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Criteria for smart grid deployment in Brazil by applying the Delphi method

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ABSTRACT

The deployment of smart grids has become a global trend in the most diverse electrical systems. This strategy aims to increase the control and efficiency of electrical systems. However, this deployment requires major changes to systems, for example, the information of a telecommunications infrastructure and the provision of adequate equipment, human resources and financial resources. In Brazil, which is territorially large and contains a power distribution system with centralised generation, the deployment of smart grids tends to be time-consuming and could require decades to complete, as well as a large monetary investment. Therefore, the elaboration and implementation of well-defined criteria are necessary for the planning steps of this deployment to minimise the investment cost.

This article aims to develop a methodology for selecting electrical systems that will be implemented in smart grids in Brazil by applying the Delphi method based on technical, financial and human resources and environmental applications. This methodology will be used to evaluate electrical systems in their current operating conditions. The results obtained in this research are the creation of a priority factor to determine the order of Smart grid deployment to achieve the best cost benefit in electrical systems evaluated.

1. Introduction

Smart grids represent an important evolution in the design and operation of electrical systems because they integrate automation solutions, different asset optimisations, process improvement, monitoring and control, the integration of multiple sources of energy (renewable) and the development of new products and services. This integration is already being implemented in several countries via communication infrastructure systems, open standards and information technology.

The goal of this modernisation process is to provide more dynamism in the networks of electrical systems and increase the amount of available information to increase the transparency of activities for both consumers and regulators. This process also aims to enhance the quality and quantity of services offered to the consumer through differentiated tariffs and dynamics that stimulate the optimisation of consumption. However, this process requires the installation of smart metres and increasing the reliability and stability of electrical systems.

The complexity of electrical systems is positively correlated with the challenges posed to all agents of a given system to be successful in the deployment of smart grids in a country. However, the expected benefits for a company as a result of this new paradigm compensate for the required effort during the initial implementation.

In different countries, the majority of smart grid projects have begun with pilot projects or deployment in specific areas. Evaluating real cases before initiating global implementation is critical, independent of the deployment strategy employed. The samples should be representative, and the benefits offered should cover the entire company to leverage further results. The integration of generation, transmission, distribution and consumers must be sought in gathering such results. All regulatory aspects and necessary infrastructures must be considered in deploying smart grid projects, and the involvement of consumers from the beginning is essential for success [1–7].

This article proposes criteria for smart grid deployment in Brazil's electrical power system by applying the Delphi method and the creation of a priority index. Section 2 presents aspects of smart grid

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DEC X Year

Year	DEC
1996	26,09
1997	27,19
1998	24,05
1999	19,85
2000	17,44
2001	16,57
2002	18,07
2003	16,66
2004	15,81
2005	16,82
2006	16,32
2007	16,08
2008	16,61
2009	18,82
2010	18,35
2011	18,40
2012	18,65

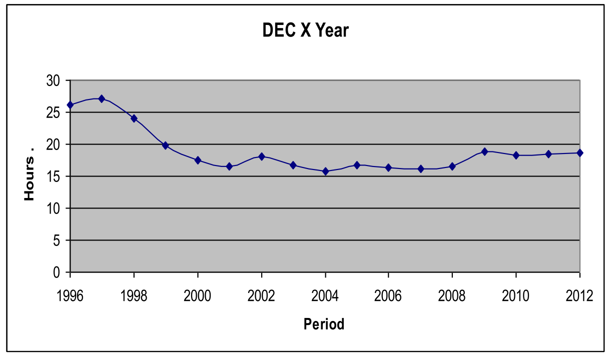

Fig. 1. Equivalent duration of interruption per consumer unit (DEC). (Source: ANEEL [8]).

deployment in Brazil. Section 3 presents a survey of the variables that can affect the deployment of a smart grid. Section 4 presents the criteria for selection of the relevant variables and the representation thereof as indicators. Section 5 discusses the application of the Delphi method and the steps to be followed to evaluate the electrical systems that must be established for smart grid deployment. Section 6 provides concluding remarks and recommendations.

2. Aspects of smart grid deployment in Brazil

The Brazilian energy market is based predominantly on centralised generation. The electric energy sector has always been essentially managed by the actions and initiatives of utilities and regulators of the Regulatory Agency (ANEEL – Electric Energy National Agency) and the national system operator (ONS).

In Brazil, the electric generation and transmission systems employed by electric utilities are already supervised by automated systems that use digital technology to monitor consumption processes in virtually all major centres. These systems offer several features such as tele-supervision, remote control and remote sensing by an SCADA system (system control and data acquisition). These systems indicate the operating conditions of all real-time and automated systems that can track large volumes of cargo.

The reality of the distribution system in Brazil (which features a voltage of less than 34.5 kV) is very different. Due to its complexity and a high number of consumers (approximately 68 million), the automated deployment of these systems is still in its infancy and their management is still performed conventionally. For example, power is measured manually in approximately 95% of consumer units via electromechanical metres, which contributes to the vagueness of measurements and poor monitoring of loads [8].

The graph in Fig. 1 shows the monitoring of an important indicator of quality, Equivalent Duration of Interruption per Consumer Unit (DEC)/year in Brazil.

The monitoring of this indicator is appropriate because it indicates that the average time of interruption was 18.35 h in 2010 and 18.40 and 18.65 h in 2011 and 2012, respectively. This indicator has grown in recent years, which suggests a need for greater system control.

The current scenario of electric systems in Brazil presents the following features:

- Obsolescence of the assets of the distribution system.
- High level of technical and non-technical losses.
- Generation and transmission systems are automated (SCADA).
- The equivalent duration of interruption per customer-annual (DEC) has grown in recent years (a decrease was observed after the automation of generation and transmission).
- System recovery is slow and precarious.
- Slow modernisation of the networks and deployment of smart grids.

One of the main factors that must be considered for smart grid deployment in Brazil is the possibility of preventing fraud and illegal connections. Each year, utilities lose approximately $5 billion due to this problem [9]. Conversely, the need for high initial investments and the definition of clear government regulations are barriers to the expansion of this market. However, this motivation does not apply to the entire territory, which has resulted in the heterogeneous deployment of pilot projects, various project types and smart grid technologies.

The Electric Energy National Agency (ANEEL) and the Ministry of Mines and Energy (MME), in conjunction with national dealers, manufacturers, research institutes, etc., are seeking to create a national smart grid model that meets the profile of the Brazilian consumer and the existing infrastructure, with all of its virtues and shortcomings.

Although the market still awaits a clear definition of regulatory agencies to structure their offerings and set business plans, some of the resources of the smart grid are currently being tested by utilities in the form of pilot projects. The following are examples of such projects being conducted in various Brazilian states:

- Sete Lagoas (Minas Gerais): The CEMIG concession has been conducting a project called "Cities of the future" since 2009, which analyses the capacity and the benefits of the adoption of a smart grid architecture based on tests of the electrical system of the city. The project examines the feasibility of expansion for the concession area of CEMIG and evaluates the products, services and solutions available in the market. New metres and modern

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