a sustainable manner, encouraging active citizenship by the users through the rational use of resources. Metering and friendly information could transform customer relationship, improve energy value recognition and social-environmental compromising, seeking to live up to the new management trends for electricity services and providing, as well, a fruitful field of information for the utility companies. This level of intelligence is possible when you take into account the sensory aspects and those related to information gathering by an advanced metering infrastructure (AMI) network, focusing on customers' services [25].

The progression of the networks, of the utility companies, of the consumers, of the regulation, and of energy use and generation use needs to be better articulated.

Incentives must be implemented to best practices and regulatory guidance, mainly for the regions or sub-regions with low-consumption customers and social commitment, seeking a cultural change, as well as control high default or electricity deviation. Actions to make this consumption more efficient, and the understanding of the specific regional needs, may guarantee the breaking of the historic cycle regulation-cost-default-cut-theft. The creation of income conditions and the broadening of the feeling on electricity value, respecting commitments and rights, are very important to minimize the issues that are both social and cultural in nature.

To sum up, a level of commitment to an energy efficient and sustainable model will depend on a number of rearrangements at the Brazilian energy industry and country governmental guidelines, such as the adequacy structure of generation and delivery, regulatory and standardization reinforcement, and also the understanding of customers' needs and socio-cultural efforts to motivate the conscious use of energy.

In consonance with the theme, the relationship with the regional client is presented as the basis for regulating service supply. Thus, new regulations involving the electrical and telecommunication industries must develop an anchor role and be used as guidelines for the developing of smart grid (and reinforce smart metering characteristics) in economic and industrial relationships guiding the development of this sector in the country.

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