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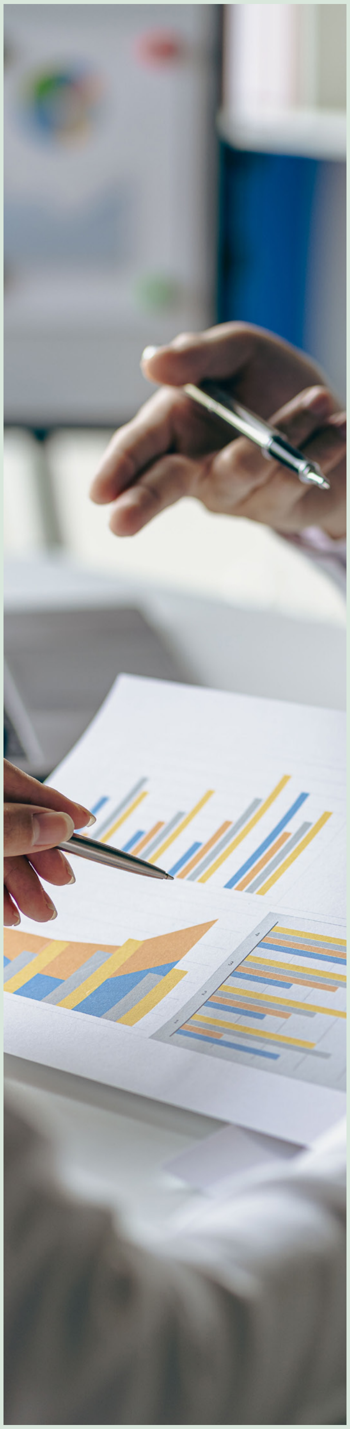

EVOLUTION OF THE SYSTEMS INTEGRATOR'S ROLE IN A CHANGING AMI LANDSCAPE

AMI: THE CHANGING ROLE OF SYSTEMS INTEGRATORS

Abstract

As the utility industry transitions from the first-generation advanced metering infrastructure or AMI 1.0 to the next-generation AMI 2.0, it is worthwhile to note the role played by systems integrators in ensuring successful adoption. AMI 2.0 heralds an era of advanced technologies, efficiency, and reliability for utility companies – and systems integrators are crucial to delivering these next-gen capabilities.

This paper looks at the scope of work undertaken by systems integrators when partnering with utility companies for AMI adoption. It considers the entire AMI deployment lifecycle – from strategy to implementation and benefit realization – and also provides some key best-practice recommendations from Infosys.

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Introduction

Advanced metering infrastructure (AMI) is far more than a single technology implementation. It is a fully configured infrastructure comprising smart meters, communication networks, and many diversified systems. Each of these systems has complex integration requirements with several new and existing utility business processes and their associated applications.

Consequently, the activity of systems integration in AMI has been transformed from pure data collection to a more comprehensive strategy involving data management and utilization. Thus, AMI systems integrators must have broader skillsets to ensure a robust, secure, and functionally rich AMI ecosystem.

The US Department of Energy has released a guide titled, "Voice of Experience Leveraging AMI Networks and Data" based on insights from over 120 electric power professionals who have deployed AMI technology. The guide helps users:

Discover new opportunities such as how to:

- Use AMI beyond meter reading
- Effectively monitor AMI systems remotely
- Effectively manage demand response (DR) programs
- Leverage predictive outage management

Address the challenges presented by AMI such as how to:

- Integrate AMI with legacy systems
- Enhance customer satisfaction

How AMI Can Streamline Utility Business Processes

AMI implementation starts with replacing traditional electro-mechanical meters with smart meters that support two-way over-the-air communication between utilities and their customers. The adoption of smart metering equips utilities with valuable data, enabling a more efficient, customer-centric, and reliable energy grid. This shift improves utilities business processes in the following ways:

Table 1 – Business processes that are enhanced by AMI rollout

Business process	Impact considerations
Meter rollout	Smart meter rollout involves careful planning of meter rollout by factoring optimal routes, billing cycles and districts, seamless back-office integration, efficient meter exchange, exception handling, and smart meter registration process.
Meter reading	Data from smart meters is transmitted over the air, enabling the collection of accurate data that is exported to back-office systems using new interfaces.
Billing	With utilities gaining control over granular-level meter data, multiple new rates and dynamic pricing options can be offered to customers including net metering, time of use (TOU), etc.
Customer service	Customers gain access to a host of information and insights including real-time usage, bill forecasts, etc., to better understand consumption patterns and control their energy usage.
Demand management	Utilities gain insights into peak usage times and implement programs to encourage off-peak consumption such as critical peak pricing (CPP), peak time rebate (PTR), etc.
Outage detection	AMI systems can identify outages faster, leading to quicker response times and improved customer satisfaction.
Third-party data sharing	With a focus on energy efficiency programs, utilities can share customer interval data with third parties and market aggregators to offer personalized energy-saving tips and smart home management tools, and enable customers to participate in DR programs that reduce energy usage and bills.

Clearly, the role of systems integrators must evolve to ensure operational and process efficiencies without any business disruption when adopting AMI. The scope of work, hence spans understanding the impact on IT systems, integration types, integration models, and testing.

Evolution of Systems Integration from AMI 1.0 to AMI 2.0

It is believed that AMI 2.0 will go beyond the benefits of AMI 1.0 and enable a paradigm shift for utilities seeking to enhance efficiency, reliability, and customer satisfaction. The key differences between AMI 1.0 and AMI 2.0 are:

AMI 1.0 was the foundational step in modernizing the utility industry. It automated meter reading, improved billing accuracy, and introduced analytics using meter data for energy accounting, outage, and tamper detection.

AMI 2.0 will help utilities make a paradigm shift from achieving customer-centric operational efficiencies to offering solutions focused on decarbonization, decentralization, and grid resiliency with real-time data and control over energy usage.

Thus, as utilities transition from AMI 1.0 to AMI 2.0, the role of systems integrators is also transforming to keep pace with technology advancements and rising customer expectations. Systems integrators, too, must shift their focus towards next-gen enablement. To help their clients tap into long-term growth opportunities, systems integrators must re-examine their role, go beyond mere integration, and deliver strong differentiation by:

- **Moving from data collection to data insights** through real-time data analysis and distributed intelligence (DI) capabilities
- **Focusing on data management and security** by ensuring compliance with data privacy regulations
- **Enabling edge computing** to process data locally before sending it to the central system
- **Introducing advanced analytics and integration** to extract valuable insights
- **Driving partnerships and collaboration** with data analytics aggregators, cybersecurity firms, etc.

Key Activities for Systems Integrators During AMI Implementations

1. AMI implementation – IT system impact

With the adoption of smart meters and business process changes enabled by AMI, it is important to understand how data is ingested by different utility IT systems. Systems integrators must be aware of these systems and their importance to enabling AMI.

Table 2 – Core IT systems that leverage smart meter data

IT system	Role played in AMI system integration
Head-end system (HES)	HES acts as a central hub for communication between smart meters, backhaul, and utility back-office systems such as MDMS, data warehouse, SMOC, etc.
Meter data management system (MDMS)	MDMS is the source of truth for meter data that runs through the data validation, estimation, and editing (VEE) process. It is used for usage calculation and gets shared during on-cycle/off-cycle customers' billing.
Customer information system (CIS)	CIS is the core system for the meter-to-cash process and is integrated with the AMI systems to enable AMI functionalities like over-the-air on-cycle and off-cycle billing, remote service switch, etc.
Field management system (FMS)	FMS is used by the utilities field workforce to dispatch technicians, optimize routes, track work progress, and manage inventory.
Work and asset management system (WAMS)	WAMS is used by utilities to manage physical assets like transformers, power lines, substations, meters, etc., by tracking asset inventory and work order management. It also includes resource allocation for field visits and performance monitoring.
Outage management system (OMS)	OMS handles outage-related information from smart meters, streamlines the restoration process, and improves customer communication.
Analytics platform	This analyzes meter data to identify trends, predict demand, and provide valuable insights for demand management, outage prediction, grid optimization, etc.
Security solutions	AMI involves continuous data exchange between utility back-office systems. To protect sensitive customer and meter data, AMI implementation needs to include multiple layers of security including network security, data security, and physical security.

AMI implementation involves key IT systems that use standardized protocols like ANSI, DLMS/COSEM or interfaces like IEC 61968-9 or open metering interface (OMI) to leverage smart meter data and ensure seamless data exchange. Figure 1 illustrates the architecture needed for such AMI implementations.

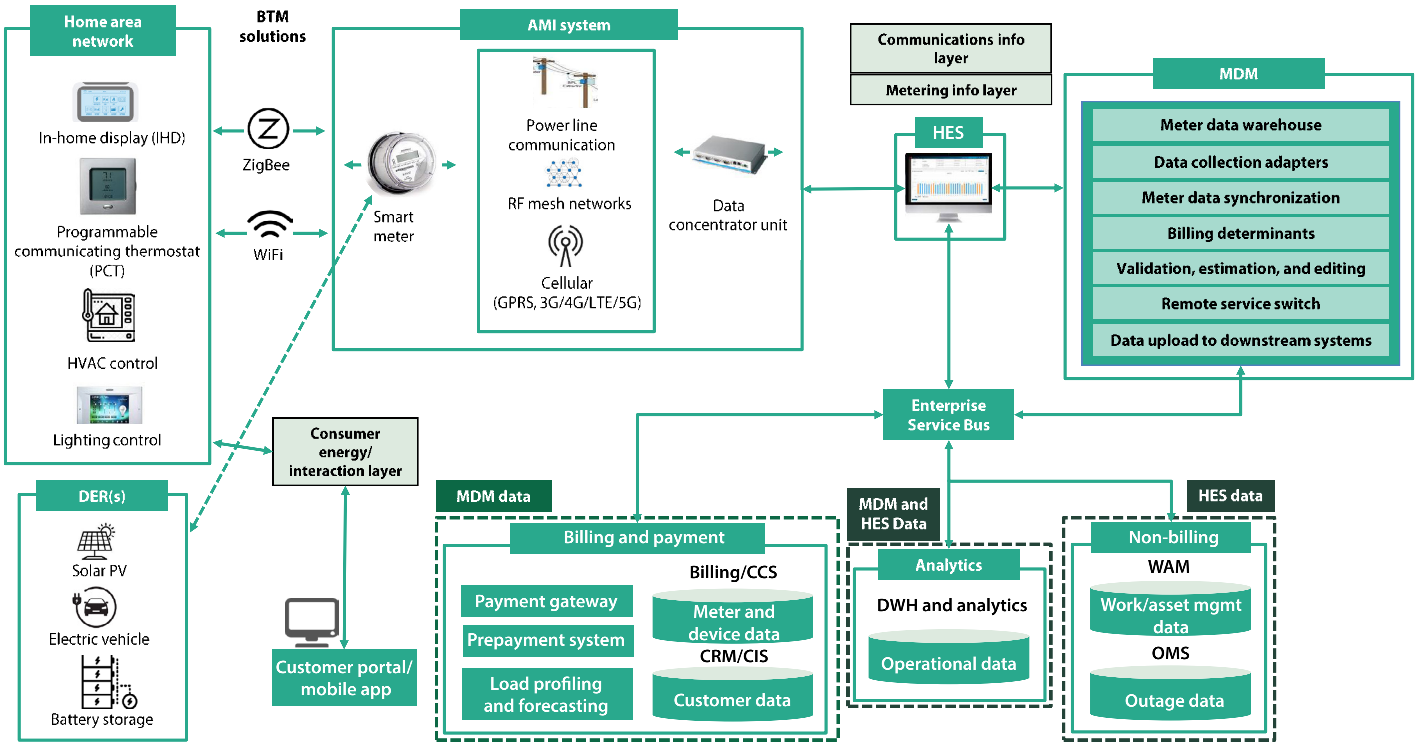


Figure 1 – AMI infrastructure architecture (Source: Infosys)

2. AMI integration types

There are several types of systems integrations that utilities can use when introducing new systems into their AMI landscape, as shown in Table 3.

Table 3 – Types of integration for AMI

Integration types	Description
Point-to-point integration	This integration establishes direct connections between individual devices and systems like HES, MDMS, and back-office (billing, CIS) systems.
Integration layer approach	The integration layer approach involves a central integration layer that acts as a mediator between various AMI applications like HES, MDMS, and back-office systems.
Enterprise service bus (ESB)	ESB facilitates communication between different systems within the AMI network. Studies have shown that the ESB approach reduces the cost of buying new interfaces by up to 50% and of maintaining that interface by up to 80%.
Event stream management (ESM)	ESM platforms are designed to capture, store, and analyze high-volume real-time data streams from various sources, including AMI systems.
Event-driven architecture (EDA)	EDA employs loosely coupled components that communicate through asynchronous events. When a specific event occurs, a message is published and interested systems can subscribe and react to it.

3. AMI integration models

AMI integration models focus on how different components within the system communicate and share data. Utilities can choose any of these integration models for their AMI implementation.

Table 4 – Types of integration models for AMI integration

Integration models	Description
Vertical integration	The vertical approach involves a hierarchical structure with a central MDMS at the core. Smart meters directly communicate with data collectors (DCs) or data collection units (DCUs) that then send data to the MDMS via HES.
Horizontal integration	The horizontal way emphasizes peer-to-peer communication among devices. Smart meters can communicate directly with other devices like distributed energy resources (DERs) or in-home displays.
Hybrid integration	This method combines elements of both vertical and horizontal integration. It leverages the centralized control of vertical integration while enabling some peer-to-peer communication for specific applications.
Cloud-based/ combination of cloud and on-premises	This approach utilizes cloud platforms to host the MDMS and other back-office systems. AWS IoT SiteWise service simplifies the process of ingesting, storing, and analyzing data from industrial assets including smart meters.

4. AMI systems interfaces

AMI systems rely on various interfaces to facilitate communication and data exchange between the components. These interfaces are also necessary for utility downstream application systems that use smart meter data.

Head-end system

Central nerve center of AMI systems. It manages communications, maintenance, tracking, and configuration of end-points, cell relays, routers, etc.

Meter data management system

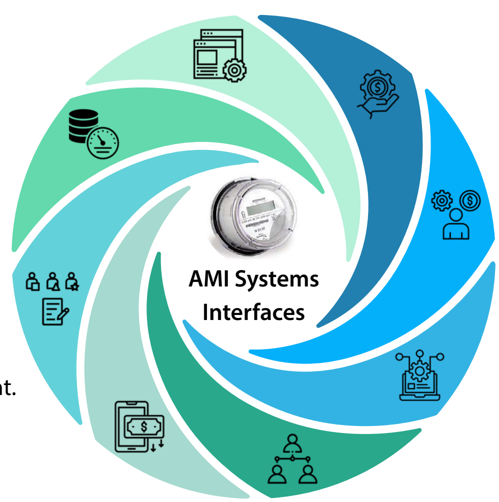
Central smart meter data collection system with critical AMI functions like validate, edit and estimate (VEE), remote service switch, etc.

Customer information system and billing

Customer master data repository. It is responsible for smart meter customer billing and end-to-end customer service management.

Customer energy portal

Customer portal for end-customer self-service including requests for new services, termination of existing services, visibility into energy consumption data, bill forecast, energy saving tips, etc.



Field management system and work and asset management

FMS streamlines field operations ensuring efficient meter deployment and maintenance. WAMS takes care of asset inventory, work order management, and asset performance.

Outage management

Responsible for overall outage management including outage detection, response, restoration, and end-customer notifications for PONs and PRNs, etc.

Reporting and analytics platform

Responsible for data pattern analysis, reporting, and deriving insights like demand forecasting, outage detection and prediction, customer behavior analysis, etc.

Third-party interaction

Responsible for smart meter data sharing across third-party systems in adherence to regulatory mandates like demand response programs, etc.

Figure 2 – AMI systems interfaces (Source: Infosys)

5. AMI testing

AMI implementations are complex primarily due to the need for an integrated network of smart meters, communications networks, and data management systems. Hence, it is vital to have a robust end-to-end testing lifecycle to ensure that all disparate AMI systems are interconnected and deliver the expected AMI business outcomes without affecting quality, security, performance, and regulatory aspects.

The end-to-end testing lifecycle encompasses many phases as listed below:

Table 5 – Testing phases during AMI implementation

Testing category	Description
Factory acceptance testing (FAT)	FAT is conducted by the meter manufacturer to ensure that individual meters meet performance specifications before dispatching these to utility companies.
Site acceptance testing	This is performed after meter installation to verify proper communication with the central system and data accuracy.
Functional testing	Functional testing evaluates whether the AMI systems fulfill all intended functionalities including meter reading, data communication, and integration with other systems.
Interoperability testing	This verifies seamless communication and data exchange between the AMI systems and other existing utility infrastructure components.
Systems integration testing (SIT)	SIT simulates real-world scenarios to assess the entire AMI system's functionality from meter data collection to data analysis and visualization.
User acceptance testing (UAT)	UAT is performed by business users by simulating real-life business scenarios to confirm that the AMI systems meet the utility's specific needs and operational workflows through identification of any usability challenges.
Regression testing	This ensures that new software updates or system modifications do not introduce unintended bugs.
Performance testing	Performance testing measures the ability of the system to handle expected data volumes, response times, and overall performance under various load conditions.
Security testing	This assesses the vulnerability of the system to cyber attacks, ensures data privacy, and checks that security measures are functioning effectively.
Security penetration testing	Penetration testing includes ethical hacking attempts to identify potential vulnerabilities in the AMI systems and strengthen the overall security posture.

By rigorously testing all aspects of AMI systems, utilities can ensure a smooth and secure transition to a data-driven, efficient, and reliable AMI system.

Risks and Key Challenges in AMI Implementation

Adopting AMI offers numerous benefits for utilities and its customers. However, it also presents risks and challenges that require proper planning and mitigation, as described below:

Table 6 – Risks and challenges when adopting AMI

Areas	Description
Large-scale mass meter exchanges	Coordinating the rollout of smart meters across a vast customer base along with manual meter exchange is a complex logistical undertaking. It requires efficient planning, execution, and inventory management.
Communication network limitations	Establishing a reliable and secure communication network that reaches all meters, especially in geographically dispersed areas, can be difficult.
Full/first-time data synchronization	Data (customer, meter, etc.) synchronization across AMI systems covering all parameters for initial setup can be challenging.
Migration (in-flight data issues)	Data migration or synchronization for ongoing business activities (like inflight move-ins, move-outs, tariff changes, meter exchanges, bill corrections, etc.) during the transition phase can be very complex.
Incremental data synchronization	Incremental data synchronization across multiple discrete systems often poses a challenge owing to the nature of data flow (real-time, batch, event-driven, etc.)
Unbilled revenue	As the billing engine incurs several changes due to AMI implementation, utilities must factor unbilled revenue situations arising from multiple flavors of billing.
Regulatory non-compliance	Non-compliance with regulatory requirements like missing third-party data sharing, usage data not available to end-customers, etc., can result in huge penalties.
Data validation	Distributed intelligence (DI) algorithms may be different from the utility back-office algorithm. Utilities must take this into consideration for necessary validation.

Infosys Recommendations for Successful AMI Implementations

As a systems integrator for several AMI implementations, Infosys has gained valuable hands-on knowledge of the best-practices and value-added mechanisms that ensure successful AMI implementations. Here are some of our key recommendations:

Choose a combination of AMI integration types

The optimal integration approach for AMI systems depends on several factors including the size and complexity of the network, existing IT infrastructure, and specific business needs. Infosys recommends a combination of AMI systems integration, event stream management (ESM) and event-driven architecture (EDA) for AMI.

Evaluate the right AMI integration model

By carefully considering the different integration models and the new-age requirements like AMI 2.0 edge computing use-cases, Infosys recommends a combination of cloud-based and hybrid integration models. This approach can unlock the full potential of distributed intelligence and advanced analytics at the meter level, enabling efficient grid management and optimization, enhanced customer engagement, and smarter energy usage.

Use accelerated toolkits

In order to accelerate the implementation and integration of the AMI systems successfully, Infosys recommends that systems integrators leverage accelerated toolkits like reusable frameworks, dashboards, one-stop AMI services platforms, etc.

Create an effective meter rollout strategy

The success of AMI hinges on an efficient meter rollout strategy. It should cover aspects like rollout inclusions/exclusions, meter types, meter models, customer class, and optimizing the grouping of rollout areas using a combination of districts, routes, and billing cycles, etc.

Ensure a full/first-time data synchronization

All of the customer and meter data must be synchronized with the MDM system. This is key for an AMI program implementation. It must factor all customers, meters, and ongoing business activities (like inflight move-ins, move-outs, tariff changes, meter exchanges, bill corrections, etc.) in transition state.

Proactively prepare for unbilled revenue

The utility billing system incurs several changes during an AMI implementation. Utilities must factor in unbilled revenue situations that arise due to various billing activities like bill through meter change, short bills till meter change, net metering, time-of-use and data-related challenges like meter data mismatch, missing customer information, tariff mismatch, non-communicating meters, etc.

Monitor meters to avoid 'missing read' scenarios

With AMI implementation, utilities collect meter data over-the-air, creating avenues for 'missing read' situations. These situations can lead to several downstream issues such as high meter data estimation using VEE, meter reading gaps, and MDM exceptions that create unplanned workloads for AMI operations. Thus, utilities must monitor and address non-communicating meters, loss of meter data over the air, intermittent AMI network connection glitches, etc.

Establish a smart meter operation center (SMOC)

SMOC plays a key role in efficient AMI operations. It acts as the central nerve system in the organization's AMI landscape by managing and optimizing AMI networks, data operations, analytics, etc. It converts numerous discrete systems into coherent data networks, thereby increasing efficiency, saving money, and enhancing sustainable initiatives.

Conclusion

As utilities transition to AMI 2.0, it is important to consider the changing role of systems integrators. When implementing AMI 2.0, systems integrators need to differentiate themselves by providing next-gen capabilities that unlock further value from AMI 2.0. They should widen their horizons and aim to enable data insights, distributed intelligence, data security, edge computing, advanced integration, and strong partnerships for cybersecurity. Moreover, their scope of work will increasingly include choosing the right integration type, integration model, and end-to-end testing. Such differentiation will support successful AMI implementations delivering long-term value to utilities and help them attain strategic business goals.

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