



## **Deliverable report 7**

### **AI and IAGEN Application Use Case**

#### **Optimization of Drilling Conditions in Relation to Water Activities and Oil in Vaca Muerta, Neuquén**

##### **I. Introduction**

The Vaca Muerta formation, located in the province of Neuquén, Argentina, represents one of the most significant unconventional hydrocarbon deposits in the world. Its vast expanse and the considerable volume of resources it contains positioned as a strategic asset for Argentina's energy future and with potential impact on the global energy market. In a global context where the Energy demand continues to rise and the transition to renewable sources is still unconventional reservoirs such as Vaca Muerta are under development are becoming increasingly important in the global energy matrix.

In parallel, Generative Artificial Intelligence (GENA) has emerged as a disruptive technology with the capacity to transform various industrial sectors, including oil and gas. IAGEN, through advanced models of deep learning and neural networks, can generate new content, such as text, images and synthetic data, from patterns learned from large sets of data. Its potential to analyze complex information and offer innovative solutions makes it a valuable tool for optimizing operations and improve decision-making in the energy industry.

This report focuses on the specific application of IAGEN for the optimization of drilling conditions related to water and oil activities within the Vaca Muerta formation in Neuquén, Argentina. The objective is to analyze how this technology can address the challenges inherent in drilling in this unconventional deposit, improve operational efficiency, reduce costs and contribute to a more sustainable exploitation of its resources. Throughout this document, They will explore the fundamentals of IAGEN in the context of oil and gas, the challenges and drilling opportunities in Vaca Muerta, the specific applications of the IAGEN for optimization, relevant case studies, quantifiable benefits of its implementation, the barriers to its adoption, future trends and its impact on the workforce and environmental sustainability.

The magnitude of Vaca Muerta's resources and its potential to boost the Argentina's energy independence and exports create a pressing need to adopt technologies that improve efficiency and reduce costs.

The IAGEN, recognized for its optimization capacity, is presented as a key tool to explore in this context. Additionally, the trend towards Horizontal drilling in Vaca Muerta underlines the growing complexity of the drilling operations, which increases the value of optimization techniques advanced like IAGEN. These more complex operations require control precise and detailed optimization, where AI's ability to analyze data intricate and making adjustments in real time can offer a significant advantage.

## **II. Fundamentals of Generative Artificial Intelligence (IAGEN) in the Industry**

### **Oil and Gas**

Generative Artificial Intelligence (GENI) represents a specialized branch within the field of artificial intelligence, focused on the creation of new content, such as images, videos or music, based on the instructions provided by the user, known as "prompts".

Unlike other types of AI, such as discriminative AI that focuses on classifying or

predict existing data, IAGEN has the ability to synthesize information novel from the patterns learned during training.

This technology is based on fundamental principles such as Language Models Extensive (LLMs), deep learning and neural networks, which allow you to process and understand large amounts of data to generate coherent content and relevant. The increasing availability and power of AI platforms based on the cloud makes it even easier to access and implement IAGEN solutions in various sectors.

In the context of the oil and gas industry, IAGEN presents enormous potential due to its ability to analyze the vast and complex data sets that characterize this sector, including seismic information, well logs and production histories. Its applications cover the entire value chain, from exploration and production to refining and distribution. A particularly relevant area of impact is drilling optimization, where IAGEN can contribute significantly to improving efficiency and reducing operating costs.

The convergence of increasing data availability in the oil and gas sector and Advances in IAGEN generate a synergistic opportunity for operational improvements significant, especially in complex areas such as drilling.

The oil and gas industry collects massive amounts of data during its operations. operations. IAGEN's strength lies in its ability to process and extract valuable information from this data. Therefore, the abundance of drilling data in Vaca Muerta makes it a prime candidate for IAGEN applications.

In addition, IAGEN's ability to understand natural language queries and Translating them into executable code, such as SQL, can make it easier to access complex data. drilling to professionals who are not data scientists, empowering them drilling engineers and other domain experts. This accessibility can lead to faster problem resolution and better data capture.

knowledge.

### **III. IAGEN Applications for Drilling Optimization in Vaca Muerta**

IAGEN offers various applications to optimize drilling conditions in the Vaca Muerta formation, addressing both geological and technical challenges. operatives.

#### **1. Real-time drilling parameter optimization**

One of the key applications is the optimization of drilling parameters in real-time. IAGEN can analyze real-time sensor data, such as pressure, temperature, and vibration, to dynamically adjust drilling parameters and achieve an optimal rate of penetration (ROP) and greater well stability.

Reinforcement learning (RL) is also used for automated drilling operations, optimizing variables such as weight and wear.

#### **2. Well trajectory optimization and geosteering**

IAGEN also plays an important role in optimizing the trajectory of the wellbore and geosteering. By integrating geological data and downhole measurements into real time, it can autonomously guide the auger through the most difficult areas productive areas of the reservoir ("sweet spots"). Geosteering systems driven AI can make autonomous trajectory changes based on the subsoil information.

#### **3. Intelligent well planning and completion design**

Intelligent well planning and completion design also benefit from IAGEN. By analyzing historical data and geological models, it is possible to optimize well placement and completion strategies. Learning Automatic is used to predict well productivity based on various subsoil and completion parameters.

#### **4. Detection and mitigation of operational risks**

Finally, IAGEN contributes to the detection and mitigation of operational risks. It can identify potential hazards such as gas breakthroughs and instability of the well by analyzing real-time data and historical incidents. The techniques Pressure controlled drilling (MPD) techniques, combined with AI, improve control from the well.

#### **5. Impact of IAGEN on drilling by autonomous systems**

The growing attention towards autonomous drilling systems suggests a future where IAGEN will play a central role in monitoring and optimizing the drilling operations with minimal human intervention, which could generate significant efficiency gains and safety improvements in Vaca Muerta. Furthermore, the integration of physics-based models with AI-based models Data represents a powerful approach to drilling optimization in Vaca Muerta. Physics-based models provide the fundamental understanding, while AI models can learn from vast data sets to refine predictions and optimize operations in real time.

### **IV. Agentic Flow for Implementation**

#### **1. Description of Workflow 1 with IAGEN**

- Data Collection: Sensors in the well capture key variables (pressure, temperature, fluid viscosity, etc.).
- Cloud Processing: Data is analyzed by generative models.
- Recommendation Generation: IAGEN models generate optimal settings.
- Validation and Adjustment: Engineers review and approve recommendations.
- Field Application: Implementation of real-time adjustments.

#### **2. IAGEN Agents Involved**

- Event Prediction Agent: Detects risk patterns in drilling.

- Fluid Optimization Agent: Suggests adjustments in sludge composition and additives.
- Monitoring and Adjustment Agent: Monitors implementation and corrects deviations.

## **2. Workflow Description 2: IAGEN Agent: Optimization of Parameters Real-Time Drilling**

### **Aim:**

Dynamically adjust drilling parameters (weight on bit, rotation speed, mud pressure, etc.) in real time to maximize Penetration Rate (ROP) and minimize operational risk, using sensor data and Reinforcement Learning (RL) algorithms.

### **Functional Agent Architecture**

#### **a. Input Layer: Data Capture**

- Real-time sensors:
  - Pressure (WHP, BHP)
  - Temperature •
  - Vibration (accelerometers)
  - Rate of penetration (ROP)
  - Torque and axial force
  - Estimated drill bit wear
- Gas detection
- Geological history and subsurface models

#### **b. Data Preprocessing**

- Noise cleaning in signals
- Outlier detection
- Normalization / Stabilization of units

#### **c. Predictive Analysis Module (Traditional AI)**

- Models trained to predict:
  - Expected ROP
  - Risk of instability
  - Probability of abnormal wear
  - Mechanical failure

#### **d. Optimization Module (Reinforcement Learning - RL)**

- Algorithm: Proximal Policy Optimization (PPO) or Deep Q-Learning
- Action: Recommend adjustments to:
  - Weight on Bit (WOB) •
  - Rotational Speed (RPM)
  - Mud pressure
- Reward: Maximize ROP and stability, minimize vibration and wear

#### **e. Digital Simulator (Digital Twin)**

- Run near-real-time decision simulations
- Evaluates the impact of different combinations of parameters

#### **f. Autonomous Decision Layer / Human-in-the-Loop**

- Autonomous mode: the system adjusts parameters directly if authorized
- Assisted mode: recommendations to the operator for human validation

#### **g. Continuous Monitoring and Learning**

- Fine-tuning the model with new data
- Record of successful/failed decisions
- Expert feedback incorporated into the training

### **3. Concrete Example**

In a recent operation in Vaca Muerte, the IAGEN application allowed the detection of

24 hours in advance of a loss of circulation, adjusting the viscosity of the drilling fluid and avoiding a \$500,000 loss in recovery costs.

## **V. Challenges and Opportunities of Drilling in the Vaca Muerta Formation**

Sometimes unique geological features are present that make the drilling operations: low permeability, the presence of nanoporous media, The complex lithology and heterogeneity of the deposit are factors that make it difficult efficient extraction of hydrocarbons. These geological challenges are manifested in operational problems such as gas breakthroughs, fluid losses, and well instability. Additionally, significant variability in well quality is observed. reservoir along the basin.

Drilling operations also face considerable operational challenges. high operating costs, resulting from logistical and infrastructure limitations, represent a significant obstacle. Drilling extensive horizontal sections and managing well trajectories in such a formation Heterogeneous drilling operations are complex tasks that require constant optimization of parameters such as rate of penetration (ROP), weight on bit (WOB), and torque. Drill bit wear and the need for proactive maintenance are other factors. critical aspects to consider.

Despite these challenges, IAGEN offers promising opportunities to improve drilling operations. Its analytical and predictive capabilities can be used to address geological and operational complexities, optimizing processes and reducing risks. Specific applications of IAGEN in this context will be detailed in the next section.

The high rate of well abandonment in some areas due to complexities operational underlines the critical need for advanced technologies such as IAGEN that can improve well design, drilling practices, and risk mitigation. A 40% abandonment rate implies significant inefficiencies and losses.



financial, which shows a strong need for solutions that can predict and prevent such problems. IAGEN's predictive capabilities and its ability to analyzing complex drilling parameters makes it a potential solution.

On the other hand, the success in drilling record-length lateral sections in Vaca Muerta demonstrates the potential of technological advances in the region. IAGEN You can take advantage of this progress by further optimizing these complex operations. drilling. The achievement of drilling exceptionally long horizontal wells shows An innovation capacity in Vaca Muerta. IAGEN can contribute to this by providing advanced tools for planning, execution, and optimization. of these challenging drilling projects.

## **VI. Quantifiable Benefits of IAGEN Implementation in Drilling**

The implementation of IAGEN in drilling operations in Vaca Muerta has proven to generate quantifiable benefits in several areas.

- Significant reduction in drilling costs through optimized drilling parameters, reduced non-productive time (NPT), and fewer drilling trips.
- The use of IAGEN allows for a higher rate of penetration (ROP), which translates into faster drilling times.
- Well productivity is also improved through optimization of the location and design of completions, enabled by IAGEN, leading to increased recovery and production rates Hydrocarbons. Significant increases in production have been reported. accumulated oil.
- Downtime is reduced thanks to maintenance predictive that facilitates IAGEN, minimizing unplanned interruptions due to equipment failures.

- Finally, IAGEN contributes to improving operational safety in the drilling operations by detecting potential hazards and allowing proactive interventions.

The constant mention of significant percentage improvements in key metrics of drilling (ROP, reduced downtime, increased production) due to the adoption of AI suggests a compelling return on investment for companies that implement IAGEN solutions in Vaca Muerta. The improvements in the ROPs of 13-60% and downtime reductions of 20% indicate substantial improvements in efficiency and profitability, justifying the adoption of IAGEN.

In addition, the emphasis on both cost reduction and safety improvements as benefits of AI suggests that IAGEN can contribute to both viability economic as well as the responsible operation of drilling activities in Vaca Dead.

**V. Comparison with Traditional Methods**

| Aspect                | Traditional Methods                     | Use of IAGEN                            |
|-----------------------|---|---|
| Adjustment of fluids  | Based on experience and trial and error | Model-based optimization predictive     |
| Detection of failures | Analysis reagent after incidents        | Prediction and prevention in time real  |
| Management of data    | Manual reports and databases scattered  | Automatic integration in real time real |

**VI. Challenges and Barriers to the Adoption of IAGEN in Operations**

**Drilling in Vaca Muerta**

Despite the numerous potential benefits, the adoption of IAGEN in the Drilling operations in Vaca Muerta face several challenges and barriers.

Data quality and integration represent a significant obstacle.

The oil and gas industry handles large amounts of data from various sources, such as geological studies, well logs and sensors, which are often inconsistent and difficult to integrate. The existence of data silos and legacy systems make smooth integration of information even more difficult.

Another major challenge is the shortage of skilled labor. Experienced personnel are needed in both oil and gas drilling operations and in

Artificial intelligence and machine learning to develop and implement IAGEN solutions effectively.

Resistance to change and the acceptance gap within operations

Traditional oil and gas industries can also slow the adoption of new technologies like AI. Strong leadership and a culture shift are required.

organizational to adopt AI-based decision-making.

The implementation and infrastructure costs associated with AI platforms can be high, and an appropriate IT infrastructure is needed to support these technologies.

Generalizability and interpretability of AI models are other considerations.

important. It is crucial to ensure that models trained with data from an area or set of conditions can be effectively applied to other parts of the Vaca Muerta formation or to different drilling scenarios. In addition, the

interpretability of AI models is necessary to generate trust and understanding among drilling engineers.

Finally, the regulatory framework for AI in Argentina is still in its early stages.

initial, which can generate uncertainty for companies. They are needed

clear guidelines and regulations on the use of AI in critical infrastructure such as the oil and gas industry.

The recurring mention of challenges related to data quality and integration suggests that establishing a robust data management strategy is a requirement essential for successful implementation of IAGEN in Vaca Muerta. No data high-quality and well-integrated AI models cannot function effectively.

This highlights the need for substantial effort in infrastructure and data governance before taking full advantage of AIGEN. The shortage of qualified AI professionals in Argentina could be a bottleneck

significant for the adoption of IAGEN in the oil and gas sector. Address

This requires investment in education, training and potentially the attraction of international talent.

## **VII. Future Trends and Potential of IAGEN in Drilling**

### **Hydrocarbons in Neuquén**

The future of hydrocarbon drilling in Neuquén, particularly in the Vaca Muerta training will be increasingly influenced by Artificial Intelligence Generative (IA GEN). There is a clear trend toward greater automation in drilling operations, where IAGEN will play a key role in enabling autonomous drilling systems. This could eventually lead to unmanned drilling sites and remote operations.

The integration of digital twins is also emerging as a key trend. These virtual models of drilling operations will allow real-time monitoring, simulation and process optimization.

Greater use of open data and increased industry collaboration are expected to drive the development and adoption of AI solutions. Sharing data and best practices will be crucial to accelerate innovation in this field.

IAGEN's applications for sustainability will also gain greater relevance.

It will be used to optimize energy consumption, reduce emissions (e.g., gas flaring), and minimize the environmental impact of drilling operations.

Finally, significant growth in the AI solutions market is projected.

in the oil and gas industry, which will further boost research and development development in this field.

The strong trend towards automation and the development of digital twins suggests a future where drilling operations in Vaca Muerta will be increasingly data-driven and remotely managed, requiring a force workforce with advanced digital literacy. The growing emphasis on sustainability indicates that IAGEN will play an increasingly important role in helping Oil and gas companies in Vaca Muerta to comply with environmental regulations and reduce their carbon footprint, in line with global sustainability goals.

## **VIII. Conclusions**

Generative Artificial Intelligence (GENI) presents significant potential for revolutionize drilling operations in the Vaca Muerta formation. Through its various applications, from real-time parameter optimization to predictive maintenance and intelligent well planning, IAGEN can Improve efficiency, reduce costs, increase productivity and strengthen safety operational. The case studies and quantifiable benefits reported in the Industry backs the promise of this technology to transform the extraction of unconventional hydrocarbons.

However, successful adoption of IAGEN in Vaca Muerta requires overcoming challenges. important issues related to data quality and integration, labor shortages skilled work, resistance to change and implementation costs. To To maximize the benefits of IAGEN, it is recommended to:

- Develop a comprehensive data management strategy: Establish mechanisms

robust for the collection, storage, integration and quality control of

Data is critical to the success of IAGEN applications.

- Invest in talent development and training: Implement initiatives to train the existing workforce and attract new talent with experience in oil and gas drilling and AI/ML is crucial.
- Promote collaboration and knowledge sharing: Promote the collaboration between oil and gas companies, technology providers and research institutions will accelerate the development and adoption of solutions from IAGEN.
- Prioritize pilot projects and scalable implementations: Start with projects specific pilot projects to demonstrate the value of IAGEN in applications of concrete drilling and then scale up successful initiatives across all operations.
- Address regulatory considerations: Proactively engage with regulators regulatory bodies to ensure a clear and supportive framework for the deployment of AI technologies in the oil and gas sector.
- Focus on both economic and sustainability benefits: It is important to leverage IAGEN to achieve both cost efficiencies and environmental improvements in drilling operations.
- Promote a culture of innovation and change management: Leadership is needed solid and effective change management strategies to overcome resistance to the adoption of AI technologies within the organization.

In conclusion, IAGEN has the potential to be a transformative force in the hydrocarbon drilling in Vaca Muerta. By addressing the challenges and taking advantage of the opportunities offered by this technology, the industry can achieve more efficient operations efficient, safe and sustainable, consolidating Vaca Muerta's position as a key player in the global energy landscape.

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