STRATEGIC WHITE PAPER

Smart Choices: Establishing a Solid Foundation for an Effective, Future-Ready Smart Metering System

Today's electrical power industry is under intensifying pressure to curb unconstrained energy use. Electricity-generation infrastructures are struggling to keep up with intense seasonal demand peaks. While simply expanding that infrastructure might seem a logical solution, in reality doing so is enormously expensive and time-consuming, and enlarges rather than minimizes society's environmental footprint.

The electrical power industry is therefore seeking solutions that will enable the effective management of energy consumption and preserve the natural resources required to generate power. Smart metering is precisely such a solution. By introducing two-way communications between electricity consumers and power suppliers, smart metering creates opportunities for power utilities to shape demand patterns and raise consumer awareness of power consumption.

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Getting a Handle on Demand

The traditional metering model for power utilities is a passive one. Readers visit customer sites and take readings at regular intervals, billing against consumption. There is no interaction between customer and supplier, and a minimum of information is exchanged.

In times when supply is abundant and cheap and demand is predictable, this is a perfectly fine approach. Today, however, power networks are nearing or at capacity, the costs of electricity generation and distribution have shot up, and changing patterns of use have created sharp demand peaks that are immensely challenging for today's grids to manage.

Power utilities need more information from their customers about the power they're using and when they're using it—in real time. They need also to communicate the implications of that usage directly to consumers, especially if they are to smooth out demand patterns by encouraging off-peak consumption through financial and other incentives.

Smart metering technology puts the tools to achieve these goals in the hands of power utilities around the world. Yet smart metering is not simply a matter of deploying new devices at customer sites: realizing its full promise requires the deployment of an advanced metering infrastructure (AMI) that can support two-way communications and diverse applications. With the widespread adoption of IP-based communications, establishing such an infrastructure has become an economical proposition—one with the flexibility to accommodate long-term evolution and protect power utilities' communications-technology investments.

What Smart Metering Communications Looks Like

As Figure 1 shows, numerous communications technologies may be incorporated into an AMI. Some of the more common options include:

- Architectures based on LAN (Local Area Network) or NAN (Neighbourhood Area Network) technologies such as meshed radio, PLC and DLC. In these, meter data concentrators act as application-aware aggregation points. An appropriate WAN (Wide Area Network) solution, typically based on IP, is required to provide connectivity between the meter data concentrators and the data center where the meter-management systems are located.
- IP-enabled meters connected directly to the WAN (Wide Area Network) using GPRS/3G, WiMAX, GPON, BPL, etc. Direct communications between individually addressable smart meters and meter-management systems at the data centers are possible. IPv6-based meshed radio, although considered NAN technology, also allow meters to be directly IP-connected—without requiring application-aware meter data concentrators in the field.

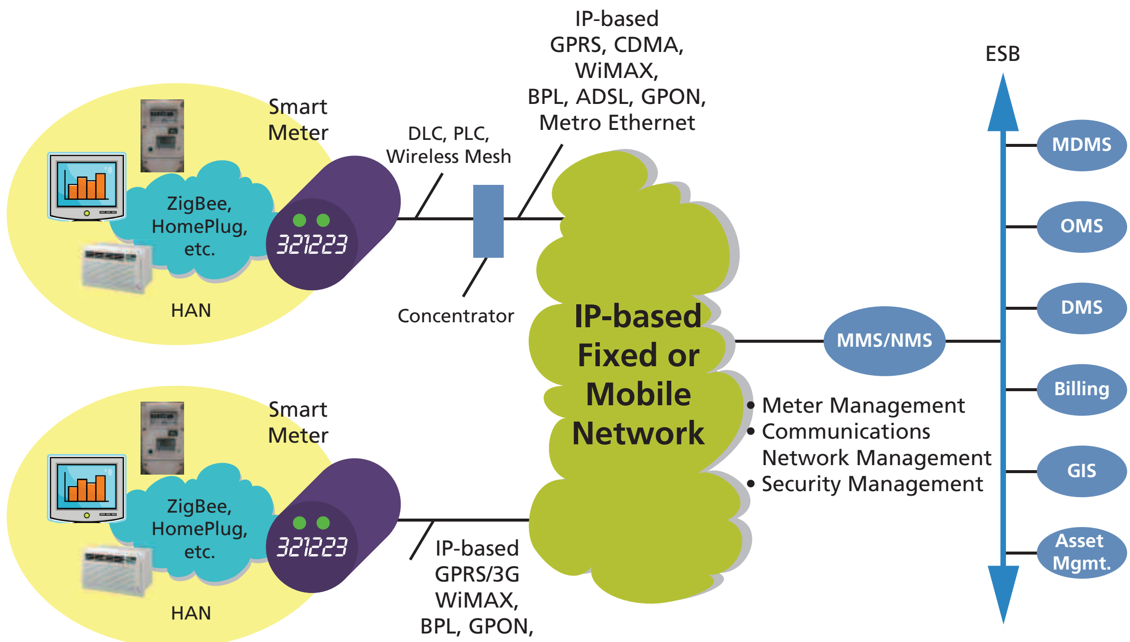

Figure 1: A typical AMI architecture

There is no one-size-fits-all solution applicable to every power utility. Even within a single power utility's service area, a mix of two or more technologies may be required due to the following factors:

- the need to opimize communications-network costs based on different customer densities;
- location constraints, such as coverage dead spots; and
- disparities between communications technology and metering lifecycles: communications technologies evolve at a much faster pace, making it more likely that a mix of them will be introduced—co-existing with each other over the 15- to 20-year typical life of a smart metering project.

Strategic Decisions: What Power Utilities Must Consider

When designing smart meter networks, power utilities and their communications partners must weigh several factors:

TECHNOLOGICAL FLEXIBILITY AND APPROACH

- Access-network agnosticism: Will the chosen smart metering architecture accommodate the evolution of communications technologies over time without asset overhaul?
- Standards-based versus proprietary approaches: What are the advantages or disadvantages of being tied to a single vendor's equipment in the long term?

REGULATORY REQUIREMENTS AND SOCIAL IMPACT

- Realizing societal benefits without jeopardizing ROI: What kind of smart metering/AMI rollout is required?

MAINTAINING COMMERCIAL LEVERAGE

- Reducing initial investment by using public mobile networks: What are the perils and how to avoid carrier lock-in?

PRIVATE VERSUS PUBLIC OWNERSHIP

- Private ownership of the communications network: How important is it for power utilities to own their own networks?

LEVERAGING SYNERGIES

- Maximizing operational benefits and shareholder returns across the entire organization: How can the smart metering solution enhance overall operational efficiency?

SECURITY

- Ensuring a comprehensive approach: Can the smart metering solution support end-to-end application layer security?

COMMUNICATIONS NETWORK ASSURANCE

- Managing the communications network: What is required to reduce communications network downtime in a complex multi-vendor, multi-technology environment?

The considerations associated with each of these are explored more fully in the sections that follow.

Technological flexibility and approach

ACCESS-NETWORK AGNOSTICISM

As mentioned earlier, given that a typical smart metering project has a 15 to 20-year lifespan, power utilities should expect the related communications technologies to evolve over that time. Any solution should therefore be designed modularly, preventing the need for overall system changes when a particular part or product becomes obsolete. For instance, the need to upgrade neighbourhood area network (NAN) technology at some point in the future should not necessitate replacement of wide-area network (WAN) technologies or meter-management systems and applications. Each should be independent.

As well, architecture of the AMI should not depend on any one specific access-network technology. Instead, a standards-based approach leveraging IP at the network layer and established protocols at the application layer is strategically the better option. One example of such an application layer protocol is ANSI C12.22, although it has yet to be universally adopted.

STANDARDS-BASED VERSUS PROPRIETARY APPROACHES

Further to the point above, adopting standards-based rather than proprietary technologies provides greater stability and flexibility over the lifecycle of a solution. Standards-based technologies provide more options for replacing equipment—ensuring that that equipment will in fact be available when needed—and also deliver economies of scale in production that get passed along to power utilities when they purchase network elements. Ultimately, a standards-based approach facilitates a lower total cost of ownership over the long term.

Regulatory requirements and social impact

REALIZING SOCIETAL BENEFITS WITHOUT JEOPARDIZING ROI

Deploying smart metering solutions is a costlier proposition in some regions than others for a whole range of reasons (geography, lack of infrastructure, etc.). These 'challenge areas', on average, can account for between 10 and 20 percent of the total customer base. Especially where there is regulatory pressure to roll out smart meters, power utilities should prepare to engage in constructive negotiations with regulators. With a well-designed solution, companies might strike on a reasonable near-term compromise of, for example, converting 80 to 90 percent of customers to smart meters and ensuring that the minimal functional requirements also be met for the remaining 10 to 20 percent. In other words, a staged, tiered-service approach may be acceptable and protect the power utility's returns while satisfying regulatory expectations.

Maintaining commercial leverage

ASSESSING PERILS OF CARRIER LOCK-IN

Where mobile technologies such as GSM, GPRS and 3G are considered to enable wireless communication in smart meters, power utilities must carefully weigh the question of obligating themselves to a single mobile service provider. Fundamentally, choosing a sole provider weakens the power utility's bargaining position when negotiating communications costs, and can effectively neutralize the cost benefit of switching providers due to the expense of swapping out SIM (subscriber identity module) cards in deployed metering devices. Power utilities should seek technology solutions that allow them to own and fully manage the SIMs such they continually have the ability to choose which mobile network operator to use at any location over time.

Private versus public ownership

PRIVATE OWNERSHIP OF THE COMMUNICATIONS NETWORK

Power utilities' operations are mission-critical, requiring control over a number of factors that more or less necessitate private ownership of network resources. Considerations include:

- Service levels: Network resources may not be guaranteed by public networks when congestion occurs.
- Obsolescence: Public network operators cater to the mass market, yet their decisions also have direct effects on power utilities using their networks. For example, power utilities depending on public CDMA services for remote monitoring in a particular country were inconvenienced when this technology was phased out nationwide.
- Coverage and capability: Public network operators increase their returns on investment by concentrating their offerings where the economic returns promise to be highest. This may not align with the needs of power utilities and their customers.
- Service restoration times: Public networks do not give priority to any one customer segment when service drops out and has to be restored. This could be unacceptable when smart metering moves towards applications that support the power utilities' operational network, such as emergency load control.

For all of these reasons, it is strongly recommended that power utilities plan to maintain private AMIs and smart meter communications networks rather than rely on public network service providers for connectivity and data transport.

Leveraging enterprise-wide synergies

MAXIMISING OPERATIONAL BENEFITS AND SHAREHOLDER RETURNS

Where permitted by their regulatory environment, power utilities can reap a number of additional operational and financial benefits by capitalizing on the investment driven by smart metering. A well-designed smart metering communications solution should be able to offer the following utility applications and services:

- Operational mobile voice
- Distribution automation, providing extended monitoring and control of the power distribution network, such as roadside transformers
- Workforce mobility, providing increased productivity and efficiency through the use of mobile tools such as field-force PDAs and rugged notebooks with narrowband and broadband wireless connectivity. Access to work orders, engineering, planning, etc, is available as and when required, anywhere in the field
- UTelco services, to increase unregulated revenues by leveraging BPL and WiMAX to deliver communication-network services directly to customers, or indirectly through electricity retailers within the power utility's service area

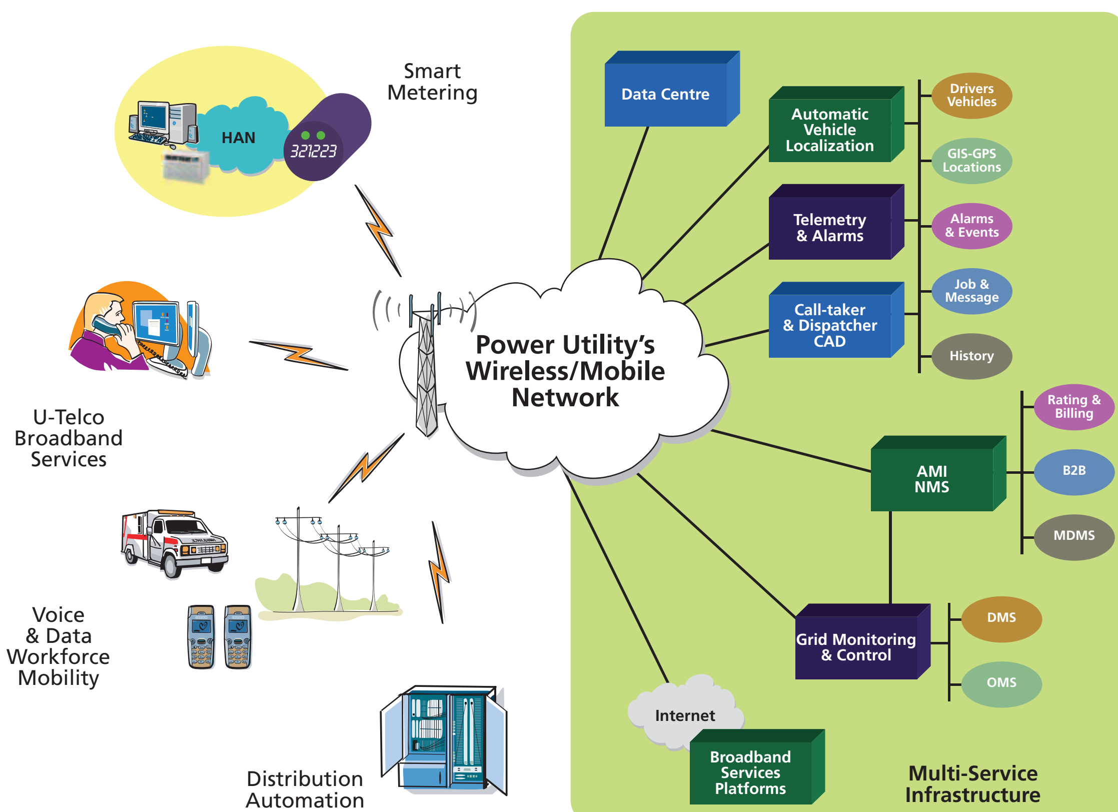

Figure 2: Possible service offerings enabled by a power utility's wireless/mobile network

Security

ENSURING A COMPREHENSIVE APPROACH

The mission-critical functions of the AMI demand a dependable security solution that provides for emergency load control, connect/disconnect and other essential capabilities. Not only is it essential to protect privacy of consumer's usage data, but it is even more critical to ensure that malicious organizations or individuals are not provided with security vulnerabilities that allow them to issue commands that impact on the operational network. Given that the smart metering communications network consists of multiple interlinked technologies, end-to-end encryption and application-layer security must be considered. This ensures integrity regardless of any individual weak or misconfigured links along the communication path. ANSI C12.22 encryption or IPSEC tunnels are examples that offer end-to-end encryption.

Communications network assurance

ENSURING HIGH AVAILABILITY IN A COMPLEX MULTI-VENDOR ENVIRONMENT

Poor operational efficiency and high network downtime may result from the deployment of disparate, proprietary management systems in a multi-vendor and multi-technology smart metering communications network environment. Power utilities must consider a 'manager-of-managers' system architecture that provides a full and cohesive view of all events and alarms that occur in the entire end-to-end communications network. Appropriate systems must be put in place to make sense of all this information by filtering and correlating these events and alarms, and ultimately by performing automated root-cause analysis.

Functionality

It is important to consider not only near-term technology requirements but also how chosen solution elements will adapt to future needs. Obviously, this is not an exact science, but certain assumptions about the ongoing evolution of functionality requirements may be made to inform present-day purchasing decisions. There are two possible avenues that could lead to investment in sub-optimal technologies that may not meet future requirements:

- Embarking on a smart metering program before regulatory requirements are finalized in an effort to realize immediate benefits specific to the power utility (such as reducing revenue leakage or manual meter-reading costs). In such cases the consequences could be pricey, as the power utility may be have to reinvest later on to meet regulatory requirements.
- Failing to anticipate unforeseen applications or increased demand in existing applications (such as more frequent HAN messaging or more frequent data downloads in order to offer near-realtime pre-paid billing options).

  For example, low-speed communications technology options—such as existing low-voltage distribution line carrier (DLC) technologies that support communication at total throughputs of about 2.4 kbps shared by a large cluster of meters — are barely able to cope with daily downloads of 30-minute interval data, and are flatly incapable of supporting more frequent downloads or uploads. These, then, are short-term technologies only and should not be included in the design of a future-facing smart metering system.

As an integral step in choosing an optimal smart metering communications technology, power utilities should create traffic models based on projected functionality requirements, including any regulated performance SLAs. Not only must bandwidth be considered but also session concurrency requirements, as the latter may prove to be a key dimensioning parameter for certain network types such as WiMAX or public mobile networks.

What kind of traffic—and in what proportions—flows through such a network? The following is an empirical example based on a sample set of assumptions and traffic profiles. The relative contributions of the different categories of functionality are provided in FIGURE 3. For this example profile, a daily average of 4.95 kilobytes of data was transferred from the smart meter to the meter management system, and 3.50 kilobytes of data in the opposing direction. The contribution of network management traffic was inflated to account for meter pinging once every 10 minutes.

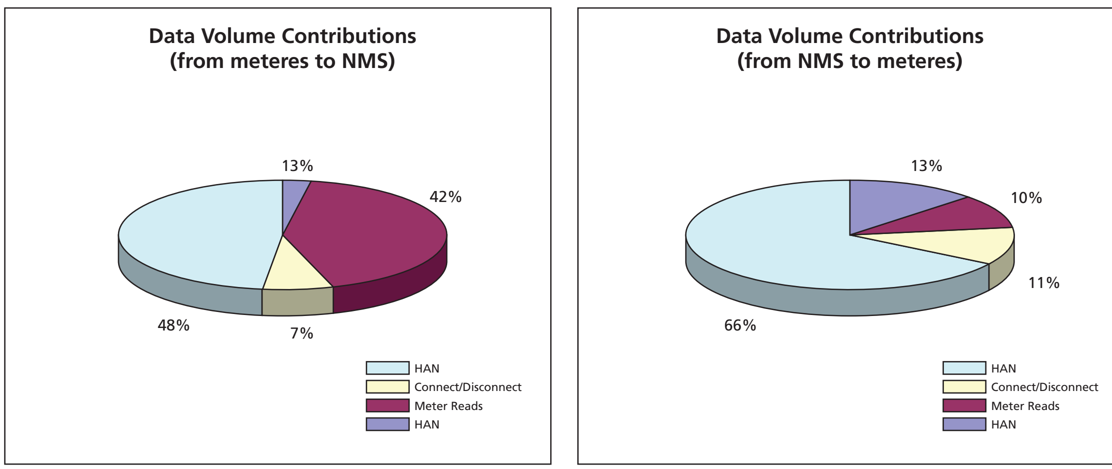

Figure 3: Contributions of the different categories of functionality

Some key functions of the AMI/smart metering solution that must be planned for in a power utility's technology choices include:

Meter reading – automated and on demand

In a smart metering paradigm, meter data should be collected at frequent intervals to maintain a real-time or near real-time perspective on consumption and facilitate communication with users about usage and demand. The ability to support frequent two-way communication in fact enables new pricing and billing models: for example, pre-paid electricity service without the need to deploy specialized pre-paid meters. The same model of meter may be installed in every customer house: those on pre-paid plans will have their consumption tracked and will receive communication if they near their paid threshold in order to either adjust their behavior or authorize an overage (potentially at a premium rate).

Connect/disconnect, emergency load control and appliance control

The AMI is not merely a communications network. With respect to emergency load control, it serves also as an operational control element—secure and reliable. As smart metering demand management models evolve, the AMI may be used to control of customers' electrical appliances—such as air-conditioners, water heaters and pool pumps.

Home area network (HAN) messaging

As capabilities evolve with the maturation of smart metering networks, some power utilities may eventually want to offer services unanticipated in the original AMI architecture, requiring sophisticated home area network (HAN) messaging at the customer's site. In these cases, power utilities should consult with a trusted, specialized communications networking partner to make sound decisions about adding new functionality and potentially bandwidth to the communications network. Often, the apparently high costs of communications network evolution appear prohibitive, but are not appropriately weighed against the benefits a higher-bandwidth communications network can offer.

Network management

Alerts pertaining to power outages often depend on receipt of a "last gasp" from a smart meter. Some communications technologies require connection-setup processing before transmission of this "last gasp." Power utilities should be aware that connecting the meter directly to the WAN (as in the case of GSM, GPRS, 3G, WiMAX and other such deployments) can cause avalanche conditions in the WAN base station and meter management system.

Where proactive "last gasps" are not available from the chosen smart meter, other polling methods, such as ICMP pings, may be employed.

In either case, impacts of network management traffic must be taken into account, especially where the communications technology offers finite simultaneous sessions and requires connection setup and teardown.

Smart Choices for Smart Metering

Smart metering provides power utilities with a flexible, evolvable means of exercising control over energy demand and consumption, offering new services and establishing new connections with customers. More than a communication tool, a smart metering system built on the right foundation—a well-designed advanced metering infrastructure (AMI)—holds out potential for power utilities to enhance their own operations and reap greater financial returns.

Realizing the full possibilities of smart metering demands careful decision making by power utilities at the outset. Several factors must be weighed to establish a clear vision of what the final system should be able to do—and certain technological choices must be made to ensure that the end result can adapt, cost-effectively and with minimal disruption, to technological change and new market dynamics. Working with an experienced, knowledgeable communications network partner—one that is vendor-neutral and proficient in systems integration—can be extremely helpful in these respects, offloading the burden of communications network expertise so that power utilities can continue to focus on their core business.

About the Author

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Tim Mew is a member of the Alcatel-Lucent's Industry and Public Sector Solutions division, responsible for managing end-to-end services-based solutions for vertical markets including energy and utilities.

Previously, Tim was head of the Solution Design and Innovation team in Australasia, focusing on railways, highways, oil and gas, and security solutions. Tim's generalist background allows him to take an end-to-end multi-vendor, multi-technology view on the integrated solution requirements of Industry and Public Sector customers. His experience lies in architecture, technology planning and service development disciplines in the technology areas of Next Generation Networks, VoIP, Intelligent Networks, PSTN, CTI, Internet and IP, CCTV, e-commerce, and wireless communications.

Before joining Alcatel-Lucent, Tim served in Architecture Manager, Senior Engineer, Brand Manager and CTO roles in a number of industries including two challenger carriers (AAPT and CLEAR Communications), an ISP (IHUG), and an ecommerce incubator (eVentures NZ).

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