Opportunities and Challenges of DSM in Smart Grid Environment

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***Abstract*—The demand side management (DSM) is a set of techniques and policies that can help to provide greater efficiency in the planning and operation of the electrical network. The problem is that the full deployment of the DSM for the totality of consumers requires data availability of the loading curve and also requires devices that can operate in real-time in the system of each consumer, individually. In Brazil, the current power grid does not have these features. This article introduces the basic features of Brazil's electrical sector, covering the issues associated with the challenges of deployment of DSM in current scenario and discusses their deployment in Smart Grid environment, showing how new technologies can help to facilitate the implementation of DSM in Brazil's electrical network.**

Keywords -DSM; Smart Grid; electrical network.

I. INTRODUCTION

The increasing complexity of electrical systems from new markets is a worldwide phenomenon and is resulting from the significant growth of the electric network, which has changed the number of consumer units and also the use of renewable energy sources that can supplement the energy supply avoiding problems of energy shortages [1].

This fact implies the increase of initiatives and actions that contribute to the search for greater efficiency in energy management, involving a greater control in delivering quality, cost reduction and attention to environmental issues [2].

The idea is not only to increase the supply of energy, but also to control the shape of consumption through the use of energy management techniques by the demand side. In addition to conservation policies, the fight against waste involves the use of devices and more modern and efficient technologies [3].

The demand side management (DSM) is a set of techniques and policies that act to equalize the levels of demand of energy consumption throughout the day. The DSM allows the control of the consumer loads in order to operate the system more efficiently.

The DSM can be defined as a program or activities organized by the concessionaire that will affect the amount of time and energy used by consumer to postpone investment in new electrical installations [3].

The major challenge in the implementation of the program of DSM is the quest for knowledge of the daily behavior of the loads of the electrical system, which normally is not available on systems based on electromechanical meters.

In this scenario, the emergence of new technologies like the Smart Grid creates an environment that introduces a convergence between the infrastructure of generation, transmission, distribution, energy, information technology and digital communications infrastructure that enables the exchange of information and control actions among the various segments of the power grid.

This paper discusses issues associated to the DSM before and after deployment of the Smart Grid in Brazil and how new technologies can contribute with new applications for the management of the electrical sector. Section 2 of the article presents the basic characteristics of the electrical system and the challenges of implementing DSM programmes in Brazil in the current scenario. Section 3 discusses the implementation of DSM programmes in Smart Grid environment including opportunities and challenges and Section 4 presents the concluding remarks and future prospects.

II. BRAZIL'S ELECTRICAL SYSTEM AND THE DEPLOYMENT OF DSM

The installed capacity of electric power generation plants of Brazil reached 117,135 MW in 2011, according to Agency National Electric Energy(ANEEL) [4]. Table 1 indicates that the weight of the residential customer is quite significant, about 36%, commercial 24%, industrial 23%

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and pubic power 12%, included the public lighting [1] for a total of more than 68 million consumers. The residential sector is what contributes the most to the tip of the electric system.

TABLE I. ENERGY CONSUMPTION IN BRAZIL IN APRIL 2011

Consumer class	Electrical Energy consumption (MWh)	Number of consumer units
Residential	9.276.139	58.220.152
Industrial	6.446.334	557.120
Trade Services	6.054.848	4.949.915
Rural	1.387.517	3.963.534
Public authorities and other	3.179.562	673.546
Total	**26.344.400**	**68.364.267**

Source ANEEL.

Currently, in Brazil's electricity sector, the generation and transmission systems of energy companies already have systems of automation, supervision and control that use digital technology to monitor processes in virtually all major centres. These systems offer several features such as supervision, remote control and remote measurement through the SCADA (System of control and data acquisition) implemented in the Centres of Operation and indicate the operating conditions of all system automated in real time.

In the case of Distribution System in Brazil (voltage less than 34.5 kV) the reality is very different. Due to its complexity and a high number of consumers, about 68 million according to Table 1, the automation deployment of these systems is only at the beginning and its operation is still performed conventionally. Power measurements for billing are made manually in about 95% of consumer units, from the electromechanical meter reading, which makes for a poor monitoring of the workloads.

To deploy a DSM program efficiently, it is necessary to perform the following steps [5]:

- the study of this market present and growth prospects in the short and long term;
- study of various forms of energy supply, with the costs involved;
- study of characteristics of system loads;
- definition and implementation of an appropriate modeling system loads in the study;
- consumer awareness and encouraging their participation;
- analysis of the overall costs involved and of the evolution of the program,.

The most commonly used DSM techniques are shown in Figure 1.

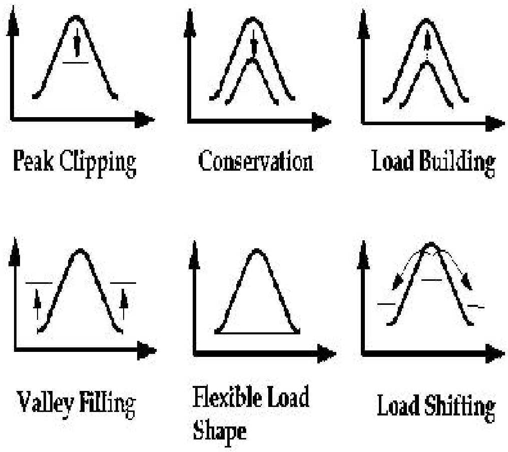

Figure 1. Techniques DSM

A. *Peak Clipping*

Peak Clipping is a program of load cutting, demand reduction in time for a heavy load. Cutting or reducing the duration of the peak can be reached by direct load control, by shutdown of consumer equipment or by distributed generation.

B. *Filling the valleys*

It is a program which encourages the off peak consumption. It builds non-peak consumption periods which is particularly desirable as the cost of production is lower, which causes a decrease in the average price and improves the efficiency of the system. Incentives in several ways. such as discount into account should stimulate special consumers to change their habits.

C. *Conservation strategic*

It is a program for seasonal energy consumption reduction mainly through efficient consumption and combating energy waste. This program is quite comprehensive and includes incentives for technological change.

D. *Load building*

It is a program to control the seasonal energy consumption increase in building. The dealership employs intelligent systems, processes, more efficient equipment and more competitive energy sources to achieve energetic efficiency.

E. load shifting

It is a program, with the workload transfer period of greatest consumption (peak period to period of lower consumption), move tip out loads, without changing the total consumption. This is also possible with distributed generation.

F. flexible modeling

It is a set of actions and integrated planning between the concessionary and the consumer, subject to the needs of the moment. It is a partnership in order to model consumer loads, without affecting the actual conditions of security, limiting the power and energy that the individual consumer can use at certain times, through the installation of load limiting devices.

The implementation of these techniques requires a daily monitoring of load type of consumer units so that the most appropriate technique can be chosen for each case.

The collection of consumer load curve is the first step in the load characterization study. The reliability of the data obtained is a key point, because this will be the entire basis of the studies for the implementation of policies required to achieve efficiency in energy management [5].

Obtaining of data of daily load curve all consumers of an electric system, without the aid of new technologies is technically impossible or nearly impossible, because the conventional energy meters do not registers these daily curves for each consumer and in this case the curve is typically made from sampling of a small portion of the population and are later using statistical tools to characterize the entire population [6].

In Brazil, the data collection is made through a campaign of measures held every 4 years (or in special campaign), that consists in the installation of demand meters which will record the consumption and the time during a given period of a small sample of the population. This method is used to calculate tariffs.

This sample is chosen randomly and normally should represent the profile of a population that will be analyzed the variables of interest.

The biggest problem in this case is the inaccuracy and lack of representativeness caused by the production of daily load curve of a small portion of the population, every 4 years. Since there is a high probability that the consumption profile change significantly during this period and may not serve as a exact model for the choice of appropriate policies for each type of consumer, once hardly this process reflects the dynamics of consumer habits. In addition, some policies of DSM as the direct load control presents the difficulty of implementation in conventional systems [8].

For these reasons, in Brazil, the implementation of DSM policies has been carried out in isolated cases with few projects pilots deployed and which are still in operation.

III. DSM AND SMART GRID

The Smart Grid is based on the integrated use of information technology, automation, telecommunications and electric network control, that involves smart meters, sensors and digital network management devices, bi-directional, allowing deployment of control strategies and optimization of electric network with real-time data processing [7].

This convergence of technologies provides real-time data volumes with high reliability, enables the power grid to be controlled with more autonomy to the consumer units and enables energy management to be implemented on a decentralised basis, requiring the development of new methods of control, automation, and optimization of the operation of the electric system.

Figure 2 shows a basic scheme of Smart Grid that involves all sectors of the system: generation, transmission, distribution and consumers with or without generation.

The Smart Grid environment introduces features that allow [8,9]:

- The integration of a variety of energy sources of various dimensions and technology, allowing any consumer to produce energy and store or sell the surplus;
- Consumer empowerment from the more decentralised energy management and demand management by remote actuation in consumer devices, registration of consumer behaviour in the processes of planning and operation of the network;

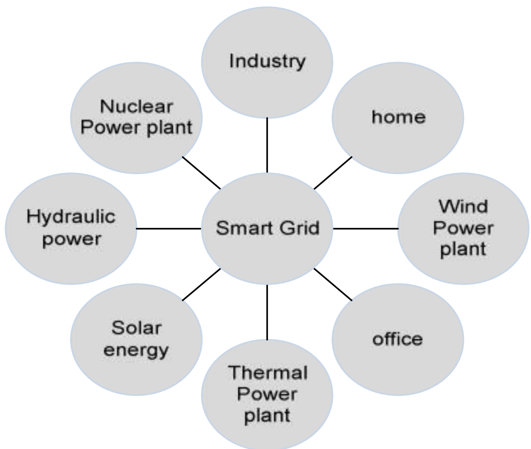

Figure 2. Basic scheme Smart Grid

- Monitoring and reduction of technical and commercial losses of the electric power sector;

- Trend of sustainability: reduce the environmental impact of electricity-producing system, since it can diversify sources, reducing losses and using sources of low environmental impact;
- The integration of a variety of energy sources of various dimensions and technology, allowing any consumer to produce energy and store or sell the surplus;
- Monitoring and reduction of technical and commercial losses of the electric power sector;
- Trend of sustainability: reduce the environmental impact of electricity-producing system, since it can diversify sources, reducing losses and using sources of low environmental impact;
- Differentiated tariff and dynamics tariff ;
- Power quality monitoring: from data and indicators in real time;
- Creation of a database of load curves: record of consumer units in real time and off line to be used subsequently in energy management programs;
- Self-healing: ability to automatically detect, analyze, respond and restore network failures;
- Make and take advantage of competitive energy markets, favoring the retail market and distributed generation or microgeneration.

The implementation of a program of DSM in a system with a large number of consumer units, as in the case of Brazil, requires high reliability and ability to collect and process data from the network. In addition to devices, computational tools can contribute to deciding which policy is best suited for each consumer profile

The success of the management program is directly associated with the monitoring of loads 24 hour per day, so if you get the behavior of each type of load, observing the days not typical for each load and from this monitoring to provide precise actions for each case.

Despite the Smart Grid is a global trend, the deployment process is normally done slowly and in well defined stages, because it involves many challenges, such as [10]:

- Hardware's standardizing, software and protocol communication of the devices;
- High investment for replacement of conventional devices by microprocessor and change data capture infrastructure in each unit of the electric network;
- Study for regulation and tariff policy that may result from the new system;
- The large volume of data to be processed and its security against attacks
- Choice of functionalities of network devices namely, may enable the remote load or promote cut access to the Web via the mains, or measure the energy per unit equipment.

Brazil has set goals for Smart Grid deployment that requires high investments until 2020. Several proposals are already beginning to be discussed by ANEEL, energy companies and industry sectors and research centers.

The first Smart Grid project of largest-scale in Brazil is called Inovcity and is being deployed in the city of Aparecida and it consists in the installation of 15300 electronic meters in the city, that will transmit in real time all information of each consumer. The new equipment will eliminate the traditional manual reading made on each unit and will avoid measurement errors. Another benefit is to reduce fraud and improve the quality of energy delivered to consumers.

A basic scheme of a system with these characteristics must submit at least three levels of network with two-way communication, as is represented in Figure 3.

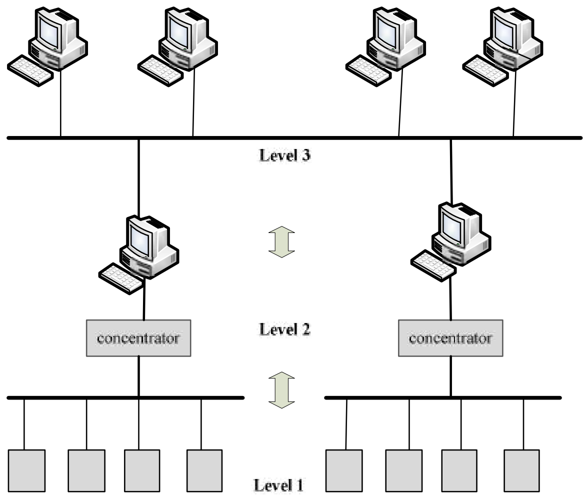

Figure 3. Control system scheme

Level 1 is the level of consumer units (in case of large consumers or special) or set of consumer units connected by hubs. This network is formed by smart meters, with fixed address on the network, where should be installed the tools that enable each unit to apply all of the management features, like sending real-time data, measures, indicators, system information, load curve, tariff schedule price, consumption, etc.

Level 2 is the concentration of a group of consumer units in a particular region. The information for a full region is centered at this stage with the possibility of use of the

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system control tools and access to region information in real time, in addition to data storage for later study.

Level 3 is the network that concentrates and totals information of the system as a whole and carries out communication and information exchange with the SCADA systems of transmission and Generation of the concessionaire.

It is important to note that this architecture, from smart devices have the ability to provide energy management bi-directionally, because currently many consumer units can also store energy or have alternative energy sources that will meet the utility's system at certain times. This can be quite handy, since it can supply the electrical system in times of need or in a contingency, with reliability and security.

Another important factor is the management policy of differentiated tariffs.. The effect of differentiated tariff is of great impact [11]. It is already used in large industrial consumers and it allows a better distribution of load throughout the day. This also is only possible with the installation of smart meters.

In this scenario, it becomes evident the need to have systems with the features of the Smart Grid, able to process a large volume of data in real time and choose the best configuration of the network, as well as to indicate the electrical system trends for the short, medium or long term using tools like the demand projection."

In Brazil, the issues associated with efficient power management and deployment of DSM are widely discussed, but still there are many challenges such as lack of adequate infrastructure and investment to the power sector to modernize.

IV. CONCLUSION

The concept of energy management has been expanded in recent years because of the new demands of the global market, which is alert to indicators of quality, efficiency and sustainability of the electric system.

The challenge is to devise economically viable technical alternatives capable of optimising energy consumption and enable the postponement of investments in the expansion of the energy supply.

Smart Grid is a world trend that presents exactly these features and functionality, as does the electrical system work as a large interconnected system, where there is strong interaction between company and consumers, bi-directionally which enables energy management with the effective participation of consumers.

As described in this article, in the case of Brazil, a long way should be done and there are many issues and technical and economic obstacles to be overcome, although part of the electrical system (high and voltage mean) presents considerable advances in the automation of its processes.

It is important to note that in this initial stage of change of the electric sector there is the emergence of a new environment full of opportunities in developing applications for the Smart Grid, from new algorithms and artificial intelligence techniques for decision support.

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