HUB TECH IA

Deliverable report 55

AI and IAGEN Application Use Case

Artificial intelligence to optimize logistics and water transportation in Vaca Muerta

I. Introduction

This report analyzes the potential of artificial intelligence (AI) to optimize water logistics and transportation in the Vaca Muerta region of Argentina. Water plays a critical role in oil and gas operations in Vaca Muerta, particularly in hydraulic fracturing.

The implementation of AI offers a significant opportunity to improve the efficiency, reduce costs, and potentially enhance the sustainability of these processes. The report's key findings highlight the potential benefits of AI in water demand forecasting, transportation route optimization, predictive maintenance of water infrastructure, optimized management of water storage and distribution, and improved efficiency in water treatment and reuse.

While there are challenges to AI adoption, such as data quality and integration and upfront costs, the most promising areas for AI application include predictive maintenance of water pipelines and pumps, optimized transportation route planning, and real-time monitoring of water treatment and reuse processes.

II. Current overview of water logistics in Vaca Muerta

Currently, water for hydraulic fracturing operations in Vaca Muerta is obtained primarily from rivers. Regulations prohibit the use of groundwater for hydraulic stimulation, making surface water resources crucial and highlighting the need for efficient management to avoid pressure on these resources.

Water is transported from source to well sites primarily using flexible pipes. These flexible water lines are becoming common for delivering water to fracking sites, reducing the need for heavy truck traffic. This trend indicates a move toward more efficient and less disruptive transportation methods, which AI can further optimize.

Current water logistics in Vaca Muerta face challenges such as transportation costs, the potential for bottlenecks, environmental concerns related to water use and disposal, and the need for efficient resource management. Hydraulic fracturing requires enormous volumes of water, which could exacerbate water scarcity problems in regions.

arid areas like Vaca Muerta. Furthermore, climate change threatens the availability and quantity of water for various uses, including oil and gas production in Vaca Muerta, further emphasizing the need for resilient and optimized water management strategies, to which AI can contribute.

III. The promise of AI in logistics

Overall, AI is being used to optimize supply chains across a variety of industries, including demand forecasting, inventory management, route optimization, predictive maintenance, risk management, and supplier relationship management. Early adopters of AI in supply chain management have seen significant benefits, such as reducing logistics costs by 15%, decreasing inventory levels by 35%, and increasing service efficiency by 65%.

AI helps oil and gas companies forecast market prices, plan and schedule, optimize crude oil portfolios, create smart warehouses, maintain inventory, manage transportation operations, hedge risk, and improve delivery.

AI also contributes to more sustainable logistics practices by optimizing resource utilization, reducing fuel consumption, and minimizing environmental impacts. Its potential to transform supply chain management is significant, allowing companies to more accurately forecast demand, optimize transportation routes, and manage inventories to reduce emissions and resource use.

IV. Potential AI applications for water logistics in Vaca Muerta

- AI can analyze drilling programs, historical water usage data, weather patterns, and river flow levels to predict future water demand and optimize supply strategies. ML algorithms can analyze historical data, market trends, and external factors to predict demand for oil and gas products, allowing companies to optimize inventory levels and reduce costs. This principle can be extended to forecasting water demand based on operating schedules. By accurately forecasting water needs, companies can avoid over-extraction from rivers during low-flow periods, mitigating environmental risks.
- AI-powered route optimization algorithms can determine the most efficient routes for tanker trucks (if they are still in use) and monitor pipeline conditions to prevent leaks and optimize flow. AI algorithms optimize transportation routing and scheduling, improving delivery times and reducing fuel consumption. This is crucial for minimizing the costs and environmental impact of water transportation in Vaca Muerta. The reduction in truck traffic due to optimized routing can also lead to reduced road wear and improved safety.
- AI-powered predictive maintenance systems can monitor the health of pipelines, pumps, storage tanks, and treatment facilities, predicting potential failures before they occur. By analyzing data from equipment sensors, AI can predict machinery failures before they occur, allowing companies to proactively perform maintenance, thereby reducing downtime and maintenance costs. This is vital to ensuring a reliable water supply for hydraulic fracturing operations. Proactive maintenance prevents unexpected breakdowns, which can lead to costly delays in fracturing operations and potential environmental incidents.
- AI can manage water levels in storage tanks based on forecast demand and optimize water distribution to different well sites based on their operating schedules. AI can help coordinate operations equipment with the warehouse to ensure the availability of critical components. This principle can be applied to coordinating water availability with fracturing programs. Real-time

monitoring of water levels and predictive demand can help optimize pumping schedules, reducing the energy consumption associated with water transfer.

- AI can also support strategic logistics network design decisions, for example, determining where to install storage pools or water collection centers to reduce transportation distances. Using facility location optimization models, thousands of potential candidate locations can be evaluated based on well geography, water availability, and construction costs, seeking to minimize total truck travel. Clustering techniques would also be useful: algorithms such as *k-means* can group nearby high-demand wells together, suggesting the best spots for a single truck to efficiently serve multiple nearby locations.
- Instead of reacting to "lack of water" or "excess water," AI enables proactive delivery planning. Predictive machine learning models (e.g., neural networks or random forests trained on historical water production and fracture consumption data) can predict truck demand days or hours in advance. AI can also optimize loading and unloading schedules, avoiding wait times: each truck is given an optimal time window to reach the collection point or well, synchronized so that personnel and equipment are always available to pump water without delay. This maximizes fleet utilization—trucks spend more time transporting water and less time stopped.

Today, these opportunities are being optimized through the use of generative AI models. Generative Artificial Intelligence (GENI) is a branch of artificial intelligence that focuses on creating new content—such as models, images, code, or text—from existing data. This technology uses advanced algorithms to analyze vast amounts of information, identify patterns, and generate new and original content that is often indistinguishable from human-created content.

V. AI Agents and Agentic Workflows. The Evolution of Generative AI.

1. IAGEN Agents Concept

In recent years, generative artificial intelligence (GAI) has revolutionized the way we interact with technology, enabling the development of systems capable of generating content, answering complex questions, and assisting with high-demanding cognitive tasks.

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From this capability, a new technological architecture emerges: 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 environment.

An IAGen agent combines large language models with additional components such as external tools, memory, planning, and autonomous execution. This allows them to operate in complex environments, with the ability to break down objectives into steps, coordinate multiple actions, interact with digital systems (such as databases, APIs, or documents), and adapt to context changes in real time. These qualities distinguish them from traditional chatbots and open up a range of more sophisticated and customizable applications.

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

Furthermore, agentic workflows—structures where multiple agents collaborate to solve complex problems—allow responsibilities to be distributed among different agent profiles, each with specific functions. This creates hybrid work environments where humans and agents coexist, optimizing time, costs, and results. The ability to connect agents with tools such as Google Drive, CRMs, or document management platforms further expands their capabilities.

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

Among the benefits of authentic workflows powered by generative AI models is the ability to automate entire production processes, end-to-end, and even add value by leveraging the capabilities of language models based on these technologies.

However, its implementation also poses technical, ethical, and legal challenges, ranging from responsible design to human oversight. Therefore, understanding its architecture, operational logic, and potential impacts is critical for its effective and safe adoption in diverse professional contexts.

2. Proposal for the design of agent models

IAGEN Agent for Water Logistics Optimization – Vaca Muerta

Type: Generative + Predictive AI Agent
Objective: To optimize water transportation, storage, and use in hydraulic fracturing operations using artificial intelligence.

a. Main functions of the agent

Water demand prediction

- Uses ML models and neural networks to predict future consumption based on weather, drilling, river flow, and planned operations.

Route optimization

- Plan efficient routes for tanker trucks or mobile pipelines, considering road conditions, traffic, and environmental objectives.

Predictive maintenance

- Monitors the status of pipes, pumps, and tanks and proposes interventions before failures occur, reducing downtime.

Generating reports in natural language

- Produces automatic reports with KPIs (km traveled, CO_2 emissions, fleet utilization percentage) for management and auditing.

Intelligent logistics coordination

- Assign trucks, loading and unloading shifts, and suggest logistics network redesigns based on historical data and simulated scenarios.

Infrastructure planning

- It uses clustering and facility location algorithms to propose locations for new collection centers or tanks, optimizing distances.

Real-time monitoring

  - Integrate data from SCADA, IoT, GPS, and sensors to visualize critical operations live and adapt to contingencies.

b. **Agent outputs**

- Automated daily/weekly logistics plan (routes + schedules)
- Interactive map of operations
- Automatic PDF reports with KPIs
- Predictive alerts for maintenance or bottlenecks
- Web panel for operators, supervisors and analysts

c. **Usage flow examples**

- **Data loading** (drilling, historical consumption, routes)
- **Automatic** demand prediction by area
- **Route planning and fleet allocation**
- **Real-time monitoring**
- **Report generated by IAGEN** for management and operational improvements

Advanced version

With collaborative AI, you can add:

- Integration with n8n to automate tasks from Google Sheets or Drive.
- Comparator of logistics contracts or legal clauses.

- Conversational interaction with supervisors to explain decisions or alternatives.

VI. Comparison with traditional methods and key improvements

With traditional methods, route planning is typically done in a decentralized manner: each transport company or field supervisor decides when and where to dispatch their trucks, often through telephone communications and informal daily coordination. Such planning tends to be reactive—acting on the basis of immediate need—rather than proactive.

In contrast, with AI and digitalization, planning is comprehensive and proactive. The system considers the entire operation as a whole: all available water sources, all wells requiring service, and all trucks in circulation, in order to optimally coordinate. This allows, for example, to group geographically compatible deliveries and pickups, something that would be very complex to calculate manually on a daily basis. Another key improvement is real-time adaptability.

There's also a substantial difference in data use. Traditional decisions were based on personnel experience and rules of thumb ("X trucks per fracturing rig," "This route is often in poor condition"). These human heuristics, while valuable, fail to capture the full complexity and are not constantly updated. An AI system leverages vast volumes of historical and live data to detect patterns and anomalies that would otherwise be missed by the human eye.

In terms of results, the performance gap between traditional methods and AI is significant. As mentioned, pioneering companies achieved a 15% reduction in logistics costs and improvements of up to 65% in service levels with early adoption of AI.

In short, where there was previously fragmentation, delay, and uncertainty, AI brings coordination, speed, and precision. Key improvements include unified multi-variable planning, instant response to changes, continuous learning of operational patterns, and more disciplined execution (each actor knows what to do and when according to an optimal plan). This translates into fewer miles, lower costs, and improved compliance. AI-powered Logistics 4.0 thus overcomes the limitations of the conventional paradigm, making it possible to manage Vaca Muerta's growing complexity sustainably.

VII. Direct operational and strategic benefits

- Implementing AI in Vaca Muerta's water logistics can lead to cost reductions through optimized transportation routes, reduced fuel consumption, minimized downtime due to predictive maintenance, efficient water use, and optimized chemical treatment.
- Improved operational efficiency can also be achieved through faster delivery times, reduced delays, optimized resource allocation, and streamlined processes. The incorporation of AI and ML is transforming operational costs, efficiency, and decision-making processes in the oil and gas sector.
- Less obvious but critical benefits are achieved: the standardization and documentation of logistics. An AI system records every trip, its times, volumes, and any incidents, generating a valuable database. With this information, managers can measure key KPIs (costs per km, tons per truck, fleet utilization percentage, CO_2 emissions per m^3 transported, etc.) and identify bottlenecks or areas for continuous improvement. In short, the direct benefits include economic efficiency, operational certainty, safety, and improved decision-making. This positions the company competitively and prepares it to scale operations: logistics ceases to be a hindrance to growth and becomes a strategic ally, capable of quickly adapting to new projects or peaks in activity.

VIII. Concrete opportunities and benefits: impact on costs, time, efficiency and safety

AI implementation not only brings qualitative improvements but also quantifiable results. Below are some opportunities and estimated impact metrics:

- Reduction in kilometers traveled: By optimizing routes, it is possible to significantly reduce the total distances traveled by the fleet.
- Fuel savings and operating costs: Fewer kilometers and less driving time translate into direct fuel savings, which are also typically around 15-20%.
- Improved delivery times and productivity: With AI, delivery timeliness increases dramatically, giving frac crews greater certainty. Overall, equipment productivity increases: the same pumping resources can fracture more stages per month thanks to synchronized logistics.
- Increased fleet efficiency and operational capacity: A routing algorithm can eliminate *empty trips* by, for example, combining the delivery of water to one well with the withdrawal of production water from a nearby well on the same route.
- Impact on safety and the environment: fewer kilometers traveled and better operational control translate into fewer road incidents. From an environmental perspective, optimizing water logistics reduces CO_2 emissions and other pollutants. It also reduces the impact on roads .

IX. Challenges to AI adoption and strategies for overcoming them

While the benefits are clear, implementing AI solutions in Vaca Muerta's logistics faces significant challenges that must be addressed with appropriate strategies:

1. **Technical challenges:** Integrating AI into field operations first requires the availability of reliable data. An initial hurdle is collecting accurate data on well locations, up-to-date road maps (many of which are unpaved and constantly changing), real-time tank levels, etc. Information can be dispersed across multiple systems (SCADA, payroll, contractor systems), so data will need to be consolidated and cleaned. For continuous data flow (truck GPS, telemetry),

investment in satellite communications or private field networks may be necessary.

2. **Organizational and cultural challenges:** The introduction of AI entails changes in the way logistics teams, drivers, and supervisors work. There may be resistance to change due to fear of the unknown or fear of "machines replacing people." To overcome this, it is crucial to invest in training and cultural change.
3. **Economic and ROI challenges:** Implementing advanced AI systems entails a financial investment in software, infrastructure, and training. While the long-term return on investment is positive, in the short term, some companies may be hesitant to allocate capital to this type of project, especially in a challenging macroeconomic environment. To justify the investment, a solid business case must be presented. Strategy: Focus on *quick wins* —AI features that generate immediate savings—and implement them incrementally. It is also possible to explore *SaaS contracting models* or partnerships where the technology provider assumes part of the initial investment in exchange for performance-related payments (e.g., a percentage of the savings achieved), reducing the financial risk for the operator.
4. **Regulatory and contractual challenges:** Hydrocarbon logistics is subject to regulations (maximum axle weight, maximum driving hours, insurance, etc.) that the AI system must incorporate as "hard" constraints. Ensuring that the algorithm fully complies with transportation and safety regulations is mandatory; any plan that violates a regulation (to optimize costs) must be automatically discarded. This adds complexity to the modeling process. The solution is to integrate all these rules from the design stage and validate the system with transportation lawyers and contractor representatives to align expectations.
5. **Other barriers** include issues such as poor road infrastructure—which is beyond the direct reach of AI. If roads are impassable, even the best algorithm won't be able to optimize logistics. The strategy here is to use the data generated by AI to argue for infrastructure improvements to authorities: for example, demonstrating with numbers how many additional kilometers are

traveled due to avoidable detours, or how many extra liters of fuel are consumed due to the poor condition of a road, to drive public investment.

In all cases, the key to overcoming these challenges is a strategic and collaborative approach: combining business knowledge (logistics, production engineers, etc.) with data and AI experts, starting from the bottom up, and maintaining open communication with all stakeholders. This way, obstacles are addressed one by one, preventing them from derailing the overall initiative.

Recommendation:

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

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