Smart Grid System Selection: Best Practices and Lessons Learned

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

Executive Summary

Selecting a Smart Grid communications system is a large investment to be made starting with the most important criteria for a well-structured top-down decision process. Among the most important aspects in successfully choosing a system:

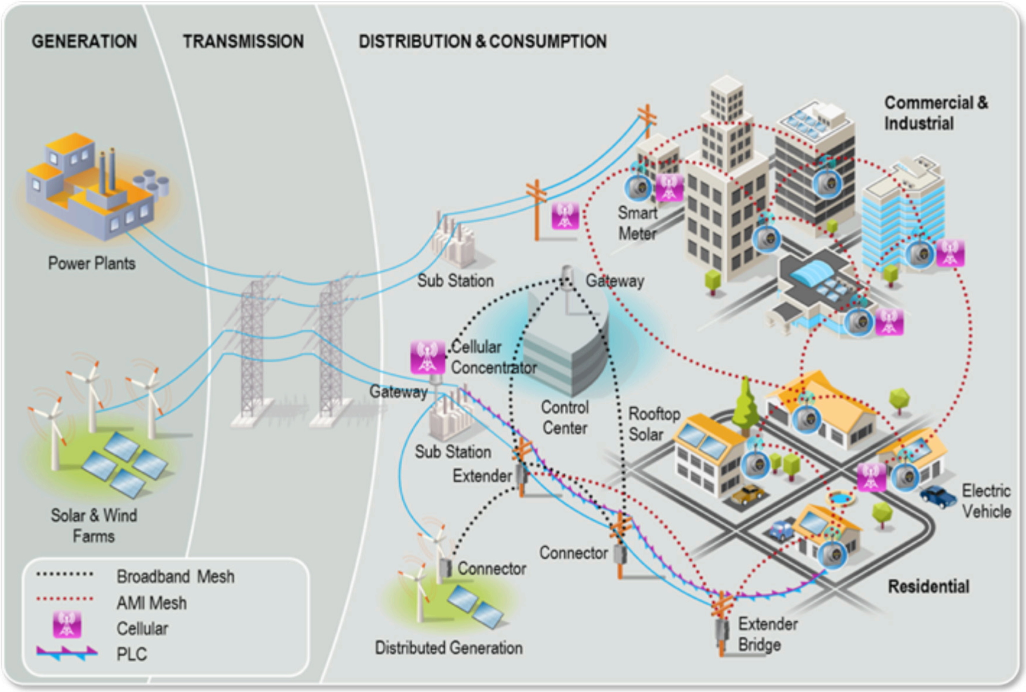
- Vendor criteria are the most important
- System criteria weigh in next
- Approach is critical – classic vendor-client vs. side-by-side work ethos
- Interview likely candidates' production customers, test with pilot projects

Introduction

Utilities today face many pressures and are expected to change more rapidly than they have throughout their existences. Societal pressures to reduce emissions and increase the use of renewables while supporting electric vehicles drive in one direction. The newfound focus of international cyber attackers on the electric grid as a key element of the critical infrastructure drive in another direction.

Together, they yield a veritable flood of utility grid modernization efforts that embrace IP networking technologies as new enabling cornerstones to replace existing legacy, non-inter-connected, "or siloed", point-to-point power control and information network architectures. These "Smart Grid" implementations significantly add to overall network data flow while changing processes and procedures as never before.

Fortunately, vendors can learn lessons both positive and negative from the many early Advanced Metering Infrastructure (AMI) and Neighborhood Area Network (NAN) deployments. This paper focuses on organizing and analyzing the many criteria for selecting a communications system for Smart Grid and AMI. Government stimulus spending in the US accelerated a raft of early deployments, yielding a strong crop of lessons. Many, though not all, of the lessons learned in the US apply equally to the rest of the world.



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

Business Lessons

Of course, these are the first and most important issues to consider. Aspiring vendors must satisfy commercial conditions – both common and those unique to each utility. While some are clear and contractual, and others more subjective, all are critical to the success of these major AMI projects. Business conditions relate to vendor attributes and commitments, and to top-level system criteria. They include the aforementioned approach– classic vendor-client vs. side-by-side work ethos – as well as credibility, reliability (commercial and execution), and experience. Also contributing here are ability and willingness to adapt to your individual utility situation – level of service desired, need for additional support, terrain, device housing, radio regulations and risk profile. This can be summed up by a focus on finding out what potential vendors have done (talking to reference customers) and will do (running pilot programs).

Lessons Learned

- Run pilots with top potential vendors, see how they behave, perform
- Cost estimates sometimes contain conflicting assumptions
- The importance of experience – been there and done that

Questions to Ask

- How much will it cost under real deployment conditions?
    - *Look at cap ex vs. op ex*
    - *What system options are built-in to adapt to unique requirements, deal with unexpected developments and/or reduce cost?*
    - *What will cost extra?*
- Do you have confidence that each vendor can deliver?
    - *Talk to their customers*
    - *How many issues?*
    - *How quickly were those resolved?*
    - *Quality of production references?*
- What are the system's performance metrics?
    - *What is our confidence level in those and/or are they guaranteed?*
- Risk: will vendors give you necessary commercial and system guarantees?
- Level(s) of partnership: Will vendors work with you, your requirements, adapt to your unique situation?
    - *Will they be there beside you all the way through the project?*

System Lessons

After business and customization issues have been thoroughly considered, system attributes must also be well-considered when choosing AMI communications. Top-level system requirements include maintaining the specified level of quality of service. Your AMI communications system and all its elements must deliver this quality of service. Characteristics include availability, outage and disaster recovery, Over The Air (OTA) firmware download reliability, flexibility and openness of platform, network management tool quality and secure communications.

In security, industry standards are especially important. There is enormous benefit to having many eyes and minds review and test every aspect of best practices and technologies. Keeping up with the moving targets which are current threats, current impacts, current controls, etc. is no easy matter. The pace of that evolution has greatly accelerated lately. Process, architecture and partners are all necessary. Utilities need security which is designed in to their AMI from the beginning. They also need security which can adapt (over 20 years) as all the elements of security (threats, controls ...) AND the potential impacts on both new and old applications they secure, support and interface to (beyond AMI) change as and after the system is deployed.

A common system security approach has been for experts and / or regulators to specify technologies – lists of technologies, architectures, approaches, etc. However, as part of the US stimulus projects a few years ago, the US Department of Energy had recipient utilities adopt a new security approach. This approach looked at the entire project lifecycle, from beginning (concept/planning) to end (decommissioning). The project lifecycle approach requires periodic updates of assessments of threat environments, risks, controls, etc. Along with the new process, maintaining best practices such as looking for vendors who design security in to your communications systems from the beginning, remain important.

Lessons Learned

- Many utilities have found bandwidth claims are made assuming low meter/gateway ratios while pricing is based on high meter/collector ratios. This results in the need to “upgrade” bandwidth by installing additional network equipment
- It is the system and network which determine performance and reliability
  - *System attributes such as mesh, alternate path routing, retransmissions, etc. mean that many mature radios can work*
- Mesh networks avoid single points of failure
- Project lifecycle security process means change in procedures, staffing
- Ensure that your AMI communications security enables (policy-based) direct data exchange in the field for current and future applications
- Ensure that OTA firmware upgrade function supports a “resume” capability so that meters in fringe coverage areas are able to upgrade their firmware reliably
- Many utilities are disappointed by the low percentage of meters which correctly detect and notify an outage, including not distinguishing momentary outages
- RF complements, works in parallel to PLC

Questions to Ask

- How much infrastructure is necessary?
  - *Coverage, density?*
  - *What is the average bandwidth available per meter from the collector based on the proposed network design?*
- What are installation and maintenance costs?
- What is the system availability, percentage of meter reads made?
- For what percentage of meters does the network correctly detect & notify an outage?
  - *After an outage how quickly does the network recover?*
- Was security designed into the communications system from the beginning?
- How complete and mature are network management tools?
  - *Do potential network vendors provide comprehensive field tools for use in maintaining the network and diagnosing network issues?*
- How reliable is the OTA firmware upgrade process?
  - *Does it resume after connection failure or does it require the re-start of the entire upgrade process?*

Technology Lessons

In the beginning, we focus on what the vendor has done and will do. Then we look at what the overall system does, how it performs. Of course, how the vendor's system works internally may also be part of the evaluation process.

In this section, we discuss last-mile NAN radio technology. For clarity, this is distinct from HAN technology, where all vendors offer the ZigBee HAN system, and perhaps other options as well, to communicate from the meter into the home.

Technology standards deliver many benefits to utilities, but several factors are important to keep in mind. Just having a standard is not very useful, unless there is also compliance testing. This can take a while to develop, as different implementers of the standard may read the "standard" differently. Typically, repeated multi-vendor test cycles needed to iron out differences. Also, as technology veterans know, too many options can reduce or eliminate the potential benefit of a "standard." Finally, once a new technology standard can pass multi-vendor interoperability tests, it is important to see how the new technology will change the AMI system into which it is being added / replaced.

Roadmap: Interoperability. Combined with IP, the new NAN standard IEEE 802.15.4g brings the utility industry a step closer to interoperability, but we are not there yet. 15.4g has many options, some there for legacy reasons, and getting all vendors on same radio modulation will take longer in utilities than it has in consumer technologies, due to the longer equipment refresh cycles utilities require. In addition, interoperability requires that there be technology standards for all layers of the AMI stack, which are not yet present.

The OFDM modes of 15.4g appear to be good radios, and can be a step forward for AMI NAN networks, using different modulation techniques to drive higher bandwidth in different bands, though we will not know this for sure until these radios, and later the systems built upon them, mature. When utilities deploy 15.4g-based systems, they should ask if the 15.4g mode employed is one of these legacy option modes, or one of the new OFDM modes.

The AMI market is now beginning the process of moving to 15.4g OFDM-based systems, but it will take time to complete to complete that transition. The system maturation process includes interoperability testing, certification, lab testing, and pilot testing, with IC and RF design improvements at each stage.

Much has been written and said about both the 900 MHz and 2.4 GHz bands. Both are proven in deployments. The 900 MHz band is proven for AMI with 26 MHz of bandwidth and 1W, which is available in some countries, while the 2.4 GHz band is proven for AMI in the nearly global 83 MHz allocation.

Unfortunately, many countries do not allow 900 MHz usage for AMI. Others may allow usage of a 5 MHz band in the 900 MHz range. Deploying AMI in a band of 5 MHz is akin to deploying a new system, as infrastructure needs and other system attributes are re-discovered, and potential issues such as dense urban deployments and new interference mitigation plans are developed. Comments have been made by 900 MHz proponents that regulators should open more bandwidth where only 5 MHz is currently available because 5 MHz is not sufficient bandwidth for reliable AMI operation. This suggests regional risks, so waiting for a proven 5 MHz deployment, or at least successful pilots, may be prudent before giving more credence to other claims that 5 MHz is sufficient.

Lessons Learned

- IP Networking - most vendors support this, it offers many advantages
- Measurable criteria and independent references should be well-considered
- Spectrum selection
  - *Both 900 MHz and 2.4 GHz are proven in AMI deployments, your spectrum choice depends on your unique requirements, and on your system choice*
  - *Regulations – Some frequency band choices may result in spectrum costs*
  - *Bandwidth - Choosing a narrower band may result in congestion problems in urban areas, and can reduce system capabilities*
  - *Coverage - Different bands may require different amounts of network infrastructure (e.g. collectors and repeaters)*
- Radio selection
  - System and radio maturity each make a significant difference in performance
  - Though DSSS is more advanced that FHSS, both are proven in deployments. Your radio choice depends on your unique requirements, and on your system choice.
  - Digital processing enables DSSS to mitigate interference and reflections, especially beneficial in urban areas

Questions to Ask

- Spectrum Selection
  - *Is it legal in the country of deployment?*
  - *What bandwidth is available?*
    Is this sufficient for current needs?
    Is this sufficient for future needs?
  - *Are there guard bands in part of, or adjacent to, the band?*
  - *Will this band incur any interference from GSM, RFID and/or rail operators?*

Conclusions

Utilities continue their important, challenging work to reliably deliver on our global society's new energy vision. Through this work, many Smart Grid and AMI lessons have already been learned, and many more are yet to come as the smart grid evolves and matures. One of the primary lessons so far is that choosing which Smart Grid or AMI system in which to invest is a decision to be made starting with the most important criteria for a well-structured top-down process.

This means starting with commercial and vendor criteria, weighing them most heavily, then factoring in system metrics and factors and of course the partnership approach. Finally, speaking directly with references and running pilot projects must be part of the top-level decision.