The role of communication technology in Europe's advanced metering infrastructure

Technical Paper
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An analysis of the current deployment of smart meters across Europe, as dictated by EU directives 2009/72/EC and 2009/73/EC.

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1. Introduction

Smart metering is considered the cornerstone for future smart grids. As such, smart electricity meters are being deployed all over the industrialized world. Europe had an early start in the 2000s when the Italian utility, ENEL, completed the first nationwide roll out of smart meters for more than 30 million customers. Deployments followed in the Nordic countries and, as of 2010, Spain, France and the United Kingdom have become the most active markets. Berg Insight estimates that smart electricity meter installations in Europe will grow at a compound annual growth rate of 19.4 percent between 2010 and 2016 to reach 130.5 million units at the end of the period.

Smart meter deployment aims to deliver improved grid operations, customer services, and financial benefits. In terms of the latter, advanced metering infrastructure should enable utilities to reduce equipment and maintenance costs, suffer shorter grid outages while driving down support costs. However, smart meter deployment requires huge investment and must therefore be optimized at all stages. Two-way communication plays a major role in building the modern metering platform, with communication solutions potentially achieving an optimal trade-off between system costs and performance.

Despite perceived reliability issues during its early deployment, power line communications (PLC) presents an attractive transmission solution that can be built at reasonable procurement, installation and operational/maintenance cost. New open orthogonal frequency division multiplexing (OFDM)-based PLC systems developed and tested in a number of international field trials have rehabilitated PLC’s early image, and OFDM-based PLC systems are now seen to offer reliability, higher throughput, and support for a range of smart grid applications. Thanks to this progress, some European electrical utilities have gravitated toward PLC testing and pilot projects.
2. Communications in Advanced Metering Infrastructure (AMI)

Advanced metering systems are comprised of state-of-the-art electronic/digital hardware and software, which combine interval data measurement with continuously available remote communications. These systems enable measurement of detailed, time-based information and frequent collection and transmission of such information to various parties. AMI typically refers to the full measurement and collection system that includes meters at the customer site; communication networks between the customer and a service provider, such as an electric, gas, or water utility; and data reception and management systems that make the information available to the service provider. However, privacy protection must be fully assured for the processing of personal data by smart metering systems, as outlined by the European Commission in recommendation C(2012) 1342 final of 9.3.2012, on preparations for the rollout of smart metering systems.

The various components of AMI architecture are illustrated in Figure 1. The customer premises are equipped with an electronic meter that collects time-based data and alarm events. Meters cover all three commodities: electricity, gas and water consumption, and have the ability to transmit collected data through commonly available fixed networks such as Broadband over Power Line (BPL), Power Line Communications (PLC), Fixed Radio Frequency (RF) networks, and public networks (for example, landline, cellular or paging). The meter data is received by the AMI host system (also called the head-end) which will process the data and send it to the meter data management system, which manages data storage and analysis to provide the information in suitable forms to the utility. Because AMI is built on two-way communications, downlink communication from utility to meter is also used to send commands to meters, to set values and eventually update the meter firmware.

Global European forecast for smart metering 2020

EU directives 2009/72/EC and 2009/73/EC require member states of the European Union to install “intelligent metering systems* for electricity consumption, for at least 80 percent of customers by 2020—where the “cost business analysis“ for such a rollout is positive.

Consequently, various activities are running in most European countries, including testing, piloting and massive deployment of smart meters with communication solutions and metering data management systems. These activities are growing in Europe, as illustrated in Figure 2.

Figure 1: Building blocks of AMI architecture

![AMI Architecture Diagram](source)

Source: Accenture

Figure 2: AMI current and 2020 forecast

![AMI Forecast Map](source)

AMI deployment is progressing at varying speeds across most European countries. An estimate of deployment progress, according to utilities initiative, country regulatory requirements and deployment size is illustrated in Figure 3.

Communication technology requirements in AMI

The communications solutions deployed in AMI have to fulfill a set of requirements in order to confirm the economic viability and functional reliability of the whole system.

High reliability and long lifetime

Smart meters (and the communications technologies supporting them) should be able to stay online for 10, 15, or even 20 years without requiring replacement components or direct maintenance. Therefore, metering communications technologies must be highly reliable and designed with industrial-grade specifications to meet extreme environmental conditions of shock, corrosion, temperature, vibration and humidity. While telco solutions generally evolve every two years, business cases for utility solutions are based on a 20-year meter life span, presenting utilities with the challenge of managing these solutions over an extended period.

Interoperability

Smart metering communication systems should be based on standard metering protocols to confirm interoperability with changing energy supplier equipment and/or consumer equipment over the life of the meter.

Cost effectiveness

Smart metering communication technologies deployed on a massive scale must be designed to minimize costs and provide excellent value. The cost effectiveness of the communication infrastructure should cover the following three aspects of Capital Expenditures (CAPEX) and Operations Expenditures (OPEX):

1. Low energy consumption: First, the communications module must be designed to operate using the lowest current supply that the meter can provide. Second, suppliers need to verify that communication systems are energy-efficient for cost reasons. After all, even when smart meters and their communication systems are consuming a relatively small amount of power, that consumption adds up when millions of meters are connected point-to-point.

2. Low installation costs: It is estimated that installation makes up 30 percent of the total system cost of any smart metering project. Suppliers need solutions that simplify installation and reduce the time and expertise required to deploy smart meters. For example, in a low-power radio frequency deployment, installation technicians require an advanced skill set and a variety of equipment to verify that the smart meter communication system and antenna are properly deployed and functioning as intended.

3. Low maintenance: During the 10- to 20-year smart meter communication device life span, the module’s firmware will likely be upgraded to, for example, add new features, enhance security, or maintain compliance with the latest communication standards and regulatory requirements. Utilities need to be able to remotely manage, configure, test, validate and upgrade firmware over device management services that the utility or service provider can easily deploy. Smart metering solutions should also employ modular designs so that, for example, a WAN module can be changed without having to replace the entire meter.

Security

When two-way command and control systems are embedded into energy management systems, several security threats must be addressed, including guaranteed: confidentiality of data, which only allows authorized entities to access the data; integrity of data, which assures that data is not manipulated; authenticity of data, which confirms that the data is sent by a dedicated entity; and availability of data, confirming that data is available when needed.
3. Power Line Communications (PLC) and alternatives

Transmission technologies for power utilities

A qualitative comparison of the different alternative solutions for the "last mile" part of the smart metering network is given here (Table 1).

The table shows that there is no definitive choice in terms of smart meter communication technology. However, because the technical requirements of the smart metering application are moderate in terms of delay, instability and bandwidth, the total cost of ownership (TCO) for deployment of the technology often becomes the decisive factor. The TCO is mostly dependent on deployment environments, which influence the required investments. Therefore, the evaluation of the technology suitability needs to be done according to the deployment environment.

Table 1: General qualitative comparison of the most used transmission technologies for smart metering last mile
(Rating: ++/+/0/-/--)

<table>
<thead>
<tr>
<th>Access technologies</th>
<th>PLC</th>
<th>RF mesh</th>
<th>Public mobile network</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meter point cost (including communication infrastructure such as data concentrator/RF collectors) in medium to dense areas such as villages and cities</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Meter point cost (including communication infrastructure such as data concentrator/RF collectors) in rural areas</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Meter point installation costs</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Performance for smart metering</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>OPEX over lifetime</td>
<td>++</td>
<td>++</td>
<td>--</td>
</tr>
<tr>
<td>Risk of service discontinuation in 15 years</td>
<td>++</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Maturity</td>
<td>0*</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Standardization</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Reliability</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

*OFDM-based PLC
In the study, “Smart Grid Networking and Communications,” it is indicated that alternative data transmission technologies are likely to be required by distribution utilities, and therefore their deployment will increase—albeit at different speeds—as illustrated in Figure 4.

Challenges for wireless solutions

The wireless cellular network, especially GPRS, is seen by Accenture as the secondary choice for communication within smart grids and utilities. Various smart meters have been deployed based on GPRS and most of these projects have led to similar conclusions concerning the pros and cons of this solution. The following key learnings regarding GPRS were taken from Ireland’s smart metering project report and have been confirmed by other European utilities:

- GPRS is an open standards technology. There are many vendors who will support a GPRS solution.
- GPRS proved to be a very effective and reliable technology during the course of the trial.
- GPRS worked well and was (very) reliable for the 95 percent of customers covered.
- The meters were easy to deploy, the auto-registration process was very effective.
- It is essential to work closely with the Mobile Network Operators to confirm compatibility of modems and determine optimal configuration.
- Issues related to mobile network lock-in (that is, being forced to be associated with same vendor/operator) need to be resolved if a mobile network-based solution is to be considered as a viable long-term solution for a full rollout.
- There is an issue for mass upgrade or mass on-demand activity as the system is point-to-point and lacks a broadcast/multicast capability. This will be restrictive for some future potential smart metering services.
- While GPRS worked for the trial there is an issue over how long this technology will continue to support all mobile operator networks, particularly given the anticipated life span of the smart metering system, which could remain in place until 2032.
4. Status of PLC mass deployments in Europe

PLC deployment in Europe

Some of the Nordic countries and Italy have already completed the deployment of AMI based on PLC, although other projects are still under consideration. Spain and France, which have some of the largest distribution system operators (DSOs) in Europe, have also managed large-scale rollouts. Germany and the United Kingdom, because of the diversity of DSOs, have numerous medium-sized rollouts (Figure 5).

Figure 5: PLC smart metering deployment in Europe—Status
PLC variants in the field

The first countries interested in PLC smart metering have chosen Echelon, Meters and More or G1-PLC. Current pilots are now largely with Prime, G3-PLC, or proprietary technologies, as illustrated in Figure 6. The primary characteristics of deployed PLC variants in Europe are defined in Table 2.

Table 2: Deployed PLC variants in Europe

<table>
<thead>
<tr>
<th>PLC variants</th>
<th>Main characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1</td>
<td>Open specifications for PLC communication, S-FSK-based, Max. bit rate 2.4 kbps, IEC 61334</td>
</tr>
<tr>
<td>G3</td>
<td>Open specifications, OFDM for the CENELEC A Band, Frequency Band: 36-90.6kHz, Bit rate (kbps): 5.6-45, 36 channel-based OFDM system, 6LoWPAN adaptation layer to transmit IPv6 over PLC, Signal crossing the MV/LV transformers</td>
</tr>
<tr>
<td>PRIME</td>
<td>Open specifications, 97 channel-based OFDM system, Frequency Band: 42-89kHz, Bit rates up to 128kbps</td>
</tr>
<tr>
<td>Meters and More</td>
<td>Open technology Founded by Enel and Endesa, Selected for standardization in OPEN meter project, BPSK modulation, Bit rate up to 4.8 kbps</td>
</tr>
<tr>
<td>Echelon</td>
<td>BPSK-based, Proprietary Narrowband PLC Solution, CENELEC A Band (In utility applications)</td>
</tr>
</tbody>
</table>

Source: Accenture
5. Conclusions

Diverse and intensive smart meter deployment is happening throughout Europe as a consequence of EU directives 2009/72/EC and 2009/73/EC.

Power utilities are funding this deployment and need to fully engage in the critical decisions inherent in building a cost effective, secure and reliable two-way grid communication infrastructure. Even a small differential in terms of cost and performance of the communication component can have a decisive role in delivering a successful deployment.

Utilities must therefore plan now for communication diversity and balance the most efficient, cost effective and durable communication technologies to help ensure grids built today remain smart beyond the foreseeable future.

Hence why many are considering power line communications and new related technology options. Of course, homogeneous technology is always an attractive ideal in the short-term. However, a strategy that integrates diverse communication technologies can offer utilities the flexibility, and potentially the competitive advantage, to handle at least 15 years of unpredictable industry evolution to come.
References


3 Olivier Pauzet: “Cellular Communications and the Future of Smart Metering,” Sierra Wireless, Inc.


What is the path toward the future digital grid?

Accenture’s Digitally Enabled Grid program provides actionable insights and recommendations around the challenges and opportunities utilities face along the path to a smarter grid. Drawing upon primary research insights from utilities executives around the world as well as Accenture analysis, The Digitally Enabled Grid examines how utilities executives expect smart grid technologies and solutions to contribute to their future networks.

For more information on Accenture’s Digitally Enabled Grid program, go to www.accenture.com/digitallyenabledgrid.

About Accenture Smart Grid Services

Accenture Smart Grid Services focuses on delivering innovative business solutions supporting the modernization of electric, gas and water network infrastructures to improve capital efficiency and effectiveness, increase crew safety and productivity, optimize the operations of the grid and achieve the full value from advanced metering infrastructure (AMI) data and capabilities. It includes four offering areas which cover consulting, technology and managed solutions: Work, Field Resource Management; Transmission & Distribution Asset Management; Advanced Metering Infrastructure and Grid Operations.

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