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HUB TECH IA

Deliverable report 14

AI and IAGEN Application Use Case

Energy optimization activities - energy efficiency - protocols and guidelines for energy optimization

I. Introduction

Vaca Muerta is one of the main hydrocarbon formations conventional in the world, located in the province of Neuquén, Argentina. With significant reserves of shale gas and oil, the exploitation of these resources has driven the industrial and energy development of the region, generating a high demand for energy consumption in its operations.

Exploration and production activities in Vaca Muerta involve processes of extraction, transportation and refining, which require large volumes of energy. In this context, optimizing energy consumption not only contributes to reduce operational costs, but also allows for improved efficiency and decreased the environmental impact of the industry.

The application of Generative Artificial Intelligence (IAGEN) offers an innovative solution to this problem. Through real-time data analysis and Generation of predictive models, IAGEN allows the development of dynamic protocols to improve energy efficiency at every stage of the industrial process.

II. Application of IAGEN in Energy Optimization

Generative Artificial Intelligence (GENAI) is a branch of artificial intelligence that focuses on creating new content, such as models, images, code, or text,

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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.

The implementation of IAGEN in energy optimization in Vaca Muerta implies the collection and analysis of operational data from different sources, including IoT sensors, SCADA systems, and historical records. From this data, the Generative AI models can:

- Identify energy consumption patterns and detect opportunities for improvement. • Optimize the configuration and operation of equipment such as pumps, compressors and turbines to reduce consumption without affecting productivity.
- Generate automated protocols to improve operational efficiency and ensure optimal use of energy resources.
- Dynamically update optimization guides, adapting them to changes in operational and climatic conditions.

The incorporation of IAGEN in energy optimization allows for improvements to be achieved substantial changes in resource management, including:

- Standardization of procedures for energy optimization.
- Automation of monitoring and control to detect inefficiencies and correct them in real time.
- Reduction in energy consumption by up to 20%, generating savings significant in operational costs.
- Increased lifespan of equipment and machinery by operating in harsh conditions optimal.

Design and maintain updated operational guides and energy protocols optimized to automatically adjust to actual reservoir conditions, maximizing energy efficiency and reducing operational costs.

1. Specific use of IAGEN in the case

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- Generates personalized and adaptive energy protocols, based on data operating reals.
- Dynamically updates work guides, incorporating changes in weather, load, pressure, age of the equipment and well productivity.
- Integrates multiple data sources and prior knowledge to design automatic, clear, and actionable recommendations for field personnel.

2. Operation

a. Analysis of historical and real-time data

- Learn from previous energy operation configurations (under different temperatures, flow rates, well states).
- Identify which operational combinations were most efficient.

b. Automatic generation of custom protocols

- Write step by step for technical staff: how to operate pumps, valves, pressure or ventilation systems to minimize consumption without affect production.

- Provides different scenarios (“winter mode”, “intensive production mode”, “maintenance mode”).

c. Natural language and visual guides

- Protocols are delivered in clear text and/or visual format (diagrams, schemes) adapted to the technical level of the operating team.

- They are updated in real time, with suggestions for direct action.

d. Feedback and continuous improvement

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• The system learns from human feedback and real results.

• Adjusts guides when it detects that there are more efficient alternatives.

3. Examples of protocols generated by IAGEN

Protocol Type	Automatically Generated Content
“Start efficient of “injection pumps”	Reduce the number of cycles and establish pressure optimal according to temperature and flow rate.
“Operation on days with low temperature"	Suggests calibration of valves and preheating to reduce losses energetic.
“Overdraft Protocol energetic"	Indicates which systems to deprioritize without compromise safety or production.
“Eco mode for end of week"	Minimize consumption during non-productive hours without completely shutting down the systems.

4. Implementation roadmap

Stage	Action

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1ÿDiagnosis	Review of current guides and energy data sources available.
2ÿTraining either	Initial modeling with historical operational and manual data.
3ÿ Piloting	Generation and validation of protocols on one or two assets clue.
4ÿDeployment	Integration with mobile apps/tablets for operational staff.
5ÿEvolution	Incorporating human feedback, maintaining models and scaling.

III. Agentic Flow for Implementation: IAGEN Agent – “EnergyFlow Optimizer”

1. Concept of IAGEN agents

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

An IAGen agent combines large language models with components additional features such as external tools, memory, planning and autonomous execution.

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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 changes in context in real time. These qualities distinguish them from traditional chatbots, and open up 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 take on human resources, legal, financial, or logistics tasks, and even those related to the technical areas of production processes, acting as intelligent assistants that collaborate with human teams. This ability to integrate knowledge and execute tasks autonomously transforms the way organizations can scale your operations without losing quality or control.

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

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

2. IAGEN-powered agent application design proposal for the activity

a. Purpose of the Agent

Generate, update and distribute customized operating protocols to optimize the energy use in oil and gas facilities, adapting to the conditions specific to each well, plant or equipment in real time.

b. Agent Architecture

Agent Name: EnergyFlow Optimizer

Inputs:

- Real-time data from IoT sensors (flow, temperature, consumption, pressure).
- Energy consumption history and protocols used.
- Weather conditions (current and forecast).
- Condition of the equipment (useful life, recent maintenance).
- Schedule, shift and operating regime.
- Efficiency objectives defined by management (e.g., 10% reduction in consumption without loss of flow).

c. Agent Functional Pipeline

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[1] Data collection (IoT + historical + weather + SCADA)

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[2] Analysis with LLM + Energy optimization models

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[3] Generation of Custom Protocol in natural language

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[4] Automatic validation of operational risks

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[5] Sending the protocol to the operating team (App, PDF or Panel)

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[6] User feedback and base protocol update

d. Agent Skills

Ability	Description
Generation adaptive	Create guides according to installation type, conditions climatic and mode of operation.
Simulation of impact	Calculate expected reduction in energy consumption with each suggested protocol.
Explanation contextual	Justify why a certain configuration is recommended. pumps or valves.

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Self-learning	Learn from results and human feedback to improve future protocols.
Multi-format	Delivers protocols in text, voice (for field radios), PDF or interactive dashboard.

5. Example of Agent-Generated Protocol

Efficient Operation Protocol – Well L-42 (Winter – Night Shift)

- Activate secondary pump in intermittent mode (cycle 40s ON / 20s OFF).
- Set line pressure to 2.3 bar (adjusted for temperature -5°C).
- Use partial bypass on V-14 valve to reduce pressure loss.
- Monitor pressure differential every 15 minutes during the operation.
- Estimated savings: 17% of usual consumption without reduction of production.

e. Security and Audit

- The agent includes cross-checking logic with SCADA systems to avoid incompatible instructions.
- The protocols include a unique identifier for traceability and control of versions.

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f. Suggested Technology Stack

- Data source: SCADA + IoT sensors + weather data (API Meteoblue or NOAA).
- Processing: Python, Pandas, TensorFlow/Keras for optimization energetic.
- Generative model: GPT-4 Turbo or private fine-tuned model with data energy efficiency history. •

Interface: Web dashboard (Streamlit / React) + REST API for mobile integration.

- Storage: PostgreSQL + S3 for generated protocols.

VIII. Quantifying the Impact of IAGEN on Energy Optimization

- Economic Benefits: Reduction of Energy Costs:

The implementation of optimized protocols generated by AI-based systems, like IAGEN, has the potential to generate substantial cost reductions energy. AI-powered energy management systems analyze consumption data in detail to identify areas of energy leakage and optimize the operational configuration of the equipment.

This precise identification of inefficiencies allows the creation of protocols that They directly address the sources of waste, resulting in savings significant. Case studies have demonstrated the economic impact of AI on the industrial energy optimization.

- Improving Operational Safety through Precise Monitoring:

AI's ability to accurately monitor and detect early operational anomalies is essential to improve safety in environments industrial. AI systems can monitor the status of equipment in real time. real and predict potential failures before they occur, helping to prevent dangerous equipment malfunctions.

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The use of drones powered by AI and computer vision enables the
Automated, real-time monitoring of energy assets, detecting problems
such as overheating or physical damage, reducing the need for
workers are exposed to hazardous environments.

In the nuclear energy sector, AI is applied to improve safety and reduce the
human error in plant monitoring. In addition, AI is used to create plans
dynamic safety systems for utility work sites, adjusting the
protocols based on real-time data such as temperature spikes or fatigue
the workers.

- Predictive Maintenance Optimization:

IAGEN, like other AI-based systems, plays a crucial role in the
enabling and improving predictive maintenance. AI algorithms analyze the
equipment data to predict maintenance needs, reducing the
downtime and optimizes energy consumption by ensuring that equipment
operate at maximum efficiency.

Case studies have shown that AI-driven predictive maintenance
can generate significant improvements in machine uptime and
Reductions in emergency repairs. AI can analyze specific data
such as vibrations, temperature variations and performance histories for
predict equipment failures.

In the renewable energy sector, integrated AI is used for monitoring in
real-time monitoring of wind turbines, predicting potential failures before they occur, which
reduces downtime and repair costs.

- Concrete Benefits:
  - Reduction of Energy Consumption by Up to 20%: The systematic application
    of optimized protocols, facilitated by systems such as IAGEN, can lead to
    significant reductions in energy consumption. A report by the International Renewable Energy
    Agency (IRENA) indicates that AI can increase

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the efficiency of wind energy production by up to 20%.

In addition, AI-powered energy storage can reduce costs.
energy by up to 20%, which often correlates with more efficient use
and therefore a lower demand for energy.

- Living Protocols: Autonomous Update: The concept of "living protocols"
  refers to the capacity of energy optimization protocols
  generated by AI to continuously update and adapt without intervention
  direct human intervention. AI systems can monitor building operations in real
  time and automatically adjust systems such as HVAC and
  lighting to optimize performance.

AI-driven controls can adapt to weather conditions,
load and constantly changing machinery to optimize the use of resources and the
energy consumption. AI algorithms have the ability to learn and
evolve from data, enabling energy management systems
adapt to changing conditions and optimize operations in a way that
continues. In the oil and gas sector, "evergreen models" in AI software are
easily updated with the latest data, ensuring that models are
always reliable for operational decision-making.

- Fewer Operating Errors: The generation of clear and adapted instructions
  to the real context through IAGEN can contribute to error reduction
  operational. AI can reduce skills barriers, helping more people gain proficiency
  in diverse fields, potentially
  leads to fewer operational errors due to better understanding and
  execution of tasks.

AI-driven automation reduces the burden on human resources to
repetitive tasks and minimizes the risk of human error, contributing to a more reliable
and consistent operating environment.

AI can provide real-time monitoring and analysis, enabling

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immediate identification and correction of errors in manufacturing processes.

AI-powered systems can create custom checklists and
complete for routine inspections and audits, ensuring accuracy and
data reliability.

- Total Traceability: IAGEN, like other advanced AI systems, can
  incorporate mechanisms to provide full traceability of all
  suggested changes and protocol updates. Traceability in
  AI systems is crucial as it tracks the history of data and
  decisions made by the system, allowing stakeholders
  audit decisions and ensure accountability. AI can improve
  Traceability in manufacturing by automating the collection and analysis of
  data, documenting the entire life cycle of a product.

Data visibility and traceability in AI development offer benefits such as increased trust, bias mitigation, and improved regulatory compliance.
and faster debugging.

- Better Compliance with ESG Goals: The implementation of IAGEN can
  contribute significantly to the achievement of environmental, social and governance (ESG)
  objectives by reducing emissions resulting from
  Unnecessary energy consumption. Energy management solutions
  AI-powered technologies are crucial to reducing costs and increasing sustainability
  and minimize environmental impact. AI helps companies find impactful decarbonization
  opportunities in manufacturing. AI can
  optimize energy use throughout the value chain, helping to reduce
  unnecessary consumption and the company's carbon footprint. AI plays a role
  a vital role in integrating renewable energy sources into the grid,
  ensuring stability and efficiency, and promoting sustainability.
  In addition, AI can assist in carbon capture, utilization and storage (CCUS) processes by
  optimizing carbon dioxide capture.
  carbon.

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V. Challenges and Strategies to Overcome Them

- Barriers to Implementation:
  - Lack of Digital Infrastructure: The effective implementation of AI solutions for energy optimization, such as IAGEN, may be hampered by the Presence of legacy systems, diverse technologies, and quality issues of data. Inadequate digital infrastructure hampers collection, management and analysis of the large volumes of data needed for AI function optimally.
  - Resistance to Change: In the energy industry, often dominated by a traditional engineering approach, there may be resistance to adopting advanced technologies such as AI in operations. This resilience can arising from a preference for established practices, the emphasis on analysis formal and perfection, rather than the flexibility and rapid decision-making that characterize digital transformations. In addition, the speed at which The advances in AI often contrast with the more conservative pace of adoption of new technologies in key players in the energy industry.
  - High Initial Investment: Although the medium-term economic benefits of the implementation of AI for energy optimization can be substantial, the initial investment required may be perceived as a barrier. The energy industry often involves central fixed installations expensive, and any new digital application must demonstrate clear value to justify its integration. It is also important to consider that the AI has an energy cost and an environmental footprint that must be taken into account. account when evaluating the overall benefits.

- Recommended Strategies:
  - Progressive Implementation: A gradual implementation of IAGEN, starting with pilot projects in selected units. This allows you to demonstrate success in controlled environments, build trust, and refine

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implementation strategies prior to a large-scale implementation. Pilot projects can provide valuable data to quantify the IAGEN's effectiveness and return on investment.

- Development of a Digitalization Plan: It is crucial to develop a digitalization plan. robust digitalization to improve data collection and analysis. This includes modernizing infrastructure to integrate AI into the existing systems, improving data quality and establishing data governance practices. A solid digital foundation is essential for IAGEN to effectively access and process the necessary information.
- Short-term investment in AI agent implementation teams Technology and training: Investment in proof of concept and pilot tests. The focus here has to be on training talent to implement, since there is a trend towards cost reduction in systems that allow "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.
- Staff Training: Comprehensive staff training is essential to ensure the correct adoption and use of the AI technologies. It is important to educate and train the workforce on the benefits and applications of AI to foster a culture of innovation and ensure effective management of AI solutions. Training should include the responsible use of AI and the importance of maintain a balance between human oversight and AI capabilities.

VI. Conclusions and Final Recommendations

The implementation of IAGEN in the energy optimization of Vaca Muerta represents a significant opportunity to reduce costs, improve efficiency and standardize

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energy protocols in industry.

Potential benefits include substantial reductions in consumption energy, improvements in operational safety through precise monitoring and optimized predictive maintenance, the implementation of dynamic protocols and self-managed, minimization of operational errors, complete traceability of the operations and better compliance with ESG objectives.

While there are implementation challenges related to infrastructure digital, resistance to change and initial investment, these can be overcome through well-planned strategies that include progressive implementation, development of a comprehensive digitalization plan and exhaustive staff training.

For stakeholders in the Vaca Muerta region looking to improve the efficiency and sustainability, it is recommended:

- Initiate pilot projects to evaluate the effectiveness of IAGEN in your context specific operation.
- Invest in the digital infrastructure needed to support implementation and use of AI-powered energy management systems.
- Develop training programs to equip your workforce with the skills skills needed to effectively leverage IAGEN.
- Explore collaborations with technology providers and institutions Research to advance the application of AI for energy optimization in the region.
- Consider the potential of using local resources, such as waste gas, to power the AI infrastructure required for IAGEN.

In conclusion, the adoption of artificial intelligence frameworks such as IAGEN has the potential to drive a more efficient and sustainable energy future for the sector industrial, with particularly promising opportunities in the Vaca region Muerta, Argentina.

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