Cellular and the Smart Grid: A Brand-New Day

WHITE PAPER

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IDC ENERGY INSIGHTS OPINION

Commercial cellular solutions play an increasingly visible role in smart grid deployments, which use the technology to ensure data delivery, security, and accessibility for utility applications. Cellular is widely used as a backhaul technology in the utility space, yet business and technical developments position cellular to support advanced smart grid applications such as distribution automation, smart metering, and home energy management.

Commercial cellular viability in the smart grid has advanced due to several factors:

- Cellular carriers have launched smart grid–specific service solutions and priced services to win market share.
- In growing numbers, power equipment manufacturers natively support cellular connectivity.
- Cellular-based smart grid network solutions meet and beat performance and reliability expectations.

Commercial cellular solutions possess strengths compared with alternative wide area networks (WANs) and neighborhood area networks (NANs), including:

- Use of licensed spectrum to ensure network performance and extensibility
- Mature technology providing true broadband performance
- Proven scale to support tens of millions of devices and open industry standards compliance in hardware and software

Commercial cellular can also address reliability and security concerns with enabling device technology. Multimode cellular modules allow devices to connect to multiple networks, bringing ubiquitous coverage one step closer to reality. At the same time, strong device and network security services provide assurances such as data integrity and confidentiality.

This white paper contains practical examples of cellular used in smart grid deployments at Duke Energy, Texas New Mexico Power, ECOtality, and CPS Energy that demonstrate the flexibility, wide range of applications, and innovative ways utilities utilize commercial cellular solutions for smart grid applications.

IN THIS WHITE PAPER

In this IDC Energy Insights White Paper, we review drivers for the increased adoption of commercial cellular in smart grid applications and how commercial cellular network technology meets utility requirements. Finally, brief case studies of the practical uses of commercial cellular demonstrate the adoption and flexibility enjoyed by utilities today.

SITUATION OVERVIEW

The utility industry continues to innovate with the collective push to automate greater portions of the electric grid. By overlaying information and communications technologies (ICT) onto the grid, the industry has given birth to the notion of a "smart grid." Applications supporting programs for energy efficiency, reliability, and new revenue sources include demand response (verification), plug-in electric vehicle (PEV) charging (to signal an optimal charging period), smart metering (outage detection and restoration confirmation), small-scale renewable generation (distribution harmonization), and dynamic pricing analytics (market purchase optimization), to name a few.

The smart grid requires near-real-time, accurate, reliable, and secure data from the field to enable optimization of operational systems and automated market functions.

In the effort to automate greater portions of the distribution grid, utilities face a new set of challenges upgrading communication networks, deploying devices, and installing management software. Central command and control network design is giving way to distributed intelligence at the edge of an expanding network of smart devices. The mixture of devices includes line sensors, smart meters, power control modules, routers, charging stations, renewable generation units, remote terminal units (RTUs), and more. In this environment, communication networks play the critical role of ensuring data delivery, security, and accessibility.

Smart grid builds on top of the communication networking capabilities placed between the substation and the meter. The utility ICT infrastructure supporting a smart grid encompasses a heterogeneous network environment, which includes fiber, microwave, Ethernet, cellular, PLC, and even satellite.

WANs and NANs become critical infrastructure for connecting the myriad of field devices. Since wireless networks enjoy distinct cost, deployment, and maintenance advantages over wireline networks, impressive growth for wireless network solutions has resulted. Increasingly, the viability of cellular network–based services is becoming evident to utilities.

Carriers Driving Change and Adoption

Cellular communication service providers (wireless carriers) have serviced the utility industry for over 20 years. Service offerings revolved around basic network access and data transport for commercial and industrial (C&I) revenue meters and select remote transmission and distribution (T&D) devices. However, wireless carriers began to compete in the U.S. smart grid market four to five years ago. Utilities embraced the offerings with dispassion as the carriers offered a suboptimal value proposition that did not address utility and regulatory concerns for network security, control, and affordability.

Since that time, national wireless carriers responded to the utility market with a greater breadth of competitive offerings, winning service contracts as a result.

The drivers for increased adoption and viability of cellular for smart grid include:

- **Attractive pricing.** Wireless carriers have aggressively lowered prices to increase the value proposition compared with alternative private network solutions. For example, high-volume machine-to-machine (M2M) service contracts hovered at $10+ per month per device in 2008, dropping below $0.50 per month per device by 2010.

- **Supported hardware.** Transformers, line sensors, gateways, smart meters, and a number of other devices from multiple vendors natively support cellular in hardware configurations.

- **Proven reliability** in large-scale deployments. Cellular is a reliable link in advanced metering infrastructure (AMI) networks. IDC Energy Insights estimates that close to 90% of endpoints supported by wireless mesh networks use public cellular networks for backhaul.

- **Smart grid service offerings.** National wireless carriers launched a number of core services including network access, security, and data management, as well as emerging application services such as meter-to-cash management and transformer monitoring.

Wireless carriers describe the smart grid opportunity as a frontier to advance M2M services using standards-based, high-performing cellular communication networks. To the carriers, the smart grid's strategic importance becomes evident when considering the utility-focused services being brought to market.

Strengths of Commercial Cellular for Smart Grids

Each generation of cellular technology is successively more efficient, economical, powerful, and high-performing. Cellular technology, whether 2G, 3G, or 4G or GSM[1] or CDMA[2] based, is a WAN technology. Cellular technology is flexible, acting as a viable substitute or complement for NANs used for AMI, for example. The role of commercial cellular versus alternative communication technologies needs to be considered as part of a comprehensive smart grid strategy. In these pages, the capabilities and use of cellular technology are presented in the context of various smart grid applications.

Technical requirements for throughput, latency, security, scalability, and more are addressed by network IT and enterprise architect professionals. On the other hand, *business* requirements such as vendor stability, risk mitigation, ROI, and business fit are the responsibilities of utility executives and regulatory commissioners who make strategic purchasing and funding decisions. Together, technical and business requirements provide a foundation for making informed decisions.

Organizations that are considering smart grid network solutions should take into account the strengths of commercial cellular technologies compared with competing alternative WAN and NAN wireless networks.

Spectrum

Wireless networks operate over either licensed or unlicensed spectrum. All commercial cellular networks operate on licensed bands. Unlicensed spectrum eliminates the cost for spectrum licensing. However, unlicensed spectrum comes at a cost: Power transmit limits are lower for unlicensed spectrum bands, which increases the amount of physical infrastructure (base stations, access points) required to cover a service territory. Additionally, unlicensed spectrum allows no control over competing devices that use the same slice of spectrum (e.g., 900MHz, 2.4GHz), thereby increasing network performance risks. On the other hand, with licensed spectrum, users can be assured that the spectrum is managed exclusively by the service provider.

[1] GSM — Global System for Mobile communication — digital cellular network standard developed by the European Telecommunications Standards Institute (ETSI)

[2] CDMA — code division multiple access — a channel access method that uses a form of spread spectrum signaling

Technology Maturity

Commercial cellular became available in 1983 and is now utilizing the latest 4G technology. With nearly 30 years of research and development activities, cellular technology's maturity underpins network stability, security, and scalability advantages not found in new, first-generation smart grid network technologies.

Proven Scale

Wireless carriers such as AT&T, Sprint, and Verizon connect tens of millions of devices to their networks. For context, "If every water, gas and electric meter in the U.S. (about 300 million meters) transmitted a day's worth of 15-minute interval data [over the AT&T network], it would amount to an increase of less than 2/1000th of 1 percent (specifically 0.00018%) in the amount of data that a carrier like AT&T currently transfers across its network on a daily basis [over 18,000 terabytes]."[3] As a result, the utility M2M market benefits from the scaling capabilities needed to support consumer market devices.

Standards Support

Commercial cellular networks build on open industry and de facto standards whether CDMA (EV-DO, 1xRTT) or GSM (GPRS, EDGE) based. The advantages manifest themselves in the ease of migration to next-generation technology, mitigation of technology obsolescence risks, affordable hardware, rapid software development, and pools of engineering expertise.

Commercial cellular solutions possess many advantages over competing private solution alternatives, yet concerns about reliability and security persist. Both reliability and security can be ensured, beginning with the current state of the enabling device technology.

Multimode Cellular Modules Advance Possibilities for Leveraging Commercial Cellular in Smart Grid Systems

Concerns are often weighed against commercial cellular's ability to meet the reliability needs of a utility's smart grid, triggering various responses from cellular players to address such apprehensions. One of the more powerful approaches leverages multimode cellular modules as a basic building block of smart devices. A multimode module allows a device to be connected to more than one cellular network. For example, a multimode-enabled device could connect with the utility using AT&T, Sprint, or Verizon networks without requiring any hardware modification.

[3] SmartSynch, 2011

Multimode cellular modules enable a utility to overcome several aspects of reliability concerns, including:

- **Coverage.** The best possible cellular coverage can be achieved by having the flexibility to run over multiple networks (e.g., CDMA and GSM). Between national and regional wireless cellular carriers, cellular covers 99.8% of the population and 76.3% of the U.S. land mass.[4]

- **Disaster backup.** Running over a primary cellular network provides 99.99%+ annual uptime (less than 50 minutes of downtime annually). However, any network could suffer damage from natural disasters such as hurricanes and earthquakes. The ability to switch to an alternative cellular network reduces risk of downtime.

- **Longer lifetime.** The use of multimode cellular modules helps mitigate the risk of network obsolescence or carrier technology lock-in.

- **Cost/affordability.** Multimode modules offer an affordable way to achieve network redundancy without building overlay networks.

Network reliability can be effectively addressed with device technology such as multimode cellular modules. By bolstering the device capabilities, end users can take advantage of the security features, ensuring reliable data and device protection.

Security Is Center Stage in Cellular Network Deployments

Utility smart grid strategies promise extensive use of communication network infrastructure. Yet, security and risk concerns continue to permeate conversations in many industries, including utilities, as cyberattacks such as Stuxnet and Night Dragon expose specific utility system vulnerabilities. These concerns extend to the communication network infrastructure as security threats build as expanding networks increase the "surface area" for external attacks (i.e., more devices act as entry points). All communication network infrastructure can suffer from traditional vulnerabilities such as denial-of-service (DOS) and channel jamming attacks.

Telecommunication equipment vendors have continued to harden security by implementing enhanced transport protocols and encryption. In addition, wireless carriers offer enhanced security services.

[4] Federal Communications Commission's 15th Annual Mobile Wireless Competition Report (released June 27, 2011)

While cellular infrastructure plays a critical role in backhaul for dozens of utilities today, some take the use of public network steps further by connecting smart meters directly with embedded cellular modules. The use of cellular technology in this configuration brings with it security advantages versus private wireless mesh:

- Commercial cellular reduces the number of hoops that data has to go through, hence providing better control over the data.
- Commercial cellular provides an all-IP communication fabric, which enables greater end-to-end visibility of the data transactions.

Cellular providers have enhanced security features and capabilities over the years such as encryption, remote tunneling, point-to-point data protection, intrusion detection, and data access.

Carriers offer managed security services, which are rigorously tested and deployed in diverse customer locations and application. Carriers utilize network management features to gain deeper visibility into the devices and their data communication paths. In addition, they provide authorization and authentication services, which are key to any security deployment, that help detect known and unknown (rogue) devices entering the corporate network. Furthermore, cellular providers such as Verizon Wireless and AT&T can be instrumental in achieving NERC-CIP compliance. They offer extensive NERC-CIP consulting capabilities that provide utilities with controls and advice to help achieve required compliance levels.

CASE STUDIES

In this section, we present practical examples of cellular used in smart grid deployments at Duke Energy, Texas New Mexico Power, ECOtality, and CPS Energy. The four case studies demonstrate the flexibility, wide range of applications, and innovative ways utilities utilize cellular for smart grid applications.

Practical Scenarios Using Commercial Cellular Networks in Smart Grid Deployments

Duke Energy: Developing the Communications Platform to Enable a More Intelligent Electric Grid

Duke Energy owns and operates four utilities in North Carolina, South Carolina, Ohio, Indiana, and Kentucky. The company counts 4 million electric customers and approximately 500,000 gas customers in the South and Midwest. In 2011, Duke Energy agreed to buy Progress Energy for $13.7 billion. The company set out on an ambitious $1 billion capital spending project to implement a digital grid infrastructure to enable a more efficient and reliable T&D system, implement energy efficiency programs, and integrate distributed energy resources to decrease carbon emissions.

Duke Energy faced a number of challenges that could not be addressed by the communication network systems and approaches deployed by utilities today. The company needed the flexibility to take advantage of newer generations of communication networks instead of relying on single application–enabling infrastructure (i.e., AMI systems).

Duke Energy decided to create an architecture that placed gateway nodes powered by public cellular WAN as the primary network to manage and operate various smart home, smart meter, and distribution devices. The nodes support WAN, LAN, and NAN configurations for a myriad of devices.

The advantages with a field node supporting multiple network technologies include setting a single set of rules for data management regardless of the vendor, device, or network technology used. A universal interface allows utility IT to see the condition of the equipment throughout the grid, which allows the utility to remedy problems quickly and accurately. From a security perspective, data can be managed from a single authority, which strengthens the integrity of the end-to-end network, including legacy and newer IP-based devices.

TNMP: Direct to Meter Using Commercial Cellular

Texas New Mexico Power (TNMP) is a distribution company that serves over 230,000 electric residential and C&I customers spread out over 76 geographically diverse cities and towns in 12 service territories over 10,000 square miles throughout Texas. In 2007, TNMP set out to modernize elements of its technology infrastructure, rolling out a host of smart grid technologies and establishing long-term strategic capabilities.

TNMP needed to choose a communication network solution that would initially support AMI (called AMS in Texas) and allow for future additional home and building energy management applications. The utility sought rate case recovery for the project through the Texas Public Utility Commission (PUC), which requires distribution companies to implement AMS to support two-way communications, remote connect/disconnect, and automated/remote meter reading, providing real-time data access to customer and retail electric providers.

Each of its 12 service territories is unique in its own right. For example, the central Texas area, which includes the city of Clifton, is largely a rural area with a low population density. North of Dallas, in the city of Lewisville, the service area has a greater population density per square mile in an urban setting. The service territory's geography has a significant impact on communications infrastructure costs and performance, which factored into TNMP's choice of AMS technology.

TNMP management chose a public cellular network solution to directly connect the 230,000+ smart meters. Multiple factors were considered. The main reasons behind the decision to choose a cellular public network approach were:

- **Reliability for net metering applications.** For over 20 years, TNMP, and hundreds of other utilities, have successfully used cellular networks for C&I revenue meters. While cellular has come under recent scrutiny for its reliability concerns, the fact remains that wireless mesh–based AMI networks rely on cellular for concentrator/router backhaul nodes today.

- **Performance and coverage.** Not only are the cellular networks already built but the devices can be provisioned immediately to reach nearly 100% of the population in Texas, regardless of density or topography. In addition, TNMP has experienced a 99.50% success rate on first-time reads and a 100% read rate success within 12 hours — a critical requirement of the Electric Reliability Council of Texas (ERCOT).

- **Flexibility for future requirements.** Management needed a solution that had sufficient bandwidth in its current form and allowed for extension to support additional applications. In particular, TNMP sought demand response, outage management, time of use rates, and home energy management applications.

- **Network staffing and maintenance streamlined.** TNMP felt strongly that its core business is the transmission and distribution of energy and calculated that the maintenance requirements of the various service areas were best managed by professionals outside the company.

ECOtality's EV Project: Cellular Networks Connect Electric Vehicle Charging Stations

Electric vehicles are expected to bring many environmental benefits, such as less reliance on petroleum, a reduction in greenhouse gases, and the ability for consumers to generate and store electricity. The U.S. Department of Energy (DOE) has outlined many initiatives to enable utilities and consumers to save energy. It is in this spirit that the DOE is funding the EV Project, an endeavor in partnership with ECOtality to roll out 8,300 fully electric and plug-in vehicles as well as 15,000 at-home and public charging stations.

ECOtality received $99.8 million in grant money in 2009 and an additional $15 million in 2010 from the DOE to roll out its Blink-branded charging station in 18 major cities in the United States.

Blink charging stations will communicate over a cellular network to transfer usage data, download firmware updates, and publish pricing availability to electric vehicle drivers in real time.

The charging station will connect via the ECOtality control center to the utility's network. The consumer interfaces with the charging station via a Web application or smart device that allows the customer to regulate when the charger starts. The station itself can also be timed for personal convenience or to automatically work in sync with off-peak electricity times and rates.

Public cellular technology provides a critical backbone for the EV Project, as it will enable the collection and analysis of data from the Nissan LEAF and Chevy Volt initially, and for future models as well. Vehicle and charging station information, including energy usage, charges times, and duration, will be accessed. This proof of concept project will help demonstrate the viability of plug-in electric vehicles and the use of a communication platform that facilitates data sharing in real time with users, service providers, and utilities.

CPS Energy: Home Energy and Demand Management Gets Cellular Connectivity

CPS Energy is leveraging cellular technologies to help bring to life its Save for Tomorrow Energy Plan (STEP). According to the STEP program, CPS Energy aspires to save 771 megawatts of energy by 2020. CPS Energy realized that empowering its customers was key to achieving this ambitious goal. The plan was to enable customers to interact with the utility directly, thus driving energy savings and, in turn, saving money with variable rate plans.

In February 2010, CPS Energy announced a pilot with Consert to roll out its Virtual Peak Plant technology to 100 San Antonio homes. The pilot was later expanded to 1,000 households and small businesses. To facilitate energy and demand management, the Consert solution for this initiative includes GE smart meters with Zigbee and 3G radios, smart thermostats, load control devices for pool pumps and water heaters, and customer portals to monitor and manage energy usage via customer devices.

A critical component is the communication architecture that allows for flexibility and economies of scale for CPS Energy. In this case, smart meters connect to a cell tower via Verizon's 3G link, while a cellular backhaul link connects a cell tower to the Consert datacenter and finally to CPS Energy's operations center. As a result of using a managed IP infrastructure, CPS Energy expects to reduce operations and maintenance costs while providing real-time price and demand signals to shave peak loads.

The results to date have been encouraging. For instance, one study showed that 45 participants saved 153 kilowatts in only two hours. CPS Energy decided to expand its initiatives and supply Consert's solutions to its 140,000 household and small business customers. The aggregated system will create a 250 megawatt virtual peak plant over the next four years.

As with many new technologies and processes, there are potential challenges, such as lack of customer engagement. However, CPS Energy will benefit from an end-to-end communication architecture that can scale and address its needs for the foreseeable future, allowing the company to share data with its customers and interact in real time while maintaining a lower cost of ownership.

FUTURE OUTLOOK

Opportunities, Challenges, and Considerations

Increasing the role of commercial cellular for smart grid communication networking requirement is not without challenges. As discussed earlier, the technical capabilities of commercial cellular are not a cure-all for smart grid, but commercial cellular does possess many characteristics that will be deemed superior to those of competing technologies. The hurdles hinge primarily on nontechnical business issues such as:

- **Working with the regulatory structure that favors capital expenditures.** The regulated rate of return granted by regulatory commissions allows utilities to earn a return on investment for capital expenditures (capex). Public carriers are built on a service model where expenses are incurred on an ongoing basis, which is treated as an operational expense (opex). This puts service carriers at a disadvantage, reducing choices for rate payers and providing incentives to (over)spend on capex. Utilities, PUCs, and carriers will need to work together to find ways to capitalize long-term service contracts (e.g., 10, 15 years).

- **Challenging utilities' perceptions and understanding of cellular service affordability.** Wireless carriers initially went to market with service costs well above those of the competing private network solutions. Utilities could not justify the service costs, and regulators would not approve them. Since 2009, wireless carriers have priced services to aggressively compete with private network solutions. Wireless carriers will need to educate utilities, regulators, and ecosystem players, such as systems integrators, about the viability and affordability of their services in smart grid applications.

- **Managing the device development and carrier certification process.** The cellular industry requires device makers to certify the products before allowing connections to the network. The certification process ensures that network integrity, security, and performance are maintained. The challenge is that many developers new to the cellular industry are unaware that this requirement exists.

CONCLUSIONS

Commercial cellular solutions play an increasingly visible role in smart grid deployments, which use the technology to ensure data delivery, security, and accessibility for utility applications. Cellular is widely used as a backhaul technology in the utility space, yet business and technical developments position cellular to support advanced smart grid applications such as distribution automation, smart metering, and home energy management.

Commercial cellular solutions possess strengths compared with alternative WANs and NANs, including licensed spectrum. Cellular is a mature technology that ensures network performance and extensibility. It provides true broadband performance. It is a proven technology with the scale to support tens of millions of devices. In addition, it is supported by open industry standards that help ensure compliance in hardware and software.

Commercial cellular services are appealing to utility CIOs who require robust communication architecture with embedded security and network management. IDC Energy Insights advises CIOs considering commercial cellular solutions to:

- Explore implementation of multimode cellular–based deployments, leveraging multiple cellular carrier networks to increase the coverage, reliability, lifetime, and cost-effectiveness of the overall solution

- Seek agreements defined with cellular providers that consider data protection and privacy

- Consider building data breach notification into the service that tracks anomalies in information flow

- Implement processes such as incident response and management to ensure readiness in case of a breach

- Explore service options from cellular network aggregators and M2M service providers, as well as with network operators directly

- Work with power equipment providers to enable communications to legacy equipment as well as address new device communication needs

