DIAGNOSIS OF ADVANCED DISTRIBUTION AUTOMATION IN THE BRAZILIAN ELECTRIC SECTOR DISTRIBUTION

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ABSTRACT

A strategic R&D project was developed in Brazil during 2011, aiming at elaborating a national plan for the evolution of smart grids within the next twenty years.
The project was developed as to diagnose the current state of the Brazilian Electric Sector Distribution as regards to technologies involved in this concept.
This paper presents such a "Diagnosis" considering the research of the situation of Advanced Distribution Automation (ADA) in Brazil, stratified by functionality types, features implemented, segments of the distribution system contemplated, technology equipment, and associated IT infrastructure and communications.
In order to establish the current state of Distribution Automation in Brazil, the following activities were carried out:

- *Questionnaire distributed to affiliates of ABRADEE (Brazilian Association of Electricity Distributors), in order to assess the current state of distribution automation companies in the country.*
- *Literature overview on the issue of national distribution automation, with primary focus for smart grids.*

These activities resulted in an overview of the current stage of the distribution companies in Brazil. The questionnaire was answered by a group of companies, which serves about 60% of the Brazilian market, thus representing quite well the national reality.

INTRODUCTION

Throughout the year 2011 an R&D Strategic Project, on smart grids was developed, which aimed to determine a National Plan that could envisage the technology migration of the current stage of the Brazilian electric sector towards the full adoption of the concept of smartgrids over the whole Country.
Any study that involves the definition of a "roadmap" must answer four key questions in order to optimize costs and benefits arising from the future desired deployments:

1st At which stage are we? (Diagnosis)
2nd Where do we want to go? (Target)
3rd What is the best trajectory?
4th When shall we reach specific targets?

In this sense, the first step in the process of defining a national roadmap and perhaps the most difficult, given the heterogeneity inherent to the Brazilian reality, is to define the current state of distribution automation in Brazil, the object of this paper.
The preparation of this diagnosis was obtained by applying specific questionnaires that aimed to survey key points regarding the advanced automation throughout the distribution system.
In order to achieve this goal, which is to raise the Current State of Automation Distribution, the following main activities were carried out:

- Conducting a literature survey, based on technical reports, scientific journals and articles published in national and international events;
- Preparing a questionnaire submitted to the Distribution Companies in Brazil, so as to provide the current status of the deployment of Distribution Automation, contemplating: (i) characterization of companies, (ii) diagnosis of automation functionalities in distribution companies, (iii) telecommunication and IT infrastructure for Automation, (iv) pilot projects already developed or under development as well as future plans.
- Statistical evaluation of the questionnaires through the QuestionPro tool. The analysis involved 16 Distribution Companies, with subsequent analysis and synthesis of results.
- Analysis and synthesis of questionnaires submitted to and answered by seven manufacturers in the industry, by using the QuestionPro tool as well.

The main results and conclusions of this diagnosis are presented in the following items.

DEVELOPMENT

Survey on Advanced Distribution Automation

Under the Project on SmartGrids promoted by ANEEL (Brazilian Energy Agency) and captained by ABRADEE, a survey involving the associated DISCOS was carried out in order to identify and assess the stage of technological applications and distribution automation in Brazil.

The survey was conducted through a questionnaire that was

sent to a set of 37 affiliated DISCOs. Out of them, 16 responses were obtained from the DISCOs in the South, Southeast and Northeast of the Country, totalling approximately two thirds of the market in terms of consumers and consumption.

Besides the physical characterization of the companies, the questionnaire covers physical aspects of electrical networks, operating procedures and practices used in distribution automation solutions.

The sample covered by this questionnaire involves 42.9 million users, that amounts to a monthly consumption of approximately 15,500 GWh, corresponding to about 63% of the total consumption of the Distribution Sector. The sample includes approximately 68% of consumers in the Northeast, 87% of consumers in the Southeast and 51% of the South, with no presence of companies in the North and Midwest.

Structure of the Questionnaire

The questionnaire involved five segments, namely:

a) Segment 1 - Characterization of companies

b) Segment 2 - Diagnosis of the Current Automation Features in the Company:

- Distribution substations
- MV and LV networks
- Distributed Generation
- Control of Voltage and Reactive
- Predictive Maintenance
- Load cuts
- Surveillance Assets
- Emergency teams
- Commercial Losses
- Power Quality
- Suppliers
- Barriers

c) Segment 3 - Telecommunication Structures

d) Segment 4 - IT Resources and Technical Systems

e) Segment 5 - Pilot Projects

Characterization of Distribution Utilities

The companies were characterized by some physical, operational and market attributes. Given the diversity and heterogeneity among utility companies in the country, this characterization allows them to be analysed in similar groupings (clusters), which makes the establishment of the roadmap feasible. Moreover, important information from companies and corresponding market were tabulated.

By way of illustration, Figure 1 below highlights the average consumption per customer (total consumption ratio by the total number of consumers) in Brazil, the U.S. and Europe. Obviously, these results should be taken into account especially when deploying advanced distribution automation (e.g. features of demand response) and, in particular, AMI.

Figure 1 - Average monthly consumption – Brazil, USA and Europe

Distribution Automation Diagnosis

Based on the survey, the following key findings were obtained:

- Monitoring and control busses connected to the transmission system: most points of connection to the transmission (about 63%) are monitored by SCADA, with very few control functions.
- Monitoring and Control of Distribution Substations: Most (about 80%) of the substations are monitored and controlled by SCADA, especially primarily circuit breakers, reclosers and capacitor banks, but also with plenty of local automation.
- Monitoring and Control of Distribution Networks: Most of the feeders are monitored and controlled (71%) in Substations bays. There are increasing numbers of feeders with automatic switches/reclosers being installed. Out of the reclosers installed, 23% operate remotely and 77% with local automation. The capacitor banks, installed in 52% of feeders, operate with local automation and without communication. Voltage Regulators, installed on 21% of the feeders, also operate with local automation and without communication.
- AMR / AMI: Practically all HV (subtransmission - 138kV level) customers have remote measurement systems. There has been an increasing number of MV customers with remote measurement systems installed. In most companies, 10 to 40% of customers MV have remote measuring systems, whereas fewer companies show more than 60% of the MV customers with such systems. The main functions implemented are as follows: periodic reading and upon request reading, meter maintenance and integration with business systems.
- Faults in the network: in most cases, customer are still responsible to inform the COD for energy interruptions, but Substation and network automation become increasingly used. Fault location is, in most cases, carried out by emergency crews. However the survey shows increasing use of fault indicating devices and automation systems that communicate with the Operations Centre. The fault isolation is to a large majority held by field crews, though remote control is already used in many situations. The restoring of downstream consumers is performed field crews, but an increasing number of applications for

remote switches and reclosers is underway. Restoring after repair is usually done by field teams.

- Load management: it was noted the presence of few companies with automatic features and centralized load cutting, primarily in HV consumers.
- Volt/VAR control: voltage levels and reactive power flows are monitored and controlled particularly at substations, being about 50% locally and about 80% remotely. Most feeders present local monitoring and control of voltage and reactive (about 70%) and very few feeders (17%) show remote control.
- Video surveillance or alarm: remote monitoring functionalities are implemented in companies for occurrences related to unauthorized access, vandalism, theft and accidents, by video or alarms, especially in Substations.
- Preventive maintenance: About 70% of the companies surveyed have features for monitoring electrical, thermodynamic and physicochemical attributes in their facilities and equipment in order to direct predictive maintenance actions.
- Remote access for corrective maintenance: Approximately 30% of the companies surveyed provide remote access to maintenance corporate systems.
- Interaction between the distribution and transmission systems in situations of load shedding: in response to the Regional Scheme od Load Shedding (named ERAC), companies have automatic load shedding systems, mainly operating in High Voltage lines (46%), in Distribution Substations (77%) and feeders (69%), and to a lesser extent, with operations in consumers (HV-15%, 8% and MV-LV-8%).
- Commercial losses: In the surveyed companies, commercial losses are basically identified by periodic measurements only (17%), for energy balance in distribution transformers only (17%), and by combinations of periodic measurements and Data mining (42%).
- Power Quality: The monitoring of power quality is realized by means of specific meters, especially in SEDs and in corresponding outcoming feeder bays.

Telecommunications Structure

The questions about the basic structures of telecommunication refer to communication technologies and communication protocols.

Among the companies surveyed, eight companies reported that 100% of their substations are automated, providing a very high rate. However, these automations are relatively old, reflecting in communication technologies employed, focusing on Digital Radios (radio modem), Private Lines (LP), satellite, and fiber optic cable (in more modern facilities). Internally at substations, SCADA-based automated systems use industrial area communication technology for connection between the meters and the active elements. Among the used protocols Modbus, Fieldbus, and other proprietary protocols for equipment manufacturers were identified.

- Communication Technology: Figures 2, 3 and 4show, respectively, the distribution of communication technologies used in substations, feeders and consumers. Note that in substations there is a predominance of UHF digital radio technologies, satellite, fiber optics and private line. In the case of feeders and consumers, the vast majority is based cellular system.

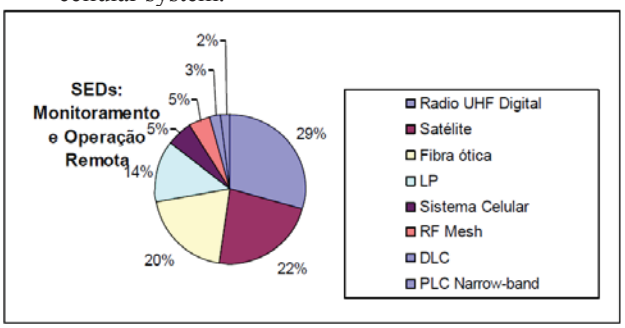

Figure 2 - Communication technologies used in substations

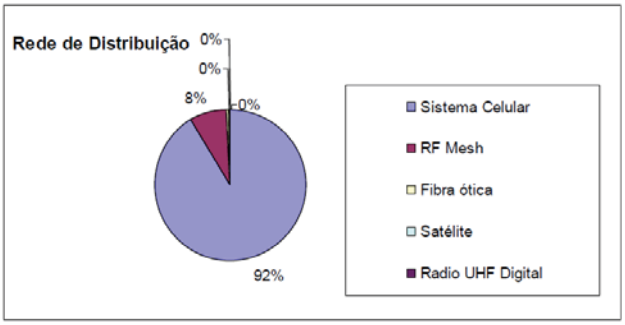

Figure 3 - Communication technologies used in feeders

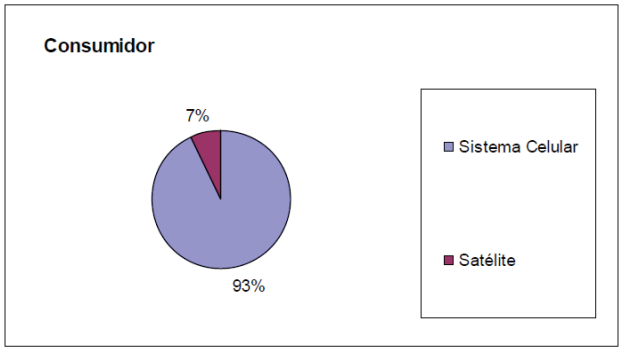

Figure 4 - Communication technologies used in consumers

- Communication protocols: the protocols used in substations and distribution networks denote the weight of the legacy standards, such as the DNP3. In substations, even on a smaller scale, communication protocols IEC 61850 and IEC 60870 are used.

IT Resources and Interoperability

- IT Resources: All companies surveyed have SCADA (supervisory control), with broad coverage in

substations and medium voltage networks. Almost all companies use GIS (Geographical Information System) deployed to cover high, medium and low voltage networks. OMS systems (interruption occurrence management systems) are deployed in 87% of companies surveyed, while others plan their deployment. However, OMS solutions are quite old, suggesting difficulties in deploying smart grids. About 50% of the companies surveyed have or plan the deployment of DMS (Distribution Management System) but there is still a lack of standardization regarding the features of a DMS system. Most companies have implemented maintenance systems.

- Interoperability: The vast majority of companies surveyed still maintain a structure of interoperation and integration of processes and systems based on specific interfaces, which certainly represent a major obstacle to deploying smart grids.

Pilot Projects

- Smart grids: the questionnaire identified few pilot projects on smart grids in the distribution companies surveyed. However, there is some concern in carrying out specific projects. In this regard, 13% of companies have already conducted some pilot project, 26% have ongoing projects and 20% plan to do some pilot. Out of these projects, 53% were directed to urban areas.
- Distributed resources: regarding pilot projects on distributed resources, 20% of companies surveyed have already conducted pilot projects in distributed generation, 26% in electric vehicles and 13% in energy storage.

CONCLUSIONS

This paper provides an overview of distribution automation functions implemented in Brazilian distribution companies. The analysis was performed by means of questionnaires answered by 16 companies associated with ABRADEE (Brazilian Association of Electricity Distributors), which supply approximately 63% of the national market.

Based on the results obtained, two current levels of automation in the Brazilian electric distribution sector can be defined. At the first level, with a lower degree of automation and intelligence, IT systems are poorly integrated. Supervision and control equipment are mainly directed to the transmission system and substations. Remote measurement is available for HV consumers and large MV consumers, besides some important rural consumers.

At the second level, with a higher degree of automation and intelligence applied to networks, one can already observe initiatives of feeder's automation, either through features like remote control of switches with more elaborated self-healing local or centralized controls.

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