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Smart Grid and its Development Prospects In the Asia-Pacific Region

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ABSTRACT

The purpose of this paper is to explain the importance of Smart Grid Deployment in Asia-Pacific region. The paper throws the light on various problems and challenges related to electricity grids that are faced in Asia-Pacific region and the solution to manage those problems by adopting the vision of a "Smart Grid." The essence of this vision is "a fully-automated power delivery network that can ensure a two-way flow of electricity and information between the power grids and appliances and all points in between". The paper also provides the overview on the three key technological components of Smart Grid that includes:

- Distribution Automation(DA)
- Personal Energy Management(PEM)
- Advanced Metering Infrastructure(AMI)

Focusing in on the role of the above three key components of Smart Grid , this paper lays out the Introduction on the factors that are pulling and pushing the utilities to change the way they operate in order to improve the current services. The flow then involves the explanation on Moving beyond AMI to Adopt Smart Grid Vision which includes the overview of all the key components of Smart Grid and thus focusing on the requirement to make the electricity grid "Smart" and revolutionizing the electric power networks. The further explanation is on the Ongoing and Future Projects on Smart grid in Asia-Pacific region. Finally, the paper concludes with the suggestions and proposals for the Regional Approach to Smart Grid Development that explains the demand for Smart Grid capability within Asia which is quite diverse in nature ranging from reflecting the sophisticated nature of electricity demand in developed nations such as Japan and South Korea, to the need for first deployment of grids and massive grid upgrades in the developing economies of India and China.

1. INTRODUCTION

The significant increase in the retail prices of electricity is experienced in the several countries of Asia-Pacific region. This has resulted for the interest in Advanced Metering Infrastructure i.e. AMI by utilities which involves Demand Response programs through which the customers can lower their monthly electricity bills. Often the areas in this region are facing the outage problems especially when the demand is high. The population in countries like India, China etc. is large and so is the demand for electricity. These are some of the reasons that utilities are now actively considering the AMI investments. The utilities have many ongoing pilot programs to consider the effectiveness of new pricing structures enabled by AMI.

AMI involves many features/ways to mange the peak loads like:

1. Demand Metering which is a billing method in which the customer is charged for the normal energy usage plus an additional charge for the peak usage.

2. Time of Use Metering which is again a billing method where the utility varies the price of electricity during different periods of a 24 hour day depending on ON peak and OFF peak hours. The other major benefits of AMI are:

- Automated Meter Reading
- Remote Customer Disconnect
- Outage Management
- Call Center Integration
- Theft Detection
- Distribution Automation

The internal factors are "pushing" the utilities to change the way they operate in order to improve current services. The factors include:

- Grid Performance
  - Reliability
  - System Efficiency
  - Safety
  - Security
- Supply and Demand
  - Pending rate increases

The external demand drivers are "pulling" the utilities to offer new services. The drivers include:

- Evolving customer experience
  - Demand-side Management
  - Value-Added Services
  - Customer Service Quality
- Environmental Pressure
  - EE and RPS mandates
  - Carbon abatement
- New forms of Generation
  - Distributed Generation and Storage
  - Intermittent and renewable Generation

2. MOVING BEYOND AMI TO ADOPT A SMART GRID VISION

Metering was all about "Feeding" utilities commercial processes that include metering, meter

reading, billing and clearing. Utility networks are "One Way" networks and the last mile is still "BLIND".

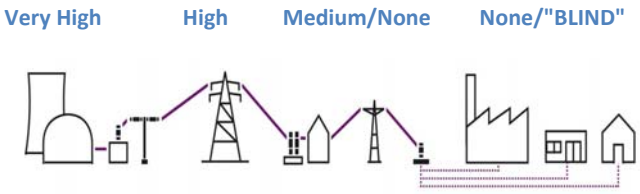

Figure 1 Automation/Real Time Feedback

This paper focuses on this "last mile" i.e. the growing urgency to make the Electricity Grid "SMART." We are in transition phase today. The major challenges in this region are:

- quality, security and reliability of supply
- cross-border power trading and grid services
- ambitious energy policies and environmental goals
- electric vehicles
- real time and variable pricing
- growing expectations from consumers

As power failures occur relatively in this region especially India, Nepal, China as compared to other regions, there's been an urgent need to renovate the country's power network and since 2005 the research projects and government policies focusing on smart grid and next generation electric networks have been carried out. The above challenges can only be met if we move towards the future vision of electricity system and making our electricity network "Smart". The user specified quality, security and reliability of supply for the digital age can be achieved. Harmonized legal frameworks facilitating cross-border trading of power and grid services, extensive small and distributed generation connected close to end customers etc…all can be achieved. But all this is very far until and unless we move our approach towards Smart Grid.

"A Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it –generators, consumers and those that do both in order to efficiently deliver sustainable, economic and secure electricity supplies." Smart Grid refers to next generation Electric power network that makes use of IT and other high technologies so as to operate intelligently. Compared to telecom industry the power sector has not developed remarkably in terms of innovative technologies. But if we see the scenario of telecom industry, earlier say 8-10 years back the telecom industry was not developed as it is today. The mobile phones were just used as a means of wireless communication i.e. just for outgoing and incoming calls. But now the remarkable revolution has been observed in this industry from past 5-8 years wherein now this industry with the use of latest IT and other innovative technologies offer thousands of services to its end customers. Now it's the turn of power sector, as, smart grid by revolutionizing the electric power networks and being almost as powerful as the Internet, is attracting many attentions among various industries.

Smart Grid is a system that enables two-way communications between consumers and electric power companies. The must requirement for Smart Grid is the intelligent meter i.e. the smart meter which is installed on the consumer side. You can have "Smart Metering" without the "Smart Grid"…but the "Smart Grid" is built on "Smart Metering." The basic drivers for Smart Grid are:

- Energy Efficiency
- Demand/Response
- Integrated Multi-Energy
- Revenue Protection
- Operational Efficiency
- Customer Satisfaction

Smart Grid is a One System for Advanced Metering Infrastructure (AMI), Distribution Automation (DA) and Personal Energy Management (PEM). It is a secure, scalable, interoperable, intelligent and proven system with the path to future enabling applications for Smart Grid today. In a Smart Grid system, consumer's information is received by the electric power company in order to provide the most efficient electric network operations. This paper focuses on explanation of smart grid with the short description on AMI and DA followed by the description on PEM which is yet to be achieved and is the major part for smart grid initiative along with the solution as to how PEM can be integrated with smart grid.

Advanced metering infrastructure (AMI) is architecture for automated, two-way communication between a utility's smart meter with an IP address and a utility's head end systems. The goal of an AMI is to provide utility companies with real-time data about power consumption and allow customers to make informed choices about energy usage based on the price at the time of use. AMI differs from traditional Automated Meter Reading (AMR) in that it enables two-way communications with the meter. It involves the intelligent use of Demand/Response system where the end customers are aware of the pricing rates of electricity when the demand is high or low and the customers can use their electric appliances accordingly.

Distribution Automation System provides tools for the distribution power network's security, economical operation. It guarantees power quality, perfecting facility management as well as increasing working efficiency and providing a series of solutions for the distribution automation system. The system supplies the function of power grid monitoring, control, failure management, and power balance and charge management. It improves reliability with real-time monitoring and intelligent control. This system is basically head-end network management software. It provides network speed enhancements. Improving efficiency and reliability of a distribution network is a critical goal for many utilities. Two-way communications with the protection and control devices on the distribution portion of the smart grid is fundamental to achieving those energy efficiency and reliability goals. Distribution Automation (DA) devices themselves are evolving to be more robust and reliable,

offer higher computing power, and act as a source of planning data. And given utilities' continual focus on improving energy efficiency and power reliability, matching these improvements with real-time communications is a key. Understanding the status of devices like: switches and reclosures, capacitor banks, voltage regulators and transformers in real time enables much faster outage detection and notification and improves fault location and isolation. It also increases energy efficiency through better capacitor and voltage control and improved asset management. Many analysts believe DA is the secret to making the Smart Grid pay for itself.

Personal Energy Management (PEM) is a critical component of the smart grid. It opens the door for energy consumers to become directly involved in monitoring and controlling energy use. It provides utilities with the tools to more uniformly control peak load, and ultimately support new sources of generation and new uses of electricity. Personal energy management is the future of energy efficiency. This is one of the aspects of the Smart Grid that has only recently begun to emerge: using Home Area Network to engage the energy consumer more directly in the energy management process. Today's advanced metering technology provides a ready communication gateway into the residence or business that didn't exist before. A smart distribution grid requires the means to remotely, securely and automatically capture information, monitor performance, and execute commands that enable efficient and reliable power delivery. Personal Energy Management takes this concept directly to the consumer with a variety of applications for reducing peak load, monitoring alternative generation, managing recharging of plug-in hybrid vehicles and prepayment of electric service. The Smart Grid solution for home automation utilizes the advanced digital meter with secure **ZigBee** communications to support a variety of personal energy management features, including:

- **Variable pricing:** - using an in-home display, consumers are notified of peak pricing and time-of-use rates. In addition, consumers are able to monitor and track kWh (real energy usage) consumption over time. Alerts can warn customers of unexpected or high consumption, leading to better efficiency and reduced costs.
- **Load management:** - two-way, verifiable load control for appliances and commercial/agricultural equipment provides reliable information and control for load reduction programs.
- **Programmable HVAC controls:** - programmable, communicating thermostats provide another option for control of air conditioners and heating systems during peak periods.
- **Distributed generation:** - integrated communications provide opportunities to track net generation and transition customers from site-generated or stored power back to the utility's distribution system during optimal times.

In the Home Area Network, each meter has a separate radio for home communication. ZigBee which is a low power wireless communication technology provides an affordable and standards based approach to home automation, which allows for robust, but simple and cost effective solutions to be developed that can provide increased convenience, efficiency and safety for the average home owner. The Home Automation Profile supports a variety of devices for the home including lighting, heating and cooling, and even window blind control. ZigBee technology and the Home Automation profile provide interoperability from different vendors that allow a greater range of control and integration of different devices in the home. The ZigBee technology also supports commercial controls for lighting, HVAC, water heating and distributed generation.

3. ONGOING PROJECTS IN ASIA-PACIFIC REGION

China has embarked on a 10-year project to build a "Smart Grid" that will catapult its power transmission into the digital age, securing electricity supplies and boosting energy conservation. The Government of India has devised a scheme which is called the Restructured Accelerated Power Development and Reforms Program to address the strengthening & upgrading of the Indian transmission and distribution network. The program calls for an investment of US $ 10 billion over a five year span.

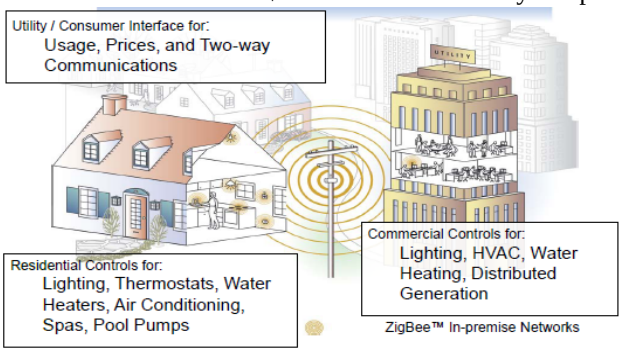

Figure 2 ZigBee Gateways Interface Consumer's Devices to the Utility

The Japanese trade ministry has estimated the shift to renewable power will require a grid upgrade at a cost of between US$ 51 Billion and US$74 Billion by 2030. Korea aims to create a nationwide Smart Grid by 2030 for an electricity market worth US$ 60 Billion.

4. CONCLUSIONS AND SUGGESTIONS FOR REGIONAL APPROACH TO SMART GRID DEVELOPMENT

The scope of service providers have been limited in the power transmission and distribution systems across the globe. However, the willingness to improve the service quality of the power delivery mechanism has led to incorporation of new features in the system. The smart grid aims at improving the involvement of client in the

power delivery mechanism. The development and expenditures on Smart Grid-related projects in Asia are already impressive. Nonetheless, even after massive power sector reforms, China, India and other Asian nations still face shortages in electric power. According to the US Energy Information Administration, the world's electricity generation is projected to increase by 77 percent from 2006 to 2030. But the Asian countries will increase generation by 200% over that period. So the need for grid improvements is increasing. Individual States in Asia-Pacific Region face significant challenges in evaluating and shaping utility Smart Grid proposals, since it represents a complex technical challenge. Commission staffs, for the most part, do not have personnel trained in this area and lack the finance resources needed to hire outside consultants. Without obtaining additional help, individual states run a significant risk of simply responding to utility AMI agendas and forgoing any opportunity to move forward with their own Smart Grid agendas which could potentially create more competitive and robust market activity and substantially greater customer benefits.

An additional consideration for states is the need to coordinate their activities with one another. Many of the interoperability and functional specification issues are common throughout the region and are probably best dealt with regionally rather than on an individual state basis. It is suggested therefore that the states in this region work together in a collaborative fashion to come forward for developing the AMI systems that will support a Smart Grid vision. The key issues that need to be dealt with this regard includes: - resolving interoperability issues, defining the minimum technical requirements for the system and establishing the appropriate technical standards.

Further, because of growing environmental concerns, it is suggested that Asian grids need to become far more flexible than they are today, accommodating distributed power generation from renewable sources and use several energy-efficiency techniques.

Within Asia, the demand for Smart Grid capability is quite diverse in nature ranging from reflecting the sophisticated nature of electricity demand in developed nations such as Japan and South Korea, to the need for first deployment of grids and massive grid upgrades in the developing economies of India and China. Yet, there is also general consensus that existing electricity grids in Asia are not sufficient in terms of capacity, efficiency, reliability, security, and environmental impact to supply the electrical power needs of modern societies. Therefore the need of the hour and for modern revolutionizing societies of Asia-Pacific region is to adopt Smart Grid Vision.

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