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Cooperation of Conventional Electric Power Grids and Smart Power Grids

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Abstract: *The origin of the power industry, electric networks has become today the focal point of various technological innovations. The development of smart grids in our country and throughout the world has been making progress with rapid steps through the merger of currently operational grids with brand new technologies in many aspects. In the foundation of this transition lies the purpose of benefiting even more efficiently from the previously established infrastructure of the currently operational grids. With the integration of smart grids scattered between distinguished lands, smart grids in a national sense will be transformed into international smart networks. Today, many research centers around the globe have been working for facilitating this transition by developing next-generation technologies required for smart grids. In this study, an analysis of currently operational grids and recently formed smart grids is conducted, and certain predictions regarding the transition process have been evaluated.*
Keywords: *smart grid; power systems; smart meter; distribution networks*

I. Introduction

While the distribution system of the past is radial-mute, that of the future will be a smart one. [1,2]. Broadband communication is utilized for these distribution implementations [3]. In addition, grids with advanced protection technologies, and provided with storage and distributed production, thanks to ring systems [4,5,6]. With the help of smart grids, access to the data on the network will be easier, and operations and planning will require less effort. Therefore, system reliability will increase, and an increase in revenues from the perspective of the investor will be observed, for the management of assets will get easier [7].

It is possible to lay a foundation for smart grids through a careful revision of the infrastructure, communication and circuit infrastructure. Although smart grids are established upon the logic of horizontal integration within its fundamental philosophy beginning from its advent until our day, capabilities of a genuine smart grid will be constructed upon top-level implementations, that is vertical integration. For example, it would not be possible to switch to a smart grid system without tight integration of smart meters and home area networks that represent customers at the bottom of the chain in the hierarchical power grid [8]. For this reason, with the emergence of the smart grid, it is necessary to incorporate the existing grid into a serious revision and transform it. Smart grid will be achieved with the installation of control and monitoring systems distributed in the existing electricity network in strategic points. If we evaluate the existing grid as inanimate, the grid will be live, functional and technological with control and monitoring elements.

Around the globe, public companies are usually the first investors and service providers of the energy industry. The goal is to solve the problems with minimum cost and as quickly as possible, without putting critical services at risk. In the process of establishing smart grids, developing countries have a clear advantage over developed countries. Instead of spending time and labor for the integration of the old grid with the smart grid, installing a new smart grid from scratch without experiencing the problem of backward compatibility with currently operating grids will yield more advantageous results.

II. Transition from Existing Grid to Smart Grid

The current electric grid is one of the outcomes of rapid urbanization and infrastructure developments which have taken place during the last century in various parts of the world. Despite being established in many different areas, public service companies have generally adopted similar technologies. Economic, political and geographical factors have had an impact on both the infrastructure and the development of the electricity system in a different manner for each electricity company. Despite such differences, the basic topology of the current electrical system has not changed. Since its inception, sub-systems such as energy sector production, transmission and distribution have allowed them to be operated independently on their own. For this reason, every local area has shaped the automation, the change and the transformation at different levels.

Although the current network is designed to withstand the expected peak demand against the maximum load, the stability of the system has been reduced when the backwardness factor in the electrical infrastructure investments is combined with the excessive increase in the electricity demand [9-12]. It has become possible for any unexpected overvoltage or disruptive power failures to occur in the presence of system anomalies or an excessive demand for the distribution network that is considered to be safe. To troubleshoot malfunctions and simplify maintenance, public service companies have included command and control functions in their electrical networks at various levels [13-18]. The Scada system, known as a typical remote monitoring and data collection system, is commonly utilized throughout the world, and used in our country to a limited extent. Although these systems allow limited control of service companies, there is no real-time control of the system available for distribution networks. For example, while in North America, one of the most advanced electrical systems in the world, only one fourth of the distribution networks are equipped with information and communication systems, this system has never been implemented in our country.

Given that approximately 90% of power failures and malfunctions in the distribution system originate from customers who constitute the lower part of the distribution network, it is necessary to start smart grid operations from the customers. In order to increase their production capacity and their incomes in the direction of increasing demand for electricity, public service companies are trying to accelerate distribution network modernization with new technologies, because of the rapid increase in the cost of fossil fuels[13-18].The distribution network management scheme given in Table 1.

	Technology	**Capability**
Smart Grid	IntelligentAgents + Smart Applications + Network Management	Smart Devices
		CustomerPortals
		Distributed / Cogeneration
		Emission Control
		Auto / Prevent - Improvement
		Transformer Center Automation
AMI	Distribution Automation + Smart Sensors + MutualCommunication	Distribution Automation
		Customer Information System
		Asset Management
		DetectingandRepairingErrors
AMR	OneWayCommunication	AutomaticBilling

Table 1. Distribution network management scheme

In this sector, the distribution network automatic meter reading (AMR) systems provide consumption records, some interruption warnings and remote status reading capability. As shown in Figure 7, AMR technology with a one-way communication system is limited for having the capability of data reading only, although AMR technology initially proves to be attractive. These devices do not allow corrective precautions to be taken, which are based on information at any distance. AMR systems do not allow switching to the smart grid in this respect. As a result, AMR technology was short-lived. Instead of AMR meters, (AMI) meters, the measuring infrastructure of which is advanced throughout the world, have begun to be used. As well as the two-way communication it conducts, The AMI Counter also provides the ability to change customer service level parameters. Thanks to AMI, it meets the requirements of freight management and not reducing incomes. It has become possible to obtain instant information about individual and collective demand from AMI counters, and to develop continuously changing concepts in smart grids. As distribution companies move with AMI technology, they will catch up with smart grid topologies and technologies over time.

III. Transition from Micro Smart Grids to Macro Smart Grid

We can define smart grid as the entirety all technologies, concepts, topologies and approaches that allow end-to-end communication and control within the hierarchy of production, transmission and distribution. The smart grid is a live, intelligent, fully integrated environment powered by all stakeholders enabling efficient exchange of data, services and processes in terms of goals and needs. Smart grids will provide consumers with benefits, if energy management systems are utilized to adjust energy consumption and reduce energy costs. The smart grid is also a self-improving system. It introduces improvements to prevent or reduce system problems by forecasting the drawbacks that will occur.

The integration of the following components is generally required for an intelligent micro-grid network, city-block-based modes of which can operate both connected to the grid and independently [9, 10].

• While micro grids are benefiting from the distribution system in meeting the local demand, they also aim to benefit from the power plants which are not used in the electricity network. Such plants usually use renewable energy sources; such as wind, sun and biomass.

• They provide various services to all customers; including residential, office and industrial loads.

• They provide the use of local and distributed power storage capacity to improve the intermittent performance of renewable energy sources.

• The meters used include sensors that can measure many of the consumption parameters (e.g.: active power, reactive power, voltage, current, demand, etc.) at acceptable precision and accuracy at any distance.

• They have a compatible communication infrastructure for reliable information and command exchange.

• By the help of smart tips, they have the ability to accept commands to control their own performance and service level. They can be moved for loads, statuses and communications in line with user or service requirements.

• This includes a smart core consisting of an integrated network, computer and communication infrastructure elements visible to the user in the form of energy management applications that provide command and control over all nodes within the network. The smart micro-grid and macro grid topology show in Figure 1.

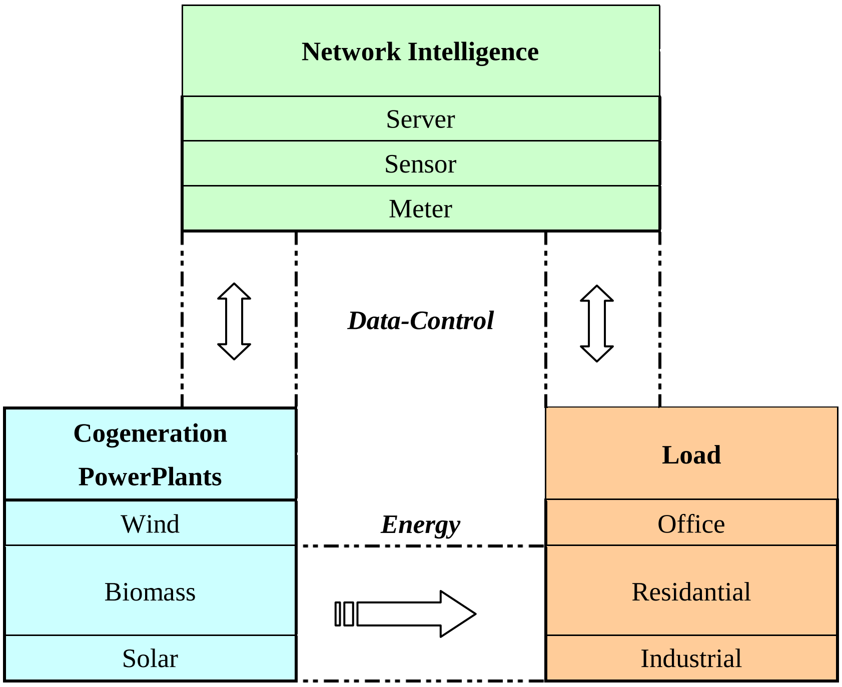

Figure 1. Smart micro-grid and macro grid topology

The emergence of smart micro grids is a necessity introduced by increasing smart grid capabilities and rapid interaction other micro-grids, integration and needs. Depending on the diversity of geographical areas in respect of the work, smart grids, according to the combination of main energy sources and other factors as well as the load condition, will produce special solutions specific for each region with different capabilities and structures.

IV. The Association of Two Generations

With the latest developments in AMI systems, distribution companies have reached to the point where they could begin to evolve from existing grids to smart grids with AMI systems. The costs associated with the transition of distribution companies to the AMI counter systems for the smart grid will be too high for an ultimate transition. For the revision under consideration to be carried out, the function to be given to the old grid should be rendered to work side by side with the new grid, and over time, it must be possible to carry electrical load from the old grid to the new smart grid. Therefore, in the near future, the smart grid will be widely used. As a result; live, integrated smart micro grids with command and control functions in the distribution network will emerge at every level. This grid topology, which encompasses the old and the new smart grid, is a mixed solution, and will be confronted when the systems mature as a function of time and intelligence.The topology of transition to smart grid show in Figure 2.

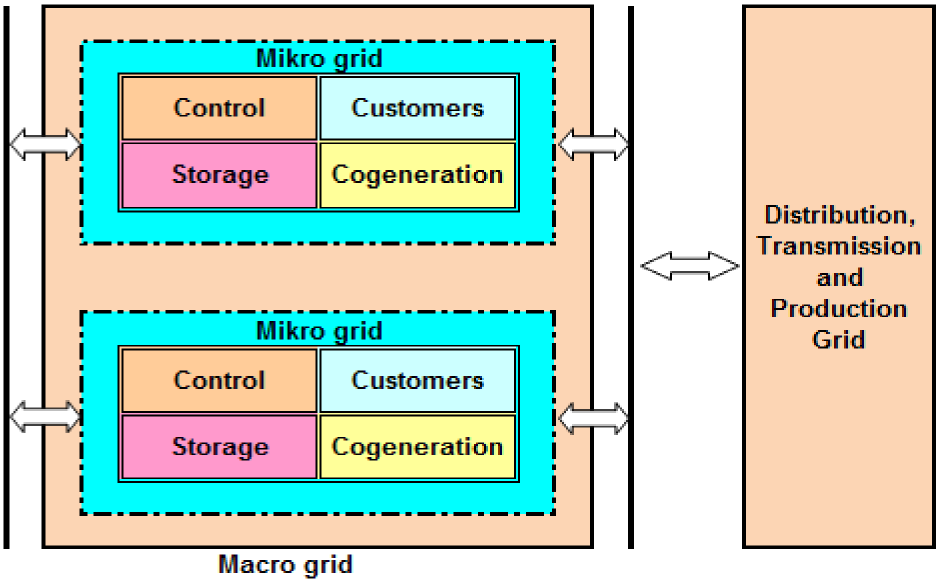

Figure 2. Topology of transition to smart grid

It is natural for distributor companies to avoid investing, because of the difficulties of infrastructure and transition processes intended for an uncertain future. Although smart grids have emerged as very critical service providers with all their capabilities, today, investors are still not convinced how successful smart grids will become. Because adapting to the new technology has always been troublesome. The only way to accelerate the transition phase is to increase the number of R&D studies to validate applications and solutions related to smart grid technologies. The problem is not related to the fact that most public service providers are not equipped with the suitable technology. On the contrary, it is related to its application to the industry (e.g.: communication protocols, computer motors, sensors, algorithms and models) to understand useful applications on many different technologies and to solve possible problems within the smart grid. The problem is that these new technologies do not yet induce enough confidence in public service providers. Given the necessity of making investments that require a great responsibility and in connection with the protection of critical electrical infrastructure, it cannot be expected from any party to boldly venture without making proper preparations for new territories, new technologies and new solutions. Programs need to be developed, tested and distributed with actual loads that verify the necessary smart grid solutions in the presence of various consumption profiles.

V. Conclusions

The electricity sector, as well as undergoing a rapid change, is in a critical period with regard to whether the application of smart grid is to take place. Variables such as increased energy costs, collective electrification of everyday life, and climate change will determine the speed of smart grid transitions. This process is not only a move that influences countries' own industry or consumers, but also is the electrical organization policy and technology of that country. In order to demonstrate the applicability of smart grid systems, which have not been implemented in our country so far, and to encourage customized distribution company regions, it is important that the smart grid implementations are carried out by the state in the distributing companies under the control of the state. The critical services of the existing network will be developed through improvements by shifting the load and functions of the old grid over the new smart grids. For example, the most fundamental problem of the system; that is, the stability problem, will be overcome.

Distributed generation and energy cogeneration will be facilitated via smart grids.The integration of alternative sources will also be facilitated by reducing system's energy management and carbon emissions.

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