IoT Enabled Smart Grid

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Abstract— Due to availability of internet and evolution of embedded devices, Internet of things can be useful to contribute in energy domain. The Internet of Things (IoT) will deliver a smarter grid to enable more information and connectivity throughout the infrastructure and to homes. Through the IoT, consumers, manufacturers and utility providers will come across new ways to manage devices and ultimately conserve resources and save money by using smart meters, home gateways, smart plugs and connected appliances. The future smart home, various devices will be able to measure and share their energy consumption, and actively participate in house-wide or building wide energy management systems. This paper discusses the different approaches being taken worldwide to connect the smart grid. Full system solutions can be developed by combining hardware and software to address some of the challenges in building a smarter and more connected smart grid.

Key words: IoT, Smart Grid

I. INTRODUCTION

The Internet of Things (IoT) is the network of physical objects embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data.[1] In existing electricity infrastructure there are few bigger central generating stations which deliver energy to the different consumers. However in order to tackle the ever rising need for energy and comply with social and economic demands, the usage of alternative energy resources are increases which are smaller and decentralized. This leads to a very dynamic future energy network, where electricity will be produced in a distributed way, where customers will be not only consumers but also producers and where bidirectional interaction between producers, consumers and other entities will be possible.

The Smart Grid is a highly dynamic complex ecosystem of energy production and consumption parties that heavily uses Information and Communication Technologies (ICT) in order to be more efficient compared to its current traditional operation[2]. One of the major components of Smart Grid is to have timely monitoring and control. The functionality offered by the networked embedded devices that would realize the monitoring and control part which is crucial for the success of the Smart Grid[3]. Because of The Internet of Things the networked embedded devices will not only be connected but will be able to exchange information over the Internet in an open way.

The Smart Grid can give prediction for sunny and windy weather which will mean that more energy will be produced by green generators. This information can also flow into energy production plants of power plants that can now reduce their production. Factories can plan to schedule energy hungry tasks during that time as electricity will be available from local generators (e.g. photovoltaic panels), and electric cars can fully charge benefiting from low electricity prices. Due to the dynamic distributed nature of Smart Grid, as well as its large scale, optimizations will result at local level, and negotiations and cooperation among all entities will eventually lead to energy efficiency.

II. MAKING THE GRID INFRASTRUCTURE, METERS HOMES AND BUILDINGS MORE CONNECTED

The Internet of Things (IoT) is expected to grow to 50 billion connected devices by 2020 (Cisco, 2011) providing valuable information to consumers, manufacturers and utility providers[4]. Within the IoT, devices across a variety of industries will be interconnected through the Internet and peer to- peer connections as well as closed networks like those used in the smart grid infrastructure. With the global focus on energy and water management and conservation, the IoT will extend the connected benefits of the smart grid beyond the distribution, automation and monitoring being done by utility providers. Management systems for in-home and in building use will help consumers monitor their own usage and adjust behaviors. These systems will eventually regulate automatically by operating during off-peak energy hours and connect to sensors to monitor occupancy, lighting conditions, and lot more[5].

III. THE GRID NEEDS TO CHANGE TO FACE TODAYS CHALLENGES

In the simplest terms, building a smart grid means securing the future of energy supply for everyone in a rapidly growing population with a limited power production capacity. A smart grid reduces the losses, increases efficiency, optimizes the energy demand distribution and also makes large-scale renewable energy such as solar and wind deployments a reality. With an older infrastructure, the grid is facing severe challenges including recurring black-outs in major industrialized cities around the world, more than 30 percent electrical energy is lost from production to homes.[6]

The grid topology needs to adapt and shift from a centralized source to a distributed topology that can handle different energy sources in a dynamic way. There is a need to track real time energy consumption and demand to the energy supply:

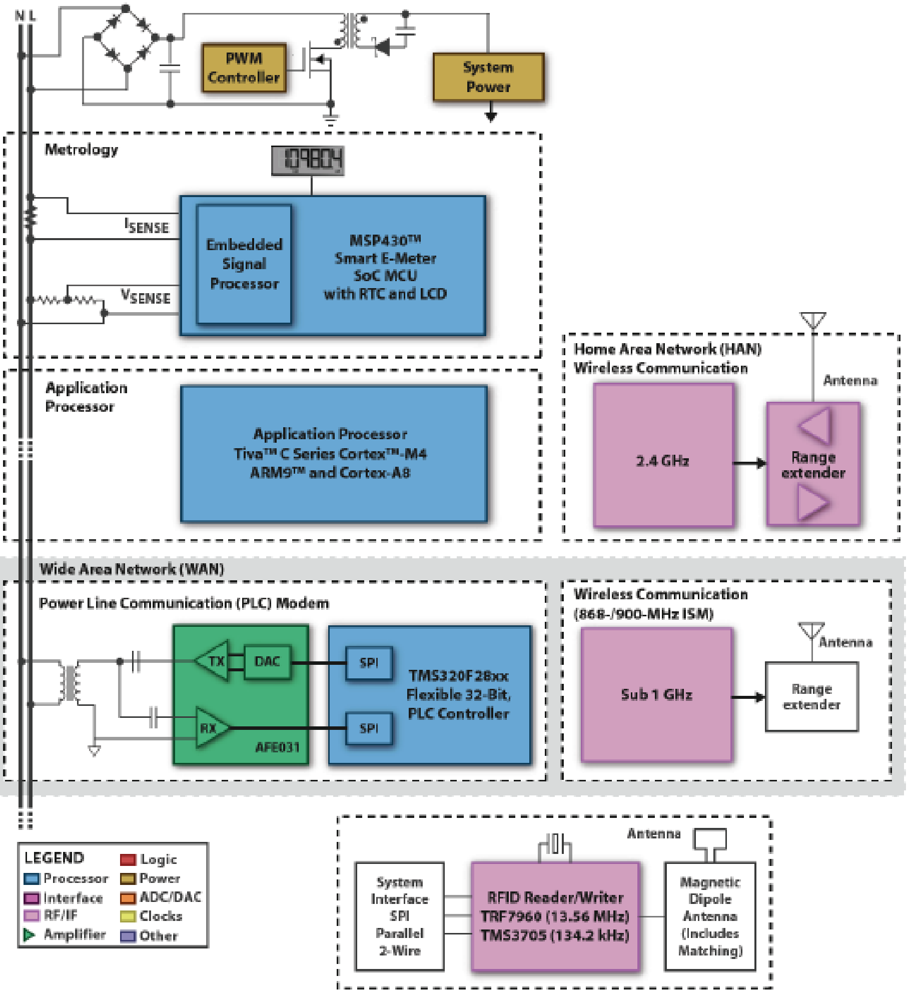

Fig. 1. A smart electrical meter supporting multiple connectivity options

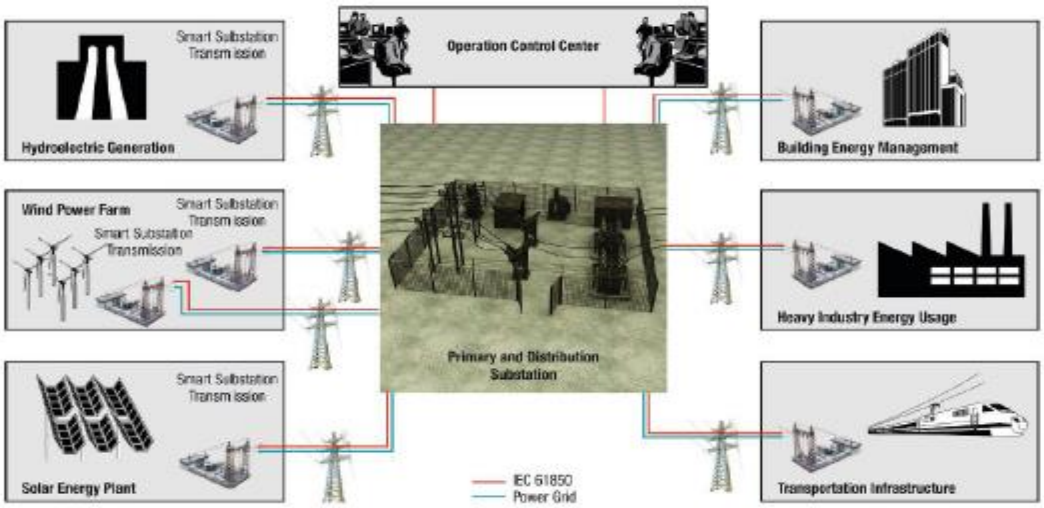

Fig. 2. Power grid and substation communication network

this goes with the deployment of more remote sensing equipment capable of measuring, monitoring and communicating[7]. The connected smart grid provides a communication network that will connect all the different energy related equipment. Essentially electrical meters are extending their functions from an energy measuring device to a two-way communication system as shown in figure 1. Smart meters need to report energy consumption information from houses and buildings back to the utilities. Making the IOT real requires a larger portfolio that can go from wired to wireless and sometimes combined together. The meter needs to deliver useful power consumption information into the home through an in home display or a gateway. This information allows consumers to adapt energy behavior and lower utility bills. Electrical meters are becoming smart sensors that communicate both ways, inside and outside homes and buildings, connected to each other in a mesh network while reporting essential energy data to utilities[8].

As shown in figure 1, On top of the metrology piece that measures energy consumption, several radios or PLC solutions are now integrated onto the meters. Sometimes, prepayment and near field communication (NFC) functions are also implemented. The needs of host microcontrollers (MCUs) are changing, which require them to have greater memory size and more connectivity and security options to carry the communication protocol. Additionally, the MCU on a smart meter needs to support advanced functions like dynamic pricing/ demand response, remote connect and disconnect, network security, over-the-air downloads and post-installation upgrades so utility providers do nost have to send out technicians to each meter[9].

IV. SMART SUBSTATIONS

From production to consumption, the substation is the key of grid equipment that establishes the link between utilities and homes and building premises[?]. A substation transforms voltage, drives the flow of power, isolates and reroutes the power path as needed, manages and coordinates distributed energy source from solar to wind and deals with power outages and recovery as shown in figure 2. The ability to dynamically locate, map, monitor and control the substation is one of the key goals of an automated distribution to ensure better grid operation. The equipment in substations like breakers, transformers, and generators create a time-sensitive network, collecting all the substation information in a centralized operation center, which also establishes a two-way communication. With connected smart meters and substations as shown in figure 2.

V. ENERGY SAVING, COMFORT AND SECURITY: SMART GRID AND THE IOT FOR CONSUMERS

One of the side benefits of the smart grid was to proactively allow repair teams to pinpoint outages by using the communication system in neighborhoods. By driving inquiries to the home and office, critical infrastructure could be restored sooner than the traditional method of self-reporting outages. A critical piece of the demand response system was connecting smart appliances to the energy-monitoring portal to give customers the flexibility to defer energy usage to non-peak times. The introduction of electric smart plugs, in-home displays, and smart thermostats has given consumers a choice on which household devices they want to monitor. Simply plug the appliance into the smart plug and add it to the home network. Through ZigBee or Wi-Fi the user can then connect to the Internet to get information through a home gateway or allow direct connection via cloud connectivity with a smart phone or tablet[10]. Consumers are adopting smart plugs more quickly than high end appliances with smart technology since they are lower cost and allow retrofitting of existing appliances[11].

VI. CONCLUSIONS

Migrating to smart meters adds a new layer of complexity, the return on investment, such as improved customer experience and energy efficiency, is becoming more apparent. The grid itself is also changing and moving towards a fully automated substation network. The connectivity and accessibility that the IoT brings further enhance the customer experience and efficiencies allowing greater interaction and control for consumers. Additionally the IoT delivers more data for manufacturers and utility providers to reduce costs through diagnostics and neighborhood-wide meter reading capabilities. Ultimately, the IoT will be instrumental in building a more connected, cost-effective and smarter smart grid.

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