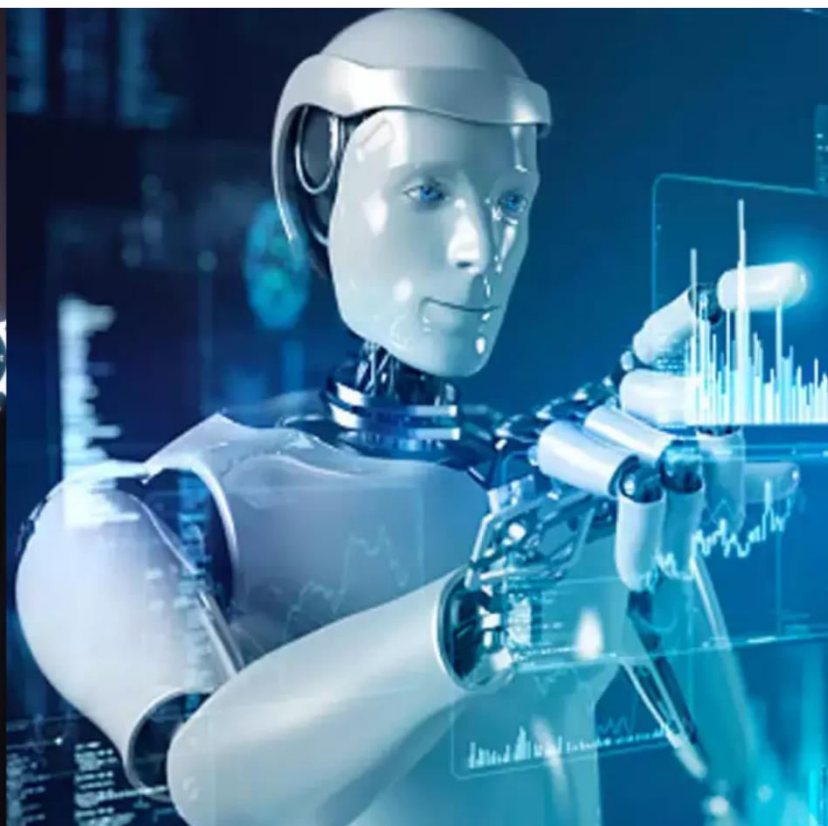




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Heavy Oil Production in the Patos-Marinza Field: Mitigating High-Viscosity Constraints and Enhancing Recovery Efficiency

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ABSTRACT: The Patos-Marinza field, located in Albania, operated by Bankers Petroleum since 2004, is one of the largest onshore heavy oil reservoirs in Europe. The field is geologically complex and includes several producing formations: Driza, Goran, Marinza, and Bubullima, characterized by varying depths and crude oil densities. The Driza and Goran formations contribute the most to oil production but contain highly viscous crude, posing significant extraction and transportation challenges. To improve oil mobility and reduce viscosity, diluent injection has been widely used, aiding both in lowering oil density and in breaking water-oil emulsions. However, the high cost of diluents has highlighted the need for more efficient and cost-effective recovery methods. Since december 2008, horizontal drilling has replaced vertical wells as the dominant production approach, significantly enhancing oil output. Polymer injection has also been implemented, resulting in recovery factor improvements of 15-23%. Yet, increasing reservoir heterogeneity has limited its effectiveness in recent years. In response, cyclic steam stimulation, a thermal EOR method, has been introduced in the southern Goran zone. While initial results are promising, high oil viscosity, continued reliance on diluent, the limited depth for the application of the method, as well as the unavailability of gas as a fuel source for the steam boiler, remain major barriers. This paper provides a comprehensive overview of the field's geological characteristics and evaluates the performance and challenges of the applied recovery techniques.

KEYWORDS: Patos-Marinza Field, Heavy Oil, Enhanced Oil Recovery (EOR), Horizontal Drilling, Diluent and Polymer Injection, Cyclic Steam Stimulation.

I. INTRODUCTION

The Patos-Marinza oil and gas field is the largest heavy oil reservoir not only in Albania but also in Europe, with a considerable area of approximately 180 km² in the region of Fier city [1], [2] (see Figure 1).

Field Characteristics [1], [2], [3]:

- Oil type: Heavy oil with high viscosity (8-12°API) and high sulphur content.
- Geology: Composed predominantly of Neogene formations, including claystone and sandstone layers with high porosity (18-30%), creating favourable conditions for hydrocarbon accumulation.
- Reservoir depth: Ranges from 800 to 2,500 metres.
- Oil-bearing layers and sublayers (suites): Goran (G₁-G₆), Driza (D₁, D₂, D₂₀, D₃, D₄, D₅), Marinza (M, M₀, M_P, M₁-M₅), and Bubullima (B₁ to beyond B₁₈).
- Oil density in the oil-bearing layers: 7-8°API (Goran), 8-11°API (Driza), 11-30°API (Marinza and Bubullima).
- Oil quality by formation: Goran and Driza contain heavy to extra-heavy oil; Marinza and Bubullima contain lighter oil.

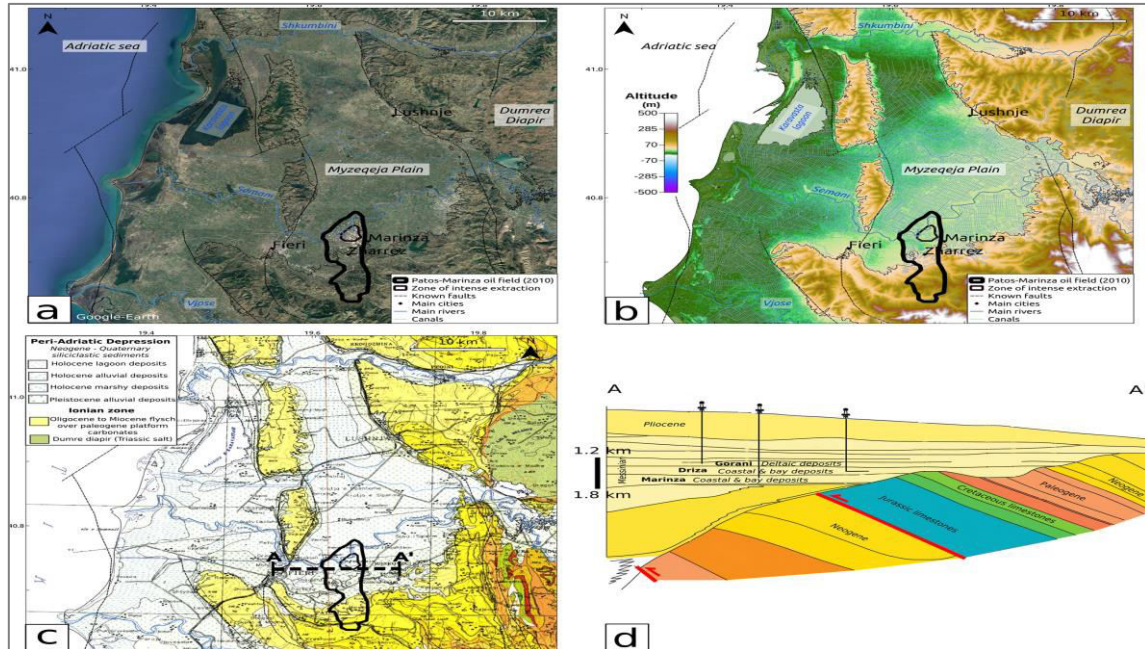


Figure 1. Geological profile of the Patos-Marinzha oilfield [4]

II. LITERATURE SURVEY

As shown in the graph below (Figure 2), Driza and Goran represent the main producing layers, accounting for approximately 90% of heavy oil production. However, from 2013 onwards, the trend appears to have reversed, with lighter oil from the Marinzha and Bubullima formations contributing more significantly to the final production than before 2013.

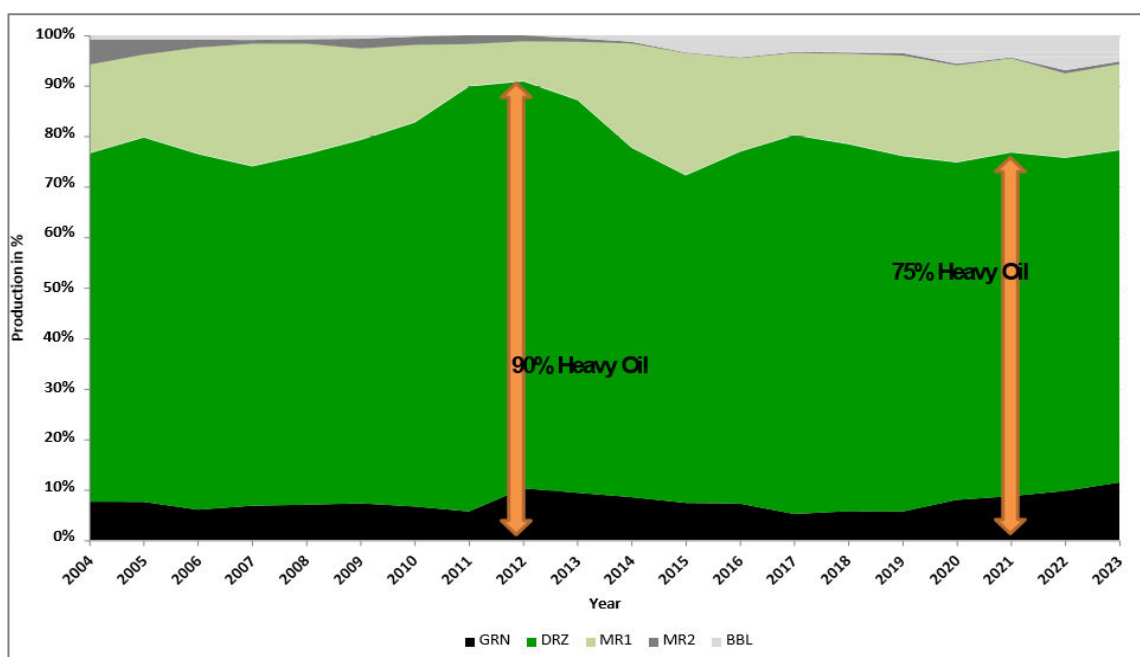


Figure 2. Heavy oil production by formation [5]

This shift is due not only to the drilling of new horizontal wells in these formations but also to polymer injection in lighter formations, namely the Lower Driza (D₃-D₅) and Upper Marinza (M₀, M₂) in 2013.

The process begins with water injection, which includes surfactants to reduce the interfacial tension between oil and water phases and to alter the reservoir rock's wettability, thereby improving the oil recovery factor. Subsequently, the polymer is mixed with water and injected over an extended period (up to several years). Once approximately 30-50% of the reservoir's pore volume in the target area has been injected, polymer addition is halted, and drive water is injected through the injection well to displace the polymer solution and oil zone towards the production well [6], [7].

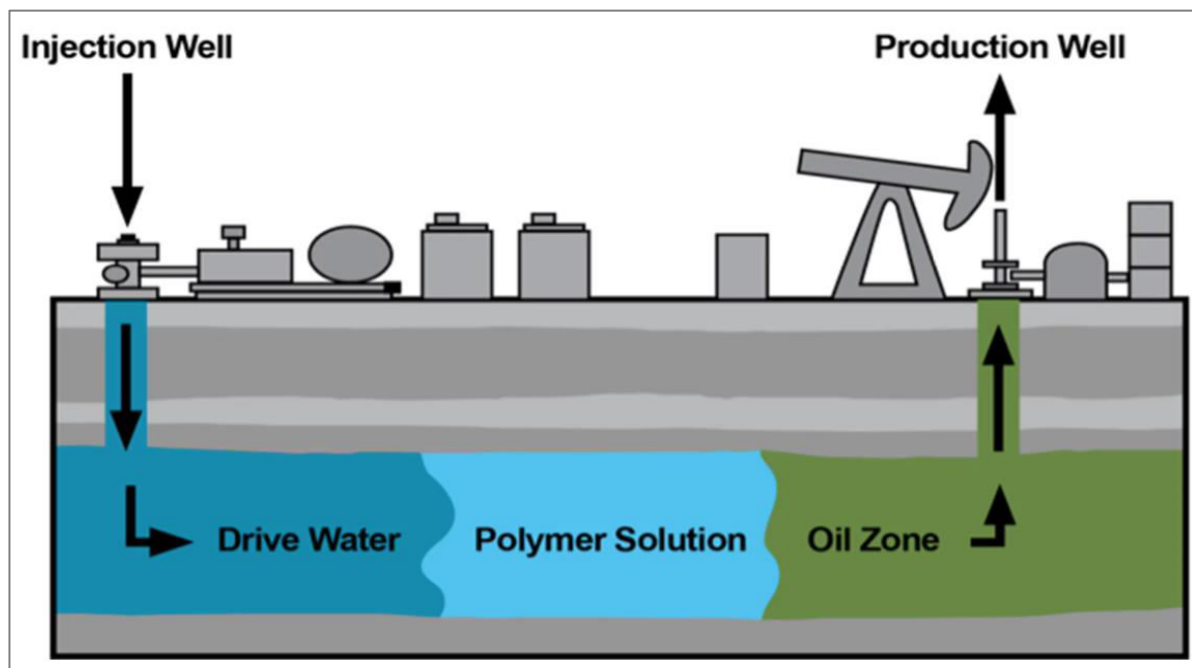


Figure 3. Polymer injection scheme [8]

The challenges of extracting this heavy oil in a multi-layered sandy reservoir, where the reservoir quality, oil viscosity, and pressure vary from zone to zone and surface to surface, are based on [1]:

- Reducing oil viscosity;
- Lowering density;
- Enabling transport.

III. METHODOLOGY

Light oil from the Marinza and Bubullima formations is used as a diluent during the exploitation of the Driza and Goran formations, which are characterised by heavy oil. However, since the recovery ratio achieved through this method alone was suboptimal, the need arose for a product known as a DILUENT. This blend, characterised by low density ($<0.9 \text{ g/cm}^3$) and minimal viscosity, not only managed to treat water-oil emulsions, allowing better phase separation, but also supported the drilling of new wells in zones with very heavy oil (G₃-D₂₀), where oil gravity does not exceed 10°API and viscosity reaches up to 20,000 cP [1].

IV. EXPERIMENTAL RESULTS

As illustrated in the above chart, the use of diluent from the beginning of this well's production not only maintained its output and ensured its continuity but also enabled the extraction of this oil.

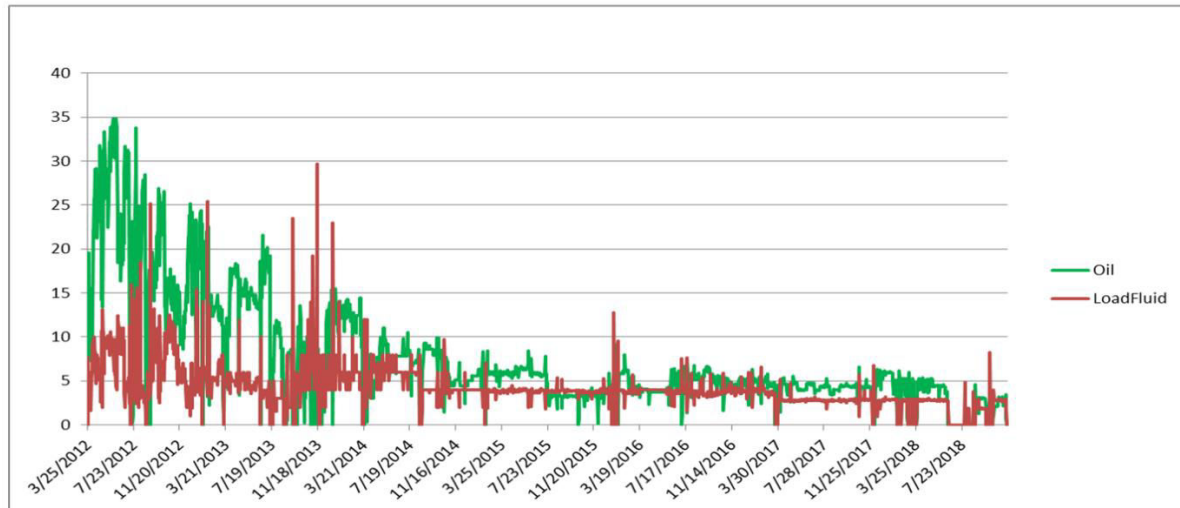


Figure 4. Oil production performance in a horizontal well in Goran using diluent [1]

From 2004 to 2014, the amount of oil produced in the Patos-Marinza field increased tenfold, reaching 1.2×10^6 tonnes following the implementation of horizontal drilling and polymer injection into the formation (Figure 5) [2]. The results demonstrated the success of this method, particularly given the heavy oil characteristics. Existing wells were converted into injectors, situated near producing wells that still had production potential. The distance between injection and production wells is about 100 m, forming what is known as an injection-production block or pattern.

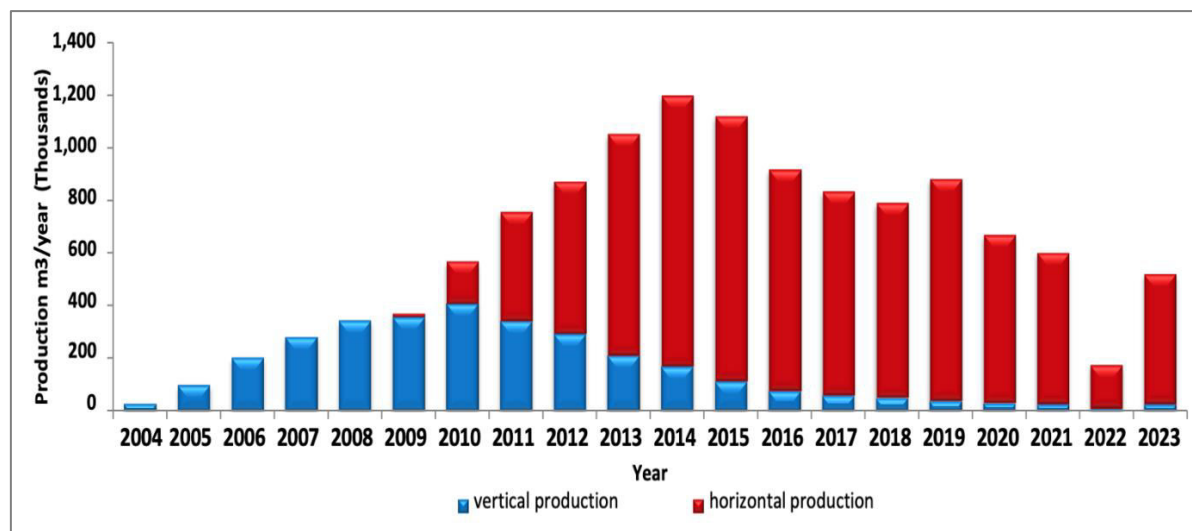


Figure 5. Production performance in the Patos-Marinza oilfield [5]

As a result, a comparison between primary production (without EOR) and secondary production (with EOR) showed a recovery factor increase in the range of 15-23%, depending on the geological layer. Polymer project production accounts for 45% of total field production. In recent years, drilling activity has decreased, and consequently, oil production volumes have declined, contributing to a reduction in diluent usage, now below 0.2% [1].

Since this volume mixture (light oil, diesel, and gasoil), despite its advantages, has a significant drawback, the high cost of oil extraction, reducing diluent use has become a major objective for anyone facing the challenge of heavy oils in the field.

Some techniques used to reduce diluent consumption in the Patos-Marinza oilfield include:

- Drilling new wells in lighter oil zones, such as Marinza 1 and Bubullima;
- Increasing production from existing wells located in lighter oil zones, e.g. through polymer injection in zones D₃, D₄, D₅, M₀, and M₂;
- Adding chemicals and demulsifiers to reduce viscosity and density and improve oil transport;
- Adding thermal pipeline heaters to enable better oil-water separation and treatment of produced oil;
- Initial and individual treatment of oil at each well.

After twelve years of horizontal drilling and polymer injection, the further development of the Patos-Marinza field, which consists of zones with high surface and vertical heterogeneity, resulting in uneven front displacement from polymer injectors to producers, and where oil viscosity and reservoir pressure vary from area to area, remains a major challenge. The injection of water and polymers has altered the water saturation distribution, which has now become highly complex and unpredictable. This has hindered new drilling and conversion of wells for polymer injection, as it leads to continuous polymer injection, translating into higher costs and production decline.

Nevertheless, polymer injection requires certain conditions to be met in order to enhance production:

- Injection in low-pressure zones to increase pressure and sweep the reservoir, maintaining injection pressure below the fracture pressure of the formation;
- High initial production rate;
- Rapid production decline;
- Low water cut;
- Low Gas-to-Oil Ratio (GOR);
- Low sand production;
- Injection performed in zones with densities of 8-20°API and viscosity below 1600 cP (although injection has also been conducted in zones with much higher viscosity >4000 cP, results showed that production was lower than in zones with viscosity <1600 cP).

During the development of this heavy and extra heavy oilfield through horizontal drilling and polymer injection, production decline has been inevitable. Given the geological reserves and the low oil recovery factor in well-saturated sandstone layers in the southern part of Goran (G₄ and G₅), where very heavy oil is found, it is believed that Cyclic Steam Stimulation (CSS) will be the future technology to enhance production in the Patos-Marinza field. In 2023, Bankers Petroleum launched a pilot CSS project in the oil-bearing field of Patos-Marinza. The distinctive feature of this stimulation method is that the same well is used for both steam injection and oil production, applying the “huff and puff” technique, where the injector well is converted into a producer. The process is repeated in cycles defined by the oil production performance [1], [2].

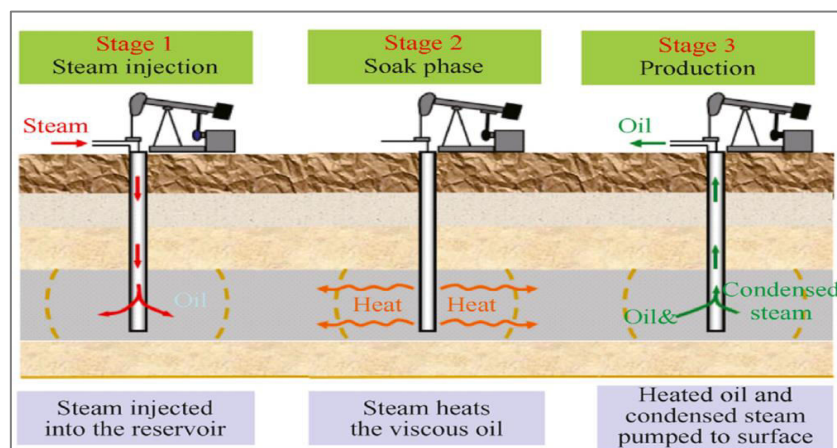


Figure 6. Cyclic steam injection scheme [9]

Cyclic Steam Stimulation (CSS) consists of three stages [10]:

- Phase I - Steam injection phase: Steam is injected at high pressure for 10-30 days, and the well is shut in.
- Phase II - Soaking phase: Followed by a soaking period, during which the accumulated heat diffuses before the well is placed back into production; this lasts 3-10 days.
- Phase III - Production phase: During this period, reservoir oil is produced along with a portion of the injected steam as hot water over a span of several months.

Thermal projects involving steam injection are applied in reservoirs located at depths below 1,000 m, with a productive layer thickness >10 m, which in the field has resulted to be 12-16 m. Since the productive horizons in the Patos area are mostly separated by shale, each productive horizon was considered to be explored individually, in order to maintain control over heat propagation and the steam injection front. New horizontal wells have been drilled for cyclic steam stimulation in sandstones with good saturation, specifically in the southern parts of G4 & G5, where very heavy oils are found.

Additionally, existing wells have recently been converted to experiment with the method [2]:

- To ensure a successful steam injection process in the Patos-Marinza oilfield, a common string is used for both injection and production, in order to reduce losses and workovers;
- The casing strings of existing wells are thermally insulated and adapted to minimise heat losses and consequently avoid a high steam-oil ratio, which would lead to low method efficiency. Therefore, effective reduction of heat losses in the well has been achieved through vacuum-insulated tubing or thermal gel, as well as nitrogen injection in the annular space;
- The type of pump was adapted (entirely metallic screw pump);
- A bottomhole filter was installed to prevent pump clogging;
- The packer was set to prevent steam from entering the casing;
- Successful sand control was achieved using a 7-inch premium screen;
- Light oil or surfactants are injected;
- Laboratory tests are carried out to determine the water content (%) in the water-oil emulsion (formed under high temperatures).

However, the application of this method has encountered several significant challenges in Patos-Marinza [2]:

- Extra-heavy oil with densities ranging from 2.2°API to 6.2°API;
- Increased demand for large quantities of diluent, reaching 12-16% of the produced oil volume;
- Depth limitations of the applicable layers (>1,000 m);
- Surface constraints due to hilly and inhabited areas;
- High cost of using crude oil as boiler fuel due to the absence of natural gas availability.

V. CONCLUSION

In conclusion, the Patos-Marinza oil field represents one of the most significant onshore heavy oil resources in Europe, yet also one of the most technically demanding. Its complex geological structure, consisting of multiple formations with varying depths and fluid properties, poses major challenges to efficient hydrocarbon recovery. Over the years, a range of Enhanced Oil Recovery (EOR) techniques have been applied with varying degrees of success. Diluent injection has played a crucial role in improving oil mobility and reducing viscosity, but its high cost continues to impact the economic viability of operations. Horizontal drilling, adopted extensively since 2008, has led to considerable improvements in production by increasing contact with the reservoir and accessing previously unrecoverable zones. Similarly, polymer injection has contributed to recovery factor enhancements, though its effectiveness has been increasingly limited by growing reservoir heterogeneity.

The introduction of cyclic steam stimulation in the southern part of the Goran formation marks a new phase in thermal EOR application in the field. While early results are encouraging, the combination of high oil viscosity, persistent reliance on expensive diluents since light oil produced from the field itself is used for dilution, the limitation of depth or

unavailability of gas as a fuel for the steam boiler, and the use of crude oil instead, underscores the need for further advancements. The field's development strategy must now focus on integrating and optimizing existing recovery methods while also exploring innovative, cost-effective solutions tailored to the reservoir's specific conditions. Overall, maximizing recovery from Patos-Marinza will require a multidisciplinary approach that combines detailed reservoir characterization, adaptive EOR techniques, and improved economic efficiency.

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