



Deliverable report 7

AI and IAGEN Application Use Case

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

I. Introduction

The Vaca Muerta formation, located in Neuquén Province, Argentina, represents one of the most significant unconventional hydrocarbon deposits in the world. Its vast expanse and considerable volume of resources position it as a strategic asset for Argentina's energy future, with potential impact on the global energy market. In a global context where energy demand continues to rise and the transition to renewable sources is still underway, unconventional reservoirs like Vaca Muerta are gaining increasing importance in the global energy mix.

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

This report focuses on the specific application of AIGEN for the optimization of drilling conditions related to oil and water activities within the Vaca Muerta formation in

Neuquén, Argentina. The objective is to analyze how this technology can address the challenges inherent to drilling in this unconventional field, improve operational efficiency, reduce costs, and contribute to a more sustainable exploitation of its resources. Throughout this document, the fundamentals of AIGEN in the context of oil and gas, the challenges and opportunities of drilling in Vaca Muerta, concrete applications of AIGEN for optimization, relevant case studies, the quantifiable benefits of its implementation, barriers to its adoption, future trends, and its impact on the workforce and environmental sustainability will be explored.

The magnitude of Vaca Muerta's resources and their potential to boost Argentina's energy independence and exports create a pressing need to adopt technologies that improve efficiency and reduce costs. AIGEN, recognized for its optimization capabilities, is a key tool for exploration in this context. Additionally, the trend toward horizontal drilling in Vaca Muerta underscores the increasing complexity of drilling operations, increasing the value of advanced optimization techniques like AIGEN. These more complex operations require precise control and detailed optimization, where AI's ability to analyze intricate data and make real-time adjustments can offer a significant advantage.

II. Fundamentals of Generative Artificial Intelligence (GENAI) in the Oil and Gas Industry

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 user-provided instructions, known as "prompts."

Unlike other types of AI, such as discriminative AI, which focuses on classifying or predicting existing data, AIGEN has the ability to synthesize novel information from patterns learned during training.

This technology is based on fundamental principles such as Rich Language Models (LLMs), deep learning, and neural networks, which allow it to process and understand

large amounts of data to generate coherent and relevant content. The increasing availability and power of cloud-based AI platforms further facilitates access and implementation of IAGEN solutions across diverse industries.

In 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 span the entire value chain, from exploration and production to refining and distribution. A particularly relevant area of impact is drilling optimization, where IAGEN can significantly contribute to improving efficiency and reducing operating costs.

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

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

Furthermore, IAGEN's ability to understand natural language queries and translate them into executable code, such as SQL, can make complex drilling data easier for non-data scientists, empowering drilling engineers and other domain experts. This accessibility can lead to faster problem resolution and improved knowledge capture.

III. IAGEN Applications for Drilling Optimization in Vaca Muerta

IAGEN offers a variety of applications to optimize drilling conditions in the Vaca Muerta Formation, addressing both geological and operational challenges.

1. Real-time drilling parameter optimization

One of the key applications is the real-time optimization of drilling parameters. IAGEN

can analyze real-time sensor data, such as pressure, temperature, and vibration, to dynamically adjust drilling parameters and achieve optimal rate of penetration (ROP) and improved wellbore stability.

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

2. Well trajectory optimization and geosteering

AI GEN also plays an important role in well trajectory optimization and geosteering. By integrating real-time geological data and downhole measurements, it can autonomously guide the drill bit through the most productive zones of the reservoir ("sweet spots"). AI-powered geosteering systems can make autonomous trajectory changes based on subsurface 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, well placement and completion strategies can be optimized. Machine learning is used to predict well productivity based on various subsurface 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 wellbore instability by analyzing real-time data and historical incidents. Controlled pressure drilling (MPD) techniques, combined with AI, improve well control.

5. Impact of IAGEN on autonomous drilling systems

The growing attention toward autonomous drilling systems suggests a future where AI GEN will play a central role in controlling and optimizing drilling operations with minimal human intervention, potentially leading to significant efficiency gains and safety

improvements at Vaca Muerta. Furthermore, the integration of physics-based models with data-driven AI models represents a powerful approach to drilling optimization at 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 fits.
- 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 to mud composition and additives.
- Monitoring and Adjustment Agent: Monitors implementation and corrects deviations.

2. Workflow Description 2: IAGEN Agent: Real-Time Drilling Parameter Optimization

Aim:

Dynamically adjust drilling parameters (weight on bit, rotation speed, mud pressure, etc.) in real time to maximize Rate of Penetration (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 Muerta, IAGEN's application allowed for detection of lost circulation 24 hours in advance, 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

Unique geological characteristics sometimes complicate drilling operations: low permeability, the presence of nanoporous media, complex lithology, and reservoir heterogeneity are all factors that hamper efficient hydrocarbon extraction. These geological challenges manifest themselves in operational problems such as gas breakthroughs, fluid losses, and wellbore instability. Additionally, significant variability in reservoir quality is observed throughout the basin.

Drilling operations also face considerable operational challenges. High operating costs, resulting from logistical and infrastructure constraints, represent a significant obstacle. Drilling extensive horizontal sections and managing well trajectories in such a

heterogeneous formation are complex tasks that require constant optimization of parameters such as rate of penetration (ROP), weight on bit (WOB), and torque. Bit wear and the need for proactive maintenance are other 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 operational complexities underscores the critical need for advanced technologies like IAGEN that can improve well design, drilling practices, and risk mitigation. A 40% abandonment rate implies significant inefficiencies and financial losses, highlighting a strong need for solutions that can predict and prevent such problems. IAGEN's predictive capabilities and ability to analyze complex drilling parameters make it a potential solution.

On the other hand, the successful drilling of record-length lateral sections in Vaca Muerta demonstrates the potential of technological advances in the region. IAGEN can leverage this progress by further optimizing these complex drilling operations. The success of drilling exceptionally long horizontal wells demonstrates a capacity for innovation in Vaca Muerta. IAGEN can contribute to this by providing advanced tools for the 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) to be achieved,

which translates into faster drilling times.

- Well productivity is also improved through completion location and design optimization enabled by IAGEN, leading to increased hydrocarbon recovery and production rates. Significant increases in cumulative oil production have been reported.
- Downtime is reduced thanks to predictive maintenance facilitated by IAGEN, minimizing unplanned interruptions due to equipment failures.
- Finally, IAGEN contributes to improving operational safety in drilling operations by detecting potential hazards and enabling proactive interventions.

The consistent mention of significant percentage improvements in key drilling metrics (ROP, downtime reduction, increased production) due to AI adoption suggests a compelling return on investment for companies implementing AIGEN solutions at Vaca Muerta. ROP improvements of 13–60% and downtime reductions of 20% indicate substantial improvements in efficiency and profitability, justifying the adoption of AIGEN. Furthermore, the emphasis on both cost reduction and safety improvements as benefits of AI suggests that AIGEN can contribute to both the economic viability and responsible operation of drilling activities at Vaca Muerta.

V. Comparison with Traditional Methods

Aspect	Traditional Methods	Use of IAGEN
Fluid adjustment	Based on experience and trial and error	Optimization based on predictive models
Fault detection	Reactive analysis after incidents	Real-time prediction and prevention
Data	Manual reports and scattered	Automatic real-time integration

management	databases	
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VI. Challenges and Barriers to IAGEN Adoption in Drilling Operations in Vaca Muerta

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

Data quality and integration represent a significant obstacle. The oil and gas industry handles vast amounts of data from diverse sources, such as geological surveys, well logs, and sensors, which are often inconsistent and difficult to integrate. Data silos and legacy systems further hamper seamless information integration.

Another significant challenge is the shortage of skilled labor. Personnel with experience in both oil and gas drilling operations and artificial intelligence and machine learning are needed to effectively develop and implement AIGEN solutions.

Resistance to change and the acceptance gap within traditional oil and gas operations can also hinder the adoption of new technologies like AI. Strong leadership and a shift in organizational culture are required to embrace AI-based decision-making.

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

The generalizability and interpretability of AI models are other important considerations. It's crucial to ensure that models trained with data from one area or set of conditions can be effectively applied to other parts of the Vaca Muerta Formation or to different drilling scenarios. Furthermore, the interpretability of AI models is necessary to build trust and understanding among drilling engineers.

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

create uncertainty for companies. Clear guidelines and regulations are needed 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 fundamental requirement for successful AIGEN implementation in Vaca Muerta. Without high-quality, well-integrated data, AI models cannot function effectively. This highlights the need for substantial effort in data infrastructure and governance before fully leveraging AIGEN. The shortage of skilled AI professionals in Argentina could be a significant bottleneck for AIGEN adoption in the oil and gas sector. Addressing this requires investment in education, training, and potentially the attraction of international talent.

VII. Future Trends and the Potential of IAGEN in Hydrocarbon Drilling in Neuquén

The future of hydrocarbon drilling in Neuquén, particularly in the Vaca Muerta formation, will be increasingly influenced by Generative Artificial Intelligence (GENI). There is a clear trend toward greater automation in drilling operations, where GENI will play a pivotal 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 enable 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 accelerating 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 is projected for the AI solutions market in the oil and gas

industry, which will further drive research and development in this field.

The strong trend toward 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 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 comply with environmental regulations and reduce their carbon footprint, in line with global sustainability goals.

VIII. Conclusions

Generative Artificial Intelligence (GENI) has significant potential to revolutionize drilling operations in the Vaca Muerta Formation. Through its diverse applications, from real-time parameter optimization to predictive maintenance and intelligent well planning, GENI can improve efficiency, reduce costs, increase productivity, and strengthen operational safety. Case studies and quantifiable benefits reported in the industry support the promise of this technology to transform unconventional hydrocarbon extraction.

However, successful adoption of IAGEN in Vaca Muerta requires overcoming significant challenges related to data quality and integration, a shortage of skilled labor, resistance to change, and implementation costs. To maximize the benefits of IAGEN, the following are recommended:

- Develop a comprehensive data management strategy: Establishing robust mechanisms for data collection, storage, integration, and quality control is critical to the success of IAGEN applications.
- Investing in talent development and training: Implementing initiatives to train the existing workforce and attract new talent with experience in oil and gas drilling and AI/ML is crucial.
- Fostering collaboration and knowledge sharing: Promoting collaboration between oil and gas companies, technology providers, and research institutions will

accelerate the development and adoption of IAGEN solutions.

- Prioritize pilot projects and scalable implementations: Start with specific pilot projects to demonstrate the value of IAGEN in specific drilling applications and then scale successful initiatives across all operations.
- Address regulatory considerations: Proactively engage with 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.
- Promoting a culture of innovation and change management: Strong leadership and effective change management strategies are needed to overcome resistance to adopting AI technologies within the organization.

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

Sources cited

1. An Overview of Recent Developments and Understandings of Unconventionals in the Vaca Muerta Formation, Argentina - MDPI, accessed: February 16, 2025, <https://www.mdpi.com/2076-3417/14/4/1366>
2. Innovative Artificial Intelligence Approach in Vaca Muerta Shale Oil Wells for Real Time Optimization | Request PDF - ResearchGate, accessed: February 16, 2025, https://www.researchgate.net/publication/335884274_Innovative_Artificial_Intelligence_Approach_in_Vaca_Muerta_Shale_Oil_Wells_for_Real_Time_Optimization
3. YPF Boosts Competitiveness in Vaca Muerta with New Drilling Record - Energy Circle, accessed: February 16, 2025,

<https://www.energycircle.org/news/ypf-boosts-competitiveness-in-vaca-muerta-with-new-drilling-record>

4. Vaca Muerta Shale Drives Argentina's LNG Export Ambitions - JPT - SPE, accessed: February 16, 2025,

<https://jpt.spe.org/vaca-muerta-shale-drives-argentinass-lng-export-ambitions-restricted>

5. of Argentina Vaca Muerta: the future, accessed: February 16, 2025, <https://www.pwc.com.ar/es/assets/document/invest-in-vaca-muerta.pdf>

6. Vaca Muerta shale - JPT - Society of Petroleum Engineers, accessed: February 16, 2025, <https://jpt.spe.org/tag/vaca-muerta-shale>

7. Vaca Muerta: Argentina on the global energy stage - Tecpetrol, accessed: February 16, 2025, <https://www.tecpetrol.com/en/news/2025/techint-group-at-ceraweek>

8. YPF achieves record in Vaca Muerta with the drilling of the longest lateral well - Inspecnet, accessed: February 16, 2025, <https://inspenet.com/en/noticias/record-in-vaca-muerta-by-ypf/>

9. Generative AI in Oil & Gas: 5 highly complex use cases - Nubiral, accessed: February 16, 2025, <https://nubiral.com/generative-ai-in-oil-gas-5-highly-complex-use-cases/>

10. Generative AI for Oil and Gas | Enhanced Efficiency | 7P - 7Puentes, access: February 16, 2025, <https://www.7puentes.com/generative-ai-for-oil-and-gas/>

11. Empowering Drilling and Optimization with Generative AI - SLB AI, accessed: February 16, 2025, <https://ai.slb.com/blog/drilling-genai-optimization>

12. The Future of Oil & Gas: AI-Powered Exploration & Production - DTskill, accessed: February 16, 2025, <https://dtskill.com/blog/generative-ai-in-oil-and-gas/>

13. Generative AI in Oil & Gas Companies | Market Research Future, accessed: February 16, 2025, <https://www.marketresearchfuture.com/reports/generative-ai-in-oil-gas-market/companies>

14. Generative AI for Oil and Gas: Unleashing the Potential Through Digital Transformation, accessed: February 16, 2025, <https://tovie.ai/blog/generative-ai-for-oil-and-gas-unleashing-the-potential-through-digital-transformation>

15. SLB adds AI-driven geosteering to its autonomous drilling solutions to achieve more efficient and productive wells, accessed: March 18, 2025, <https://investorcenter.slb.com/news-releases/news-release-details/slb-adds-ai-driven-geosteering-its-autonomous-drilling-solutions/>
16. SLB Adds AI-Driven Geosteering To Its Autonomous Drilling Solutions To Achieve More Efficient And Productive Wells - TechDogs, accessed: March 18, 2025, <https://www.techdogs.com/tech-news/business-wire/slb-adds-ai-driven-geosteering-to-its-autonomous-drilling-solutions-to-achieve-more-efficient-and-productive-wells>
17. Drilling Down: How AI is Changing the Future of Oil and Gas - Sand Technologies, accessed: March 18, 2025, <https://www.sandtech.com/insight/drilling-down-how-ai-is-changing-the-future-of-oil-and-gas/>
18. Original Article: The Role of Artificial Intelligence in Optimizing Oil Exploration and Production, accessed: March 18, 2025, https://www.ejcmpr.com/article_210864_5e5c481a5590952690c1c1ebebb4bf66.pdf
19. AI in Oil & Gas Exploration: Maximizing Discoveries, Minimizing Costs - Datategy, accessed: March 18, 2025, <https://www.dategy.net/2024/01/09/ai-in-oil-exploration-maximizing-discoveries-minimizing-costs/>
20. AI in Oil and Gas: Benefit and Use Cases - Apptunix, accessed: March 18, 2025, <https://www.apptunix.com/blog/artificial-intelligence-in-oil-and-gas-benefit-and-use-cases/>
21. AI in Oil and Gas: Future Trends & Use Cases - Moon Technolabs, accessed: March 18, 2025, <https://www.moontechnolabs.com/blog/ai-in-oil-and-gas/>
22. AI in the Oil and Gas Industry - Numalis, accessed: March 18, 2025, <https://numalis.com/ai-in-the-oil-and-gas-industry/>
23. data analytics and machine learning workflows for optimization of unconventional assets. case study: neuquén basin, vaca muerte play, accessed: March 18, 2025, <https://www.iapg.org.ar/conexplo/PENDRIVE/pdf/simposios/vaca/vacamuerta18.pdf>
24. AI in the Oil & Gas Industry: From drilling optimization to market prediction |

HCLTech, accessed: March 18, 2025,
<https://www.hcltech.com/blogs/ai-in-the-oil-and-gas-industry-from-drilling-optimization-to-market-prediction>

25. Intelligent Drilling and Completion: A Review - Engineering, accessed: March 18, 2025, <https://www.engineering.org.cn/engi/EN/10.1016/j.eng.2022.07.014>

26. Drilling optimization solutions - Halliburton, accessed: March 18, 2025, <https://www.halliburton.com/en/well-construction/drilling/halliburton-sperry-drilling-optimization-solutions>

27. Automation initiatives show untapped potential in drilling optimization, accessed: March 18, 2025, <https://drillingcontractor.org/automation-initiatives-show-untapped-potential-in-drilling-optimization-69603>

28. Oil Drilling Automation: Revolutionizing the Industry for Efficiency and Safety, accessed: March 18, 2025, <https://www.hpinc.com/resources/product-highlights/oil-drilling-automation-revolutionizing-the-industry-for-efficiency-and-safety>

29. Drilling Optimization - DeepIQ, accessed: March 18, 2025, <https://deepiq.com/drilling-optimization/>

30. Drilling into the Future With Artificial Intelligence in Oil and Gas Industry - Techugo, accessed: March 20, 2025, <https://www.techugo.com/blog/drilling-into-the-future-with-artificial-intelligence-in-oil-and-gas-industry/>

31. SLB Introduces AI-Driven Tool for More Efficient Autonomous Drilling Solutions, accessed: March 20, 2025, <https://www.oedigital.com/news/520055-slb-introduces-ai-driven-tool-for-more-efficient-autonomous-drilling-solutions>

32. Revolutionizing Oil & Gas: The Impact of Automation on Drilling Efficiency and Safety, accessed: March 20, 2025, <https://oilgasleads.com/revolutionizing-oil-gas-the-impact-of-automation-on-drilling-efficiency-and-safety/>

33. AI's Role in Oil and Gas Exploration | DW Energy Group, accessed: March 18, 2025, <https://www.dwenergygroup.com/ais-role-in-oil-and-gas-exploration/>
34. Artificial Intelligence in the Oil and Gas Industry: Benefits & Use Cases - Ksolves, accessed: March 20, 2025, <https://www.ksolves.com/blog/artificial-intelligence/applications-in-oil-gas-industry>
35. Shale Analytics: AI-based Production Optimization in Shale - SPE, accessed: March 20, 2025, <https://www.spe.org/en/training/courses/shale-analytics/>
36. AI & ML in Oil & Gas Market Size, Forecasts Report 2025-2034, accessed: March 20, 2025, <https://www.gminsights.com/industry-analysis/ai-and-ml-in-oil-gas-market>
37. Unlocking the True Potential of the Vaca Muerta Shale via an Integrated Completion Optimization Approach | Request PDF - ResearchGate, accessed: March 20, 2025, https://www.researchgate.net/publication/287785351_Unlocking_the_True_Potential_of_the_Vaca_Muerta_Shale_via_an_Integrated_Completion_Optimization_Approach
38. A Review of AI Applications in Unconventional Oil and Gas Exploration and Development, accessed: March 20, 2025, <https://www.mdpi.com/1996-1073/18/2/391>
39. Analyzing Vista's Record-Setting Vaca Muerta Wells with Oil and Gas Machine Learning Models - Novi Labs, accessed: March 20, 2025, <https://novilabs.com/blog/vista-record-analysis-machine-learning-oil-and-gas-data-model/>
40. Operator drills Argentina's longest lateral and deepest well - Halliburton, accessed: March 20, 2025, <https://www.halliburton.com/en/resources/operator-drills-countrys-longest-lateral-deepest-well>
41. www.iapg.org.ar, accessed: March 20, 2025, <https://www.iapg.org.ar/conexplo/PENDRIVE/pdf/simposios/vaca/vacamuerta16.pdf>
42. The Vaca Muerta Comes of Age | Enverus, accessed March 20, 2025, <https://www.enverus.com/blog/the-vaca-muerta-comes-of-age/>
43. Integrated managed pressure drilling system improves insights for enhanced performance, accessed: March 20, 2025, <https://worldoil.com/magazine/2025/january-2025/features/integrated-managed-pressure-drilling/>

[ure-drilling-system-improves-insights-for-enhanced-performance/](#)

44. Land drillers usher in era of super-spec rigs - Drilling Contractor, accessed: March 20, 2025,

<https://drillingcontractor.org/land-drillers-usher-in-era-of-super-spec-rigs-48413>

45. Drilling at the Cutting Edge of Performance With Shaped-Cutter Technology - JPT - SPE, accessed: March 22, 2025,

<https://jpt.spe.org/drilling-at-the-cutting-edge-of-performance-with-shaped-cutter-technology>

46. Oil Drilling Automation: Revolutionizing the Industry for Efficiency and Safety, accessed: March 22, 2025,

<https://www.helmerichpayne.com/resources/product-highlights/oil-drilling-automation-r-evolutionizing-the-industry-for-efficiency-and-safety>

47. Maximizing the impact of AI in the oil and gas sector | EY - US, accessed: March 22, 2025,

https://www.ey.com/en_us/insights/oil-gas/maximizing-the-impact-of-ai-in-the-oil-and-gas-sector

48. Oil and gas can be slow to change. Can AI be a disruptor? | GlobalSpec, accessed: March 22, 2025,

<https://insights.globalspec.com/article/23508/oil-and-gas-can-be-slow-to-change-can-ai-be-a-disruptor>

49. (PDF) Argentina's Potential in Artificial Intelligence - ResearchGate, accessed: March 22, 2025,

https://www.researchgate.net/publication/387172794_Argentina's_Potential_in_Artificial_Intelligence

50. Rise of the Machines: Fracking Execs Plan Profits by Using ..., accessed: March 22, 2025,

<https://www.resilience.org/stories/2018-07-05/rise-of-the-machines-fracking-execs-plan-profits-by-using-automation-to-shrink-workforce/>