GE VERNOVA

ARTIFICIAL INTELLIGENCE FOR ENERGY ENTERPRISES

Examining the Potential of AI for Data-Rich Power and Energy Resources Organizations

FOREWORD

Around the world, industries are racing to adopt new artificial intelligence (AI) technologies. Manufacturers are using AI to improve quality control and coordinate supply chains. Financial services are deploying AI to reduce fraud and enhance customer service. Transportation companies are improving route planning and demand forecasting.

Can energy organizations also benefit from AI? That's the big question—and this whitepaper explores the answers by looking at:

- How AI could help energy firms achieve new levels of operational excellence, cost reduction, and business resilience.
- What energy organizations need to keep in mind when deploying AI solutions.
- How GE Vernova is leading the way in AI technology for the energy industry.

Key Terms
Throughout this whitepaper, you'll come across several variations of AI. Here are the five terms used, with a brief definition of each.

AI
Used as a blanket term to refer to any kind of artificial intelligence.

Machine learning (ML)
Used to refer to algorithms and models that identify patterns within data.

Generative AI
Used to refer to tools that create content based on patterns in existing data.

Agentic AI
Used to refer to models that act autonomously toward defined goals, adapting to environments using reasoning, memory, and feedback loops.

Human-in-the-loop
Refers to a deployment strategy whereby a human being is always involved in decision-making and monitoring of AI outputs.

INDUSTRY USE CASES FOR AI

Organizations in the energy sector are already deploying AI models to improve operational effectiveness, reduce risks, and plan more strategically. Below are examples of current implementations, organized by industry.

Industry	AI/ML Use Cases	Generative/Agentic AI Use Cases
Oil and Gas	**Predictive Maintenance:** Forecast equipment failures (e.g., compressors, pumps, pipelines) to reduce downtime. **Reservoir Optimization:** Analyze seismic data for better drilling decisions. **Energy Trading and Demand Forecasting:** Support trading strategies for hydrocarbons. **Asset Integrity and Safety**: Support monitoring of pipeline leaks and facility hazards with computer vision.	**Automated Reporting and Compliance**: Generate reports for regulatory bodies (e.g., EPA, OSHA). **AI-Driven Process Optimization:** Automate refinery optimization, adjusting parameters based on real-time data. **Enhanced Knowledge Management:** Organize unstructured data (engineering docs, maintenance logs, manuals).
Power Generation	**Predictive Maintenance for Turbines and Transformers**: Reduce forced outages by detecting anomalies. **Grid Optimization and Load Balancing:** Forecast demand and supports decisions to adjust energy dispatch accordingly. **Renewable Energy Forecasting:** Predict solar and wind generation to enhance grid reliability. **Asset Lifecycle Management**: Increase plant efficiency by analyzing historical performance data.	**Automated Energy Market Trading:** Support near real-time energy bids with AI agents. **AI-Augmented Workforce:** Assist operators by analyzing vast amounts of data. **Intelligent Grid Self-Healing:** Autonomously isolate faults and re-route power.
Metals and Mining	**Ore Grade Prediction and Exploration:** Analyze geological data to identify high-yield deposits. **Autonomous Drilling and Haulage:** Reduce operational risks with AI-powered vehicles. **Energy Optimization in Smelting and Refining:** Reduce energy consumption in metal extraction. **Workforce Safety and Hazard Detection:** Improve safety by using computer vision when navigating unsafe conditions in mines.	**Intelligent Production Scheduling:** Autonomously adjust mine output based on demand fluctuations. **AI-Powered Maintenance Assistants:** Provide troubleshooting guides and insights for engineers. **Automated Environmental Reporting**: Generate Environmental, Social, and Governance (ESG) reports.

Industry	AI/ML Use Cases	Generative/Agentic AI Use Cases
Specialty Chemicals	**AI-Driven Chemical Formulation:** Accelerate research and development for new chemical compounds. **Process Optimization:** Fine-tune reaction conditions to maximize yield and minimize waste. **Predictive Equipment Maintenance:** Help prevent failures in reactors, distillation units, and mixing systems. **Supply Chain and Demand Forecasting:** Improve chemical production based on market demand.	**AI-Powered Lab Assistants:** Synthesize research insights for chemists. **Automated Compliance Management**: Generate safety data sheets and regulatory documentation. **Self-Optimizing Manufacturing:** Adjust chemical processes in near real-time to improve efficiency.
Discrete and Process Manufacturing	**Predictive Maintenance for Turbines and Transformers**: Reduce forced outages by detecting anomalies. **Grid Optimization and Load Balancing:** Forecast demand and supports decisions to adjust energy dispatch accordingly. **Renewable Energy Forecasting:** Predict solar and wind generation to enhance grid reliability. **Asset Lifecycle Management**: Increase plant efficiency by analyzing historical performance data.	**AI-Augmented CAD Design**s: Accelerate product design iterations. **Factory Automation with Agentic AI:** Autonomously optimize assembly lines. **Digital Twin and AI Simulations:** Test process changes before real-world deployment.

LIMITATIONS WHEN DEPLOYING AI SOLUTIONS

When considering AI solutions for your organization, it's important to be mindful of potential complications. These can be sorted into two categories: Operational Limitations and Technology Limitations.

Limitation 1: Operational

These issues relate to the limitations some energy organizations may experience when deploying AI solutions as a result of their existing architecture.

Data Quality and Availability

Siloed, unstructured, or incomplete operational and asset data are all signs of poor data governance—and this can lead to sub-optimal results since the AI is working with inconsistencies and low-quality information.

Scalability and Interoperability

Legacy systems might not easily integrate with AI-powered solutions, so models built for one site or asset type may not generalize well across a fleet. Also, organizations may lack standardized data formats and APIs, creating more friction when deploying AI.

Trust and Explainability

Engineers and operators may require AI models to be interpretable and aligned with physics-based models. Due to some of the complexity, "black box" AI recommendations are met with skepticism by experts in the field. More so, regulatory and compliance requirements may even demand auditability of AI decisions.

Cybersecurity and Risk Management

AI could increase attack surfaces, potentially making energy infrastructure more vulnerable to cyber threats. For critical grid and asset operations, it's necessary to have an AI that is resilient to adversarial attacks and false positives.

Workforce Adoption and AI Fluency

The industry is heavily dependent on domain experts who may be resistant to AI-driven workflows, making the concept of using AI intimidating. More broadly, it remains challenging to build trust about the effectiveness and security of AI.

LIMITATIONS WHEN DEPLOYING AI SOLUTIONS (CONTINUED)

Limitation 2: Technology

These issues relate to the limitations some energy organizations may experience when deploying AI solutions as a result of their existing architecture.

Data Hallucination and Fabrication Risks

GenAI models may generate false or misleading insights that appear authoritative. If used in decision-making for asset maintenance or grid stability, hallucinations could lead to failures.

Loss of Domain-Specific Accuracy

While AI can rapidly analyze vast amounts of data, it lacks the deep physics-based accuracy needed for critical infrastructure. Generative models may override or misinterpret first-principles engineering models and require some time to train.

Automation vs. Human Oversight

Agentic AI could introduce risks in high-stakes environments. Fully automated decision loops may not have the necessary human oversight, potentially leading to unintended operational disruptions.

Ethical and Regulatory Uncertainty

Governments and regulatory bodies have yet to fully define AI governance policies for critical energy infrastructure. AI's ability to generate reports, analyses, or even code may raise concerns about accountability, liability, and compliance.

Increased Compute and Cost Burden

Running advanced AI models, especially GenAI and Agentic AI, at scale requires significant computational power. Many organizations are already struggling with costs, meaning AI could further strain budgets when operated in-house.

OVERCOMING THESE LIMITATIONS

So far, this whitepaper has outlined the potential of AI, industry-specific use cases, and considerations for deployment. How then, can energy organizations ensure effective deployment and avoid the aforementioned risks?

Below are four general deployment guidelines to help safely achieve the benefits of AI.

1. **Improve Existing Data Governance and AI Validation**
   By establishing strong data pipelines within their organization, energy companies can reduce the risk of poor data quality—which could lead to weak or misleading insights. With AI monitoring systems, organizations can keep an eye on AI outputs to maintain quality.

2. **Prioritize Explainability and Trust**
   AI-generated insights are only valuable if they align with established, physics-based principles and should usually conform with widely accepted industry knowledge. By prioritizing explainability, energy organizations can improve trust in their insights.

3. **Assess AI ROI Before Scaling**
   As mentioned previously, taking AI one step at a time can help energy organizations avoid overcommitting to tools that don't work for them. By prioritizing high-value AI use cases, like predictive maintenance and asset optimization, they can assess the ROI of AI tools before choosing to scale.

4. **Choose a Reliable Provider**
   By ensuring that the provider of AI solutions has experience in the field, including how to navigate the nuances of AI for energy, organizations can be confident that their AI deployment is in safe hands.

How GE Vernova is Ensuring Effective AI Usage

Taking a Human-in-the-Loop Approach

Instead of giving AI tools full autonomy in decision-making processes, GE Vernova solutions keep humans in the loop, essential for operations. This will help organizations not only avoid negative outcomes but also empower teams to work with these tools to improve operations.

Deploying Built-In Security

Energy organizations must build AI systems with robust security (both physical and cyber) and regulatory foresight. GE Vernova models include safeguards against prompt injection and jailbreak detection, enforce redaction, scanning, and content moderation, and embed authentication to access sensitive data.

AI IN ACTION: GE VERNOVA SOFTWARE

This section outlines how GE Vernova's Software business is helping organizations start and scale AI programs today.

How to Prepare Your Organization for AI

The potential for AI is enormous. But to enable your organization to effectively adopt AI tools, you must first look at your existing analytics capabilities. The first analytics stage, descriptive, is the least conducive to working with AI. The fourth stage, prescriptive, is the most. By progressing across the four stages of analytics, your organization can best prepare itself to achieve value through AI.

Many organizations opt to start out with descriptive and diagnostic analytics before progressing with predictive or prescriptive diagnostics as their appetite grows. Taking a "baby steps" approach can give teams more confidence when adopting AI technologies, instead of going "all in" at once.

This helps provide a clear view of both historical and near real-time asset performance. By aggregating data (from sensors, EAM systems, work orders, historical logs, etc.), descriptive analytics offer a snapshot of current conditions and recent trends. This can help energy organizations understand the state of their assets, track key performance indicators, and identify areas for improvement.

This can help organizations identify the underlying causes of equipment issues. By identifying anomalies or performance degradations, energy organizations can move from reactive to proactive problem-solving, often preventing minor issues from escalating into costly failures.

This can help energy companies anticipate future asset behavior by using data patterns to forecast potential equipment failures and performance changes. Predictive analytics can support proactive maintenance, allowing operators to address issues before they cause unplanned downtime.

This branch of data analytics focuses on identifying the best course of action based on data analysis and modeling. It simulates scenarios and predicts the outcomes of various actions. After predicting outcomes it generates recommendations to help improve overall asset and operational performance.

EXISTING AI CAPABILITIES POWERING GE VERNOVA SOLUTIONS

This section walks through the interoperable and composable approach that GE Vernova uses with Asset Performance Management (APM) software and other applications that allows for point or enterprise use.

Essentials Platform

GE Vernova's Essentials is a microservice-based platform that helps organizations integrate and manage data from numerous systems. It achieves this by breaking down complex software architectures into modular, independent services.

This allows users to ingest and normalize structured and unstructured data from disparate sources—whether from industrial assets, enterprise IT systems, or third-party applications—without the constraints of legacy platforms. With flexible visualization tools, users can create real-time dashboards and reports tailored to specific operational needs, transforming raw data into actionable insights.

Additionally, the platform's open architecture supports advanced analytics and AI/ML model deployment. This enables organizations to bring their own models, harness prebuilt analytics, and apply AI-driven predictions—all of which can help optimize asset performance, detect anomalies, and automate decision-making. This unified yet modular approach improves scalability, accelerates innovation, and empowers energy enterprises to unlock the full potential of their data.

Below is an overview of our available software applications, including how they can each deploy AI for energy organizations:

- **SmartSignal** uses predictive and prescriptive analytics to assess when an asset may fail and recommends maintenance actions.
- **Autonomous Inspection** uses AI in the form of computer to translate images, infrared data, and other visual inputs into time series data in APM. Using custom, scalable models, users can identify, create, train, and deploy AI to solve asset concerns. Autonomous Inspection can provide alerts to help reduce inspection costs, increase reliability, and enhance employee safety.
- **Performance Predictions** uses neural networks to develop prescriptive analytics to improve market performance for power generators. Using AI-enabled probabilistic insight into the future capacity and energy prices for day-ahead market participation, this solution supports more efficient usage of renewables by the generator.
- **Autonomous Tuning** uses adaptive neural networks to automate the fuel/air split for aeroderivative turbines, adjusting based on changes in ambient temperatures. This helps reduce emissions and improve efficiency.
- **CERius** uses neural networks and similarity-based modeling to automate emissions data collection and verification. CERius is able to use historical and near real-time emissions data to identify areas for emissions improvement. It can also perform scenario-based modeling to forecast emissions and recommend strategies to help reach net-zero targets.

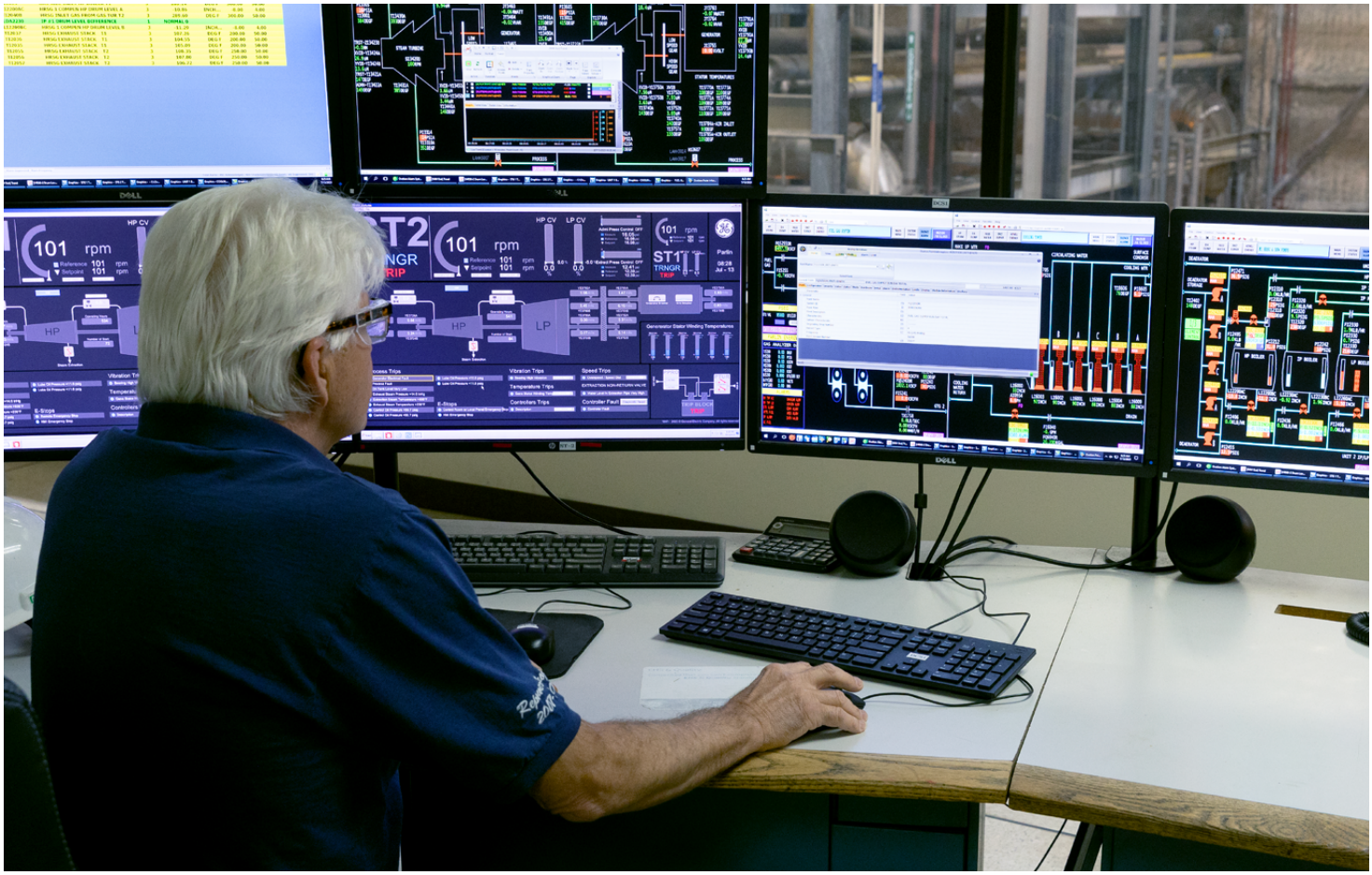
GE VERNOVA'S AI ROADMAP

New AI tools, such as Generative AI and Agentic AI, are bringing a wealth of new possibilities that can help energy organizations to:

- **Improve employee efficiency** by automating routine tasks, data analysis, anomaly detection, and reporting.
- **Increase innovation** by providing tools for predictive maintenance, failure mitigation, and performance improvements.
- **Create prescriptive content** by analyzing asset performance data to generate actionable recommendations tailored to specific assets.
- **Harness deep learning** by processing vast amounts of data to dive deeper into asset performance metrics.

GE Vernova is currently running beta applications, proofs of concept (POC), and pilots to investigate use cases for GenAI within APM. Focus areas of the work include:

- Prescriptive recommendations in GE Vernova's SmartSignal application.
- Structured and unstructured data summarization for assets, starting with APM Integrity use cases.
- False positive alert detection for SmartSignal and other APM alerts.
- In-application query capability functionality for APM users.
- Optical character recognition for inspection document processing for Autonomous Inspection.



AI and GenAI Future **for Platform**

Through customer feedback and collaboration, the potential for GenAI to provide increased value through data visibility and actioning was expressed. Therefore, GE Vernova continues to explore with customers the proper models and outcomes required to see a return on value. For example, GE Vernova is currently testing the use of Amazon Bedrock within our platform layer.

- Amazon Bedrock is a fully managed service that offers a choice of high-performing foundation models (FMs) from leading AI companies including AI21 Labs, Anthropic, Cohere, Meta, Mistral AI, Stability AI, and Amazon through a single API, along with a broad set of capabilities needed to build generative AI applications with security, privacy, and responsible AI.
- Since GE Vernova's APM already uses AWS services such as EC2, RDS, Keyspaces, S3, SageMaker, and others, the extension of services into Bedrock becomes more feasible. On the flexible Essentials platform, GE Vernova is able to use AWS Bedrock in production to leverage data, execute tasks, and more.

AI and GenAI Future **for Applications**

By using Large Language Models (LLM), APM applications are able to ingest more data sources and types, extrapolate data in the context of asset performance, and generate intuitive alerts for end users. For each APM application, GE Vernova is exploring the best ways to use structured / unstructured data, co-pilots, and other functionality to better support end users in their daily asset tasks.

Use cases under development include:

- Prescriptive Analytics in SmartSignal: Using LLMs, organizations can gain expert recommendations from ingested data. The user could receive a maintenance recommendation for asset maintenance, and with human-in-the-loop, can select the proper course of action and decline recommendations to help train the models based on human expertise. This can help retain tribal knowledge, scale new hires more quickly to support APM processes, and support a more efficient operation. From the work at the platform level, SmartSignal could also increase the accuracy of alerts coming from time series and sensor data.
- Structured and unstructured OEM data ingestion in APM Integrity: Organizations could use a model to ingest long-form written documentation (handbooks, maintenance logs, etc.) and convert it into information that will be able to get queried by a user. For APM Integrity, this could mean an overall better understanding of fixed asset inspection requirements.
- Addition of Small Language Models (SLMs) or LLMs to Computer Vision in Autonomous Inspection: Supports a wider variety of data ingestion at scale.
- Addition of AI to APM Health for advanced analytics: As an expansion of the descriptive and diagnostic analytics, AI capabilities will further refine criticality advisories, finetune limits overtime, and add fidelity to the Asset Health Index by querying all data sources for quick verification.

CONCLUSION

When looking at the current use cases across multiple industries (energy, manufacturing, logistics, etc.), it's clear that AI has the potential to transform businesses.

For energy organizations, APM can be greatly improved through analytics, generative AI, and Agentic AI. When implemented effectively, these tools can help organizations reduce downtime, optimize maintenance strategies, and extend the life of critical infrastructure.

AI adoption also comes with challenges around data complexity, integration, and security. Without a clear strategy and the right use cases, AI initiatives risk becoming costly experiments rather than value-generating solutions.

AI is not a one-size-fits-all solution. That's why GE Vernova works closely with customers and partners to develop AI applications that address real-world challenges in Asset Performance Management.

Whether it's leveraging computer vision for equipment inspections, neural networks for predictive maintenance, or generative AI for structuring unstructured data, GE Vernova helps deploy AI with purpose.

By integrating AI into GE Vernova's open, microservices-based platform, Essentials, enterprises can bring their own analytics, connect to existing systems, and scale AI use cases in a way that aligns with their operational goals.

As the energy industry continues to navigate digital transformation, GE Vernova remains committed to responsible AI adoption—one that empowers organizations to harness AI's full potential while maintaining control, trust, and measurable impact.

To learn more about the solutions discussed in this whitepaper, please reach out today.

Contact Us →

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