International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8 Issue-6, March 2020

Implementation of Smart Grids: Limitations and Regulations

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Abstract: ***Smart grids change the business model of power companies for the benefit of the end consumer. Today, one of the challenges facing the electricity sector in Peru is meeting the demand and energy consumption of society due to urban and industrial growth. This research aimed to analyze the current situation of smart power grids; as well as the viability of the implementation of projects of these networks taking into account the restrictions and considerations within the legal framework in the Peruvian territory. The relevance of these projects will provide electricity to less favored sectors of society and will make current services more efficient. The research is based on a hermeneutical study structured in three stages. First, an analysis of the implementation in Peru. Second, challenges to implement Smart grids in Peru. Third, regulations for the implementation of Smart grids. Therefore, it is concluded that the implementation of Smart Grids must be part of the government's public management policy, taking into account the advantages, vulnerabilities and an appropriate form of regulation in the implementation of these new technologies.***

Keywords: Smart Grid Peru, Current Situation, State of art, Limitations, Regulations.

I. INTRODUCTION

The smart societies of the 21st century have as an essential component the electrical energy system where different electrical devices and mechanisms coexist that make the development of human activities more practical [1]. Today, it is difficult to imagine a world without being supplied with electrical energy that is present in homes, institutions, industries, etc. In this regard "the electricity industry is increasingly evolving from a centralized network to one with greater interaction with the consumer. This is where smart power grids change the business model of power companies for the benefit of the end consumer" [2]. Smart Grids allow better levels of productivity, reliability, efficiency; above all, environmentally friendly and sustainable for the development and improvement of people's quality of life [3]. Smart grids achieve greater reliability, economic balance and reduce the impact on the environment using cutting-edge technologies [4]. It is evident that the needs of energy supply in these times are not the same as 20 years ago; that is why it is essential to develop and manage a smart grid system for the benefit of both those who generate electricity and those who consume it.

Peru through its Supervisory Agency for Energy and Mines Investment (OSINERGMIN) and the energy producer and distributor company (ENEL) have a strategic plan to implement Smart Grids for the country's electricity system, resulting in management energy efficient [5]. In this way, consumers will receive a better quality of service with a higher level of monitoring and automation of smart grids, which will be able to more efficiently manage their energy consumption. Currently one of the challenges facing the Peruvian electricity grid due to the growth of its population and industries is the growth in energy demand, for which Enel has been implementing a series of technologies whose horizon is to achieve intelligent network management electric. This research work aims to detail the state of the art of smart electricity grids that are being implemented in Peru and analyze the limitations and favorable conditions that the electricity sector may face and achieve at the same time.

II. THEORETICAL BASES

A. Intelligent Electrical Network (Smart Grid)

Smart grid is an intelligent network that can manage the behavior and actions of all the users connected to it (those who generate electricity, those who consume and those who carry out both actions) to ensure an efficient, sustainable and safe system with low losses and high levels of quality [6]. It is a smart way to manage electricity.

To implement a Smart Grid, cutting-edge or latest generation technologies are used to create a system that allows two-way communication of electricity or both ways between the electricity company and the final consumer. Smart Grids are essential for the delivery of sustainable, safe and economical electrical energy [7]. Some of the benefits are:

Manuscript received on February 10, 2020.
Revised Manuscript received on February 20, 2020.
Manuscript published on March 30, 2020.
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Figure 1. Benefits of Smart Grids [7]

B. Current Electrical Network vs Smart Electrical Network.

The main differences between the conventional electrical network and Smart electrical networks are shown

Features Conventional networks and Smart Grid	
Conventional Network	**Smart Grids**
Automation	
Limited stock of monitoring elements	Massive integration of sensors, actuators, measurement technologies and automation schemes
Intelligence and control	
Lacks intelligence and uses manual controls	Information and Intelligence System distributed on the network
Autotune	
Device protection before system failures	Responds to real-time transmission and distribution problems
Consumer participation and distributed generation	
Uninformed consumers who do not participate in the network. No local energy is generated implying a unidirectional energy flow	Massive incorporation that allows coordination through the network. User participation with delivery of excess energy generated locally.
Demand management	
There is no management of electrical devices	Users who adjust to energy efficiency schemes through programs
Electrical quality	
Only power outages are resolved, power quality issues ignored	Identification and resolution of power quality problems with different types of prices for various types of power quality
Optimization of public transport	
Electrical energy is lost due to poor efficiency in electrical transportation	Intelligent control systems that allow network transmission capacity
Market preparation	
They seek better models of operation. There is no integration	They seek better models of operation. There is no integration

Figure 2. Characteristics of Conventional Networks and Smart Grid [23]

C. Advanced Metering Infrastructure (AMI)

It is a bidirectional communication system where smart electric meters and other energy management devices converge [8]. This allows new services to be created such as (a) an immediate response to problems, (b) connection and disconnection services, and real-time notification of electricity prices [9]. With the introduction of the AMI counter the following services are created:

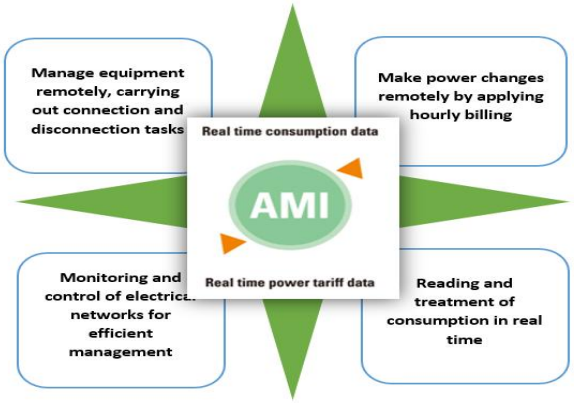

Figure 3. Ami Counter Services

D. Smart grids abroad

One of the first experiences in Europe of smart electrical networks developed between 2002 and 2006 is the CRISP project (distributed intelligence in critical infrastructure for sustainable power), whose objective was to reliably monitor, manage, control and make profitable the energy networks [10]. This project was coordinated by the Netherlands Energy Research Center. On the other hand, the DISPOWER project (distributed generation with high penetration of renewable energy sources) that took place between 2002 and 2005, whose objective was to prepare a safe, reliable and high-quality implementation of distributed generation in networks European [11]. This project was coordinated by the "Fuer Solare Energieversorgungstechnik e.V." Institute in Germany and several other countries such as France, the Netherlands, Greece, Italy, Spain and the United Kingdom, among others. Both projects integrate the resources distributed in the medium and low voltage electrical network. After these advances, more smart grid development projects were carried out in Europe. Of which the most outstanding was in 2007 with the creation of the European Smart Grid Task Force that globally promoted smart grids [12]. In the case of Spain, it shows the projects of the Basque Country and Catalonia (Figure 4) [24].

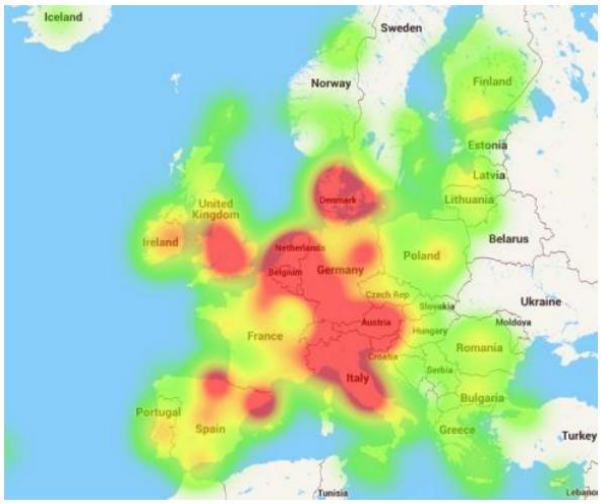

Figure 4. Overview of smart grid projects in Europe 2015 [24]

III. METHODOLOGY

A hermeneutical analysis was carried out that is framed in the comprehensive interpretive paradigm [25]. This research is structured in three stages. First, the analysis of the implementation in Peru. Second, the challenges to implement a Smart grid in Peru and the final stage is the regulation for the implementation of Smart grids.

A. Implementation in Peru

The electrical systems in many regions of Peru are made up of a set of generation plants, a high-voltage transmission network and a local distribution system that supplies industrial and residential customers [13]. However, this infrastructure is vulnerable to various threats to system reliability, such as power outages or unanticipated losses of system components. Given this situation, the management of implementing smart grids in the country is an option to alleviate these problems [14]. In addition to this, the concern as a society for the carbon emissions generated by the electricity industry, the national plan for the generation of energy with renewable resources and the development of electric vehicles that can be integrated into the grid demand an intelligent grid infrastructure. In Peru, there was a plan by the Government to implement smart grids in the electrical system at the national level, which makes it necessary to analyze its scope in the future [14]. The current government presents a Draft Law No. 4335 that promotes the development and implementation of smart electrical grids in the country, whose objective is to achieve greater efficiency in the electrical system, improve monitoring and control of efficient consumption of electricity, and contribute to a greater use of renewable energy and distributed generation, providing users with a benefit greater than the corresponding costs [14]. To develop an intelligent network, it is important to improve existing devices and change communication systems [15]. The implementation of smart grids in the Peruvian electricity system through the execution of smart grids (REI) projects controls the Distributed Generation produced and thus mitigates its impact on distribution grids. To support the implementation of smart grids, it is necessary to develop the legal framework that supports it.

In Peru, OSINERGMIN 2012 carried out a study to determine the costs and benefits of the implementation of Smart grids in the Peruvian network [16]. The project aimed to prepare a diagnosis of the current situation in Peru to check if the application of smart grid technology was feasible and to recommend a strategy, policy, and first projects that allow the country to benefit from the benefits of this technology. The study carried out an analysis of the infrastructure market, the price system and the legal aspect that the Peruvian electricity sector regulates to understand the current situation in the country in relation to the incorporation of this technology. Pertinently, the study recommended incorporating this new technology into the Peruvian electricity grid. Initiatives and projects to incorporate Smart Grids were proposed and a cost-benefit analysis of each of the components in the stages of generation, transmission, distribution and commercialization of electrical energy and the environmental impact plan were carried out [14]. These advantages imply a more efficient use of the energy resources of the countries, which translates into savings. A study by the United States Department of Energy that has 70 million smart meters in different cities calculated that the full implementation of the smart grid would save the country between $ 46 billion and $ 117 billion in twenty years. In addition, the study proposes an action plan for the implementation of smart grids and establishes a vision, strategy and policy for a change in the position of the Peruvian electricity sector in terms of incorporating modern technologies for the next 10, 15 and 20 years [17]

B. Challenges to implement a smart grid in Peru

Among the fundamental challenges for the deployment of a Smart Grid we have:

- The inclusion of smart grids within the electricity system as part of OSINERGMIN's strategic objectives as the competent authority in the electricity sector [14].
- An efficient management of intelligent electrical networks that provides consumption data in real time. Which is a fundamental step to reach a decarbonized, digitized and decentralized world [18].
- A pertinent regulatory framework for the implementation of the Smart grid, which allows a development of this network vision of the future [19].
- The creation of a Research Institute that helps the development of Smart Grids to carry out activities aimed at the efficient use and control of energy consumption [20].
- A demand management and energy efficiency program that contributes to security of supply, mitigates demand growth, reduces generation costs and future needs for the construction of new electrical infrastructures [19].

C. Regulation for the implementation of smart grids

Encouraging investment to improve the current infrastructure of traditional networks and implement smart grids is a government priority in public management policy and technological advances [5]. The government within the framework of regulation to implement Smart grids approved a legislative decree No. 1002 (DL 1002) 2008 for the development of electricity generation using renewable resources by applying smart grids. In the same way. The government, through Supreme Decree DS-018-2016, requires that the electricity distribution companies in Peru (EDEs) propose to OSINERGMIN an action plan to implement smart metering systems. It is essential to have a tariff system and a regulatory model that generate the appropriate incentives for investment in the application of a smart grid system [14]. with this approach, economic agents show interest in investing in the development of the transmission network that improves the reliability of the system [21]. Nevertheless; There is uncertainty regarding the potential benefits, regulation, and free-riding strategies that make international investments slow and delayed, as they expect lower-risk returns before deploying the technology. The investments mentioned refer to the distribution network, which undoubtedly have an impact on the administration of the system, its reliability and its future expansion.

Regulators must confront and manage the exercise of market power, which could result in an incentive to invest on a large scale or underinvest [22]. Many market players, such as network owners and generators, show no interest in investing in new network infrastructure if they have market power.

Due to the aforementioned, it is considered necessary in a regulation to: (a) generate adequate investments (b) improve information management and (c) provide information on the Smart grid to the different agents [14]. Incentive regulation could be difficult for new networks because the costs of integrated services are uncertain and there is unreliable information about those costs among regulators and network operators. For the regulatory body to implement Smart grids in the country, choosing the correct form of regulation is one of the most important points for success in the development of Smart grids, due to the uncertainty that exists regarding the management of future profits.

IV. RESULTS

From the results in Table I, it can be inferred that the implementation of smart grids in the Peruvian electricity system is being treated and managed as part of public management policies today. This significantly impacts the digital progression of networks towards a city of the future. Legislative norms have allowed regulating the feasibility of network projects in the region.

Table- I: Results of the research

Results		
Implementation in Perú	OSINERGMIN proposes to implement an improvement of the current electricity grid system nationwide. ENEL, the feasibility of their study showed that Smart grids must be implemented throughout Peru.	The institution accompanies with a remote-control deployment plan in the face of threats and vulnerabilities of the conventional electrical system. The high probability of inclusion of energy efficiency and information technologies will be economically relevant in terms of cost and benefit to achieve a change.
Challenges to implement Smart grids	Recent changes in the public management system of electricity grids will allow the implementation of the smart metering deployment plan (100% change from the park of traditional meters to smart meters)	Deployment plan is being presented through a relevant regulatory framework that allows the development of this future network management. The plan includes efficient management that provides consumption data in real time
Regulations	The norm DS-018-2016 demands that the energy distribution companies propose to OSINERGMIN an action plan for the implementation of smart grids. The aforementioned regulation, in addition to innovating, proposes to change important aspects of the tariff system and the generation of appropriate incentives for investment.	The importance of the participation of private and public companies in the electricity sector has an impact on the administration of the system and its future expansion. The plan includes an optimal investment schedule for its early recognition.

V. CONCLUSION

This research work concludes that a government action plan is required for the implementation of smart grids with a vision and strategy to achieve a better positioning of the Peruvian electricity sector regarding the incorporation of these technologies in estimated periods of ten to fifteen years. Likewise, a tariff system and a regulatory model are needed to generate the necessary incentives for investment in the implementation of Smart grids. Given the above, choosing an appropriate form of regulation is one of the main points for success in the implementation and development of Smart grids in Peru.

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