HUB TECH IA

Deliverable report 21

Step-by-step instructions for safe piercing

Safety guides in Vaca Muerta

I. Introduction

The oil and gas industry is constantly seeking process optimization and efficiency improvements in hydrocarbon extraction. In this context, Generative Artificial Intelligence (GENA) is presented as a tool with great potential to revolutionize operations in Vaca Muerta, one of the most important shale formations in the world.

This analysis explores the applications of IAGEN in generating guidelines for safe drilling and extraction in Vaca Muerta, considering its advantages, disadvantages, challenges, limitations, and future prospects.

II. Current Techniques and Technologies in Vaca Muerta

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.

Before delving into the IAGEN, it is essential to understand the current context of drilling and extraction in Vaca Muerta. The predominant technique is hydraulic fracturing, or

"fracking," which involves the high-pressure injection of a mixture of water, sand, and chemicals into the rock to release oil and gas trapped at great depths. This technique has been crucial to the development of Vaca Muerta, as it allows access to resources that would otherwise be inaccessible.

Vaca Muerta is positioned as a strategic field worldwide, with the second-largest gas reserves and the fourth-largest unconventional oil reserves in the world. The formation, which extends over 30,000 km2, has boosted unconventional gas production in Argentina, increasing from 1% to 35% of the national total in just 10 years. The development of Vaca Muerta has the potential to double Argentina's crude oil production in the coming years.

III. IAGEN Applications in the Oil and Gas Industry

IAGEN is transforming the oil and gas industry through a variety of applications. In exploration and drilling, IAGEN optimizes reservoir identification and drilling strategy planning. By analyzing seismic surveys, satellite images, and geological data, IAGEN can determine optimal drilling locations, reducing costs and risks.

Additionally, IAGEN is used to monitor drilling activities, identify automation opportunities, and predict when wells will run dry, enabling early warning to prevent production shutdowns.

In terms of production optimization, IAGEN analyzes historical and real-time data to identify opportunities for improvement in production rates, well spacing, and predicting equipment failures. It is also used to predict oil and gas demand, helping to optimize inventory levels and minimize risks.

IAGEN also plays a crucial role in safety and risk management. It helps prevent accidents and respond promptly to leaks, equipment malfunctions, and abnormal operating conditions. Furthermore, IAGEN can help create models that more accurately predict behaviors or outcomes, such as improving platform safety, dispatching crews more quickly, and identifying system failures even before they occur.

In the field of energy efficiency and emissions reduction, IAGEN optimizes energy consumption and helps industry achieve its emissions reduction targets through operational data analysis, real-time monitoring, and emissions management.

IAGEN also provides valuable decision and planning support, providing relevant information for informed decision-making in areas such as investment, risk analysis, and production planning.

Other IAGEN applications in the oil and gas industry include predictive maintenance, price fluctuation management, automation of administrative tasks using RPA, spill detection, supply chain optimization, and optimization of oil and natural gas transportation and distribution networks.

IV. IAGEN in the Generation of Drilling Guides

IAGEN has the potential to generate more accurate and efficient drilling guidelines in Vaca Muerta. It can analyze geological and operational data in real time to determine the best drilling trajectory, minimizing risks and optimizing production. Furthermore, IAGEN can identify patterns in the data that indicate potential problems, such as blockages or equipment failures, enabling preventive measures.

During drilling, IAGEN can provide drillers with real-time recommendations on how to adjust drilling parameters to optimize the process. It can also be used to develop intelligent conversational assistants that answer drillers' questions and provide relevant information during the operation. These IAGEN-based assistants can access large volumes of information and provide accurate and timely responses, improving the efficiency and safety of drilling operations.

V. IAGEN Driven Agent Application

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. **Agent design proposal driven by IAGEN**

a. **Intelligent Agent for the Development of Operational Safety Guides**

Data Loading

Key information is collected from various sources:

- Technical data of wells : depths, pressures, flow rates, incident history.
- Regulations and rules : provincial, national and international protocols (OSHA, ISO, IRAM, etc.).
- Previous experiences and lessons learned : internal accident reports, near misses, audits, well closure reports.
- Field staff input : forms, checklists, and unstructured descriptions.

All of this can be uploaded to a Google Drive-type environment or structured database, connected to the agent.

Analysis with NLP (Natural Language Processing)

The agent applies NLP models to:

- Extract common patterns of failures, risks and unsafe conditions.
- Classify and summarize long documents (such as manuals, minutes, and reports).
- Relate regulatory requirements to actual reservoir conditions.
- Detect regulatory gaps or inconsistencies between what is regulated and what is implemented.

Embeddings, semantic classification, and tools like LangChain can be used here to connect multiple sources.

Automatic Generation of Security Guide

Using the detected patterns, the agent (based on GPT-4 or higher) generates a customized security guide, with:

- Detailed and justified operational steps.
- Key safety indicators.
- Critical control points.
- Practical recommendations by well type and operational phase (drilling, fracturing, production).
- Color codes or alerts for quick interpretation in the field.

This step can have summarized versions for mobile devices, and full versions for printing and auditing.

Validation and Adjustment by Experts

- A group of security, operations, and compliance experts reviews the document.
- Annotations, corrections or contextual adjustments are made.
- The agent incorporates this feedback for future similar guides (supervised learning).

You can use a collaborative interface like Notion or Google Docs with active AI review.

Integration into Operations

- The validated guide is incorporated into the operational workflow through:
    - Tablets in the field.
    - Digital instructions connected to sensors or SCADA.
    - AI-assisted training.
    - Dynamic checklists connected to the base document.

Optionally, you can connect with n8n or Zapier to automate distribution, alerts, and updates.

Continuous Monitoring and Feedback

- Data is collected on compliance with the guide in the field .
- Incidents, proposed improvements, and staff feedback are documented.
- The agent analyzes this information to:
    - Suggest adjustments to the guide.
    - Prioritize periodic reviews.
    - Identify new emerging risk conditions.

This monitoring can integrate IoT sensors, maintenance reports, and HSE observations.

- Data Loading: Data on wells, regulations, and previous experiences are entered.
- NLP Analysis: Patterns are identified in documents and databases.
- Guide Generation: ChatGPT-4 produces a document with detailed steps.
- Validation and Adjustment: Experts review and adjust the document.
- Integration into Operations: Implemented in the field.
- Monitoring and Feedback: Continuous improvements are incorporated.

VI. Advantages and Disadvantages of IAGEN in Vaca Muerta

Advantage	Disadvantage	Examples in Vaca

		Muerta
Greater efficiency in drilling and extraction	High initial costs	Implementation of IAGEN systems for the optimization of drilling in horizontal wells.
Reduction of operating costs .	Lack of transparency in decision-making .	Using IAGEN to predict equipment failures, reducing maintenance costs.
Improved security and risk mitigation .	Risk of errors in algorithms .	Development of IAGEN systems for real-time anomaly detection during drilling.
Greater precision in deposit identification .	Possible displacement of jobs .	Implementation of IAGEN for seismic data analysis and the identification of new exploration areas.
Optimization of resource use .	Data quality dependency .	Using IAGEN to optimize water consumption in hydraulic fracturing.
Reduction of		Development of IAGEN

environmental impact .		systems for emissions monitoring and carbon footprint reduction.
Increased accuracy.		IAGEN implementation to improve property model accuracy by 60% and reduce response time by 75%.
Drilling optimization.		Using IAGEN to increase rig consistency, improve penetration rates, and reduce well construction costs.
Talent management.		IAGEN's application to help the oil and gas sector with its talent shortage problem.
Improved drilling		Using IAGEN to enhance shale drilling and increase recovery rates from fractured wells.

VII. Challenges and Limitations of IAGEN

Despite its potential, IAGEN faces challenges and limitations in its application in Vaca

Muerta.

One of the main challenges is data availability. AIGEN requires large amounts of high-quality data to train its models, and a lack of data, incomplete data, or inconsistent data can affect AIGEN's accuracy and efficiency. Furthermore, access to quality data for training AI algorithms can be a barrier.

Another significant challenge is the geological complexity of Vaca Muerta. The formation exhibits variations in rock composition and hydrocarbon distribution, which can make it difficult to create accurate models for IAGEN. The accumulation of hydrocarbons thousands of meters deep and the limitations of remote sensing tools in providing clear subsurface images also pose a challenge.

Integrating the IAGEN with Vaca Muerta's existing systems and technologies can be challenging, requiring adaptations and infrastructure investments. Worker acceptance and trust are also important factors, as the adoption of the IAGEN can generate resistance from those who perceive it as a threat to their jobs.

Increasingly stringent environmental regulations, which require extensive treatment of produced water during oil extraction and production, also pose a challenge. The production and processing of heavy oil, which sometimes requires blending with other elements to reduce its viscosity, also presents difficulties.

The lack of clear regulations and specific legal frameworks for IAGEN in the oil and gas industry can create uncertainty and hinder its implementation. Furthermore, IAGEN's analytical and decision-making capabilities are still under development, meaning human intervention is required in certain cases.

Oil and gas companies also face the challenge of adapting to the growing demand for cleaner energy sources and ensuring their long-term viability. Oil price volatility and its impact on investment also pose a significant challenge. Exploration and production in deepwater and Arctic environments present additional challenges due to low

temperatures, high pressure, and geographic isolation.

VIII. Solutions and Strategies to Overcome Challenges

To overcome the challenges of IAGEN in Vaca Muerta, various solutions and strategies can be implemented. Investing in high-quality data collection and processing, using technologies such as advanced sensors and real-time monitoring systems, is crucial. Water scarcity is a global problem, and water is increasingly considered a valuable resource, so optimizing its use is critical.

IAGEN models should be developed that consider the geological complexity of Vaca Muerta, using machine learning techniques tailored to the specific characteristics of the deposit. Integration of IAGEN with existing systems should be facilitated by implementing platforms and tools that minimize disruption and maximize efficiency.

Short-term investment in AI agent implementation teams is recommended, including technology and training. Investment is required in proofs of concept and pilot testing. The focus here must be on developing the talent needed to implement the solution, as there is a trend toward cost reduction in systems that enable "no-code" and "low-code" automation. For the first stage, it is also recommended to recruit teams with experience in AI agent design and implementation. Finally, it is key to form an in-house team to support and foster an agentic culture that redefines human-machine interaction.

In hydraulic fracturing, more advanced fracturing fluids and real-time monitoring technologies are being used to optimize the process and reduce environmental impact. CO2, steam, and polymer injection are being presented as an advanced enhanced oil recovery (EOR) technique to increase the amount of crude oil extracted from reservoirs.

Nanotechnology is also being applied in the oil industry to provide more precise and efficient solutions for oil extraction. Nanoparticles can be modified to improve interaction with rock formations and oil, facilitating recovery in difficult areas.

To meet the challenges of extreme conditions, the industry has developed solutions

such as special pipe alloys that resist corrosion in cold salt water and thermal insulation systems for machinery.

IX. IAGEN and Sustainability in Vaca Muerta

The IAGEN has the potential to contribute to a more sustainable oil and gas industry in Vaca Muerta. By optimizing resource use, reducing emissions, and minimizing environmental impact, the IAGEN can help the industry comply with environmental regulations and reduce its carbon footprint. The IAGEN can continuously monitor greenhouse gas emissions at oil facilities and suggest measures to reduce their environmental impact.

X. Conclusions

Generative Artificial Intelligence (GENI) is presented as a tool with enormous potential to transform the oil and gas industry in Vaca Muerta. Its ability to generate more precise and efficient drilling guidelines, optimize production, improve safety, and reduce environmental impact makes it a key factor for the future of the sector.

IAGEN can contribute to a more efficient, sustainable, and safer oil and gas industry in Vaca Muerta. By optimizing resource use, reducing emissions, and minimizing environmental impact, IAGEN can help the industry comply with environmental regulations and reduce its carbon footprint.

While there are challenges and limitations, implementing appropriate solutions and strategies will allow us to fully leverage the benefits of IAGEN. It is crucial to invest in high-quality data collection and processing, develop Vaca Muerta-specific models, facilitate integration with existing systems, promote training and collaboration, and foster the creation of regulatory frameworks.

The IAGEN also raises important ethical and social considerations, such as potential job displacement, the need for transparency and accountability in the development and implementation of AI, and the protection of data privacy and security.

Ultimately, responsible adoption of IAGEN can contribute to a brighter future for the Vaca Muerta oil and gas industry, driving efficiency, sustainability, and safety in operations.

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