SiMBA

White Paper

System for intelligent Metering, Billing and Analytics

01 HEAD END SYSTEMS

HES (Head End System) plays the main role in Advanced Metering Infrastructure (AMI) systems as the central control and monitoring hub. It is responsible for collecting, processing, and analyzing data obtained from smart meters and other AMI devices. HES facilitates communication between network devices and the central control system, as well as provides functionality for energy consumption monitoring, load management, and distribution network efficiency.

02 WHAT ARE HES AND MDM

HES (Head-End System) and MDM (Meter Data Management) are core components of modern energy infrastructures, responsible for meter control and measuring data processing.

HES and MDM play important roles within AMI systems (Advanced Metering Infrastructure):

1. HES (Head End System) is the central control system that is responsible for collecting, processing, and managing data obtained from smart meters and other devices within the network. HES establishes communication with smart meters through various communication protocols and collects data on consumption of energy, water, gas, and other resources. It may also provide features for remote meter control, network monitoring, load control, and other analytical capabilities. HES is a key component of the AMI system and plays a crucial role in data processing and management of consumption data.

2. MDM (Meter Data Management) is a data management system that receives data collected by HES and performs processing, storage, analysis, and report generation. MDM provides centralized storage and management of consumption data from smart meters and other devices. It provides functionality for tariff calculation, time-of-use (TOU) consumption analysis, energy efficiency assessment, and other advanced analytical processes. MDM ensures accuracy, integrity, and availability of consumption data, which is important for service providers and end users.

Therefore, HES and MDM are two primary components of the AMI system responsible for data collection, management, and analysis of resources consumption. HES handles data collection and processing, while MDM ensures data storage and management, providing analytical capabilities for optimizing the consumption of energy and other resources, and informed decision-making.

03 TRADITIONAL HES VS UNIVERSAL HES

The difference between traditional and universal HES lies in their functionality and ability to interact with different types of meters and devices.

Traditional HES is typically designed and configured to work with a specific type of meters or a particular equipment manufacturer. It has a rigid structure and interaction protocols set for those specific meters.

On the other hand, universal HES is designed to work with various types of meters and devices regardless of their manufacturer. It has a flexible architecture and supports different communication protocols.

In other words, universal HES is an enhanced version of a traditional HES, offering additional benefits and functionality. Here are some key advantages of Universal HES compared to traditional HES:

1. **Universatility:** Universal HES provides support and compatibility with different types of smart meters and communication protocols. It can work with a wide range of devices, making it a more flexible and scalable solution.

2. **Integration:** Universal HES allows integration of data from different systems and sources, including meters of electricity, gas, water, and other utilities. This provides a more comprehensive view of resource consumption and enhances resource management efficiency.

3. **Advanced data analysis capabilities:** Universal HES offers advanced data analysis algorithms, enabling deeper and more accurate energy consumption analysis. This can serve as a useful tool for identification of trends, anomalies, and resource optimization.

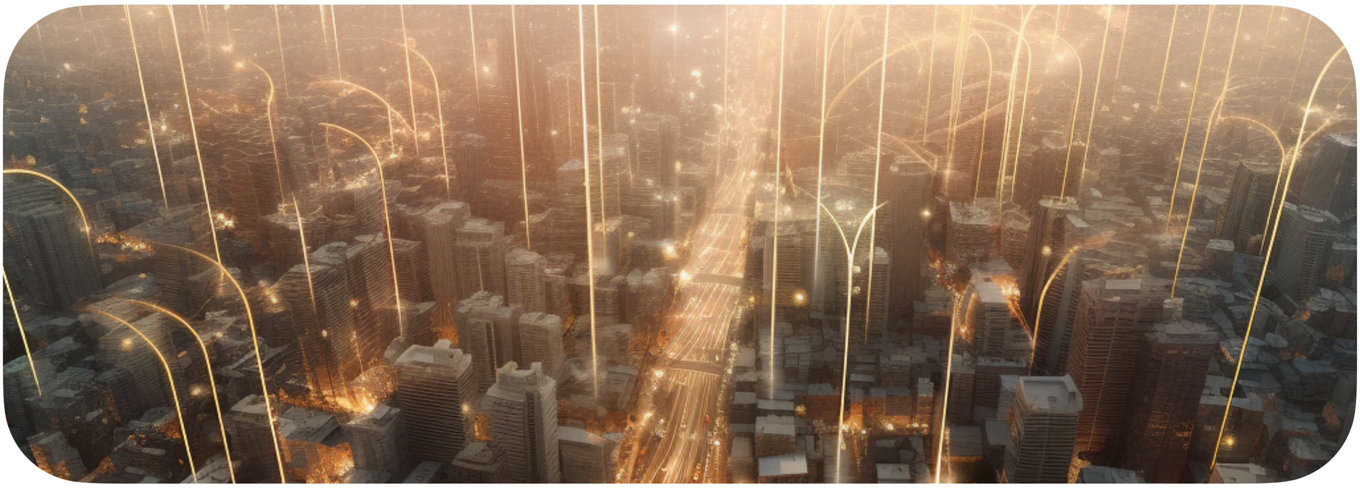
4. **Hybrid communication model:** Universal HES supports various communication technologies, including wired and wireless protocols, giving the opportunity to choose the optimal communication method depending on the requirements and characteristics of a specific infrastructure.

5. **Enhanced security:** Universal HES provides additional security mechanisms and data protection, including encryption and authentication. This is important for ensuring data confidentiality and integrity within the AMI system.

We can conclude, that universal HES offers greater flexibility, scalability, and compatibility with different types of devices, making it a preferred solution for companies dealing with diversified range of water, gas, heat, and electricity meters. These additional capabilities make universal HES a more powerful and flexible solution for managing smart meters and resources.

04 HES FOR ENERGY SUPPLIERS

HES is an integral part of modern energy network management and monitoring systems.



It plays a significant role for water, gas, heat, and electricity suppliers in the following aspects:

1. **Management and Monitoring:** Using HES, suppliers can effectively manage and monitor water, gas, heat, and electricity supply networks. This gives them the possibility of centralized management, control, and observation of processes, indicators, and system parameters.
2. **Data Collection and Analysis:** HES collects data from smart meters and other devices in real-time. It processes and analyzes the data, providing valuable information to suppliers regarding resource consumption, energy efficiency, and other parameters.
3. **Automation and Optimization:** Using HES allows the automation of various processes such as meter reading, billing, load management, and more. This increases operational efficiency and accuracy while optimizing resource consumption.

4. **Customer Data Management:** HES keeps information about customers, their meter readings, tariffs, consumption history, and other relevant data. This help suppliers to efficiently manage the customer database, provide personalized services, and improve customer service.

5. **Fault Detection and Remediation:** HES has the ability to detect anomalies, leaks, overloads, and other issues in water, gas, heat, and electricity supply networks. This allows for prompt response and troubleshooting, minimizing losses and ensuring system reliability.

HES is a key component for water, gas, heat, and electricity suppliers, providing efficient management, monitoring, data collection and analysis, process automation, customer data management, as well as fault detection and remediation. HES helps improve operational efficiency, optimize resource consumption, enhance customer service, and ensure the reliability and safety of the services provided. Thanks to HES, water, gas, heat, and electricity suppliers can effectively manage their networks and achieve optimal results in their operational activity.

05 HES ARCHITECTURE

The architecture of the Head End System (HES) means the organization and structure of the system that allows to perform its functions of data collection, monitoring, and management of water, gas, heat and electricity supply networks.

1. The primary components of HES are energy and other utilities meters, installed at consumption points, along with communication devices. Meters collect data on consumption, while communication devices send this data to HES.

2. HES requires a reliable communication infrastructure for data transmission from meters to the HES system. This can be achieved via the power lines and/or communication networks such as Ethernet, Wi-Fi, LoRa, GSM, GPRS, 3G, 4G, or other specialized communication networks that enable real-time data transmission.

3. The central HES server is the main component of the system. It receives data from meters via communication devices and performs data processing, analysis, storage, and network management. The central HES server typically has powerful computing resources and database for efficient management of large volumes of data.

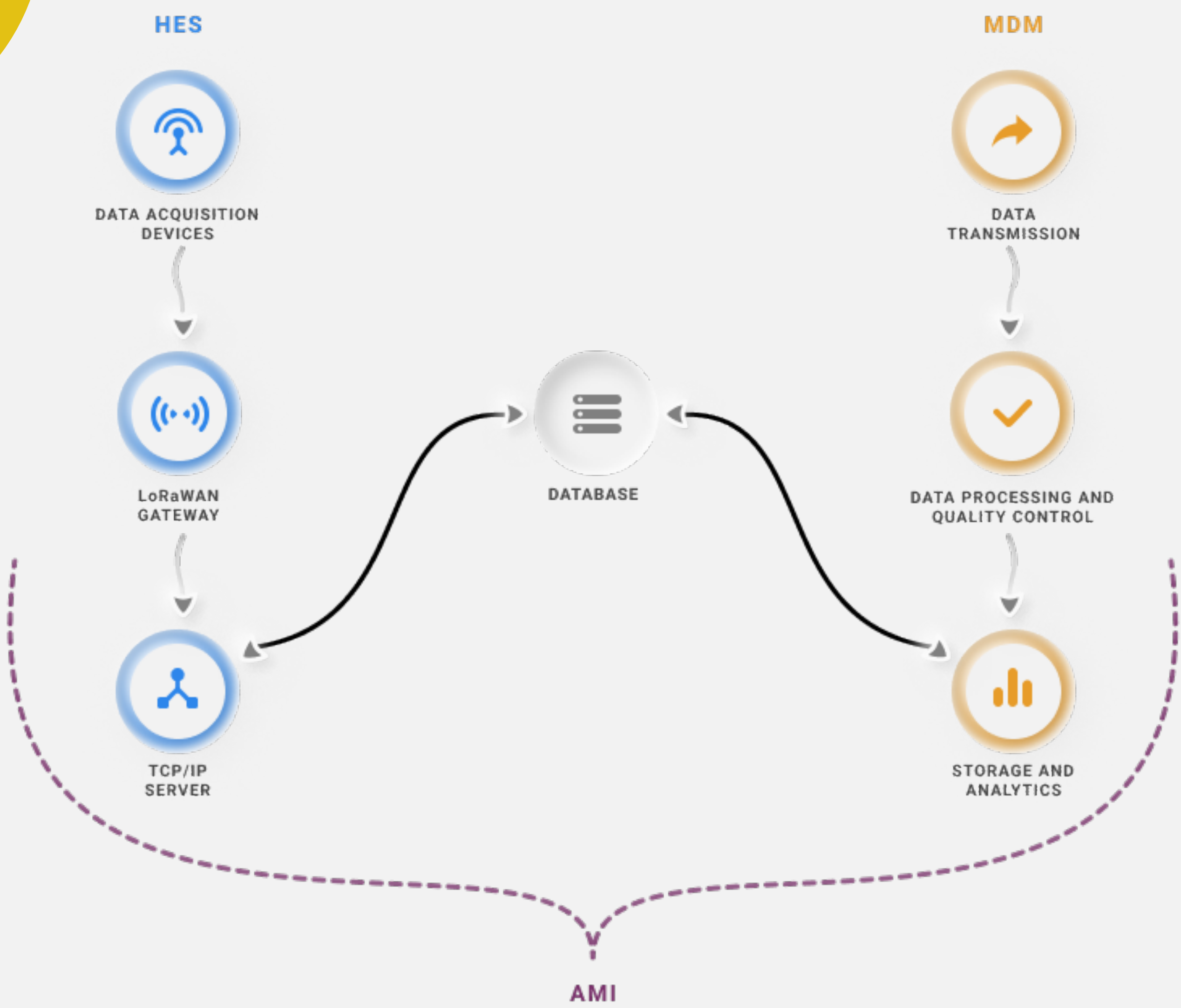
4. HES supports various communication protocols for interaction with meters and communication devices. These protocols ensure standardized communication between HES and different devices.

5. HES contains a database that stores data on energy and resource consumption, meter information, network status, and other relevant data. The database allows for storage and organization of data for subsequent analysis, reporting, and decision-making.

6. HES provides a user interface through which distribution network operators can interact with the system. This can be a web interface, mobile application, or specialized software through which users can view data, configure the system, manage loads, as well as perform other operations.

The architecture of HES is designed based on the particular requirements and needs of a specific energy company. It facilitates data collection, processing, storage, and management of the distribution network, enabling efficient energy consumption management, network reliability, and optimization of energy resources.

06 HES+MDM INTEGRATED SYSTEMS



Integrated **HES (Head-End System)** and **MDM (Meter Data Management)** systems within an **AMI (Advanced Metering Infrastructure)** environment represent a combined hardware–software solution that ensures centralized data collection, bidirectional communication, validation, storage, and analytical processing of data from smart meters and connected devices. In this architecture, **HES** is responsible for communication management, device control, and protocol handling at the network level, while **MDM** performs data consolidation, quality control, aggregation, and delivery of metering data for billing, balancing, forecasting, and integration with **SCADA**, **OMS**, **DMS**, and corporate IT platforms of utility companies.

HES + MDM systems provide energy and utility operators with a number of key benefits: access to reliable data in near real time, increase in consumption transparency; automation of billing and settlement processes through data validation and cleansing; reduced commercial and technical losses by detecting anomalies and thefts; improved network reliability through remote monitoring, control, and rapid response to incidents; load forecasting and balance optimization; scalability and interoperability with SCADA, DMS, OMS, and ERP systems; and compliance with regulatory and industry requirements related to data quality, cybersecurity, and energy efficiency.

The benefits of such systems for energy and utility providers are more than evident:

1. **Centralized data collection and management**

   Automated, bidirectional data acquisition from meters and connected devices, as well as centralized control of communications, configurations, and updates.

2. **High data quality and reliability**

   Validation, cleansing, editing, and estimation of measurements (VEE processes), which are critical for billing and regulatory reporting.

3. **Billing and settlement automation**

   Ready-to-use aggregated data for billing systems, reduced manual effort, errors, and calculation time.

4. **Reduction of commercial and technical losses**

   Detection of consumption anomalies, tampering and theft, as well as losses analysis within distribution networks.

5. **Improved network reliability and control**

   Rapid detection of events, outages, and restorations, enhancing interaction with OMS, DMS, and SCADA systems.

6. **Support for forecasting and analytics**

   Load profile analysis, demand forecasting, and optimization of network operating modes.

7. **Scalability and interoperability**

   Easy scalability to millions of devices and integration with corporate IT systems (ERP, CRM) and industrial platforms.

8. **Support for regulatory and industry requirements**

   Compliance with requirements related to data accuracy, retention, auditability, cybersecurity, and energy efficiency.

9. **Reduction of operational expenditures (OPEX)**

   Decrease in maintenance visits, manual operations, and data processing time through automation and remote management.

10. **Basis for digital services and Smart Grid**

    Creates a platform for dynamic tariffs, demand response, integration of renewable energy sources, energy storage systems, and the development of Smart City solutions.

The deployment of integrated **HES + MDM** systems is a strategic step for energy companies, as it provides a robust digital foundation for AMI, reduces losses and operational costs, improves data quality, and enhances readiness for Smart Grid development, new market models, and evolving regulatory requirements.

What is HES SiMBA

SiMBA - **S**ystem for **i**ntelligent **M**etering, **B**illing and **A**nalytics - is a system software platform designed for data collection from smart meters, data processing, visualization, storage, as well as consumer billing, big data analytics and forecasting.

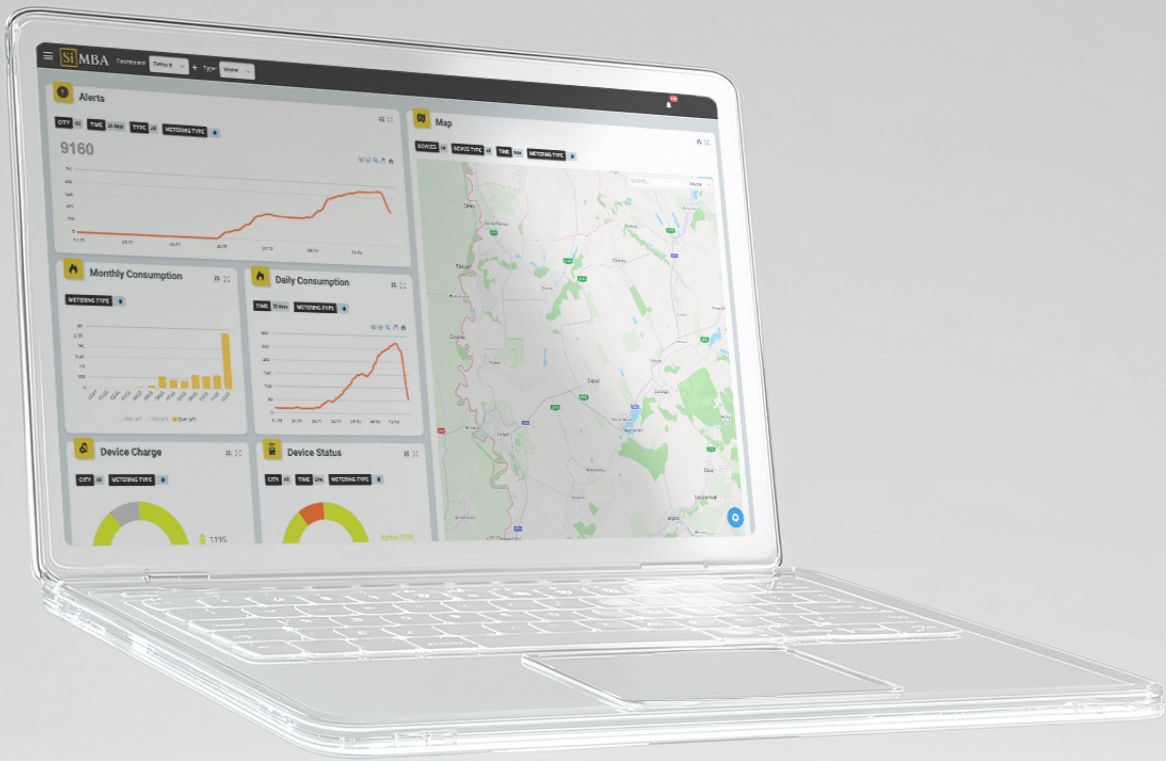
Simba was originally designed and deployed as a universal HES platform; however, at the current stage it developed into an integrated HES and MDM system.

Key components

SiMBA is a modular system, designed on a Docker-based microservices framework, and consisting of the following components:

- **S** - System module: It is the core of the entire SiMBA system, ensuring its operation and interaction with other components;
- **iM** - intelligent Metering module: Responsible for data acquisition from smart meters, processing, visualization, storage, as well as data import/export;
- **B** - Billing module: Automates record-keeping of services provided to consumers, including tariff calculation, invoice generation and payment control through integration with payment systems and electronic accounting systems;
- **A** - Analytics module: Includes methods, tools, and applications for processing large volumes of different types of data and extracting valuable information for accurate assessment and forecasting;
- LoRaWAN Network Server: A communication module that serves as the central component of the LoRaWAN network, processing data and routing them from gateways and other devices to applications, ensuring reliable communication and network management. The server is based on the open-source ChirpStack platform;

- SQL DBMS - Relational Database Management System: Used for storing data in a structured format;
- PostgreSQL is used as the primary database management system (DBMS);
- MongoDB is used for storing internal logs and processing metadata;
- ClickHouse (high-performance column-oriented DBMS) is used for processing fast telemetry data, enabling fast execution of SQL queries on large volumes of structured data;
- Redis (high performance no SQL database) used to enable fast access to frequently requested data across system microservices by caching the data in server RAM.
- UI - User Interface: Provides the possibility to control the system through a web interface and mobile applications;
- System and functional modules are developed using TypeScript (NestJS);
- The UI is created using the open-source ReactJS, TailWind and TypeScript, designed for quick development of adaptive interfaces and web applications for desktop and mobile devices;
- Mobile applications are developed for main international mobile platforms, Android and iOS, and can be customized for specific operators.



General capabilities of the HES SiMBA system

HES SiMBA provides automated data collection from smart meters for water, gas, heat, and electricity consumption through the Wireless Universal Multi-mesh (WUM) communication platform. Specifically, the system can:

- enable centralized configuration and reconfiguration of components such as concentrators and gateways;
- allow authorized users to add, remove, manage, configure, and reconfigure gateways and data concentrators directly from the system interface through two-way communication;
- offer possibility to add, replace and archive meters and pulse reading modules (in case of replacement), as well as to modify respective settings;

- provide permanent time synchro between data concentrators, pulse modules, gateways and the central system, ensuring accuracy in reading, processing, and storing primary data;
- set custom schedules and intervals for automatic data readings from concentrators and meters;
- generate various reports based on the data collected from the meters;
- support data exchange with other systems or devices to ensure synchronization and information updates;
- provide security measures to protect against unauthorized access, ensure data integrity and confidentiality of information;
- provide APIs for integration with third-party systems or software, enabling seamless integration of external systems into SiMBA.

Data transmission within the system is achieved using the TCP/IP protocol stack with the possibility to encrypt the transmitted data.

The system provides a personal cabinet for residential and non-residential consumers, giving access to current consumption data, historical consumption data, as well as parameters related to the quality of the energy supplied and produced.

Database and functionality

The HES SiMBA database management system is capable of processing large volumes of data and supports fast and efficient data input, search, and recovery.

The system aggregates the received data, structuring it by region, district, locality, object/building, and even by power substation (for electricity providers).

The HES SiMBA database allows storing detailed information on all system components - data concentrator, gateway, meter, pulse module, consumer, user, as well as the history of changes and operations for each individual component.

The database management system has the following functions:

- Distributed data processing for increased performance and fault tolerance;
- Support for transaction mechanisms that guarantee data integrity in case of failures or errors;
- Wide range of data processing tools, including complex data queries using selection, projection, merge and aggregation operations;
- Ensuring the necessary level of data confidentiality and protection against unauthorized access through access limitation and authorization based on roles and privileges, including authentication and encryption;
- Logging operational information into separate log files with quick access when needed;

- Data archives and backups, data recovery in case of failures;
- Data import and export in various formats such as CSV, JSON, XLSX, XML, TXT, allowing further processing and analysis using other systems or tools;
- Generation of reports using queries, aggregation functions and stored SQL procedures, with the possibility to send them via email in the required format (e.g., PDF, XLSX, CSV, XML).

Integration of HES SiMBA into a specific AMI ecosystem of a specific water, gas, heat, or electricity network operator provides for adaptation and customization of the electronic report generation module based on operator's requirements. This includes:

- automatic generation of specific reports, indicating date, time of generation, and reporting intervals;
- specification of the electronic document format, template, structure, name, and extension;
- determination of the file delivery method (email, Telegram, messenger, FTP, etc.).

Deployment and implementation options

SiMBA can be deployed and used in two models: SaaS and on-premises.

The SaaS (Software as a Service) model represents a cloud-based solution accessed via Internet, where the system is hosted and managed by the service provider for a subscription fee.

In contrast, the on-premises model involves deploying the software on the company's own servers and infrastructure, requiring upfront investments in hardware as well as in-house IT resources for system administration. While this approach provides a higher level of control, it also entails greater initial costs and operational responsibility.

The key differences lie in the deployment model, cost structure (operational expenditures versus capital expenditures), and responsibility for infrastructure management and updates: SaaS solutions are easier to scale, whereas on-premises solutions provide broader customization capabilities.

SaaS (Software as a Service):

- Deployment: Cloud-based, hosted by a third-party provider.
- Access: Available via a web browser or application over the Internet.
- Cost: Subscription-based (operational expenses), with lower upfront costs and predictable monthly or annual payments.
- Management: Software updates, maintenance, and security are handled by the service provider.
- Advantages: Rapid deployment, scalability, reduced IT workload, and high availability.
- Disadvantages: Reduced control over data and infrastructure, as well as potential dependence on Internet connectivity.

On-premises Deployment:

- Deployment: Installed and operated on the company's own servers and infrastructure.
- Access: Local access within the company's environment.
- Cost: High upfront investment (capital expenditures) for licenses, hardware, and system configuration.
- Management: Fully managed by the company's internal IT team.
- Advantages: Full control, extensive customization, potentially higher security for sensitive data.
- Disadvantages: High initial costs, requirement for dedicated IT personnel, slower update cycles, limited scalability.

How to choose

Choose SaaS if:

Lower upfront costs, rapid deployment, automatic updates are required, and operational expenses are preferred over capital expenditures.

Choose on-premises deployment if:

Full control over data and the operating environment is required, strict regulatory compliance or extensive customization is necessary, and sufficient budget is available for significant upfront investments.

To avoid working in multiple systems, the distribution network operators need an HES system capable of providing most of its services through an Application Programming Interface (API). This means that most functions can be performed from a central system, such as Customer Information System (CIS)

HES SiMBA can be successfully integrated into any existing AMI of a distribution network operator by interacting through APIs with other information systems such as CIS, SCADA or other.