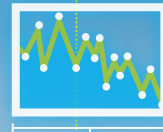




ASSET LIFECYCLE MANAGEMENT

A SUITE OF SERVICES
OPTIMIZING GRID
ASSET MANAGEMENT
STRATEGIES



TODAY'S ENVIRONMENT

Electrical grids are more and more exposed to complex and challenging environments due to technological evolutions, retiring experienced workforce, aging assets with increasing exposure to failure and continuous pressure on operating and capital expenses.



By 2020, **25% of utilities will integrate asset performance management investments with sensor data and cognitive capabilities, boosting asset efficiency** and reducing maintenance costs.

Source: IDC



Globally a **5% reduction in O&M costs** achieved through **digitalization** could save an average of **\$80 billion per year**.

Source: IEA



Most APM projects will **improve equipment reliability** and, therefore, **reduce operational risk**. Improved uptime and cost savings can be substantial, typically delivering benefits measured in **millions of dollars per year**.

Source: Gartner

60% of circuit breakers in developed countries are **over 30 years old**

85% of the effort is in **gathering and normalizing the asset data**

89% of failures **can't be prevented** with **standard time-based maintenance** approach

Sources:

1- CBR aging http://www.harriswilliams.com/sites/default/files/industry_reports/ep_td_white_paper_06_10_14_final.pdf

2- GE customer testimonial during meeting with PM

3- Source: Nowlan and Heap study

GE'S SOLUTION

GE's Asset Lifecycle Management (ALM) Services encompass a set of flexible solutions to optimize electrical substations maintenance and replacement strategy. The Services are designed to meet the customers desired level of outcome in terms of asset availability, risk management and total cost of ownership.

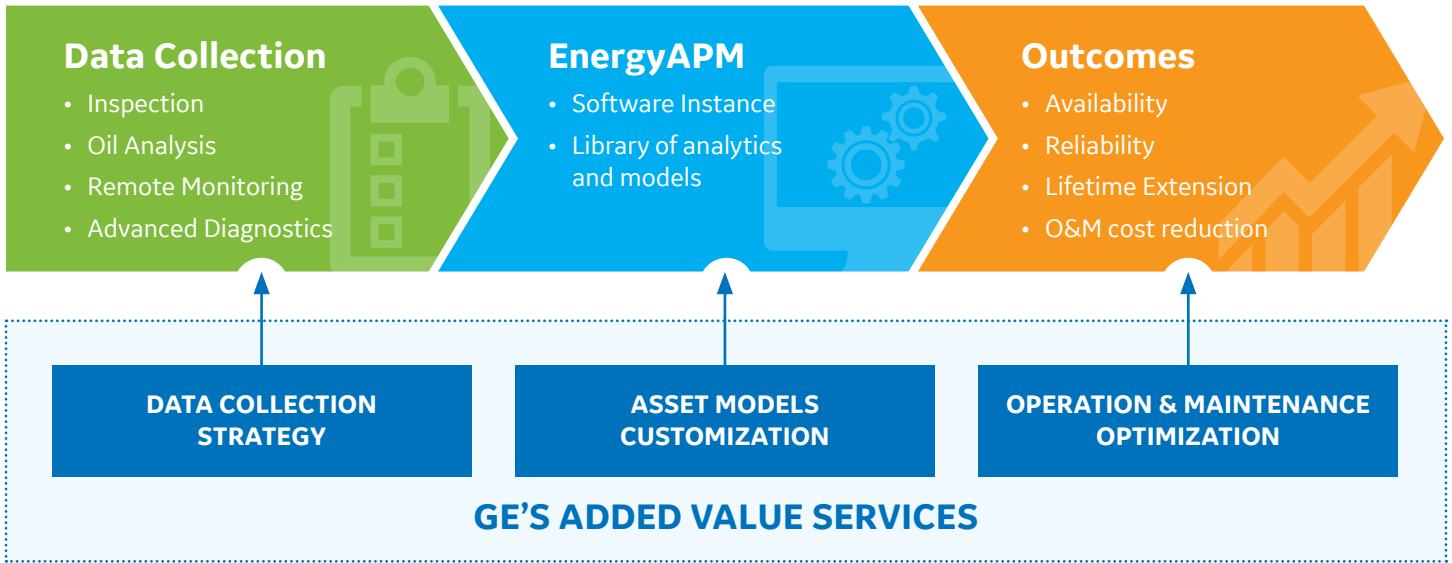
ALM Services combine GE's expertise in grid asset maintenance and reliability management with an innovative end-to-end set of digital applications and tools suitable for all types of asset independently of the original equipment manufacturer.

The ALM Services include a comprehensive portfolio of methods to collect transmission and distribution asset health data, a set of proven analytics and consulting services to build and maintain a solution tailored to support operators to achieve their asset lifecycle management goals.



OPTIMIZING RELIABILITY & VALUE

GE's Asset Lifecycle Management Services optimize utility, power generation and industrial customers' grid operations and maintenance approach to help them deliver on their business objectives. The comprehensive solution includes:



The ALM services provide customers with the following outcomes:



**REDUCED FAILURE RATES
BY UP TO 50%**

IMPROVED RELIABILITY AND AVAILABILITY

- Unscheduled outages are significantly reduced with the implementation of a condition based maintenance strategy centered on asset health and associated risk.
- Digitized processes and tools improve data quality and maintenance process consistency.



**REDUCED MAINTENANCE
COST BY UP TO 25%**

MINIMIZED COST OF OWNERSHIP

- The shift from time-based to reliability centered maintenance strategy enables asset owners to maintain and repair selected assets of a fleet.
- Unplanned maintenance is converted into planned maintenance with the detection of defaults before they occur.
- The usage of advanced data collection tools improves the efficiency of planned and unplanned maintenance.



**ASSET LIFETIME
EXTENDED BY UP TO 20%**

ASSET REPLACEMENT DEFERRED

- Decisions to set maintenance and replacement priorities are based on a consistent risk evaluation method built by combining the probability of failure with the criticality of each asset.
- Strategic plans can be established, investments can be compared and justified to regulators or shareholders using an approach compliant with the ISO 55001 standard on asset performance management.

POWERED BY END-TO-END EXPERTISE

Any significant transformation in operation and maintenance process or strategy requires the convergence of a broad range of technical capabilities and skills. For over 100 years, GE has developed extensive experience in design, installation and services of high and medium voltage equipment for generation and grid applications worldwide. This valued expertise is the robust foundation of GE's ALM Services.

UNIQUE KNOWLEDGE IN EQUIPMENT BEHAVIOR

GE has developed, manufactured and installed over 700 000 high voltage assets, and annually spends over 1 million hours of service to maintain, repair and modernize electrical substations. The growing knowledge captured day after day over decades enables GE's service engineers to better understand aging models and failure modes of assets, and make recommendations on the condition based maintenance program that best fits with the customers' requirements.

FIELD PROVEN SOLUTIONS

GE supports and troubleshoots thousands of transmission substations across the world through transactional contracts, multi-year warranty and maintenance contracts resulting in:

- Extensive experience in field proven processes, methodology & terminology that is digitized, improves accuracy and delivers faster inspection data
- Recognized efficiency of analytics implemented in GE Grid APM software

APPLICABLE TO TRANSMISSION & DISTRIBUTION ASSETS, SYSTEMS AND SUBSTATION FLEET



GE APPROACH

CUSTOMER ENGAGEMENT JOURNEY

GE works with customers to identify the target outcomes in a digital discovery workshop. The process starts with understanding the current situation, capabilities, identifying the challenges and pain points. Then the gaps to reach the target outcomes are identified and acknowledged by evaluating the potential Return on Investment (ROI) of the proposed solution. The solution can include various digitization packages focused on maintenance optimization, asset life optimization and reliability/availability improvement.

4 STEPS PROCESS TO OPTIMIZE ASSET FLEET MANAGEMENT


STEP 1 **DISCOVERY WORKSHOP**

- Target outcome definition
- Evaluation of capability/maturity level
- Identification of pain points
- Value statement-KPI target agreement

 **SOLUTION ROADMAP**


STEP 2 **SYSTEM DESIGN**

- Asset taxonomy & APM model set-up
- Data collection & connectivity analysis
- Preliminary ROI estimation
- System scope of work and deployment plan definition

 **PROOF OF CONCEPT & DEPLOYMENT PLAN**

STEP 3 **PROOF OF CONCEPT DEPLOYMENT**

- System implementation in Grid APM
- Monitoring solution for few critical assets
- Data collection through connectivity and uploads
- Results consolidation & preliminary recommendations

 **PROOF OF CONCEPT VALIDATION**

STEP 4 **PARTNERSHIP AGREEMENT**

- Multi-year partnership agreement
- Multi-site deployment
- Online monitoring & diagnostic for critical assets
- Data consolidation & review

 **FLEET MANAGEMENT OPTIMIZATION**

VERSATILE & SCALABLE SERVICES

GE's Asset Lifecycle Management Services are developed to meet the customer's required outcomes, specific application and resources. During the system design phase, GE partners with the customer to select the best solution from a comprehensive portfolio including:



ASSET SCOPE

- Asset
- System
- Fleet



DATA COLLECTION METHODS

- Advanced Inspections
- Remote Monitoring
- Oil Analysis Inspection



APM APPLICATION SCHEME

- Customer Dedicated Instance
- On Customer Premises



MODELS & INDEXES

- 80+ Asset health Models
- Comprehensive set of health indexes



SUPPORT & CONSULTING LEVEL

- Consulting on ALM
- Expertise on Assets 24/7



CONTRACTUAL SET UP

- Transactional
- Flexible Service Agreement
- Outcome Based

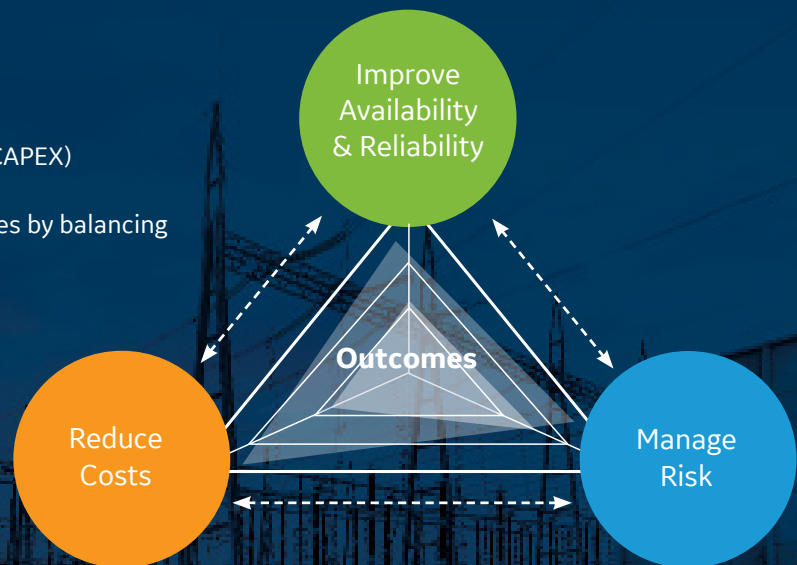
COMMITTED TO CUSTOMER RESULT

ALM services can be provided through multi-year outcome commitment agreements, this is where the achievement of target outcomes are contractually guaranteed and can cover a combination of maintenance optimization, asset life extension and availability improvement.

Possible Outcome Criterias

1. Failure rate reduction
2. Optimized maintenance (OPEX)
3. Extended asset life / amortization period (CAPEX)

GE ALM Services maximize customer outcomes by balancing traditionally competing priorities.



ADVANCED DATA COLLECTION SERVICES

DIGITALIZED INSPECTION TECHNOLOGIES

GE's service specialists are constantly evaluating and implementing new innovative inspection technologies on a large range of GE and 3rd party electrical assets, which are designed to improve the efficiency of data collection, oil analysis and online monitoring. The captured data is automatically uploaded to the GE EnergyAPM application.

OIL ANALYSIS for Transformers and Instrument Transformers

Oil testing and analysis is performed in GE's labs, and report is generated to include remedial actions and condition severity as per IEEE® or IEC® standards.

ULTRA HIGH FREQUENCY SENSORS for Gas-Insulated Substation (GIS)

Measures partial discharge to assess the condition of the SF₆ and g³ insulation.

ADVANCED NON-INTRUSIVE INSPECTION for GIS, Transformers and Circuit Breakers

Technologies are available to assess various components without the need to open the asset and include:

- Dynamic Contact Resistance Measurement to detect arcing contact wear and over-travel condition
- Digital Scan to evaluate the condition of main arcing and moving components
- Vibration Monitoring to detect operating mechanism defect

GE'S ADDED VALUE SERVICES

Data Collection Strategy

GE can recommend the Data Collection Strategy that best fits with the asset fleet. Service experts will provide support in:

- The mapping of available data from sensors, relays and remote monitoring devices to feed GE EnergyAPM and the identification of additional inspection or sensing approaches to collect missing data points.
- The selection of the most appropriate advanced inspection techniques which will improve the safety, accuracy and efficiency of site inspections.



SITE INSPECTIONS AND TESTS for the Substation

Visual Site Inspections, functional checks and electrical tests are performed utilizing well-defined standard methodology. GE's field service staff are equipped with mobile inspection tools that capture the information accurately, automate reports and enable data upload.

Cameras and sensors can be installed to perform part of the substation inspection.

AERIAL for HV lines

Utilizing drone or helicopter equipped with HD, IR, UV and LIDAR cameras, increasing the efficiency, safety and accuracy of visual inspections.

ADVANCED DATA COLLECTION SERVICES

ONLINE CONDITION MONITORING FOR CRITICAL ASSETS

When an equipment is critical to the performance of the substation, periodic visits and site inspections may not be sufficient or cost effective. Online condition monitoring devices complement and enhance asset lifecycle management strategies. They enable frequent condition assessment, pre-emptive event and alert mechanisms for critical assets in order to minimise unplanned outages and avoid major repair costs or collateral damage. The online condition monitoring solutions include:



SINGLE AND COMPOSITE GAS MONITORING

HydranM2-X, Hydran 201Ti

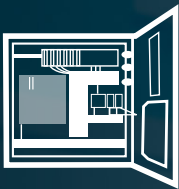
- Trend and alert for Hydrogen or Composite gas levels and moisture
- Transformer Direct Mount
- Rugged and cost effective



TRANSFORMER DISSOLVED GAS ANALYSIS (DGA), MONITORING AND DIAGNOSTICS

DGA 500, DGA 900, DGA 900 PLUS, TAPTRANS, MULTITRANS, MINITRANS, Transport X²

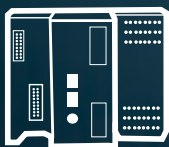
- Precise 3, 5 or 9 gas DGAs enabling remote diagnostics and fact-based asset management strategies
- Add bushing monitoring to identify bushing Capacitance and Power Factor deviations and Models to identify further insulation and LTC insights
- Transport X² portable on-site DGA for on-the-spot rapid response health checks



HOLISTIC TRANSFORMER MONITORING SOLUTION (TMS)

MS 3000, BMT330

- Transformer Monitoring Systems (TMS) providing consolidated expert level HMI
- Advanced analytics enabling remote analysis, reporting, health indexing and fleet ranking
- Bushing condition monitoring and PD activity in the main tank. Stand alone or DGA integrated solutions



CIRCUIT BREAKER MONITORING

CBWatch3

- Modular, Compact and Field Proven system to monitor HV circuit breakers.
- Measurements include operating times, SF₆ gas density, coil motor current and temperature
- Advanced analysis of timing, contact wear, time to gas refill, control circuit and storage system



GAS-INSULATED SUBSTATION MONITORING

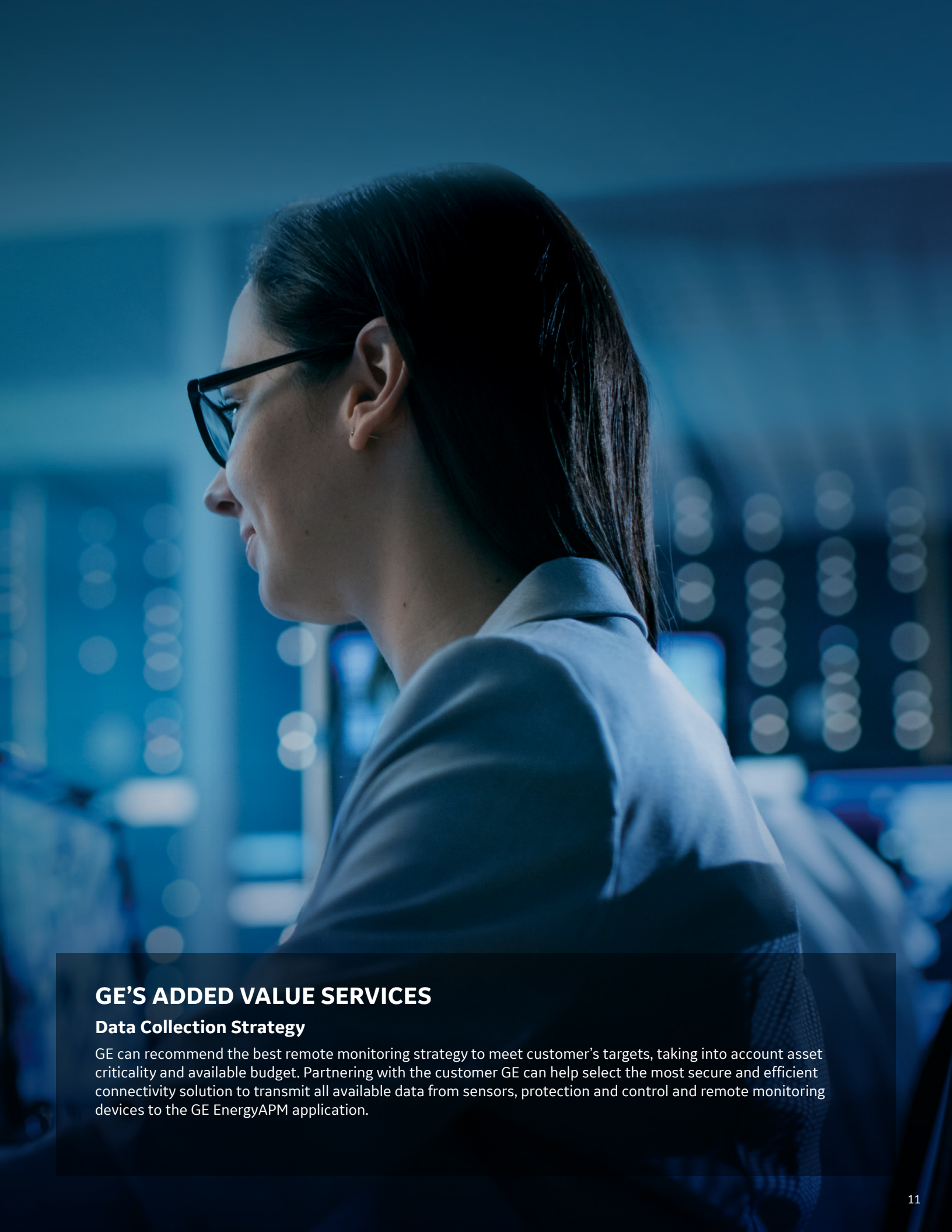
BWatch & PDWatch

- Monitoring of 6 gas density and forecast refill requirements across all compartments
- Internal arc localization
- Analysis of UHF partial discharge events



PERCEPTION FLEET SOFTWARE

- Direct connection and configuration of GE M&D Online Monitors
- Industry Standard Diagnostic Tools & Analytics
- Data Trending & Analysis Tools
- Offline Lab Data Import
- Report Generation



GE'S ADDED VALUE SERVICES

Data Collection Strategy

GE can recommend the best remote monitoring strategy to meet customer's targets, taking into account asset criticality and available budget. Partnering with the customer GE can help select the most secure and efficient connectivity solution to transmit all available data from sensors, protection and control and remote monitoring devices to the GE EnergyAPM application.

ALM SERVICES

ASSET PERFORMANCE MANAGEMENT POWERED BY EnergyAPM

ENSURING OPTIMAL OPERATIONAL PERFORMANCE AT A LOWER COST

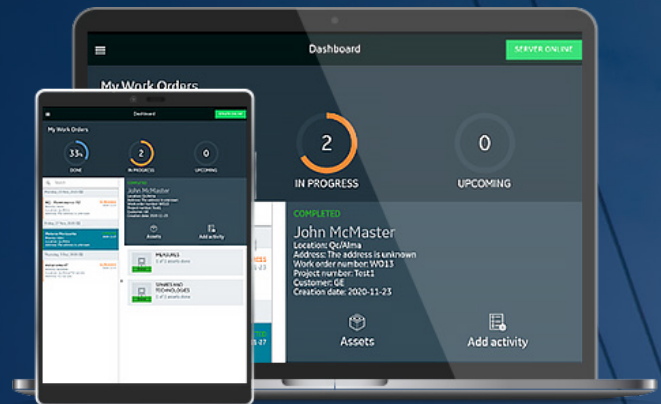
EnergyAPM is the GE data analytics software specially designed for Power Transmission and Distribution assets providing an Asset Performance Management portfolio of applications and services helping operators to develop an intelligent performance strategy for managing electrical substations.

TURNING DATA INTO INSIGHTS

Built on a microservices-based architecture (MSA), EnergyAPM allows users to build, scale and integrate seamlessly with other applications. The platform offers a suite of services, each running its own processes and communications. Each service is built, updated, and managed independently, making EnergyAPM an easy platform to maintain and upgrade.

EnergyAPM Core Services is the foundations layer of GE's APM solution, packaging core features for T&D asset operators. Beyond secure data connectivity, processing and storage, the core services provide rich user features such as historical data viewing, alerts and configuration interfaces that are seamlessly integrated into the EnergyAPM user experience. EnergyAPM Core Services include:

- Data Acquisition & Integration Services
- Data Storage Services
- Logging, Cyber security Services
- UI / UX Services
- Navigation, Search and filtering services
- Monitoring Services
- Alerts Services



EXPLORING MODULARITY AND CUSTOM SOLUTIONS

EnergyAPM is provided as both a turn-key and a customized solution integrating the different functional modules only when they are required. EnergyAPM modules include:

- **Digital Lab** – Providing advanced diagnostics and prognostics tools and a data science workbench
- **Asset Reliability** – Predicting failures and preventing outages based on Failure Mode and Effects Analysis (FMEA) analysis
- **Asset Health** – Increasing asset availability and optimizing replacement planning using a library of 80+ asset models
- **Strategy** – Supporting a Reliability Centered Maintenance (RCM) strategy using a risk-based approach
- **Works** – Managing maintenance actions thanks to the recommendations generated by the health algorithms

OPERATION & MAINTENANCE OPTIMIZATION SERVICES

ENHANCING ASSET RELIABILITY, UP-TIME AND PERFORMANCE

The services are performed on site or at GE's workshop by qualified technicians who are certified in compliance with local regulation and strict GE standards. Based on the customer's unique application needs, GE selects the right technical experts to deliver the service. Optimization services include:

RENOVATION TO EXTEND ASSET LIFETIME

- Maintenance with replacement of worn parts
- Power transformer life extension, circuit-breaker mid-life overhaul and substation refurbishment to ensure equipment safety, reliability and performance

MODERNIZATION TO MANAGE OBSOLESCENCE

- Adapt new designs and technology to equipment in operation
- Add condition monitoring systems to installed asset
- Retrofit or upgrade key components such as cooling systems or breakers
- Replacement of HV asset

EXTENSION TO ADDRESS NETWORK EVOLUTION NEEDS

- Electrical ratings increase including nominal current, and short-circuit current
- Additional bays/poles installation for GE or 3rd party substations

GE'S ADDED VALUE SERVICES

Operation and Maintenance Optimization

GE Subject Matter Experts offer support to:

- Define maintenance recommendation based on advanced diagnostics
- Transition from time-based to condition-based and reliability centered maintenance
- Perform project analysis such as repair or replace decision making
- Assist operators in the budget planning process for maintenance and replacement

CUSTOMER CASE STUDIES

ASSET LIFECYCLE MANAGEMENT SERVICES - TRANSFORMER FLEET ALUMINIUM PRODUCER - AFRICA

An aluminum plant increased its production capacity and was, at the same time, experiencing recurrent forced outages. The 19 power transformers that are critical to production were approaching 30 years of life with no clear indication of their health status and with no replacement plan in place. The company required a solution enabling a comprehensive asset lifecycle management approach.

GE'S SOLUTION: ALM PROGRAM

- Initial asset health assessment
- Estimation of asset real residual life
- Evaluation of assets' criticality
- Maintenance recommendation for each transformer



REDUCED UNPLANNED OUTAGES,
maintenance costs and production losses



100% ROI IN 1 YEAR,
from implementation of the ALM Program

EXTENDED LIFETIME WARRANTY – STATIC VAR COMPENSATOR UTILITY - NORTH AMERICA

A Static Var Compensator (SVC) system which comprises over 900 components and more than 40 asset types was integrated into the utility's electrical network. The utility wanted to secure the performance of the critical power electronics system and required the SVC system's operation and maintenance to be managed during its entire life.

GE'S SOLUTION: 30-YEAR LIFETIME SYSTEM WARRANTY

- Installation of a remote monitoring solution on critical assets
- Implementation of advanced data collection techniques
- Deployment of a reliability centered maintenance approach
- Supply and configuration of GE Grid APM including data analytics



KNOWN & FIXED COST for all
planned and unplanned main-
tenances including parts and labor



OPTIMIZED COSTS & RELIABILITY
centered maintenance strategy



**NO OBSOLESCENCE
SURPRISE**



ADVANCED DATA COLLECTION STRATEGY - HVDC OFFSHORE WIND FARMS - GERMANY

A wind farm operator required a solution to ensure optimal availability of its offshore substations which are critical for the energy supply to the region. The North sea's weather conditions and the safety constraints limited access to the offshore platform, negatively impacting the service response time in case of a problem.

GE'S SOLUTION: ALM SERVICES ADAPTED TO THE SUBSTATION LOCATION

- Deployment of transformer remote monitoring solution
- Integration of collected data in an Enterprise Asset Management platform
- Implementation of an inspection process supported by mobile and advanced tools such as smart helmet and x-ray inspections



50% REDUCTION OF EMERGENCY INTERVENTIONS on monitored assets



REDUCED NUMBER OF VISITS on off-shore substations to assess the asset condition and provide diagnosis



OPTIMIZED MAINTENANCE PLANNING

GRID SUBSTATION FLEET MANAGEMENT – T&D SUBSTATIONS UTILITY - QATAR

A utility had an ambitious business goal to control failure risk of their 150,000 electrical assets across over 15,000 distribution and 300 transmission substations by collecting asset condition data and turning it in actionable information to prioritize and plan asset maintenance and replacement.

GE'S SOLUTION: ASSET INSPECTION PLAN AND PERFORMANCE MANAGEMENT SYSTEM

- Deployment of efficient site inspection utilizing an advanced data collection approach
- Implementation of GE EnergyAPM software for data management and analysis
- Automatic upload of oil tests results from GE labs to EnergyAPM
- Selection of analytics focused on health, risk and end-of-life assessment



Optimized maintenance strategy resulting in over **50% REDUCTION OF FAILURE RATE**



Optimized replacement strategy resulting in **20% ASSET LIFE EXTENSION**



182% OF RETURN ON INVESTMENT after 2 years

For more information about
GE's Grid Asset Lifecycle Management visit
[GEGridSolutions.com/alm-services](https://www.ge.com/grid-solutions/alm-services)

[GEGridSolutions.com](https://www.ge.com/grid-solutions)

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