Harnessing the Power of the Industrial Internet

Automation & Controls Solutions

Global Footprint

INDUSTRIES

25% — Keeping oil production safe by providing control systems to a quarter of the world's blow-out preventers

50% — Automating the processes that generate half of the world's power

33% — of major metros use GE control systems to help get people where they need to go, safely and on time.

2.5K — Employees in 30 countries around the globe dedicated to customer success

[1]Early Adopter experience using GE's IICS technology and apps

OUTCOMES

+7% — Performance Gains[1]

+22% — Productivity Gains[1]

-40% — Maintenance cost reduction[1]

Contents

Technology Leadership

Partnering for Operational Success

By delivering solutions across a range of disciplines, Automation & Controls leverages process expertise from across the industry to best serve a variety of technology segments:

Power Generation **Oil & Gas** **Water Wastewater** **Mission Critical Operations** **Manufacturing** **Marine** **Mining & Metals** **Renewables**

Automation & Controls from GE Energy Connections integrates a strong portfolio of industrial automation products with engineering and integration competencies from Alstom's former Power Automation & Controls Group. Alstom's 40 years of domain expertise combined with GE's rich legacy of technology leadership deliver some of the best minds in automation and controls capable of solving our customers' toughest challenges.

In addition to a range of products for industrial automation (controllers, HMI, SCADA, operator interfaces, etc.), Automation & Controls has the capability to provide turnkey solutions, including full project management, engineering, and commissioning. These solutions range from single component controllers for turbines and generators to complete power plant Distributed Control System (DCS) solutions. Automation & Controls supports legacy GE brands as well as Alstom legacy brands such as ALSPA and P320.

Our portfolio is comprised of:

- Turnkey solutions for full plant automation, control and safety, including EPC Services (Plant Engineering, Commissioning and Project Management)
- Stand-alone industrial automation products for a variety of industries (Power Generation, Oil & Gas, Chemical & Process, Pulp & Paper, Mining & Minerals, Renewables)
- Services & Training for power plant automation

POWER GENERATION

Optimize equipment health

Overcoming challenges and improving operations begins with understanding data. You need to capture, store, contextualize, and visualize real-time information—and make it available to the right people at the right time to enable the right decisions.

GE's Asset Performance Management (APM) software enables access to the specific, role-based information your workers need to do their jobs. They can anticipate impending problems before they happen across their fleets and shift from costly reactive maintenance to efficient planned maintenance. The software helps to reduce maintenance costs, improve reliability and availability, and prevent unplanned outages and catastrophic failures.

GE's Automation & Controls provides advanced operational capabilities to the plant, including balance of plant, machine control, and dedicated control for critical components. Flexible architecture extends flexibility from the traditional unit controls to complete plant solutions for optimized performance, advanced operability, and high availability.

Renewable Energy

GE's modular, scalable Automation & Controls solutions help to provide flexibility when managing a variety of renewable plant applications. Our customized storage offerings allow plant operators to be competitive in balancing power while buffering energy output of renewable or decentralized power plants. GE's expertise in plant controls and power electronics helps to improve operational efficiency across a range of power and grid applications. Whether it's wind, solar, hydro, microgrid management, or any other renewable energy source, GE provides a variety of automation and control solutions to fit your needs. We understand the complexities of the renewable energy industry and offer highly flexible and reliable products to suit our customer's needs.

Industries Served

Partnering for Operational Success

OIL & GAS

Intelligent Operations

You need a partner that has scale and products that connect together easily and grow with your needs. But that's not all. You need solutions that help you predict the future, to proactively see problems across your operations before they happen.

GE is that partner. We understand your industry like no other. Our proven portfolio of oil and gas products—from field controls to advanced predictive monitoring—work together to deliver the performance you need to stay ahead. With our expertise and Industrial Internet-enabled solutions, oil and gas companies are transforming their business performance. They're getting smarter and pushing the boundaries on asset and operational optimization.

WATER & WASTEWATER

Consistent, efficient, and accountable water operations

Utilities face aging infrastructure, declining revenues, increasing regulations, and retiring workers—challenges that require them to plan and work smarter than ever before. But it's a struggle because information and systems are disconnected.

At GE, we understand your challenges. Combining advanced technologies and deep industry know-how, our proven water-wastewater solutions drive greater efficiency, consistency, and accountability throughout your operations. That's why thousands of utilities rely on us to help them drive intelligent water operations.

MISSION CRITICAL OPERATIONS

Highly reliable and available mission critical solutions

Reliable backup power and critical cooling systems are instrumental to many industries with mission critical facilities. Advanced power management solutions are required to effectively manage multiple on site backup power systems. GE is a leader in supplying highly reliable and innovative high availability control solutions that help customers achieve new levels of performance.

MANUFACTURING

Today's accelerated product lifecycles make it difficult to stay ahead of your competition and decrease the time to market. With GE's manufacturing solutions, you can close the loop between product design and execution on the shop floor, lower manufacturing costs, improve quality processes, and shorten NPI time to market.

MARINE

Rugged, high performance control solutions

In the harsh environments of marine applications, reliable and rugged high performance control solutions are critical. GE's expertise in controls hardware and automation can help marine industry customers advance their controls systems and lower the system's footprint.

TRANSPORTATION

Automation & Controls solutions support advanced manufacturing and provide industrial internet capabilities to help continuously improve the quality of transportation machinery. Results include enhancing performance and streamlined operations all while lowering costs for our transportation clients.

Industrial Internet Control Systems (IICS)

Built on GE's deep domain expertise of building state-of-the-art control solutions for all types of industrial environments around the world, GE's next generation of Automation & Control solutions have been developed to extract greater value from the Industrial Internet.

Industrial Internet Control System (IICS)

Component Architecture

ADAPT PROCESSES FASTER BY COMBINING ACTIONABLE DATA WITH DYNAMIC, REAL-TIME CONTROL

GE's Industrial Internet Control System augments real-time control with external intelligence delivered through market analysis, fleet and enterprise data, or asset/process knowledge to help businesses realize greater profitability and new revenue streams.

Advance your existing technology or create an Industrial Internet Control System by deploying IICS hardware with embedded Field Agent software. A variety of form factors, protocols, and memory types are designed to support most industrial applications.

GE's complete modular system of controls, I/O, Field Agents, and apps are designed into a future-proof architecture that provides dynamic flexibility, seamless upgrades and remote management of controller hardware, firmware, software, edge devices, and applications. From this suite of components, customers can craft a connected control solution that will evolve to exceed end user needs throughout the lifecycle of their system. New apps and analytics can be dropped in to create new value over time without retrofitting.

Control Server

Commercial grade server for highest-capacity Edge computing and supervisory control applications with virtualized Field Agent* technology

Smart Sensors

GE's flexible I/O solutions provide intuitive diagnostics, flexibility, and a wide range of form factors, feature sets, and price points to fit any application.

Outcome Optimizing Control

Dual or quad core hypervised controller with embedded Field Agent Technology

Field Agent Technology

Robust solution for pre-configured connectivity and secure data collection and conveyance from the machine

Smart Apps in the Cloud & at the Edge

Create a smart control system by utilizing apps like GE's Asset Performance Management (APM) Suite, Equipment Insight, Control System Health, or custom built analytics that help improve operational insight and reduce unplanned outages.

IICS COMPONENTS

IICS INTEGRATED PLATFORM

GE's Industrial Internet Control System (IICS) enables users to improve operational efficiency, optimize production, and unlock new revenue opportunities by leveraging advanced data analytics.

In many cases, only a small fraction of data gets used in industrial processes. IICS makes it possible to rapidly collect, process, and act upon the wealth of data that can be collected from industrial environments. Traditional control systems, the brains of industrial assets and processes, are not capable of dynamically adapting to changing business objectives. Employing a real-time hypervisor with embedded Field Agent technology, IICS facilitates safe and secure communication using either cloud-based or edge-based outcome-optimizing apps. Control can now be programmed to dynamically influence business outcomes, generate new forms of revenue, and improve profitability.

Built on GE's deep domain expertise of building state-of-the-art controllers for all types of industrial environments around the world, GE's IICS solution allows organizations to advance their existing technology, or upgrade to the latest technologies with a hardware platform that is both modular and flexible.

A NEW PARADIGM FOR CONTROL

The ability to extract value from the Industrial Internet of Things (IIoT), like greater production efficiency, increased uptime, and reduced costs is complicated by the complexity of managing and analyzing large quantities of industrial data and lengthy, inefficient workflows required to take timely action.

+7%

PERFORMANCE[1]

+22%

PRODUCTIVITY[1]

-40%
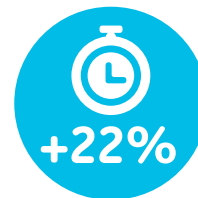
MAINTENANCE COST[2]

[1]Early Adopter experience using GE's IICS technology and apps
[2]Morgan Stanley Research

REDUCE RISK AND TOTAL COST OF OWNERSHIP

The IICS System consists of intelligent controllers, I/O modules, secure cloud connectivity solutions, advanced analytics software, and apps to provide real time process optimization and control with minimal disruption to deployed applications.

Because IICS is established on GE proven PACSystems* and Mark* VIe control platforms, customers can count on state of the art quality and reliability.

THE POWER OF PREDIX*

Leverage GE's Predix Platform to develop lightweight tools to increase engineering productivity in product development, commissioning, and maintenance. Connected controllers and Field Agents enable customers to access GE's Asset Performance Management systems, Equipment Insight, and Control System Health application to help avoid unplanned outages.

Make better decisions faster

Achieving greater production efficiency, increased uptime, and reduced cost is complicated by the complexity of analyzing and managing large quantities of industrial data and inefficient workflows required for timely action. GE's Industrial Internet Control System solutions solve this problem by augmenting real-time control with external intelligence delivered through market analysis, fleet and enterprise data, and asset/process knowledge, allowing for dynamic adaption to changing business objectives.

Field Agent Technology

The next layer of secure connectivity

Maximum potential.

GE's Field Agent technology is the critical link required in an IIoT chain for cloud and edge physics-based analytics. Both stand-alone Field Agents and embedded Field Agent technology provide a robust solution for pre-configured connectivity and secure data collection, and conveyance from the machine.

Use Field Agent to connect to nearly any industrial asset and leverage Predix, GE's Industrial Internet software platform to collect data, analyze trends, and uncover insights that improve asset performance. Streamline operational processes and optimize maintenance scheduling by incorporating real-time external intelligence into your process control system to maximize profitability and generate new sources of revenue.

WHY GE CUSTOMERS CHOOSE FIELD AGENT TECHNOLOGY:

- **Process optimization.** Leverage real-time feedback loops, live market data, and fleet-based analytics by running smart applications in the cloud or at the edge.

- **Data visualization in minutes.** Field Agent technology seamlessly integrates control with GE's complete suite of asset performance management tools, right out of the box, even across disparate systems.

- **Centralized deployment of apps and firmware upgrades.** Remotely manage security and software upgrades across thousands of devices, simultaneously.

- **Analytics in the Cloud or at the Edge.** Use GE's ready-made data monitoring and analytics applications or create your own with Predix.

- **Remote asset management.** Predict failures before they happen using physics-based analytics backed by GE's deep domain expertise of industrial assets.

- **Improved operational insight.** Analyze and optimize even the most complex application right at the source using GE's Industrial Cloud suite of advanced analytics tools.

- **Security.** Achilles certified hardened network stack and built-in firewall

Field Agent Technology

The next layer of secure connectivity

Field Agent technology leverages GE's Predix Platform to easily collect and analyze large quantities of data in the cloud or at the Edge to help businesses realize greater profitability and new revenue streams. Build out remote monitoring and diagnostics capabilities safely and securely, utilizing encrypted channels that preserve data time stamp, quality and fidelity.

Accessing and utilizing data from distributed systems to implement fast, informed operational decisions is a key differentiator for digital industry. Creating a secure link directly between the machine and asset optimizing analytics makes it possible to visualize performance and dynamically optimize uptime and productivity. Incorporate Field Agent technology into your system and proactively improve operations and maintenance by enabling intelligent machines that grow service revenue and help to win new business.

Multiple Connectivity Options
Field Agents can talk to over 150 different communication protocols. GE provides isolated RS232, RS485, USB2.0 and CAN bus. Support is available for both serial and Ethernet based networks to enable communication to a wide variety of industrial assets.

Designed with Security in Mind
Trusted platform module provides secure cryptoprocessor technology.

Direct I/O Connection
Slice I/O can be connected directly to the Field Agent to collect direct sensor data.

Ethernet or Cellular
Connect through either four Ethernet ports or cellular, and work reliably in both plant settings and in remote locations.

Predix Machine Built-in
Connect to GE's Predix platform to utilize smart apps at the control layer.

Rugged Design
Fanless design supports wide temperature ranges, industrial shock and vibration levels.

Store & Forward
Built-in Historian collector ensures you never lose valuable asset data, even during network disruptions.

FIELD AGENT FORM FACTORS

Advance existing technology or create an Industrial Internet Control System by deploying IICS hardware with embedded Field Agent software. A variety of form factors, protocols, and memory types are designed to support most industrial applications.

MINI FIELD AGENT

Stand-alone Field Agent technology ideal for pairing with traditional control systems

OUTCOME OPTIMIZING CONTROLLER

Hypervised controller with embedded Field Agent Technology

CONTROL SERVER

Server grade supervisory control system incorporates virtual Field Agent technology

Smart apps. Smarter control.

Field Agent Technology enables businesses to create Smart Control systems by utilizing apps like GE's Asset Performance Management Suite, Equipment Insight, Control System Health, and other custom built analytics that help improve operational insight and reduce unplanned outages.

Analyze and optimize even the most complex application right at the source using or building upon GE's Industrial Cloud suite of advanced analytics tools. Leverage real-time feedback loops, live market data and fleet-based analytics by running smart applications in the Cloud or at the Edge.

ASSET PERFORMANCE MANAGEMENT (APM) SUITE

GE's suite of cloud-based software and service solutions help asset-based industrial companies increase uptime, decrease costs, and reduce operational risks.

EQUIPMENT INSIGHT

Out-of-the-box remote monitoring solution helps deliver new forms of revenue by enabling OEMs to evolve from just building and servicing machines to selling and delivering a service.

CONTROL SYSTEM HEALTH

Smart App for monitoring controller health allows for collection and aggregation of controller status data, making it possible to scan and mitigate critical faults and formulate service recommendations across distributed systems, enterprises, or fleets.

USER DEVELOPED CUSTOM APPS

Leverage GE's Predix Platform and Field Agent connectivity to develop lightweight custom tools that optimize machine performance and simplify development, commissioning, and maintenance.

A new paradigm for control

GE's Outcome Optimizing Controllers address this challenge by augmenting real-time control with external intelligence delivered through market analysis, fleet and enterprise data, and asset/process knowledge, allowing for dynamic adaption to changing business objectives.
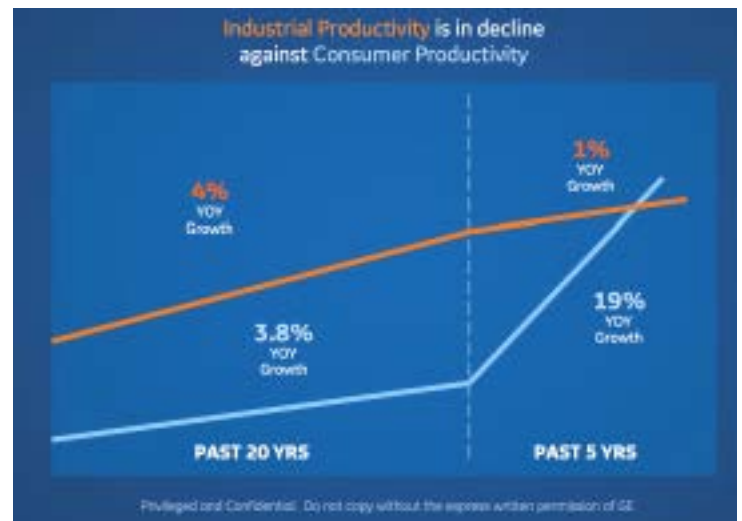
Outcome Optimizing Control

The next level of secure connected performance

Bridge the productivity gap.

Improve operational efficiency, optimize production, and unlock new revenue potential by leveraging advanced data analytics through GE's Industrial Internet Control System.

Employing a real-time hypervisor with embedded Field Agent technology, GE's Outcome Optimizing Controllers allow for safe and secure communication using either cloud-based or edge-based outcome-optimizing apps. Control can now be programmed to dynamically influence business outcomes, generate new forms of revenue, and improve profitability.

WHY GE CUSTOMERS CHOOSE OUTCOME OPTIMIZING CONTROL

- **Reduced risk.** Built-in security protocols and a broad suite of cyber-security technology and tools help protect against attacks, prevent unauthorized code and application updates, and protect against man-in-the-middle and denial of service attacks.

- **Reduced lifecycle cost.** Advanced functionality simplifies system architecture leading to a reduction in engineering costs. Additionally, our outcome optimizing controllers can provide software upgrades, patches, and antivirus updates from a central location, with minimal system disruption.

- **Decreased time to market.** Scalable performance and multiple form factors support a wide variety of industrial applications.

Outcome Optimizing Control

PACSystems RX3i

Adapt processes faster by combining actionable data with dynamic, real-time control.

GE's PACSystems* RX3i is a flexible and high performance control system that is widely used in a diverse range of applications including water–wastewater, metro, industrial steam, automotive, chemical, oil and gas, discrete manufacturing and modular machine designs. These diverse applications require a compact controller that can deliver the high performance and flexibility needed to run application specific control reliably.

The PACSystems RX3i CPE400, part of GE's Industrial Internet Control System, is the industry's first outcome optimizing controller. It augments real-time deterministic control with embedded Field Agent technology, delivering near- real time advice through market analysis, fleet and enterprise data, or asset/process knowledge to optimize the outcomes that today's businesses require. The Predix enabled CPE400 provides reliable, secure communication and analytics using either cloud-based or edge-based outcome optimizing apps. Controls can now be programmed to dynamically influence business outcomes, generate new forms of revenue, and improve profitability.

Small Footprint
Maximize limited cabinet space. DIN-rail mounting for ease of installation

Mix and Match I/O
Use integrated PROFINET with MRP for high speed connections to our RSTi-EP, RX3i, or VersaMax I/O

Ethernet Everywhere
Gigabit connections with integrated switches provide connections for controlling I/O, direct messaging, or handling of data. Uses TSN technology to allow multiple protocols over 1 wire without impacting performance.

Rugged by Design
Built for harsh environments using COM Express technology. Extended temperature range for your most demanding applications
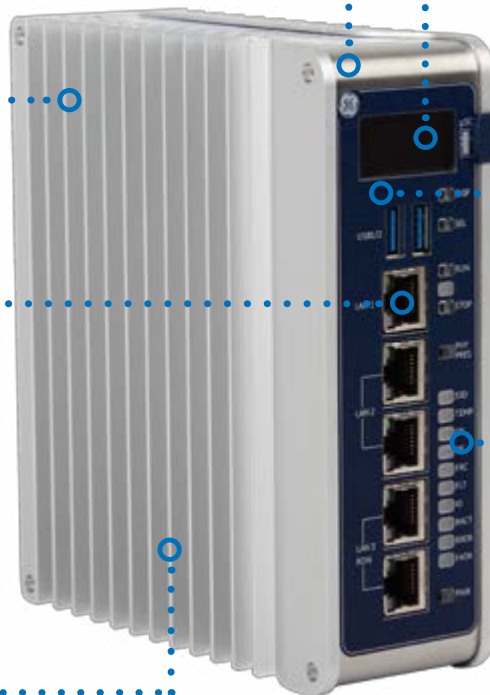
Diagnostic Display
Instant error diagnosis for rapid commissioning and maintenance

Advanced Security
- Achilles certified for robustness against service attacks
- Secure boot to prevent malicious applications and "unauthorized" operating systems
- Trusted Platform Module (TPM) on board

Real Time Virtualization (Predix Enabled)
Quad core processor with embedded hypervisor and PREDIX embedded provides ability to safely add apps running in parallel with the main control. Load PREDIX CLOUD services apps for analysis and action

INDUSTRIAL INTERNET CONTROL SYSTEM (IICS)

Build an Industrial Internet Control System (IICS) starting with GE's world-class RX3i and Mark VIe industrial control systems. Add Outcome Optimizing Control to leverage GE's Predix Analytics suite at the Edge and in the cloud to help improve profitability, reduce downtime, and lower operational costs.

RX3i CPE400

Quad-core controller for high performance PLC in infrastrucure applications with embedded Field Agent technology

RX3i 300CPU & MINI FIELD AGENT

Traditional control can be paired with stand alone Field Agent for Predix-enabled analytics

Smarter control.

RELIABLE, HIGH-SPEED PERFORMANCE

Analyze and improve even the most complex application right at the source or push to the cloud using Predix cloud-connected services.

APPLICATION SPECIFIC CONTROL

Outcome optimizing controllers are ruggedized for uninterrupted data collection, reliable performance, and are customizable to fit your application.

SECURITY

A centralized configuration allows patches and updates, including antivirus updates, to be excuted from a central location. A broad suite of cyber-security technology and tools help prevent unauthorized access.

CONNECTIVITY

For Industrial Internet connectivity, outcome optimizing controllers include Virtual Field Agent technology as a platform for applying Predix applications and connectivity to the Predix Cloud.

Outcome Optimizing Control

Mark VIe

Application specific control

GE's Mark VIe control system is an integrated control system that is widely used in a diverse range of applications including gas and steam turbines, safety systems, wind turbines, gasification, hydro, nuclear, and combined cycle power plants. These diverse applications require a compact controller that can deliver the high performance and flexibility needed to reliably run application specific control.

The Mark VIe UCSC runs on a real time operating system for high-speed, reliable, industrial applications. It can be configured for simplex, dual, or triple redundant operation, at incremental frame rates as fast as 10ms in any configuration. Since synchronization is important for high performance turbine control applications, the UCSC synchronizes the local processor clocks on the I/O modules.

Outcome Optimizing Controls offer advanced capabilities that simplify system architecture and dramatically reduce applied engineering costs. Mark VIe UCSC's flexible design allows for use in turbine control applications, and also for DCS applications, especially in steam and gas power plants. The native PROFINET capability on the UCSC provides productivity and performance advantages necessary for DCS and BoP control applications for power generation.

Small Footprint
Maximize limited cabinet space. DIN-rail mounting for ease of installation

Mix and Match I/O
Use integrated PROFINET with MRP for high speed connections to our RSTi-EP, RX3i, or VersaMax I/O

Ethernet Everywhere
Gigabit connections with integrated switches provide connections for controlling I/O, direct messaging, or handling of data. Use TSN technology to allow multiple protocols over 1 wire without impacting performance

Rugged by Design
Built for harsh environments using COM Express technology. Extended temperature range for your most demanding applications

Advanced Security
- Achilles certified for robustness against service attacks
- Secure boot to prevent malicious applications and "unauthorized" operating systems
- Trusted Platform Module (TPM) on board

Real Time Virtualization (Predix Enabled)
Quad core processor with embedded hypervisor and PREDIX embedded provides ability to safely add apps running in parallel with the main control. Load PREDIX CLOUD services apps for analysis and action

INDUSTRIAL INTERNET CONTROL SYSTEM (IICS)

Build an Industrial Internet Control System (IICS) starting with GE's world-class RX3i and Mark VIe industrial control systems. Add Outcome Optimizing Control to leverage GE's Predix Analytics suite at the Edge and in the Cloud to help improve profitability, reduce downtime, and lower operational costs.

MARK VIe UCSC

Quad-core controller for high performance PLC in infrastrucure applications with embedded Field Agent technology

MARK VIe UCSB & MINI FIELD AGENT

Traditional control can be paired with stand alone Field Agent for Predix-enabled analytics

Advanced Connectivity

RELIABLE, HIGH-SPEED PERFORMANCE
Reduced risk. Built on the strong foundation of GE's 40 years of experience providing real-time, deterministic controls for the world's industrial assets. The controller is secure by design, enabling secure operations and connectivity from Edge to Cloud.

REDUCED LIFECYCLE COST
Advanced capabilities simplify system architecture and help to reduce applied engineering costs. Costs are further reduced with embedded PROFINET, allowing a choice of dedicated I/O for application specific needs.

OPTIMIZED BUSINESS OUTCOMES
Embedded Field Agent technology allows for secure connection to the Industrial Internet, leveraging data to analyze and optimize business operations. For Industrial Internet connectivity, outcome optimizing controllers include Virtual Field Agent technology as a platform for applying Predix applications and connectivity to the Predix Cloud.

Traditional Controls Portfolio

GE's legacy of high performance industrial computing platforms

PACSystems RX3i

CRITICAL CONTROL FOR ADVANCED APPLICATIONS

APPLICATIONS

GE's RX3i control systems combine secure redundancy and advanced computing to provide the highest level of availability for critical infrastucture. Fast, easy-to-configure connectivity to GE's PACSystems controllers and extensive range of I/O options enables scalable machine automation and highly distributed modular machine designs. Analyze and improve even the most complex application right at the source. RX3i CPUs offer multiple processing cores, allowing greater capability in a smaller footprint. Store more data and access it faster than ever before. RX3i offers premier high speed performance and data handling across any multi-disciplined control system.

MAJOR SOLUTION BENEFITS

- Maximized uptime – Best in class high availability control solution is designed for maximum uptime and concurrent maintainability.

- Flexibility – Open and scalable architectures built on advanced technology allow for greater efficiency and lower total cost of ownership to protect current and future investments.

- Intelligence – Advanced computational capability provides the granular data needed for predictive analytics for better, faster decision making.

Mark VIe

OPTIMIZED PERFORMANCE, ADVANCED OPERABILITY, AND SAFETY FOR POWER GENERATION APPLICATIONS

GE's Mark VIe solution provides advanced operational capabilities to the entire fleet, including balance of plant equipment, machine controllers, and dedicated control for critical components. Flexible architecture enables optimal solutions from the traditional unit controls to complete plant solutions for optimized performance, advanced operability, and high availability. Mark VIe is widely used in a diverse range of applications including gas and steam turbines, safety systems, wind turbines, gasification, hydro, nuclear, and combined cycle power plants. These diverse applications require a compact controller that can deliver the high performance and flexibility needed to reliably run application specific control.

MAJOR SOLUTION BENEFITS

- Single user interface and tools across system for reduced training costs and improved operator productivity.

- Improved root cause analysis, diagnostics and overall operational decisions

- Reduced project risks and integration cost

VersaMax

SUPERIOR VERSATILITY

APPLICATIONS

VersaMax controllers provide powerful, reliable operation. Designed to minimize costs, these versatile controllers are easy to use and support, and offer a wide range of I/O expansion modules and communications options.

VersaMax Modular is control and IO that can be snapped together to provide a compact node with a smaller footprint than typical control/IO combinations.

The Micro line of VersaMax controllers provide superior functionality in a compact package. Their modular design offers the features and flexibility to match your application needs, with fast cycle times, a robust instruction set, and extensive memory that expands programming options. Programming and configuration is simple and intuitive with Proficy Machine Edition software.

PAC8000

RUGGED PERFORMANCE

APPLICATIONS

PAC8000 controllers are specifically designed to handle the extreme temperatures, vibration, and corrosive materials found in process applications. They include a process controller featuring DCS-style function block programming, a logic controller with 61131-style PLC programming, and a hybrid controller that provides the capabilities of both.

Network redundancy helps assure uninterrupted communications. PAC8000 controllers each have two fault-tolerant Ethernet ports to provide redundant communication LANs. If a fault occurs in one LAN pathway, communication is automatically re-routed.

PAC8000 controllers communicate directly with each other and share data on a peer-to-peer basis without having to route data through a centralized database or server.

PAC8000 Controllers can pass HART data from smart field devices to asset management software applications, allowing remote configuration and access to field instrument diagnostic information. PAC8000 controllers can also acquire HART data for use in the process control application.

Control Server

High Capacity Edge Computing

Securely deploy, design, and maintain advanced systems by incorporating multiple supervisory control applications into one easy-to-maintain virtualized server. Control Server, with Field Agent technology, is GE's highest capacity cloud-connected, edge-computing platform. Control Server operates on a server class PC to integrate the features associated with engineering and operator workstations, historians, and advanced communication gateways with new capabilities from GE's Predix analytics platform.

Predix* Cloud Connectivity
Analytics, RM&D, APMMBOC & Digital Twin

Easy Expansion
Expand your system to meet specific application needs by adding client stations or servers in a cost-effective manner

Built for Security
Provides easier user management and enables Secure mode for the controller

Improved Maintainability
Industry standard server, leveraging hypervisor, enables centralized management of configurations and easy path for migration solutions

Powerful Computing Capability
Server-grade platform hosts multiple virtual machines for Field Agent, Predix apps, supervisory control functions, and historical data storage and analytic tools

Increased Reliability
Available in both simplex and redundant forms with high availability options to best fit the needs of the application
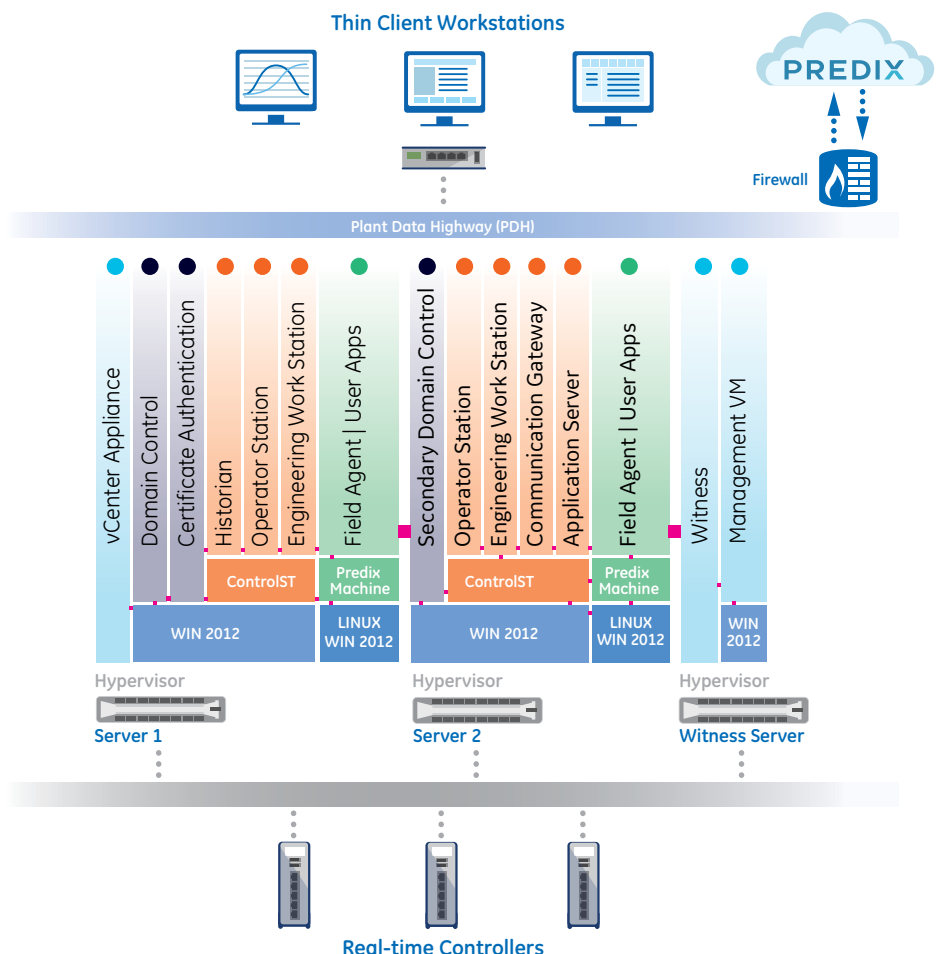
Smart Applications Powered by Predix

Virtualization technology makes it possible to leverage the vast computing power of the control server to optimize asset performance, focusing on critical metrics like output efficiency and part life. Built-in Field Agent technology makes it possible for Control Server market conditions (e.g. cost of electricity and natural gas) in conjunction with maintenance schedule (e.g. next shutdown) to optimize an overall business outcome.

CONTROL SERVER

Server grade supervisory control system incorporates virtual Field Agent technology.

MARK VIe UCSC

Predix-ready Real-Time controller for turbine and DCS control applications. Embedded Field Agent technology.

INCREASED RELIABILITY & PRODUCTIVITY

Centralized server-based architecture consolidates traditional PC-based workstations into a server class machine that provides simpler lifecycle maintenance and improved security for distributed control systems. High availability options assure reliable uptime for all functions.

EXTENSIBLE, TOTAL PLANT DCS

Simple system expansion with deployment of additional clients or server hardware as needed. Small hardware footprint supports easy installation.

CENTRALIZED DEVICE MANAGEMENT

Unlike traditional architectures that rely on separate workstations throughout the plant floor, the centralized architecture of GE's Controls Server allows for managed control of all software and versions. Remotely manage security and software upgrades across your control system.

DEFENSE-IN-DEPTH SECURITY

Security and antivirus protection are implemented from a centralized and secured server. Primary and secondary domain VM controllers are included for improved user and password management of the system. A certificate server is also included to provide a secure connection by enabling secure mode communication with Mark VIe controllers.

CONNECTIVITY

For Industrial Internet connectivity, Virtual Field Agent technology is included in the controls server as a platform for applying Predix applications and as communication connectivity to the Predix Cloud.

Smart Sensors: I/O Solutions

Powerful Flexibility

Automation & Controls' innovative I/O solutions combine a clean layout and outstanding response time while providing powerful redundancy, high density, and small footprint options. Intuitive I/O mapping options simplify installation and maintenance.

Factors such as performance requirements, environmental constraints, space limitations and cost can be a real challenge when connecting control systems to real-world sensors and actuators. Most industrial applications require a mix of I/O connectivity for basic control functions as well as robust, harsh-environment connectivity that can be deployed seamlessly and cost-effectively.

Hot Swap Capability
Easily diagnose and resolve disturbances without impacting sytem operation

Wide Ranging Communications Options
PROFINET RT, PROFIBUS, Modbus TCP, EtherCAT

Remote Diagnostics
Easily troubleshoot and maintain with integrated web server

SIL3 Machine Safety
Seamlessly integrate safety functions alongside standard I/O in one drop

Small Footprint
Maximize limited cabinet space

On-module LED
Instant error diagnosis, rapid commissioning and maintenance

MARK VIe DISTRIBUTED I/O

High-speed, networked I/O for simplex, dual, and triple redundant systems.

RX3i I/O

Rack-based I/O offering advanced diagnostics and outstanding flexibility, with a wide range of standard and advanced I/O.

RSTi-EP I/O

Slice I/O featuring an extended operating temperature range, enhanced diagnostics, plug-and-play

connectivity, and high channel density.

UNIVERSAL I/O

Instantly define or redefine sensory I/O connection for highly flexible data acquisition.

Smarter Architecture

From compact slice I/O to triple-redundant solutions, GE's flexible I/O portfolio encompasses a wide range of form factors, feature sets, and price points to fit any industrial application.

PRODUCTIVITY AND PERFORMANCE

Support for common communication options, modularity, simple scalability, improved availability, and simplified maintenance make our I/O solutions an ideal choice for enabling powerful performance improvements.

FLEXIBLE REDUNDANCY

Open architecture allows for a mix of redundant I/O to meet application requirements for footprint, performance, environment, node distances, and price point. Customize your level of redundancy to meet reliability needs for both safety and process control.

BETTER INSIGHT

Take your control system to the next level with advanced capabilities like remote monitoring and diagnostics, asset optimization, and predictive analytics. The freedom to place application-specific I/O in the right spot in a control design enables the design flexibility needed to unlock the full potential of connected control system solutions.

Industrial Computing Platforms

Rugged, high performance industrial computing platforms

The RXi IPC platform is based on GE's flexible COM Express technology. COM Express architecture extends the useful life of the IPC and future-proofs your system by allowing for fast and easy updates without retooling. As technology evolves, only the COM Express module changes. The rest of the IPC, wiring, and footprint remain the same, lowering recertification costs and reducing total cost of ownership.

GE IPCs are designed and built for maximum reliability and system uptime. They feature a fanless, solid state design and are constructed from industrial-strength components. The CPU and memory are soldered to the board, boosting reliability and resistance to shock and vibration. Patented heat dissipation technology allows RXi IPCs to perform in extreme temperature conditions.

Pre-Integrated Software Options
Preloaded with HMI/SCADA and Historian software

Flexible Performance
Dual or Quad cores provide computing power needed for the most demanding applications

Compact Form Factor
Maximizes limited cabinet space

Expandable
4 or 8 GB of storage: SSD drives, multiple Ethernet interfaces: expansion slots

Fanless Cooling Technology
For extreme temperature operation (-40°C to +85°C)

Rugged Design
Reliable performance in harsh environments

Complete Customization
Build-to-suit a wide variety of environments and application requirements

RXi-EP SLIM

Compact, rugged and highly versatile computing

RXi-XR

High performance computing, designed and certified for rail application

RXi-XP

Highest performing Industrial PC

with expandability

RXi-EP

Expandable Industrial PC ideal for collecting and analyzing data

The Power to Outperform

RXi IPCs are available pre-loaded with Proficy HMI/SCADA software, Historian, and other GE applications to create a customized solution for today's industrial operations.

THE POWER TO OUTPERFORM

The RXi industrial computing platform delivers compact, rugged, high-performance computing capabilities to run HMI, historian, and analytics applications right at the machine. The result is improved real-time control of operations and better integration into plant-wide systems. RXi IPCs are available preloaded with iFIX*, CIMIPLICITY*, or Proficy Historian software for better visibility into your system, lower integration costs, and faster time to market.

INNOVATIVE COMMUNICATION

Options include Bluetooth, modem, and direct connection to your handheld device for access to actionable data anytime, from anywhere. RXi IPCs can also be configured to enable GE Remote Monitoring & Diagnostics solutions for both users and OEMs.

Automation Panels

High Performance Connectivity

Automation & Controls' QuickPanel+* automation panels streamline operation and simplify development and maintenance by combining operator interface technology (OI) with control requirements. QuickPanel+ is an all-in-one device: an OI/HMI, a PLC/process controller, machine gateway, and a data historian. Featuring the latest touchscreen technology, it provides the high performance, connectivity and user experience expected in today's increasingly connected industries. QuickPanel+ delivers precision, speed, and flexibility even in third-party environments.

Compatibility with Third-Party Ethernet

Allen-Bradley ControlLogix	GE Ethernet Global Data	Omron FINS Ethernet	Simatic 505 Ethernet	Yaskawa MP Ethernet
Allen-Bradley Ethernet	Honeywell HC Ethernet	Omron Host Link	SIXNET EtherTRAK I/O	Yokogawa DX Ethernet
AutomationDirect EBC	Mitsubishi Ethernet	Omron Process Suite	Telemecanique Uni-Telway	PROFINET (Coming Soon)
AutomationDirect ECOM	Mitsubishi FX Net	Siemens TCP/IP Ethernet	UCON-User Configured	
GE Ethernet	Modbus Ethernet	Siemens TCP/IP Unsolicited	Driver	

Certified

- UL C1D2, C2D2, C3D1
- UL Type 4X
- DNV (Pending)
- ABS (Pending)
- ATEX Zone 2 (12&15")
- RoHS
- IP65f

Webserver, Web browser, HTML5 Dashboards, SNMP, VNC, Email (SSL), SECOMEA, Historian Collector

Multi-Touch, Capacitive Screen, Built in controller, multimedia, USB access. (CAN, Ethernet, Serial, Wifi), SD Card, adjustable sensitivity

Compatibility with Third-Party Serial

Allen-Bradley DF1	GE SNPX	Omron FINS Serial
Allen-Bradley DH485	Mitsubishi FX	Siemens S7 200
AutomationDirect DirectNet	Mitsubishi Serial	Siemens S7 MPI
Cutler-Hammer D50/300	Modbus ASCII	Simatic 505 Serial
GE CCM	Modbus RTU Unsolicited	SquareD Serial
GE SNP	Modbus Serial	UCON-User Configured Driver

QUICKPANEL[+]

The QuickPanel[+] is a high-performance controller with built-in HMI functions. It supports 5 IEC 61131-3 programming languages: Ladder Diagram (LD), Sequential Function Chart (SFC), Structured Text (ST), Instruction List (IL), and Function Block Diagram (FBD).

QUICKPANEL[+]
AS A CONTROL SOLUTION

QuickPanel[+] can be used as a compact controller combining the features and capabilities of a typical programmable logic controller (PLC) with an operator interface. The result– a simple, cost-effective, all-in-one control solution.

15"

12"

10"

7"
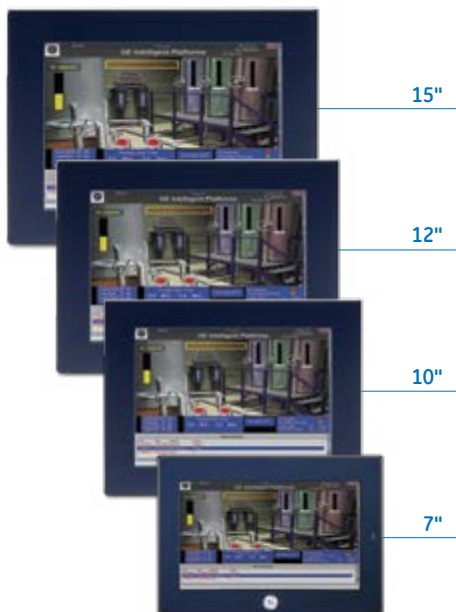
Unmatched capability

Today's engineers and operators expect the latest functionality– on the floor and in the field. QuickPanel[+] incorporates the latest display and multi-touch technology to provide an exceptional user experience. The capacitive, multi-touch screen is built to last in an industrial environment, yet is as sensitive as a smartphone or tablet.

SIMPLE BY DESIGN

QuickPanel[+] makes it simple to interact with data from connected machines without IT support. QuickPanel[+] provides the functionality of a PC, but boots up in seconds. A multi-touch, capacitive touch-screen means it's easy to navigate system-wide data.

EASY TO CONFIGURE

A common database reduces development time by eliminating the need to re-enter tag names, and an extensive library of preconfigured animation objects is provided. It's even possible to select multi-language support when the system is online.

CONNECT PEOPLE AND MACHINES

QuickPanel[+] interface runs on top of Windows® Embedded Compact 7 and offers a fully-functional web browser and multimedia support. Publish dynamic web reports and HTML5 Dashboards for viewing from any device, with intranet or Internet access. Access training videos, technical documentation and other critical information via a secure network connection.

GREATER FLEXIBILITY

Plug-and-play interoperability results in ease of use and implementation. Using serial and Ethernet connectivity, QuickPanel[+] can be used with controllers and I/O from multiple vendors for swift and smooth integration, even in complex systems. Enjoy the functionality of a PC– such as remote desktop, web browser, built-in peer networking and FTP and HTTP servers– without the IT headaches.

IICS for Steam Turbine Applications

GE's legacy of high performance industrial computing platforms

Boiler

Monitoring & Diagnostics

Compressor

Steam Turbine

Generator

Electrical Balance of Plant
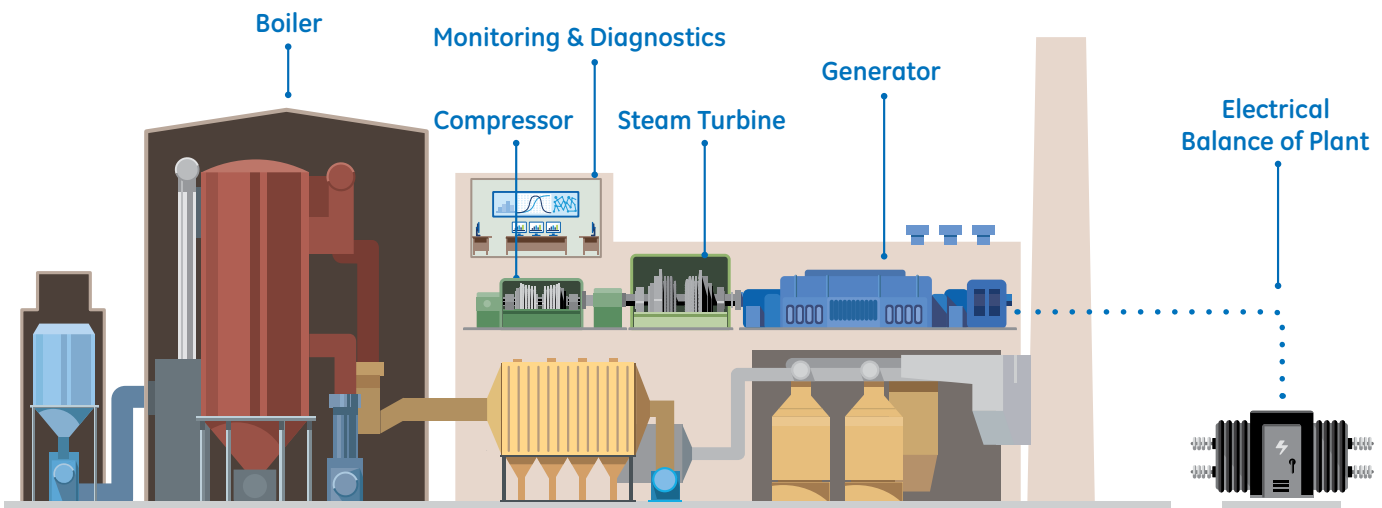
DIGITAL INDUSTRIAL STEAM

As the first manufacturer of the steam turbine in 1902, GE extends your reach by utilizing global scale to quickly service your steam turbine fleet. GE has a solid foundation with more than 142 years of experience with rotating equipment. Global locations enable us to ensure a fast response time. All steam turbine auxiliary systems are fully warranted by the GE brand.

GE has partnered with multiple steam turbine OEMs and Woodward to deliver a range of turnkey solutions for industrial steam control, including new unit applications and retrofit. GE's Industrial Steam control solutions have been tailored to applications where control of parameters like turbine speed, turbine load, turbine extraction header pressure, turbine inlet header pressure, exhaust header pressure, or tie-line power are critical.

DIGITAL TWIN

Additionally, to help customers realize the full potential of their assets, GE has developed the concept of the Digital Twin (DT). DT is grounded in a set of technologies and software that meet customers where they are today in their adoption of digital, and provides an environment to innovate and grow in both sophistication and breadth of solutions. GE's Industrial Internet control system
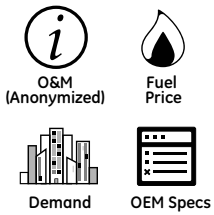
incorporates a real time feedback loop that allows processes to dynamically adjust with changing business objectives to help improve profitability and generate new sources of revenue.

WHY CUSTOMERS CHOOSE GE FOR INDUSTRIAL STEAM CONTROL:

- Increase availability & reliability (redundancy, mechanical upgrade, etc.)
- Increase safety (redundancy, SIL 3, trip bloc, etc.)
- Increase efficiency
- Simplified operation (user friendly interface) & maintenance (alarms, SOE, etc.)
- Reduce outage duration
- Cyber security
- Increase profitability (digital twin, etc.)
- Environmental compliance
- Delivering consistent MWh output
- Multiple competencies including mechanical upgrades, I&C, process knowledge
- OEM of the used electronic controller

DATA LAKE

EXTERNAL DATA

O&M (Anonymized) Fuel Price

Demand OEM Specs

MACHINE & EQUIPMENT DATA

Sensors DCS

Controls OSM

Plant Profiles Historian

PREDIX

Secure Edge Computing & Advanced Control

Operations Executive Plant Manager Lead Engineer

OPERATIONS OPTIMIZATION	PRODUCTIVITY

Operations Evaluation

Performance Optimization

Outage Planning*

Emissions & Regulatory*

PRODUCTIVITY

Reduced Fuel Consumption
Improved CapEx ROI
Increased MW Capacity
Lower Operating Costs
Lower Emissions
Dynamic Plant Flexibility

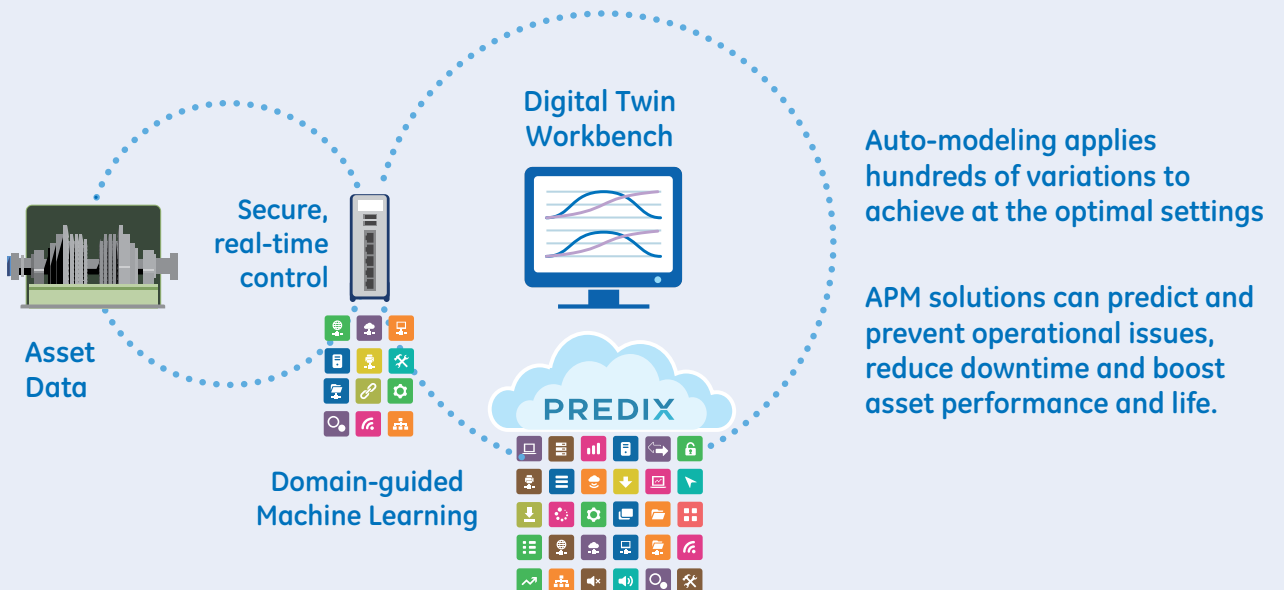Operations Executive Plant Manager Lead Engineer Asset Manager Safety Manager

ASSET PERFORMANCE MANAGEMENT	RELIABILITY

Machine & Equipment Health

Reliability Management

Maintenance Optimization*

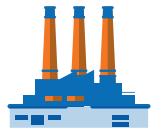**RELIABILITY**

Reduced Unplanned Downtime
Proactive Issue Identification
Improved Outage Planning
Reduce Maintenance Costs

Asset Data

Secure, real-time control

Digital Twin Workbench

PREDIX

Domain-guided Machine Learning

Auto-modeling applies hundreds of variations to achieve at the optimal settings

APM solutions can predict and prevent operational issues, reduce downtime and boost asset performance and life.

IICS for Power Generation

Capture Data to Increase Profitability

Using IICS, upgrades can be made to the plant without requiring a shutdown. This is the first opportunity of its kind in the power industry, where the bar has been lowered for making improvements– because it's no longer necessary to wait for the one-to-two times a year a shutdown is scheduled.
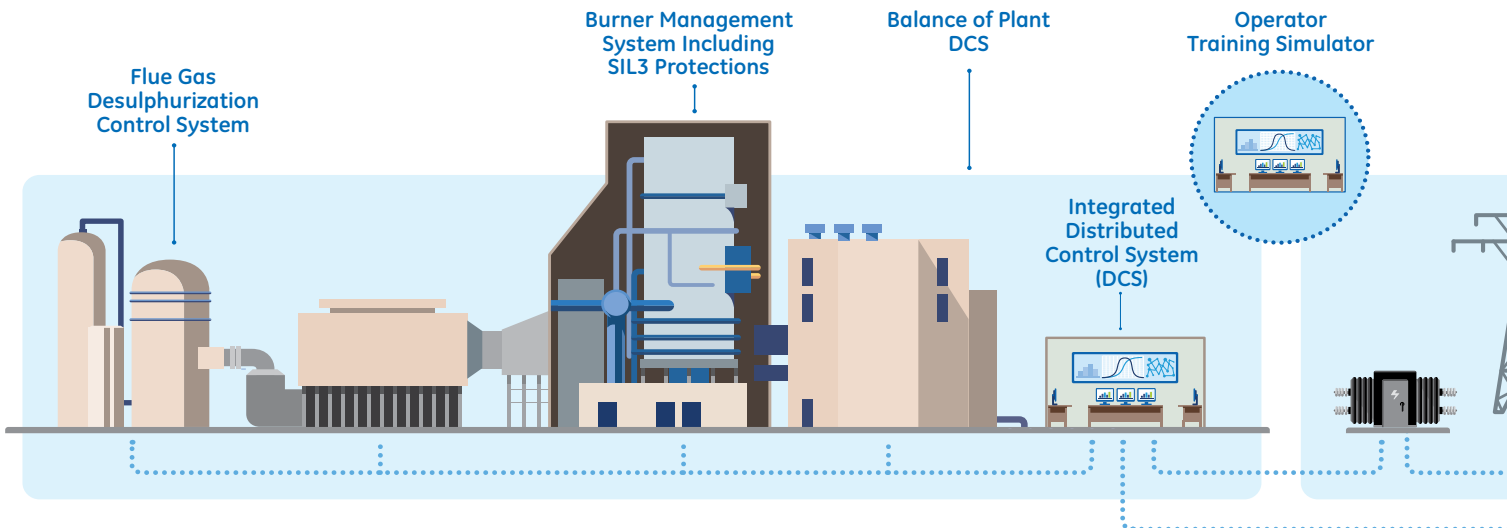
DIGITAL TWIN

To help customers realize the full potential of their facilities, GE has developed the concept of the Digital Power Plant (DPP). The DPP is grounded in a set of technologies and software that meet customers where they are today in their adoption of digital, and provides the environment to innovate and grow in both sophistication and breadth of solutions.
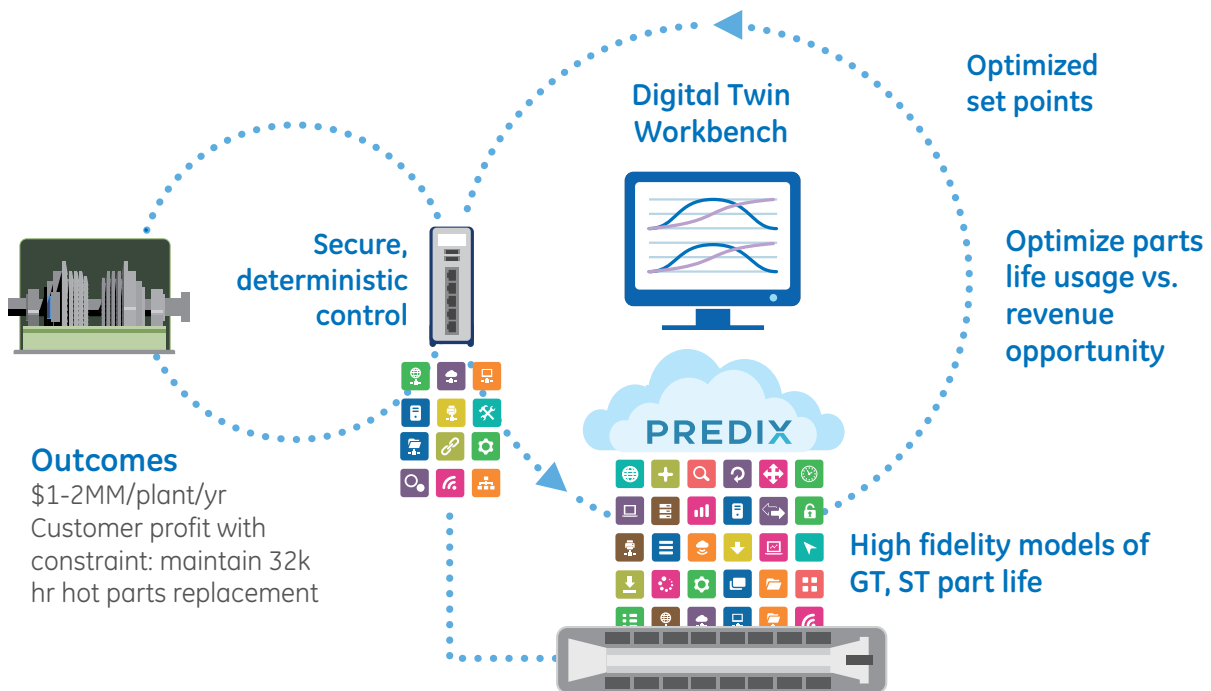
Automation & Controls is committed to fully supporting the Digital Power Plant strategy by delivering a state-of-the-art compatible suite of solutions for the plant automation, control and optimization.

GE's Power business is using IICS hardware to run an optimization application that provides service value for a combined cycle power plant.

The digital twin combines performance models of the

DIGITAL POWER PLANT

Traditional control systems look down to control the power plant to make sure it's safe, operating reliably, and performing per specification. Today's Industrial Internet Control System looks up to apply a broader context to day-to-day operation, by factoring in external data such as power prices, supply cost, and maintenance schedules, allowing users to run the plant differently based on external data. We are now connecting in a whole different context.

Flue Gas Desulphurization Control System

Burner Management System Including SIL3 Protections

Balance of Plant DCS

Operator Training Simulator

Integrated Distributed Control System (DCS)

ADVANCED CONTROL APPLICATION: GAS TURBINE COMBINED CYCLE PLANT

Digital Twin Workbench

Optimized set points

Secure, deterministic control

Optimize parts life usage vs. revenue opportunity

PREDIX

High fidelity models of GT, ST part life

Outcomes
$1-2MM/plant/yr Customer profit with constraint: maintain 32k hr hot parts replacement

entire plant with life models of the critical components. The real-time optimizer uses this digital twin with estimates of fuel costs and the price of electricity, to trade off between life of the parts and power output— essentially, maximizing power output when the price of electricity is high and conserving part life when the price is low.

The typical outcome is 2-3% additional output, or roughly

$15 million in additional revenue per power plant over the service contract term. Across the GE fleet, this amounts to $4 billion in additional revenues for our customers! What's even more impressive is that GE creates this level of value while maintaining, and in some cases, increasing productivity with GE service contracts.

Generator Excitation Control System

Monitoring and Diagnostics

Turbine Control Systems (x3)
• 1 Main Turbine
• 2 Boiler Feedwater Pump

Intentionally Blank

Plant Solutions

Control Technology for the Total Plant

Plant Solutions

OPTIMIZED PERFORMANCE, ADVANCED OPERABILITY, HIGH AVAILABILITY

Automation & Controls is a global leader in power generation with a portfolio of products covering all fuel types. From fossil and biomass to nuclear and renewables, more than 50% of the world's power production capacity depends on GE technology or services.
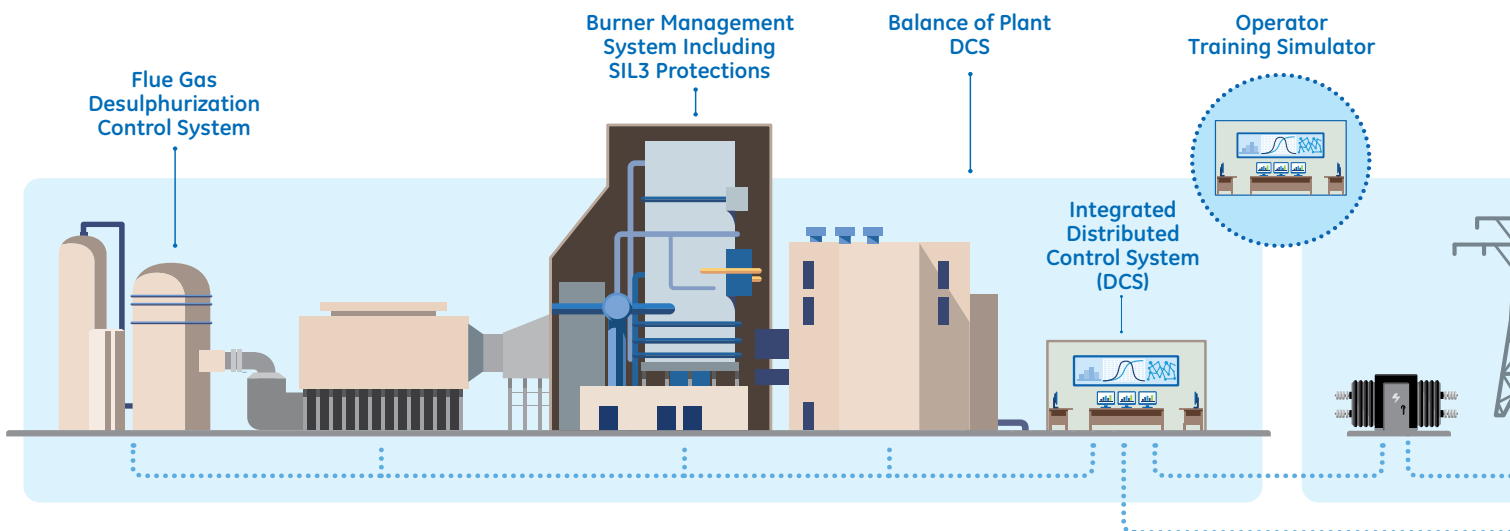
Whether in design, manufacture, procurement or servicing, GE is setting the benchmark for innovative technologies that provide clean and efficient power solutions. GE can supply anything from single components to complete turnkey power plants. Our Plant Integrator* approach and power automation and control solutions ensure the optimization of all elements to derive the maximum lifetime value from all our customer's investments.

GE has more than 100 years of experience in the engineering, procurement and construction (EPC) of new power plants. Our engineers are also experts in retrofitting, modernizing and servicing existing plants. With operations in 70 countries, GE is close to customers all over the world, ensuring rapid responses and service excellence at all times.

Our solutions are adapted to each plant and ensure the safe operation of the power generating unit. Our extensive know-how ensures high electrical quality and improves the efficiency of operation. Thanks to GE's plant process and design knowledge, operators can reap the maximum benefits from their power plants. Site security solutions help protect the plant from physical and logical intrusion.
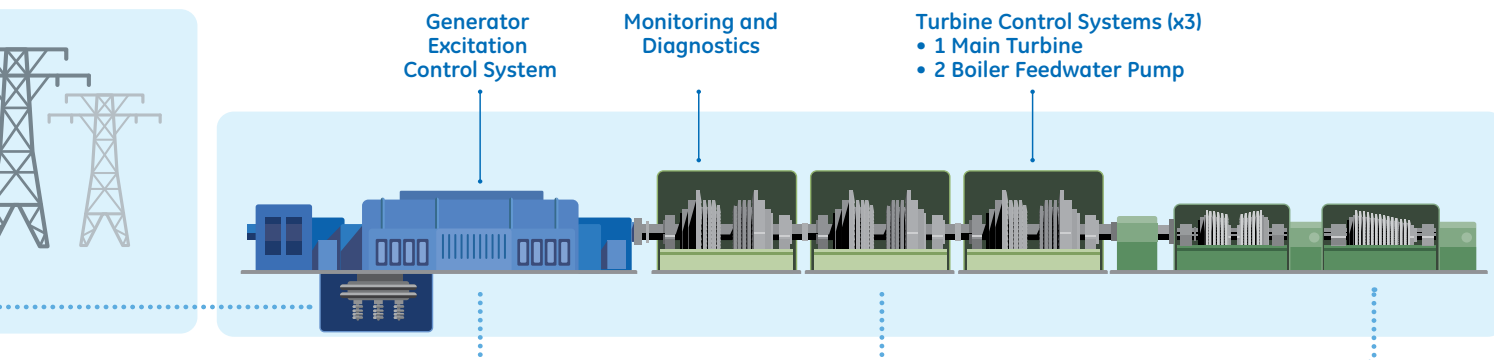
We can provide the following hardware and software solutions for your project:

- Distributed control systems
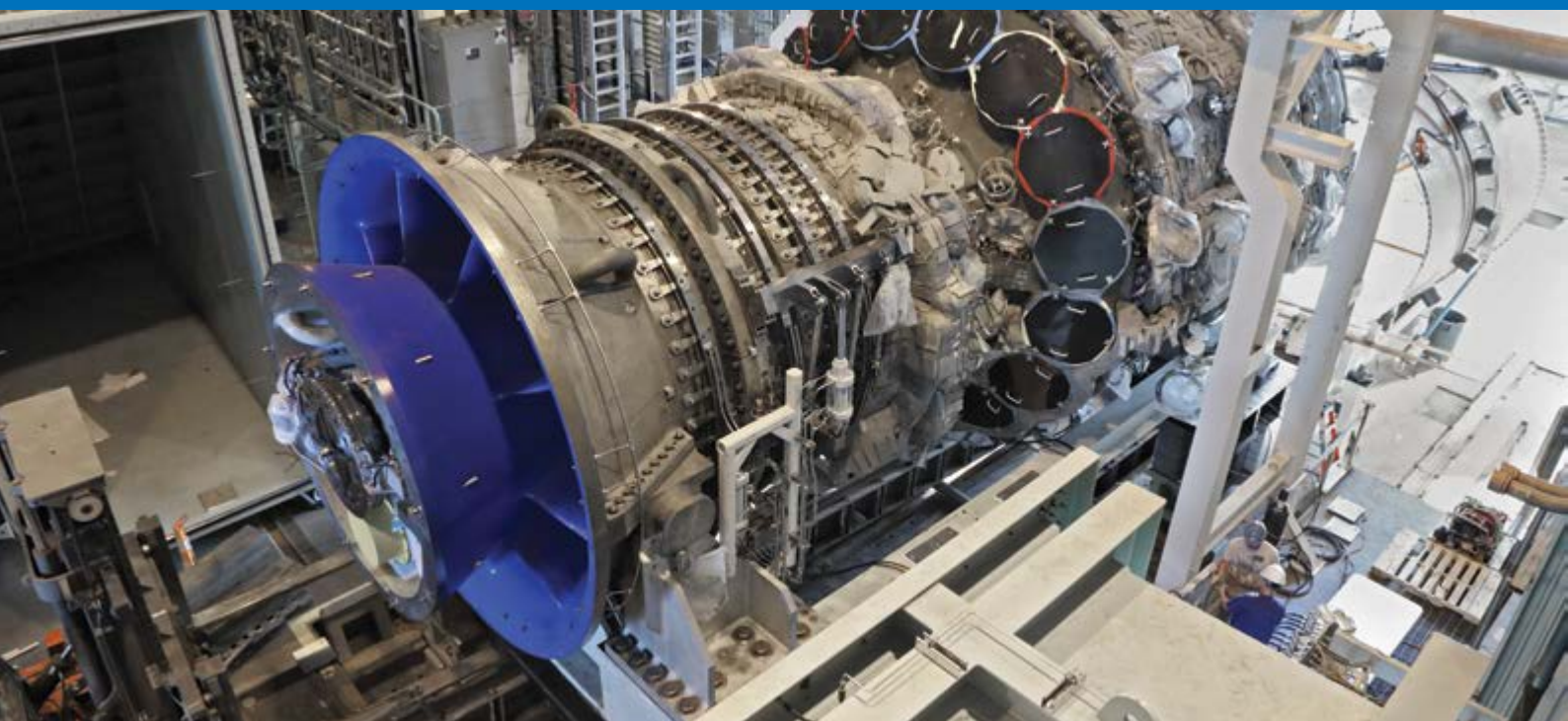- Turbine controllers
- Excitation systems

Flue Gas Desulphurization Control System

Burner Management System Including SIL3 Protections

Balance of Plant DCS

Operator Training Simulator

Integrated Distributed Control System (DCS)

PLANT SOLUTIONS CONTENTS

Generator Excitation Control System

Monitoring and Diagnostics

Turbine Control Systems (x3)
• 1 Main Turbine
• 2 Boiler Feedwater Pump

Turbine Control System

Single Integrated Solution for Safety & Control

GAS TURBINE CONTROL SYSTEM

With more than one hundred gas turbines sold per year around the world, GE's Gas Turbine Control System operates a wide range of gas turbines within various conditions and local regulations.

Today's biggest challenge is to match plant production to electricity generation demand with flexible rapid responses.GE's Gas Turbine Control System supports all the complex technologies to offer highest operational flexibility for the entire power plant, while boosting power and efficiency.

It provides advanced control algorithms that are used to implement standard closed and open loop controls such as:

- Optimized automatic startup with respect to the operating curves (temperature, etc.)
- Speed and load control
- Integrated vibration monitoring
- Integrated turbine protection

GE's Gas Turbine Control System is associated with GE's LX2100e Exciter and Starter equipment to provide a consistent solution for heavy duty gas turbines.

STEAM TURBINE CONTROL SYSTEM

GE's Steam Turbine Control Systems portfolio covers a wide range of steam turbines from the industrial units to the nuclear units, including turbo-compressors and turbo-pumps. Thanks to our controllers and IOs portfolio, Automation & Controls has developed a range of solutions adapted to each set of unique requirements.

SYNCHRONIZING SYSTEMS

GE's Mark VIe system features many options including a highly sophisticated unit synchronization system, used for turbines and generators around the world. When required, IO modules are included as part of the project and tightly integrated into the overall system design. This integration reduces the hardwiring interfaces typically required between systems. Integration of alarming, SOE, and equipment diagnostics is standard and part of the excitation system or the unit control.

INDUSTRIAL STEAM TURBINE

Automation & Controls provides all the functions for the industry that include automatic speed control, load control, and limitation, with a user friendly graphic interface to ease the operation and the maintenance of the unit. Based on a standard hardware and software configuration, additional features such as an electronic SIL3 overspeed protection may be provided with integrated test.

MEDIUM & LARGE STEAM TURBINE

Based on a standard redundant configuration, this scalable solution provides speed and load control with various limitations and includes all the steam turbine protection.

For maximum availability, the controller is also available in a full Triplicated Modular Redundancy, including a full TMR SIL 3 protection system with a normal overspeed protection and a backup overspeed protection.

The PC based graphic interface can be provided for local control or remote installation in a centralized control room. Some additional features such as Historian, and communication with third party equipment are also available.

NUCLEAR STEAM TURBINE

GE's control systems are used in dozens of nuclear power plants around the world. Thanks to this experience as the largest nuclear steam turbine manufacturer, GE has developed a strong expertise in qualifying control systems with respect to local regulations. Over the years, nuclear safety requirements have been reinforced and certain units' functions may need to be qualified according to the IEC 61513. GE's solutions for nuclear steam turbines are regularly improved to provide a high level of reliability and enable customers to meet the IEC61513 qualification.

Turbine Control System

Single Integrated Solution for Safety & Control

GE turbines generate 40% of the world's electricity. For more than sixty years GE has provided control and safety solutions for turbines of all sizes and applications. Today GE's Automation & Controls is an industry leader for every aspect of the power generation process, providing innovating features to maximize the turbine life and improve the reliability and the safety of customers' assets.

EXPERTISE

GE's solutions for turbine control are generated from a unique association of the turbine manufacturer's expertise and the control systems manufacturer's expertise that are enhanced within a community of GE's Experts (and ex-Alstom Power).

Our solutions are continuously improved to increase reliability and flexibility, and minimize unplanned outages while providing equipment designed for long term operation enabled by GE's product lifecycle policy and wide range of services.

AVAILABILITY

Avoiding unplanned outages is key. In addition to the highest availability features of Triple Modular Redundancy (TMR) architecture capability for asset control and protection, GE's Turbine Control Systems provide features for prevention and troubleshooting. Fast data recording with 1 ms time stamping and an advanced monitoring solution for real time analysis of data greatly simplify root cause analysis.

SAFETY

Without safety and security there is no sustainability. Safe operation is reinforced through IEC 61508 SIL3 Exida certified modules, fail-safe designs and TMR protection systems. GE's Turbine Control System with SIL-capable protection is designed for peace of mind, meeting the functional safety requirements of IEC 61508 and 61511. The Mark VIeS safety system is proven technology that has received the 2014 Exida safety award.

INTEGRATED SOLUTION

GE's Turbine Control System uses a common hardware and software platform with the GE DCS and Generator Control System and common configuration for both safety and control. This fully integrated solution provides single plant control for your most valuable asset, enabling comprehensive and connected plant automation powered by GE's Predix platform.

In addition, maintenance, diagnostics, spare parts, logistics, alarms, databases, and training are required for just one system— simplifying operations.

OPERATOR INTERFACE

Automation & Controls understands the importance of the operator interface. Turbine Control System mimics are designed and optimized to provide quick access to essential information, and easy to use controls to allow faster operator action for all operating situations, especially during crisis management.

CYBER-SECURITY

Cyber security is a major concern with modern Turbine Control Systems that offer a wide range of open communication with third parties. GE's control systems are hardened. Several cyber-security options are available depending on the configuration. Furthermore, most of our controllers are Achilles certified.

Boiler Feed Pumps

Control Systems

The turbine driven Boiler Feed Pumps have a critical impact on the overall availability of the unit, but also on the performance of the unit. GE's solution for Boiler Feed Pumps provides functions such as automatic speed control, water pressure control, SIL 3 protection, and monitoring of both the turbine and the pump.

The Boiler Feed Pumps Control System can act as standalone equipment with its own single or redundant controller and a user friendly graphic interface to ease the operation and the maintenance, or it can be integrated into the main steam turbine control system to provide a performant integrated system for a reduced investment.

KEY BENEFITS

- Long term protection of your investment with a wide range of services and the use of a platform controlled over the full production chain that offers an extended lifecycle thanks to incremental evolutions

- Reliable and safe

- Helps reduce unplanned outages and scheduled outage duration

- User-friendly human machine interface for operation and maintenance

- Mimic designed as a Decision Support Instrument with priorities ranking

- Optimize unit responsiveness and thermal efficiency

- Operational flexibility improvement

- Unit performance improvement with fuel consumption reduction

- Helps monitor and reduce the component stress and lifetime impact caused by flexible generation

- Provides access to secured remote data analysis and improvement applications powered by GE's Predix platform

- Specific regulation and grid codes compliance

High Fidelity Plant Simulation

Virtual Plant Solution for Operations Maintenance and EPCs

Power plant builders must hand over the plant faster while reducing commissioning costs. Operators must run the power plant as efficiently as possible and maintenance personnel must be able recognize and diagnose issues as efficiently as possible without taking assets off line or impacting performance.

GE's Plant Simulator solutions provide high-performance replication of power plant process and real-time controls. High-fidelity virtualization enables Simulation Assisted Commissioning (SAC) as well as Simulation Assisted Operations (SAO) for the full plant.

BENEFITS DURING COMMISSIONING

- Reduced lead time
- Reduced lifetime consumption and commissioning budget
- Reduced Risks

BENEFITS IN COMMERCIAL OPERATION

- Reduced risk of operator errors
- Improved operator readiness during abnormal plant behavior
- Faster reaction to production demand
- Reduced off-spec electricity production
- Faster diagnosis by maintenance personnel
- Reduced lifetime consumption
- Reduced maintenance costs

OPERATOR TRAINING SIMULATION

The Operator Training Simulator (OTS) is a high-performance solution that replicates the Power Plant Process and Real Time Controls. It trains operators to run the Power Plant in an optimum manner, and maintenance personnel to diagnose issues as efficiently as possible.
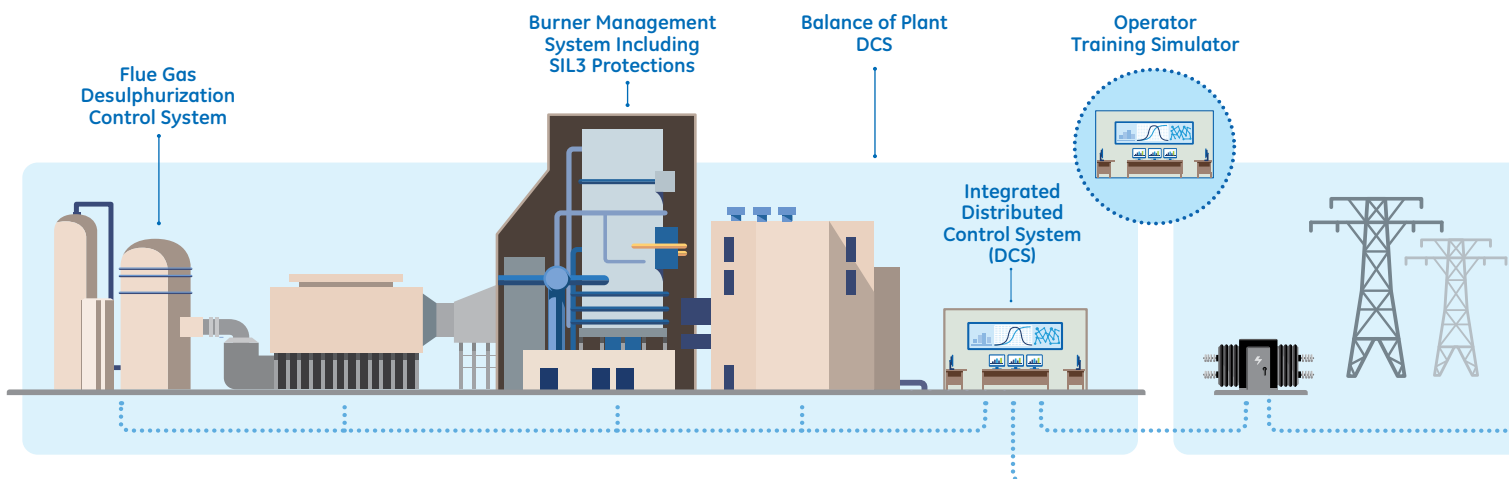
The solution is based on:

- A full plant process model complying with ANSI/ISA-77.20.01-2012 Standard
- Real-time, virtualized plant controller
- Engineering and operator stations
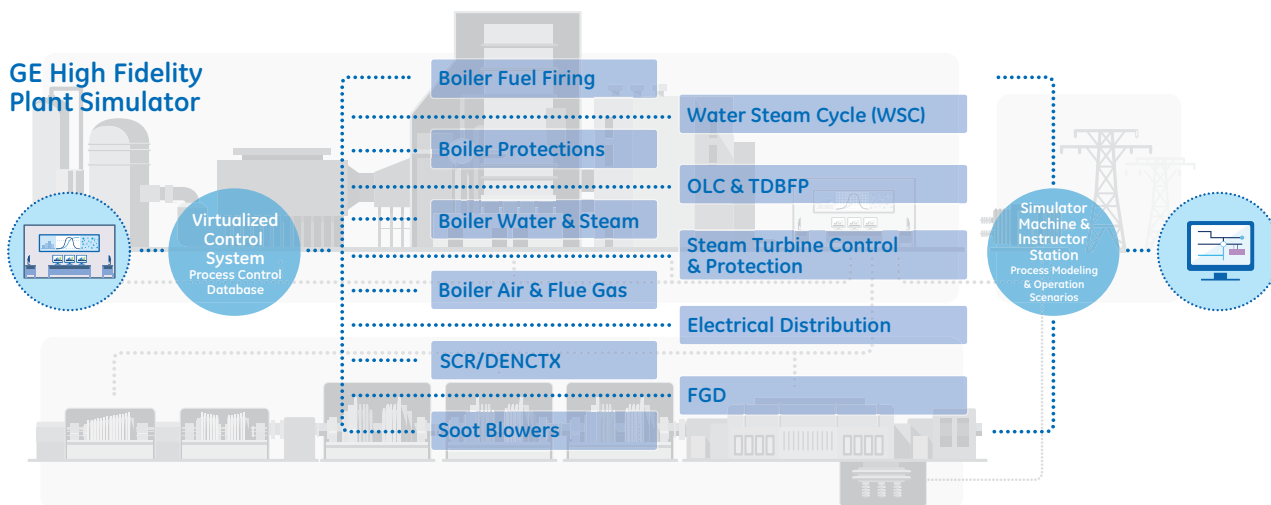- Instructor station with a set of training scenarios and tools

It is offered with the following Services:

- Instructor Training Services: Normal , Degraded, Abnormal Operation Conditions
- Case Studies Workout Session, to support best practice acquisition based on real operating conditions
- Hot Line and Remote coaching

OTS and Services are available on the following plant types:

- Steam plant, conventional, SC, USC
- Gas CCPP

Flue Gas Desulphurization Control System

Burner Management System Including SIL3 Protections

Balance of Plant DCS

Operator Training Simulator

Integrated Distributed Control System (DCS)

**GE High Fidelity
Plant Simulator**

Boiler Fuel Firing

Water Steam Cycle (WSC)

Boiler Protections

OLC & TDBFP

Boiler Water & Steam

Steam Turbine Control & Protection

Boiler Air & Flue Gas

Electrical Distribution

SCR/DENCTX

FGD

Soot Blowers

Virtualized Control System
Process Control Database

Simulator Machine & Instructor Station
Process Modeling & Operation Scenarios

HIGH-FIDELITY SIMULATOR SOLUTIONS FOR EPCs

The High-Fidelity Plant Simulator enables Simulated Assisted Engineering (SAE) of the plant controls and the Simulated Assisted Commissioning (SAC) for the full plant. The SAE and SAC Services are delivered to the Plant EPC.

The solution is based on:

- A full plant process model complying with ANSI/ISA-77.20.01-2012 Standard
- Real time, virtualized plant controller
- Engineering and operator stations

It is offered with the following services:

- Engineering Phase: Process controls verification and validation with the process owners, and when possible, some commissioning resources
- Commissioning Phase: Virtual commissioning, operating modes validation / improvement, alarms rationalization
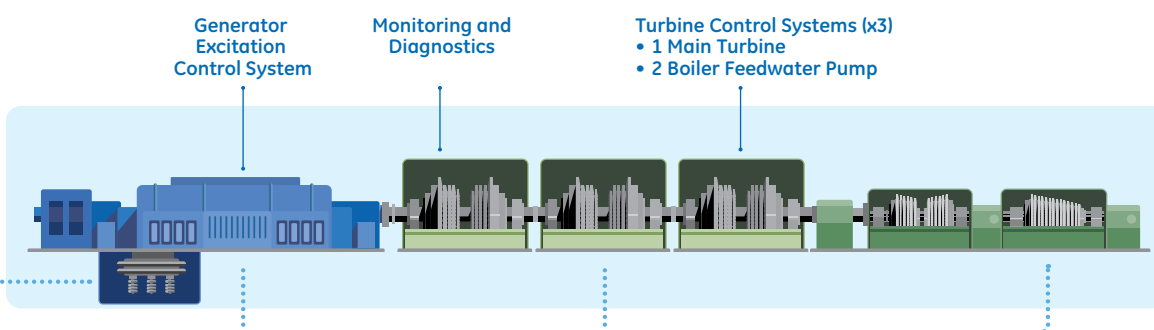
The SAE/SAC Services are available on the following plant types:

- Steam plant, conventional, SC, USC
- Gas CCPP
- Concentrated solar plants
- Hydro plants

KEY BENEFITS

- Reduced power plant delivery time by reducing the duration of commissioning phase.
- Reduced overall commissioning cost
- Reduced lifetime consumption during commissioning

Additionally, such simulators can be accessed in an as-built version to support the design of subsequent plants.

Generator Excitation Control System

Monitoring and Diagnostics

Turbine Control Systems (x3)
- 1 Main Turbine
- 2 Boiler Feedwater Pump

Excitation Systems

Reliable Generator Control for Steam, Gas and Hydro Power

Today's power grid requirements are continuously changing to meet the needs of newer power sources. Generator excitation systems need to improve their response to grid conditions and to enable future improvements.

GE's Automation & Controls offers a full range of solutions for the generator excitation systems covering most generator sizes and types. From small automatic voltage regulator systems to large static exciters, the EX2100e has a configuration available to meet project requirements.

GE's Ex2100e Excitation Control system is a software enabled generator control system applicable for steam, gas and hydro generators. The EX2100e has configurations for both new installations and retrofit of existing systems. Ex2100e control hardware and software is an integral part of the Mark VIe control product line. Integration is seamless between excitation systems, turbine control, static starter, distributed control systems (DCS), and the human-machine interface (HMI) requiring no third party interfaces or gateways.

For stand-alone retrofit applications, tight integration with plant control systems is enabled through multiple protocols including Modbus/TCP and OPC and OPA-UA. Other protocols are also available depending on project requirements.

REGULATORS FOR ROTATING EXCITERS

The Ex2100e product family includes simplex and redundant automatic voltage regulator systems, typically used for smaller generator systems. This solution has been specifically designed to address small generators and

embeds all the necessary control, limitations and protection to help the generator operate safely. This flexible excitation product can be customized to retrofit most configurations.

STATIC EXCITATION SYSTEMS

For larger generators (typically above 100 MW), GE offers a powerful excitation system for the control of synchronous generators up to 10,000 Amps field current. It offers a wide variety of innovative solutions to maximize the efficiency of the power plant, as well as customized solutions to meet specific requirements.

RETROFIT GENERATOR CONTROLS

For optimum retrofits, GE offers a Digital Front End (DFE) as the control section of the excitation system used to upgrade existing excitation systems with the latest control technology, yet keeping the existing power conversion sections, minimizing costs and downtime.

GENERATOR CONTROL PANEL

Excitation systems can be also joined with synchronizer and generator protection to provide a complete generator control.

NUCLEAR GENERATOR CONTROLS

For safety nuclear application, GE offers the latest excitation system specifically designed by GE for the control of emergency diesel generators in nuclear power plants to ensure the safe operation even under extreme conditions.

KEY BENEFITS

- DFEs minimize investments for upgrades by avoiding power converter replacement
- Limited outage duration due to fast installation of the control system
- Highly integrated with plant and turbine controls for ease of troubleshooting with integrated equipment logs and Sequence Of Events
- Integrated solution packaged specifically to reduce risk of retrofits and maintenance costs
- Enhanced reliability and system diagnostics with latest Mark technology
- Minimal component design approach reduces spare parts requirements and improves system reliability

Static Starter

Cost effective and reliable starter for heavy-duty gas turbines

GE's LS2100e Static Starter is used to provide cost effective and reliable starting for heavy-duty gas turbines. The LS2100e is a load-commutated inverter (LCI) available in four power ratings: 8.5, 11, 14, 22 MVA, matching the starting requirements of the largest gas turbine in the world. Static starter technology is a lower cost, alternative technology used to "start" gas turbines by turning the generator into a motor. LS2100e options include both 12 pulse and 6 pulse technologies.

As a member of the GE Mark VIe Controls Technology family, the LS2100e communicates peer-to-peer on the Mark VIe UDH network to reduce field wiring and to improve data coordination between the starter, Ex2100e exciter, and Mark VIe turbine controller. ControlST is the common configuration tool for the GE Mark VIe controller family including LS2100e static starter. GE's HMI systems utilize common operator stations and engineer workstations to simplify plant operations and maintenance.

To save capital costs, GE's static starter can be configured to start more than one turbine. This provides starting flexibility and choices between starting redundancy and cost savings. LS2100e can be applied as part of a new unit gas turbine installation, either as a replacement of any vintage of existing GE static starter or as a controls migration for the Innovation Series.

CONFIGURATION OPTIONS INCLUDE:

- A static starter for each gas turbine
- A static starter for multiple gas turbines (up to four)
- Two static starters cross-linked to multiple gas turbines (up to eight)

KEY BENEFITS

- Lower cost and minimal space requirement than other starting means for large gas turbines
- Ability to generate sufficient current for high acceleration torque requirements
- Common ControlST* software suite supports a wide range of starting profiles to improve ease of operation and maintenance
- Low mean-time-to-repair (MTTR) with detailed system diagnostics and an easy to repair design
- Higher power, multi start capability enabled through an integrated liquid cooling system
- Full system and Digital Front End (DFE) options to serve all starter modernization needs
- Controls are part of GE's Mark VIe family with improved life cycle management capabilities
- Improved sequencing control in cross-over applications
- Improved cooling system, sequencing, and power converter status annunciation

Synchronous Condenser

New Life for Phased-out Steam & Gas Plant Synchronous Generators

Global climate change poses new challenges for power generation and transmission. Huge amounts of renewables-based power get added to the energy mix influencing the stability of transmission networks and calling for synchronous condensers to support and improve power transmission quality.

At the same time thermal power plants with large synchronous generators and existing auxiliary infrastructure get phased-out. GE's Automation & Controls offers solutions to bring these generators to a new life as synchronous condensers supplying the electrical network with reactive and short circuit power.

GE's Static Starter operates the generator as a synchronous motor to accelerate the rotor to synchronous speed. In the meantime GE's Static Excitation system generates the necessary current to create the magnet field of the rotor.

When synchronized on the transmission network, the AVR system of the Static Excitation controls the excitation current to generate the requested reactive power, and in this way supports today's and tomorrow's sustainable, secure and efficient power supply.

KEY BENEFITS

- Based on the latest powerful GE control technology: bot, Static Starter and Static Excitation system feature the latest platform to maximize performances, efficiency, and allow seamless integration with other control systems such as Distributed Control System (DSC)

- Flexible solution to adapt to generator capacities

- Static Starters available in four different power ratings: 8.5, 11, 14 and 22 MVA

- Complete product line of Static Excitation systems available with currents up to 10,000 Amps.

- Ease of operation and maintenance with a common ControlST software suite

- Quick response time to support power system disturbances

Emergency Shutdown System (ESD or BMS)

Award-winning Integrated Safety Solution

The Mark VIeS Safety Management System reflects GE's experience of three-plus decades, four generations, and over 10,000 installed Triple Modular Redundant (TMR) systems. These proven and reliable systems perform mission critical applications worldwide, utilizing flexible Safety Integrity Level (SIL) configuration and qualified manufacturing and solution delivery processes.

The award-winning Mark VIeS Safety Management System is a complete, flexible, and reliable engineered process safety system with enhanced cyber security for critical processes such as plant emergency shutdown, burner management, critical process control, fire and gas detection, and turbomachinery safety.

Consisting of a controller, I/O and switches, programming software, project analysis, implementation and operation services, the Mark VIeS is a high-availability, Triple Modular Redundant (TMR) solution with end-to-end architecture that optimizes assets and operations and reduces costs.

The Mark VIeS Safety Management System delivers a seamless, integrated, engineered solution designed to perform in the extreme conditions found in industries such as:

- Oil & Gas
- Power Generation
- Chemical and Process
- Pulp and Paper
- Mining and Minerals Engineering

KEY BENEFITS:

- Proven to protect operations and assets
- Flexibility reduces costs and improves lifecycle management
- Rugged and reliable for increased uptime
- Integrate with BPCS for better, faster decisions
- Ethernet communications enhances connectivity and performance
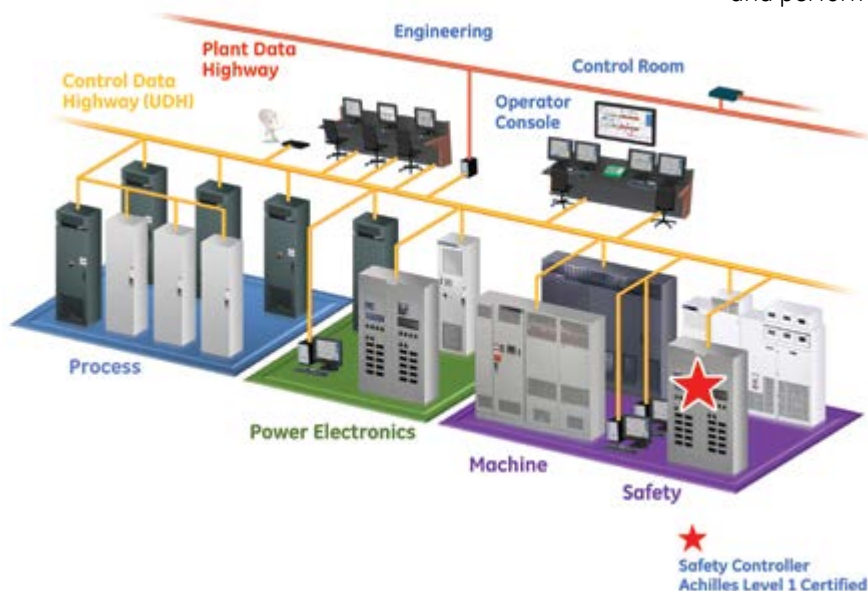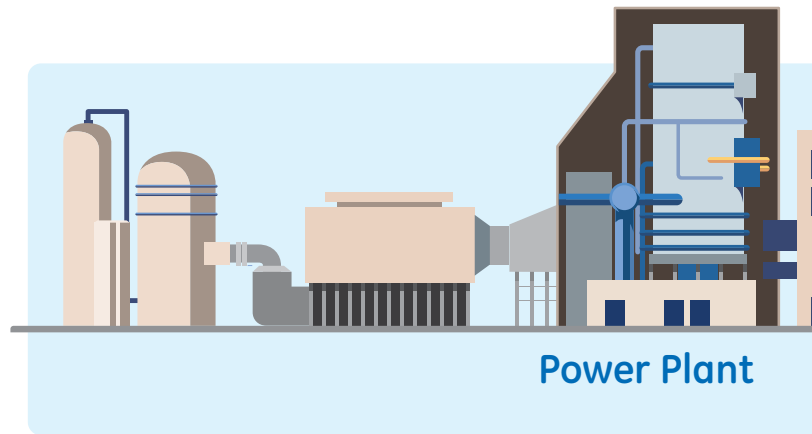
Generator Health Monitoring (GHM)

Integrated Solution for the Prevention of Main Generator Failure

GE's Generator Health Monitoring is the preferred solution for reliable and cost-effective trending of the generator condition. With a single "Care Box", you can monitor in real time any of the main generator's anomalies.

- The partial discharge module continuously monitors the partial discharges within the stator winding and bus duct.
- The Rotor flux module tracks rotor winding inter-turn short circuits and identifies the magnitude and slot location of the fault.
- The Rotor shaft voltage module detects failures in the rotor winding insulation, shaft grounding system and excitation issues.
- The End winding vibration module provides continuous monitoring of stator end winding vibration location and magnitude.
- The Temperature module constantly monitors the generator temperatures in line with operating conditions, trending deviations from design values.
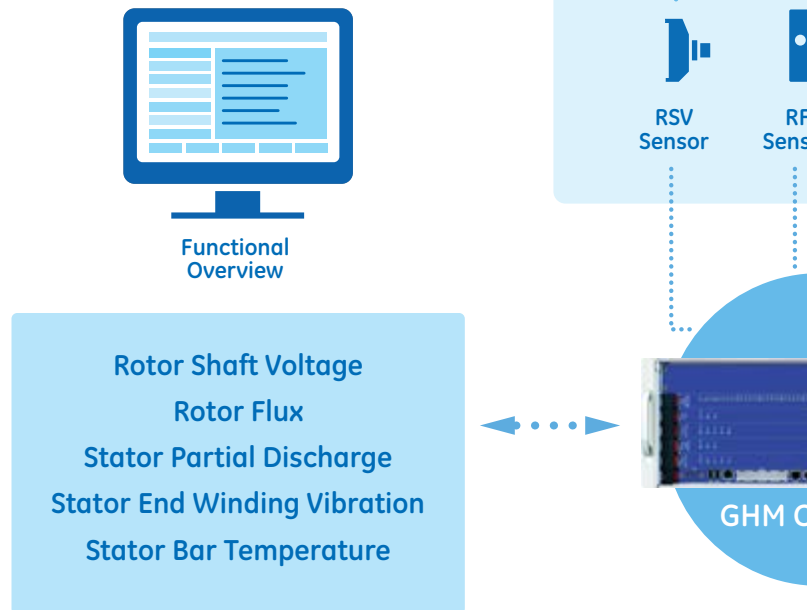
KEY BENEFITS

- Built on decades of domain experience
- Integrated solution for the prevention of main generator failures
- Modular & scalable hardware
- Native OPC UA software architecture for system interoperability
- State-of-the-art, web-based HMI for multi-user remote monitoring
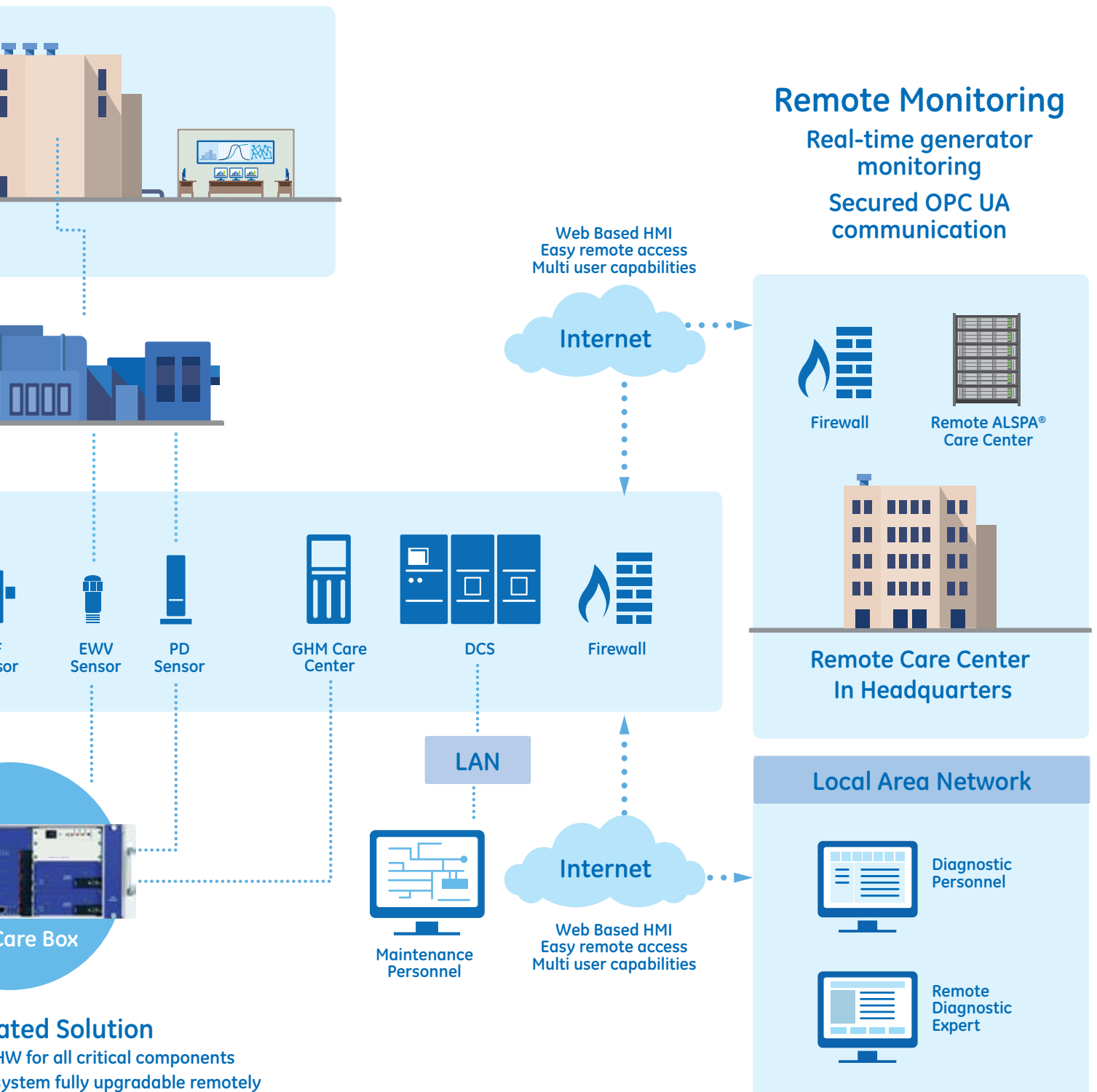- Compatible with most sensors installed by third-party manufacturers

Power Plant

Connected Generator

With advanced sensors technology and embedded knowledge for edge analytics

Functional Overview

RSV Sensor

RF Sens

Rotor Shaft Voltage
Rotor Flux
Stator Partial Discharge
Stator End Winding Vibration
Stator Bar Temperature

GHM C

Integr
Modular H
Scalable s

Remote Monitoring

Real-time generator monitoring

Secured OPC UA communication

**Web Based HMI
Easy remote access
Multi user capabilities**

Internet

Firewall

**Remote ALSPA®
Care Center**

**Remote Care Center
In Headquarters**

EWV
Sensor

PD
Sensor

GHM Care
Center

DCS

Firewall

LAN

Internet

**Web Based HMI
Easy remote access
Multi user capabilities**

Maintenance
Personnel

Local Area Network

**Diagnostic
Personnel**

**Remote
Diagnostic
Expert**

Care Box

ated Solution

HW for all critical components
ystem fully upgradable remotely

Integrated Plant Controls

Mark VIe Distributed Control System (DCS)

GE's Distributed Control System (DCS) solutions are easily adapted to the constantly evolving requirements of industries such as power generation, oil and gas, and chemical processing.

They control the entire plant, including balance of plant equipment and machine controllers. Additionally, GE provides added services to operate and maintain the plant. Comprehensive solutions cover all fuel types while integrating dedicated controllers for critical components. Flexible architecture enables optimal solutions for wind, hydro, thermal, and nuclear facilities. GE's DCS solutions extend this flexibility from the traditional unit controls to complete plant solutions delivering advanced performance, operability, and availability.

For businesses that are dependent on decades of uninterrupted machine service, a redundant control system that allows for online maintenance is critical. GE's Distributed Control Solutions are designed to provide the high level of availability and the flexibility necessary for today's most demanding applications.

Downtime is one of the greatest detriments to productivity and profitability. It is imperative to have a system in place that provides the highest levels of system reliability and availability at all times. To meet the demands of today's connected industries, GE has combined its leadership of the Industrial Internet with its rich history of process control to deliver the Mark VIe Distributed Control System (DCS).

GE's DCS solutions feature high-speed, networked I/O for simplex, dual, and triple redundant systems. Industry-standard Ethernet communications are used for I/O, controllers, and supervisory interface to operator and maintenance stations and third-party systems.

CONNECTIVITY

Ethernet-based I/O can easily be distributed plant wide across all balance of plant applications. Industry-standard Ethernet communications are used for I/O, controllers, and supervisory interface to operator and maintenance stations, as well as third-party systems.

ENGINEERING & MAINTENANCE

The integrated software suite allows efficient programming and configuration of your power plant DCS. It also embeds tools for trending, analyzing, and plant diagnostics—simplifying plant maintenance activities.

INTEGRATED APPLICATIONS

A common software suite is utilized system-wide for programming, configuration, trending, and analyzing diagnostics. It provides a single source of quality, time-coherent data at the controller and plant level to understand and adjust how a plant is operating in real time.

SAFETY

The controller comes with integrated SIL certified IEC®-61508 Safety Management modules: the Mark VIeS, dedicated to safety-critical parts of your power plant.

A COMPREHENSIVE APPROACH FOR CONTINUOUS OPERATIONS

GE's tightly integrated DCS solutions deliver robust process control with seamless connectivity and automated real-time information management to help you maximize uptime and productivity.

GE's DCS enables users to improve operational efficiency, optimize production, and unlock new revenue opportunities by leveraging advanced data analytics. The IICS System consists of intelligent controllers, I/O modules, secure cloud connectivity solutions, advanced analytics software, and apps to provide real time process optimization and control with minimal disruption to deployed applications. Deployed with secure embedded and/or standalone connectivity to the Industrial Internet, IICS provides flexible options for each unique customer application.

PREDIX TECHNOLOGY FOR DISTRIBUTED CONTROL SYSTEMS

Take advantage of outcome optimizing apps by leveraging centrally managed industrial infrastructure. PREDIX software platform supports the growing Industrial Internet of things with cloud servers and Optimization Apps. Predix is a platform as a service cloud-based platform that enables industrial-scale analytics for Asset Performance Management (APM), Operations Optimization (OO), and Business Optimization (BO) by providing a standard way to connect machines, data, and people. Predix software can do for factories and plants what Apple's iOS did for cell phones.

High-end, yet flexible, control system provides a single hardware platform, common configuration and maintenance tools, a common operator interface, and a single Ethernet network for turbine, generator, LCI, exciter, HRSG and BOP controls.

Deep domain expertise of the main assets around the power plant allows for operations optimization and minimizes instabilities during system transients. IICS ensures a future-proof plant controls environment and allows for seamless software upgrades over its life through the GE App Store.

Cyber security is a major concern with modern Turbine Control Systems that offer a wide range of open communication with third parties. GE's control systems are hardened. Several cyber-security options are available depending on the configuration. Furthermore, most of our controllers are Achilles certified.

KEY BENEFITS:

- Single operator interface for all equipment reduces training costs and improves operator productivity
- Integrated system, single control platform, utilizes common configuration and diagnostic apps to reduce programming, system checkout, and start-up hours
- Improve operator awareness of the plant with better root cause analysis, diagnostics and overall operational analytics that improve decision making.
- Reduced project risks and integration cost via single experienced OEM
- Accurate diagnostics for shorter maintenance outages; reduce productivity losses
- Optimized component start GT fast start, optimized drum level controls, via advanced control algorithms etc.
- Reach operation excellence and reduce operation risk via High Fidelity simulator
- Reduce training costs and improved operator productivity: Consolidated operator interface allows full control from one central location
- Faster commissioning though dedicated control solutions Predix apps

GE Energy Connections

www.geautomation.com