HUB TECH IA

Deliverable report 15

AI and IAGEN Application Use Case

Operations and Maintenance for Diagnosis and Detection of Faults, Delays, or Inefficiencies in Vaca Muerta, Neuquén

I. Introduction

Generative Artificial Intelligence (GENI) is a branch of artificial intelligence that focuses on creating new content, such as models, images, code, or text, from existing data. This technology uses advanced algorithms to analyze large amounts of information, identify patterns, and generate new and original content that is often indistinguishable from human-created content.

Generative Artificial Intelligence (GENI) is rapidly transforming various sectors, and the oil and gas industry is no exception. This technology, with its ability to analyze large volumes of data, identify patterns, and generate innovative solutions, offers enormous potential for optimizing operations and maintenance in oilfields. This report analyzes the specific application of GENI in Vaca Muerta, Neuquén, with the goal of diagnosing and detecting failures, delays, and inefficiencies, and improving overall operational efficiency.

Vaca Muerta, one of the world's largest unconventional oil and gas fields, faces unique challenges in terms of operations and maintenance.

The geological complexity of the formation, the vast expanse of the deposit, and the extreme climatic conditions demand advanced technological solutions to ensure production efficiency and profitability. IAGEN is presented as a key tool to address these challenges and maximize Vaca Muerta's potential.

II. IAGEN Technologies Relevant to Vaca Muerta

The following IAGEN technologies are particularly relevant for diagnostics and fault detection at Vaca Muerta:

Technologies for Prediction:

- Machine Learning: Machine learning algorithms can analyze large volumes of production data, identify patterns, and predict potential equipment failures.
- Deep Learning: Deep neural networks can analyze complex images and data to detect anomalies and predict well behavior.

Technologies for Monitoring:

- Computer Vision: Computer vision allows you to analyze images from cameras and drones to detect leaks, infrastructure damage, and other problems.

Technologies for Analysis:

- Natural Language Processing (NLP): NLP can analyze maintenance reports, production logs, and other documents to identify patterns and extract relevant information.

IV. How IAGEN Can Improve Efficiency in Vaca Muerta

IAGEN can address the challenges at Vaca Muerta and improve operational efficiency in several ways:

Logistics Optimization:

- IAGEN can optimize transportation routes, supply chain management, and maintenance scheduling, reducing costs and improving efficiency to increase

safety.

- By analyzing traffic data, weather conditions, and resource availability, IAGEN can help companies plan more efficient and safer transportation routes, avoiding delays and reducing fuel consumption.
- IAGEN can also optimize supply chain management by predicting demand for materials and equipment and ensuring they are available at the right time and place.

Failure Prediction:

- IAGEN can predict equipment failures, enabling preventative maintenance and avoiding costly production interruptions.
- Machine learning algorithms can analyze sensor data, such as vibration, temperature, and pressure, to identify patterns that indicate potential equipment failure.
- This allows companies to proactively schedule maintenance, avoiding unexpected failures that can cause costly production interruptions.

Remote Monitoring:

- IAGEN can monitor operations remotely, using drones, sensors, and other technologies, reducing the need for manual inspections and improving safety.
- Drones equipped with high-resolution cameras can inspect infrastructure such as oil and gas pipelines and wells, identifying signs of wear, structural damage, and other problems.
- This enables companies to conduct inspections more quickly, efficiently, and safely, reducing risks to personnel and minimizing disruptions to operations.

Data Analysis:

- IAGEN can analyze large volumes of data to identify patterns, optimize production, and improve decision-making.
- By analyzing production data, IAGEN can identify areas for improvement in well

efficiency, optimize hydrocarbon extraction, and predict future reservoir behavior, all of which can contribute to increased safety in the operation.

Direct benefits:

- Immediate and precise diagnosis of faults.
- Significant reduction in reaction times.
- Automation in the generation of corrective orders.

V. Concrete Solutions Based on IAGEN

Generative Artificial Intelligence (GENI) is implemented in this context through integration with existing monitoring and management systems for operational data from sensors installed in machines, equipment, and field processes.

Using specialized APIs and automated data access, advanced models such as GPT-4, PaLM 2, or LLaMA 3 can analyze critical parameters such as pressure, temperature, vibration, energy consumption, and operating times in real time. This facilitates the early detection of anomalies that could indicate technical failures or operational inefficiencies.

Below are some concrete IAGEN-based solutions for specific problems in Vaca Muerta:

- Leak Detection System: Implement an IAGEN-based leak detection system that uses computer vision to analyze drone images and detect leaks in oil and gas pipelines. This can help prevent spills, protect the environment, and prevent economic losses.
- Equipment Failure Prediction: Develop a failure prediction system that uses machine learning to analyze sensor data and predict potential failures in pumps, valves, and other critical equipment. This allows companies to perform preventative maintenance, avoiding unexpected failures that can cause costly production interruptions.
- Hydraulic Fracturing Optimization: Use IAGEN to optimize hydraulic fracturing parameters, such as pressure, flow rate, and fluid composition, to maximize

production and reduce environmental impact. IAGEN can analyze geological data, offset well information, and previous fracturing results to determine optimal parameters for each well.

- Well Integrity Monitoring: Implement a monitoring system that uses smart sensors and IAGEN to assess well integrity and detect potential structural problems. This can help prevent accidents, protect infrastructure investments, and ensure safe operations.
- Drawdown Practice Optimization: IAGEN can refine techniques for controlling well pressure and flow, optimizing drawdown practices and improving production efficiency.
- Parent-child Effect Mitigation: IAGEN can develop strategies to reduce the negative impacts of interactions between nearby wells, mitigating the parent-child effect and maximizing production from each well.
- Measures to Mitigate Casing Deformations: IAGEN can implement new practices to minimize structural deformations in wells, reducing the risk of failure and extending well life.
- Optimizing Proppant Use: IAGEN can improve the selection and application of proppants, such as sand, to increase hydrocarbon extraction efficiency.
- Fracture Conductivity Characterization: IAGEN can evaluate and improve the conductivity of hydraulic fractures, extending fracture life and maximizing production.
- Fluid Injection: IAGEN can determine optimal operating conditions for injecting surfactants, gases, or foams, improving the efficiency of hydrocarbon recovery.
- Critical Parameter Optimization: IAGEN can identify and adjust key parameters to improve hydrocarbon recovery efficiency.
- Feasibility Analysis: IAGEN can evaluate the viability of different hydrocarbon recovery technologies and methods, helping companies make informed decisions about the best strategies to maximize production.
- Field Operations Design: IAGEN can propose and develop innovative operational designs for field implementation, improving the efficiency and safety of operations.

- Emissions Reduction Initiatives: Companies such as Shell, YPF, and Vista are implementing various strategies to reduce greenhouse gas emissions in Vaca Muerta. IAGEN can contribute to these efforts by optimizing operations, monitoring emissions, and implementing mitigation technologies.

VI. Specific Technologies and Models

- GPT-4 Turbo Model: Advanced data interpretation, automatic diagnostic generation, and proposals for specific solutions.
- PaLM Model 2 (Google): Potential for advanced predictive analytics, process optimization, and response in complex scenarios.
- LLaMA Model 3 (Meta): Specific application in open environments, resource-efficient, ideal for scalable implementations.
- API Integration and Automation: For automatic data extraction and processing from SCADA and PLC systems.
- Edge Computing Technologies: For real-time analysis close to data sources.

VII. Application of agents powered by IAGEN

1. **IAGEN Agents Concept**

In recent years, generative artificial intelligence (GAI) has revolutionized the way we interact with technology, enabling the development of systems capable of generating content, answering complex questions, and assisting with highly demanding cognitive tasks. From this capability, a new technological architecture has emerged: GAI-powered agents. These agents are not simple conversational interfaces, but autonomous systems that can interpret instructions, make decisions, execute tasks, and learn from their interactions with the environment.

An IAGen agent combines large language models with additional components such as external tools, memory, planning, and autonomous execution. This allows them to operate in complex environments, with the ability to break down objectives into steps,

coordinate multiple actions, interact with digital systems (such as databases, APIs, or documents), and adapt to context changes in real time. These qualities distinguish them from traditional chatbots and open up a range of more sophisticated and customizable applications.

At the organizational level, these agents are being used to automate processes, generate data analysis, assist in decision-making, and improve the user experience, both internally and externally. For example, they can take on human resources, legal, financial, or logistics tasks, and even tasks linked to the technical areas of production processes, acting as intelligent assistants that collaborate with human teams. This ability to integrate knowledge and execute tasks autonomously transforms the way organizations can scale their operations without losing quality or control.

Furthermore, agentic workflows—structures where multiple agents collaborate to solve complex problems—allow responsibilities to be distributed among different agent profiles, each with specific functions. This creates hybrid work environments where humans and agents coexist, optimizing time, costs, and results. The ability to connect agents with tools such as Google Drive, CRMs, or document management platforms further expands their capabilities.

The development of IAGen-powered agents represents a crucial step toward a new era of intelligent automation.

Among the benefits of authentic workflows powered by generative AI models is the ability to automate entire production processes, end-to-end, and even add value by leveraging the capabilities of language models based on these technologies.

However, its implementation also poses technical, ethical, and legal challenges, ranging from responsible design to human oversight. Therefore, understanding its architecture, operational logic, and potential impacts is critical for its effective and safe adoption in diverse professional contexts.

2. **Agentic Flow Design Proposal for Implementation**

Step 1: Automatic Data Collection:

- Sensors installed in critical equipment continuously collect data.
- Data automatically sent via APIs to systems integrated with generative language models.

Step 2: Automatic Analysis with IAGEN:

- GPT-4, PaLM 2, or LLaMA 3 models analyze data in real time, detecting anomalies and patterns of inefficiency.
- The system automatically generates specific diagnoses with clear identification of the problem.

Step 3: Automatic Report Generation:

- Generative models produce clear, concise, and detailed reports on the nature of the detected problem.
- Automatic inclusion of practical recommendations to resolve each incident.

Step 4: Automated or Semi-Automated Corrective Actions:

- Automatic sending of preventive or corrective maintenance orders to ERP systems and technical teams.
- Automated monitoring of applied solutions and continuous evaluation of their effectiveness.

Specific Example: A hydraulic pump on a fracturing rig is experiencing abnormal vibration increases. The IAGEN system immediately identifies that the vibration exceeds normal limits, generating a report with a diagnosis (shaft misalignment) and a specific recommendation (check and adjust alignment). A request is automatically sent to the

technical team for immediate intervention.

IX. Concrete Opportunities and Benefits

- Reduction in operating costs: Up to 30% by reducing downtime and optimizing preventive maintenance.
- Improved operational efficiency: 20% increase in the availability of critical equipment.
- Improved safety: Reducing the risk of accidents and catastrophic failures through early detection of problems.

Compared to traditional manual or semi-automated diagnostic methods, IAGEN allows problems to be anticipated and resolved in a fraction of the time normally required, significantly improving operational efficiency.

X. Challenges in Vaca Muerta

Vaca Muerta faces specific challenges in terms of operations and maintenance, which are summarized in the following table:

Challenge	Description	Impact
Limited Infrastructure	Road and rail infrastructure in the region is limited, making it difficult to transport equipment and materials [6].	Increased transportation costs, delays in delivery of materials and equipment.

High Transportation Costs	Transportation costs are high due to long distances and lack of adequate infrastructure.	Reduction in the profitability of operations.
Shortage of Qualified Personnel	A lack of trained personnel in the region can cause delays and increase costs.	Difficulty finding staff with the necessary experience and skills.
Extreme Weather Conditions	Weather conditions in Vaca Muerta can be extreme, with very high temperatures in summer and very low temperatures in winter, strong winds, and dust storms.	Operational disruptions, equipment damage, and personnel safety risks.
Environmental Impact	Oil drilling in Vaca Muerta could have significant environmental impacts, including water and soil contamination, greenhouse gas emissions, and biodiversity damage.	Need to implement mitigation measures to minimize environmental impact.

Route Conditions	Roads in the region are often in poor condition, increasing vehicle maintenance costs and impacting travel times.	Increased vehicle wear, increased maintenance costs, and increased risk of accidents.
Environmental Challenges	Companies must implement measures to minimize the environmental impact of their operations, which may include longer or more complex transportation routes to avoid protected areas.	Increased logistics costs and operational complexity.

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XI. Conclusions

Generative Artificial Intelligence (GENI) offers enormous potential to improve the efficiency, safety, and sustainability of operations in Vaca Muerta. By applying the right GENI technologies, companies can address the reservoir's specific challenges, optimize production, reduce costs, and minimize environmental impact. The implementation of concrete GENI-based solutions, such as leak detection, failure prediction, and well integrity monitoring, can significantly contribute to maximizing Vaca Muerta's potential and to the sustainable development of the Argentine oil and gas industry.

The IAGEN can help overcome infrastructure limitations and the shortage of skilled labor in Vaca Muerta by enabling remote monitoring, task automation, and logistics optimization. Furthermore, the IAGEN can contribute to reducing emissions, optimizing resource use, and minimizing environmental impact, promoting the sustainability of operations.

The targeted and strategic implementation of Generative Artificial Intelligence in Vaca Muerta presents transformative potential for the oil industry, significantly optimizing diagnostics, reducing operating costs, and improving operational safety and efficiency in concrete, measurable, and actionable ways. The ability to utilize multiple generative models allows for better adaptation to diverse technical and operational needs, maximizing benefits in the specific context of Vaca Muerta.

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