White Paper
Advanced Metering Management system architecture

Landis+Gyr
manage energy better

Ensuring long-term AMM success with the right system architecture

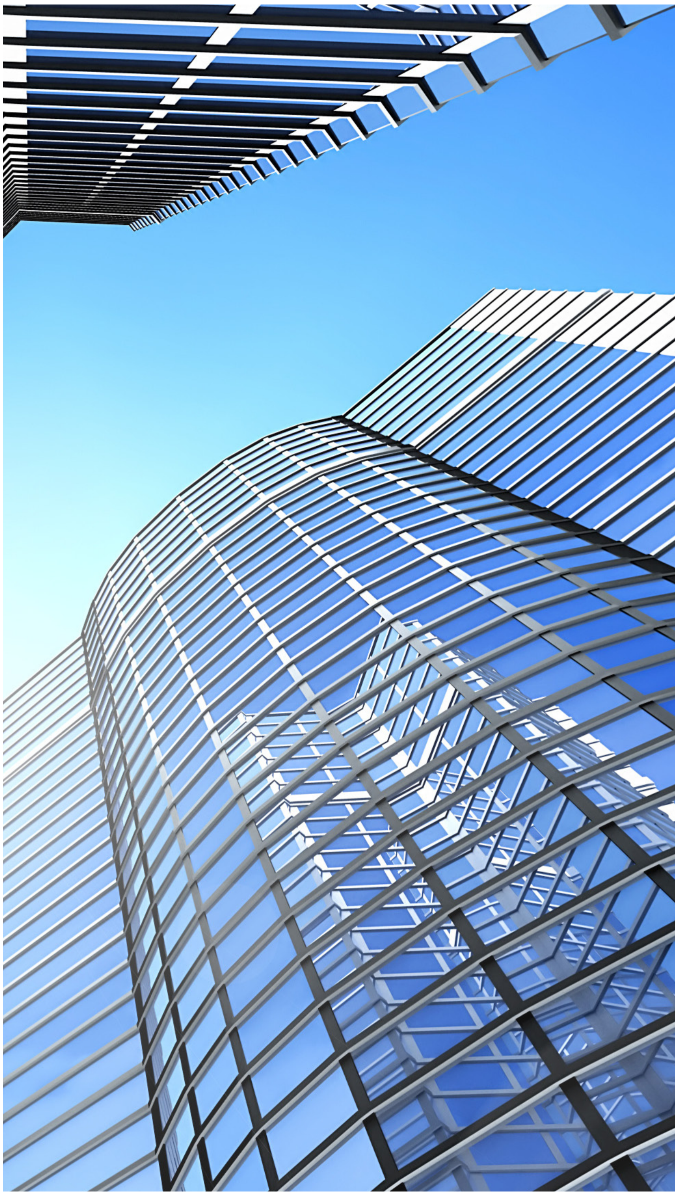
Table of Contents

Introduction

As smart metering grows in importance across the world's energy markets, one highly significant topic is the architecture design of Advanced Metering Management (AMM) systems, or smart metering systems as they are also called. In this document these terms are used in parallel. A Residential Advanced Metering Management system needs to gather data from hundreds of thousands, or millions of meters and send it all to a server within a very short space of time, compiled and verified for invoicing and other business requirements. Clearly this presents challenges to a system's architecture.

When a utility purchases a smart metering system, they are making a decision that will influence their business for up to twenty years to come. It is of vital importance that utilities consider future demands to avoid pitfalls. Therefore, the main question utilities should ask a solution vendor is:

"How can you ensure that I, as a power company, now and in the future, will always have all the relevant data that I need, timely available, in order to run my business effectively?"



Market drivers behind AMM growth

Smart metering offers many benefits. It enables utilities to make savings financially, operationally, and through increased energy efficiency. The benefits include financial savings from technicians not having to physically read meters, or connect and disconnect them. Invoicing is based on actual rather than estimated usage thereby increasing financial efficiency and cash flow accuracy. Better grid management of the supply and demand of electricity flow greatly reduces outages. Overall, the increase in measuring frequency serves the whole energy market in several ways. The benefits of consumer-based peak savings are fairly distributed; it is easier to divide consumers into smaller segments to manage them more effectively, also developing new, more targeted energy products.

Furthermore, AMM introduces environmental benefits. Studies show that using Personal Energy Management products such as in-home displays decreases peak power usage and overall energy consumption. This means reduced CO_2 emissions.

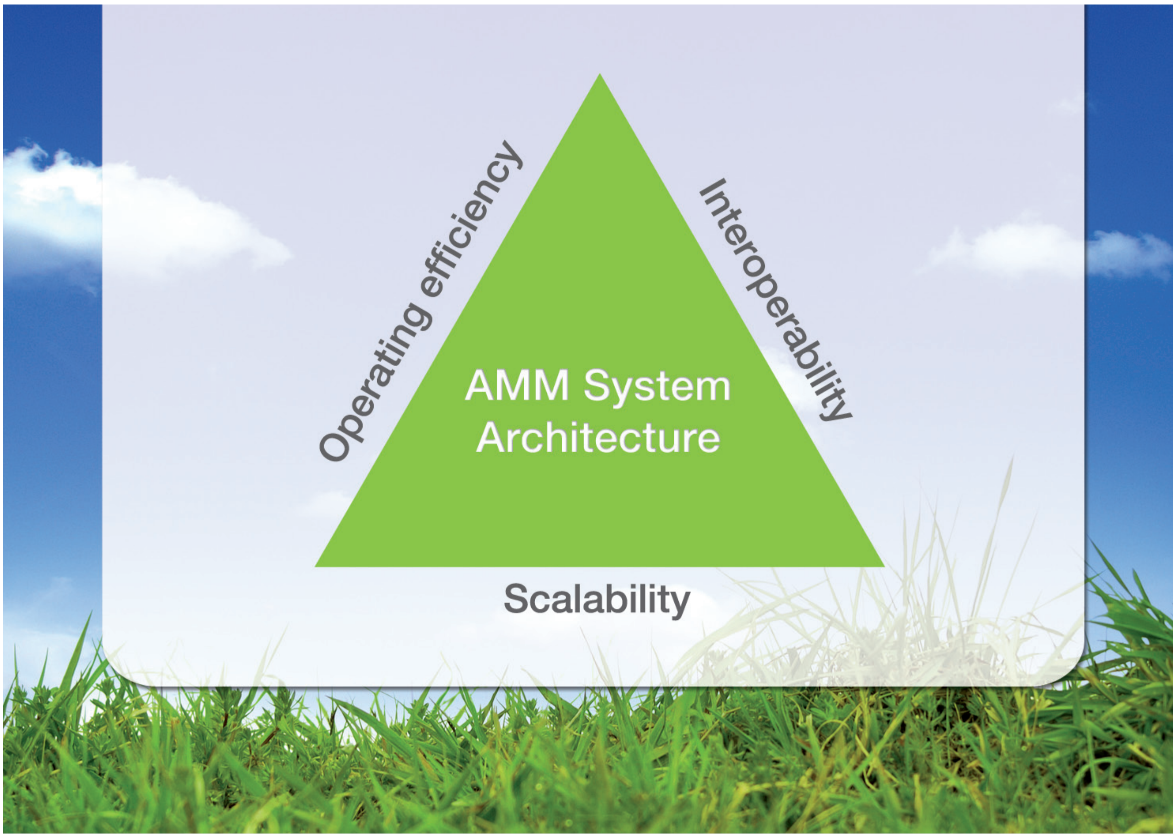
With advances in technology, utilities see and understand the promise of AMM. It enables them to read their meters whenever required, use this information to route power to where it is needed most and reduce usage of peak-power which is greater than the cost of off-peak electricity and produced with greater CO_2 emissions.

Legislation and regulations in countries across Europe are also acting as a driving force behind AMM growth. In Scandinavia, governments already have legislation in place requiring hourly data in meter reading and consumption based billing. Further, worldwide, energy efficiency demands are setting requirements for the efficient use of energy at every level.

AMM system architecture

AMM system architecture can be understood as the way the AMM system is designed and put together in order to gather, process, control and provide metering data for business processes.

System architecture and its features can be viewed from three different perspectives: scalability, interoperability and operating efficiency.



Scalability in system architecture

Long-term planning is characteristic to the energy industry and to utilities. A smart metering system needs to meet a utility's current capacity demands, which comprises the current quantity of meters, the information gathered from these meters and the frequency of meter readings. It is likely that a utility will increase the amount of metering points in its AMM system, or consequently the amount of information acquired from the meters can be increased. The system should eventually be able to cover all of a utility's meters and the data they gather in order to bring economies-of-scale and maximise a utility's savings potential.

A prerequisite for AMM system architecture is scalability. This enables a system to adapt to the long-term planning approach that utilities take. A lack of scalability can lead to constant upgrades and modifications of the utility's system, communications, meters, or a combination of all three.

Challenges of data explosion

As utilities install smart metering systems and demand more functionality, the amount of transmitted data grows exponentially. In the past, a single value from a meter was gathered once a year. When meters are converted to smart meters, however, real-time information can be gathered from the meters faster than ever before.

When the frequency of meter reading increases from yearly to monthly, it results in a twelve fold increase in the data communicated. A further increase of meter readings to every fifteen minutes causes an explosion of data. If a single value is measured from a meter every fifteen minutes, it produces 35,040 pieces of data per year.

Different types of data such as active and reactive energy, Power Quality Information (PQI), different events and multi-energy data can be measured. Measuring four different types of data at 15-minute intervals will multiply the amount of metering data to 140,160 pieces per meter in a year. The scalable structure of an AMM system discussed later in the document addresses the challenges arising from the growth of metering data.

Bottle necks through communication

Data is communicated from the meters to the AMM system using a variety of wired or wireless methods such as Power Line Carrier (PLC), GPRS, Ethernet or radio-mesh network. The data is gathered by data concentrators or directly from point-to-point as in the case of GPRS. It is then delivered to communication servers where it is compiled and sorted, passing it onto various AMM system levels.

Gathering all of this metering data is a challenge. Any bottlenecks in the data gathering process determine how quickly information flows into the data system. As the system grows in size, the potential for more bottlenecks grows. Distributed data processing and proper data flow management, discussed later in this paper, provide solutions as to how to manage this challenge.

Capacity requirements

An AMM system has different capacity requirements in each phase of its deployment cycle. Capacity requirements are predictable in the case of a normal reading cycle, when the system is already operative. However, during the system life cycle, capacity requirements vary. In the deployment phase, the deployment process and reading cycle are simultaneous processes requiring additional resources and capacity. Other cases such as emergency switching, disaster recovery due to third party complications and system version updates are all situations whereby additional capacity is required in order to catch up with the normal reading cycle.

Distributed data processing enables scalability

As discussed earlier, the amount of metering data presents various challenges to AMM system architecture.

Scalability in system architecture

At the same time, AMM system architecture largely defines how the different challenges of growing volumes of metering data can be addressed. The ways of addressing these issues include increasing the performance capacity of a single system block or, alternatively, dividing metering functions into several, more manageable, parallel blocks.

Different scalability options
If an AMM system is monolithic by design, it is not possible to increase system performance by dividing it into independent parallel data collection units. This means that performance can be increased only vertically, by assigning more central processing unit CPU power to a single data collection unit.

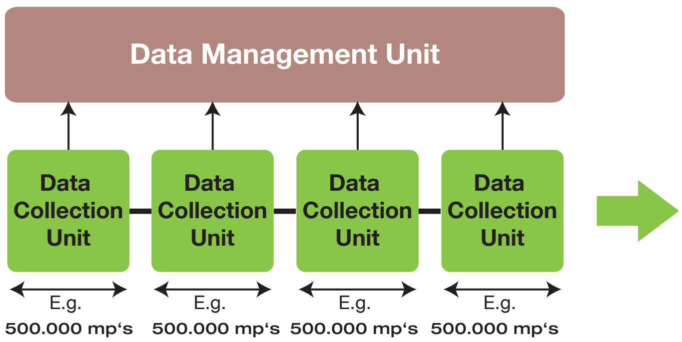
Another alternative in the vertical approach is to increase operating efficiency through third party platforms and technologies such as clustering or virtualisation. Clustering means the addition of servers within a data management unit or within a single data collection unit. This way, it is possible to grow capacity over the original maximum capacity of the system level in question. With virtualization, it is possible to allocate the central processing units of the system platform, against the capacity needs of different parts of the AMM system.

When system architecture supports the division of data collection units into multiple, parallel operating blocks, it is possible to increase performance levels by scaling the system on a horizontal level.

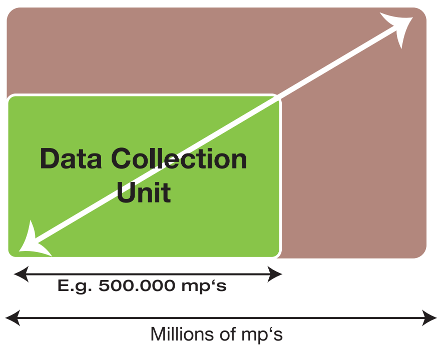
Possibilities of horizontal scalability
Horizontal scalability enables the separation of deployment data collection units from operational data collection units, or the assignment of regional data collection units for different geographical areas. It is also possible to dedicate different data collection units for different purposes. An example could be a multi-energy utility allocating separate data collection units for gas and electricity meters. Furthermore, different data collection units could use different communication technologies, such as PLC or GPRS. Horizontal scalability can also be implemented at the communication server level. By adding more communication servers under one or more data collection units, it is possible to eliminate bottlenecks between a communication network and system when transferring data onwards from the meters.

Horizontal scalability and cost efficiency
The licensing policies of platform software such as databases can lead to significant differences in cost between vertical and horizontal approaches. Implementing horizontal scalability and adding several data collection units to the system is one of the most cost efficient ways of achieving system scalability or even a planned upgrade. It also helps to eliminate the risk of a single point of failure, so that a possible performance failure of one data collection server will not affect the performance of other servers, and possible negative consequences are limited.

Example of horizontal scalability



Example of vertical scalability



Interoperability in the system architecture

Interoperability is the prerequisite for flexible system architecture.

Cooperation within the industry is rapidly growing between different industry parties and the demand for interoperability at all the levels of AMM architecture is on the increase as a result. Organisations such as The International Electrotechnical Commission (IEC) and DLMS User Association are creating new standards to further enable system interoperability. IEC is the international standards and conformity assessment body for all fields of electro technology. The DLMS User Association is a non-profit organisation with a purpose to develop and maintain the DLMS/COSEM specification. It provides an information exchange forum for users, manufacturers and system providers, test houses and standardisation bodies. It also provides a conformance testing and certification scheme for a utility's metering equipment which implements the specification. The DLMS UA is normally liaised with IEC TC 13 WG 14.

The European Smart Metering Industry Group (ESMIG) has the objective to create and implement consistent standards for metering and communications. So, research and investment in the area are growing. Yet, there are challenges to interoperability as there are several proprietary systems in the market, each carrying limitations regarding the ability to communicate with other residential meters or IT systems.
Interoperability can be viewed from two different perspectives: industry standards are crucial in creating interoperability but the system provider should be able to facilitate interoperability when standards are not available.

Interoperability through standard protocols

Industry standards are created in order to give utilities more freedom when implementing smart metering. Working with open standards provides simplicity and opportunity both for the manufacturer and the utility. For a utility, open standards provide the most benefits: they ensure a platform for interoperability and freedom of choice, and they also secure investments in large scale solutions as more than one manufacturer can be used. Furthermore, they enable communication and cooperation between utilities, manufacturers and governments.

If an AMM system can communicate through an agreed protocol with meters from several manufacturer, this means a utility is not locked into purchasing meters from only one given supplier. IP based communication networks, industry standards such as DLMS, and communication technologies used by several manufacturers such as PLAN, all contribute to progress in this area.

The challenge of IT systems

One of the most challenging areas in the AMM system installation process is the integration of the system with the existing IT systems of a given utility. As there are different types of metering data available, it is important that different functions within the utility are able to utilise the versatile information. Delivering only the data for a utility's billing purposes does not exploit the full potential of an AMM system. The main task of integration is to ensure that the metering data is regularly available for all of a utility's processes.
A utility often has several IT systems such as a Customer Information System, Billing System and Network Information Service system. The two-way integration should be able to serve many external systems at one customer's premises. Further, the data gathering mechanism should have the ability to connect to the utility's information systems through one connection, in order to avoid having a long and involved integration process. XML and web service technologies have established the first market accepted foundations for future integration standards like IEC 61968.

Interoperability in the system architecture

Enabling interoperability without standards

Development and implementation of standards is crucial within the industry. Standards facilitate interoperability. Today, it is still possible that industry standards are not implemented to cover all systems, or standardisation processes are lagging behind the rapid development of the industry.

This means that the solution provider needs to be able to provide interoperability to its customers without the support of standards. The customer should be able to tap into AMM benefits as early as possible. This means that the supplier should be proactive and on top of the most recent industry developments. The supplier should also have the skills and solid system architecture to support the proprietary and market-de-facto systems when straightforward integration supported by industry standards is not an option.

The benefits of service-oriented AMM system architecture

Solid, service-oriented AMM system architecture is crucial in the absence of standards. Service oriented Architecture (SOA) builds the foundation for modern system integrations and isolation. It gives the opportunity to gather and standardise heterogeneous functionalities – even from different legacy systems.

Services relating to different legacy systems can be encapsulated in order to keep them isolated from other services. This means that the integration interface can contain several SOA services – and they remain unchanged despite technological changes in the background. It provides the opportunity to introduce new technologies without disturbing the current SOA services architecture. When the services are properly granulated it is possible to create new services or different types of services across various customer installations – if just by combining smaller services in different ways.

Interoperability in the system architecture

Isolation for interoperability
Isolation is a system architecture feature that supports interoperability. When an AMM system is integrated into a utility's operational system there is a need for an adapter between the system provider's internal format and a utility's external format. The adapter, enabling the connection between the systems, should be isolated in a separate layer. This means that integration can be carried out by changing as few AMM system components as possible, thereby making the integration simpler.

Towards deeper system integration

Traditionally, integration between the systems has consisted of billing data being transferred between the AMM system and a utility's system in a flat file. This has been adequate for utilities in the past, but today both the amount of data and functionalities has grown. Examples of these include new metering data, consumer load management functions, changes in the billing cycle and in tariff setting.

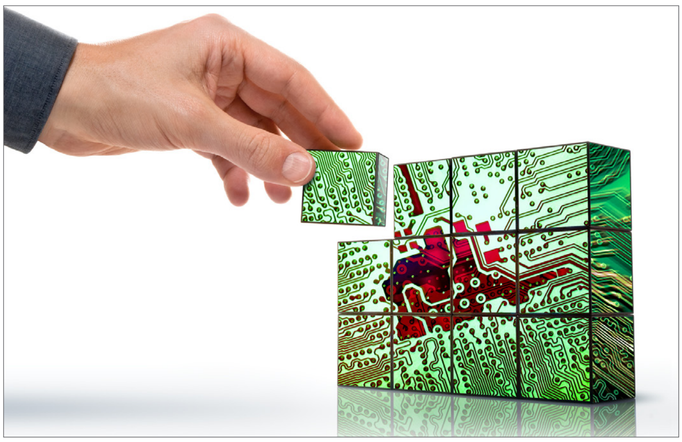
In addition to integrating the AMM system to the utility's system for information sharing, AMM system architecture should allow a deeper level of integration and interoperability between the systems. By combining the AMM system sub-services, it is possible to build customized business processes based on customer specific needs. Service-oriented architecture and the possibility to encapsulate different services further enable a deeper level integration.

System Upgrades

System upgrades plays an important role in system interoperability. By upgrading an already up and running AMM system it is possible to increase interoperability, as well as exploit the benefits offered by new technological advancements or new functionalities.

When responding to opportunities thrown up by new technological advancements, it is possible to upgrade the system within the limits of its existing hardware.

With remote upgrade it is possible to create support for new functionalities at the firm ware level. For example, it could be possible to create system support for third party meters of similar technology. This can be done either by having differences in communication protocols, or by increasing the speed of the data reading cycle.



AMM operating efficiency

Deployment of a large-scale, residential AMM system is a significant investment on the part of a utility and it requires thorough planning.

The deployment process also requires extensive human resources. The speed of deployment is crucial as the utility needs to be able to get a re¬turn on investment as soon as possible. The de¬ployment process does not have room for errors as they cost time and money both to the system supplier and to the utility. AMM system architecture should be able to meet the specific demands of different deployment stages in order to optimise efficiency.

AMM system operating efficiency is understood as how efficient an AMM system is for different usages and user groups in different system deployment and operational phases. Operating efficiency is crucial to the utility as it can significantly save a utility's resources and increase overall productivity.

Operating efficiency in deployment phase

The deployment of large scale residential systems requires a vast amount of resources. As the installation speed can reach several thousand meters in a day, it is crucial that the deployment is carried out efficiently and minimizes risk. Efficiency is required from the AMM system in the operation and physical installation process. The installation of meters is one of the biggest expenditure items in the deployment of an AMM solution. AMM system should be able to support the process to assure a swift deployment and integration to the system as well as full visibility and control over the process. Efficient system architecture enables the use of automated information management that enables a sufficient deployment speed and minimizes human error. The large scale deployment process can be utilised by supplementing consumer specific information. A well designed AMM system enables the integration of information to all relevant utility systems. Furthermore, an automated deployment process allows for deployment follow-up as well as monitoring for effective reporting, control and deviation management.

An AMM system needs to be able to simultaneously handle the ongoing deployment process and the reading of existing meters as they are joined to the AMM system. In order to be efficient, system architecture should be designed in a way that it is able to perform both deployment and operational tasks during the day. For example, data acquisition and unification, and data delivery are performed within the first six hours of the day. During the next twelve hours, customer service and operation tasks are performed and the remaining six hours could be reserved for maintenance tasks.

A system should have sufficient resources to perform both tasks and architecture should allow the grad¬ual increase of resources as deployment proceeds. This enables a utility to optimise its financial resources. For the same reason, system architecture should allow the decrease of system resources once deployment is finalised.

The operating efficiency requirements both in the system operating level and in the installation level will be further influenced in the case of multi-energy solution deployment. Single multi-energy compatible system and field tool for onsite installation, data collection and verification will increase the operating efficiency on the installation stage. Single process for introducing all installed devices to system and verifying complete functionality will rationalize the process in the system level.

Daily operating efficiency

The deployment process of a large-scale AMM system with field devices can take years. Therefore, effi¬cient operation of a system should be possible from the first day of deployment. Information should be available to the customer even when all integrations are not yet implemented and enhancement in all related systems are not yet done. Different AMM system add-on applications help facilitate this information transfer and enable a utility to exploit system benefits from the very beginning of the deployment process. Proper

AMM operating efficiency

AMM system should offer the opportunity to manage the field infrastructure and remotely carry out relevant maintenance operations such as reconfiguration and downloading of new firmware.

Investing in an agile system

Investing in a smart metering system is a significant financial commitment for the utility. Opting for a new AMM system can also require a utility to renew its other systems, such as its customer service system. How¬ever, if the AMM supplier is able to offer an agile system and system applications, the utility does not need to enlarge or renew its current systems in order to manage the new versatile information created by modern AMM systems. Data for customer service processes, network management and Power Quality Information are available to the utility without it needing to invest in its existing systems. Agile applications give time for well-thought-out development decisions and help to save a utility's resources.

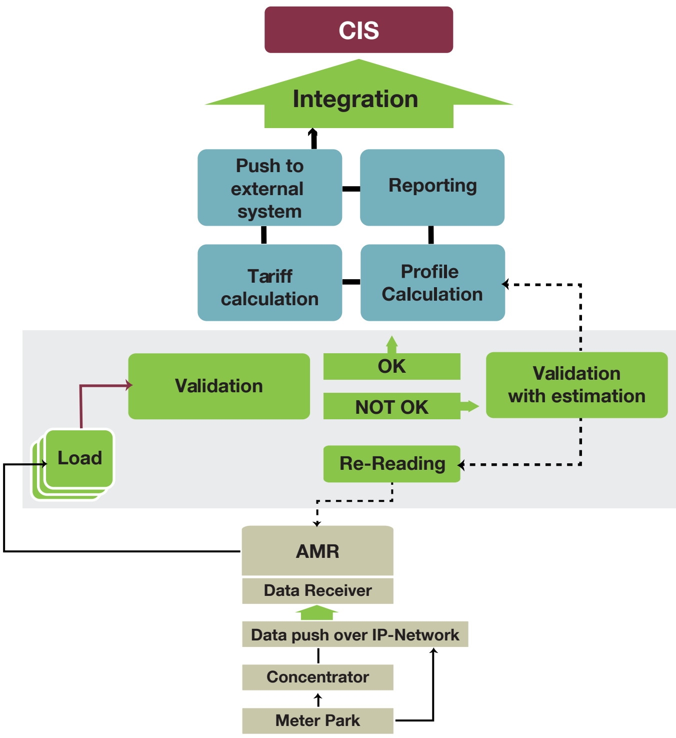
Various applications enable system efficiency

Different system applications enable the efficient use of an AMM system once deployment is finalised. System monitoring, analysis operations, data validation and processing, delivery of consolidated billing data and easy access to AMM-system metering and device data are all functions which enable the utility to streamline their processes. These functions provide various information to different user groups within the utility such as customer service and network management personnel, or man-agement. They also provide user-friendly interfaces to the system, which reduces the need for the utility to carry out complex training of the whole AMM sys¬tem. Furthermore, applications provide simple views that can be customized for different user groups or for individual needs. All this leads to the more efficient use of the AMM system, thereby enabling the utility to save resources and re-allocate them towards more productive activities.

Data flow management

As described on page six, the amount of data grows exponentially when AMM systems are implemented. Manual handling of data is no longer possible and, as a result, the system needs to continuously process the incoming data in a concise way. The system architecture needs to be able to support the constant data flow so that it fluently runs from the meters to the customer's information system. Also, the utility needs to be able to define the chain of actions taking place in the data flow. Different functions must trigger new functions automatically as the data runs along in the system. For example, if a metering value does not pass validation, it needs to be automatically directed to second validation or to rereading processes without interventions from the system user. Data flow is described in more detail in below figure.

Data Flow Management



AMM operating efficiency

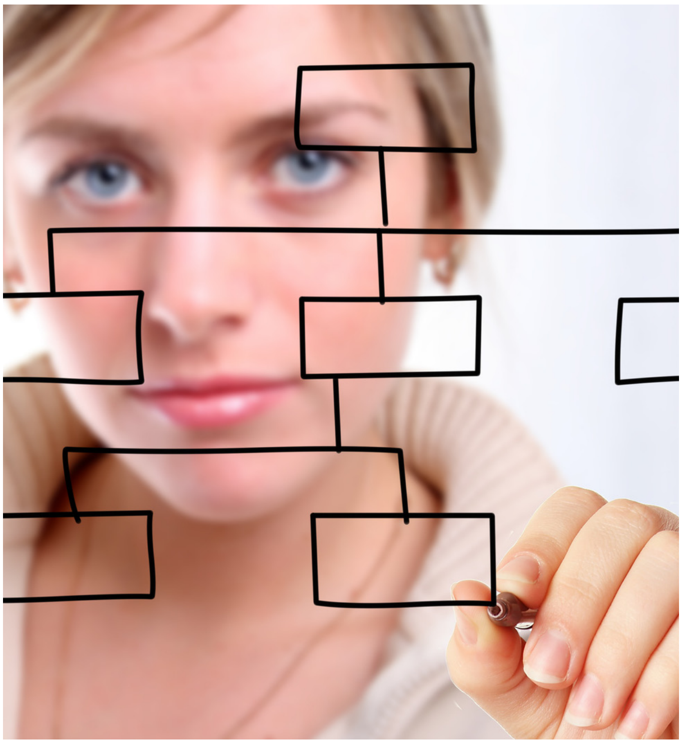
Data archiving
The consumption data gathered from the meters needs to be stored in the AMM system for a given period of time. This time is often set by law and can be up to ten years. In the system architecture it is possible to archive the data and put it into use as and when the need arises. The current trend in archiving metering data is to keep the data active during its lifecycle in order to easily use it in current and future business processes. This has been made possible thanks to modern database platforms with data partitioning capabilities. These platforms are capable of managing higher active data volumes without negative impact on performance.

System maintenance
AMM system architecture should include different daily maintenance functions. These functions include database maintenance, a system back-up function, and data clean-up. These should be freely configured so that they can take place during time windows which are not used for other operations.

Data security
An important part of daily AMM operations is securing gathered data. Both the system supplier and the utility play an important role in securing data. AMM architecture should take into consideration the following areas of data security: physical and environmental security, communication and control of operations and access control. System user roles need to be properly designed and connected to authorisation on the data level. This, in combination with the possibility to use modern authentication methods, provides the foundation to achieve versatile data security.

Increased efficiency trough partnering

As utilities' smart metering projects are becoming more complex, energy management companies are increasingly turning to partnership agreements with single main contractors. Use of one contractor will simplify the whole process from tendering to deployment process and also appoint one liable party. Main contractors are expected to gather all the necessary competence and knowledge to meet utilities' requirements throughout the metering value chain. In the most advanced level partnering can even lead to system operation after the deployment is finalised.



Investing in a best- in-class AMM system

Today, pressure for energy efficiency is greater than ever. Legislation and regulations are driving utilities everywhere to choose smart metering systems. When choosing an AMM system, a utility should evaluate system architecture from different perspectives as various challenges exist in terms of capacity, scalability, interoperability and operating efficiency. An AMM system should meet a utility's current and future capacity demands, be easily scalable, work together with third party meters and systems, and support the latest protocols and technologies. It should also meet efficiency requirements when it comes to deployment and usage of the system.

As a world leader in energy management solutions, Landis+Gyr has developed smart metering systems for more than a quarter of a century. It has gained solid experience by selling and delivering hundreds of AMM systems. Landis+Gyr built its solutions on openness and flexibility. Its AMM solution is based on standards that enable interoperability, providing seamless integration and flexibility also for future growth needs. Landis+Gyr
invests both time and money for continuous research and development work in order to further develop its systems. By working together with organisations such as IEC and DLMS User Association, the company stays on the frontier of the latest technological development and contributes to the development of whole energy industry.

Landis+Gyr operates in 30 countries across five continents. It ranks as the worldwide leader in electricity metering with a preeminent position in Advanced Metering Management. Its meters and solutions empower utilities and end-customers to improve their energy efficiency, reduce their energy costs and contribute to a sustainable use of resources. With a proven track record for more than a century, it's Landis+Gyr's primary goal to help utilities.
manage energy better.

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