GE
Grid Solutions

ASSET LIFECYCLE MANAGEMENT

FLEXIBLE 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**

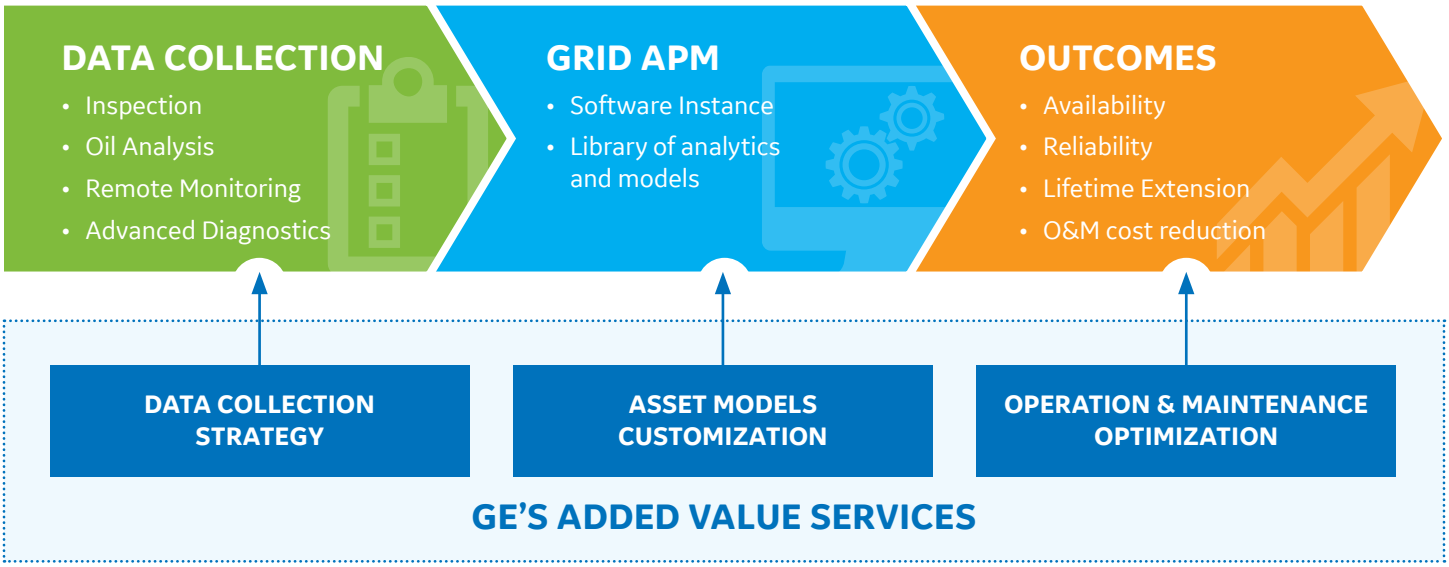
GE's Asset Lifecycle Management (ALM) Services encompass a set of flexible solutions to optimize electrical substations maintenance and replacement strategy. The Services are designed to meet the customers desired level of outcome in terms of asset availability, risk management and total cost of ownership.

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 Diagnostics
- Remote Monitoring
- Oil Analysis Inspection

APM APPLICATION SCHEME

- Multi Customers Instance
- Customer Dedicated Instance
- On Premises

MODELS & INDEXES

- +60 Asset health Models
- Comprehensive set of health indexes

SUPPORT & CONSULTING LEVEL

- Consulting on ALM
- Expertise on Assets 24/7

CONTRACTUAL SET UP

- Transactional
- Multi-Year Agreement
- Outcome Based

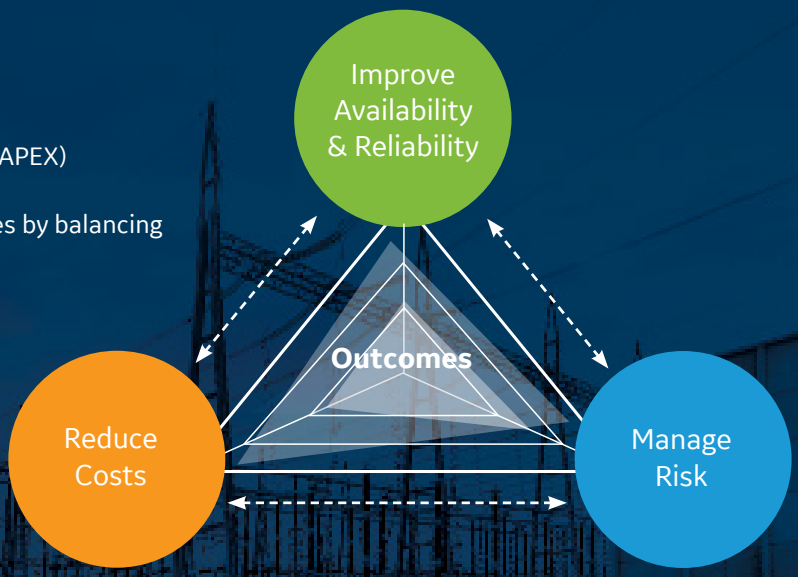
COMMITTED TO CUSTOMER RESULT

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 Grid APM 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.

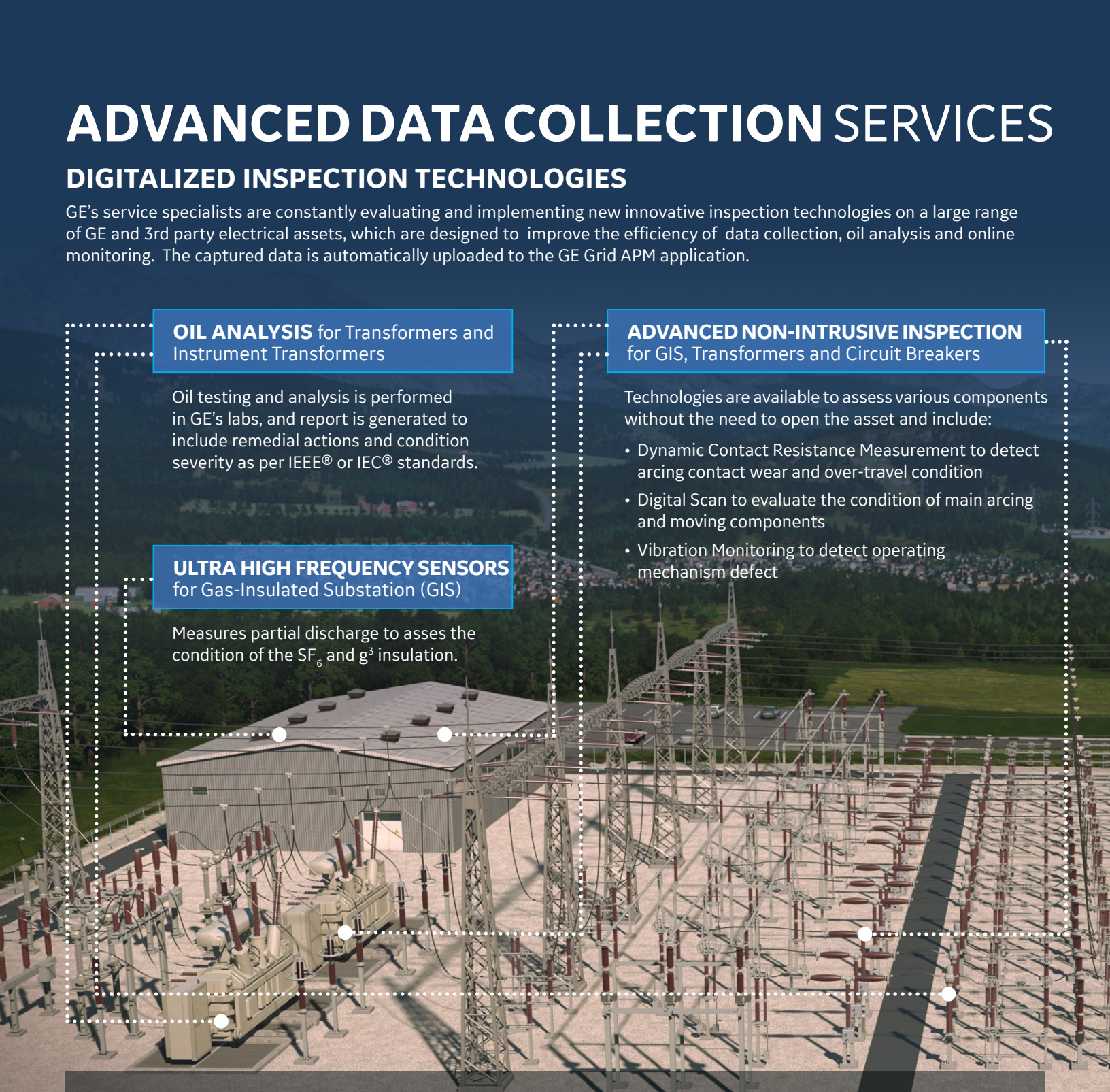
ULTRA HIGH FREQUENCY SENSORS for Gas-Insulated Substation (GIS)

Measures partial discharge to asses the condition of the SF_6 and g^3 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 Grid APM and the identification of additional inspection or sensing approaches to collect missing data points.
- The selection of the most appropriate advanced inspection technics 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.

INSPECTIONS VIA DRONES for HV lines

Utilizing Drone technology 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. Online condition monitoring devices enable real-time condition assessment, predictive and alert mechanisms for critical assets in order to minimize unplanned outages and avoid major repair costs or collateral damages. The online condition monitoring solutions include:

SINGLE OR MULTI DISSOLVED-GAS MONITORING (DGA)

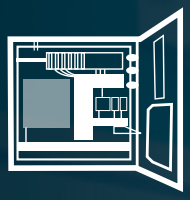
HydranM2, Hydran 201Ti, DGA 500, DGA 900, Transfix, MultiTrans, TapTrans, MiniTrans, Transport X

- Trend and alert for gas levels and moisture
- Fixed and portable DGA solutions

TRANSFORMER MONITORING AND DIAGNOSTICS

BMT 330 & MS3000

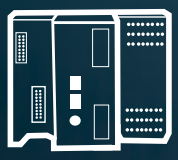
- Upgrade to 5-9 gas DGAs enabling remote diagnostics
- Add bushing monitoring to identify Capacitance and Power Factor deviations



HOLISTIC TRANSFORMER MONITORING SOLUTION

MS 3000

- Transformer Monitoring Systems (TMS) providing consolidated expert level HMI
- Monitoring of various components including active parts, tap changers, bushings, cooling system
- Advanced analytics enabling remote analysis, reporting, health indexing and fleet ranking



CIRCUIT BREAKER MONITORING

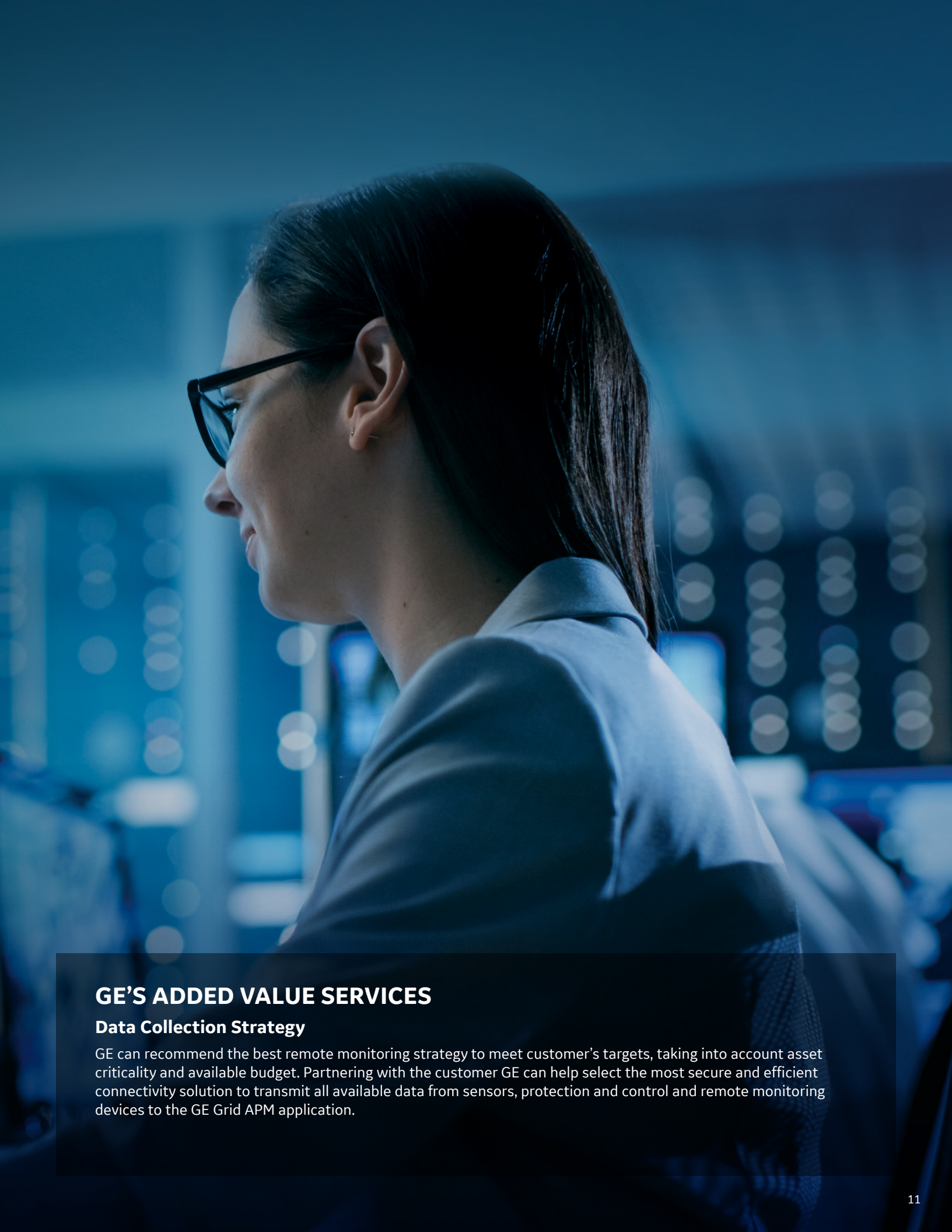
CBWatch

- Measurements include operating times, SF_6 gas density, coil and 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



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 Grid APM application.

GE **ASSET PERFORMANCE MANAGEMENT** (GRID APM)

GE Grid Asset Performance Management software delivers advanced analytics for electrical grids supporting asset owners on key decisions. Key features of the software include:

CONSOLIDATION OF ALL DATA SOURCES

GE Grid APM is the central repository collecting all asset related data, including field inspection data, operations data, real-time condition monitoring data, or historical records. It provides effective information sharing, documents management, decision support and reporting throughout the entire organization.

CUSTOMIZABLE LIBRARY OF ASSET MODELS

GE Grid APM integrates GE's expertise on electrical equipment and includes asset models for majority of HV and MV, AIS and GIS, AC and DC grid assets. A predefined set of parameters fully customizable and extensible without source code modifications, define asset strategies, evaluate the condition of the asset and issue recommendations.

FLEXIBLE ANALYTICS FOR RISK MANAGEMENT

The grid operator can prioritize actions and make decisions for condition-based or reliability-centered maintenance strategies based on a selection of analytics adaptable to all asset types including asset health and maintenance indexes with condition based maintenance recommendations, end-of-life calculations, criticality and risk assessment.

LIFE CYCLE COST ANALYSIS CAPABILITIES

The customizable life cycle cost analysis tool can be used to compare the life cycle cost of different scenarios to be applied to an asset or a group of assets over multi-year periods. For example, with this tool, a customer can compare the risk and cost of replacing or repairing an aging asset.

RELIABILITY CENTERED MAINTENANCE READY

Failure Mode and Effect Analysis (FMEA) data is populated in the software along with associated mitigation actions recommended by OEMs such as inspection tasks. This initiates a maintenance strategy for selected assets. The risk analysis tool can be utilized to evaluate the impact on cost and risk of removing mitigation actions and thereby create additional maintenance strategies. With this tool, different maintenance strategies can be created for assets of the same asset family but with different criticality.

MANAGED SERVICES, CLOUD OR ON-PREMISE INTEGRATED SOLUTION

The system can be deployed as a secure solutions suitable for companies of all sizes. The managed service approach provides viewing access to GE Grid APM without application set-up and adaptation. The cloud based or on-premise access enables customers to configure and manage the GE Grid APM, using their internal experts to customize the application to their needs without the burden of development and maintaining custom source code.

GE'S ADDED VALUE SERVICES

Asset Models Customization

GE Subject Matter Experts offer support to:

- Create new or adapt the standard models and indexes libraries to the customers' needs
- Validate customers' models and analytics
- Optimize customer models based on yearly results and annual update of GE's standard library

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
- Evaluation of assets' criticality
- Estimation of asset real residual life
- 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
- Deployment of a reliability centered maintenance approach
- Implementation of advanced data collection techniques
- Supply and configuration of GE Grid APM including data analytics

KNOWN & **FIXED COST** for all planned and unplanned maintenances 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 Grid APM software for data management and analysis
- Automatic upload of oil tests results from GE labs to Grid APM
- 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/almservices

GEGridSolutions.com

Imagination at work

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