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Improving the Grid with Cellular

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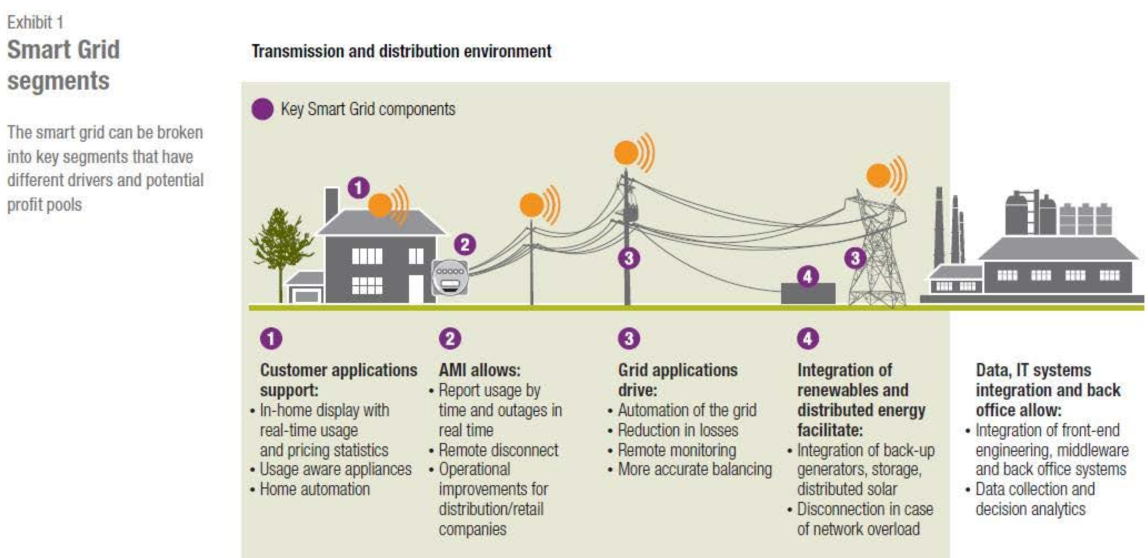
One of the greatest long-term indicators of a country's potential economic growth is the consistent delivery of affordable and reliable electricity. But devastating weather events and the aging infrastructures of public utilities make the job of keeping the lights on tougher every day.

Consider these statistics: non-weather-related power outages can cost US businesses and consumers up to $188 billion a year, according to Massoud Amin, professor of electrical and computer engineering at the University of Minnesota; and, in a study of 15 major storms that took place in the US between 2004 and 2012, power restoration was shown to take anywhere from 3 to 20 days (Executive Office of the President, "Economic Benefits of Increasing Electric Grid Resilience to Weather Outages," August 2013).

The distribution portion of the US electric grid spans well over six million miles, and the Edison Electric Institute (EEI) says it's where more than 90 percent of power outages occur. Without the ability to get real-time situational awareness data back from the distribution network, it becomes increasingly challenging to improve reliability and restore power quickly to customers. But with an investment in distribution-grid modernization, many experts believe we can make the grid more resilient to outages. The core components of grid modernization include (see figure 1 below):

- a reliable communications network (e.g., cellular or private wireless mesh) with enough bandwidth to send real-time grid data to back-office systems and cover the six million miles of the distribution network where visibility has been lacking;
- new grid-sensing equipment with the built-in ability to communicate grid conditions across the network;
- new data and IT systems with predictive grid analytics capable of sharing real-time grid conditions in order to drive more intelligent decisions.

The good news is that by using today's cellular network as the communications layer, grid modernization into the heart of the distribution network can be an affordable reality for the first time.



Source: McKinsey & Company, 2010

According to, S.M. Kaplan, an electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers, as shown on the far right of the diagram above.

Power stations may be located near a fuel source, at a dam site, or to take advantage of renewable energy sources, and are often located away from heavily populated areas as shown in 4, above. They are usually quite large to take advantage of the economies of scale. The electric power which is generated is stepped up to a higher voltage-at which it connects to the transmission network (number 3, in the diagram above).

The transmission network will move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the company that owns the local distribution network).

On arrival at a substation, the power will be stepped down from a transmission level voltage to a distribution level voltage called medium voltage. As it exits the substation, it enters the distribution wiring. Finally, upon arrival at the service location, the power is stepped down again from the distribution voltage to the required low voltage service (numbers 1 and 2 above).

Before cellular networks were a viable option, utilities really only had one choice when it came to building a communications layer across the distribution network, and that was to create their own private wireless networks. To accomplish this goal, they turned to a wide range of point-to-point serial radio systems, or private mesh networks, that operated, unlicensed, in the 900 MHz, 2.4 GHz or 5.6 GHz spectrum, where the utilities were sometimes able to get limited bandwidth with minimal interference. But creating private wireless networks required the utilities to become experts at building and supporting wireless infrastructure, which proved too costly and time-consuming to maintain throughout the years.

But now, with the availability of distribution grid-monitoring equipment with built-in cellular capabilities, not to mention the ubiquitous coverage of 3G across the US, utilities can leverage cellular networks to modernize the grid at a lower overall cost of ownership. In addition to their ubiquitous coverage, a technology comparison by Qualcomm found that cellular networks have the added benefits of higher data rates, lower message latency and better reliability (see figure 2 below). They also have built-in security features that can better protect the grid from the looming cyberscurity challenges that could plague many utilities if they had to take on the role of securing cellular networks on their own.

Summary of Technologies and Capabilities

	3G	GPRS	RF Mesh	PLC[4]
Network Type	Operator managed WAN	Operator managed WAN	Utility deployed and operated	Utility deployed and operated
Topology	Cellular	Cellular	Star, tree, and mesh	Power line
Spectrum Type	Licensed	Licensed	Unlicensed	Power-line
Typical Data Rate[1]	1 Mbps	40Kbps	9.6 - 100+ Kbps	Several to 100+ Kbps
Message Delivery Latency[2]	< 1 sec	1 sec or above	1 - 60 sec	< 1 sec
Coverage[3]	• 98%+ US population. • 10s of meters to10s of km's per cell site.	• 98%+ US population. • 10s of meters to10s of km's per cell site.	• Up to 50m. • Can enhance coverage using mesh topologies.	• Up to multiple km's. • Data rate decreases with distance.
Reliability/Avaiability[3]	Rate of successful link establishment: > 99%.	Rate of successful link establishment: > 99%.	Deployment and product specific.	Dependent on the underlying power line.
Security	Provide authentication and confidentiality for over the air link. Application layer security mechanism can be deployed to ensure end-to-end security.			

1 GPRS data represent theoretical for EDGE with 8 time-slots. PLC data rate is dependent on the link distance.
2 Typical values. Latency depends on network load and the number of hops between source and destination. Latency for RF Mesh and PLC also depends on the backhaul network used.
3 Coverage and reliability depend on both the technology and the specific deployment. The cost (both CapEx and OpEx) for deploying and maintaining a green-field network to meet the use case requirements should be taken into account.
4 Characteristics of typical narrowband PLC technology, e.g. G3 and PRIME.

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Source: Qualcomm, 2011

Grid-distribution applications using built-in cellular

Until recently, cellular networks weren't a viable option for smart grid modernization, because grid equipment lacked the radios that were necessary to access the networks. However, a new generation of smart grid equipment is coming to market with built-in cellular capabilities, making cellular not only the more affordable option but also the least complex option for a utility to deploy.

Several next-gen smart-grid solutions using cellular hit the market in 2013 from vendors such as Itron and Tollgrade.. This year, Sprint became the central technology provider for a number of smart grid sensor deployments across the U.S. and in May, AT&T announced a smart-gird project in Tennessee, using cellular-enabled smart meters from Itron. Tollgrade offers its innovative Medium Voltage (MV) Sensors pre-bundled with a five-year cellular data plan. With Tollgrade's MV Sensors, there is nothing else a utility worker needs to hang on the pole, and no complex wireless networks for the utility to architect or secure. In less than five minutes the sensors can be installed right on the distribution line, and in just one step they power up inductively (e.g., without batteries), self-activate onto a secured cellular network and begin sending real-time grid-health data back to the utility's operations center

This technology goes much deeper than smart meters, which are located at a customer's residence and can only tell if he or she has power or not. Pinging smart meters once power's been restored after an outage has been shown to be a valuable way to confirm that a utility crew's work has been successful.

However, meters alone can't identify failure locations in the distribution portion of a network. Instead, using smart grid sensors that are actually located on the distribution network and that have the ability to take advantage of the cellular network means utilities can pinpoint the problems that are causing the majority of their outages. With better outage-location information and fault data coming into their back-office systems, utilities can focus their repair efforts on faster restoration.

By retrofitting their current grid and leveraging publicly available cellular networks, utilities can better respond to the operational status of the grid to improve reliability and restore power faster. Leveraging cellular not only adds up to big savings for utilities but also for US consumers and businesses, which can now take advantage of a more reliable power grid.