Report for the GSMA

Why Mobile for Smart Utilities?

Assessing Service Opportunities in the Utility Sector for the Mobile Network Industry

GSM Association
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1. Abstract/Executive Summary

The utility industry is undergoing a significant transformation it its operating landscape, driven primarily by economic demands and regulatory mandates. A critical component in adjusting to this transformation will be a much greater level of industry reliance on tools and techniques that incorporate automation, communications and information technologies.

Most of the basic connectivity and communications requirements of the emerging smart utility industry can be satisfied using mobile network technologies. There is considerable scope to leverage the mobile eco-system's cost reduction expertise and expertise in technology change management. Taken as a whole, the mobile industry is well positioned to become a key partner for the utility industry.

Beyond the provision of simple connectivity, including scenarios where mobile technologies need to coexist with other access technologies, there will also be a range of new service and revenue opportunities. Value will be created from more efficient use of utility assets, consumer engagement for dynamic demand management, and, affinity marketing.

However, for this partnership to work, mobile network operators (MNOs), equipment and device manufacturers must first understand the business and operating needs of the utilities sector.

GSMA retained KEMA, an engineering consultancy for the utilities sector, to provide an introductory report on the utility sector, its operating structures and future needs. This report also examines the opportunities for the mobile industry in light of the requirements of the utility sector.

Primary drivers of change in the utilities sector

- **Economics:** Raw energy, site, construction and financing costs continue to rise and are problematic for capital intensive, central generation projects. Utilities must extend the value of existing plant and enhance cost effective operations of new and existing systems using automation, communications and control technologies.

- **Climate Change:** Control of Green House Gas Emissions (GHG) through the energy delivery value chain depends on remote data-monitoring and management capabilities.

- **Policy and regulatory mandates:** Governments in many countries are regulating and mandating the development and roll-out of Smart Grid technologies for increased reliability, security efficiency and reduction of GHGs.

- **Integration of Renewable and Distributed Generation**: In many countries, mandates for renewable generation in the form of wind and solar as well as distributed generation and demand response depend on two-way communications systems for effective utilisation and safe management of utility transmission and distribution networks**.**

- **Aging infrastructure:** Current energy transmission and distribution systems are very old and employ technologies that are obsolete. The existing utility communications infrastructure is limited in coverage, capacity and functionality. Future requirements call for robust, flexible and effective two-way communications systems throughout the energy delivery service territory.

- **Aging workforce:** The majority of the utility workforces in many countries are within a few years of retirement. Automation and intelligent systems will enhance the operational effectiveness of a smaller and less expert workforce.

The Smart Utility will require modern communications and control capabilities

The Smart Grid is a term that encompasses the integration of all power system elements in the utility sector using communications and control technologies. The Smart Grid has no clear universal definition, particularly as the boundaries vary among individual stakeholders in the utility eco-system. However, all definitions of Smart Grid consist of the following elements: distribution automation (DA); automated metering infrastructure (AMI); energy management, electric vehicles (EV), distributed generation and storage.

A fundamental enabler for the Smart Grid is a widely available, secure two-way communications platform. **A range of assets in the possession of the mobile industry are uniquely suited to providing such platform for the Smart Utilities, including coverage, end-to-end security, experience in managing millions of distributed objects and volumes of data, as well as financial strength and stability of the mobile ecosystem.**

Why mobile for utilities

- Utilities need communications **coverage throughout their service territory**, extending to and within the customer premises to enable new energy delivery-related products and services. This requires comprehensive coverage of two-way communications systems. Mobile Network Operators have broadband wireless network coverage of populated areas, and can quickly deploy reliable and secure machine to machine (M2M) communications and backhaul facilities, with guaranteed capacity/throughput performance and managed quality of service (e.g. VPN / VPLS; QoS / CoS etc.).

- The Smart Grid will be supported by numerous complex and heterogeneous communications networks. The utility sector requires **partners with experience in the large scale network deployment, management and security**. The mobile industry has the most extensive experience in deploying diverse networks into a cost effective and reliable fabric.

- The Smart Grid raises the challenge of **managing rapid technology** change in an industry that is accustomed to slow and deliberate development. Utilities need partners from the mobile industry which has successfully managed some of the fastest technological change and innovation of all infrastructure related industries.

- The Smart Grid opens up the possibility for utilities to offer **transactional services**, such as real-time energy pricing, payment for electric vehicle charges, and many others, directly to their customers as well as through third parties. The mobile industry offers the most extensive systems, tools, processes and experience in transactional service development, bundling, and deployment.

- The Smart Grid will require **management of millions of widely distributed managed objects and devices**. The mobile industry has extensive experience in integrated network management of large field networks.

- **Utilities prefer to work with established and well capitalized entities** that reduce operational and performance risk associate with large infrastructure projects. The mobile network operators offer the operational size and financial viability that competing providers will find difficult to match.

Immediate opportunities for mobile-utilities partnerships

The rollout of the Smart Grids will be a lengthy process. Hundreds of Smart Grid trials and pilots already in place, and the first networks are expected to be operational in 3-5 years' time. KEMA identified a wide variety of immediate connectivity and value-added application opportunities for mobile-utilities partnerships to support these deployments.

The technical and cost-competitive strengths of mobile should be focused on Advanced Metering, Distribution and Substation Automation, Distributed Generation, Demand Response, Electric Vehicles and Energy Storage Integration and Auxiliary Services. Each of these constitutes a value-added service and offers significant revenue potential to service provider partners beyond the provision of connectivity and communications.

In time, the advantages and benefits of cellular networks are expected to become more apparent and have greater impact as automation becomes more comprehensive and moves beyond to the edge of the electricity distribution network.

In markets where meter data is not utility-owned, a predominant and compelling opportunity for MNOs is in offering “Smart Home” and “Smart Business” services, bundling energy management and home/business automation services (along with existing triple-play or quad-play services). Such services can reduce customer churn for both utilities and mobile customers, and present opportunities for new revenues.

Mobile operators may also become energy delivery and management re-sellers directly to businesses and consumers. The ability of consumers to monitor, manage and control their energy usage and carbon footprint conveniently from their mobile phones nearly anywhere in near “real-time” is a form of empowerment likely to play well with both consumers and regulators. Moreover, linking mobile and utility brands through affinity marketing might help to increase consumer awareness and acceptance of new smart energy services.

Recommendations for the mobile industry

Regulatory conditions and ownership models vary greatly throughout the world and within regions, and present different challenges and opportunities for mobile operators. This report provides only a top level assessment of the steps that need to be taken by the mobile industry.

- **Communicate value and commitment**: Many Utilities have had limited success in finding common ground with the mobile industry in the past as cellular operators typically demonstrated little interest in accommodating the particular needs and specific requirements of this sector. It will be important for the mobile industry to demonstrate its commitment for the scale and longevity for utility-sector requirements. This includes making the case for the value of mobile platforms as a central building block and one that is capable of coexisting with other platforms

- **Participate in the Smart Grid standard-setting activities**: Smart Grid Standards are emerging now, driven by such organisations as NIST in the USA, CEN-CENELEC-ETSI in Europe, IEC and IEEE internationally. The mobile industry should take advantage of the opportunity to affect the market.
- **Create partnerships**: MNOs can greatly supplement/complement their capabilities and resources through partnerships with product, systems, applications and service providers catering to the specific needs of utility operators, consumers and energy market participants.
- **Create personalised and flexible service offerings that extend beyond connectivity**: From communications infrastructure to managed services to outsourced applications, MNOs' core strengths can fit multiple demands of the electric utilities. However, different utilities have different requirements and constraints. MNOs may capture greater market share by accommodating those differences effectively through suitably designed services and service-level agreements.
- **Prepare to support third parties with utilities**: MNOs and utilities can develop attractive value propositions for managed and hosted services to utility providers as well as energy management services to building managers, electric vehicle (EV) fleet managers and individual residential consumers and mobile customers.
- **Identify and fully understand the main barriers for the deployment of wireless networks for Smart Grids, and work with utilities partners to overcome those hurdles:** Differences in life-cycle of wireless and utilities product and service offers (3-5 years versus 15-20 years) will require a discussion of technology refresh for utilities partners. Other areas that need to be addressed include network availability and traffic prioritization in cases of congestion, e.g. in emergency situations, as well as the flexibility to be able to switch providers (required by regulators in some markets).

This report by KEMA takes the first step in demonstrating mobile industry interest and commitment to the utility sector. It is aimed at a very broad audience across the mobile industry because there is a need for a basic understanding of the main issues facing their utilities customers.

This report explains the architectural and operating frameworks for different types of utility operators, and the challenges facing grid operators as they migrate from aging infrastructure facilities and systems to more flexible, automated, reliable, safe and secure generation, transmission and distribution grids. It also analyzes opportunities for MNOs to play a major role in delivering technical solutions and services to support the advent of Smart Grid, providing the basis for the upcoming generation of embedded mobile devices and services.

2. Introduction to the Study

The development and deployment of the Smart Grid and Smart Utility systems represents a large, global opportunity for communications systems and service providers, device manufacturers, software and applications developers, systems integrators and hosted service bureaus; capturing the value of these opportunities depends upon a thorough understanding of the utility sector and the technical, commercial and regulatory requirements of the Smart Grid and Smart Utility environments. Further, utility sector product and service suppliers must undertake effective initiatives in a timely fashion to ensure effective positioning to offer solutions.

This report introduces and analyzes the utility sector relating directly to mobile industry potential to play a role in the Smart Utility future. It identifies the potential value of existing and evolving mobile carrier offerings within the Smart Utility vision, creates knowledge about the market opportunity and outlines critical background knowledge about the utility sector for those who intend to participate in the Smart Grid marketplace. The intent of the report is to provoke thought, to outline possibilities and to stimulate initiatives within GSMA to increase the potential for its members to be involved in this vibrant part of the utility marketplace.

Supplementing its experience in the utility sector, KEMA conducted interviews with mobile carrier representatives operating in different regions to assess specific market concerns in their respective areas. KEMA further conducted interviews with several vendors in the Smart Grid market as well as electric utilities that are actively pursuing Smart Grid programs. Insights and feedback garnered from this informal survey are incorporated into the report.

The materials provided in this report are organized as follows:

- Overview of Utility Sector Structure and Principal Components
- Description of Smart Grid Concepts, Drivers and Constraints
- Review of Smart Grid Requirements and Anticipated Market Demands
- Identification of Potential Opportunities for MNOs, and
- Presentation of Findings and Recommendations.

3. Introduction to the Utility Sector

This section provides a brief introduction to the Utility sector, covering:

- Structure of the Utility Grid Operations; elements, assets and entities of generation, transmission and distribution systems
- Ownership structure of the Utility Sector
- Legal and regulatory structure of the Utility Sector

A glossary of the terminology used in the report, and a bibliography of references are provided in Appendices H and I of this report.

The utility industry is experiencing a period of rapid change. In order to appreciate the emerging needs of utility operators and gauge the specific nature and extent of the opportunities for supplying the requisite operations and business support systems, an understanding of both prevailing regulatory frameworks and the diversity in business drivers, technology trends and specific requirements in relation to the sector’s organization and structure components is needed.

Regardless of any particular structural and regulatory circumstances, it is understood that a powerful and expansive communications infrastructure needs to be deployed to integrate many aspects of power generation and delivery – particularly with the advent of distributed generation approaches and interactive demand response programs – into a fully- functional, highly-automated Smart Grid. Outsourcing communications infrastructure, whole and in part, is a common approach for utilities throughout the world.

3.1 Utility Operations Components and Structure

The diagram shown on the following page (Figure 1) shows the principal elements of the utility operations chain include the following:

- Generation - the production of the electric energy
- Transmission - transports electricity at high voltage over long distances
- Distribution - Transports electric power from distribution substation, which steps down voltage from transmission system, to end-user facilities (commercial, industrial and residential).

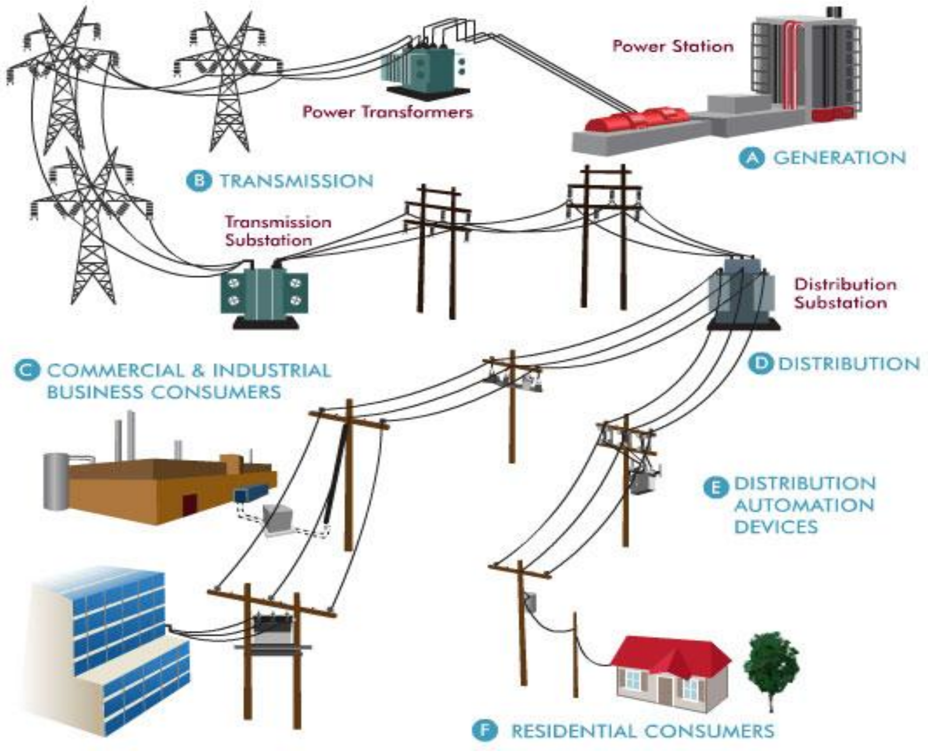

Figure 1: Principal Power System Component[1]

3.1.1 Generation Assets and Systems

Generation refers to all technologies that produce power, including traditional, centralized generation such as coal- and gas-fired, nuclear and hydropower renewable generation systems such as solar, solar-thermal and wind. A utility may use different generation sources depending on demand variations, availability and price of supply. There are base load generation assets, which include reliable, large-scale, cost-effective technologies such as coal-fired plants, nuclear and hydroelectric dams. Intermediate assets, which often take less time to come online and therefore can be more responsive to changing demand curves, include oil- and natural gas-fired Combined Cycle Gas Turbines (CCGT). “Peaking” plants, operated during periods of maximum demand, often use oil, diesel or natural gas Combustion Turbine (CT).

Operational and investment decisions by regulated and merchant generators for generation assets involve a myriad of tradeoffs. Capital and fixed costs are compared to operating costs

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[1] http://www.oncor.com/images/content/grid.jpg

(mostly driven by fuel costs). Operating costs are compared to operational flexibility, which becomes important when a utility relies on an asset to transfer from static to full generation in a short amount of time. For example, a gas-fired CT plant can be operational within 30 minutes of being dispatched. Obviously, whoever bears these costs influences investment decisions, resulting in the wide variety and patchwork of generation assets.

On a smaller scale, including distributed generation, generation options include internal combustion engines, biomass cogeneration, wind turbines, photovoltaics, fuel cells and miniature hydroelectric. Residential and small business generation will be a part of this mix, dictating new communications needs for the generation systems. A greater number of end-points need to be managed by utility systems.

3.1.2 Transmission Assets and Systems

Transmission infrastructure serves to transport electricity from the generation point to the transmission substation, reducing voltage, and then to the distribution substation, which reduces voltage again so power can be distributed to industrial, commercial, and residential customers. Feeders then take the power from the substation to the end-point customers. Transmission development in much of the world has progressed from a system of isolated generation plants, to isolated systems of generation, to regional systems, and finally, to the large, complex interregional systems that exist today.

Since electricity cannot be effectively stored in large scale, supply must be simultaneously balanced with consumption. Balancing the supply and demand of the bulk power (high voltage) system is the responsibility of the System Operator. In some markets, e.g. in the US, the System Operator may be the owner of transmission assets or the System Operator may be independent of the transmission owner, referred as an Independent System Operator (ISO).

The commercial structure of the Transmission System participants includes investor-owned regulated utilities, government-owned authorities, independent merchant suppliers and commercial Demand Response (DR) providers.

In some markets, such as the US, the transmission owners are privately-owned companies. In Canada, some European and Asian countries, the transmission owners may be state-owned entities. The ISO is usually a not-for-profit organization that serves the interest of the market participants and end-user customers via regulatory mandate.

The System Operators work with generation asset operators (either a regulated utility or merchant power generator) to balance the grid. They accomplish this with demand analysis, load flow analysis and forecasting, which determines the demand, current voltages on a power system while optimal power flow (OPF) determines the least cost dispatch of assets to reliably satisfy system loads.

In some markets, the System Operator not only manages the dispatch of bulk power, but also administers a bulk energy market. Bulk energy market participants include generation operators, transmission operators and DR operators. Demand Response is an innovation further enabled by the Smart Grid. Demand Response can participate in the bull energy market by reducing load when additional supply is being called for by the System Operator. Essentially by reducing load, the DR participant is displacing the need for additional supply for the grid.

The bulk power system is a dynamic market where prices are determined by supply and demand. Prices in commercial markets such in the Americas, Europe and Asia can vary with the term, day ahead and spot market. Effective transmission dispatch is required to avoid congestion that can affect the availability of supply to a region, and subsequently, the price.

Communications is essential to the effectiveness of the bulk power system and the Smart Grid on the transmission system. Demand monitoring and forecasting, load and supply balancing all require reliable, high-speed communications among bulk power market participants. Demand Response is enabled by widely-distributed, high-speed communications to load control devices. Additionally, monitoring the state of transmission assets such as frequency, temperature, voltage and current and phase angle, allow transmission owners and operators to manage the reliability and performance of the transmissions system.

Automated switching and voltage controls are essential for the safety and reliability of the grid. **Transmission substation automation is a key functionality enabled by enhanced communications infrastructure on the grid. Reliable, high-speed two-way communications capabilities are now indispensible to support more sophisticated monitoring, control and management applications of the transmission system.**

3.1.3 Distribution Assets and Systems

The electric distribution system begins at a delivery point through the distribution substations and distributes power to industrial, commercial and residential customers.

Distribution utilities operate and maintain the extensive network of distribution assets such as overhead and underground conductors, substations, transformers, switch gear, capacitor banks, inter-ties, etc. The ability for these entities to monitor the "real-time" condition of the distribution grid and identify faults varies greatly, as distribution substation communications are not yet pervasive. These utilities meter and bill the energy consumption of customers; some utilities operate energy efficiency programs and have implemented distribution-level DR capabilities.

Entities that distribute electricity may include regulated Investor-Owned-Utilities (IOUs), cooperatives, municipal utilities and government authorities. Depending upon the regulatory rules in their markets, Distribution Utilities may use their own generation units for existing needs and for incremental needs they will purchase power from the open (wholesale) market (vertically integrated), or as they may only be in the distribution business without their own generation capability.

Utilities operate with a mandate to keep power on at all times and distribution decisions revolve around that mandate. Price of power, of course, also weighs heavily in decision-making. **The Smart Grid will help make utilities more effective, provided they have robust communications ability. Equipment health monitoring and condition-based inspection and maintenance help reliability and reduce costs to the utility.** Such monitoring and maintenance can be done remotely: remote M2M asset management, for example, is already offered by a number of mobile service providers.

Feeder automation is an important function in the operation and management of the distribution systems, and it can serve multiple purposes:

- First, voltage control is one critical operational function; utilities must provide a certain level of voltage to end users: voltage drops as it goes through the feeder. A utility will often provide over-voltage to take into account potential losses, but with a voltage control meter at the end of a feeder, the operator will have a more accurate idea of what voltage is actually reaching that endpoint and be able to control the voltage more precisely This saves money in two ways: it reduces the amount of lost energy within the system and it reduces the wear on assets
- A second application of feeder automation relates to interties, breaker devices between feeders. Fault Location Automation allows the utility to isolate a fault – for example, when a tree limb falls on a feeder – and reroute power to minimize the number of affected customers. Minimizing outage minutes with customers raises a utility's reliability rating, a closely regulated metric.

Distribution Systems feed into customer premises. Consumption is currently monitored via mechanical meters, but there is an evolution toward automated reading via Advanced Metering Infrastructure (AMI), the primary capability on the customer service side of the utility within Smart Grid.

Advanced Metering Infrastructure provides the ability to interface with the customer and understand their behavior. Through frequent data downloads, AMI can provide the utility with vast numbers of data points about customer behavior. Through effective management of this data, the utility can implement direct load control, demand response programs and remote connect/disconnect, reliably monitoring on-site generation such as rooftop photovoltaics. None of these capabilities will be possible without a communications system that allows the utility to be in touch with operational aspects of its system throughout its service territory in a reliable and constant way.

3.1.4 Traditional Utility Communications Systems

Utility operational communications have historically been focused in four areas critical to the business of electricity delivery:

- Supervisory Control and Data Acquisition (SCADA) communications - SCADA systems are used to monitor parameters of interest that effect electricity distribution network performance and reliability such as voltage, power, power quality and Volt-Ampere-Reactive Units (VAR);
- Field-force communications - Land Mobile Radio (LMR) systems have historically been limited to voice application, using high-power analog FM vehicular radios up to 30W and handsets up to 5W;
- Backhaul communications - Backhaul facilities widely used by utilities to support high-capacity communications needs include point-to-point microwave radio links, generally in the 6 GHz band and SONET/SDH fiber;
- Teleprotection, or protection of high voltage and extra-high voltage bulk transmission systems - have historically been performed by dedicated purpose-made Power Line Carrier systems traversing the transmission system or dedicated communications links (copper or fiber) between teleprotection relays.

Further details about traditional utility communications systems are provided in Appendix C.

3.2 Ownership Structure

There are three principal different ownership models: investor-owned utilities, publicly-owned utilities and cooperative electric utilities.

Investor-owned utilities are privately owned and oftentimes vertically integrated, therefore owning all aspects of the value chain from the generation asset to the meter. IOUs are regulated from a financial perspective at the state level. They operate within a Cost of Service regulation which dictates their business model. IOUs are paid their total costs (capital and operating costs) and a reasonable return on investment (ROI) in assets. **In some regulated markets, IOUs do not generate ROI by selling power; they generate ROI by deploying capital to build assets. Operating expenses such as fuel costs and operating costs are passed through to the customer, i.e. there is no margin, so those costs contribute to revenue, but not to profitability.**

Publicly-owned utilities are non-profit government entities organized at either the state or local level. Municipal utilities are one type of publicly-owned utility organized at the local level. “Munis” were designed to provide services at cost and generally refund a portion of their net income to consumers.[2] They can finance their development needs with inexpensive tax-exempt bonds, so their rates are often less expensive than those of neighbor IOUs. They often buy power through regional markets such as the PJM Interconnect, a bulk power wholesaler.

Cooperative electric utilities are owned by their members who are the customers they serve. Some provide only retail electric service, while some provide generation and transmission as well. Cooperatives often serve rural customers in areas that were historically viewed by IOUs as unprofitable to service because of low customer density. They are required to provide electricity at cost to their customers and are incorporated under state laws. Typically, co-ops do not have the resources to make expensive capital expenditures such as Smart Grid-related equipment, and certainly do not often have the manpower to manage such a system even if they did have the resources to deploy one**. Co-ops would be very likely to outsource significant aspects of Smart Grid operation such as network management.**

Regulatory conditions vary throughout the world and within regions, and other regulatory paradigms present different challenges and opportunities for mobile

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[2] Energy Information Administration, “Electric Power Industry Overview 2007”

operators. In Norway, as in other European countries, an interesting challenge arises because there is no automatic return on capital expenditure by utilities unlike in other jurisdictions such as the United Kingdom and the United States. This dramatically different structure significantly alters the economic and business case for Smart Grid deployment. Larger utilities can take advantages of scale and outsource smart metering because of favorable economics while keeping their own employees focused on core activities.

Australia has one of the most deregulated, dynamic electricity markets, creating potential opportunity. The Australian Energy Market Operator (AEMO) is responsible for balancing demand and supply by dispatching the correct amount of generation to meet demand. Since the National Energy Market was established, the electricity market has become progressively more deregulated. Customers are able to choose their own supplier and AEMO has to support that choice. The systems required to support customers switching retail energy suppliers accept data from a variety of meter types and can process up to 10mm meters' worth of information. State regulators in Australia handle retail delivery regulation.

These differing ownership models and regulatory frameworks directly impact the incentives for deploying extensive Smart Grid infrastructures and capabilities and the need for sophisticated and expansive communications networks.

3.3 Legal and Regulatory Structure

Utilities are highly-regulated entities. They are often regulated at the national level of governments, at the state (or regional) level and at the local level. Governments ensure that electric power is available everywhere, and, as a concession to that mandate, utilities are often granted a monopoly to transmit and deliver power within a certain geographic area.

A particular regulatory structure, which can differ markedly between states or provinces, often dictates a utility's revenue stream. Depending on how a utility is allowed to make money, it can have more or less flexibility with capital and operating expenditures. In many cases, especially in the United States, a utility only makes a ROI on capital expenditures. The costs of providing energy are simply passed through, without mark-up, to ratepayers. The sole source of revenue is ratepayers (customers) who are charged depending on what the particular regulator allows.

A rate case is a process whereby a utility presents a business case for capital and operational expenditures to a regulatory commission charged to approve investments and expenditures.

Every aspect of a utility’s operational plan and the nuances of their pro forma financial statements must be presented and justified. This paradigm accounts for a great deal of their economic and operational inflexibility regarding technology investment and change.

As potential business partners or vendors to utilities, mobile carriers must be aware of the fact that these regulatory paradigms exist and that they vary greatly in detail across geographical boundaries.

Regulatory drivers are central to utilities’ economic decisions. In the United States, Public Utility Commissions (PUCs) are looking into the nuances of capital expenditures vs. operational expenditures (as well as overall incentives to utilities for promoting conservation), because utilities get paid for energy used; clearly one would suspect they wouldn’t want to disincentive energy usage.

In any case, MNOs may benefit by looking at ways to move some operational costs into capital expenditures when engaging utilities in today’s existing business cases, or may see changes as PUCs change their policies, which is a much longer process but one that would open up more opportunities for utilities to work with 3rd parties instead of building out and operating their own infrastructure.

4. The Smart Utility of the Future

The Smart Utility of the Future is a company that:

- is committed to modernizing, optimizing and transforming its electric power infrastructure to form the Smart Grid;
- uses distributed energy resources;
- utilizes two-way communications, information management and automated control technologies in the energy production, delivery and consumption infrastructure.

Guiding concepts for Smart Grid for the Utility of the Future have been formulated in various forums over the past decade; policies, regulations and standards are in various stages of development and implementation around the globe. Smart Grid plans generally include specific objectives for employing more reliable, secure, efficient and cost-effective means for the production and distribution of energy, with increasing emphasis on achieving the goals in an environmentally-friendly fashion.

Central generation energy production is becoming more capital intensive, leading to an increase in distributed generation resources such as rooftop solar panels. To manage these resources, which greatly complicate the power distribution system, effectively, utilities must adopt 21st century communications technology. **Smart Grid, which is fundamentally the integration, by control and communication, of all power system elements, will rely upon effective communications technology and infrastructure throughout the electric power system.** Today, most utilities do not have communications throughout their service territory to implement the Smart Grid concept. Typically, they may have some communications in their substations, likely wireline, and they may have a land mobile radio and multiple address system for SCADA data, all on a highly-limited, private network.

The Smart Grid requires communications to all devices throughout a utility's service territory, including meters, feeder automation devices and distributed generation assets. Network infrastructures for Smart Grid are digital, capable of two-way communication, designed to be highly reliable, even self-healing, and must accommodate the integration of renewable energy sources into the power generation, transmission and distribution systems.

A Smart Grid enables active participation by consumers by connecting them to their consumption of electricity through every relevant modern technology. It accommodates a variety of power generation and storage options while enabling new products, services and markets. It integrates innovative tools, technologies, products and services from generation, transmission and distribution infrastructure all the way through to consumer appliances and equipment. Advanced sensing, communications and control technologies are critical to making the grid and electricity consumption more efficient, reliable and sustainable.

Utilities and the electric power system are highly-regulated entities. They are generally slow to adopt new technology and have not invested significantly in their systems in the last 30 years. This investment gap creates enormous opportunity for modernization as the aforementioned drivers of change become more relevant. In the next decade, there will be billions of dollars of investment in Smart Grid; a 2010 ABI Research study forecasts over $45 billion in Smart Grid investment worldwide through 2015. **Utilities will need to adopt new technology, business methods and partnerships to be successful.**

4.1 The Vision and Promise of Smart Energy

Today's electric power grid is aging and outmoded. Unreliability costs consumers millions of dollars. The grid as it exists today is vulnerable to attack and natural disasters. Extended loss of electric power, given our reliance on it for every part of our daily lives, could be catastrophic to our security, economy and quality of life. Today's power system is not capable of addressing the threats and challenges of the 21st century, include energy security and changing economic and environmental paradigms. Smart Energy promises to enable the grid to be more efficient, secure, economical, environmentally friendly and safe. It will operate resiliently against attack and natural disaster, optimize assets, enable fundamental changes in transportation options and buildings, allow active customer participation in energy use and conservation and anticipate and respond to system disturbances.

One significant trend is in the proliferation of distributed assets, as illustrated below in (Fig. 2), with regards to generation sources, requiring sophisticated coordination, control and monitoring systems and processes.

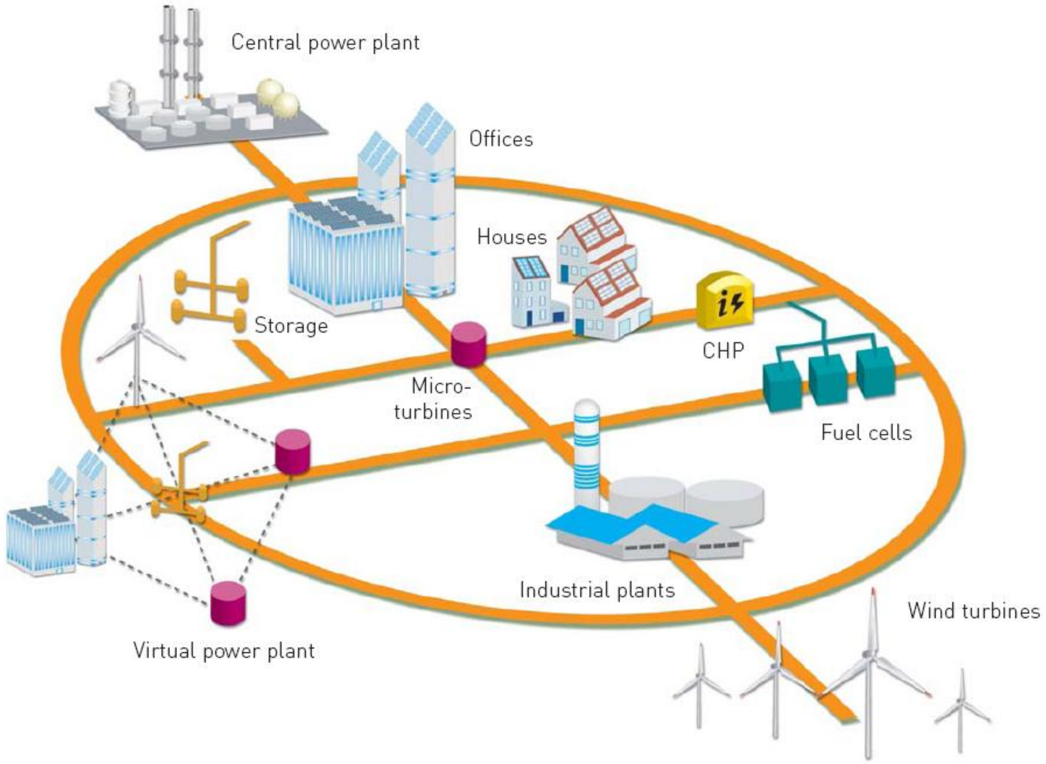

Figure 2: Future Network – Central & Distributed Generators[3]

4.1.1 Market Participants' Smart Utility Vision

The challenge and opportunity for utility operators and their suppliers is in defining and executing an effective plan for the design and implementation of the network infrastructure and operations and business support systems needed to optimize operational benefits and enable the innovative services expected from a Smart Grid.

The Smart Grid, however, has no clear universal definition, particularly as the boundaries vary among individual users. However, all definitions of Smart Grid consist of the following elements: distribution automation (DA); automated metering infrastructure (AMI); energy management, electric vehicles, distributed generation and storage. Additionally it can encompass generation, transmission, substations etc.

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[3] Acknowledgement: Image sourced from the EU's Research DG Smart Grids Vision Report – EUR 2040

At opposing ends of the broad Smart Grid spectrum, Smart Generation evolution, with renewable Distributed Generation, and Smart End-User focus on different aspects of the Smart Grid paradigm that continues to evolve. The following illustration (Fig. 3) identifies the diversity of the Energy Market protagonists and the variety of the respective capabilities to be enabled by Smart Grid.

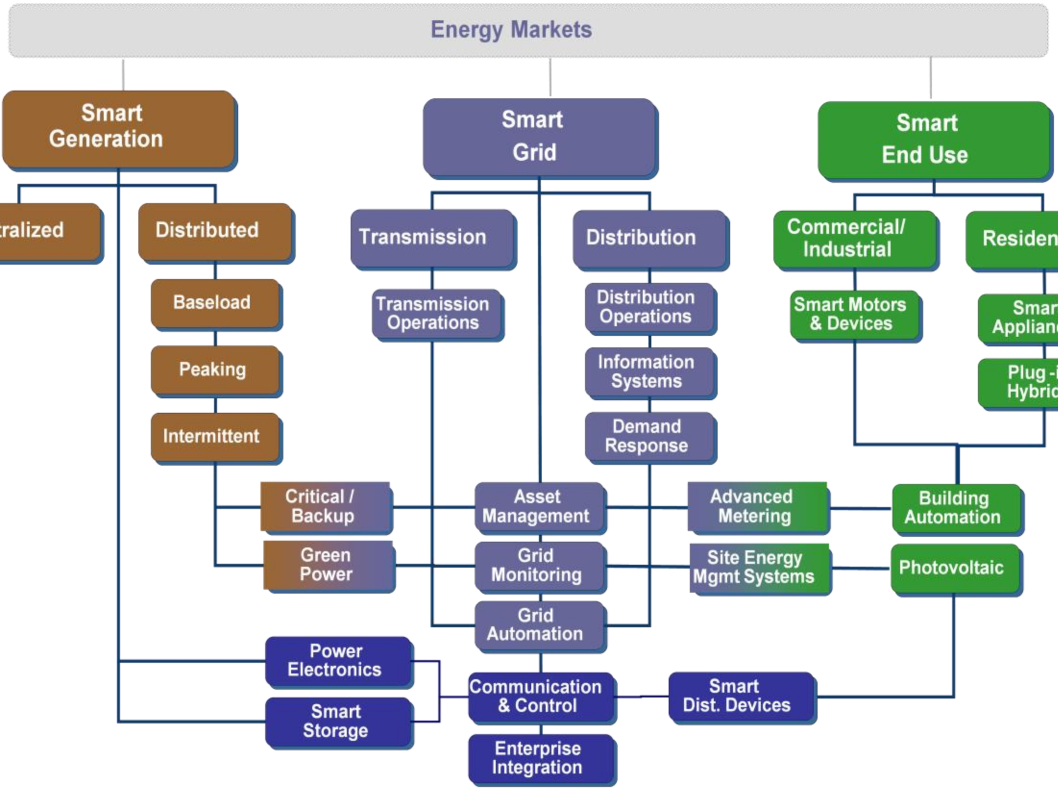

Figure 3: Energy Market Entities and Smart Grid Functions Sought[4]

4.1.2 Evolving Utility Value Chain

Utilities have been operating under the same fundamental market and operating conditions for decades. Change has come rarely, and, when it has, slowly. The figure below indicates how Smart Grid processes will be integrated into the traditional utility value chain.

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[4] Source: Global Environment Fund and The Center for Smart Energy

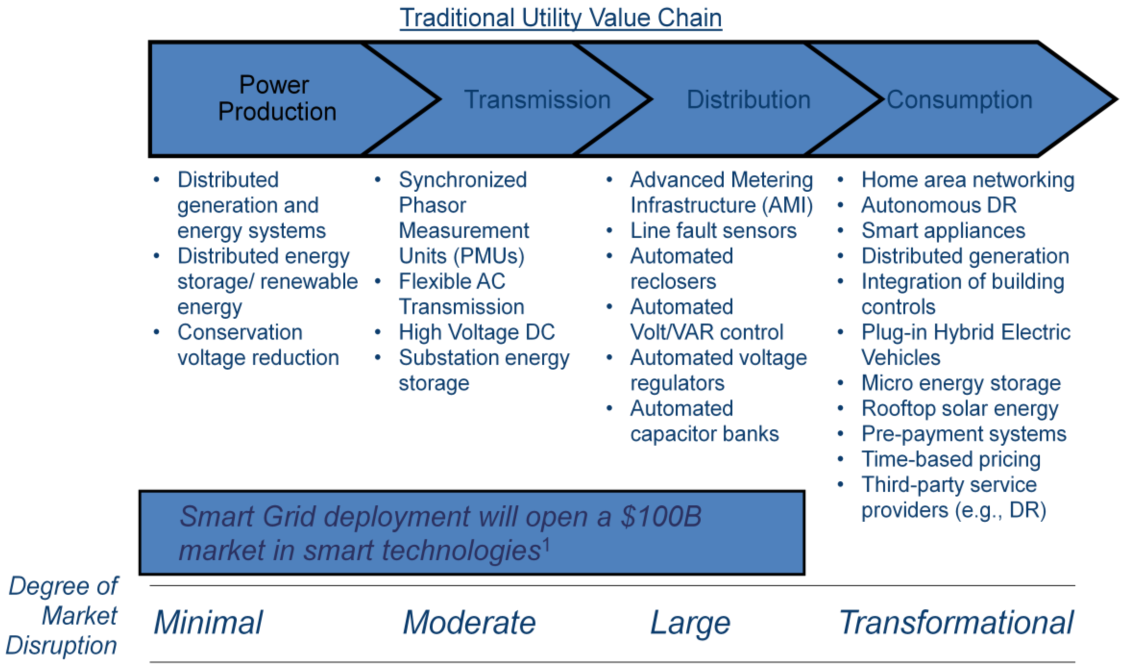

Figure 4: Utility Value Chain[5]

Utilities are facing many challenges to become "smart." Electric power infrastructure is rapidly aging and in need of increased maintenance, and, in many cases, replacement. The average transformer age is over 30 years, the average circuit breaker age is over 35 years and new equipment installation peaked in the 1970s. The Smart Utility understands that integrating the latest technology and updating the grid is in everyone's interest.

Since many grids around the world are out-of-date and out-of-sync with new digital technology and advances in computing architecture, there is an opportunity now to improve grid reliability. Reliability in the digital age means having the ability to "see" the entire grid which will require a retooling of antiquated control systems.

4.1.3 Smart Grid Mandates, Initiatives and Investments

There is a global movement to bring about the interconnectivity of widespread operational devices within electric power systems. Utilities need to be able to control intelligent devices

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[5] *Department of Energy; The Reform Institute, "The Smart Alternative: Securing and Strengthening Our Nation's Vulnerable Electric Grid"*

throughout their operations chain. These factors are driving market progress toward a Smart Grid. There is a growing demand for tools and processes to ensure a more robust, secure and reliable grid; these depend on communications solutions that enable the type of information gathering and control that is critical to Smart Grid implementation. Governments, industry and other organizations around the world are undertaking activities to move toward the implementation of Smart Grid. An overview of major Smart Grid initiatives is provided in Appendix A.

One representative global forecast of the Smart Grid market according to the Deutsche Bank is depicted in the following chart (Fig. 5):

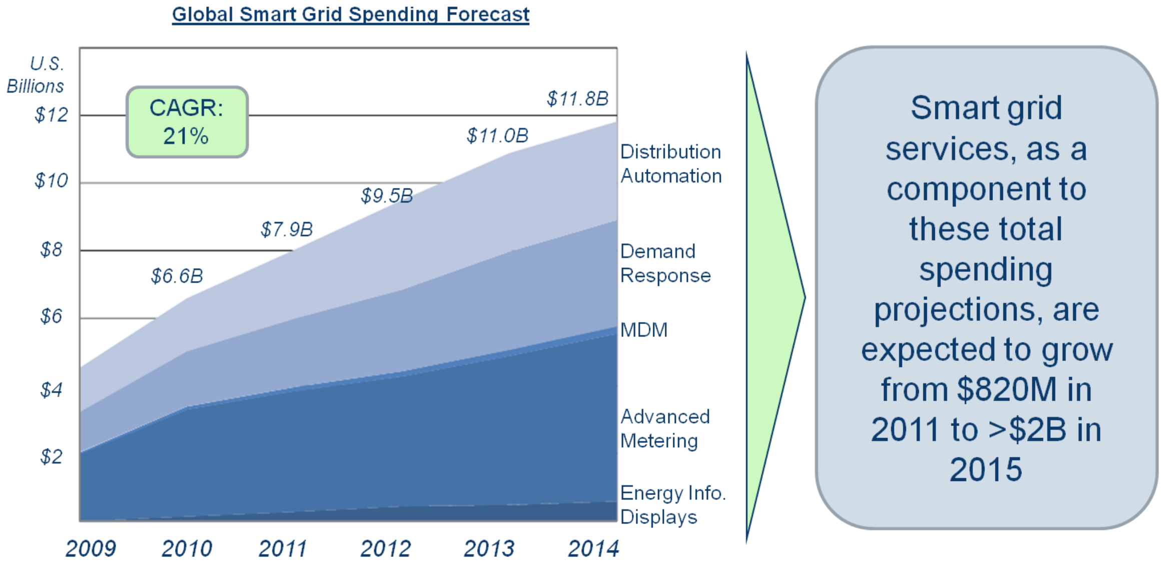

Figure 5: Smart Grid Spending Forecast[6]

Approximately half of the 2015 forecasted total is expected to entail smart sensors and other intelligent electronic devices while another encompasses communications infrastructure and other automation-enabling equipment and services; smart metering systems would capture up to a 15% share and EV management systems accounting for less than 5% of the total. **Approximately 40% of the infrastructure spending is addressable for the mobile industry.**

These market size figures translate into tremendous business opportunities for a vast range of commercial entities in supplying the requisite products and services to utility companies engaged in the deployment of Smart Grid capabilities in response to goals mandated by

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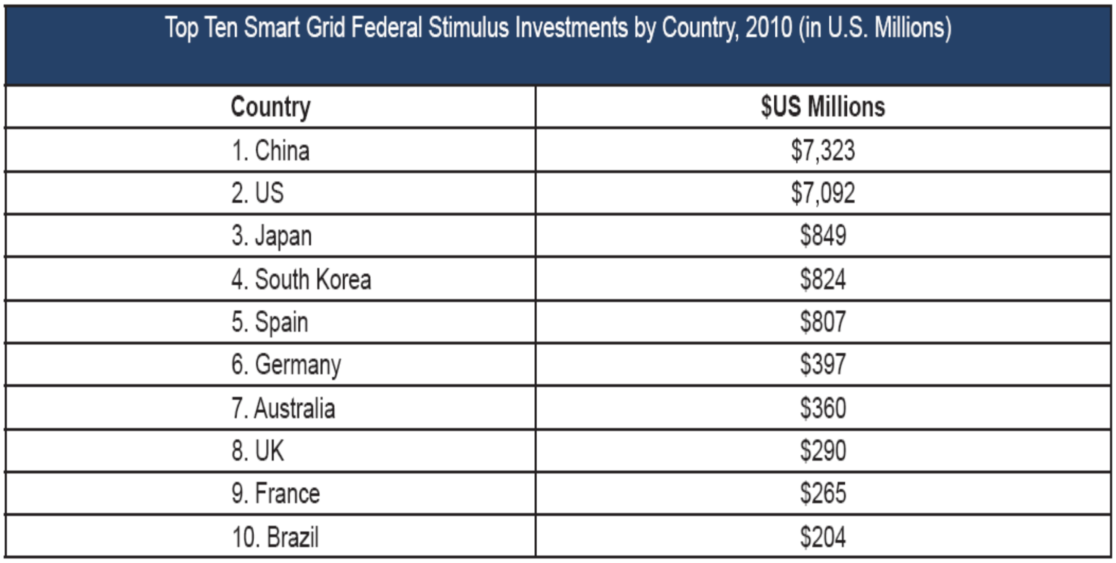
[6] Deutsche Bank, Securities, Smart Grid Overview, October 2010

government policies, market and societal pressures and tapping into the various financial incentives and funding programs provided in many countries especially for this purpose.

The greatest opportunities for these suppliers reside in the United States, Europe and Asia where Smart Grid stimulus investments are most aggressive. The following top 10 list of countries in terms of Smart Grid stimulus investments was compiled by KEMA in early 2010 (Fig. 6):



Top Ten Smart Grid Federal Stimulus Investments by Country, 2010 (in U.S. Millions)

Country	$US Millions
1. China	$7,323
2. US	$7,092
3. Japan	$849
4. South Korea	$824
5. Spain	$807
6. Germany	$397
7. Australia	$360
8. UK	$290
9. France	$265
10. Brazil	$204

Figure 6: 2010 Smart Grid Stimulus Investments[7]

Much of these anticipated investments are targeted for Advanced Metering Infrastructure (AMI), which is widely considered as the initial phase of Smart Grid capability implementation. Advanced Metering Infrastructure provides increased network connectivity and communications between the customer and the utility. Behind the meter, or inside the home, a variety of “smart” devices including appliances and heating, ventilation and air conditioning (HVAC), will link to the grid through the smart meter. Other utility meters, such as gas or water automated meter reading (AMR) meters, can also link through the smart meter.

The smart meter will transmit information to the utility back office and enable services such as outage management and advanced billing. In addition to meters, AMI technologies will enable two-way communication between the utility and the electricity consumer, perhaps through a

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[7] KEMA Data Compilation, published in April 2010 issue of our *Automation Insight* Newsletter

consumer portal and/or a home area network designed to allow the consumer to manage consumption more effectively.

In 2009, Pike Research estimated that some 250 million smart meters would be installed worldwide by 2015; more recent forecasts indicate that the extent of smart metering deployment may well surpass 2.5B installed smart meter units worldwide by 2020, with Europe, Asia-Pacific and North America leading the charge with a 25-to-30% share each; besides the United States, the UK, France, Germany and Spain, the most ambitious smart meter deployment plans belong to China, India, Brazil, Japan and South Korea.

4.2 Smart Utility Communications Requirements

4.2.1 Emerging Operations and Business Support Needs

New operation and business support demands experienced by utility providers drive the need for new services and capabilities, including:

- Desire or need to integrate renewable/intermittent sources of generation, including photovoltaics, wind, and storage, both large-scale and distributed small-scale, into the existing grid which was designed for dispatchable, large-scale generation and one-way energy flow
- Desire or need to gain electrical efficiencies in the distribution of electricity, improvements in power quality and improvements in transmission/distribution network stability and availability
- Improved grid resilience and recovery ability in the face of natural disaster, physical- or cyber-attack
- Desire or need to gain operating efficiencies, primarily by reductions in staff required to operate or maintain the transmission/distribution system, driving the need for mobile data as well as voice for field-force automation
- Desire or need to cut costs associated with customer metering (meter reading), to align customer charges with actual utility costs (for generation, transmission and distribution), through time-of-use and/or critical peak pricing of electricity, demand-side load controls and/or empowering customers to shift load off-peak to conserve electricity use through demand response capabilities, and

- Continuing phase-out/obsolescence of existing circuit-switched and time-division multiplexing (TDM) communications equipment, legacy remote terminal units (RTUs) and corresponding continued high cost of maintaining these operations. Utilities historically have relied on dedicated bandwidth for operationally critical communications; equipment vendors and telecom operators are evolving to packet-switched data networks and new Intelligent End Devices (IEDs) that replace the RTUs of the past. Such devices invariably incorporate IP/Ethernet communications.

These objectives create enhanced or entirely new requirements for communications to/from the customer meter, and through the meter to the home area network, as well as for enhanced distribution automation (DA) serving additional control and monitor points along feeder lines and in substations. In particular, where utility operational communications in the past were concentrated to/from substations, coverage and capacity requirements are expanding to feeder lines and customer premises.

4.2.2 Requirements of Smart Utility Communication Systems

The above operations support requirements translate into specific network capabilities that need to be met. These include coverage, security, capacity, obsolescence and cost.

Coverage and capacity. Utilities must have required service and capacity where needed; this will increasingly mean service to neighborhood area network take-out-points (ToP) for AMI systems and sensors and controls distributed along feeders for feeder automation. Some of these feeders in more rural areas may traverse areas of low customer density where coverage is currently limited or unavailable; the cost-benefit case for additional MNO infrastructure (base stations and communications backhaul) is likely to hinge on feeder line and substation DA rather than AMI in early deployments; that equation could, however, change radically based on increased penetration and need to integrate renewables/intermittent energy sources and storage, including PEVs.

Availability. AMI, which enables the transmission of time-of-use metering data, power quality data, outage messages and pricing information, presents modest requirements on communications availability. Generally, this information must be transferred once or twice a day, with no hard deadlines on delivery. Even on-demand reads, in support of a customer call center or web-based inquiry, need not be delivered in less than 30s for at least 95% of inquiries.

Availability requirements for distribution automation applications are far more stringent: typically 2 – 4 seconds maximum round-trip communications latency for most SCADA and distribution automation requirements. This same availability requirement could be pushed out further to the electricity distribution edge by incorporating a sampling of customer AMI meters into the distribution automation network to potentially save feeder line sensing costs, while optimizing delivery efficiency and power quality and/or the need to intelligently integrate distributed generation/storage from renewables/intermittent sources. Utilities will want committed information rates (CIRs) and maximum latencies guaranteed by service level agreement (SLA), which will require proper network (over-) dimensioning and/or capacity reservation.

Cyber-security. No area within Smart Grid has received more attention recently than communications and information security and protection from cyber-attack ("cyber-security"). Utilities in North America are under strict regulatory requirements from the North American Electric Reliability Corporation (NERC) for Critical Infrastructure Protection (CIP). CIP defines an asset- and impact-based methodology which identifies critical infrastructure assets and associated cyber assets with "qualifying connectivity," which means those assets use a routable protocol which must be protected using technical, procedural and organizational means. Similar regulatory requirements for critical asset protection and cyber-security are implemented or under review for implementation in Europe and elsewhere. Whereas most of the CIP focuses on "bulk electricity delivery" assets and systems, DA, and even AMI systems are not immune to NERC CIP requirements. For example, a system which controls and therefore can shed 300 MW of demand or more, such as spoofing an AMI smart meter disconnect command to 300K customers or more, is accepted by most utilities to qualify under NERC CIP cyber-protection requirements.

The Smart Grid envisions a massive extension in the scope and scale of communications - primarily IP-based - and data processing infrastructure, much of which is not physically securable, opening the door to a wide array of potential vulnerabilities and attacks. The recent furor over Stuxnet32 worm attacking the Siemens Energy Management System and various components managed by that system, using a number of highly-sophisticated attack vectors, including forged PKE certificates, is just a single, highly-public example of what has emerged as numerous sophisticated threats detected in utility operational software and systems.

Furthermore, cyber-security requirements are highly fluid and evolving as knowledge of the threat evolves and better compensating controls become readily available. The draft NERC CIP-10 and CIP-11 was released in December 2010 to the Federal Energy Regulatory Commission for regulatory approval. These recommendations would entirely change the existing cyber-asset identification methodology, eliminate the concept of “Electronic Security Perimeter,” broaden those assets requiring protection and weaken the current routable-protocol exemption.

From the mobile industry perspective, impacts of Utility cyber-security concerns are likely to be as follows:

- Expect cyber-security concerns, controls and third-party certifications of any proposed service and/or supplied devices (embedded modems/modem cards) to be raised at the outset; this will include support for VPNs based on the preferred TLS 1.0 (SSL 3.1 or higher) for end-to-end security rather than ipSEC, and SNMP v3 for management. **This is an area where cellular–based AMI services or DA services can offer significant benefits compared with current 868 MHz / 915 MHz / 2.4 GHz ISM mesh services by extending such a VPN to each and every end device.** (Further discussion on this point can be found in Section 5.1.1 of this report.)
- Support for strong two-way authentication, message authentication and integrity (such as using HMAC); key distribution mechanisms (such as Diffie-Hellman), with privacy/encryption issues less of a concern insofar they facilitate other kinds of attacks;
- Communicating devices on the network that are not physically securable, such as AMI ToPs, AMI meters, DA sensors and/or controls installed on feeders, should have a high degree of protection of critical security parameters such as tamper-proof storage that never exposes these keys and is resistant to temperature/voltage stressing and SPA/DPA, and
- The home area network, which is often 2.4 GHz ZigBee, beyond the meter opens the door to variety of new vulnerabilities in the AMI system or services. Embedded cellular modems incorporating ZigBee transceivers must take extra precautions.

Obsolescence. Electric utilities generally expect 15-25 year installed asset lifetimes, which is considerably longer than the standard in the telecommunications industry. **Utilities are likely to require strong commitments from the MNOs to continue to provide the contracted communications service**, whether General Packet Radio Service (GPRS), Enhanced Data Rates for GSM Evolution (EDGE), Wideband Code Division Multiple Access / High-Speed Packet Access (WCDMA/HSPA), for a period of 15 years or more, or to absorb the costs of migrating/replacing the installed equipment to newer technical air interface or operating frequency band standards.

For the MNOs, this dynamic raises the critical question of opportunity costs to continue to support broadly non-competitive or obsolete service on increasingly valuable spectrum that could serve other services with high average revenue per user (ARPU). One way to mitigate this challenge is by designing modems which can support more advanced standards such as WCDMA/HSPA or even Long Term Evolution (LTE), which would largely future-proof embedded communications equipment.

While this approach would incur costs which are relatively high for simple AMI applications, that is not a concern for DA applications or advanced AMI systems which function more like extensions to the electricity distribution edge of DA. As a result, new sources of value are exposed including: intelligent integration of renewable and intermittent generation; optimization of electricity delivery efficiency and network stability; and, savings on feeder line sensors/controls. In these scenarios, the cost-benefit calculation is likely to easily absorb the added communications element costs.

Cost. Regulated utilities are generally permitted cost recovery through the rate base of “prudent and necessary” costs consistent with the Government and regulator policy objectives regarding required generation and delivery of efficient and reliable electric service to customers.

5. Opportunities for the Mobile Industry

The utility sector (in general) and Smart Grid development represents a large and fast growing market for all of the mobile communications industry. There are opportunities for MNOs, network management providers, solutions developers, device manufacturers and service bureaus. A significant portion of the Smart Grid expenditure anticipated for the next decades will be associated with the communications and support systems. This fast-emerging market offers new business opportunities in areas of the mobile industries' strengths. Those opportunities include:

- **Complete utility's communications network connectivity**

  The Smart Grid will require utility companies to have reliable and secure two-way communications throughout their service territory for machine-to-machine and traditional communications systems. The cost to build and operate these communications networks is a challenge for many utilities, both in capital resources as well as operational personnel and expertise. The opportunities exist in all layers of the utility network hierarchy, e.g. the Home Area Network, Access Network, Field Network, and for backhaul and inter-Control Center communications.

  Advantages of using cellular: in many markets, existing mobile data networks already cover as much as 99% of the total population. Furthermore, in some markets, such as Germany, new LTE networks are deployed in rural areas to deliver universal broadband services. This coverage is unmatched by any other fixed or wireless technology. In order to achieve a near-universal geographic (rather than population) coverage that might be required for DA, MNOs need to explore combining cellular networks with other technologies.

- **Deliver solutions and platforms for a variety of two-way monitoring and control functions**

  The Smart Grid requires sophisticated and flexible applications such as meter data management, outage management, distribution automation, distributed generation integration, power quality and control as well as electric vehicle transactions and control. These applications can be complicated and expensive to acquire and operate, particularly for the mid-market and small utilities.

Advantages of using cellular: The solutions needed are similar to those developed in the mobile industry for public safety and government systems and can be offered at great economies of scale by the mobile industry.

- **Provide operations support services**

  Utilities are being faced with the daunting task of handling hundreds of thousands of managed objects with the deployment of Smart Grid. The mobile industry has experience, systems, processes and procedures that can be used to offer utility-tailored managed systems and services, such as Network Management Systems, Outage Management Systems and Field Force Automation.

- **Enable the Smart Grid in the wholesale energy market**

  The introduction of renewable generation through the imposition of Renewable Portfolio Standards and other regulatory mandates forces utilities and system operators to accommodate intermittent supply on the grid. The mobile industry may offer the devices and systems that can monitor and forecast the state of intermittent generation to allow the renewable generation to be integrated with the grid without undue risk. Further, Demand Response (DR) requires wide-scale machine-to-machine (M2M) communications and control to enhance the capture of benefits of DR.

- **Offer value-added energy management services**

  Fundamental to the Smart Grid on the consumer side is the management of energy through a web-based energy information portal. This will allow consumer-tailored remote access to energy efficiency and home automation information and also to control capabilities. This functionality can be provided on smart phones over public mobile networks, allowing the mobile industry to leverage existing mobile consumer systems and bundle new products and services. Mobile service providers can leverage years of experience in billing for prepaid services and dynamic tariffing, to assist utilities companies in launching innovative payment options.

  Mobile operators are also uniquely positioned to support the advent of Electric Vehicles (EVs), for example, providing mobile payment and billing to individuals rather than geographic locations. As the Smart Grid becomes a reality in energy markets throughout the world, value-added services such as Building-to-Grid, Vehicle-to-Grid and Building

Management System, as well as Electric Vehicle fleet management, Distributed Energy Resources and Demand Side Management applications, become increasingly important to the sector.

Advantages of using cellular: Mobile service providers can be instrumental to generating consumer awareness and acceptance of smart energy services. By leveraging existing customer segmentation systems, MNOs can create highly customized customer campaigns and joint affinity marketing programs with utility partners.

- **Big data storage and retrieval**

  The Smart Grid is estimated to generate multi-petabytes of data, and the regulatory treatment of such data is dynamic, so most utilities are planning on storing all data for 10 years or longer. This large volume of data generation, storage and retrieval creates new and growing requirements for data management, that the mobile industry has both the experience and resources to offer the marketplace.

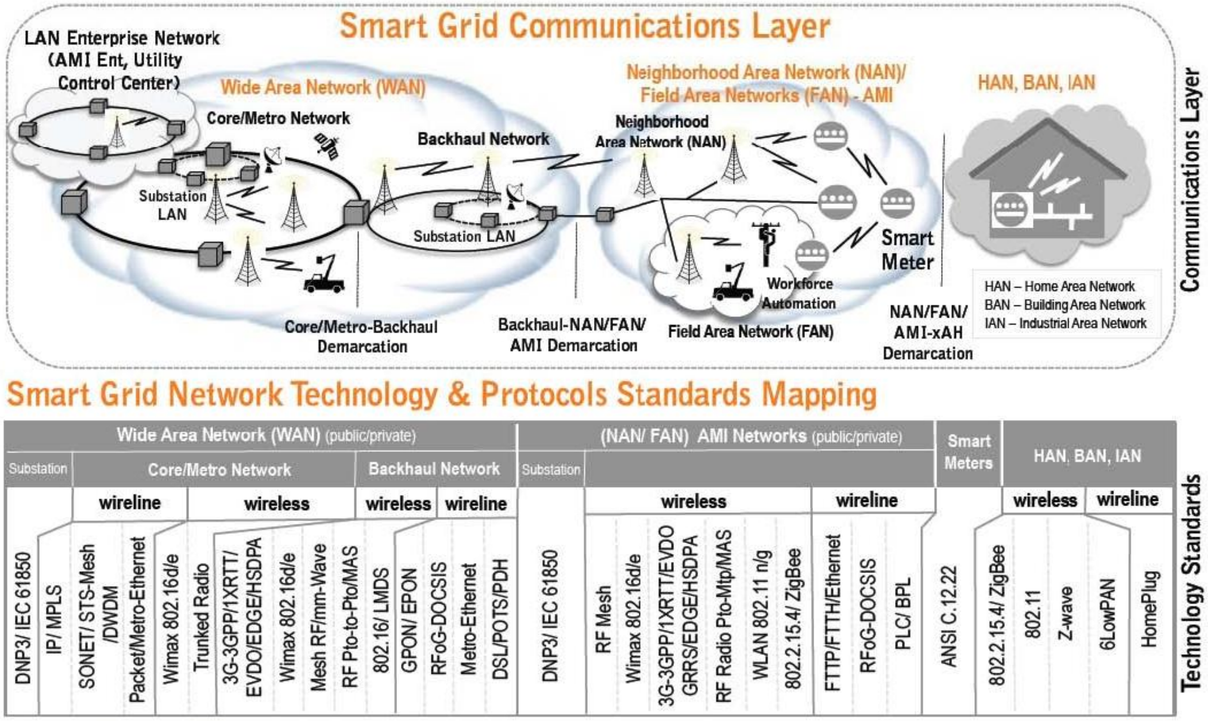
5.1 Products, Services and Solutions

The utility sector offers opportunity for the mobile industry to offer new products and services that offer high value and margin, as well as large and long term revenue opportunities.

5.1.1 Cellular Connectivity vis-a-vis Other Wireless Technologies

In delivering these Smart Grid products and services, there are a variety of technologies and standards protocols (as Figure 7 illustrates). Mobile networks need to be positioned against complementary and competing wireless technologies.

Compared to some of the competing technologies, cellular is a homogenous, secure platform, with a potential to leverage economies of scale.



Source: IEEE (P2030 SGA WG)

Figure 7: Smart Grid Comunications Technology and Standards[8]

A comparison of selected communication technology options indicates that cellular stacks up well against alternative solutions in all technical aspects, provided that coverage is adequate in the targeted locations and assuming that the needed throughput and availability can be consistently delivered and guaranteed by the service provider. The use of leased facilities does imply very low capital expenditures but relatively high recurring operating costs.

The following table provides high level comparative ratings of selected communication alternatives with respect to a variety of technical and non-technical attributes.

It should be noted that variations in technology applications (e.g. 2.5/3 vs. 4G cellular for example with respect to bandwidth and traffic prioritization feature; PLC can offer anywhere from very low (3 Kbps) capacities to 500 Kbps (IEEE 1901.2) and implementation approaches (e.g. level of redundancy and diversity deployed) can significantly impact these generic ratings.

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[8] per IEEE P2030 Smart Grid Architecture Working Group

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The relative suitability of wireless technologies for high or low density end-point deployments (e.g. in urban vs. suburban settings) is a primarily a function of bandwidth availability and propagation characteristics, which can vary considerably depending on prevailing constraints and particular circumstances.

Figure 8: Smart Grid Communications Technology and Standards

		Bandwidth / Throughput	Coverage / Range	High Density Application	Low Density Application	Scalability	Security	Standards / Interoperability	Availability / Reliability	Maturity for Utility Apps.	Ecosystem / Suppliers	Capital Cost	Operating Expense
Private / Owned	**PLC**	~	◕	◕	◔	◔	◑	◔	◕	◕	◑	◑	○
	RF P-MP	◕	◑	◑	◔	◑	◑	◔	◑	◕	◑	◕	○
	RF Mesh	◕	◑	◕	◑	◑	◑	○	◕	◕	◑	◑	○
Public / Leased	**WiMax**	●	~	◕	◕	◕	◕	●	~	◔	◑	~	~
	Cellular 2G	◔	~	◑	◕	◕	◕	●	~	◔	◕	○	◕
	Cellular 3G	◕	~	◕	◕	◕	◕	●	~	◔	◕	○	◕
	Cellular 4G	●	~	●	◕	◕	◕	●	~	◔	◕	○	◕

Relative Rating:	
Very Low	○
Low	◔
Med	◑
High	◕
Very High	●
Varies	~

Cellular wireless technology solutions (including GPRS, EDGE, WCDMA/HSPA, and now LTE) offer MNOs a number of intriguing opportunities well-aligned with current and anticipated Utility Smart Grid M2M communications needs.

The following analysis includes the following portions of the network – AMI backhaul communications; direct-to-meter connectivity and DA communications – comparing the capabilities of mobile networks against utility service requirements, specifically, coverage, capacity and latency, as well as the ability of other technologies to do the same.

AMI neighborhood area network backhaul communications: communications between Take out Points (ToPs) (aggregators/gateways) and the Head-end system. **Generally, there exists adequate flexibility in ToP location to take advantage of the MNO's existing coverage without the need for investment in new base stations and base-station backhaul.** Traffic models are driven primarily by the range of supported/theorized HAN services and applications rather than metering data, but are expected in the range 0.1 – 5 bps/customer averaged over 24 hours, or after typical (1000 – 5000 customers/ToP) concentration levels, 100 bps - 25 Kbps per ToP averaged over 24 hours. The availability of spectrum to accommodate AMI backhaul networks is severely restricted**. Utilities are reluctant to depend on the unlicensed bands to carry operational traffic. This offers MNO's an opportunity to leverage their established private networks to provide AMI NAN services.**

Neither the metering data nor HAN data are considered "real-time" (even an "on-demand" meter read can acceptably take as much as 30s), and the traffic is generally highly asymmetric. Except for occasional over-the-air (OTA) firmware downloads, traffic flows primarily in the reverse link from customer to Head End. Peak data rates are similarly HAN-dependent, but are unable to exceed 100Kbs/250Kbps per ToP given over-the-air data rate limitations of today's currently favored 868 MHz/915 MHz/2.4 GHz unlicensed ISM band mesh network AMI systems. Furthermore, none of these communications are considered time-critical in delivery, so traffic buffering and shaping can be used effectively at the ToP modem (or even after aggregating traffic from several ToPs) to reduce peak demands to levels suitable for GPRS (GMSK) or EDGE (GMSK/8PSK) if required. Suitable solutions therefore include GPRS and EDGE modems.

It must also be noted that any move to incorporate a sampling of customer smart meter data power-quality data in "real-time" (say with 2-4 seconds) for use in control of the distribution network, that is as an actual extension of the SCADA or DA system, and/or for direct control of locally-sourced wind- or solar-power generation or storage at the customer premises, can be expected to increase the required communications traffic and reduce the delivery latency requirements substantially. **However, in these same neighborhood area mesh networks, the networks themselves are likely to choke or require commensurate reductions in concentration, requiring additional ToPs.** Some utilities have begun planning or evaluating such an approach to distribution automation, i.e., where (a sampling) of customer smart-meter sourced data is used, in part, for continuous "real-time" management and optimization of the distribution network. It should be noted that the use of cellular backhaul in this "real-time" fashion will place much more stringent demands on MNO network availability and SLA agreements.

AMI – direct to the meter: cellular communications direct to the meter provides an interesting, cost-effective and potentially value-adding option to mesh networks in many service areas. **Unlicensed 968 MHz, 915 MHz and 2.4 GHz neighborhood area mesh networks effectively trade capacity for coverage, and are subject additionally to a wide range of in-network and out-of-network (including WiFi, Bluetooth, ZigBee etc.) interferers. The resiliency of mesh networks against isolated node or ToP failures is equally matched in most cellular urban/suburban deployments by overlapping base-station coverage.**

2.4 GHz coverage is severely limited at best compared with 800-900 MHz licensed spectrum. Cost-effective cellular modems, using embedded SIM, equipped as well with a single-chip ZigBee transceiver for the HAN, are likely to be no more expensive today than current mesh network offerings from the likes of Silver Spring Networks, Itron and others. **An additional point of differentiation may be cyber-security-proven strong two-way authentication, message integrity and encryption along with secure storage of critical security parameters, which can surpass those controls employed in current ISM mesh networks.**

Perhaps the most intriguing and differentiated application for embedded modems and MNOs will result from any move to incorporate a sampling of customer smart meter data power-quality data in "real-time" for use in control of the distribution network, that is, as an actual end points of the SCADA or DA system, and/or for direct control of locally-sourced wind- or solar-power generation or storage at the customer premises, which can be expected to increase the required communications traffic and reduce the delivery latency requirements substantially. By the same token, it must be noted that use of mobile communications in this "real-time" fashion will place much more stringent demands on MNO network availability and SLA agreements.

In short, the MNO can offer substantially higher capacity in support of "real-time" DA incorporating the end user customer-premises metering in the control loop for optimizing electricity distribution efficiency, power quality and effective integration of renewables/intermittent sources of power generation while maintaining complete network stability. This substantially-higher capacity and low latency does not generally exist in corresponding ISM-band mesh networks and is a value-added proposition to utilities. Potentially higher costs would be offset by savings in feeder line metering, monitoring and automation, as well as by the added operating efficiencies. To ensure that suitable availability and performance are delivered by MNO facilities, guarantees specified under SLA agreements would be expected /required by the Utilities.

Coupled with the necessarily increased SLA, this application can alter the cost-benefit equation enough to perhaps justify additional base-station and base-station backhaul build-outs to meet the required coverage and SLA agreements, or to perhaps incorporate WCDMA/HSPA or LTE modems, providing the Utility a high degree of protection from obsolescence.

Distribution Automation (DA) communications: Similar to the above case of direct mobile communications to/from the meter, but generally even less cost-sensitive regarding communications, but also generally requiring the same/more stringent SLA agreements and service availability guarantees.

LTE air interface, infrastructure, and, most critically, LTE modems are likely to retain their cost-competitiveness and resilience against obsolescence. It is true that WiMax (802.16.e) can offer technical communications capabilities similar to LTE in any given operating frequency band, especially for fixed-users. However, WiMax has inferior reverse-link performance with respect to mobile battery operating time. Moreover, WiMax cannot provide the economies of scale comparable to cellular technologies. Major wireless carriers including AT&T and Verizon in the United States have elected to deploy LTE over WiMax.

Except for substation gateways, data rates are expected in the 10s of Kbps average sustained and 100s of Kbps peak per IED, well within the capabilities of cellular data services. Substation gateways (such as CybecTec and others) which serve as interface/protocol converters, data concentrators and substation data processing/distributed control can have data communications requirements in the multi- Mbps area on a sustained basis and more on a peak basis, so low-latency, high- bandwidth WCDMA/HSPA and LTE solutions appear best suited for use as primary (or back-up communications to fiber or copper) communications to the substation.

5.1.2 Managed Services

What may perhaps be the most interesting opportunity open to many MNOs is to offer “Smart Home” or “Smart Business” services. These take the form of energy management and home automation services, provided through:

- the AMI meter/HAN network,
- a separate WiFi/ZigBee/HomePlug gateway (or both),
- and, web-based services accessible through the smart phone and/or DSL-PC connection.

The effectiveness of this combination is dependent on integrating each of the different communications components, ideally based on standards-based designs that support interoperability.

ZigBee-equipped Smart Meters and HAN devices and/or ZigBee-equipped WiFi Gateways and access points/routers are likely to support numerous connectivity options. This opens up additional business opportunities that apply remote monitoring techniques to enable assisted living services, for example.

Bundling such services along with existing triple-play (voice, video, data) and/or quad-play (wireless cellular, voice, video, data) services can reduce customer churn and present new opportunities for Smart Home service revenues and possible transaction processing revenues.

5.2 Business Models and Value Propositions

The Smart Grid offers a number of business models that may be beneficial to the mobile industry. A number of MNO’s are offering Cloud-based, end-to end Smart Grid solutions. The business models are structured around a service offering whereby the MNO provides all of the services necessary to the utility from the meter to the Meter Data Management (MDM) system, as well as field force automation or any portion of the infrastructure and service offering that is not provided by the utility. Some MNOs are targeting the data management and energy services as a direct energy offering to commercial and industrial energy consumers. Others are offering “virtual power plants” through the leverage of widely distributed Demand Response and Storage programs.

Still other business models where the customer owns the in-home equipment or the MNO owns the in-home devices are both viable, although it seems likely that the Utility will always own the smart meter itself. Revenues (ARPU) to the MNO from home or building energy management services are likely to far exceed what can be charged for M2M smart-meter communications connectivity alone to Utilities (whether AMI backhaul or direct-to-meter).

Utilities may well come to view MNOs attempting to penetrate this space as competitors and may attempt to restrict MNO access to electricity usage and metering data obtained from the Utility through the AMI system; this is likely to lead to increasing political/regulatory in-fighting as to exactly who owns the customer usage data – the Utility or the customer? **The success of the bundled services' model is likely to come down, in the end, to exactly who controls this customer electricity usage data and who can offer value-added services which critically leverage this data.** Potential controversy regarding the use of data accessed by beyond-the-meter services and devices can, however, be avoided entirely: inexpensive in-home devices can gain much of the benefits of the meter without its complexity or cost. **A MNO or other mobile industry participant could offer additional revenue streams by enabling home energy management and making associated information available to third parties without involving the utility meter.**

Third parties such as energy equipment manufacturers, commercial enterprises and government agencies all have benefits that can be derived by the capture of the data, detailed analytics, forecasting and managing and energy consuming systems. The MNO's are well-placed to service these third parties, either in cooperation with electric utilities or in partnership with third parties.

6. Conclusion and Next Steps

This report presented a range of opportunities for mobile operators to adopt the role of leading partner for the utilities making a difficult transition to the Smart Grid as well as offering services to current and energy market participants and retail customers:

- Connectivity
- Two-way asset monitoring and control
- Operational support services, including network management and security
- Value-added services, including wholesale and retail tailored solutions
- Value-added energy management services
- Big data storage and retrieval

As our analysis indicates, the choice of opportunity is tightly linked to the nature of the utility market regulation, the market dynamics and culture of the utilities in the market. Thus, MNOs need to conduct a detailed assessment of their specific utilities markets that show promise and determine the applicable regulatory treatment, the pace of the development and the culture of the market participants.

Moreover, we have concluded that MNOs are able to address all or most major requirements of their utilities' customers and partners, including coverage, capacity, security, availability and cost. Yet, their participation in the smart grid rollouts is not assured: the size of the opportunity and complex nature of smart grid requirements means many different technologies will compete or collaborate.

MNOs need to:

- **Communicate commitment** to the participation in the energy sector generally, and Smart Grid projects, specifically
- **Leverage the GSMA** to perform detailed analysis of the target markets, regulation and culture

- **Help define the market into which MNOs seek to sell**: Involvement in utility industry forum and standards development organizations has the potential to reap significant rewards from a business case and core competency perspective when the time comes to go to market with standard compliant technology and tailored service solutions

- **Develop partnerships in the utility sector:** The utility sector is a large market made up of a relatively few market participants. The MNO's should partner with established players in the utility sector to enhance the successful introduction, penetration and expansion of the energy sector

- **Develop a product and service mix** that addresses the needs of the utility sector while leveraging established facilities systems and resources of the MNO. Further develop a roadmap that closely aligns with the progress of the Smart Grid

- **Define the level of quality of services** that can address the demands of the utilities. SLA for utility systems are demanding, and offers one of the more difficult obstacles to entry

- **Develop utility-focused commercial terms** that accommodate the unique requirements of the utilities. These terms tend to be longer in duration than other industries and generally offer very low churn.

- **Analyze opportunities in the smart home**: By leveraging the understanding of consumer adoption of new technology, the mobile industry has opportunities to lead consumer-focused energy services.

Appendix A: Global Smart Grid Initiatives

North America Smart Grid Initiatives

In North America, two major pieces of legislation provide drivers for Smart Grid evolution. The Energy Independence and Security Act of 2007 codified support of the modernization of the electric transmission and distribution system to maintain reliability and infrastructure protection into US policy. The bill included Smart Grid funding from a national level for technology research, development and demonstration. It further encourages state level consideration of Smart Grid though regulatory reviews. The American Recovery and Reinvestment Act, signed into law in February 2009, is a major funding source for Smart Grid-related tax incentives, investment grants and demonstration projects, $4.5 billion in total. It also is a major funding source for Energy Efficiency programs at the state level through block grants. Tax incentives include a 50% special depreciation allowance for utility property through 2009 and a 30% investment tax credit for Smart Grid technology manufacturers. The tax credit has expired and there is little prospect of it being renewed.

Technology platforms continue to be developed in anticipation of Smart Grid evolution and adoption. Major contributors to this effort include:

- The U.S. Department of Energy Modern Grid Initiative
- The U.S. Department of Energy Advisory Committee and Task Force
- The GridWise Alliance
- The GridWise Architecture Council
- Demonstration projects via key national laboratories (e.g. Pacific Northwest)
- Numerous utility programs including both demonstration projects and full SG deployment efforts

European Smart Grid Initiatives

In Europe, the European Union (EU) Technology Platform, launched in 2006, is bringing together key stakeholders from across the industry. The primary goal is to develop a shared vision for the future of Smart Grid which encourages engagement of multiple, independent parties. The platform seeks to identify research needs and build support for an increased public and private research effort on electricity networks, as well as to align ongoing R&D projects and new European, national and regional programs on electric Transmission and Distribution (T&D)

systems. Additionally, the Strategic Energy Technology Plan – European Electricity Grids Initiative was launched in June 2010. Several other initiatives to spur Smart Grid development are underway, including:

- A new energy package as of August 2009
- A task force for Smart Grids launched in November 2009
- A European Infrastructure Package passed in November 2010
- An energy efficiency action plan planned for 2011[9]

In March 2011, the EC issued mandate M/490 to initiate a set of Europe-wide standardization, which was followed by the Communication on Smart Grids on 12 April 2011. Both are expected to give a shot in the arm for the European smart grid projects, R&D and investment. The proposed actions include generation of a first set of EU-level smart grid standards by the end of 2012. The EU member state will be required to set action plans with targets for the implementation of Smart Grids. [10]

In preparation for the burst of standardization activity in 2011-2012, the existing CEN-CENELEC-ETSI Joint Working Group – the European standardization body in the area of smart grids established in May 2010 - has re-organized as the Smart Grid Coordination Group (SG-CG). Its participants are:

- CEN: European Committee for Standardisation
- CENELEC: European Committee for Electrotechnical Standardisation
- ETSI: European Telecommunications Standards Institute[11]

Four sub-groups of the SG-CG have been set up to execute the M/490 work program:

- Sub-group on sustainable processes
- Sub-group on architecture
- Sub-group on first set of standards
- Sub-group on security

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[9] EU Directorate-General for Energy, IEEE Smart Grid World Forum, Brussels, December 2-3, 2010

[10] European Conference on the Deployment of Smart Energies, Brussels, April 14, 2011.

[11] DG for Energy, European Commission, European Conference on the Deployment of Smart Energies, Brussels, April 14, 2011.

Smart Grid Australia Movement

The Smart Grid Australia movement continues to gain momentum after it launched in April, 2009. It is a non-profit, non-partisan alliance dedicated to an enhanced and modernized electric system. The alliance holds meetings, organizes committees and assists with government initiatives and issues communications to accelerate progress. Key stakeholder groups within the movement and a key aspect of this effort for MNOs to consider, include:

- Electric utilities
- Telcos building intelligent communications networks
- Vendors selling equipment, software and services
- Energy investors
- Federal, state and municipal agencies
- Research organizations
- Non-profit organizations

Energy policy in Australia at the federal level – in a federal system very similar to that in the United States – consists mainly of setting goals and standards. Much of the specific policy and legislation is created at the state level. Individual state governments have been actively pursuing Smart Grid policy for several years.

The state of Victoria, for example, mandated in 2008 that Smart Meters be installed in every home and business. The goal of the project is to deploy 2.5mm meters by 2013, to provide meter data every 30 minutes and to lead to dynamic pricing of electricity depending on time of use. Australia is aggressively pursuing upgrades to its telecommunications infrastructure, a major contributor to future plans for Smart Grid functionality.

The National Broadband Network, a public/private partnership, will bring broadband, with 100 megabits/second download speed, to 90% of Australian homes within eight years. Wireless with speeds of 12 megabits/second is part of the plan as well. [12]

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[12] IEEE, http://smartgrid.ieee.org/public-policy/australia

China Smart Grid Developments

The Chinese are pushing forward aggressively with Smart Grid development. In 2007, East China Power Grid Co. Ltd., had a pilot project to strengthen Smart Grid in China by focusing on an advanced dispatching center and united information platform. In 2008, Shanghai Electric Power Co. Ltd., started a project focused on smart distribution network, including smart meters, distribution automation and user interaction. North China Grid Co. Ltd., focused on the use of digital meters on the user (customer) side of the value chain.

The goal of the State Grid Corporation of China (SGCC) is to independently develop an integrated and strong Smart Grid with ultra-high voltage (UHV) transmission as its backbone and subordinated grids in coordinated operation. Such a grid will be IT-based, digitalized, automated and interactive. At its 2009 meeting about UHV, SGCC outlined three stages:

- 2009-2010: Pilot Study
- 2011-2015: Complete Construction
- 2016-2020: Improvement

It is clear that China has the motivation and the resources to aggressively pursue these goals.

India Smart Grid Policy

India’s smart grid policy is driven by a critical need to increase reliability for the world’s fastest growing economy, to bring electricity to a large underserved rural population and to curb significant losses in its system. The central government controls generation and transmission, and the state governments control distribution. The financial realities of this structure are unbalanced: the states are unable to fulfill that which is demanded of them and are constantly looking to the central government for funding. India’s Ministry of Power (MoP) is directly associated with all electricity and Smart Grid policy. There is also the Central Power Research Institute, the Central Electric Authority and the Power Finance Corporation.. Beyond the MoP, India now has a Smart Grid Task Force, which also includes representatives from the telecommunications arena, the Ministry of Communications and Information Technology.

The nongovernmental Center for Study of Science, Technology, and Policy is a critical contributor to India’s Smart Grid policy landscape. Together with government, it has assisted in defining the following central goals of India’s Smart Grid vision:

- End of Load Sharing – need demand response to accomplish this

- Reliable Power – need self-healing capabilities through monitoring
- Cheaper Power – need “real time” monitoring of load sources to minimize losses
- Shifting peak generation away from costly sources – need better utilization of assets
- More sustainable Power – integration of “green” and renewable resources (demands a dynamic grid)

Currently, there are regulatory roadblocks to achieving several of these goals that relate to meters. For commercial and industrial customers, the legacy meters are not changing due to regulatory conditions. Regulation also prevents software uploads to smart meters. Given one of the central elements of the business case for installing smart meters is that they only have to be touched once – that is, a utility can eliminate every meter-related truck roll except the installation of the unit – the inability for meters to be updated remotely appears to be a significant hindrance to the economic argument for their deployment. Similarly, there, is no regulatory structure for demand response or remote disconnect. AMI infrastructure is used for tamper protection and theft control, but someone needs to be physically present to disconnect meters. Updated policies have been framed but not yet solidified.

Appendix B – Integrated Smart Grid Networks

Network Architecture

Smart Grid communications spans the enterprise from back office systems to substations, to distributed end devices and automated meters to mobile workforce members. The architecture and configuration of the Smart Grid communications system varies based on the strategy and requirements of an individual utility as well as the installed legacy systems and economic constraints.

The requirements drive the architecture which, in turn, drives selection of appropriate technology. The Smart Grid may include Automated Metering Infrastructure, Home Area Networks, Feeder and Distribution Automation, Substation Automation, Workforce Automation, and Systems Protection. These functions have different communications requirements and characteristics such as availability, capacity, latency, resilience, outage recovery and security.

Automated Metering Infrastructure can involve fairly large traffic volume, but the latency requirements are not particularly demanding. Distribution automation offers lower traffic volumes but availability, reliability and latency requirements are more demanding. Systems protection has lower traffic volume, but the highest requirement for low latency and recovery.

The following diagram illustrates the interconnectivity between systems within the Smart Grid ecosystem. The interconnectivity is critical to providing the control and operation functionality that enables Smart Grid.

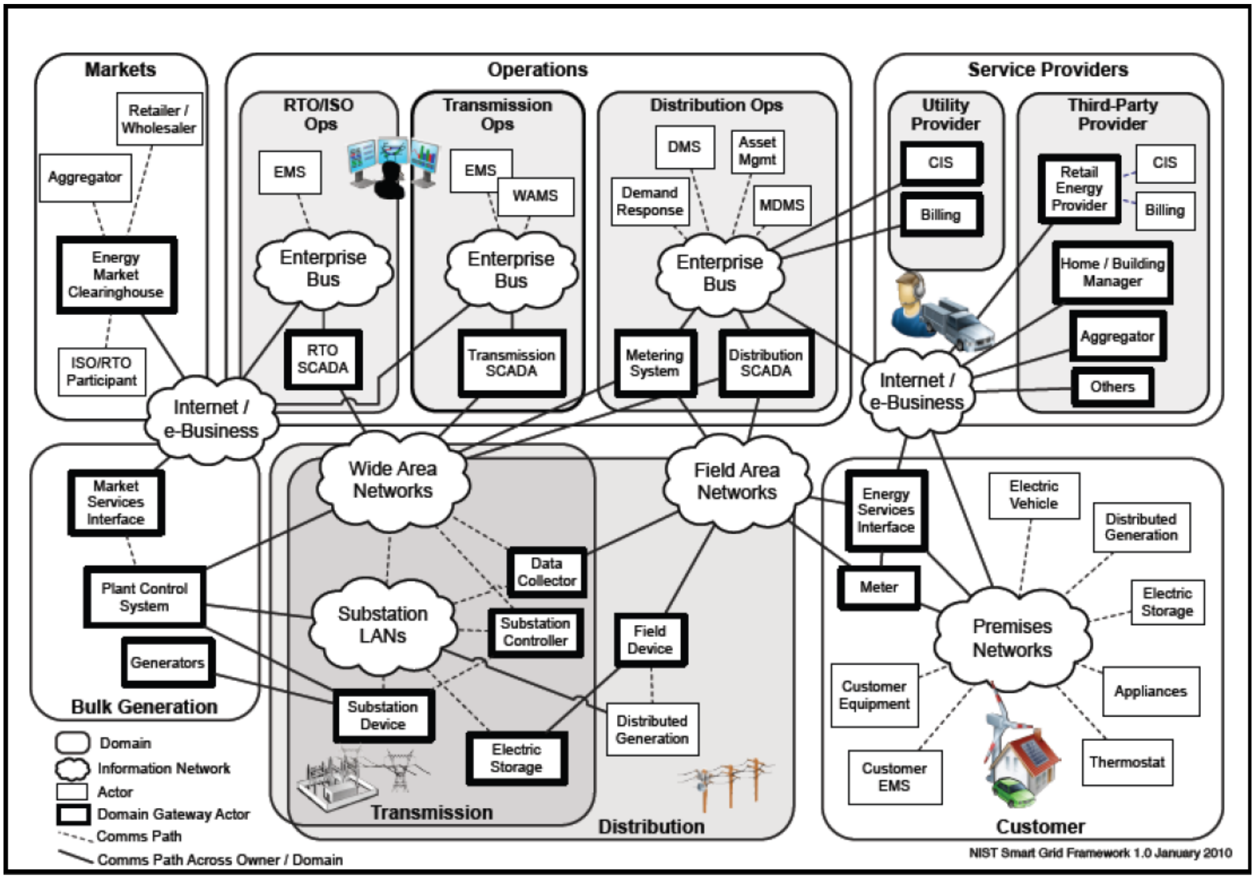

Figure 9: Smart Grid Ecosystem Interconnectivity[13]

The data a utility needs to collect, transport and access is either "operational" or "non-operational." One can distinguish between these two categories by determining the extent to which the delivery of the data is critical to enabling the core functions of the utility.

Different systems present different security requirement as well as vulnerability modalities. AMI/HAN traffic may well be considered non-critical, but DA/SCADA, Direct Load Control, distributed generation, storage control and public Plug-In Electric Vehicle (PEV) recharging station control may be deemed "operational" or "critical." If it is, it is unlikely to be operated over a public network.

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[13] NIST Smart Grid Framework 1.0, January 2010

Private networks in unlicensed (902-928MHz, 2.4GHz, 5.4/5.7GHz, etc) or lite-licensed (3.65-3.7GHz) bands run immediately into questions of availability/reliability, QoS, or infrastructure cost of coverage; private networks in licensed spectrum run up nearly immediately against availability of spectrum and choice of technology standards, including the key considerations of frequency re-use and cost of coverage.

The most recent Federal Communications Commission (FCC) National Broadband Plan in the United States clearly indicates that the FCC has no near-term interest in setting aside spectrum for specific classes of users, specifically Utilities, and intends to focus instead on “hardening” third-party cellular service providers and potential opportunities for sharing radio access networks. Utilities and public safety entities would share, while the FCC continues to auction re-claimed TV band spectrum to third-party commercial operators.

Technical Standards

Electric Utilities have been, to a certain extent, slow or reluctant to commit to certain Smart Grid initiatives because of the risk of stranded investments. Until system-system and vendor-vendor inter-operability standards have been settled, this hesitancy reflects the difficulty utilities have recovering their costs in a highly-regulated environment.

Historically, there have been relatively robust and widely accepted standards in teleprotection, substation automation and SCADA (such as IEC 61850, GOOSE, DNP3, ANSI C37.94, ANSI C19.12). There have been few but proprietary solutions to AMI in particular.

In the United States, the National Institute for Standards and Technology is responsible for rationalizing and proposing the set of interoperability standards and cyber-security guidelines/practices in order to remove barriers to Smart Grid adoption. The process is a consensus-driven approach, which has, thus far, yielded few concrete benefits and only five identified candidate standards for submission to FERC for rulemaking:

- IEC 61970 and IEC 61968: Providing a Common Information Model necessary for exchanges of data between devices and networks, primarily in the transmission (IEC 61970) and distribution (IEC 61968) domains
- IEC 61850: Facilitating substation automation and communication as well as inter-operability through a common data format
- IEC 60870-6: Facilitating exchanges of information between control centers

- IEC 62351: Addressing the cyber-security of the communication protocols defined by the preceding IEC standards.

Of these five, only IEC 62351 addresses cyber-security requirements. Although the National Institute of Standards and Technology (NIST has taken a leading role as well in identifying cyber-security standards, and has issued its own Interagency Report NISTIR 7268 Guidelines for Smart Grid Cyber Security (August 2010); only IEC 62351 has been so far identified and submitted for rulemaking to FERC.

In addition to NIST, much standardization activity is going on in Europe at IEC and CIGRE, and is believed to be moving forward as well in China and Japan. The IEEE and ITU also have active working groups officiating in various countries across all continents.

Appendix C – Traditional Utility Communications

SCADA systems are used to monitor parameters of interest that affect electricity distribution network performance and reliability such as voltage, power, power quality, and Volt-Ampere-Reactive Units (VAR). SCADA also tells of unusual or unexpected events such as overload conditions or circuit-breaker trips and can implement control activities at substations and on feeders. SCADA manages a variety of devices, including voltage and power monitors, voltage regulators, capacitor banks for VAR control, inter-ties, re-closers and switches.

Historically, monitor and control devices (Remote Terminal Units or RTUs have been serial-data connected (such as RS-232/RS-422, X.21, G.703) or worked through 4-wire analog telephone line signaling, or low-speed telephony modems (9600 baud or less). They have relied on Utility-owned as well as carrier-leased copper lines and Multiple Address System radio systems providing 9600/19200 baud operation in licensed narrowband (12.5/25 KHz) 900 MHz channels using a single Master Station polling multiple addressed slaves.

It is important to note that historically, nearly all deployed RTUs have been located in substations with very few, if any, on feeders.

In general, the latency requirements for most SCADA-driven applications ranged from four to six seconds for receiving a response to poll at the Energy Management System. However, the emergence of renewable and intermittent sources of generation, along with continuing limited storage in the distribution network as well as other factors potentially impacting power quality and distribution network stability, are likely to lead to shrinking this time requirement to the 0.1s to 1s range in the near- to mid-term. The frequency of scheduled polls, as well as on-demand reads, is also likely to increase very substantially.

Field-force communications Land Mobile Radio (LMR) has historically been limited to voice, using high-power analog FM vehicular radios up to 30W and handsets up to 5W. Many utilities make use of licensed VHF communications (220 or 450 MHz) to achieve the required wide-area coverage, with UHF (800-900 MHz) channels less frequently deployed. Repeaters and simulcast systems also have been widely deployed where required to extend coverage and minimize the need for licensed channels.

Recent movements in the United States, such as FCC narrow-banding requirements and elsewhere to reduce congestion, add capacity and move to higher-efficiency spectral utilization for LMR voice, has meant a shift to (trunked or conventional) digital systems (generally with backward-compatible conventional analog FM capabilities). These systems include P25, TETRA, and ETSI DMR, which support narrowband data (9600 baud) communications in addition to mobile voice.

Backhaul facilities widely used by Utilities to support high-capacity communications needs include point-to-point microwave radio links, generally in the 6 GHz band and SONET/SDH fiber. Historically, these systems have been deployed to expected minimum availability of 99.999% and often to 99.9999% availability, by exploiting hot-standby, fully redundant equipment, diverse routes and/or protected ring architectures. These systems have typically been used to connect substations, control centers, generation facilities, MAS masters, and other points of significant traffic aggregation rather than feeders or feeder automation systems.

Teleprotection, or protection of high-voltage and extra high-voltage bulk transmission systems, has been performed historically by dedicated purpose-made Power Line Carrier systems traversing the transmission system or dedicated communications links (copper or fiber) between Teleprotection relays. Teleprotection has the most demanding availability and latency requirements of all Utility operational communications. Communications latencies under ¼ cycle (4.2 – 5 ms depending on 60Hz/50Hz) are generally required. Additionally, current differential teleprotection ordinarily requires less than 1ms latency asymmetry between forward and reverse connection paths. This requirement finds no analogy in the telecommunications space and may dictate GPS-disciplined, ovenized or Rubidium high-stability clocks at each relay.

Appendix D – Other Commercial and Regulatory Challenges

Regulatory and Government Relations

The legal framework surrounding the electric power industry in the United States is extensive. At the federal, state and local levels, policymakers have significant control over the market paradigm in which electricity is generated, transmitted and delivered. The United States, however, does not have a top-down uniform national energy policy. Much power is held at the state level to determine electricity prices, prescribe service areas, permit rights-of-way and construction of generation facilities, implement renewable energy standards and pilot programs for future technologies.

At the state level, Public Service Commissions and Departments of Public Utilities regulate retail service and distribution assets. Utilities are granted monopolies to serve a particular area (a "service area") and in return, have an obligation to serve every customer in their designated area. Smart Grid implementation flows naturally from this regulatory structure. While there is financial support from the federal government, the implementation is happening at an enterprise level. Those utilities tasked with distribution of electricity are regulated most tightly at a state level, so we see a diverse patchwork of progress on Smart Grid depending on the enterprise and the particular state in which the enterprise operates. Duke Energy, for example, has a Smart Grid pilot program in North Carolina, but Smart Grid deployment activity in both Ohio and Indiana. In this case, the Smart Grid policy and implementation is inconsistent within an enterprise for regulatory, economic and business case reasons.

This patchwork of state commissions governs how utilities can recover their costs and make an ROI for equipment and products they need to deliver electric power. Because of the regulatory power of the commissions, they hold a great deal of sway over the progress of Smart Grid deployment, and therefore, over the potential for mobile carriers to be successful in a particular state in the United States. Awareness of the market environment on a granular basis is critical to understanding the business needs of a utility and what would be an attractive product proposition.

Utilities in the United Kingdom, for example, face 50% sunk costs on investment in smart meters. Because of the lack of increase in the rate base to support such an investment, smart meters must be funded by the energy retailer. Retailers are faced with a business proposition that involves recovering only half the cost of implementing a technology that will cause customers to use less of the product. Energy retailers can seek to defray costs through various federal funding programs.

The classic role of the regulator is also the need to accommodate the new investments in smart metering during the price control process for metering and/or network usage charges. The application of incentives to promote investment in new metering infrastructure is quite diverse. In many European Union member states, regulators are hesitant to allow for higher user charges to accommodate investments into smart metering. In some of these cases, regulators state cost coverage should basically come from existing revenues. In Spain, for instance, where a national roll-out has already been decided, an increase of the monthly metering fee of around 0.3 € is allowed. In Austria, the metering charge for smart metering was set equal to that of conventional metering.

With regard to metering programs, in the majority of the Energy Regulators Regional Association (ERRA) countries, which include 23 Eastern European and Commonwealth of Independent States (CIS) states, metering remains part of the regulated DSO functions, although sometimes consumers and suppliers are also allowed to own meters. The costs of meters are recovered via the regulated network charges and investments in metering equipment are subject to regulatory approval. Although the regulatory regimes vary from country-to-country, all regulatory regimes known to us apply an ex-ante regulatory review and explicit approval of investments before inclusion of costs in the allowed revenue.

New tariff schemes are certainly of high practical relevance, as major benefits possibly stemming from a smart metering roll-out cannot be achieved without innovative tariff schemes. Together with new tariff schemes, new payment schemes will also emerge. Smart metering can enable or simplify a wide variety of possible payment schemes such as pre-payment schemes. In the Netherlands and United Kingdom, pre-payment schemes are already fairly common, especially for bad creditors. As in these payment schemes, feedback on the level of consumption and associated costs is given in a very direct way, and energy saving incentives are comparably strong.

Regulatory policy regarding utility Operational Expenditures (Opex) and Capital Expenditures (Capex) weighs heavily on the business case for smart grid in different global regulatory climates. In the United Kingdom, as the above example illustrates, utilities face a more problematic economic choice than do some utilities in the United States. In the United States, as we've noted briefly in Section 3.2, investor-owned utilities make a return, provided it is approved by a regulator, on Capex. So it is in their best interest, and the best interest of their shareholders, to deploy as much capital as possible on infrastructure they own. This would discourage those utilities from outsourcing services in most cases. Outsourcing could reduce the amount of Capex and therefore ROI, while increasing Opex, on which the utility earns no return.

The business case for smart grids in Europe is completely different from the US: in most European countries, the consumption is one third to half of that in the US, which means that there is much less volume to save and to shift from one part of the day to another. Establishment of sustainable, affordable and secure supply of energy on a pan-European basis is the key objective for the European Commission's activity in the area of smart grids. The 'climate and energy package', which is a binding legislation to implement the 20-20-20 targets, was agreed by the European Parliament and Council in December 2008 and became law in June 2009. These targets are:

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

Since 2004, the EC has spent several million Euro on research and pilot projects through the 6th and 7th Framework Programmes dedicated to Research and Technological Development (FP6 and FP7). To date, the smart grid deployments in Europe are still at a relatively low level, and the focus of the EC regulation is now changing from supporting research and small pilot projects to encouraging large-scale rollouts.

Key EU regulation on smart grids includes:

- The Energy Efficiency Directive (2006/32/EC, Annex3) identified smart meters as one of the main measures, contributing to the overall energy efficiency improvement.
- Renewables Directive (2009/28/EC, Art16) views Smart Grids as an enabler for integration of increasing renewable energy into the grid and obliges the Member States to develop transmission and grid infrastructure towards this aim.
- The 3rd package for the Internal Energy Market (Directives 2009/72/EC+ 2009/73/EC) agreed on concrete set of goals, such as an obligation to rollout smart meters by 2020. It also encouraged decentralisation of generation and energy efficiency.
- EU Smart Metering Mandate M/441
- EU Electrical Vehicle Mandate M/468

A recent survey by EURELECTRIC, the Association of the electricity industry in Europe, concluded the following about the development of Smart Grid:

- Inadequate rates of return and regulatory instability are hampering investment in Smart Grid
- Lack of clarity about the roles and responsibilities of individual market players is delaying smart meter rollout
- Regulators are largely encouraging business-as-usual expenditures by taking a narrow view when evaluating cost-efficiency, the desirability of extra R&D expenditure, or smart grid pilot projects.[14]

The mobile industry must be keenly aware of different business case dynamics within different states, regions and countries. A central challenge to entering the utility market is to justify the business case of any particular product or service in light of esoteric regulatory paradigms that often seem counter-intuitive to much of the business community. Additionally, the mobile industry should focus on defining aspects of their capabilities that offer a true competitive advantage in light of the many opportunities that could evolve. Flexibility will be an important attribute of any successful strategy.

Flexibility is key, especially in light of the different outcomes that could befall the Smart Grid movement. Most of the market dynamics around this movement are undefined. While Utilities are active in moving forward on Smart Grid, basic market drivers, like standards, have yet to be defined. What it means for Smart Grid-related solutions to be economically and technically viable is largely undetermined. As standards and other market drivers settle towards resolution, mobile operators who adapt quickly and understand how to adapt their business case for relevant products, given a particular regulatory paradigm, will succeed. There is a significant opportunity as well for mobile operators to help to define the direction of Smart Grid and guide the development of business case arguments around technologies that hold a competitive advantage for a particular operator.

When combined with a strong business capability and an understanding of core competency, flexibility around that core competency (and engagement with Utilities and regulators) is the essence of strong regulatory and government relations.

US and European Standards Bodies

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[14] "Regulation for Smart Grids", a EURELECTRIC Report, February 2011, p. 7.

Standards development continues to be one of the most pressing challenges to the full deployment of the full potential of Smart Grid.

In the United States, National Institute of Standards and Technology (NIST) announced an aggressive three-year program to develop standards by the end of 2009. That process continues today. The Smart Grid - Interoperability Panel (SGiP) supports NIST in fulfilling its responsibilities under the Energy Independence and Security Act (EISA) of 2007. The SGiP will identify, prioritize and address new and emerging requirements for Smart Grid standards. It will further develop the initial NIST Framework and Roadmap for Smart Grid - Interoperability standards, release 1.0, released in January 2010. The overall goals have been to reach consensus among utilities, equipment suppliers, consumers and standards developers as to how to proceed.

Other active organizations in standards development are the Grid-Interop Forum, operating in association with the GridWise Alliance Architecture Council. There is a Common Information Model working group and the Institute of Electrical and Electronics Engineers (IEEE’s) Smart Grid Interoperability Standards Project P2030. The National Energy Regulatory Commission (NERC) in the United States has a Smart Grid Task Force, the purpose of which is to assess the reliability impacts of integrating Smart Grid technology on the bulk power system (as distinct from the distribution system). Of course, there is industry involvement as well, by companies like Oracle, Cisco, ZigBee, GE and SAP.

In Europe, the most significant effort to date has been in AMI standards development. There is widespread activity, but little coordination, and the EU is pushing member states to coordinate standard development.

Appendix E – Industry Participation

Technical and Standards Participation

MNOs can help define the market into which they seek to sell: involvement in utility industry forum and standards development organizations has the potential to reap significant rewards from a business case and core competency perspective when the time comes to go to market with standard compliant technology and tailored service solutions.

Mobile network Operators (MNOs) must be active participants in policy-making forums, standards development organizations, vendor associations and user groups and conferences and other events where major stakeholders and decision-makers and representatives of utility operators, suppliers and user advocates shape the future of the energy sector.

At the industry level, there are trade associations and industry standards groups in which MNOs should be engaged. It is interesting to note that there are few, if any, MNOs who are members of the UCA International Users Group. That group is "a not-for-profit corporation consisting of utility user and supplier companies that is dedicated to promoting the integration and interoperability of electric/gas/water utility systems through the use of international standards-based technology."[15]

International Telecommunication Union (ITU) ITU is a key organization at the global level: its new G.hnem Smart Grid Standards are in the final stages of approval, addressing smart grid applications such as distribution automation, AMI, demand side management, grid-to-home communications, home/building energy management, home automation, vehicle-to-grid and vehicle-to-charging station communications.

These organizations are important because of the visibility they can bring members with each other and because of influence particular companies can have on the direction of initiatives and decisions and, ultimately, standards. The goal of effective engagement comes back again to the goal of aligning industry direction with one's own core competency and strategic plan.

At a government level, organizations such as the National Institute of Standards and Technology (NIST) and Federal Energy Regulatory Commission (FERC) in the United States

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[15] http://www.ucaiug.org/aboutUCAIug/default.aspx

take a great deal of guidance from the industry-based North American Electric Reliability Corporation (NERC). In Europe, involvement with Council of European Energy Regulators (CEER), Smart Grid Co-ordination Group (SG-CG) and the European Regulators' Group for Electricity and Gas (ERGEG) could prove pivotal; in India, the Ministry of Power (MoP) and the Center for Study of Science, Technology, and Policy (CSTEP). Across the globe, governments are working now to define standards for Smart Grid. Now is the time to be involved.

Industry Leadership

Industry leadership helps companies gain visibility and to interact with potential customers, suppliers and competitors. One gains insight and invaluable information from attending events such as DistribuTECH, GridWise Global Forum, PowerGen Europe and the CEO Conference of the Association of the Energy Supply Industry of East Asia and the Western Pacific.

Attending these forums provides useful information, will generate business insights and build relationships. Helping to lead the organization of the forums is an additional step companies can take into a more powerful leadership position to help define the direction of agendas and seek to not only move the market but to participate in it.

Public Relations

The mobile industry needs to undertake a combination of marketing, government affairs, industry involvement, and any/all activities that take place to further the agenda of the company in the eyes of external parties. Specific actions that are useful to take are:

- Develop whitepapers that demonstrate a leading command of market dynamics
- Develop and guard a strong media campaign strategy
- Use conference leadership and attendance to deploy messaging effectively

Especially at this stage of Smart Grid development, when there are many elements of the market left undefined, companies who can carefully choose their strategy and insightfully and define themselves in the public’s mind stand to gain significant ground from those who are unable to develop a leading public persona.

Appendix F – Other Communication Technologies Competing with Mobile

The use of public mobile networks for Smart Grid communications has certainly not been a preferred approach to date. There are a number of competing technologies that have obtained an early advantage in serving the needs of Smart Utilities. Mobile Network Operators (MNOs) should be aware and prepared to compete with these various technologies in order to succeed in the energy market.

RF Mesh – Many utilities have chosen to build proprietary wireless mesh networks to provide connectivity for Smart Meters. RF Mesh solutions are offered by a good number of meter manufacturers, such as Itron and Landis + Gyr, as well as independent network providers like Silver Spring Networks. While current deployments of mesh networks are limited in terms of bandwidth and latency, they offered a cost-effective solution for basic meter telemetry by the time that the cost of mobile modems and mobile data plans was prohibitive for massive Smart Grid deployments.

Power Line Carrier (PLC) – Transmission of data over power lines has been the preferred approach in Europe for connecting smart meters, beginning with the flagship deployment of over 27 million PLC-connected meters in Italy by the local utility, Enel. Since then, several other European countries have followed suit in using PLC technology.

Tower-based Narrowband RF – Meter manufacturer Sensus, with its FlexNet technology, is the leading proponent of tower-based RF connectivity for grid assets. Leveraging licenses of narrowband spectrum in the United States, Sensus deploys towers and base stations across utility service territories. Use of FlexNet alleviates concerns from the part of utilities about using unlicensed spectrum for mission-critical purposes.

WiMAX – A number of vendors in the utility space support the deployment of private WiMAX networks for utility communications. With the promise of a similar performance compared to advanced mobile networks, various utilities tested and committed deployments of private WiMAX as their preferred communications solutions. Nevertheless, many of those decisions are subject to revision nowadays given the lack of traction of WiMAX technology in the telecom space.

Fiber & Microwave – While use of fiber optics and microwave communications is not economical for Smart Meter connectivity, the low latency and reliability of such technologies made them a preferred approach for distribution and transmission automation applications. Utilities use fiber and microwave technologies to connect assets like substations, phase-measurement units, capacitor banks and grid switches.

Appendix G: Doing Business with Utilities

There are many opportunities to make indirect contact with key decision makers at utilities. Trade shows are a prime example of an informal – that is, outside the utility procurement office – way to interface with company leaders who are interested in talking about technology. Figure 9 illustrates the utility procurement structure in several markets. The Utility Procurement Office is involved in evaluating bids, but generally not in final buying decisions. As vendors, the selling process should begin with key executives well before the procurement office gets involved. Industry association meetings provide another more relaxed place to build personal relationships, often without distraction from competing suppliers.

Utility Type	Technology Champion	Other Key Buying Influencers	Final Decision Maker(s)
Investor Owned	• Director – *Particular Technology* • *Technology* Program Manager	• Vice President – Distribution • VP – Customer Service • VP – Information Technology • VP – other key areas	• Senior Vice President – Customer Service • SVP - Distribution • CIO • COO
Municipal	• Metering or Public Services Manager • AMR/AMI Project Manager	• Department Heads – • Director – Planning • Director – Public Works	• City Manager • Mayor • City Commissioners
Cooperative	• Metering Manager • AMR Manager	• Vice President – Distribution • VP – Customer Service • VP – Information Technology	• President/General Manager/CEO • Board of Directors

Figure 10: Utility Types and Decision Makers

Another key way to do business with utilities is through partnerships. One key example of a successful relationship involving communications infrastructure is the Tennessee Valley Authority (TVA), a large generation and transmission company in the United States. The TVA needed basic wireless communications coverage for field force operations which was not available. The TVA partnered with a mobile carrier which built base stations on TVA property and provided mobile service to TVA. This was a positive economic situation for both partners – the TVA reduced its cost of capital because it avoided building its own network infrastructure, and the carrier avoided the expense of purchasing the site for the base stations.

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Appendix I: Glossary of Acronyms

AEMO	Australian Energy Market Operator
AMI	advanced metering infrastructure
ARPU	average revenue per user
CCGT	combined cycle gas turbines
CEER	Council of European Energy Regulators
CDMA	code division multiple access
CIR	committed information rate
CIP	critical infrastructure protection
CoS	class of service
CSTEP	Center for Study of Science, Technology, and Policy
CT	combustion turbine
DR	demand response
DA	distribution automation
EDGE	enhanced data rates for GSM evolution
ERGEG	European Regulators' Group for Electricity and Gas
EV	electric vehicle
GPRS	general packet radio service
HMAC	hash-based message authentication code
HSPA	high speed data access
IOU	investor owned utilities
ISO	independent system operator
ITU	International Telecommunications Union
LMR	land mobile radio
LTE	long term evolution
MNO	mobile network operator
MPLS	multi-protocol label switching
NERC	North American Electric Reliability Corporation
NIST	National Institute of Standards and Technology
NISTIR	NIST Interagency Report

OPF	optimal power flow
OTA	over-the-air
PUC	public utility commission
QoS	quality of service
ROI	return on investment
RTU	remote terminal unit
SCADA	supervisory control and data acquisition
SDH	synchronous digital hierarchy
SGCC	Smart Grid Corporation of China
SLA	service level agreement
SNMP	simple network management protocol
SONET	synchronous optical networking
TDM	time division multiplexing
TLS	transport layer security
TOP	take-out point
UHV	ultra high voltage
VAR	Volt-Ampere-Reactive units
VPN	virtual private network
VPLS	virtual private local area network service
WCDMA	wideband CDMA