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HUB TECH IA

Deliverable report 9

AI and IAGEN Application Use Case

Adjusting Drilling Conditions in the Oil, Gas and Petroleum Industry Water in Vaca Muerta, Neuquén, Argentina

I. Introduction

1. Presentation of the Sector and Specific Activity

Vaca Muerta, located in the Neuquén basin within the province of Neuquén, Argentina represents one of the largest reserves of unconventional hydrocarbons. significant at a global level, with significant production of shale oil and gas.

This formation is estimated to contain about 308 trillion cubic feet of gas and 16.2 billion barrels of oil, which makes it the second largest world's largest reserve of unconventional gas and the fourth largest reserve of unconventional oil.

In 2024, shale gas production in Vaca Muerta averaged 64.1 million cubic meters per day, constituting 49% of total gas production of the country, while shale oil production reached 353,000 barrels per day, representing 55% of national production. The total increase in Shale production in Argentina has increased by 150% since 2020, reaching 740,000 barrels of oil equivalent per day (boepd). Projections suggest continued production growth through the end of this decade and beyond. considering that only approximately 20% of the training has been developed.

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During the last decade, Vaca Muerta has experienced accelerated development, which which has resulted in significant reductions in extraction costs and a increase in productivity.

Drilling activity in Vaca Muerta is characterized by its complexity, derived of the intricate geological conditions, high pressures and temperatures, and the reservoir heterogeneity. These variables require extensive planning and constant adjustments during the drilling process to ensure efficiency and security of operations.

In addition, the variability in subsoil properties and the risks inherent in the wells make the process highly sensitive to decisions made in real time. A weak interface has been identified within the field that has caused numerous cases of casing deformation.

The presence of high pore pressure and a resistant lithology are characteristic common, which has led to operational complexities and well abandonment in some areas. At various stratigraphic levels, problems have been encountered such as gas ingress and fluid loss, and the actual hardness of the lithology often exceeds initial estimates.

2. Problem, Challenge or Opportunity

One of the challenges that operating companies may face, in general, lies in in the ability to adapt drilling conditions efficiently and real-time dynamics.

An automated system capable of predicting and adjusting drilling parameters during operations can generate operational efficiency, an increase in costs and an extension of drilling times.

Given this scenario, the implementation of advanced artificial intelligence technologies, particularly Generative Artificial Intelligence (IAGEN), is presented as

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an innovative solution with the potential to transform conditions management drilling.

IAGEN offers the possibility of making dynamic, predictive and precise adjustments that optimize the operation. This opportunity is crucial for Argentina to consolidate as a key player on the global energy scene and to maximize the vast Vaca Muerta potential.

II. Application of IAGEN in the Specific Activity

1. Description of the IAGEN Application

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

In this context, IAGEN is defined as the ability to generate optimal solutions in real-time data-driven management of drilling conditions from multiple sources such as drilling sensors, real-time monitoring real and historical operations data.

Through advanced generative models, IAGEN can automatically adjust the drilling conditions from the interpretation of real-time data.

Generative Artificial Intelligence also has the potential to act as a co-pilot for maintenance and improvement of operational efficiency in drilling activities.

2. How the IAGEN App Works

- Real-Time Data Collection: Advanced sensors are installed in drilling tools and monitoring equipment on the platform, the

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which provide information on critical variables such as pressure, temperature, drilling speed, torque and characteristics of the fluids. These sensors include downhole devices that capture data in real time on parameters such as temperature, pressure, torque and vibration, as well as surface sensors that provide drilling data measurements in real time. High-fidelity measurements are also used at the bottom of the well for geosteering. This data is transmitted to monitoring systems real-time processing.

- Generation of Predictive Models: Using deep neural networks and generative models such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs), the system analyzes data in real time to predict future behavior of drilling conditions and wells. GANs have demonstrated their ability to predict drilling parameters such as circulating pressure, wellhead pressure, and flow rate. penetration (ROP) with high accuracy. In addition, GANs are applied to improve the resolution of well image logs acquired during drilling (LWD), allowing for better real-time understanding of structures geological. VAEs, on the other hand, are capable of learning distributions of complex data and could generate valuable information to optimize the drilling parameters. In general, machine learning is used widely used for predictive drilling and optimization of drilling parameters in Vaca Muerta.
- Dynamic Adjustment of Drilling Conditions: Based on predictions generated, the system automatically adjusts the operating parameters of drilling, such as drill bit feed rate, fluid flow rate drilling, pump pressure, and other operation-related parameters. Artificial intelligence can analyze data from sensors drilling in real time and dynamically adjust flow rates, pressure and other parameters to optimize results. Automated systems drilling control contributes to improving wellbore accuracy and stability.

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- Real-Time Simulation and Optimization: Generative models allow
  perform real-time simulations to anticipate potential risks or problems.
  For example, if the drilling tool approaches a zone of high resistance or unstable pressure,
  the system can simulate different scenarios and
  Propose adjustments before a problem occurs, avoiding disruptions and damage
  to the teams. Artificial intelligence is used to optimize the parameters of
  drilling, improving the rate of penetration (ROP) and reducing friction of the
  drill string. It also plays a crucial role in optimizing unconventional drilling by monitoring
  and adjusting parameters in
  real time.

III. Agentic Flow for Implementation

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 additional components such as external
tools, memory, scheduling, 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 range of
more sophisticated and customizable applications.

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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 those related 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 their 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. Phases of the Workflow with IAGEN designed and proposed

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- Data Capture: Advanced sensors continuously capture data from drilling in real time. These include parameters such as pressure subsoil, drill bit temperature, fluid viscosity, geological characteristics, rate of penetration (ROP), weight on bit (WOB) and revolutions per minute (RPM). Both bottom hole sensors are used well and surface for comprehensive data acquisition. The data from the Sensors are converted to standardized formats such as WITS (Wellsite Information Transfer Specification).
- Predictive Processing and Analysis: IAGEN uses learning algorithms automatic and neural networks to analyze this data and generate models predictive that project future behaviors of conditions Drilling. Specific AI models such as GAN-LSTM are applied to predict Multiple drilling parameters and VAEs to learn data patterns complex. AI is also used for anomaly detection and predictive maintenance of drilling equipment.
- Generation of Optimal Conditions: Predictive models generate recommendations for adjusting operating parameters in order to optimize the drilling conditions. These adjustments seek to maintain optimal conditions, prevent damage and maximize efficiency. IAGEN has the potential to suggest points optimal adjustment for parameters such as weight on the bit, RPM and differential pressure. AI can also provide real-time recommendations real for drilling settings.
- Implementation and Feedback Loop: The optimal conditions generated are implemented either automatically through drilling systems automated or by human operators guided by the recommendations of the system. A feedback loop is essential where the results of the Implemented adjustments are continuously monitored and fed back to the IAGEN system. This feedback allows AI models to learn continuously and improve their predictive accuracy and capabilities optimization.

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3. Case summary

a. Data Capture Agent

Sensors (on the surface and downhole) are used to measure variables in real time. as:

- Pressure, temperature, ROP, WOB, RPM, geology and fluids.

The data are standardized (WITS format) to facilitate analysis.

b. Predictive Analytics Agent with AI

IAGEN uses artificial intelligence models (GAN-LSTM, VAE, etc.) to:

- Predict how drilling conditions will behave.
- Detect failures or anomalies before they occur.
- Anticipate maintenance needs.

c. Agent for Optimal Recommendations

The system generates real-time suggestions for:

- Adjust parameters such as RPM, WOB and pressure.
- Prevent damage, improve safety and maximize energy efficiency and operational.

d. Application and Learning

- Recommendations are applied automatically or with human supervision.
- The system monitors the result and continuously learns, improving its

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decisions with each cycle.

3. Concrete Example of Implementation

While drilling a well, sensors detect unexpected variability in
the pressure in the shale layer. The IAGEN automatically adjusts the pressure of the
pump and drilling speed to avoid a well collapse, while adjusting the
amount of drilling fluid to maintain well stability, optimizing the
production without compromising safety.

IV. Concrete Opportunities and Benefits

1. Measurable Impact on Efficiency, Costs, Operating Times and Safety

Direct Benefits in Operational and Strategic Terms

- Operational Risk Reduction: The ability to dynamically predict and adjust drilling conditions improves
  operational safety,
  reducing the risk of drilling failure, tool damage and possible
  accidents.
- Production Optimization: Dynamic adjustments of production parameters
  Drilling techniques allow for improved drilling speed without compromising the
  well integrity, resulting in higher production at lower costs.
- Improvement of Well Quality: By generating conditions of
  More precise drilling, well quality is optimized, which improves long-term oil and gas recovery.

- Operational Efficiency: IAGEN systems generate automatic and efficient adjustments
  precise drilling conditions, reducing downtime by
  minimum. By optimizing drilling speed and reducing failures in the
  tool, the overall efficiency of the operation is increased. The software

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Predictive drilling, such as Corva, has shown improvements in the rate of penetration (ROP) and cost savings per pad and per well.

- Cost Reduction: Through accurate prediction of problems and the optimization of operating parameters, costs associated with the manual intervention, equipment repair and management of unforeseen events. AI-powered drilling automation can generate savings significant in the costs of the string and drill bit per well.
- Improved Operating Times: Automated decision-making allows that operations continue to be carried out without unnecessary delays, as the Adjustments are made in real time. In addition, IAGEN helps improve planning. of resources and tools, which reduces waiting times between Drilling. Predictive drilling has completed lateral sections faster.
- Increased Security: With the ability to detect possible failures in the system before they occur, such as drill bit collapse or overflow pressure, IAGEN can prevent accidents and serious damage to equipment and personnel, thus improving the safety of operations. AI plays a role important in improving security management on platforms and in the issuing risk alerts, in addition to predicting security problems for avoid accidents.

2. Comparison with Traditional Methods

- Traditional Methods: Conventional drilling methods depend on largely dependent on operator experience and manual adjustments based on historical records and limited data. Although technological advances such as Real-time monitoring systems have been integrated, these still require human intervention to adjust drilling conditions. These methods are typically reactive and limited by operator experience and availability of comprehensive data in real time, making them less adaptable to the complex and dynamic conditions of Vaca Muerta.

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• Advantages of IAGEN:

In comparison:

- IAGEN automates adjustments proactively and predictively, using large volumes of data to predict conditions and make adjustments dynamic without human intervention, which improves accuracy, reduces margin error and optimizes operations in real time.
- The proactive and predictive nature of IAGEN allows for optimization before problems arise, which leads to significant efficiency advantages, costs and security.
- IAGEN's automation and data-driven nature reduce margin of human error, resulting in more precise drilling operations and reliable.
- IAGEN's real-time optimization capability is critical to Maximize efficiency and mitigate risks in Vaca's dynamic environment Dead, a capability largely absent in methodologies traditional.

Feature	Traditional Methods	IAGEN
Data Dependency	Mostly historical, data analysis limited in real time	Extensive real time data of multiple sensors, data historical

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Adjustment Mechanism	Manual settings by operators	Automated adjustments and dynamic based on AI predictions
Decision making	Based on experience operator's and guidelines predefined	Decisions based on data reported by predictive models of AI and simulations
Proactivity	Reactive, settings made after that problems arise	Proactive, anticipates and adjust before problems occur
Optimization	Limited, centered mostly in immediate parameters	Continuous optimization and in real time multiple parameters
Risk Mitigation	Based on consciousness of the operator and standard procedures	ID and predictive mitigation of potential risks
Efficiency	Minor, potential of delays and inefficiencies	Larger, optimized ROP and unproductive time (NPT) reduced
Cost	Potentially greater due to delays, errors	Minor due to optimized operations, downtime

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	and failures	reduced and fewer failures
Security	Dependent of the operator surveillance	Enhanced by predictive detection of dangers and responses automated

V. Challenges and Strategies to Overcome Them

1. Technical, Regulatory and Economic Barriers

- Technical Barriers: The technological infrastructure necessary to implement IAGEN effectively includes advanced sensor systems, real-time data platforms, and cloud processing. Initial investments in These technologies can be expensive. Integrating data from various sources and their quality assurance also represent challenges. In addition, requires the use of high specification equipment capable of handling wells of extended reach to maximize production.
- Regulatory Barriers: Since the energy industry is heavily regulated, The adoption of new technologies must comply with strict regulations in Regarding safety, the environment, and operational quality. There is uncertainty on how these regulations will apply to IAGEN. The regulatory approach to the unconventional fossil fuel production in Vaca Muerta has been fragmented. There are also environmental concerns related to the fracking, such as water contamination and possible induced seismicity.
- Economic Barriers: While IAGEN promises significant long-term savings, Initial implementation costs can be a barrier. There is a gap in the cost competitiveness between drilling in Vaca Muerta and regions such as the U.S. Permian Basin. Substantial annual investment is needed in fracking and infrastructure to fully develop Vaca Muerta.

2. Solutions and Strategies

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- Short-term investment in AI agent implementation teams
  Technology and training: Investment in proof of concept and testing is required
  The focus here must be on developing the talent to implement it, as there is a trend toward 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.
- Investment in Technical Capabilities: It is crucial that operating companies invest in staff training and in the acquisition of technologies advanced monitoring that are compatible with IAGEN. Partnerships with Technology companies can accelerate implementation. It's also important to develop data management and digital transformation strategies.
- Regulatory Compliance: Work closely with the authorities regulatory to ensure that IAGEN-based solutions comply with the required standards. This may include pilot testing and collaboration with government agencies to validate the security and effectiveness of technology. It is essential to maintain transparency and a proactive communication with regulatory agencies.
- Gradual Financial Strategy: Companies should implement IAGEN in a gradual manner. phased, starting with pilot projects to assess return on investment (ROI) before committing to larger implementations. It is also must explore financing options and demonstrate the economic benefits to long-term to stakeholders.

VI. Conclusion: Strategic Implications and Future Trajectory

IAGEN offers significant benefits for drilling in Vaca Muerta, including Greater efficiency, reduced costs, increased safety and operating times

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optimized. Its transformative potential lies in the ability to move from a reactive management to proactive and predictive management of drilling conditions.

Future advancements in IAGEN technology could include the integration of more sophisticated AI models, improved sensor technologies, and enhanced data processing capabilities. optimized real-time simulation.

IAGEN has broader implications for non-carbon resource development. conventional beyond Vaca Muerte, with potential applications in other shale formations worldwide. It could also contribute to more sustainable drilling practices by optimizing resource use and reduction of environmental impact.

It is recommended that oil and gas companies operating in Vaca Muerta prioritize the evaluation and adoption of IAGEN technologies to improve their operational performance and competitiveness.

Technology providers must continue to invest in the development and refinement of IAGEN solutions tailored to the specific challenges of unconventional drilling in regions like Vaca Muerta.

It is important for regulatory bodies to collaborate with stakeholders the industry to establish clear guidelines and standards for implementation safe and effective AI-powered drilling optimization technologies.

Finally, foster collaboration between AI experts and IT professionals. Drilling is essential for the successful integration and utilization of IAGEN in the industry of oil and gas.

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