

RESEARCH ARTICLE

The Oil Industry in Ecuador: History, Current Situation and Challenges

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Abstract: Etymologically, the word petroleum comes from the Latin words petro (rock) and oleum (oil): rock oil. Petroleum is a complex natural mixture of hydrocarbon compounds found in a rock. It originated from the decomposition of organic matter over long periods, when the Earth was very unstable and was populated by dinosaurs, dinosaurs populated by dinosaurs, plants and trees that were buried and transformed into hydrocarbon by pressure and heat. In more detail, hydrocarbon reservoirs are generally found in sands, sandstones, conglomerates, limestones and porous dolomites. The compaction of the sediments where the oil originates is in a sedimentary rock called source rock. After its formation, the migration of hydrocarbons takes place. This is a slow process, not known until now, where fluids seek lower pressures and migrate to the surface. For a reservoir to form, it is necessary for the oil to encounter some obstacle, formed by source rocks, which prevent it from continuing to migrate to the surface. The structures that fulfill this purpose are called oil traps and the rock where the oil finally accumulates is called reservoir rock and must have an adequate porosity to contain it. The largest oil reserves are concentrated in a few countries, while the largest consumers are almost devoid of the resource. This makes access to reserves an important factor in geopolitical terms. important factor in geopolitical terms. The oil exploration and production industry face numerous challenges as it addresses the world's growing demand for energy. Especially now, when there is a huge need for sustainable operations, declining production from older fields and the discovery of new resources in demanding environmental settings. In this sense, this study analyzed the history, current situation and challenges of the oil industry in Ecuador.



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1. Introduction

The oil industry is one of the most powerful in the world economy. More than 4 billion tons of this black gold are produced every year, a third of which comes from the United States, Saudi Arabia and Russia. It is worth mentioning that, although Middle Eastern countries still account for more than half of the world's oil reserves, the United States has managed to overtake them in terms of production volume, thanks to the exploration of shale oil and tar sands [1,2]. It is no coincidence that in 2022, the American giant generated almost one-sixth of the total number of barrels per day produced worldwide [3].

Oil plays a crucial role in the current industrial era, being today the main engine of the world economy. This fossil energy source has become the most widely used resource for powering industrial machinery, transportation and electricity production. Its versatility and high calorific value have allowed for years an unprecedented development in modern society. This has favored the growth of key industries such as the automotive, petrochemical and aviation industries. However, in recent decades, its relevance has generated a constant debate about its depletion and environmental impact [4]. As a result, the search for sustainable alternatives to ensure the planet's energy and environmental future has been driven. In short, oil has been and continues to be a fundamental pillar of industrial progress. However, clean energies are taking away its prominence on the road to a more sustainable global economy [5].

Oil tells a story of ages and decaying organic matter, when, millions of years ago, the remains of plants, algae and plankton sank to the seabed. Time progressed and they were buried under the weight of sediments and successive layers of strata at enormous temperatures. In such an extreme environment as that geological trap, oxygen disappears and organic matter is transformed into a substance called kerogen, a kind of proto-crude [6,7]. "With all that heat, pressure and time, the kerogen undergoes a process called catagenesis and hydrocarbons are formed," explain the Galp oil company, among which are coal, natural gas and oil itself. Oil includes hydrogen, with 13% by weight, carbon (85%), as well as sulfides (0.5%), oxygen (1%), nitrogen (0.5%) and metals such as copper or nickel (less than 0.1%) [8,9].

Oil can be found distributed in multiple territories throughout the Earth. The areas richest in oil reserves tend to be those where there was a large accumulation of organic matter in the past, such as ancient seabeds and lakes. Some of the main oil-producing regions are the Middle East, with Saudi Arabia, Iraq, Iran and Kuwait leading the way; South America, in countries such as Venezuela and Brazil; and finally North America, with Mexico and the United States being major players in the oil industry. Although these are the main ones, there are other places with significant hydrocarbon reserves [10,11]. Countries such as Norway and the United Kingdom extract oil from the North Sea in Europe. In Asia, Russia, China and Indonesia also participate in this industry with their reserves. It should also be noted that the search for new deposits is still underway with good results, proving that oil continues to be a valuable and strategic source of energy worldwide [12].

These hydrocarbons are organic compounds formed by hydrogen and oxygen whose combination gives rise to unlimited types of molecules and to the different types of oil (Brent, West Texas Intermediate and Dubai-Oman) and gas. In other words, the diversity of these compounds will depend on the variations in heat and pressure undergone. The most important source of Ecuador's economy is the export of crude oil and derivatives, which in the last 10 years has ranged between 43% and 66% of the country's total exports and between 43% and 59% of the State's general budget [13]. Ecuador, in its 40 years of oil exploitation, has had a rather disastrous history for the country's oil exploitation has a rather disastrous record for the national economy as well as for the degradation of natural ecosystems. The purpose

of this study was to analyze the history, current situation and challenges of the petroleum industry in Ecuador.

2. History of the oil industry in Ecuador

The oil industry was responsible for Ecuador's transformation from a rural, agricultural-producing country to one with a thriving middle class and a rapidly developing economy, driven by the third largest oil reserves in South America. Although the first concessions for oil exploration were granted on the coast in 1878 and in the Amazon in 1921, it was only in the 1970s that Ecuador became an oil-producing country [14,15].

Between 1928 and 1957, the country exported 42 million barrels of crude oil, equal to the volume exported in 1972 alone, the year in which the oil boom era began. For nearly forty years, from 1928 to 1959, oil exploitation was concentrated in the Santa Elena peninsula. However, in those years several foreign companies such as Shell, Standar Oil, California Oil, Tennessee, and the Western Geophysical Co, obtained more than 5 million hectares in new concessions for oil exploration in the Ecuadorian coast as well as in the Amazon region [16,17].

The first oil well was drilled in the coastal region in 1911. The English company Anglo arrived in the country in 1922, and for 67 years exploited, commercialized and refined crude oil from the Santa Elena Peninsula. In 1937 Shell, which was working with Exxon, left Ecuador after closing some wells in the Amazon that were not productive [11,12]. In 1967 Texaco drilled the first commercial well in the Amazon. In the following years, the major infrastructure works were the SOTE Trans Ecuadorian Oil Pipeline System and the Via Coca. Until 1990 Texaco extracted 88% of the total national oil production and operated the pipeline. It drilled 399 wells and built 22 drilling stations [18].

The Texaco company discovered oil in Lago Agrio in 1967, beginning the era known as the "oil boom", a time that changed Ecuador forever. From then on, Ecuador's oil industry began to gain strength with well-known companies such as Gulf, Texaco, Occidental and Repsol among others. Texaco Petroleum Company operated as a monetary partner of Petroecuador until 1990, when the state-owned company took control of 100% of the operations of the CEPE-Texaco consortium [19,20].

Until 1971, thousands of hectares had been handed over to half a dozen oil companies, with almost no regulation, nor had contracts been signed with these companies. In this year Ecuador was governed by a military dictatorship, which with a nationalist spirit decided to enter OPEC, in effect, on June 23, 1972 the Ecuadorian State Oil Corporation CEPE was created and the first export was on August 17, 1972 with 308,238 barrels at USD. 2.34 per barrel, from the Port of Balao in Esmeraldas. The Hydrocarbons Law was put into effect, and royalties for the state were increased [11,21]. It was established that oil contracts could last a maximum of 20 years and their extension was set at 200,000 hectares, with which the companies returned 80% of their concessions that were originally granted for 50 years. In September 1989 PETROECUADOR was created to replace CEPE and a Holding Company was formed, i.e., a parent company and six Subsidiaries: three permanents: PETROPRODUCCION, PETROINDUSTRIAL and PETROCOMERCIAL; and three temporaries: PETROPENINSULA, PETROAMAZONAS and PETROTRANSPORTE [10,22].

Since 1982, due to pressures from multilateral organizations and the companies themselves, oil policy has been turned towards opening up to transnationals. In 1993, by decision of the government of Sixto Durán Ballén, Ecuador withdrew from OPEC and rejoined in 2007–2008. From

1985 to 1996 there have been 8 oil rounds that occupy an area of approximately 4.2 million hectares of which almost 3.6 million correspond to the 13 million hectares that make up the Ecuadorian Amazon, which in turn represents 46% of the national territory. The ninth round took place in 2002 where the fields on the coast were put out to bid, excluding those in the Amazon [19,23]. By the end of 2002, the Heavy Crude Oil Pipeline (OCP) was completed as part of the strategy to expand the oil frontier. In 2003 the government announced the tenth oil round for the concession of areas in the territories of Napo, Pastaza and Zamora Chinchipe, in addition to the continuation of the ITT project (Ishpingo, Tambococha, Tiputini), which is located in the Yasuní National Park and the Cuyabeno Fauna Reserve [10,20].

In 2006, the state declared the expiration of the exploitation contract of block 15 that the state had with Occidental. In that year record crude oil prices were reached worldwide. At the beginning of 2007 the new government announced the construction of a new refinery in the province of Manabí with a refining capacity of 300,000 barrels per day [24,25]. This year also saw the beginning of the exchange of crude for derivatives with Venezuela (around 1.5 – 1.6 barrels of Ecuadorian crude for 1 barrel of Venezuelan derivatives). In this same year oil contracts were renegotiated with the Spanish–Argentine Repsol, the French Perenco, the Brazilian Petrobras, the Chinese Andes Petroleum and the US capital company based in Panama, City Oriente. In spite of the initial proposal published by presidential decree, which stated that Ecuador would negotiate a 99% profit compared to the 1% differential price set in the concession contract, the final agreement was to change the nature of the contract from crude oil owned by the companies to a service provision contract, in which the state pays for the extraction of crude after the presentation of invoices, in addition to submitting eventual divergences to a mediation center in Chile [23,24].

3. Current situation of the oil industry in Ecuador

EP Petroecuador's production in the fourth quarter of 2022 was 35.29 million barrels, with an average daily production of 383.64 thousand barrels, higher by 0.7% and 21.6% compared to the previous quarter and fourth quarter of 2021, respectively. The production of the public company EP Petroecuador represents 78.1% of the total average daily production for the period October–December 2022; while 21.9% corresponds to private companies [12,25].

The increase in EP Petroecuador's production in the fourth quarter of 2022 compared to the third quarter of the same year was due to the fact that the public company has made operational improvements in the extraction of crude oil; while the increase compared to the fourth quarter of 2021 was due to the fact that in the month of December 2021 EP Petroecuador stopped the transportation of crude oil through the Trans Ecuadorian Oil Pipeline System (SOTE) and the Heavy Crude Oil Pipeline (OCP), due to the risk faced by the oil infrastructure as a result of the advance of erosion in the Piedra Fina river in the province of Napo [22,23]. EP Petroecuador's annual production was 136.92 million barrels, equal to an average daily production of 375.12 thousand barrels, with an increase in average daily production of 0.7% with respect to 2021 and 1.7% lower than in 2020 [25,26].

The increase in production of EP Petroecuador, in 2022, was due to the efforts of the public company to increase production; thus, since April the production of the first well in the Ishpingo field began, which maintains an approximate production of 2,500 barrels per day. In July there were positive results in the Pucuna 19H well, belonging to the Pucuna field, which has an average production of 2,100 barrels per day, in October production increased in Blocks 43–ITT3, the Auca field and in the Shushufindi field. In the fourth quarter of 2022, private companies recorded

production of 9.87 million barrels per day. 9.87 million barrels, averaging 107.33 thousand barrels per day. This production was 0.9% lower than in the previous quarter and 22.2% higher than in the fourth quarter of 2022. 22.2% compared to the fourth quarter of 2021 [20,21,26].

The quarterly reduction in production was due to the fact that, in the fourth quarter of 2022, some private companies had to suspend their activities due to well workovers; while the increase with respect to the fourth quarter of 2021 was due to the aforementioned pipeline shutdowns. In annual values, in 2022 private companies had a production of 38.63 million barrels, with an average of 105.83 thousand barrels per day, registering an increase in average daily production of 5.5% compared to 2021 and higher by 8.2% compared to 2020 [11,21,24].

From October to December 2022, the country's oil exports amounted to 31.38 million barrels, equivalent to USD 2,328.80 million, valued at a quarterly average price of USD 74.22 per barrel. Quarterly crude oil exports, with respect to the previous quarter, showed an increase in volume (9.8%) and a decrease in both value (1.1%) and price (9.9%) [1–3,27,28]. On the other hand, with respect to the fourth quarter of 2021, exports were higher in volume (31.2%), value (38.8%) and price (5.8%). In annual values, in the course of 2022 oil exports were equal to 116.66 million barrels, for a value of USD 10,013.12 million, at an annual average price of USD 85.83 per barrel, lower in volume (0.7%), higher in value (37.6%) and price (38.5%) than those marketed during 2021 [29–31].

3. Challenges

Operational efficiency. To improve operational efficiency in this industry and increase productivity and profitability, it is necessary to optimize processes and reduce downtime, which can be achieved by implementing well-defined processes and intelligent technological solutions that allow the use of real-time data to monitor and predict possible machinery failures. In other words, it is necessary to provide equipment with optimal maintenance that does not involve unplanned downtime. **Cost reduction.** By reducing costs in an industry where prices are so volatile and difficult to predict, oil companies would strengthen their market position and combat the current challenges in this sector. To achieve this, it is essential to have strategic allies or technological solutions that optimize energy management, automate repetitive tasks, use advanced algorithms, among other functions that minimize unnecessary costs.

Comprehensive safety. Accidents at oil facilities can have catastrophic consequences for both personnel and the environment. For this reason, it is important to ensure the safety of people and the ecosystem during all stages of the oil production process by implementing solutions that enable real-time data monitoring and analysis to identify potential safety issues and risks in a timely manner. **Data-driven decision making.** With the help of digital solutions that facilitate the collection and analysis of data on the equipment used in the oil industry, it is possible to obtain valuable information that helps us make strategic and operational decisions with greater clarity in order to optimize processes, streamline costs and improve safety levels in oil facilities.

Software development: key to industry growth. To meet the challenges facing the oil industry today, it is important that you consider the adoption and integration of custom software development. With the help of a custom software development service, you will be able to automate repetitive tasks to increase process efficiency and reduce unnecessary costs; improve the real-time monitoring strategy of your equipment and processes; and improve or support your decision making by immediately obtaining valuable information.

Improving production processes Meeting the needs of the crude oil market requires experts to help streamline the process. Oil and gas companies are constantly searching for methods to optimize resources, reduce costs and increase production efficiency, without neglecting product quality. Hydrocarbon production involves long working days, handling heavy equipment, working outdoors in difficult terrain, and all of this implies the possibility that something could go wrong. Hence the importance of specialists in the field contributing to the improvement of safety protocols, risk prevention and the development of action plans in the event of a crisis.

Reaching complicated deposits: As existing sources are exploited; it is necessary to look for new ones at greater depths. It is very common for these deposits to be difficult to access, which is why it is essential to discover and apply new technologies to obtain more product, even in places that seem unreachable. Responsible production: The ecological issue also concerns this industry, which demands the help of experts who contribute to the implementation of green technologies to improve both the extraction processes and the reduction of environmental impact.

4. Conclusions

In Ecuador, oil is exploited in two areas: in the Santa Elena peninsula and in the Ecuadorian Amazon. Historian Jenny Estrada, in her book *Ancón*, points out that the oil in the peninsula was known before the arrival of the Spaniards to these coasts. The natives called it copey or copé. Later these deposits were exploited primitively and the production was exported to Peru for the manufacture of pitch. Father Juan de Velasco, in his *History of the Kingdom of Quito*, reports that in the towns of Chanduy and Chongón, in the province of Santa Elena, there were various natural perennial springs of tar and tar, which were used to caulk the ships.

Since the 1950s, oil has become the world's leading source of energy, supplying more than 30% of the world's energy needs. It is also the main raw material for transportation fuels (cars, trucks, airplanes). It is also an irreplaceable raw material for the petrochemical industry, as it is required as raw material to produce a large number of everyday products such as plastic, paints, dyes, cosmetics, among others. Additionally, oil is one of the most important natural resources in the world, due to its industrialized use. For this reason, it is called "black gold". Moreover, it is a great energy generator and the world economy evolves with energy. This hydrocarbon contributes about 2.5% of the world's Gross Domestic Product. However, only a small portion of oil and gas emerges from the earth by natural causes, therefore, petroleum engineering intervenes, developing and employing diverse methods to extract this precious resource. Bearing in mind that it is a fossil fuel whose reserves are limited on a planetary scale.

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