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Electricity utility managers are exploring the potential of AMI systems for benefits beyond their energy sensing and control capabilities. >>

AMI — The Power of Dynamic Systems

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Advanced Metering Infrastructure (AMI) or 'smart metering' is an integrated system of wired and wireless technologies that supports dynamic data management for electricity utilities and their customers.

Beyond billing and managed rate structures, AMI systems provide real-time and near-real-time responses that enable new services, such as Home Area Networks (HANs), connected thermostats, in-home displays, and energy management systems. Analytics based on Meter Data Management (MDM) systems, which include Geographical Information Systems (GISs) and Volt/Volt-Ampere Reactive (Volt/VAR) control, help make utility operations more efficient and facilitate better customer engagement.

AMI Systems

AMI systems offer many advantages for flexibility and scalability:

- **Pricing and Billing:** Smart meters enable utilities to use Time-Of-Use (TOU) rates for dynamic kilowatt rates based on daily, monthly, and seasonal fluctuations. Customers are able to easily see and compare costs.
- **Cost Control:** Because electricity cannot be stored, prices vary substantially depending on supply-demand conditions and time of day; advanced meters record usage in short time intervals that allow dynamic pricing or tariffs to be applied to residential customers; and Real-Time Pricing (RTP) passes the actual electricity cost to the customer.
- **Demand Response (DR):** DR programs help utilities operate more efficiently during peaks by providing hourly and sub-hourly responses to incoming data.
- **Consumption:** AMI deployments link smart meters with smart thermostats for residential DR. The goal is to motivate customers to better manage usage. For example, Electric Vehicle (EV) recharging and prepaid billing allow charging stations to be integrated with TOU rates to encourage off-peak charging.
- **Data Analytics:** MDM systems provide a more complete picture of system status for helping utilities take more informed actions, make better investment decisions, and enable applications, such as outage and distribution management, DR, TOU rates, power quality monitoring, behind-the-meter Distributed Energy Resources (DER) integration, and home energy management.

Smart Meters

Smart meters are at the core of AMI deployments and must meet certain requirements, independent of the communications network or specific local, regional, or federal regulations.

Basic requirements include:

- Capture and storage of two or more channels of usage data at programmable intervals — typically from five minutes up to one hour or more and stored for a minimum of 30 days and sometimes up to a year
- Certified to accuracy standards for measuring power consumption
- Certified to meet environmental and reliability standards for outdoor environments
- Prepared to meet or exceed standards for physical and communications security
- Secure, remote firmware upgrades without interrupting service
- Support for sub-metering to co-located gas, water, or temperature controllers

Data Software

As new applications emerge, Meter Data Management Systems (MDMSs) are needed. MDMSs collect, process, and store meter data to help utilities improve the value and efficiency of grid operations.

Though meter data repositories have existed as part of the utility IT suite for years, the widespread introduction of AMI platforms overwhelmed legacy MDMSs with unanticipated amounts of interval data from smart meters. The updated MDMS solutions offered increased throughput capacity plus a new focus on analytics, scalability, and flexibility. Today, MDMS vendors see more utility companies prioritizing data architectures as a critical implementation factor that must be in place before any smart meter deployment, whereas traditionally, the data management component has been treated as an afterthought.

AMI Telecommunications

Many smart meter benefits require an AMI communications network to link the devices with the data centers to enable the real-time and near-real-time data flows that utilities and customers must rely on for making moment-to-moment decisions. Numerous wired and wireless technology choices are available to facilitate this level of Neighborhood Area Network (NAN) connectivity.

In general, Radio Frequency (RF) or wireless mesh technologies prevail in North America, while Power Line Communication (PLC) leads in Europe and is gaining in the Asia Pacific region — though there are always exceptions as market dynamics continue to shift. In other regions, the technology choices are defined by regulatory factors, the specific needs of each utility, and prevailing metering technologies.

PLC

PLC uses existing power lines as the communications medium. Multiple types of systems are associated with many standards and PLC, including Low-Speed PLC and Narrowband PLC (N-PLC). Some systems are targeted for use on the Low Voltage (LV) portion of the grid (from the transformer to the premises) and/or the Mega-Volt (MV) portion of the grid (neighborhood regional distribution to local transformers).

Broadband-over-Power-Line (BPL) systems generally refer to PLC systems supporting data rates over 1 Mbit/s. One example is Huawei's Broadband PLC (BPLC), which is designed to accommodate greater numbers of transformers in series, real-time monitoring, remote upgrades, and programmable measurement control. Like N-PLC, there is no shortage of BPL systems and proposals for in-home use.

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Because BPL technologies generally operate at carrier frequencies well above the CENELEC bands used in N-PLC and defined by EN 50065, they experience inconsistent and challenging spectrum characteristics. Reliable communications are difficult to achieve and often cause significant electromagnetic interference.

Business experiments in which electric utilities offer Internet services to consumers via BPL have failed, forcing utilities to refocus on their core electrical distribution businesses. In-home broadband technologies may be deployed for HAN applications and potentially could be expanded to external LV segments in the future.

Most BPL services intended for use by utilities are planned to be future-proof to supply adequate bandwidth for both current and over-the-horizon applications such as home energy control, distributed generation tools, and EV management. N-PLC systems often fail the future-proof test, as the increase in modern security controls over advanced networks requires too much bandwidth. Fatter pipes are needed to adequately secure state-of-the-art utility communication networks down to the meter level.

The Huawei HiSilicon Semiconductor Business Group developed a Hi-PLC carrier chip with a data rate of 2 Mbits/s for bi-directional, real-time, high-speed communications over power lines for improved performance over narrowband systems that, unlike wireless solutions, does not require peripheral devices or RF antennae.

Other Technologies

RF mesh networks form web-like topologies. When a node is not in range of its target destination, such as when a meter transmits data to a concentrator, intermediate nodes in the mesh will relay that node's data. Data packets en route between source and destination nodes in a mesh network may hop through many intervening nodes, thereby extending the effective range of the network well beyond that of any single transmitter or receiver.

RF Point-to-Multipoint (P2MP) systems use licensed spectrum allocations at transmit power levels sufficient to communicate between centralized tower-based nodes and multiple nodes (including meters) within range. Wireless cellular phone infrastructures are public RF P2MP networks, where each cell tower has a limited range and multiple towers provide overlapping coverage. In private RF P2MP NAN implementations, tower-based gateways provide overlapping coverage to all nodes and meters within range. These are characterized as star topologies, where each node is within direct range of the center of the star — the network gateway.

Where the expense is justified, smart meters with integrated cellular modems are in widespread use for Commercial and Industrial (C&I) customers over public P2MP infrastructures. There are, however, financial obstacles for using the public cellular network for residential NAN applications, particularly in North America where wireless carriers tend to treat smart meters like consumer cell phones. The typical business model for mobile wireless subscribers yields high revenue-per-node operating costs compared to the overhead for private networks, and the wireless carriers do not see a profitable business case for smart-meter connectivity. Cellular wireless is commonly used for Wide–Area-Network (WAN) connectivity to NAN concentrators where the cost for individual nodes is amortized over hundreds or thousands of smart meters.

An emerging NAN solution promoted by GE Energy and its partner Grid Net is the combined use of Worldwide Interoperability for Microwave Access (WiMAX) and 4G/LTE solutions.

AMI Connectivity

The components of a typical AMI system include a HAN to connect all devices in the home, such as displays, thermostats, load-control devices, and smart appliances, to the smart metering node. NANs connect each smart meter within a neighborhood to the local utility's WAN communication infrastructure, and the WAN links the meter data concentrators to the local utility's IT system. The HAN may also connect other meters, such as gas and water, to the NAN.

Business Outlook

The market for smart electric meters is very much in flux. The conditions in different countries and regions vary and are affected by local regulations, economic conditions, and technical practices that impact meter data accuracy, energy efficiency and conservation, grid modernization, and high loss rates due to theft of services. Regulatory policies are a major force driving many smart meter deployments, as policymakers believe smart metering is a key technology for helping to reach goals related to climate change, increased energy security, and greater on-premises energy efficiency by enabling better peak demand shifting.

The primary reasons for utilities to deploy smart meters are largely operational:

- Remote service connections and disconnections reduce labor and operating costs.
- Remote meter reading eliminates the cost of field personnel having to visit each and every customer site.
- Two-way meter communications enables more accurate outage detection and swifter service restoration.
- Exact billing eliminates of-use estimates.
- Active theft detection has increased total energy supply up to 20 percent in some markets.
- Demand response programs are enabled to help utilities operate more efficiently during periods of peak demand.
- Trends analysis helps utility operators better gauge loads and determine appropriate investments in new equipment.
- Timely rates-of-consumption and costs-of-service data enable better informed decisions by each utility and increased customer engagement.

There are a number of barriers that have slowed the growth of smart metering:

- A German cost-benefit analysis determined that a national rollout was unwarranted and would not be mandated; a selective approach would be used instead.
- High tariffs in developing countries have inhibited the wide-scale deployment of smart meters — which, in turn, has prevented the creation of an insurmountable financial hurdle for local populations.
- A legal framework or favorable policies in support of new deployments are lacking.
- Multiple standards for meters and communications protocols produce device incompatibilities.
- Small and midsize utilities may lack the in-house competencies necessary to support AMI development, deployment, and ongoing operations.
- Customer concerns over health and privacy force regulators to mandate opt-out programs for individual customers.

Ecosystem

AMI and IoT trends will continue to overlap and, in so doing, will bring third-party vendors to supply hardware, software, and services to support deployment opportunities. **>>**

AMI's Future

Utilities are adopting AMI systems as part of a long-term transformation to create a more intelligent grid. New AMI installations and upgrades to existing smart meter platforms offer significant growth potential. In the past, meters were replaced about every 20 years; however, North America, Europe, and China have recently been experiencing disruptive replacement cycles as large-volume smart meter deployments changed the norm. AMI and IoT trends will continue to overlap and, in so doing, will bring third-party vendors to supply hardware, software, and services to support deployment opportunities.

Although the adoption rates vary by region, advanced meters will increasingly become the standard. AMI solutions provide grid operators with highly granular data collection and control capabilities that enhance system efficiency. Smart meters are vital to a future of increasingly distributed energy resources, including rooftop solar, EV, and new energy storage options. Old-style meters were never designed for connectivity to an intelligent grid. The bottom line is that smart meters enable customers to self-monitor the efficiency their electrical energy consumption, which is an essential function for consumers and industries looking to reduce costs and regulators seeking to define equitable rates. ▲