Data-Driven Energy: The Advanced Energy Management Solution
Executive Summary

Transmission utilities today are challenged to generate, transmit, and deliver electrical energy in a safe and reliable way while optimizing network operation at the lowest possible cost. The penetration of central and distributed intermittent renewable generation, together with new business players and an increase in consumer expectations, are disrupting the utility energy ecosystem. Billions of data points collected from multiple sources — in the field, from consumers, between utilities — are available for Network-Level Optimization. This is the new world of data-driven energy management — known as “Digital Energy.”

Digital Energy relies on Network Level Optimization to provide ultimate value, by considering all constraints in real time while keeping an eye on the future. The evolving nature of these constraints (technical ratings or probabilistic uncertainties such as a weather forecast for renewable sources or consumer response behavior) cannot be addressed by a conservatism margin on assets or an N-1 contingencies approach alone. What’s needed is advanced reliability and resiliency analysis — evaluated with the support of data science and big data technology — as well as fast automation (such as phasor WAMS technology can now deliver).

All constituents of the energy value chain (generation, transmission, distribution, aggregators, consumers and prosumers) will benefit from the Network Level Optimization approach.

The Advanced Energy Management System (AEMS) empowers Network Level Optimization, integrates phasor measurement data inside the Wide Area Management System (WAMS), masters renewables, and offers real-time, enterprise-wide analytical insights. The AEMS solution delivers network reliability, optimal generation dispatch, operational efficiency, and business opportunities for the forward-thinking utility.

Utilities around the world are on a digital journey. With International Data Corporation (IDC) predicting that 75% of utilities will be using some form of asset performance management (APM) to improve operational performance by 2019, there’s little doubt that future competitive advantage comes from digital technology. On the transmission side of the energy business, we’ve already seen movement to engage power players as digital utilities of the future. Yet, technology has already evolved to position the Advanced Energy Management System (AEMS) as the solution of choice to map and move forward with digital data-driven energy. Transmission players today are more committed than ever to their fundamental missions.

- Generating, transmitting, and delivering electrical energy in a safe, and reliable way.
- Optimizing network operation at the lowest possible cost and maximum flexibility.
- Complying with regulations on security reserve, black out restoration plan, voltage control, and cyber security, as well as new regulations on data privacy and sharing.
- Facing increasing challenges — the main one being to integrate generation intermittency and the impact of distributed energy resources (DERs).

New technologies are available to fulfill these missions and proven to address the challenges. The extraordinary power of phasor measurements and WAMS, alongside the data science analytics capabilities from industrial big data platforms, are now integrated and interoperating with the AEMS.

The Advanced Energy Management System is designed for the digital utility of the future

The EMS Reference for optimal network operations integrating WAMS, renewables and analytics

AEMS represents an innovative breakthrough empowering network-level optimization, integrating WAMS, mastering renewables, and offering real-time, enterprise-wide analytical insights. AEMS is the reference EMS, and offers the network reliability, operational efficiency, and business opportunities now required by utilities.
Utility Digital Evolution

For many utilities, the digital transformation journey is an uphill one. At the entry level, the utility relies on SCADA and EMS data and is reactive and responsive, often waiting for a power loss to analyze stability issues.

Still, the utility looks to venture up to the predictive level where it can extensively model true demand and all types of generation. It can also anticipate the impact of generation intermittency on network stability and capacity, which translates into managing generation flexibility.

Beyond this, the forward-thinking utility can use digital technology to reach the predictive level. Machine learning and artificial intelligence can enable optimization and orchestration to prevent and minimize the extent of outages and recommend optimal generation mix, network switching in real-time and for the foreseeable future.

Ultimately, as fast reaction time is required, the target is autonomous network operation with extensive self-healing and self-provisioning operations requiring limited human intervention. The AEMS solution supports every step along the way.

AEMS Elevates Every Facet of Network Operation

Wherever the utility is on its journey to digital transformation, AEMS positions forward-thinking utilities to optimize network and generation, advantageously integrate WAMS and master renewables, and achieve predictive transmission (ultimately, autonomous) with real-time data and a future-focused digital solution.

A Unified View of All Facets of the Future Digital Utility

The AEMS interacts with GE’s data analytics platform to manage data and provide operational intelligence. This unified and intelligent platform offers operational knowledge beyond the grid’s control room:

- Planning systems to design and prepare future network evolution.
- Substation systems for acquisition, automation, protection, and control.
- Corridor management systems —such as a high-voltage direct current (HVDC) link.
- Distribution management systems with distribution utilities.
- Market management systems for independent operators.
- Microgrid management systems for energy hubs.
- Asset management and condition monitoring systems.
- Generation fleet management systems for market participants.
- Communication system infrastructures designed for power companies.
**Experience Situation Awareness and User Interface**

**WAMS Monitoring, Analysis, Control**
- **A New Vision of Your Network**
  - AEMS now embeds WAMS and PDC as an inside component of the solution. Network security and efficiency is augmented as a result of data resolution provided by phasor data and associated analysis. Coupled with DSA TSA model approach, **WAMS Look Ahead** predicts future network situations.
  - **Stability applications**: Angle based Grid Management, Enhanced Island Management, Enhanced Disturbance Management, Alarm management.

**Renewables and DER**
- **Master Deployment of Renewables**
  - AEMS Renewables Operation Portal models, monitors, and controls renewable and distributed energy resources to anticipate and respond to power balance requirements.
  - **AEMS Renewables Look Ahead** forecasts potential risk and provides recommendations for remedial actions to operators to optimize generation dispatch and control, and overall improve grid security.

**Network and Generation**
- **High Performance Networks and Generation Apps**
  - AEMS includes advanced optimization engines which can take a very large number of input data and constraints: all generation and storage resources, multiple types of constraints, and market environments to deliver the optimal schedule for various time horizons (yearly, short-term, or look-ahead) in coordination with AEMS Energy Market trading.

**Analytics**
- **Extracting Value from Industrial Data**
  - AEMS provides a unified intelligent platform to manage data and provide operational intelligence. Utilities can get a unified view of their Network, customer, assets, and data to rapidly build Apps to drive business outcomes.

**Real-Time Data Across the Enterprise**

**AEMS** includes and integrates corporate information systems that rely on relational databases from leading providers. Through a set of power tools, such as SOA adapter or the CIM-based modeling environment, any data is accessible in real-time across the enterprise. AEMS has a powerful graphical user interface which displays data relevant to operators, analysts, and supervisors. The web-based UI optimizes and visualizes data in an easy-to-use manner.

**Network Model Manager**
- **Scada**
- **Intelligent Alarming**
- **Outage and Switching Management**
- **Cyber Security**
- **Data House**
  - **On prem**
  - **Cloud**

**Robust Core Technology Solid foundation for data accuracy, high availability and exceptional performances**
- **NMM** – NMM is the CIM-based modeling tool, which supplies information to all systems that use a power system model.
- **Scada** ensures real-time data and process management services (Scada, PDC, Front end).
- **Cyber security** is the cyber security environment for all your real-time systems in use in your control center.
- **Data House** includes a real-time and historical information system environment.

**GE is a Leader in Advanced Energy Management Systems.**
Large interconnected systems across the globe rely on GE AEMS to run their grids reliably, securely, and efficiently.
Effectively Integrating WAMS

Increasing energy demand, restricted transmission grid expansion, and increasing volatility due to more renewable and distributed generation, all add complexity across the electricity network. Yet transmission assets often remain under utilized. Digitalization with AEMS provides a new vision of the network. AEMS now embeds Wide Area Monitoring Systems (WAMS) and Phasor Data Measurements (PMU) collected through Phasor Data Concentrators (PDC) as an inside component of the solution. Transforming instantaneous synchrophasor measurements into valuable information through real-time “measurement-based” analytics and combining them with “model-based” predictive visibility, provides advanced decision support tools to better assess grid reliability and maximize transfer capacity. This gives grid operators a holistic and accurate view of current grid status; better intelligence to understand, predict, and mitigate potential developing events; and unmatched historical data quality for better offline post-event analysis, model tuning, and power system control.

**Solution Highlights**

**Full EMS WAMS Integration**

- Energy Network Visibility at WAMS resolution.
- Unlocking Network capacity ensuring Grid stability.
- Preventive stability assessment with WAMS and DSA Look Ahead.
- Enhanced Operation with WAMS controls.
- Capacity, Efficiency Utilization and Business Optimization with WAMS Predictive Analytics.
- Operator training with Dynamic DTS.
Mastering Renewables Deployment

Utilities are looking to grid modernization to compensate for solar, wind, and electric penetrations and prepare for the associated issues. In the U.S., distributed solar installations are predicted to nearly double from roughly 2 million in 2018 to almost 3.8 million by 2022. At the same time, behind-the-meter battery storage is forecast to grow from around 200 MW to nearly 1,400 MW, according to GTM Research. And European utilities are already facing much greater DER disruption. ENTSO-E, the European Network of Transmission System Operators representing 43 electricity transmission system operators (TSOs) from 36 countries across Europe, has developed plans in which renewable generations will rise from over 40% in 2030 to over 60% in 2040.

Empowering the utility to address the uncertainties inherent to renewables, the AEMS provides full visibility of renewable generation. The Renewable Operation Portal models, monitors, and controls renewable (such as smart dispatch and curtailment) and distributed energy resources to anticipate and respond to power balance requirements (active and reserve power). Considering the renewable energy situation, the forecast, and operational impact, the AEMS Renewable Look Ahead forecasts potential risk and improves overall grid security.

With AEMS, the utility:

- Supports acceleration of central and distributed renewables penetration and retirement of fuel-based generation.
- Controls intermittency and low inertia of renewable generation creating electric instability and black out risk.
- Forecasts potential risk and provides recommendations for remedial actions to operators to optimize generation dispatch and control and improve grid security.

WAMS BASED FAST FREQUENCY RESPONSE WITH LOW INERTIA FROM RENEWABLES

WAMS Fast Frequency Response mobilizes generation to accelerate energy injection at the right place and the right time.
Utility Capabilities with AEMS

Network Security and Optimization
These core network modular apps drive energy management systems. Complemented with WAMS measurements and applications, they deliver higher performance and more robust results:

- Topology Processor
- Quick Network Analysis
- State Estimation
- Load Flow Calculation
- Contingency Analysis
- Operator Guide
- Security Enhancement
- Security Constraint Dispatch
- Contingency Planning
- Voltage/VAR Dispatch
- Volt-Var Control (VVC)
- Loss Minimization
- Corrective Controls
- Short-Circuit Analysis
- Optimal Power Flow
- Special Protection Schemes and Remedial Action Schemes (RAS)
- Topology Estimator
- Dynamic Line Rating
- Voltage Stability
- Transient Stability
- Small Signal Stability

Generation Control and Optimization
These core generation apps of an energy management system operate in regulated or non-regulated markets. These applications are renewable-ready to manage a wind farm, PV injection, and storage (batteries):

- Load Forecast
- Transaction Scheduling
- Unit Commitment
- Economic Dispatch
- Multi-Area Load-Frequency Control
- Automatic Generation Control
- Reserve Monitoring
- Real Time and Study Modes
- Impact of DER including Storage
- Renewable / DER Smart Dispatch and Curtailment
- HVDC Control
- Generation Scheduling
- Market Interface

With real-time and study environments, the AEMS platform not only improves physical asset performance, but it also increases the skill level and situational awareness of the utility’s human assets. Operators can train better with the AEMS’s Dynamic DTS.
ADVANCED EMS

REALTIME SYSTEM RESTORATION MANAGER (RTSRM)
SECURES AND ACCELERATES THE SYSTEM RESTORATION PROCESS

• Supports various types of power system restoration processes.
• Significantly improves system assessment capability during the restoration purposes.
• A Platform for real-time coordination amongst multiple entities participating in the restoration process
• Available in Real-time & DTS.

ADVANCED EMS

NETWORK MODEL MANAGER

NETWORK MODEL MANAGER (NMM): THE COMMON INFORMATION MODEL (CIM) COMPONENT OF NETWORK DIGITAL TWIN

A modeling environment designed with input from real users, reflecting the best modeling practices and productivity features.

A new power system model management application for effectively managing time-based models, across multiple business domains within the enterprise (Operations, Planning, Protection) and with neighbouring utilities. It provides a complete business process automation for importing, aggregating, validating and exporting models in different formats, including CIM-16/CGMES. The models are validated for wide areas from a network security or market perspective. They are validated for the short and mid-term for multiple time points.

- Model merge and validation capabilities.
- Comprehensive Network Analysis Study for Wide Area and Look Ahead on single or merged models.
- Elimination of duplicate modeling efforts.
- Automation of manual processes and reduced response time to complete studies.
- Import/export of different formats (CIM/CGMES Standards and multiple vendors.)
- Supports planning, operational and a combination of both models.
- Improves quality and accuracy of the model, thus reducing likelihood of errors.
- Based on the same algorithms proven in Real-Time EMS.

Key Benefits

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Empowering Network Level Optimization

Outage Switching Management

Utility digital transformation requires switching be performed to ensure optimal asset utilization, maintenance, and performance. Yet many stakeholders in different departments, organizations, and sites are involved. This means the process is often managed using multiple siloed tools and manual processes.

Digitalization of switching management is essential to safe delivery in the face of increasing demand for optimal operations and capacity utilization of the network. AEMS includes advanced optimization engines able to handle a large volume of data. Unlock network capacity and ensure grid stability with a comprehensive suite of apps — integrating all generation and storage resources, multiple types of constraints, and market environments to deliver the optimal schedule for various time horizons (yearly, short-term, or look-ahead) in coordination with AEMS Energy Market trading.

Efficiently Manage Alarms

Renewable energy penetration and intermittency require maximum network capacity and flexibility utilization. As a result, network assets are operating closer to their limits, and operators have less time to diagnose alarms and launch an effective response.

Intelligent Alarming suppresses nuisance alarms, creating one synthetic alarm and generating a diagnosis that indicates the faulty device.

With AEMS, the utility:

- Ensures fast response to alarms, transparency (fully readable logic), adaptability to complex situations, and scalability by users who own and create their methods and rules.
Offering Real-time, Enterprise-Wide Data

The robust technology at the core of the AEMS solution provides a solid foundation for data accuracy, high availability, and exceptional performance.

Through a set of powerful tools, such as the Network Model Manager CIM-based modeling environment or Service-oriented Architecture (SOA) Adapter, AEMS provides data access, in real-time, across the enterprise. AEMS is, therefore, a powerful way to unify applications, data repositories, and organizational interoperability. Massive data ingestion handles complex, disparate, and numerous data volumes to create a common data framework — driving new analytics capabilities and providing utilities with a unified view of their network, customers, assets, and other data to drive business outcomes.

By harnessing real-time and historical information from the ecosystem, the utility can increase grid reliability to severe and attack events (for example weather, asset failure, cyber and physical attack) and master the exponential growth of data of any kind, from across sources, at any time and frequency.

With AEMS, the utility:
- Evolves at its own pace to integrate cloud computing, computer science, machine learning, and artificial intelligence.
- Lowers operation and maintenance costs while optimizing asset performance to allow utilization above current limits.
- Understands and contains the cost of aging transmission infrastructure.
- Overcomes the challenges of a retiring utility workforce thanks to more automation, embedded processes, and rich user experience.

GE ADVANCED GRID ANALYTICS SUITE

GE SOLUTIONS

Asset
- Strategy
- Reliability
- Health

Distribution
Network Model
Storm Response

Transmission
Fault & Event Analysis
Inertia Prediction

AMI
AMI Network Operations
Revenue Protection

Analytic Applications

Core Analytics Platform

Analytic Library
- Outage Prediction
- Facility Damage
- Connectivity
- Anomaly Detection
- Forecasts
- ETR
- AI-based Tag Mapping
- Pattern Matching

Runtime & Orchestration

Common Data Model / Data Fabric
- Weather
- Markets
- GIS
- OMS
- ADMS
- ...
- EMS

External Data Sources
Operational Systems with Siloed Data

MACHINE INTELLIGENCE TO AUTOMATE DATA INTEGRATION AND DATA MODELING

Siloed Data Sources

CREATE SEMANTIC MODEL

Intelligent Integration to Target Model

USE CASES EXAMPLES

RENEWABLES CURTAILMENT
Wide-area perspective on the conditions to curtail wind due to congestion.

FAULT AND EVENT ANALYSIS
Collects and analyzes fault and event information (FEI) from relays and DFR’s after a fault occurs.

RESERVES FORECAST
Anticipates imbalances and reserves to allow more Wind and PV penetration.

RENEWABLES INERTIA PREDICTION
Leverages WAMS and AI/ML to predict power system inertia.

Key Attributes
- Applications built to address specific customer outcomes.
- AI/ML techniques deliver predictive and prescriptive analytics.
- Pre-built analytic tools and pre-defined data models.
- On-prem / cloud alignment.
- Reduced ingestion and integration costs across data silos.
- Abstraction of data ingestion and operationalization frees staff to focus on value-added activities.
Utilities must secure myriad data while also complying with industry security regulations, such as NERC-CIP, and customer demands for privacy. Beyond the data in the control room, the AEMS interacts with many devices and applications (on-premise, at the edge, and in the cloud) across a broad ecosystem. Securing the shared data, therefore, demands a robust cyber security posture. With the AEMS solution, the utility effectively integrates operation and information technology to remain compliant with organization policies and obligations (e.g., strong authentication, the company active directory, network zoning) while securing data.

The Modular AEMS Solution — Make It Your Own

With proven architecture, out-of-the-box integration, and system agnosticism, GE’s AEMS offers smooth migration and modular upgrade from existing EMS or legacy systems. GE’s evolving toolset is modular and interoperable on-premise and/or in the cloud for transmission system operators, regional transmission organizations, independent system operators, generation companies, aggregators, microgrids, and municipal/co-op players.

Further, the modularity of GE’s AEMS solution suits the fragmenting energy ecosystem. Offering network-level optimization, WAMS and DER integration, and powerful analytics, the AEMS’s modular components smoothly integrate with third-party systems to provide a full view of all utility assets.

Integrating digital technology and legacy systems to reach the destination of choice for the future — a network that can one day act intelligently and autonomously — GE’s AEMS systems are fully integrated with GE’s real-time Wide Area Management solutions and Renewable Management Solutions and interoperate with GE’s industrial analytics-leading platform. As an integral part of GE’s Digital Energy management solutions portfolio, the AEMS helps enable utilities and industry to effectively manage electricity from the point of generation to the point of consumption, helping to maximize the reliability, efficiency, and resiliency.
With AEMS, the utility:

- Masters renewable generation in the network for every penetration level (over 50%).
- Benefits from interconnected systems crossing geographical borders with a high megawatt exchange due to HVDC.
- Drives energy efficiency by enabling a low total energy cost and customer empowerment in peak and congestion scenarios.
- Gains a platform for real-time coordination among multiple entities participating in the restoration process.
- Secures and accelerates the system restoration process by significantly improving system assessment capability and supporting various types of restoration processes.
- Get more from network and generation applications, due to wide-area perspective (WAMS) which provides insights into grid condition, congestions, Total Transfer Capacity, Net Transfer Capacity, and Available Transfer Capacity calculations and more.
- Optimizes efficiency and capacity with WAMS Predictive Analysis to anticipate system imbalances and reserves needed.
- Automates the switching procedure while keeping safety and security at the highest level.
- Uses analytics to reveal more flexibility and efficiency gains.

Proof Points

1. WAMS early detection of oscillation 30 minutes before black out.
2. Up to 18 GW DR in US RTO.
3. In multiple European utilities renewables are over 50% of the total production supply.
4. Fast Frequency Response with WAMS.
5. DLR up to 25% additional usable capacity (source DOE 2014.)
6. Optimal asset maintenance.
7. OSM — over 100k switching by year for a US utility customer.
8. From 300 controls to over 600 by day for an Australian utility customer.
9. Faster SE convergence, increased observability, and full angles.

Endnotes

4. Including Supervisory Control and Data Acquisision (SCADA), Information Systems (IS), Pro-grammable Logic Controller (PLC), Operation Technology (OT) and more.