An Overview of Smart Grids in Brazil

Opportunities, Needs and Pilot Initiatives

Cesare Quinteiro Pica, Daniella Vieira, Gabriel Dettogni
Reference Centers of Innovative Technologies – CERTI
Florianopolis-SC, Brazil
e-mail: cqp@certi.org.br, dpv@certi.org.br, gdt@certi.org.br

Abstract—**With the Smart Grid boom, vendors and investors are already looking for the opportunities in this area. Some of the greatest possibilities might be constructed in Latin America, especially in Brazil. This article aims to present an overview about Smart Grid developments in Brazil. Furthermore, four cases are described to show the challenges that confront energy companies in constructing and implementing the base for an efficient and real Smart Grid.**

Keywords: Smart Grid; Research and development; Pilot Initiatives; Regulatory demands.

I. CURRENT SCENARIO OF SMART GRIDS IN BRAZIL

Latin America is also a region of the world that is showing significant Smart Grid activity. In many Latin American countries, utilities have undertaken pilot projects in Smart Grids. Since 2008, there has been a growing interest in smart energy technologies among Latin American countries, with Brazil leading the way. Currently, the concept of Smart Grid is the subject with the greatest emphasis in the Brazilian energy sector [1].

Brazil is identified as a country that recently has had and continues to have huge economic growth and, hence, the need for expansion and modernization of the electric power system, in order to cope with the increased energy demand. According with the Brazilian National Energy Plan for 2008-2017, the government set a goal to build 54 gigawatts of installed capacity to attend the increase of the consumption expected in 60 percent [2].

In 2010, almost all Brazilian electric utilities began studying Smart Grid in order to prepare themselves and to strategically direct their investments in new infrastructure and Research and Development (R&D) projects towards the modernization of the Brazilian electric system.

The following issues might be considered as motivating factors for Smart Grid implementation in Brazil: (i) reduction of non-technical losses; (ii) increase of the operational efficiency; (iii) expansion and automatization of the electric power system with standardized smart technologies; (iii) improvement of the system reliability and power quality, especially for industries and high-tech based companies.

This paper aims to present an overview of Smart Grids in Brazil and is organized as follow. In Section 2, information about investments for R&D activities is provided. In Section 3, some initiatives and challenges for the implementation of Smart Grid are presented. In Section 4, the most important Brazilian pilot projects are detailed. Finally, in Section 5, some final highlights of opportunities for Smart grid development in Brazil are presented.

II. INVESTMENTS FOR RESEARCH AND DEVELOPMENT

Due to a Brazilian law [3], all public service concessionaires of electric power distribution must invest approximately 1% of their operating revenues in research and development programs that could be conducted by universities, research centers and innovative companies.

Most of the investment in addressing these issues is being made by energy companies (Generation, Transmission and Distribution). These initiatives are: (i) Research and Development Program; (ii) Energy Efficiency Program, that are coordinated by the energy companies which support practical actions; and (iii) Government Fund, that support the modernization of the Brazilian electric power system and other development projects. The data shown in Table 1 represents how much companies must invest in each of the three initiatives.

TABLE 1. INVESTMENTS IN EACH INITIATIVE

	Research and Development	**Energy Efficiency**	**Government Fund**
Distribution	0.2%	0.5%	0.3%
Transmission	0.4%	-	0.6%
Generation	0.4%	-	0.6%

For this reason, the Brazilian Electricity Regulatory Agency (ANEEL) improved the segment's R&D Program with the objective of encouraging the constant search for innovation and to confront the technological challenges of the electrical sector.

A report prepared by the Brazilian Development Bank (BNDES) shows that overall investments in energy infrastructure will increase by 7.4% per year until 2013 [4]. Between 2010 and 2013, Brazil will invest around US$60 billion in the electric system, solely taking into account

 ISBN: 978-1-61208-136-6

projects that already have been granted or have had authorization given by the government.

Other investments are being launched by private companies. Large companies such as IBM, Silver Springs Networks and GE are already making investments in this sector in Brazil. The Brazilian market for Smart Grids is seen as a potential for many countries and there should be great opportunities for business development, especially due Brazil hosting the World Cup of 2014 and Olympic Games of 2016.

III. INITIATIVES AND CHALLENDGES

The Brazilian Ministry of Mines and Energy (MME) has recently established a work group responsible for studying and planning the deployment of a Smart Grid in the country. The members of the work group, besides the MME, are representatives from the Energy Research Company (EPE), the Electric Energy Research Center (CEPEL), the ANEEL and the Operator of the National Electric System (ONS). The work group is expected to complete its work during the first half of 2011. This group has to review the technical studies and prepare an analysis with recommendations on measures that should be adopted, focusing principally on: (i) the consolidation of Smart Grid programs in Brazil; (ii) the adequacy of regulations and standards for distributors of electricity; (iii) the identification of resources for funding and promoting incentives for the production of equipment in the country; and (iv) the regulation of potential new players in the market, including consumers and distributed generation providers [5].

At the moment the main challenges related to the implementation of Smart Grid architecture in a Brazilian context are: size of matrix energy in Brazil, remote areas like Amazon and rural areas, reliability standards, illegal connections and regulation of the sector.

In Brazil Smart Grid is being implemented mostly through large scale adoption of electronic meters, as a strategy for distribution companies to increase operational efficiency through remote meter readings, and to reduce energy commercial losses. As an example, in 2009, the city of Rio de Janeiro's total energy losses were about 21% which corresponds to 5TWh. Of this total, around 15% refers to commercial losses. In 2009, energy commercial losses in the whole country represented approximately US$5 billion in economic losses for distribution companies [6].

In 2009, the ANEEL opened a public hearing on Smart Metering and also approved a regulation allowing the use of Power Line Communication (PLC) throughout the country. The agency ANEEL announced plans for replacing around 65 million electromechanical energy meters, nowadays installed in residential and commercial buildings in Brazil, with new Smart Meters. In the near future, Smart Metering will enable the registration of the energy generated by residential consumer units by means of solar panels and residential wind turbines, for example.

Another important challenge in Brazil is that there are not yet specific policies and regulations for free markets tariffs. The agency will invest in efforts to define the regulations that permit differentiated tariffs by time, which will enable consumers to manage their consumption.

IV. PILOT PROJECTS IN BRAZILIAN COMPANIES

Despite many financial and regulatory barriers, several national companies are already working on pilot projects. In this section we highlight four cases that were constructed by pioneer companies within Smart Grid. They are: CEMIG, AES Eletropaulo, COPEL and CELESC.

Figure 1. Some smart grids initiatives in Brazil.

Case 1: Cities of the Future in Minas Gerais (CEMIG)

The *Companhia Energética de Minas Gerais* (CEMIG) [7] has been working to construct the innovative solution to automate the infrastructure of energy distribution. In this model, the concept of the Smart Grid architecture contribute to modelling the integration of technical and commercial systems, providing an approach focused on client, on service quality, on ambiental sustainability and on energy market.

For this reason, CEMIG adopted projects that are integrated with the categories of Smart Grid architecture. The main projects in course are Distribution´s automatization and City of the Future.

In 2009, the project City of the Future was started. The project has the objective to validate products, services and innovative solutions applied to Smart Grid architecture, in an appropriate and representative scale for the company.

The city that was chosen to start the implementation of this program is Sete Lagoas, located near Belo Horizonte. This is a municipality with a big diversity of economic activities in the industrial, agriculture and service sectors with a population of over 200,000 inhabitants and more than 80,000 customers. Another point is that the location had the capacity to integrate experiments with consumers of telecommunication systems.

The project City of the Future includes actions that cover all business processes focusing most notably in the following areas: (i) automation of consumers' measurement, (ii) automation of substations, (iii) automation of energy distribution grid, (iv) telecommunications systems, (v) operational computer systems, and (vi) management and integration of distributed generation. In 2010, the R&D projects started and the first step for implementation was realized.

 ISBN: 978-1-61208-136-6

For CEMIG, the principal difficulty in constructing Smart Grid architecture is that the rules for implementation were not defined for ANEEL. For this reason, the process to obtain financial resources has been difficult. However, the adopted practices for the implementation and the expected results are strategic for all stakeholders with emphasis for the company and governmental entities.

The project City of the Future has as expected result: serve as a model for implementation of new real time tariffs and billing; reduce the energy costs and losses; improve efficiency of the power grid; optimize the management and control; improve quality of the services and promote R&D.

Case 2: Smart Grid in Sao Paulo (AES Eletropaulo)

Since 2007, AES Eletropaulo [8] has been conducting initiatives related to the comprehension and dissemination of Smart Grid concepts. In 2010, the company invested R&D resources in a pilot project to develop a smart distribution system integrating communications solutions, advanced equipment and information systems. At this stage, the project aims to monitor the electrical system and automate the process of power distribution.

The Smart Grid pilot project is being implanted over a circuit that has 4.4 kilometers of overhead and underground cables which make up distribution grid, in Ipiranga, São Paulo. This region has 2,000 units consumption of low and medium voltage, in residential, commercial and industrial segments. In this region, electronic meters were installed to monitor the customers' energy consumption, as well as monitor the energy balance in 39 secondary circuits and allow the remote execution of various services, such as power reading, cutting and reconnection.

AES Eletropaulo started doing experiments that involve communication between electronic meters, substations, toggle switches and other equipment, as well as integration between the company systems. The company intends to analyse the information, obtained from the measurement system, and integrate it with the automation and operation systems of the concessionaire.

To put the project into practice, various features of the intelligent grids' concept are being tested and among them is "self-healing" (a tool that reduces recovery time from a failure in the electrical system). In the case of power failure, a voltage sensor detects the interruption and sends information to the distribution management system of the company, which will automatically identify an alternative to restore the power supply. If it was not feasible, the system will send an alert to the specific distributor's operations center, which will trigger a team to meet directly at the site identified.

AES Eletropaulo has continuing investing in R&D initiatives and organizes a multidisciplinary committee to coordinate and analyze the activities.

Case 3: Companhia Paranaense de Energia (COPEL)

The COPEL [9] plans to invest more than $ 330 million in projects that are related to Smart Grids concepts until 2014. The main view is to transform Curitiba into a digital city. The investments are directed towards infrastructure, including installation of electrical networks and adaptation of modern systems to energy transfer. Some projects are already being implemented, while others remain in the preparation and study stage.

The technology platform, based on the Smart Grid concepts, is been tested in Fazenda do Rio Grande, in Metropolitan Region of Curitiba, covering 100 million consumers.

The COPEL's program is being formulated in coordination with other public services, under the coordination of the State Secretariat of Urban Development. The planned actions are intended to expand and modernize the electric system.

Projects intend to spread the Smart Grid by 2020 to reduce the rates of equivalent duration of interruption per customer (DEC) and equivalent frequency of interruption per customer (FEC) [10]. The priority is to improve the supply. In addition, technical losses tend to fall from 6.5% to 4% and the commercial 1.5% to 0.5%.

Over the next few years, COPEL will automate all operational keys and automatic reclosers installed that supply the 650,000 consumer units. This action will reduce the number of interruptions and shorten the time needed to restore services. The company also expects to build 700 km of new compact power grids.

The idea for new projects incorporates sensing, monitoring, information technology and telecommunications for the best network performance. In the next step of implementation the system will be able to identify early failures and be able to reestablish itself, therefore improving performance. COPEL sees that the system itself, supplied by data and information collected by geoprocessing techniques, will identify the items that are being repaired, define the process of isolation and restore power within minutes.

Another initiative related to Smart Grids concepts, in 2010, was the launch of the first electric taxi at the Afonso Pena airport, in São José dos Pinhais, COPEL installed the first electric fueling station. The station that recharges the batteries will also be used within the project site for studies on vehicle performance and the impacts of its use on the electrical system. Today the charging time of this car is 8 hours, but they expected to improve that performance.

Case 4: Micro Grid of Sustainable Energy (CELESC)

The CELESC [11] company is developing R&D pilot projects with the objective to build structures to accommodate the Smart Grid architecture. Accordingly, the projects are reported: (i) Demand Response in Florianópolis, (ii) Measurement system in Blumenau and (iii) Planning District Distribution Network and Generation of Sustainable Energy.

To be approved by ANEEL, the project Demand Response in Florianópolis, Santa Catarina, has the objective to improve load factor of distribution systems, through the technology used for demand response. The project will

 ISBN: 978-1-61208-136-6

install load control devices in 10,000 consumer units and smart meters in 3,500 consumer units. The company hopes to avoid the occurrence of blackouts and shutdowns, especially in critical times during the summer. The demand management and the most efficient use of the power system will reduce the costs.

CELESC launched the Project Measurement system in Blumenau that aims to serve 3,670 consumers in the municipality. The project uses PLC (Power Line Communications) technology to send and receive information through the power energy distribution grid. The project implementation consists of three steps: replace the mechanical meters for electronic meters, install a new communication system between each meter and the Blumenau´s substation and install a control center in headquarters in Florianopolis.

Information regarding consumption will be obtained remotely. The installed meters are connected to a communication module, called transponder, which sends signals with information about electricity consumption. These signals are sent through a distribution network, before they reach the CELESC's substation. In this place, special equipment receives and retransmits the signals to a central control, which analyses the collected data.

The automated measurement system introduces many facilities and benefits for consumers, such as: automatic metering reading; remote connection and disconnection modules in meters and automatic restart after the cut-off; lifting load curve of consumption; automatic record of power failure, with date and time of occurrence; monitoring the voltage on the grid.

A project will be started in 2011, Planning District Distribution Network and Generation of Sustainable Energy aims to achieve integration planning for alternative sources of generation energy (renewable, waste and sewage) in a distribution district. This project will be applied in Sapiens Park [12], in Florianopolis, with the purpose to be sustainable in generation and consumption.

Sustainable Energy district networks are defined as local electrical systems (consisting of generators, loads, storage and distribution) but with different features as well as been sustainable. These systems provide connection to the current energy system in CELESC. The project will elaborate on the methodology for developing these networks and devised a test case. This project must justify the deployment of district networks in different environments of interest, promoting, for example: (i) energy efficiency and quality, supported by local management and operation of the system; (ii) opportunity in the market for Smart Grids and offering new services and rates; (iii) convergence of energy and environmental solutions.

The results can be applied in different environments/districts that seek quality and energy and environmental sustainability. Moreover, it is noteworthy that the solutions studied in the project can be implemented to modernize the electrical system, even if initially these solutions are not grouped in the form of district networks.

V. CONCLUSIONS

In Brazil, the concept of Smart Grid has become the subject with greatest emphasis in the energy sector. The focus for now remains on Smart Meters. Very soon other smart solutions are expected to emerge on the national landscape with very positive forecasts for distributed generation, communication infrastructure and IT applications.

The Brazilian market for Smart Grids is seen as a potential market for many countries. Moreover, even with many financial and regulatory barriers, several national companies are already working on pilot projects to increase the national energy capacity and define models for future deployment of Smart Grid in Brazil.

Regarding the barriers for Smart Grid implementation in Brazil, most of them are the same as other countries. They are principally: (i) Market uncertainty and lack of policies on market structure and rules; (ii) Low public awareness and engagement; (iii) Interoperability and scalability assurance, (iv) Revenue uncertainty due to lack of regulatory definitions. In addition to these barriers, it is worth mentioning other particular issues in Brazil: (i) The electric power grid in Brazil is very large and it requires a huge amount of investment; (ii) More than 70% of the Brazilian energy matrix is hydropower and for this reason, another kind of renewable system is not easily accepted; (iii) In Brazil there are large and low density rural and remote areas and (iv) The electric energy and the telecom agencies are not aligned in relation to the roadmap for Smart Grid development in Brazil [5].

As described in this article, the companies have initiatives that explore the reality of Smart Grid. CEMIG are exploring a defiant idea of constructing a pilot in a city. AES Eletropaulo was the first to implement and integrate the Smart Metering in their systems. COPEL has worked to implement electrical vehicles and contributed to transform Curitiba into a digital city. And CELESC has been investing in new R&D projects that involve demand response.

Therefore, it is understood that there is a great opportunity to R&D and do business in Brazil, a country that is prominent in the global economic environment, with opportunities for investors in both the energy sector, and Smart Grids.

ACKNOWLEDGEMENT

We had the pleasure to write this paper with the important contribution of:

- Mr. Ricardo Van Erven, Director of Technology and Service, at AES Eletropaulo. He related the company's experiences about pioneering projects in Smart Grid presented in *Case 2: Smart Grid in Sao Paulo*.
- Mr. Daniel Senna Guimarães, at CEMIG, who discussed the challenges involved in implementing the project presented in *Case 1: Cities of the Future in Minas Gerais*.

 ISBN: 978-1-61208-136-6

REFERENCES

[1] Smart Grid Spotlight: Brazil. <http://www.itsyoursmartgrid.com/blog/2009_12_4_brazil.jsp>. March, 2011.

[2] International Energy Outlook 2010. <http://www.eia.doe.gov/oiaf/ieo/electricity.html>. March, 2011.

[3] Brazilian Electricity Regulatory Agency. Law Nº 12.212. <http://www.aneel.gov.br/area.cfm?idArea=546&idPerfil=6>. March, 2011.

[4] PUGA, Fernando Pimentel. *Visão do Desenvolvimento*. Brazilian Development Bank. <http://www.bndes.gov.br/SiteBNDES/export/sites/default/bndes_pt/Galerias/Arquivos/conhecimento/visao/Visao_81.pdf>. March, 2011.

[5] ECOEE Energia Eficiente. Smart grid: moving from theory to practice and in the fast lane in Brazil & Latin America. Report of the III Smart Grid Latin American Forum. Sept. 2010.

[6] Brazilian Electricity Regulatory Agency. <http://www.aneel.gov.br/areaPerfil.cfm?idPerfil=13>. March, 2011.

[7] *Companhia Energética de Minas Gerais.* (CEMIG). <http://www.cemig.com.br/sites/en/Pages/default.aspx>. March, 2011.

[8] AES Eletropaulo. <http://www.aeseletropaulo.com.br>. March, 2011.

[9] *Companhia Paranaense de Energia* (COPEL) < http://www.copel.com/hpcopel/english/>. March, 2011.

[10] DEC and FEC. <http://www.aneel.gov.br/cedoc/prt1978046.pdf>. March, 2011.

[11] *Centrais Elétricas de Santa Catarina* (CELESC). <http://www.celesc.com.br/>. March, 2011.

[12] Sapiens Parque in Santa Catarina. <http://www.sapiensparque.com.br>. March, 2011.

 ISBN: 978-1-61208-136-6