HUB TECH IA

Deliverable report 5

AI and IAGEN Application Use Case

Optimization of Maintenance Cycles in Vaca Muerta

I. Introduction

Located in the province of Neuquén, Argentina, the Vaca Muerta formation is
It stands out as one of the largest unconventional gas and oil fields
important in Latin America, possessing considerable potential for development
regional energy.

The High Risks of Equipment Maintenance

The infrastructure required for hydrocarbon extraction is intrinsically
complex, which entails high operating costs associated with the maintenance of
the equipment and machinery used.

Extended equipment downtime not only disrupts business objectives,
production, but also significantly increases operating costs.

Globally, unexpected equipment failures are estimated to cost the oil and gas industry
approximately $42 billion annually. Even a
Minimal interruption, as little as 1% of the time, can translate into losses
annual. The complexity of the infrastructure in Vaca Muerta implies a vast
number of possible points of failure, which underscores the need for methods of
more sophisticated and scalable maintenance than traditional approaches.

Opportunities of AI and IAGEN

Artificial intelligence and generative artificial intelligence models provide optimization opportunities, with concrete benefits.

II. Artificial Intelligence and its Application in Maintenance

AI Models and Techniques for Predictive Maintenance

Various AI models are applicable to equipment failure prediction, including Artificial Neural Networks (ANN), Machine Learning (ML) algorithms, Deep Learning, Support Vector Machines (SVM), Gradient Machines Boosted (MGI) and Long Short Term Memory (LSTM) networks.

These models analyze historical and real-time data from sensors. installed in the equipment, such as pressure, temperature and vibration, to identify patterns that may indicate potential failures. For example, AI algorithms may Analyze vibration data from rotating machinery to predict impending failures in the bearings based on anomalous patterns.

Condition-based maintenance (CBM) is another technique that complements predictive maintenance. CBM techniques, such as vibration analysis, Oil analysis and thermography provide real-time data on the condition of the teams, which can then be used by AI models to evaluate their condition and possible wear.

The choice of AI model should be tailored to the specific type of equipment, operating conditions and the nature of the data available in Vaca Muerta.

Improving Traditional Maintenance with AI

AI not only predicts failures, but can also improve business practices. maintenance of existing ones rather than replacing them completely. Maintenance Prescriptive, for example, uses AI to suggest the best actions to maintenance based on historical data and current conditions. In addition, AI

plays a crucial role in optimizing maintenance programs and resource allocation.

AI integration should focus on empowering maintenance staff with better knowledge and tools, rather than being perceived as a substitute for your experience.

III. Leveraging Generative Artificial Intelligence for Optimization

Maintenance Cycles in Vaca Muerta

Generative Artificial Intelligence (GENAI) 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 content and original that is often indistinguishable from that created by humans.

IAGEN has the capability to develop sophisticated predictive models through the analysis of large data sets including sensor readings, logs maintenance history and operating parameters.

The training of these models is done with specific data from the equipment. used in Vaca Muerta, taking into account the variable operating conditions typical of the site.

IAGEN can identify subtle anomalies and predict failures with a high degree of accuracy. precision, reaching accuracy rates of up to 92% in predicting possible faults.

The need to train AI models with data specific to Vaca Muerta is essential due to the unique geological and operational conditions of the field. Generic models may not offer optimal performance in this context particular.

1. Generation of Optimized Maintenance Plans

IAGEN can automatically generate maintenance plans tailored to the needs of current operating conditions and the predicted needs of each piece of equipment. These plans consider critical factors such as temperature, pressure, vibrations and other relevant variables. In addition, these plans are dynamic and can be adjusted in real-time based on continuous monitoring, which is known as planning maintenance dynamics. The dynamic nature of maintenance plans generated by AI allows for more efficient resource allocation and minimizes unnecessary interventions compared to static plans based on fixed programs.

2. AI-Driven Simulations for Evaluating Strategy Maintenance

IAGEN can generate simulations to model the life cycle of equipment and evaluate the impact of different maintenance variables. These simulations help optimize preventive and predictive maintenance programs.

The use of simulation software in the oil and gas industry and the concept of Digital twins allow the creation of virtual replicas for simulation and testing. Digital twins, powered by AI, can simulate the behavior of oil fields and optimize production strategies. The use of Simulations and digital twins provide a risk-free environment for testing different maintenance strategies and optimize them before implementing them in the real world in Vaca Muerta.

3. Intelligent Analysis of Maintenance Data

IAGEN can analyze historical and real-time maintenance data to Identify trends, patterns and areas for improvement in maintenance processes. AI has the ability to learn from past maintenance activities and

continually refine their predictions and recommendations.

This continuous analysis of maintenance data allows for a cycle of feedback where the AI system learns and improves over time, which leads to increasingly accurate predictions and more efficient maintenance strategies. effective in Vaca Muerta.

IV. Use of agents based on generative artificial intelligence

1. Concept of IAGEN agents

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 tasks high-demand cognitive skills. From this capacity, a new architecture emerges Technological: IAGen-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 around.

An IAGen agent combines large language models with components additional features such as external tools, memory, planning and autonomous execution. This allows them to operate in complex environments, with the ability to break down Step-by-step objectives, coordinate multiple actions, interact with digital systems (such as databases, APIs or documents) and adapt to changes in context in real time. These qualities distinguish them from traditional chatbots, and open up a spectrum 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 assume human resources, legal, financial or logistical tasks, and even those 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 your operations without losing quality or control.

In addition, agentic workflows—structures where multiple agents collaborate with each other to solve complex problems—allow responsibilities to be distributed between different agent profiles, each with specific functions. This generates Hybrid work environments where humans and agents coexist, optimizing times, costs, and results. The ability to connect agents with tools such as Google Drive, CRMs or document management platforms further expands its capabilities.

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

Among the benefits of authentic workflows driven by business models generative artificial intelligence, the possibility of automating processes is found complete, end-to-end production systems, and even add value from the leveraging the skills of language models based on these technologies.

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

2. Proposal - example: IAGEN-based agent design for the Implementation

Step 1: Data Collection

IAGEN agents begin by collecting data from sensors installed in equipment (pressure, temperature, vibration, etc.) and historical information maintenance.

Step 2: Data Analysis and Processing

AI agents process and analyze this data using predictive models. Here, the agent identifies anomalous patterns and behaviors that may indicate a possible equipment failure.

Step 3: Prediction Generation

Once the data is processed, the agents generate predictions about when and what type of maintenance will be necessary, adjusting the maintenance plan accordingly of current operating conditions.

Step 4: Generation of Maintenance Plan

IAGEN agents generate an optimized maintenance plan that includes scheduled interventions, the acquisition of spare parts and the allocation of resources humans.

Step 5: Execution and Monitoring

The maintenance plan is being implemented on the ground. The agents continue monitoring team performance in real time, adjusting the plan accordingly necessary.

V. Concrete Benefits and Opportunities for Operations in Vaca Muerta

Significant Reduction in Operating Costs

The implementation of IAGEN has the potential to generate significant reductions in operating costs. For example, AI-driven predictive maintenance can

reduce maintenance costs by up to 20%, and in some cases, up to 40% compared to reactive maintenance.

This reduction is achieved by minimizing non-operational downtime. planned, optimizing resource allocation (including spare parts management) and efficient scheduling of maintenance interventions.
The potential for substantial cost savings provides a strong financial incentive for oil and gas companies in Vaca Muerta to invest in IAGEN.

Greater Equipment Availability and Increased Production

Predictive maintenance enabled by IAGEN can minimize downtime equipment downtime by proactively detecting and addressing potential failures, which which translates into a potential increase in uptime. For example, the AI-driven predictive maintenance can increase uptime equipment by 25%, and reduce unplanned downtime by up to 75%. There is a direct correlation between increased equipment availability and increased production, which is crucial to meet the energy needs of Argentina and its export ambitions.

Improving Operational Efficiency and Optimizing Workflows

IAGEN can optimize maintenance workflows by providing timely information, automate the generation of maintenance plans and facilitate better coordination of resources. AI can also optimize tasks such as spare parts inventory management and work order management. Optimization of workflows and improved efficiency can lead to better utilization of workforce and resources in Vaca Muerta, improving the overall productivity.

Greater Security

Proactive identification and mitigation of potential equipment failures through IAGEN can significantly improve operational safety by reducing the risk of accidents and catastrophic failures.

For example, AI-driven predictive systems rely on integrations of software that monitors overall system performance to anticipate system failures equipment, improving safety and reducing costly accidents.

AI can also monitor safety parameters and ensure the compliance with regulations. The potential for significant improvements in safety It is a key benefit in the high-risk environment of oil operations. and gas in Vaca Muerta.

Comparison with Traditional Methods

Traditional maintenance methods, based on regular scheduling or Manual interventions do not always manage to predict imminent failures or identify wear patterns. In contrast, IAGEN allows for real-time optimization data-driven, which improves maintenance prediction and scheduling, overcoming the limitations of conventional methods.

VI. Challenges and strategies

Infrastructure

- Integration with Existing Infrastructure: The integration of existing infrastructure systems IAGEN with the diverse range of technologies existing in Vaca Muerta, including the SCADA systems and legacy systems, can be a challenge. Legacy implementations of SCADA systems often suffer from cluttered screens and alarm overload, hampering performance and AI integration. To address this, it is necessary to develop application programming interfaces (APIs) and middleware that enable a flow of data

fluid between IAGEN and existing systems. The prevalence of systems legacy in the oil and gas industry represents a major obstacle for the adoption of AI in Vaca Muerta, which requires planning careful and investment in integration solutions.

- Data Quality and Availability: Ensure high-quality data and easily available to train and operate IAGEN models in the petroleum environment and gas presents challenges. Poor data quality is responsible for a significant percentage of AI project failures in environments industrial. Problems include data silos, data formats inconsistent and the need for data cleaning and preprocessing. The success of The implementation of IAGEN in Vaca Muerta depends largely on the establishing sound data management and quality assurance practices and the accessibility of operational data.
- Interoperability Problems: The lack of interoperability between the different equipment and systems in Vaca Muerta may complicate the implementation of IAGEN. The various data formats in the oil and gas industry can hinder AI applications, which thrive on consistency. To address For this, standardized data schemas and exchange protocols are needed. Overcoming interoperability challenges requires collaboration across the industry and the adoption of common standards to facilitate seamless integration of IAGEN solutions in Vaca Muerta.
- Short-term investment in AI agent implementation teams Technology and training: Investment in proof of concept and testing is required pilot. The focus here has to be on training the talent to implement, since There is a trend towards cost reduction in systems that allow "no code" and "low code" automation. For the first stage, we also recommends using teams with experience in design and implementation AI agents. Finally, it is key to form an in-house team for the accompaniment and appropriation of an agentic culture that redefines the

human-computer interaction.

Regulation

- It is essential to consider the regulatory landscape in Argentina with respect to the adoption of new technologies in the energy sector.

IAGEN solutions must comply with local regulations and standards
Operational security of the energy sector. Navigating the Argentine regulatory environment
is crucial to the successful deployment of IAGEN in Vaca Muerta. The lack of regulations
Specific AI initiatives in Argentina could present both opportunities and challenges.

Economy

- Initial investment in infrastructure and training can be an obstacle to few companies in the region. However, financing opportunities exist. For example, National Grid Partners has pledged to invest $100 millions in AI startups powering the future of energy. It's It is important to identify strategic partners and public-private financing that help mitigate initial implementation costs. Although the initial investment in IAGEN can be significant, the savings potential substantial long-term benefits and increased efficiency can provide a convincing economic justification for its adoption in Vaca Muerta.

Culture

- Cultural resistance to using AI tools or trusting their results is a common challenge. It is essential to develop training programs that involve employees in the implementation process, highlighting how the IAGEN can complement your work and improve your productivity. Overcome the Cultural resilience and fostering a data-driven culture through management Effective change management and comprehensive training are crucial for successful adoption and IAGEN's sustainable development in Vaca Muerta.

VII. Conclusion

Generative Artificial Intelligence represents a transformative potential for the Optimization of maintenance cycles in Vaca Muerta. Its implementation strategic can generate significant benefits in terms of operational efficiency, cost reduction, increased equipment availability, and improved safety. Despite the challenges inherent in adopting new technologies, an approach strategic that addresses technical, regulatory, economic and cultural barriers will allow energy sector companies in Vaca Muerta to make the most of it IAGEN's capabilities. In the long term, this optimization will contribute to strengthening the Argentina's position as a key player in the regional and global energy market, driving the efficiency, profitability and sustainability of its operations hydrocarbons.

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