Digital Solutions for Optimizing Fleet Operations and Maintenance

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The energy transition toward a net zero carbon emissions electricity grid is underway.[1] The International Energy Agency (IEA) has presented the "essential conditions" for the global energy sector to reach net-zero carbon emissions by 2050.[2] The UN reports that more than 70 countries have adopted a net-zero target. Further, over 1,200 companies across the globe have adopted carbon reduction targets consistent with the IEA's net zero target.

In November 2021, the U.S. Department of State and the U.S. White House released their long-term strategy (LTS) outlining how the U.S. can reach its goal of net-zero carbon emissions no later than 2050, submitting it to the United Nations Framework Convention on Climate Change (UNFCCC) at the 26th Conference of the Parties. The three-step LTS states the U.S. is committed to achieving at least a 50% reduction from 2005 levels in economy-wide net greenhouse gas emissions (GHG) by 2030, creating a carbon-free power sector by 2035, and achieving net zero emissions economy-wide no later than 2050.[3]

Several states have also enacted legislation designed to reduce GHG emissions significantly over the same period. Five New England states (MA, CT, ME, RI, and VT) have pledged to reduce GHG emissions by at least 80% by 2050 (Table 1). Each plan requires a significant wind and solar power generation expansion as the future grid must bear the increased burden of electrification of heating and transportation needs.

A recent (July 2022) ISO New England (ISO-NE) study identified three critical factors to guide the transformation of the grid to meet its carbon reduction goals.[4] First, "energy adequacy" acknowledges that renewable resources are variable and will continue to require dispatchable resources in the future, although those new resources do not have to be carbon-emitting. Second, the future grid requires "resource and demand flexibility" with adequate reserve margins, which may be difficult with high electrification and aggressive retirements of existing plants. These critical issues were addressed in previous reports.[5] Finally, the "resource mix diversity" of the future grid must be addressed. With increasing wind and solar, the stress of the grid may shift from summer to winter peaking, which may require a significant increase in capacity to meet required reserve margins. The ISO-NE report suggests the reserve margin "may need to increase by an order of magnitude by 2040 (i.e., from 15% to 300%)" to "keep the system reliable in times of stress."

The common factor identified by ISO-NE is the need for utilities to optimize the operation of their existing fleet of conventional and renewable plants to meet the region's growing demand for electricity while avoiding degrading system reliability. In other words, optimal performance and high equipment reliability are inseparably linked in a future low-carbon world. Discussions of energy transition often overlook that grid transformation must occur without degrading grid reliability.

GHG Reduction Required	State Requirement(s)
≥ 80% by 2050	Five states mandate GHG reductions economy-wide: MA, CT, MW, RI, and VT (mostly below 1990 levels)
Net-Zero by 2050 80% by 2050	MA emissions requirement MA clean energy standard
90% by 2050	VT renewable energy requirement
100% by 2050 Carbon-neutral by 2045	ME renewable energy goal ME emissions requirement
100% by 2040	CT zero-carbon electricity requirement
100% by 2030	RI renewable energy requirement

Table 1. New England state emission reduction and energy decarbonization goals. California requires overall GHG emission reduction to 1990 levels by 2020 and 40% below 1990 levels by 2030. California achieved its first goal four years early. Source: *ISO NE; California Air Resources Board.*

[1]Technically, CO2 accounts for about 75% of total GHG emissions. However, the term "carbon" is often used to refer to CO2 or GHG emissions in general.

[2]International Energy Agency. "Net Zero by 2050: A Roadmap for the Global Energy Sector." https://www.iea.org/reports/net-zero-by-2050.

[3]U.S. Department of Energy. Carbon Capture, Transport, & Storage. U.S. Department of Energy Response to Executive Order 14017, "America's Supply Chains." February 24, 2022. https://www.energy.gov/sites/default/files/2022-02/America's%20Strategy%20to%20Secure%20the%20Supply%20Chain%20for%20a%20Robust%20Clean%20Energy%20Transition%20FINAL.docx_0.pdf

[4]ISO New England. https://www.iso-ne.com/static-assets/documents/2022/07/2021_economic_study_future_grid_reliability_study_phase_1_report.pdf

[5]GE Digital. "Digital Solutions for Optimizing Combined Cycle Plant Operations" and "Digital Solutions for Optimizing Renewable Generation."

GE Digital's Asset Performance Management (APM)

The transition of the electricity markets from fossil fuels to renewables has placed enormous pressure on utilities to perform while transforming. As previously noted, fleet operators can't decarbonize at the expense of grid reliability – they must go hand-in-hand. As conventional plants are retired, the remaining dispatchable plants must be highly reliable to balance variable renewable generation to serve as a path to meet ever-increasing decarbonization goals. Of course, these goals are not without cost constraints as well. Implementing asset performance management, as a lifecycle continuous improvement process, across the entire enterprise can help utilities balance sustainability, reliability, and affordability as they transform through the energy transition (Figure 1).

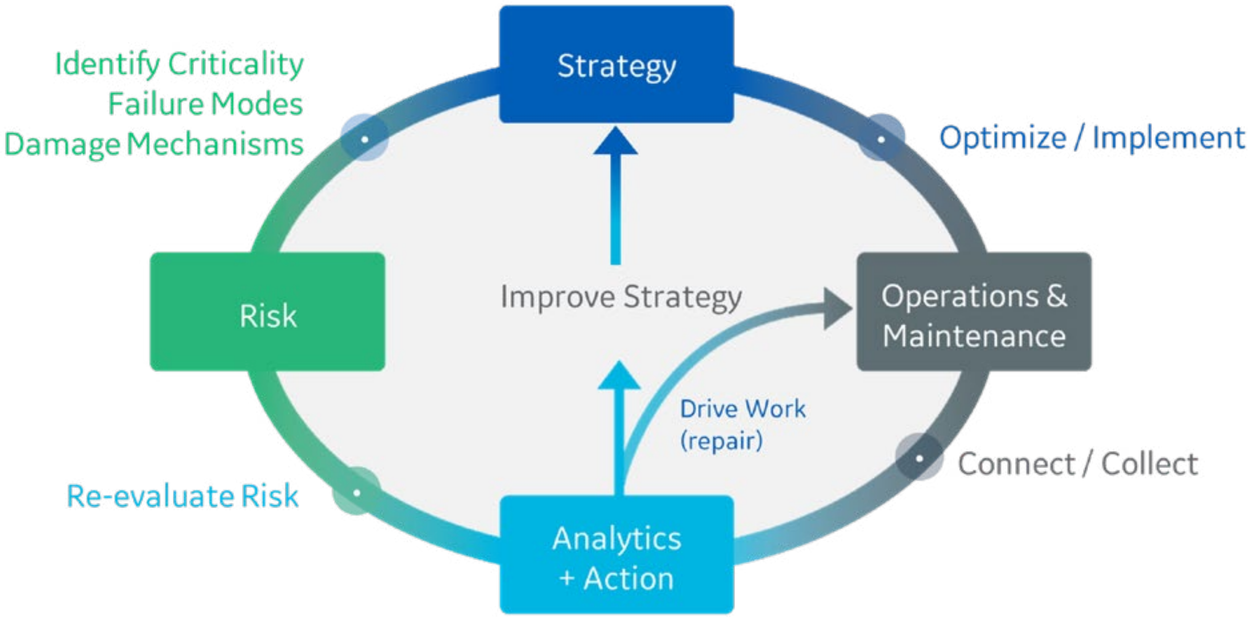

Figure 1. Asset Performance Management provides a best practice model for continuous improvement. Source: *GE Digital*

At a high level, the process follows the Deming cycle of plan-do-check-act by assessing asset criticality and risk; establishing and implementing asset strategies to balance risk with cost optimally; monitoring and analyzing asset health to drive improvements back into the management of risks and defining strategies. Typically, utilities will start with standardizing their asset criticality assessment and comparing that to how maintenance strategies are often handled today. However, that is not enough to move away from time-based maintenance, which has shown to not always be optimal. An end-to-end solution is needed to achieve optimal value (i.e., avoiding unplanned downtime and optimizing capital and O&M budgets). The solution must combine the process threads of condition monitoring, predictive analytics, and reliability management to refine asset strategies focusing on condition-based maintenance. Point solutions can help with a few pain points. Still, critical to enabling the outcomes desired, is a robust, enterprise-level software solution that can drive standardization and productivity across the organization.

GE Digital's Asset Performance Management (APM) software suite allows owners to optimize asset performance and O&M efficiency across equipment types, a plant, or an entire fleet with modules in Strategy, Reliability, Health and Integrity, and more (Figure 2). APM Strategy and APM Reliability solutions shown in the figure are discussed in this report in further detail, followed by an introduction to GE Digital's Command Center, given its importance to fleet operations and maintenance.

APM Strategy

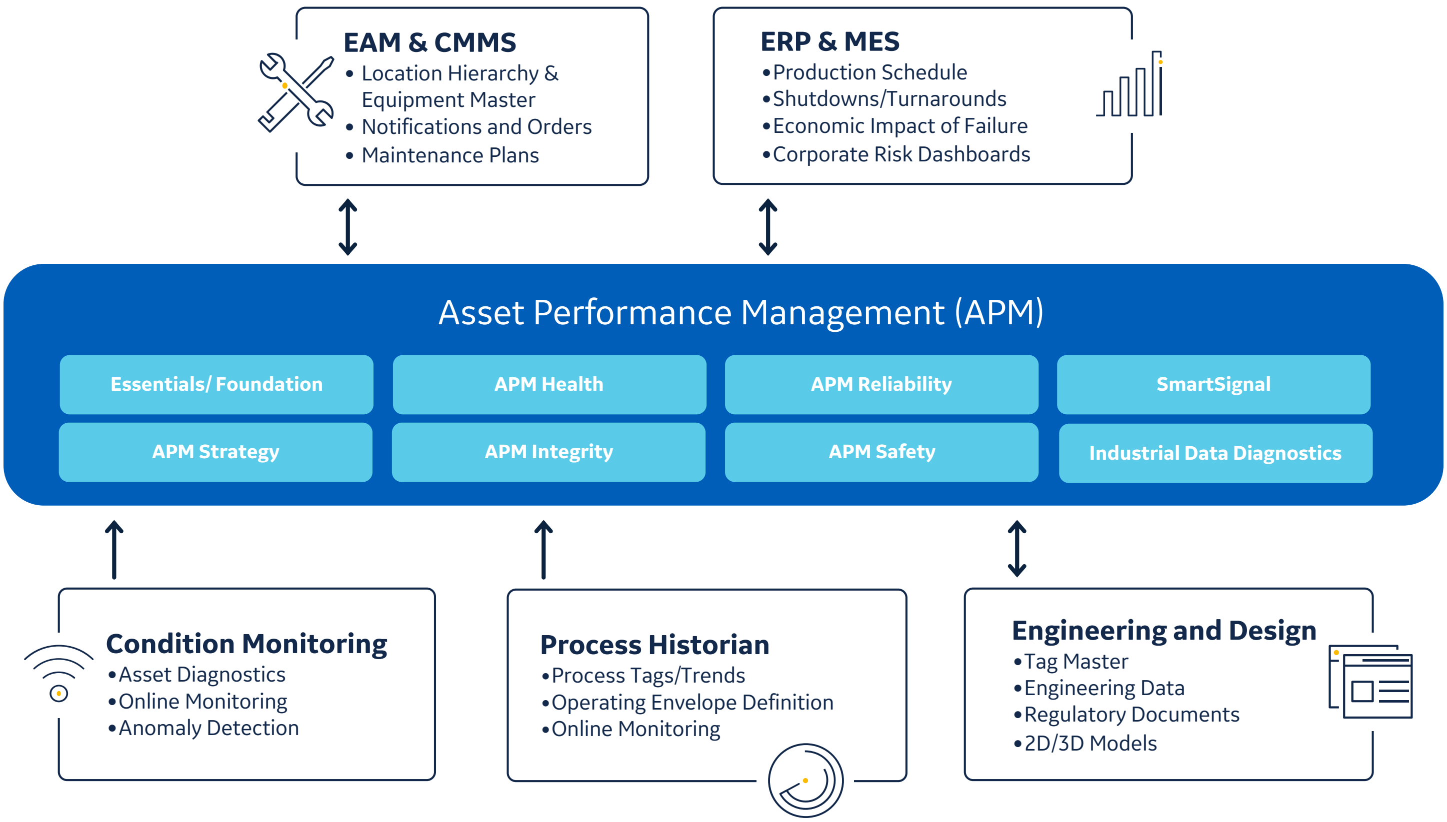

Figure 2. GE Digital's Asset Performance Management represents a suite of solutions available to meet a customer's requirements for fleet asset management. APM Reliability and APM Strategy are discussed in detail in this report. Source: GE Digital

Power generation organizations must adapt and modernize to maintain sustainable and profitable operations within certain constraints, such as limited expertise and resources, changing energy demands and resource types, and aging equipment. APM software helps organizations identify and minimize risk and embed process efficiencies and data analytics in their workflows to continuously improve their asset management practices and strategy. In sum, APM Strategy guides users to develop strategies and tactics that position them ahead of the competition.

Developing a unit or fleet APM Strategy begins by identifying and assessing business-critical assets from a performance and reliability point of view, particularly those assets subject to legal and regulatory scrutiny. Organizations should expect to facilitate change management and encourage employee buy-in in trusting their APM software's data and predictive analytics to transform maintenance, asset replacement, and work processes.[6] APM Strategy establishes and sustains equipment strategies to mitigate risk, optimize costs, and maximize plant reliability, including RCM/FMEA and life cycle analysis tools.

The APM Strategy uses a range of tools to reduce operating risk and to optimize life cycle cost, such as,

- Align equipment strategies to achieve business objectives for risk avoidance, cost containment, and sustained reliability improvements
- Optimize and prioritize equipment strategies based on asset criticality and known risks
- Standardize best practice equipment maintenance, monitoring, and inspection strategies across the enterprise
- Provide organizational visibility, control, and approval of equipment strategies
- Harmonize strategy management and execution systems

[6]See "The Total Economic Impact Of GE Digital Asset Performance Management For Power Generation Operations," a commissioned study conducted by Forrester Consulting on behalf of GE Digital, July 2022.

APM supports an overall continuous improvement process that includes all the industry best-practice steps necessary to ensure optimal asset performance to maximize your desired outcomes.

The work process development consists of five key steps

STEP 1

Assess the criticality of assets

The task begins with identifying which assets and systems are most critical to the business and quantifying the potential negative impact or consequences that the asset or system has on the business if a failure occurs.

One of the cornerstones of a risk-based asset strategy management program is the concept of asset criticality. An effective criticality assessment helps customers quantify the potential negative impact or consequence that an asset or system has on the business if a failure occurs. Understanding and quantifying how critical an asset or system is in preserving the safety, environmental and operational requirements is one of the first steps in optimizing and prioritizing asset management investments. Thus, a consistent criticality assessment approach must be used across the fleet. The criticality assessment prioritizes fleet-wide O&M expenditures for risk-based asset management strategies and necessary corrective actions.

The GE Digital Asset Criticality Analysis application within APM Strategy is a tool you can use to define the criticality of assets. The ACA module enables users to determine the criticality of support based on the worst likely case consequence of a failure of the asset to provide an overall criticality value. Using ACA, you can determine which of your systems, locations, and equipment are critically based on your organization's definition.

After you have determined which of your assets are critical, other GE Digital APM applications may be used to analyze further and safeguard those systems, locations, and equipment. Based on the asset's criticality, additional tools and methodologies within APM Strategy can be utilized to develop maintenance, inspection, or monitoring strategies for optimizing the performance and reliability of the asset.

STEP 2

Identifying risks and mitigating actions

Once an organization understands which assets and systems represent the most risk exposure to their business through criticality assessment, the next step is to determine the specific known risks or failure modes associated with those assets and quantify the degree of unmitigated risk that each represents. Identifying and documenting the known ways an asset, or system, can fail is critical to establishing an optimized and effective mitigating action plan or asset strategy. These individual risks can be quantified through the probability or frequency of occurrence and the potential negative consequence incurred by the business if they do occur. Methodologies such as Reliability Centered Maintenance (RCM), Failure Modes and Effects Analysis (FMEA), and Risk Based Inspection (RBI) are industry standards that can be leveraged to provide a framework for documenting and quantifying unmitigated risks as well as the necessary mitigating actions.

Unfortunately, the majority of this information is historically tribal and not well documented. Documenting the criticality and known risks for assets is the first step in capturing and retaining critical engineering intelligence, knowledge, and expertise required to sustain a risk-based asset management program through changing resources, retiring O&M staff, and reliability subject matter experts. Documenting this information is vital to implementing a living risk-based asset management program.

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STEP 3

Optimize mitigation strategies for risk and cost

Establishing the right balance between the level of risk mitigation desired based on the criticality of an asset and the cost of the action plan is the key to an optimized risk-based asset management program. Quantitative and qualitative analyses enable the transition to an optimized risk-based PM program.

A risk-based mitigation strategy must address the negative impact of a suboptimal maintenance strategy on profits. For instance, if an inadequate amount of maintenance is performed, this could lead to assets failing at an unacceptable rate leading to high emergency corrective maintenance costs and a constantly reactive culture. Conversely, the business will incur unnecessary direct labor and material costs if too much maintenance is performed. Further, underutilization of assets leads to decreased production and lost opportunity costs. Other areas that should be addressed include:

- Costly and unnecessary planned maintenance tasks could be eliminated
- Existing tasks could be modified to relax current maintenance intervals without increasing operational risk
- More effective and less costly condition-based maintenance tasks could replace inefficient and outdated calendar-based tasks

Risk-based PM Optimization can also be performed on existing maintenance plans by importing the plans from Enterprise Asset Management (EAM) or CMMS systems.

Once the asset management strategies have been optimized for risk and cost, the results can be communicated to the EAM or maintenance execution system to ensure harmonization. Additionally, predefined asset-specific preventive maintenance strategies developed by subject matter experts can be provided as content to ease the burden and give quicker time to value. The result is year-over-year savings through risk-based optimization operations and maintenance expenditures and maximization of profits through improved asset availability and uptime.

STEP 4

Manage and implement fleet-wide asset strategies

Establishing and sustaining an effective risk-based O&M program across an entire fleet, regardless of size or complexity, is challenging for even the most well-run organizations. An enterprise application with well-defined supporting work processes, and a library of strategies, is required to move an organization from a reactive to a more proactive O&M program. Holistic management of the entire asset management strategy includes developing, reviewing, approving, implementing, and re-evaluating steps to support and maintain a continuous improvement cycle.

The GE Digital Asset Strategy Management (ASM) application uses a risk-based approach to manage fleet-wide asset strategies. ASM provides a standard methodology to define risks and their mitigating actions for any asset, providing the ability to evaluate existing plans with qualitative risk analysis tools. Managers can validate existing plans or consider strategy options to update and implement plans which helps manage risk more effectively. Once risk-based strategies have been defined and validated, the mitigating actions can be implemented directly within APM or external EAM systems via export capabilities.

The GE Digital Asset Strategy Implementation (ASI) application enables users to build implementation packages containing operation and maintenance plans, maintenance items, and task lists for implementation in SAP. Further, the ASI allows multiple strategies to be combined in a common package and implemented into SAP. The implementation packages in ASI are tied directly to any revision made to the associated asset strategies in ASM.

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STEP 5

Drive corrective actions and continuous improvement

GE Digital's Lifecycle Cost Analysis application is designed to help asset lifecycle costs to be viewed from the perspective of the total cost of asset ownership. The Lifecycle Cost Analysis capability offers standard tools to help facilitate the analysis process, import and account for costs, and enable continuous monitoring of strategy effectiveness. By contributing to decisions regarding when to repair versus when to replace, asset strategies and equipment performance can be optimized over the long term, thereby helping to reduce costs for entire sites or fleets over defined accounting periods.

This real-time view of how people, systems, and physical assets are performing, and the potential emerging threats, can help minimize safety and environmental risks and ensure high asset utilization at an optimal cost. Intelligent asset strategies bridge the gap between systems and transform the information into valuable insights and perspectives not possible with various point solutions.

Over time equipment ages, business and compliance requirements change, process conditions alter, and asset health can deteriorate. Intelligent Asset Strategies enable you to monitor emerging threats dynamically and automatically take actions, whether that be a notification that the strategy should be adjusted or automatically creating a recommendation for corrective repair work. This approach provides governance and management of the effectiveness of the overall asset management program and ensures a continuous cycle of improvement.

APM Reliability

A clear picture of plant-level performance and equipment reliability is essential to implement meaningful O&M strategies at the right time for your entire fleet. APM Reliability optimizes and prioritizes equipment operation strategies based on asset criticality, known risks and standardizes best practices for equipment maintenance, monitoring, and inspection across your entire fleet.

The P-F curve (Figure 3) illustrates how utilities can move from corrective to optimized preventive maintenance (Precision maintenance) with the capabilities of the APM Strategy. Now, let's investigate the next level of capabilities around Proactive Maintenance (Predictive maintenance) with further insights utilizing Machine Learning and Digital Twins.

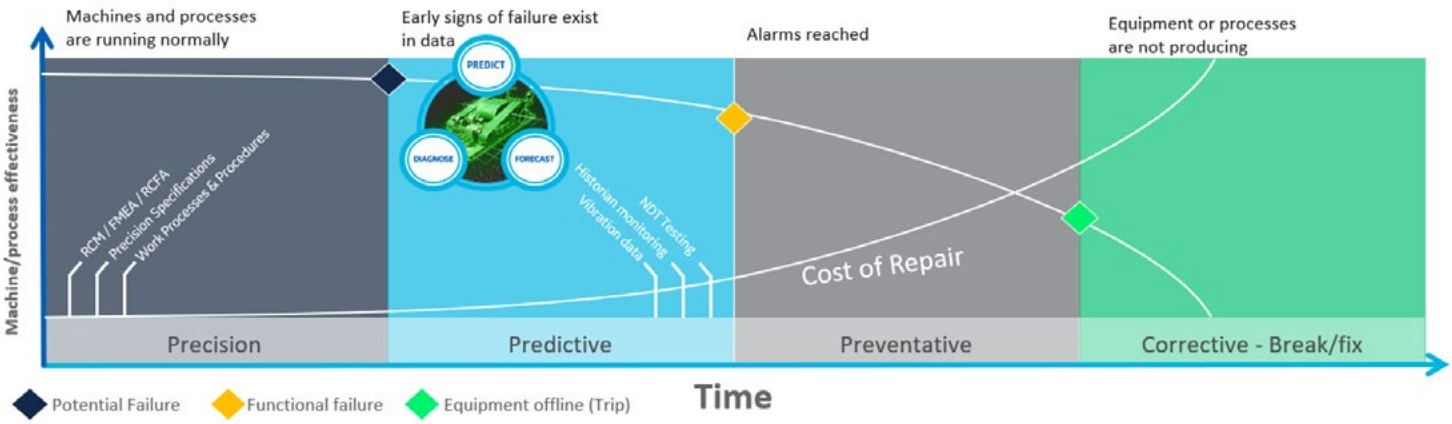

Figure 3. P-F Curve moves away from corrective (break/fix) and preventive maintenance (when an asset is moving towards a functional failure) to predictive maintenance by identifying issues when signs of a potential failure first appear with by utilizing software like APM Strategy for precision maintenance. Source: *GE Digital*

Maintenance challenges due to the rising complexity of an asset base are a common predicament for many fleets. Predictive analytics have demonstrated that users can optimize fleet maintenance planning to improve fleet performance and reliability. APM, featuring Digital Twin analytics, work process automation, and built-in GE industry experience, gives a nearly 360-degree view of the performance and O&M status of all fleet generating assets to unlock improved operational efficiency and avoid unplanned downtime by balancing cost, risk, and performance (Figure 4).

Real-time visibility to thermal performance for increased fuel savings

Diagnostic analysis for actionable insights that expedite remediation

Optimize plant economics with quantified performance and financial impacts

Thermal and data models configured to your actual plant and equipment designs

340 GE and non-GE reliability blueprints continuously being updated with new failure modes for accurate analytics relevant to your assets

Figure 4. GE Digital's APM Reliability begins with real-time visibility of actual equipment performance compared to expected performance based on a Digital Twin model. Performance deviations are reported to expedite remediation. GE Digital has a library of over 340 Digital Twin models that can be quickly configured to meet customer goals. Source: *GE Digital*

Digital Twins represents a software representation or model of a physical asset in operation. A Digital Twin reflects the asset's current condition and includes relevant historical data about the asset. A Digital Twin can model a single component, a system of components, or a system of systems. The Digital Twin may predict future behavior, refine control, or optimize operation(Figure 5). Subject matter experts develop multivariant models beginning with understanding the asset's engineering specification and the most common failure modes/degradation mechanisms associated with the asset and all its sub-components. Further, sensors on the asset(s) provide operational data that allows continuous updating of the predictive models.

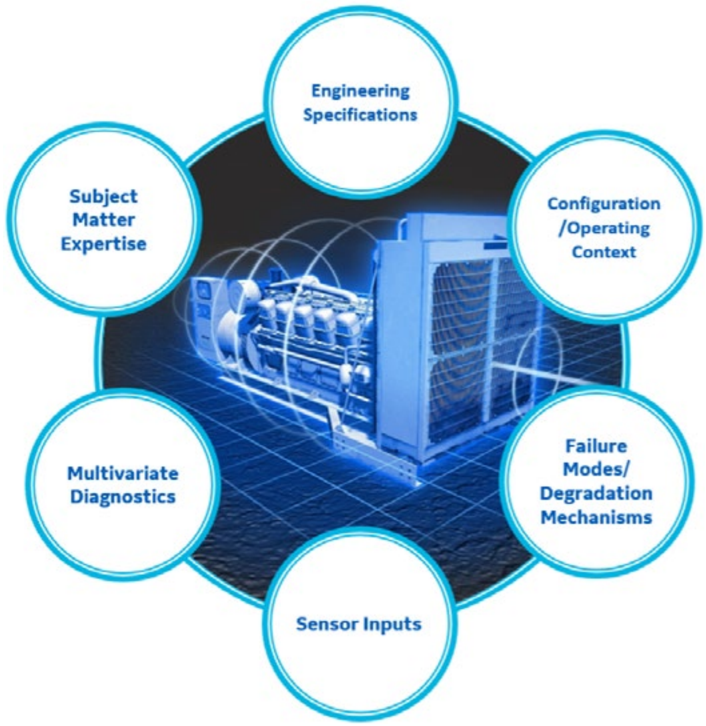

Figure 5. Content provided within a Digital Twin. Source: *GE Digital*

The Accelerator Library offered by GE Digital is the starting point for asset modeling. Many of our customers have added their knowledge and Intellectual Property into these Digital Twin Blueprints while using the software autonomously. Taking this Digital Twin template and creating dozens, if not hundreds, of individual assets and models is the key to scalability. Making changes and updates to the template and propagating to all the assets built from that template is critical in allowing for scalable and efficient operations.

The ever-changing dynamic in how plants, sites, and assets operate is important so the software can dynamically account for different operating profiles. With many older plants being designed to run at certain baseload conditions, accounting for these new operating conditions becomes even more critical when looking at improving the reliability of the cycling assets and ensuring the fleet is optimized. Utilizing machine learning algorithms, the expected/predicted measurements of the sensors under these conditions (Figure 6) can give earlier insights into potential issues arising and be planned according to the following maintenance window or planning an inspection during the downtime of the asset.

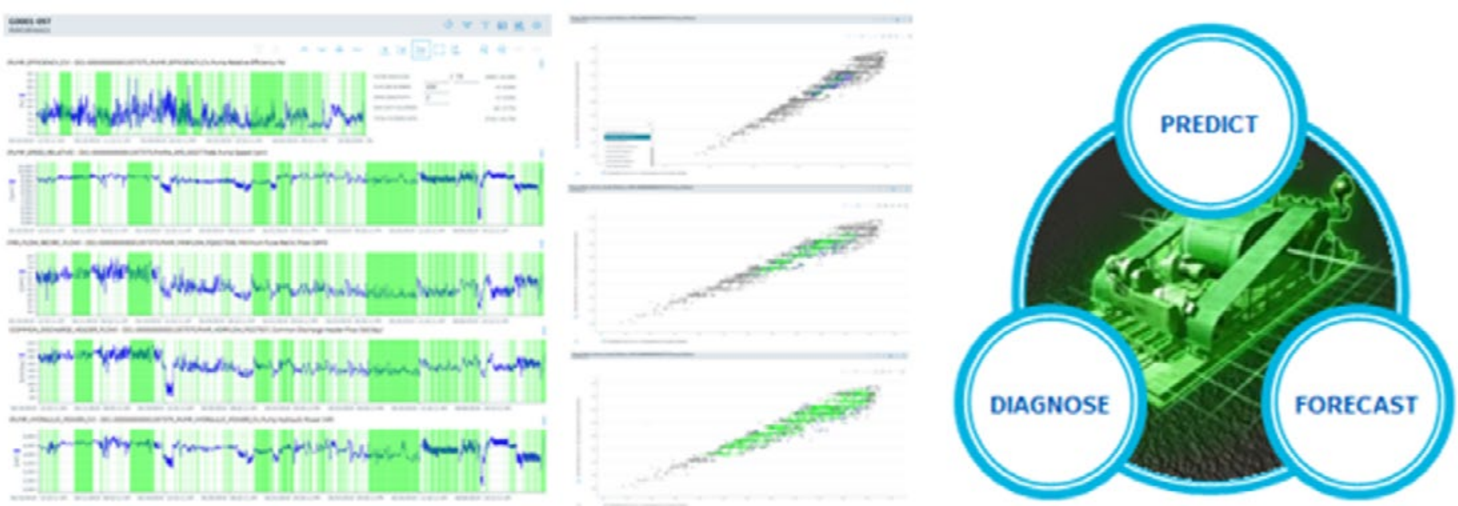

Figure 6. All the asset's sensor data is fed into machine learning algorithms to predict, diagnose, and forecast emerging issues before they occur to improve overall reliability and optimize fleet operations. Source: *GE Digital*

[3] Currently part of GE Digital future roadmap plans

By utilizing the out-of-the-box content developed inside of a Digital Twin to accelerate deployments and configuring the models with the asset's operating profiles, organizations will be able to generate predictive models, have ample time to diagnose issues before they occur, and forecast when the optimal time for performing proactive maintenance will be to improve overall reliability and optimizing fleet operations. GE Digital provides out-of-the-box, OEM-specific blueprints that make it easier for organizations investing in renewables to ensure sensor placement accuracy and day-one failure mode insights, covering over 60 critical asset types in the emerging renewables space.

Alongside these predictive analytics and Digital Twin models, GE Digital also provides other Reliability techniques within the product suite. This capability provides a comprehensive set of analytical tools to help understand the causes of asset failure patterns and the cost of such failure. This allows Reliability engineering principles to help make informed maintenance and operational equipment management decisions. Data is analyzed through Production Analysis, System Reliability Analysis, Spares Analysis, Reliability Distribution Analysis, Probability Distribution Analysis, Reliability Growth, and automation rules to develop strategies to improve reliability (Figure 7).

KEY CAPABILITIES

Reliability Analytics

- Production Analysis: Identify and understand your "hidden plant" losses
- Probability Distribution: Understand demonstrated asset performance and identify improvement strategies
- Reliability Distributions: Understand if your asset is wearing out and when it may fail
- Reliability Growth: Identify if asset reliability is improving or deteriorating
- Spares Analysis: Identify optimum holding levels for critical spares
- System Reliability Analysis: understand future asset reliability using asset connectivity modeling and scenario simulations

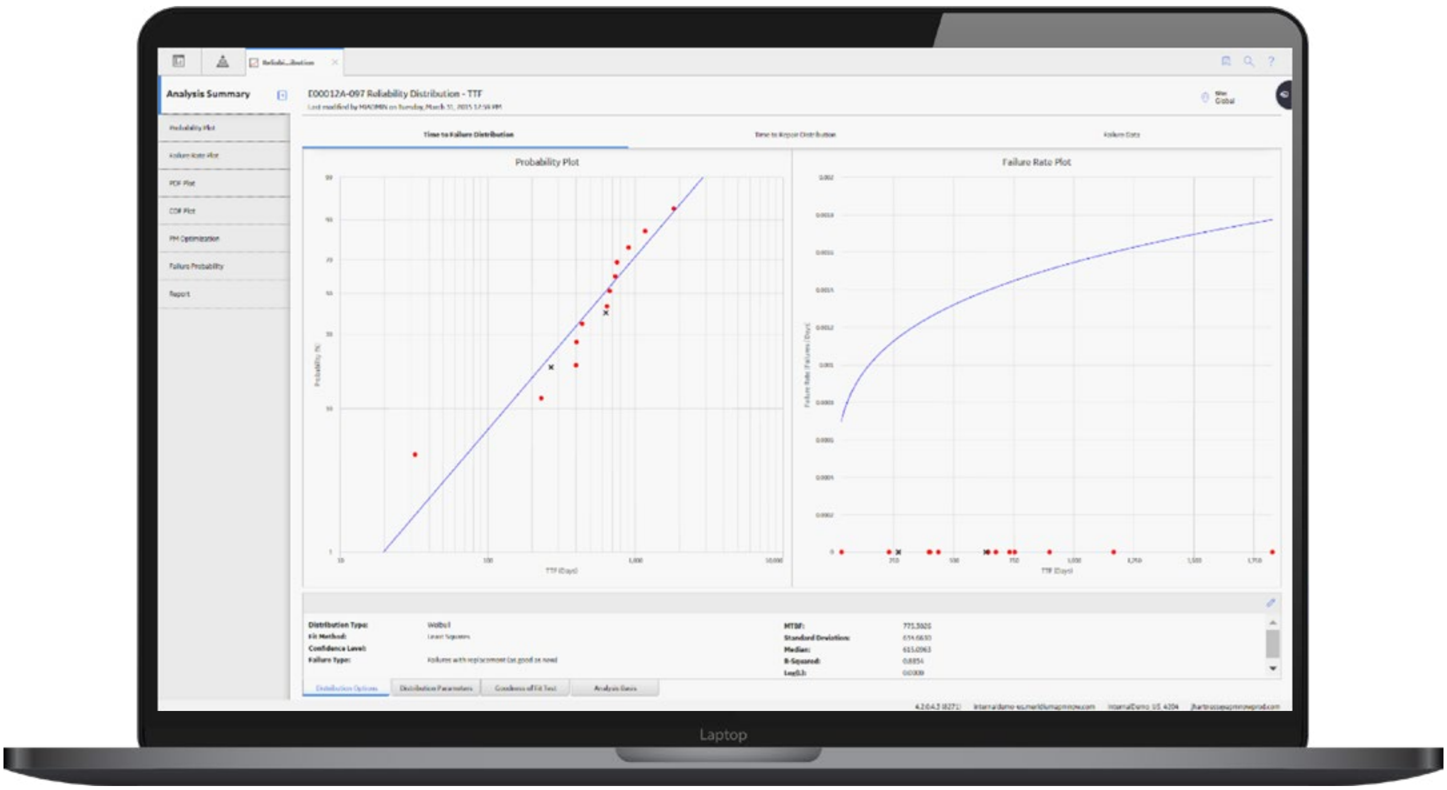

Figure 7. Using Reliability and Probability Distributions to understand asset performance, reliability, and calculating MTBF. Source: *GE Digital*

Another way to break down data silos for optimizing fleet operations and maintenance is through the Root Cause Analysis (RCA) module. This capability helps an organization to better understand and analyze the underlying causes of failure and captures and institutionalizes that information to help prevent future occurrences. GE Digital's tools to facilitate a standard process of performing an RCA are based on the PROACT methodology: Preserve, Order, Analyze, Communicate, and Track. By creating a team to conduct an RCA, users can create a logic tree and investigate the different hypotheses, perform a 5-Why analysis, preserve records, create an event timeline, track, report, communicate findings, and develop recommendations to ensure these events are mitigated. Data can be mined for similar failure scenarios across an enterprise or fleet of assets and analyze/determine causes of failures. Following the PROACT methodology, templates can be created and standardized for an RCA process. Or, utilizing GE Digital's Accelerator library, 300 out-of-the-box RCA templates are available for many critical asset types. RCA also allows an organization to track the subsequent performance of the equipment following the implementation of recommendations to mitigate the risk of it reoccurring (Figure 8).

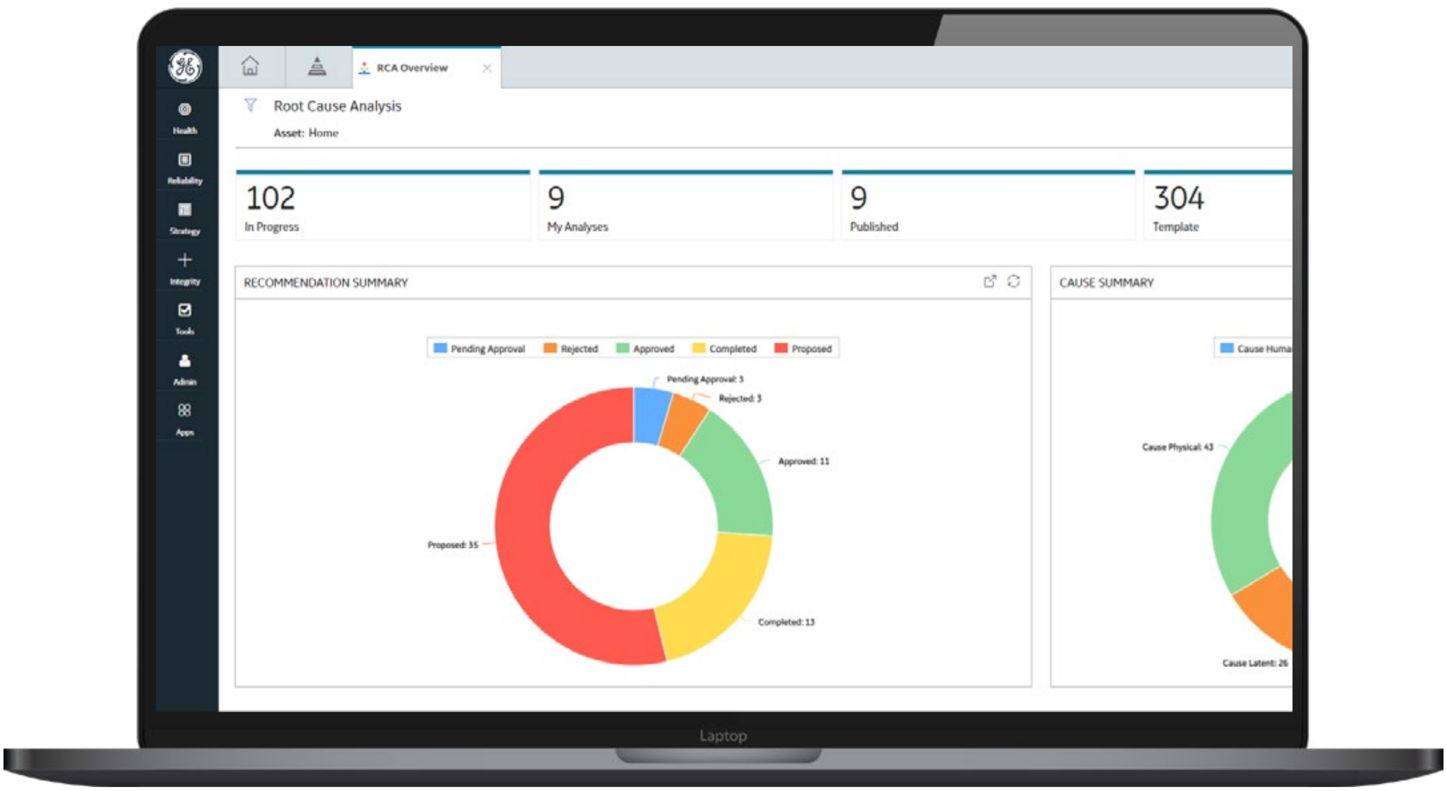

Figure 8. The RCA module allows organizations to perform Root Cause Analysis, create event diagrams and logic trees to find what caused a failure, communicate findings, and create recommendations to mitigate these failures from happening on similar assets across a fleet. Source: *GE Digital*

Generation Availability Analysis (GAA) and GAA-Wind are two additional modules used in the Power Generation space. GAA helps companies to report generation and loss event data to the North American Electric Reliability Corporation (NERC) or the Canadian Electricity Association (CEA). Companies can view and modify event and fuel consumption data to create performance records pertaining to the overall power generation for a given period. Organizations can then generate reports that follow the GADS mandatory reporting requirements and submit those reports to NERC or CEA. GAA-Wind module uses the International Electrotechnical Commission (IEC) event data from the GE Renewables Digital Wind Farm suite to help you record generation and loss data for each wind plant in your fleet.

The data collected in GAA and GAA-Wind can be analyzed and used differently. The APM Metrics capability can provide visibility and conditional alerts to KPIs and related targets. A review of capacity event records can lead to further analysis with the Root Cause Analysis and Failure Mode and Effects Analysis capabilities to help prevent recurring problems. Generation nameplate data can be used to analyze trends by the manufacturer to help improve fleet performance. Forced outage visibility can help provide planners with windows of opportunity to perform corrective maintenance (Figure 9).

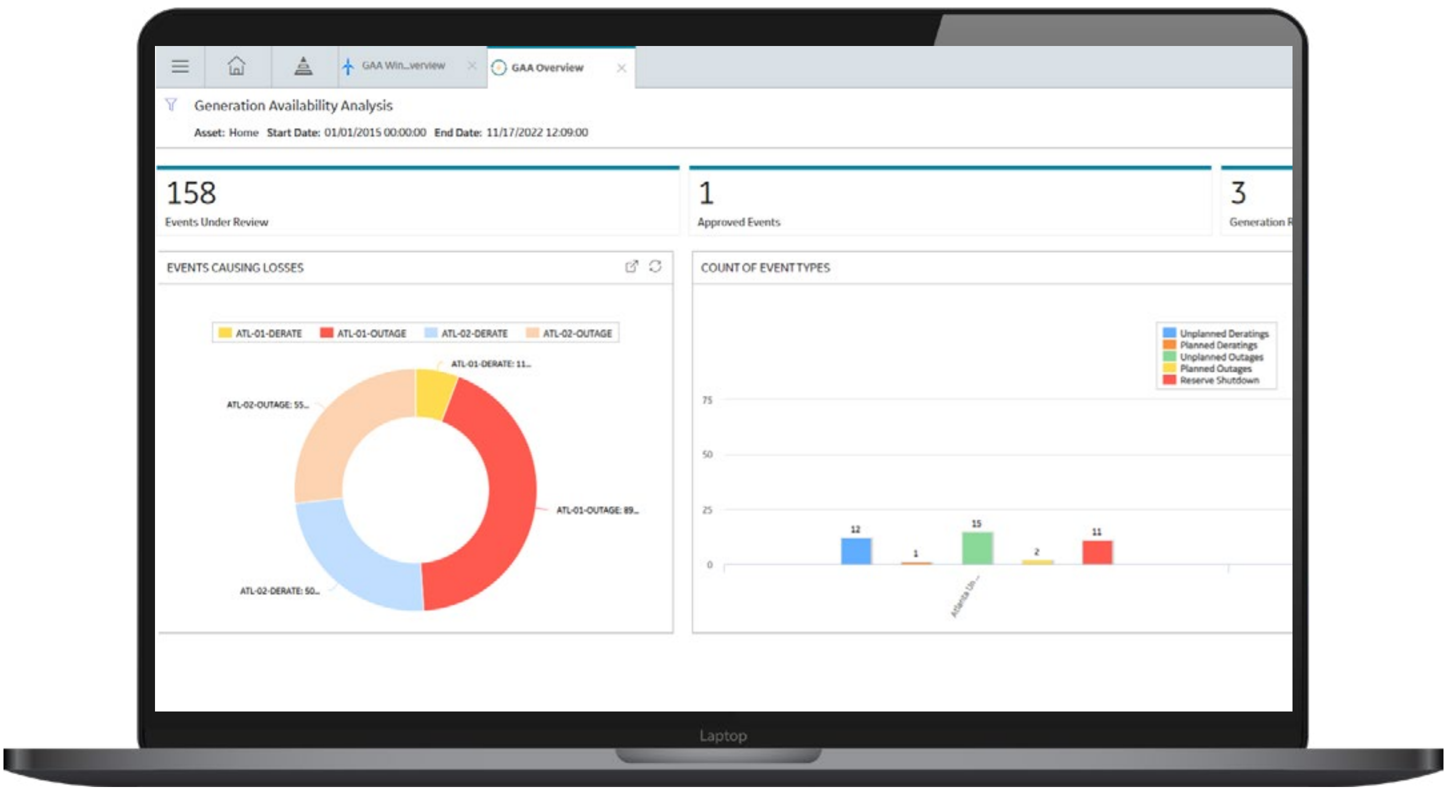

Figure 9. GAA and GAA-Wind overview page allows organizations to look at all the different events across a fleet, KPIs for Generation losses, and report generation. Source: *GE Digital*

Included in the Reliability suite of products is Performance Intelligence. The combined insights of reliability and performance give a holistic view of how to maintain and optimize the output of your power generation equipment.

Performance Intelligence utilizes physics-based Digital Twins specific to your power plant equipment to establish nominal performance by digitally replicating the equipment design and plant process. It then measures your actual operating conditions near real-time and compares them against model expectations. Deviations between actual performance and model-expected values are provided as notifications, alerts, and performance recovery advice.

APM Reliability Suite with Performance Intelligence can improve fleet performance in several ways

Thermal Performance

- Improve and maintain equipment performance and overall plant heat rate
- Perform accurate heat rate and efficiency calculations across the load range and operational conditions
- Provide real-time CO_2 production and historical aggregations of actual plant emissions – calculated from plant fuel consumption data
- Receive performance improvement advice that provides plant impacts, including capacity, fuel, and carbon

Consolidated Data and Diagnostics

- Real-time alerts with diagnostic insights and impact on plant capability provide data-based decision support
- Consolidated dashboard views available on one easy-to-use platform
- Identify and diagnose performance shortfalls that drive increased fuel consumption and reveal hidden equipment issues through actionable data reports
- Allow a fleet to maintain capacity for peak seasons by monitoring the entire load range and operating conditions through seasons to reveal developing trends and potential derates

What-If Tools and Economic Tradeoff Advisors

- Simulate operating conditions to understand performance & economic impacts
- Simulate alternate plant configurations to address demand
- Identify optimal time to execute gas turbine performance recovery actions based on economics with user-defined maintenance costs, operation profile, and fuel price
- Automatically detect water wash and effectiveness
- Evaluate inlet filter house performance and maintenance options

Flexibility Performance Monitoring

- Improve plant flexibility and operational performance
- Provide critical insights for start fuel consumption, start time, ramp rate, and minimum loads, such as combustion turbine turndown performance relative to expected minimum load fuel savings and operational benefits
- Provide visual intelligence on best and worst performers and minimum load operations

In sum, to reduce fuel and emissions, knowing each asset's thermal and operational performance with accurate field data and easy-to-use software enables plant operators to see which assets are best performers, know where improvements are needed and achieve equipment at entitlement.

GE Digital's Remote Operations and Command Center

Many organizations are re-evaluating emergency preparedness and employee health measures to ensure the continuity of reliable operations with reduced on-site staff. GE Digital's Remote Operations is a remotely deployable, turnkey solution to rapidly enact critical procedural changes to help protect both your operations and your employee's safety.

Remote Operations is a packaged software and appliance solution that provides remote/mobile operator access to essential on-site monitoring and control functions. A unique secure network system, hard-token credentials, and granular access controls ensure that remote, mobile, and on-site operators can work independently or together in a secure and NERC-CIP-compliant environment. Data encryption, two-level authentication, DMZ hosting, and virtualization are a few of the NERC-CIP prescribed preventive measures Remote Ops utilizes to reduce overall cyber risk.

Remote and mobile operators have secure and managed access to equivalent on-site HMI visualizations and essential operational controls regardless of HMI solutions in production. Managed security and operational validation safeguards to ensure that remote, mobile, and on-site staff could work remotely or together in a secure and compliant remote operations center environment. As an example, this can allow an expert at one location to easily troubleshoot an issue at another without physically having to be at the site.

Furthermore, when this technology is brought to a fleet level, in a Command Center, it provides secure remote access to all the plants in a fleet but also enables the aggregation of data across the sites, regardless of OEM or fuel type, and with configuration only enables a centralized or decentralized team to visualize, analyze and access data in a consistent way to streamline decision-making. It is an open ecosystem, so diverse and multi-generation assets of all types may be integrated with data-sharing (Figure 10).

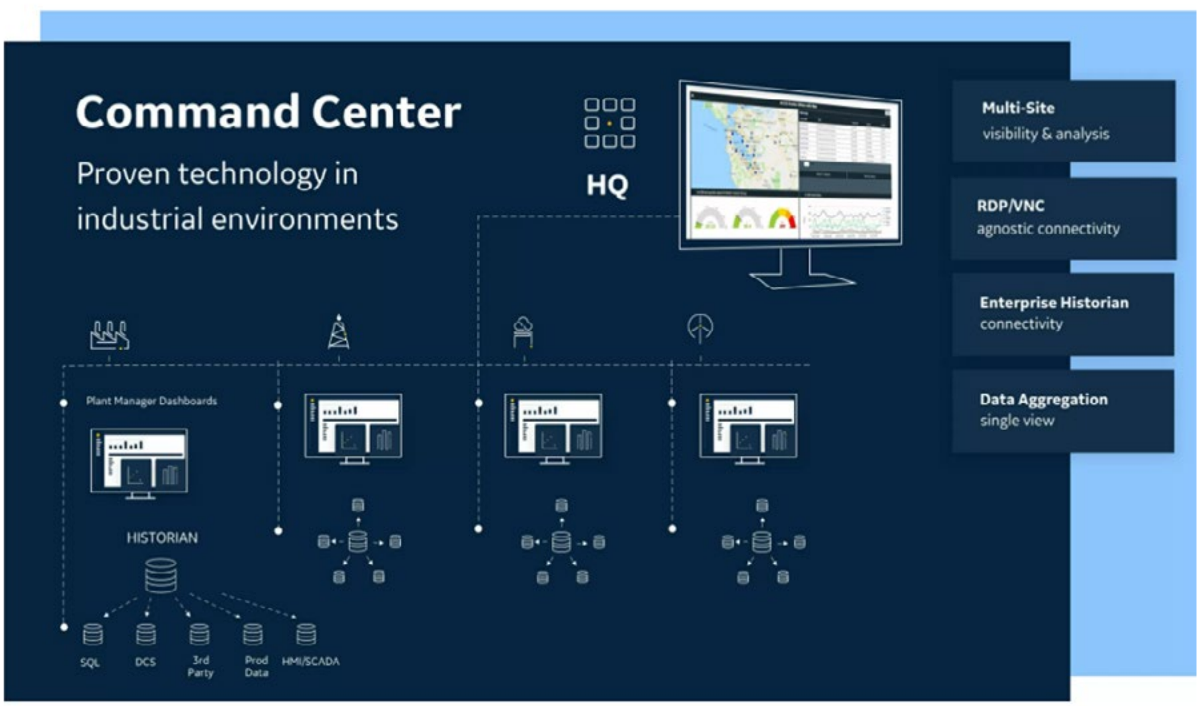

Figure 10. GE Digital's Command Center is a single system to consolidate, aggregate, visualize, analyze, and access data across enterprise systems. Source: *GE Digital*

GE's Command Center open source quickly consolidates any UI regardless of manufacturer or system. Third-party data, corporate systems, and business applications can also be integrated into the Command Center. This capability differentiates GE Digital from historical constrictive technologies out in the market. Further, the solution's flexibility means customers can implement a centralized or decentralized model. Each plant within a fleet can become the Command Center to manage the entire fleet (Figure 11).

Figure 11. GE Digital's Command Center shows a consolidated view of an entire fleet from one centralized location. Source: *GE Digital*

Conclusion

The energy transition is moving forward smartly. The bold, audacious goal of net zero carbon emissions by 2050 will require significant changes in the type of power-generating assets employed and reimagining the interconnecting grid. Determining how existing power generation assets are economically and reliably used during the energy transition without compromising grid reliability is perhaps the most significant challenge facing utility executives today. Traditional plant planning and executing plant O&M practices will no longer ensure individual plants remain competitive.

A holistic asset strategy is required that optimizes O&M practices across a fleet to achieve business goals, contain costs, and sustain reliability improvements. GE Digital APM solution addresses these issues by developing integrated work processes, optimizing O&M and PM programs, and establishing a culture of continuous improvement for your fleet of plants. The APM will predict, diagnose, and forecast critical assets and systems failures to ensure high plant reliability. Further, the APM will identify high-value, high-consequence opportunities for continuous improvement across the asset base. Work may then be prioritized based on its impact on business performance.

GE Digital has delivered its APM to over 400 customers globally across ten industry sectors, reducing operational risk, increasing availability and reliability, reducing reactive maintenance, and improving employee productivity.

Representatives of GE Digital are available to help you assess its APM's potential value to maximize your fleet's economic value.

Book a free consultation today.

GET STARTED