HUB TECH IA

Deliverable report 26

AI and IAGEN Application Use Case

Hydraulic Fracturing Design: AI Models Fracturing Propagation Fractures and Optimizing the Use of Resources in Argentina

I. Introduction

Hydraulic fracturing has established itself as an essential technique for the extraction of hydrocarbons, particularly in low-grade geological formations permeability classified as unconventional, such as shale.

This method involves high-pressure injection of fluids into the subsurface to induce fractures in the rock, thus facilitating the release and flow of oil and gas. However, Hydraulic fracturing operations are inherently complex and require the optimization of various parameters, including the quantities of water and sand (used as a proppant) and the chemicals used in
the fracturing fluid.

The need to improve efficiency, reduce operating costs and minimize environmental impact has driven the exploration of innovative technologies.

In this context, artificial intelligence (AI) emerges as a tool with a significant potential to transform fracturing design and execution hydraulics. By accurately modeling the propagation of the generated fractures and Optimize the use of critical resources, AI offers the promise of revolutionizing internships in the oil and gas industry.

This report focuses on the analysis of how AI models the spread of fractures with the aim of optimizing hydraulic fracturing, exploring its benefits, the challenges inherent in its adoption and the future outlook for its application in the Argentine oil and gas sector, with special emphasis on the formation of Vaca Dead.

II. The Argentine Oil and Gas Sector and Vaca Muerta

The oil and gas sector plays a key role in the economy of Argentina, contributing significantly to its industrial development and its balance commercial [1]. In recent years, total hydrocarbon production has experienced fluctuations, but a general trend of growth is observed, especially in oil production. In 2023, total oil production in Argentina increased by 9% compared to the previous year, reaching 635.3 thousand barrels per day. This increase is mainly attributed to prices international reference and improvements in evacuation capacity.

A crucial aspect of the Argentine energy sector is the growing contribution of unconventional production to the total. In 2023, 74% of gas reserves and resources natural and 67% of oil reserves and resources were classified as non-natural conventional. This transition towards greater dependence on non-conventional production Conventional emphasises the importance of optimising extraction techniques, such as hydraulic fracturing, to ensure economic viability and maximization of the production. The presence of large international oil companies in Argentina, particularly in Vaca Muerta, suggests an environment conducive to the adoption of advanced technologies such as AI in fracturing operations, since these Companies often have access to and experience with cutting-edge technologies.

The Neuquén Basin, where the Vaca Muerta formation is located, concentrates the largest proportion of production and reserves, especially with regard to unconventional resources.

Vaca Muerta stands out as one of the non-hydrocarbon formations
largest conventional ones worldwide, with estimates that place it as the
second largest reserve of shale gas and fourth largest reserve of shale oil on the planet. It is estimated that
Argentina has 802 trillion cubic feet of shale gas and 27 billion cubic feet of
barrels of shale oil, with Vaca Muerta being the main contributor to these figures.

The development of Vaca Muerta is crucial for Argentina to achieve self-sufficiency.
energy and position itself as a regional and even global exporter of
hydrocarbons .

Current unconventional oil and gas production in Vaca Muerta has
experienced significant growth.

III. Fundamentals of Hydraulic Fracturing and Fracture Propagation

The basic process of hydraulic fracturing involves the high-pressure injection of a fluid composed primarily of water (approximately 95%), sand (around 4.5%), and a small proportion of chemical additives (approximately 0.5%) into the drilled well until hydrocarbons are formed.

This high-pressure fluid injection overcomes the strength of the rock, creating a network
of fractures that increases the permeability of the formation and allows the
hydrocarbons flow more easily into the well.

In unconventional formations such as shale, it is common to use drilling
horizontal, which allows access to a greater extension of the formation from a single
well, and multi-stage fracturing, where the fracturing process is repeated throughout
from the horizontal section of the well to stimulate a significant volume of rock.

The composition of the fracturing fluid is critical and is adjusted according to the characteristics specific to the training and treatment objectives. In addition to water and sand,
Various chemical additives are used to modify the properties of the fluid, such as

its viscosity, proppant transport capacity and reactivity with the rock.

Prediction and control of fracture propagation in the subsurface represent significant challenges due to the inherent heterogeneity of the rock, the variability of in situ stresses and the complex interactions that can occur between the induced fractures and pre-existing natural fractures.

Achieving an optimal fracture network is essential to maximize the permeability of the formation and, consequently, the production of hydrocarbons.

However, fracture propagation does not always follow a planar pattern and may reorient itself based on the direction of the maximum horizontal stress in the rock. This The unpredictable nature of fracture propagation underscores the need for advanced modeling tools, such as those based on AI, to improve the planning and execution of hydraulic fracturing treatments. The capacity of AI to model complex and non-linear systems can provide better understanding fracture behavior under various conditions geological and operational, thus helping to design more effective treatments and efficient.

III. Optimizing Resource Use with AI

Artificial intelligence plays a crucial role in optimizing resource use. essential in hydraulic fracturing, such as water, sand (proppant) and chemicals.

AI models can:

- Analyze large amounts of historical and real-time data to determine the optimal amount of water needed to achieve the desired stimulation in different geological formations.
- By more accurately predicting pore pressure and other conditions of the

reservoir that influence the efficiency of water use, AI allows the operators adjust water injection volumes more effectively. This optimization is essential for the sustainability of operations. fracturing. Case studies have shown how AI has helped reduce significantly reduce water consumption in fracking projects, reducing both operating costs and environmental impact on the local water sources.

Regarding proppant (sand) optimization:

- AI can model the transportation and placement of this material within the induced fractures. This ensures optimal conductivity of the fractures long term, keeping the flow paths open for the production of hydrocarbons.
- AI models can also predict the risk of "screen-out" (fracture blockage with proppant) and optimize the concentration and size of proppant particles used. In doing so, AI helps reduce the amount total amount of proppant needed without compromising hydrocarbon production, which which translates into improvements in stimulation efficiency and a decrease in the costs associated with the acquisition and transportation of large volumes of sand.

AI also plays an important role in optimizing product usage. chemicals in hydraulic fracturing:

- AI models can analyze the interaction of different products chemicals with the specific properties of the rock and reservoir fluids. This allows operators to determine fluid formulations of most effective fracturing and the optimal amounts of each chemical to use.
- In addition, AI has the potential to identify greener or more environmentally friendly alternatives.

reduce the amount of harsh chemicals needed to achieve the desired results.

- Optimizing chemicals can not only improve efficiency of fracking, but can also minimize the environmental impact associated with the use of potentially harmful substances in the process.

IV. Application of agents powered by Generative AI

The mentioned opportunities can be included within an agent based on AI that also incorporates IAGEN-based models to increase efficiency.

1. IAGEN Concepts

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.

2. **Concept of IAGEN agents**

In recent years, generative artificial intelligence (GAI) has revolutionized the way we interact with technology, enabling the development of systems capable of generating content, answering complex questions and assisting with tasks high-demand cognitive skills. From this capacity, a new architecture emerges Technological: IAGen-powered agents. These agents are not simple conversational interfaces, but autonomous systems that can interpret instructions, make decisions, execute tasks and learn from their interactions with the around.

An IAGen agent combines large language models with components additional features such as external tools, memory, planning and autonomous execution. This allows them to operate in complex environments, with the ability to break down

objectives in 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 a spectrum of more sophisticated and customizable applications.

At the organizational level, these agents are being used to automate processes, generate data analysis, assist in decision making and improve the user experience, both internally and externally. For example, they can assume human resources, legal, financial or logistical tasks, and even those linked to the technical areas of production processes, acting as intelligent assistants that collaborate with human teams. This ability to integrate knowledge and execute tasks autonomously transforms the way organizations can scale your operations without losing quality or control.

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

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

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

However, its implementation also poses technical, ethical and legal challenges,

from responsible design to human oversight. Therefore, understanding your architecture, its operational logic and its potential impacts is fundamental to its effective and safe adoption in various professional contexts.

3. Agent Design Proposal: OptiFrac IA

a. General Objective:

Optimize in real time the use of **water, proppant and chemicals** in hydraulic fracturing operations, minimizing costs and reducing impact environmental.

b. Agent Components:

Data Ingestion

- Historical well data (depth, formation, pressure, production, etc.)
- Real-time sensors (bottom pressure, flow rate, temperature, microseismicity)
- Inventories and prices of water, proppant and chemicals

AI Module for Water

- Predicts pore pressure and formation characteristics
- Estimate the minimum volume of water needed for effective stimulation

- Dynamic flow adjustment based on well behavior

AI Module for Proppant

- Simulates transport and placement of the proppant
- Detects *screen-out* risk and suggests concentration adjustments
- Recommends optimal sizes and combines proppant types if necessary necessary

AI Module for Chemists

- Models fluid-rock chemical interaction
- Optimizes formulations for each type of training
- Suggests eco-friendly alternatives and reduces harsh chemicals

Optimization Engine

- Evolutionary or multi-objective optimization algorithms
- Balances efficiency, cost and sustainability

- Presents sensitivity curves and comparative scenarios

Smart Control Panel

- Viewing recommendations
- Key indicators: water savings (%), proppant reduction (kg), chemical eco-score, estimated ROI
- Possibility of AI-assisted manual intervention

c. Integrations and Automations

- **API connectors** to SCADA, field sensors, simulation platforms geological
- **Automation with n8n or Zapier:** update spreadsheets, generate PDF reports automatic, email/WhatsApp alert
- **Google Drive / BigQuery:** centralized repository and analysis of results

d. Expected Benefits

- Up to 20–30% reduction in water use per stage
- Reduction in cost per ton of proppant and transportation
- Safer chemical formulations adapted to each deposit
- Faster, data-driven decision-making

V. Benefits of AI in Hydraulic Fracturing

The application of artificial intelligence in hydraulic fracturing offers a wide range of range of benefits for the oil and gas industry.

One of the main ones is the increase in operational efficiency. AI can optimize fracturing parameters in real time, resulting in more precise treatments effective and, ultimately, in increased hydrocarbon production. In addition, the AI has the ability to automate certain aspects of the fracturing process, which which reduces the need for human intervention, minimizes non-productive time and improves the consistency of operations.

AI also contributes significantly to cost reduction in hydraulic fracturing operations. Optimizing the use of key resources, such as water, sand and chemicals, using AI models generates substantial savings in operating costs. Likewise, AI's ability to predict potential equipment failures and optimize maintenance programs It allows to reduce repair costs and minimize downtime. facilities.

Another important benefit of AI in hydraulic fracturing is the improvement in rates hydrocarbon extraction. By helping to design more efficient fracturing treatments Effectively, AI leads to higher oil and gas recovery from reservoirs AI also has the potential to identify areas within deposits with a high production potential, allowing operators to focus their efforts stimulation in the most promising areas.

Finally, AI contributes to minimizing the environmental impact of fracking. hydraulics. By optimizing the use of resources and reducing the amount of chemicals used, AI encourages more sustainable fracking practices. In addition, AI has the potential to improve the management of waste generated by operations fracturing and reducing greenhouse gas emissions, including

methane, which is a potent global warming gas. Growing concerns about
The environmental impact of hydraulic fracturing makes the benefits of AI in
This aspect is particularly valuable for industry and society.

VI. Challenges and Barriers to AI Adoption in Argentina

Despite the numerous benefits that AI can bring to fracking,
hydraulics in Argentina, there are several challenges and barriers that can hinder its
widespread adoption.

First, technological barriers include the possible lack of infrastructure
adequate technology in some areas and the need to integrate AI solutions
with legacy systems existing in companies in the sector.

Additionally, AI projects can be complex and require expertise.
specialized in both data science and petroleum engineering, skills that
may not be widely available in the Argentine labor market.

Secondly, economic barriers are significant. The implementation of
AI solutions often carry high initial costs associated with acquisition
specialized hardware and software, as well as the hiring and training of
trained personnel. In addition, there may be uncertainty about the return of the
investment (ROI) in AI projects, which can make companies reluctant to
make the necessary investments.

Thirdly, cultural and organizational barriers also play a role.
important. There may be resistance to change within organizations,
especially if the workforce is unfamiliar with AI technologies or
fears that these could replace their jobs. Promote a culture that
value innovation and provide training and development opportunities
skills for the existing workforce are crucial to overcome this resistance and

facilitate the adoption of AI.

Fourth, regulatory and political barriers may influence the adoption of the AI in the Argentine energy sector. There may be challenges related to the existing regulations that do not specifically address AI or with a lack of frameworks clear regulatory frameworks for its application in the oil and gas industry. The support of Government policies that encourage investment in technology and innovation will be essential to overcome these barriers.

Finally, data barriers are a major challenge. Quality, availability and accessibility of the data needed to train and use AI models may be limited.

Benefits	Challenges	Recommendations
Increased efficiency operational	High initial costs	Investment in infrastructure technological
Cost reduction operatives	Lack of talent specialized	Programs of training and development of skills
Improving rates extraction	Cultural resistance to change	Promote a culture of innovation
Minimizing impact environmental	Regulatory barriers and policies	Development of a framework clear and regulatory support

Optimizing the use of resources	Quality and accessibility of the data	Implementation of solid strategies of data management

Short-term investment in agent deployment equipment is recommended. of AI in technology and training:

Investment in proof of concept and pilot testing is required. The focus here is on be the training of talent to implement, since a trend is verified cost reduction in systems that enable “no code” and “low code” automation. For the first stage, it is also recommended to use teams with experience in design and implementation of AI agents. Finally, it is key to form an “in” team "house" for the accompaniment and appropriation of an agentic culture that redefines human-machine interaction.

VII. Conclusions

Artificial intelligence presents transformative potential for the healthcare industry. hydraulic fracturing in Argentina, especially in the context of the development of the vast Vaca Muerta formation.

By accurately modeling fracture propagation and optimizing resource use critical resources like water, sand, and chemicals, AI offers the promise of increase operational efficiency, reduce costs, improve extraction rates and minimize the environmental impact of this essential technique for the production of unconventional hydrocarbons.

Despite the challenges and barriers that still exist for its widespread adoption in Argentina, the potential benefits of AI are significant and justify further

investment and research in this area.

Case studies and industry examples from around the world demonstrate the value tangible that AI can bring, and future research directions suggest a continuous path towards even more sophisticated and sustainable solutions.

For Argentina to fully exploit the potential of AI in fracking hydraulics, it will be necessary to address technological, economic, cultural, regulatory and data, promoting collaboration between the different actors of the sector and promoting an environment that values innovation and the adoption of new technologies.

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