The Robust and Resilient Smart Grid: Many Applications, One Powerful Platform

WHITE PAPER

Trilliant helps leading utilities and energy retailers achieve their smart grid visions through the Trilliant Communications Platform, the only communications platform purpose-built for the energy industry that integrates disparate systems of systems into a unified whole. The Trilliant Platform is deployed with more than 200 utilities worldwide to enhance energy efficiency, improve grid reliability, lower operating costs, integrate renewable energy resources and electric vehicles, and empower consumers to better manage their energy consumption.

1100 Island Drive
Redwood City, CA
94065
t 650-204-5050
f 650-508-8096
www.trilliantinc.com

Introduction

The Smart Grid promises numerous benefits for utilities and their customers alike. Meters are read more accurately and automatically. Service is more dependable as outages get restored more fully, quickly and efficiently. Power quality improves, while losses are minimized. Workers in both the office and the field are more productive, while automation minimizes their workload. Periods of peak demand are mitigated through demand response and demand-side management programs. Changes like distributed generation and electric vehicle charging become easier to accommodate.

Very few utilities have yet been able to achieve these benefits, however. Those that have tried inevitably confront a major challenge: The specific applications needed to implement a Smart Grid span the organization. For example, an Advanced Metering Infrastructure (AMI) is likely to be handled by a metering group, while a separate engineering group would be responsible for Distribution Automation (DA).

Although these two utility functions have different drivers, the potential exists for them to share infrastructure and resources in a mutually beneficial way. Unfortunately, that potential often remains elusive for a variety of reasons, resulting in lost opportunities, increased capital and operational expenditures, and assets being obsoleted soon after being deployed.

At the root of the problem is often the operational "silos" that exist across the organization. And while these silos may have had valid reasons to exist in the past, they are incompatible with Smart Grid of the future. The full set of measures needed to replace the silos with integrated management capabilities is beyond the scope of what any vendor can do or what any white paper can cover. But one such measure is clearly needed to be successful: a fully integrated, end-to-end network infrastructure.

This white paper outlines the requirements of a fully integrated Smart Grid platform, and describes how two different utilities are using just such a network in very different ways. Both utilities are, however, employing the same "put in the right Smart Grid Platform" strategy by focusing on a single application initially, then adding others gradually. To work well, this approach requires a thorough up-front understanding of the end-to-end smart grid platform requirements.

Smart Grid Communications Platform Requirements

There are literally dozens of applications possible in Smart Grid, and the network requirements for each can vary considerably. The discussion here organizes these applications into six categories based on their network requirements:

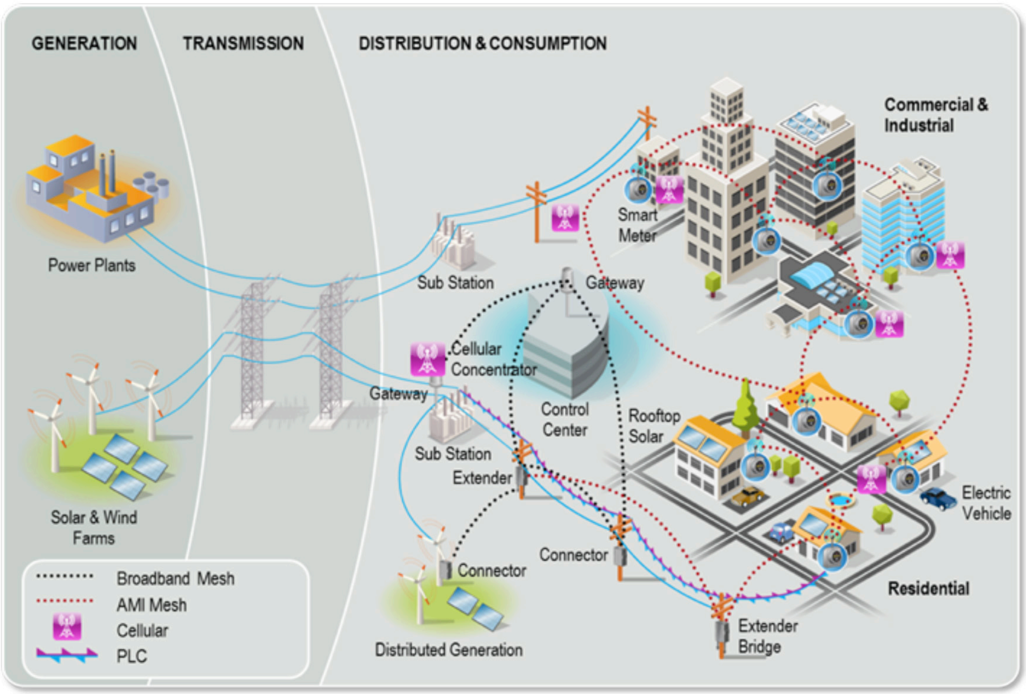
- Advanced Metering Infrastructure or Smart Metering
- Demand Response and Demand-side Management
- Distribution/Feeder/Substation Automation
- Distributed Generation and Storage
- Video Surveillance
- Field Area Network

While the primary purpose of an Advanced Metering Infrastructure (AMI) is to perform interval reads of the meters, the meters themselves can also be used to support service connect/disconnect and some Distribution/Feeder Automation applications, particularly for outage management.

Demand Response (DR) and Demand-side Management (DSM), including Direct Load Control (DLC), requires the AMI to extend into the customer premises. For residential customers, this is usually achieved with a Home Area Network (HAN) to enable the meter to communicate with an In-Home Display (IHD) or Programmable Communicating Thermostat (PCT).

Distribution, Feeder and Substation Automation (DA, FA and SA) encompass a wide range of different applications that involve monitoring and managing power reliability and quality, including: Distribution Management and Outage Management Systems (DMS and OMS); Fault Detection, Isolation and Restoration (FDIR); Voltage Monitoring; Conservation Voltage Reduction (CVR); Volt/VAR Control (VVC); Switch and Recloser Automation; Transformer Monitoring (Pole and Pad); Capacitor Bank Controls; and Asset Management. A utility can choose to use its Smart Grid platform initially for VVC and FDIR.

Distributed Generation and Storage are becoming increasingly important as customers deploy renewable sources of energy, such as wind and solar, potentially in microgrids. This change, encouraged by Renewable Portfolio Standards (RPF) and various financial incentives, disrupts the traditional one-way flow of power in distribution grids, and can create power quality and safety issues if not properly managed.



Scalable...Secure...Meter Independent...Multi-Technology Platform

Video Surveillance is a cost effective way to enhance security at unattended substations and for other remote equipment throughout the distribution grid. Central monitoring and optional recording of video feeds make it possible to react to events as needed in a timely manner, as well as to collect evidence for subsequent forensic investigation and/or prosecution.

A Field Area Network (FAN) is an application that can often leverage the Neighborhood Area Network (NAN) used for AMI communications. The FAN provides basic Wi-Fi access for workers, and optionally supports Voice-over-IP (VoIP) to minimize or eliminate the need to use mobile phones, or to provide voice communications in areas where radio coverage is unavailable or limited. A utility can plan to implement a FAN in Phase I of its Smart Grid roadmap.

Trilliant recommends that the set of communications requirements established should include support for all of these applications. That is not to say that all will be needed, either initially or even eventually. But designing a network capable of supporting all is now both feasible and affordable, and such a comprehensive approach also minimizes the risk of stranding assets or incurring major upgrades in the future.

The reason is: Communications technology has advanced to the point where every Smart Grid application described (and some others that might emerge in the future) can be supported on a single communications platform, resulting in efficiencies and economies of scale that afford significant cost savings.

A proven way to assess communications requirements and evaluate available communications technologies is to consider the three C's of Coverage, Capacity and Capabilities. Of course a fourth C, Cost consisting of both capital and operational expenditures, is also an important consideration. But it is the three C's that constitute the network requirements

Coverage

Coverage varies by application. For example, AMI generally requires the communications platform to extend throughout the utility's entire service area in order to reach every customer. By contrast, SA and some DA applications may require only a limited reach.

Most vendors of wireless communications systems have solutions that can provide whatever coverage is required. A key determining factor, however, is the range of the equipment; the longer the range, the more cost-effective the coverage. A shorter range also increases the number of nodes or the "hop count" required as traffic traverses the network end-to-end, and this can increase latency or exceed specified limits for some applications.

Capacity

Capacity is characterized by a single communications platform capability: bandwidth. Designing a single communications platform to support multiple applications requires ample capacity for each and every one. Some individual applications consume a considerable amount of bandwidth, such as AMI and video surveillance. Most others consume relatively little bandwidth individually, but in the aggregate could potentially exceed the capacity of the communications platform's design.

The better communications platform solutions enable capacity to be increased in an incremental fashion and without a need to replace any existing systems. This ability is ideal for any utility adopting a "putting in the right Smart Grid platform" approach to its Smart Grid journey.

Capabilities

Communications Platform possess many different capabilities, and these have varying degrees of importance for different applications. For example, all applications require reliable and secure operation, with the latter being particularly important in a network supporting multiple applications. Only a few applications, however, place critical importance on another capability: low latency. These applications include any that must operate in real-time or near real-time, such as VVC and VoIP.

Most wireless communications platforms support these real-time applications through various traffic management and Quality of Service (QoS) provisions capable of giving each a relatively higher priority. But only some solutions have the granular controls needed to guarantee satisfactory performance under worst case conditions, such as when available capacity is saturated or node failures are causing excessive traffic congestion.

The table on the following page provides a summary of how the two most critical communications requirements, bandwidth and latency, vary by application. Note how AMI and Video Surveillance demand moderate or high amounts of bandwidth, respectively, but are tolerant of high latency. Video Surveillance does, however, require minimal jitter, which is the variation in latency. Note also that while Distribution, Feeder and Substation Automation consume little bandwidth, they all require low latency for successful operation of the real-time applications involved.

Application	Bandwidth	Latency
Advanced Metering Infrastructure	Moderate	Tolerant
Demand Response and Demand-side Management	Low	Tolerant
Distribution/Feeder/Substation Automation	Low	Low
Distributed Generation and Storage	Low	Tolerant
Video Surveillance	High	Tolerant (Low Jitter)
Field Area Network (without VoIP) - With Support for VoIP	Low Low-Moderate	Tolerant Low

Additional and detailed information about wireless network requirements is available in two other Trilliant white papers: Application Domain Partitioning for the Smart Grid; and Wireless WAN for the Smart Grid.

Several Illustrations of Examples in Using a Smart Grid Platform

Outage Management or Fault Isolation, Detection and Repair are often among the first applications implemented on a Smart Gird, and for good reason. A report published by the Lawrence Berkeley National Laboratory titled Understanding the Cost of Power Interruptions to U.S. Electricity Consumers put the cost of power outages in the U.S. at more than $80 billion annually. This report also found that outage costs are not related to outage duration in a linear fashion with its finding that 67 percent of all outage-related economic losses result from short interruptions.

Power quality is also often a high priority application for the Smart Gird. A report from the Electric Power Research Institute and the Electricity Innovation Institute titled The Cost of Power Disturbances to Industrial & Digital Economy Companies found that substandard power quality can cost customers an estimated $15 billion to $24 billion per year.

Power outages and poor power quality also cost utilities. Regulators in the U.S. have both denied and significantly diminished permitted returns on investment for utilities in recent rate cases owing to poor historical performance for metrics like the system average interruption frequency index (SAIFI) and the customer average interruption duration index (CAIDI).

Costs to utilities can also come in the form of fines. For example, New York's largest investor-owned utility, Con Edison, was ordered by the state's Public Service Commission to disburse $5 million (of a maximum penalty of $112 million) to ratepayers for failing to meet reliability standards. National Grid was fined $18.7 million by the Department of Public Utilities for a series of failures in its response to Tropical Storm Irene and the October 2011 snowstorm that left thousands of its customers without power for days. NSTAR Electric and Western Massachusetts Electric Company were fined $4 million and $2 million, respectively, for poor response during those same storms.

The avoidance of fines is only part of the business case for a Smart Grid, however. Duke Energy in Ohio, for example, anticipates saving over $115 million over the lifetime of its AMI deployment by leveraging the network for integrated voltage control. Below are several illustrations on how utilities can experience the financial benefits of minimizing outages and improving power quality.

Utility A, Operating in a Territory Prone to Storms and Hurricanes

Utility A has successfully deployed an AMI with smart meters across its entire service area, and did so on an aggressive schedule and within a tight budget. The system is operating efficiently and with high stability, providing over 99 percent reads (both register and intervals) on a daily basis.

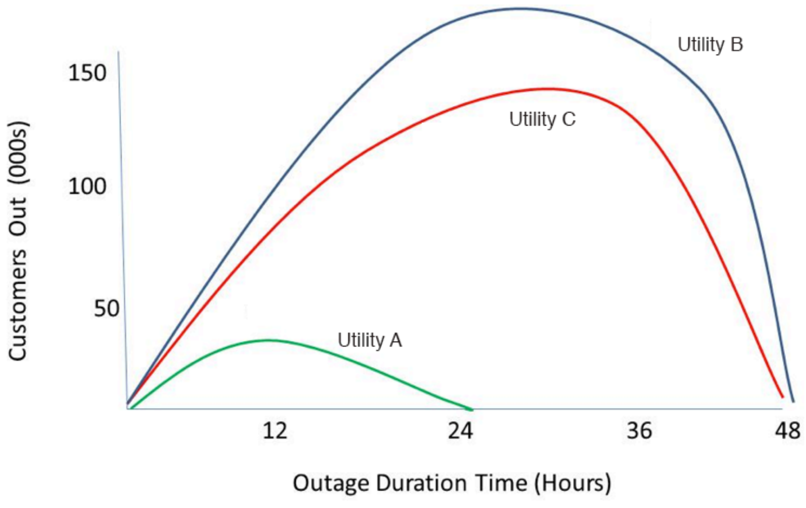
As soon as its AMI system was fully operational, Utility A began focusing on ways to achieve additional benefits and to maximize the return on investment in its service area-wide Smart Grid communications network. One of the highest priority applications involves an Outage Management System (OMS).

The need to improve outage management has been heightened in Utility A's region with the recent impacts from both large hurricanes and snowstorms. Regulatory focus has also shifted to encourage utilities to strengthen their distribution networks to better withstand severe weather impacts, as well as to recover more quickly when outages do occur.

Utility A is leveraging its AMI infrastructure by passing meter events from the head end to the Meter Data Management System (MDMS), where an enterprise service bus then makes these events available to the Outage Management System, which is part of Utility A's Distribution Management System (DMS). The specific mechanism used leverages a Smart Grid Communications Platform's innovative smart agents.

One of the key events during an outage is, of course, a meter's transmission of a "last gasp" message when power is lost. This is proof positive that an outage has occurred, and the receipt of multiple "last gasp" messages indicates where and how widespread the outage is. To account for faults that are cleared automatically by reclosers, Utility A checks the voltage status of the meters affected after 30 seconds.

There are other meter events and readings that can also be used to assess the nature and extent of outages. The Real-Time Power Outage (RTPO) report that is part of the Head-End System's management platform, for example, can isolate a particular outage to customers sharing a transformer, or a feeder or a distribution line. This ability to isolate the cause using meter data eliminates the need to conduct a field investigation before dispatching a crew, and helps ensure that every crew dispatched has both the proper equipment and parts needed to restore operation.



Utility A's advanced outage management system enabled the utility to reduce both the number of customers affected and the duration of all outages.

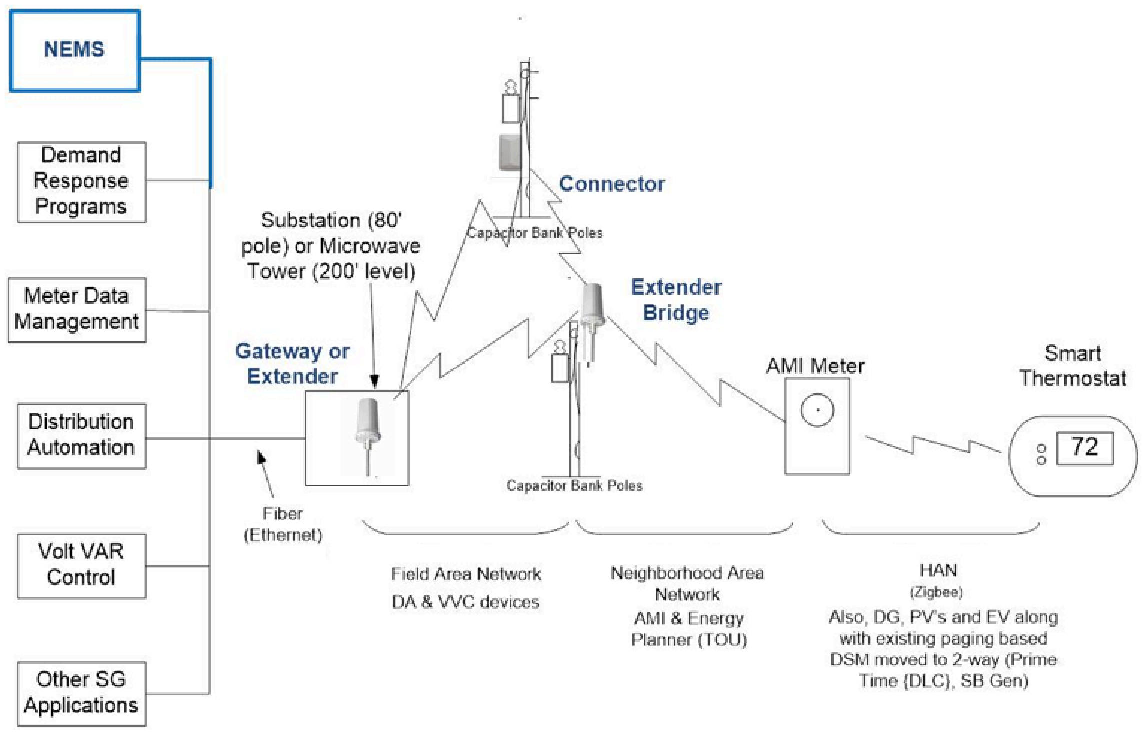
During a recent snowstorm, only a little over one percent of Utility A's customers experienced a sustained outage. By contrast, 12 percent and 22 percent of Utility B's and Utility C's customers, respectively, experienced sustained outages. This is not to say that Utility A's grid experienced less damage. Rather, it was Utility A's ability to isolate and route around some faults, and repair others faster that together minimized the outages affecting its customers.

Utility A's experience demonstrates that is both possible and beneficial to break down organizational barriers and eliminate operational silos. In Utility A's case, the challenges involved in integrating metering operations with distribution operations were readily overcome

Utility X, Smart Distribution First, Other Applications Later

Utility X is approaching its Smart Grid journey beginning with real-time Distribution Automation and Field Area Network applications, initially for Volt/VAR Control and later for Fault Detection, Isolation and Repair. These first phase applications are expected to be followed by future phases that will expand the NAN's coverage to support AMI with a Time-of-Use (TOU) rate structure to manage demand, and to add a Home Area Network (HAN) to support DLC, DG and Electric Vehicles.

Utility X's VVC application consists of thousands of Capacitor Bank Controllers. A high-bandwidth, low latency WAN provides two-way broadband communications throughout the utility's entire service area to enable centralized monitoring and management of all controllers. Each controller interfaces to an Ethernet port. Utility X chose a NAN/FAN access point, in anticipation of the future phases.



Utility X plans to implement its Smart Grid in phases, beginning with Distribution Automation and Volt/VAR Control.

Utility X is planning to leverage the full monitoring capabilities of the controllers to conduct a pilot FDIR application. As part of its primary task of Volt/VAR Control, the monitors voltage, VARs, real power, current, neutral current, temperature and conservation voltage reduction thresholds. The controller's ability to issue alarms that might indicate a fault, such as neutral current or an OverVoltage/UnderVoltage (OV/UV) condition, are useful for detecting, isolating and ultimately repairing many faults. Loss of communications with any controller could also be indicative of an outage.

Conclusion

The Smart Grid offers the potential to support a wide range of beneficial applications, and most utilities are destined to do so—eventually. No utility, however, would ever attempt, and no regulators would ever permit, the implementation of so many applications all at once. The risks and costs of such an approach would simply be prohibitive. The prudent approach, therefore, is to put in the right Smart Grid Platform from the beginning, to be able to handle not just the applications of today but also of tomorrow, as both Utility A and Utility X are illustrating.

The key to planning is to understand the full set of networking capabilities that might ultimately be required. A failure to do so with an initial application creates the likelihood of stranding assets and incurring future upgrade costs. And with advances in networking technology, there is simply no good reason for designing a network that is incapable of supporting every potential application. So when evaluating your Smart Grid network requirements, give careful consideration to the three C's of Coverage, Capacity and Capabilities, and pay particular attention to bandwidth and latency.

To learn more about networking requirements and options for your Smart Grid, please visit Trilliant on the Web at www.trilliantinc.com or call us at (650)204-5050.